



ME48



Multifunctional Reference Standard

ENERGOMONITOR 3.1KM

User's Manual

Edition 3

2016

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INTRODUCTION

The manual describes a desktop/rack-mounted/portable multifunctional reference standard meter **ENERGOMONITOR-3.1KM** (hereinafter referred to as “the EM-3.1K” or “the Device”) and contains information about its operation, maintenance, transportation, storage, manufacturer’s warranty conditions and calibration procedure.

In terms of design, accuracy and functionality, the EM 3.1KM comes in various options.

The legend (shown below) contains information about the options as specified in the purchase order:

Energomonitor 3.1KM X-XX-XXX-X-X-X-X01-X02-X05-X10-X20
1 2 3 4 5 6 7 8 9 10 11

Position 1 – design version:

"S" – stationary (19" rack mount enclosure);

"D" – desktop;

"P" – portable.

Position 2 – accuracy:

"02" – measurement errors as specified in Tables 3, 4 and 9;

"05" – measurement errors as specified in Tables 5, 6 and 10;

"10" – measurement errors as specified in Tables 7, 8 and 10.

Position 3 – extra functionality:

"000" – no additional functions;

"1XX" – DC current and DC power measurement functions available;

"X1X" – Contactless current measurements available (AC current probes of the required type included in the delivery package);

"XX1" – Comparator function available (meant for calibration of voltage instrument transformers (VTs) and current instrument transformers (CTs)).

CTs are calibrated with use of the auxiliary device CTCS-3.1 (scaling converter + switch-gear module) included in the delivery package.

Position 4 – AC voltage measurement ranges:

"0" - from 6 to 576 V [measurement subranges 60, 120, 240 and 480 V],

"1" – from 0.1 to 288 V [measurement subranges 1, 2, 5, 10, 30, 60, 120 and 240 V],

"2" – from 3 to 960 V [measurement subranges 30, 60, 120, 240, 480 and 800 V],

"3" – from 0.1 to 960 V [measurement subranges 1, 2, 5, 10, 30, 60, 120, 240, 480 and 800 V].

Position 5 – AC current measurement ranges for contact measurements (without AC current probes):

"0" – from 0.005 to 120 A [measurement subranges 0.05; 0.1; 0.25; 0.5; 1; 2.5; 5; 10; 25; 50 and 100 A],

"1" – from 0.005 to 60 A [measurement subranges 0,05; 0,1; 0,25; 0,5; 1; 2,5; 5; 10; 25 и 50 A],

"2" – from 0.005 to 12 A [measurement subranges 0.05; 0.1; 0.25; 0.5; 1; 2.5; 5 and 10 A].

Position 6 – nominal AC frequency (f_{nom}):

"50" – $f_{nom} = 50$ Hz; operating frequency range from 42.5 to 57.5 Hz;

"60" – $f_{nom} = 60$ Hz; operating frequency range from 51 to 69 Hz.

Position 7 – Nominal (rated) currents of AC current probes (accuracy class 0.1);

Position 8 – Nominal (rated) currents of AC current probes (accuracy class 0.2);

Position 9 – Nominal (rated) currents of AC current probes (accuracy class 0.5);

Position 10 – Nominal (rated) currents of AC current probes (accuracy class 1.0);

Position 11 – Nominal (rated) currents of AC current probes (accuracy class 2.0).

NOTE!

1. When listed, nominal (rated) currents of AC current probes are separated by semicolon (;).
2. Nominal (rated) currents of the current probes available are:
 - For clip-on CTs – 5, 10, 100, 200 and 1000 A;
 - For flexible current clamps – 300, 500, 3000, and 5000 A.

1 SAFETY REQUIREMENTS

1.1 The Device is included in the product range of instruments compliant with the requirements of “Interbranch Rules for Labor Safety (Safety Rules) When Operating Electrical Systems” (M, Energoatomizdat, 2001).

The symbol



placed on the panel of the Device is intended to alert the user to the presence of the important operating instructions. See section 3, “Turning on”.

1.2 The Device is operated according to the safety requirements specified in IEC 61010-1; Installation category: II; degree of protection against pollution: 1.

IEC 60529 protection code: IP20.

1.3 Electrical strength and resistance of insulation

1.3.1 Insulation between the mains supply plug pins connected together and galvanically isolated from the Device’s enclosure (the “Power” switch is set to “ON”) from one side and the “Ground” terminal of the Device from the other side provides for withstanding AC test voltage of 1350 V (rms), 50 Hz during 1 min.

1.3.2 Insulation between the mains supply plug pins connected together and galvanically isolated from the Device’s enclosure (the “Power” switch is set to Position “ON”) from one side and the Device’s 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 provides for withstanding AC test voltage of 1350 V (rms), 50 Hz during 1 min.

1.3.3 Insulation between 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 provides for withstanding AC test voltage of 3200 V (rms) during 1 min.

1.3.4 Insulation between the voltage inputs (U_A ; U_B ; U_C ; U_N) connected together from one side and the “Ground” terminal of the Device from the other side provides for withstanding AC test voltage of 3200 V (rms), 50 Hz during 1 min.

1.3.5 Insulation resistance is at least 20 MOhm (under operating conditions):

- Between the mains supply plug pins connected together and galvanically isolated from the Device’s enclosure (the “Power” switch is set to “ON”) from one side and the Device’s 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;

- Between the mains supply plug pins connected together and galvanically isolated from the Device’s enclosure (the “Power” switch is set to “ON”) from one side and the “Ground” terminal of the Device from the other side;

- Between 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;

- Between the voltage inputs (U_A ; U_B ; U_C ; U_N) connected together from one side and the “Ground” terminal of the Device from the other side.

2 GENERAL INFORMATION AND OPERATION PRINCIPLE

2.1 Sphere of application

As a reference standard, ENERGOMONITOR-3.1KM measures electrical parameters including voltages, currents, phase shifts, active, reactive and apparent powers etc. in single- and three-phase networks within the range of commercial frequencies.

The Device operates either as a stand-alone instrument (independently or with a PC that provides extended functionality) or, as part of a meter test system, it can be used for accuracy tests and calibration of reference-class and service-class measuring instruments, including:

- single- or three-phase meters of active or reactive electric energy;
- single- or three-phase wattmeters, varmeters, as well as instrument converters industrially applied for measurements of active and reactive electric power;
- phase meters and frequency meters intended for use within the commercial range of frequencies;
- voltmeters, amperimeters, and instrument converters of voltage and current intended for use within the commercial range of frequencies;
- various instruments that make measurements and record electrical parameters and power quality parameters in single- and three-phase networks;
- current (CTs) and voltage (VTs) instrument transformers.

The EM-3.1KM can be of service to various metrological labs or units run by industrial-scale enterprises, electrical power systems, certification and testing centers etc.

As a nationally recognized tool, the EM-3.1K has been registered under N 52854-13 with National Registry of Measuring Instruments, and granted Type Approval Certificate of Measuring Instruments RU.C.34.001.A N 50014 of 28.02.2013.

2.2 Environmental Conditions

2.2.1 Environmental conditions are specified in Table 1.

Table 1

Operating and calibration conditions for EM 3.1KM

Contributing parameter	Value (range of values)	
	Calibration	Operating
Ambient temperature, °C	20 ± 5	20 ± 10
Relative humidity, %	30 to 80	up to 80 at 20 °C
Atmospheric pressure, kPa	84 to 106.7	84 to 106.7
Power supply frequency, Hz	47 to 63	47 to 63
Power supply phase voltage, V	220 ± 22	220 ± 22
Total Harmonic Distortion of voltage, %	up to 5	up to 5

2.3 Delivery Package

Particular delivery package for the Device may be agreed to include items specified in Table 2.

Table 2

Name and description		Q-ty	
Energomonitor 3.1KM		1	
Mains cable 220V		1	
User Manual		1	
Manufacturer's package		1	
Cable lug for currents over 12 A		6	
PC connection cable, RS232 interface		1	
PC connection cable, USB interface (USB A plug - USB B plug, 1.8 m)		1	
Software of Energomonitoring family		1	
Accessories*			
Clip-on CTs 5 A	Supplied with EM3.1KM, modification x-x-x-1x	3	
Shunt 5A		1	
Clip-on CTs 10A		3	
Shunt 10 A		1	
Clip-on CTs 100A		3	
Shunt 100A		1	
Clip-on CTs 200 A		3	
Shunt 200A		1	
Clip-on CTs 1000A		3	
Shunt 1000A		1	
Flexible current clamps 300/3000 A		3	
Flexible current clamps 500/5000 A		3	
Transformer Calibration Switch CTCS-3.1 + one mains cable 220V + two cables for connection to EM 3.1KM		Supplied with EM 3.1KM, modification x-x-x-xx1	1
"F _{OUT} " cable			1
"Meter – F _{IN} " cable		1	
Test leads Ø 4 mm for voltage inputs of EM3.1KM (U _{max} =1000 V, 4 colors, wire cross section 1 mm ²)		4	
Test leads Ø 4 mm for current inputs of EM3.1KM (I _{max} = 12 A, 2 colors, wire cross section 2.5 mm ²)		6	
Scanning Head SH-E		1	
Scanning Head SH-I		1	
Pulse Former		1	
* Accessories are included in the delivery package as specified in the Supply Agreement.			

2.4 Technical Characteristics

Only the values for which measurement ranges and limits of permissible measurement error are specified in the tables below must be considered as the declared accuracy data.

Other values specified in the tables below are given just for reference.

2.4.1 Modifications

2.4.1.1 Design version options are as follows:

Energomonitor 3.1KMS – stationary (19’’ rack mount enclosure);

Energomonitor 3.1KMD – desktop;

Energomonitor KMP- portable (embedded in a plastic case).

2.4.1.2 Accuracy options:

Energomonitor 3.1KMx-02 – accuracy characteristics as specified in Tables 3, 4 and 9;

Energomonitor 3.1KMx-05 - accuracy characteristics as specified in Tables 5, 6 and 10;

Energomonitor 3.1KMx-10 - accuracy characteristics as specified in Tables 7, 8 and 10.

2.4.1.3 Options related to functionality:

Energomonitor 3.1KM x-x-000 – no additional functions;

Energomonitor 3.1KM x-x-1xx – DC current and DC power measurement functions are added;

Energomonitor 3.1KM x-x-x1x – Contactless measurements of current available (delivery package includes AC current probes of selected types);

Energomonitor 3.1KM x-x-xx1 – accuracy testing and calibration of current and voltage instrument transformers available (delivery package includes CTCS).

Several extra functions can be combined in one instrument.

2.4.1.4 Voltage measurement range options:

Energomonitor 3.1KM x-x-xxx-0 – 6 to 576 V [nominal values of subranges: 60, 120, 240 and 480 V];

Energomonitor 3.1KM x-x-xxx-1 – 0.1 to 288 V [nominal values of subranges 1, 5, 30, 60, 120 and 240 V];

Energomonitor 3.1KM x-x-xxx-2 – 3 to 960 V [nominal values of subranges 30, 60, 120, 240, 480 and 800 V]

Energomonitor 3.1KM x-x-xxx-3 – 0.1 to 960 V [nominal values of subranges 1, 2, 5, 10, 30, 60, 120, 240, 480 and 800 B].

2.4.1.5 AC current measurement range options (for measurements without AC current probes):

Energomonitor 3.1KM x-x-xxx-x-0 – 0.005 to 120 A [nominal values of subranges 0.05; 0.1; 0.25; 0.5; 1; 2.5; 5; 10; 25; 50 and 100 A];

Energomonitor 3.1KM x-x-xxx-x-1 – 0.005 to 60 A [nominal values of subranges 0.05; 0.1; 0.25; 0.5; 1; 2.5; 5; 10; 25 and 50 A];

Energomonitor 3.1KM x-x-xxx-x-2– 0.005 to 12 A [nominal values of subranges 0.05; 0.1; 0.25; 0.5; 1; 2.5; 5 and 10 A].

2.4.1.6 Frequency options (with respect to nominal frequency f_N):

Energomonitor 3.1KM x-x-xxx-x-x-50 – $f_N = 50$ Hz; frequency range 42.5 to 57.5 Hz;

Energomonitor 3.1KM x-x-xxx-x-x-60 – $f_N = 60$ Hz; frequency range 51 to 69 Hz.

2.4.2 Measurement ranges and limits of permissible measurement errors are specified in:

- Tables 3 and 4 – for Energomonitor 3.1KM-02;
- Tables 5 and 6 – for Energomonitor 3.1KM-05;
- Tables 7 and 8 – for Energomonitor 3.1KM-10.

Table 3

**Measurement ranges and limits of permissible measurement errors for EM3.1KM-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 ≤ 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 ;	Relative, %	P _N = U _N · I _N
			0.9 ≤ cos φ ≤ 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 ≤ 2 V
			0.2 ≤ cos φ < 0.9
		$\pm[0.015+0.004(1.44P_N/P - 1)]$	U _N > 2 V
4 Reactive power and Reactive power of fundamental harmonic ¹⁾ (Q), Var	0.1I _N to 1.2I _N	Relative, %	Q _H = U _N · I _N
		$\pm[0.03+0.01(1.44Q_N/Q - 1)]$	0.9 ≤ sin φ ≤ 1.0
		$\pm[0.05+0.01(1.44Q_N/Q - 1)]$	0.2 ≤ sin φ < 0.9
5 Apparent power (S), VA	0.1U _N to 1.2U _N ;	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 ≤ 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: - Input voltages, degrees - Voltage and current in the same phase, degrees	0 to 360	Absolute, degree	
		±0.01	0.2U _N to 1.2U _N
		±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 ±0.0005 U _N	U _{H,h} ≤ 0.01U _N
		Relative, %; ±0.05	U _{H,h} > 0.01U _N
10 RMS of voltage interharmonic of order m (frequency m·f ₁), m = 0.5...50.5 in 1.0 increments (U _{C,m}), V	0 to 0.15U _N	Absolute, V ±0.001 U _N	U _{C,m} ≤ 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 ±0.0005 I _N	I _{H,h} ≤ 0.01I _N
		Relative, % ±0.05	I _{H,h} > 0.01I _N

Table 3

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 $m \cdot f_1$), $m=0.5 \dots 50$ in 1.0 increments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A $\pm 0.0005 I_N$	$I_{C,m} \leq 0.01U_N$
		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 $1.2I_N$ $K_I(h) = 2 \dots 15\%$ $K_U(h) = 2 \dots 15\%$
		± 0.3	$h = 2 \dots 10$
		± 1.0	$h = 11 \dots 50$
14 Voltage harmonic of order h (in reference to fundamental harmonic); $h = 2 \dots 50$ [$K_U(h)$], %	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); $h = 2 \dots 50$ [$K_I(h)$], %	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; $h = 2 \dots 50$ ($P_{(h)}$), W	0 to $0.05P_N$	Absolute, W $\pm(0.00003P_N + 0.005P_{(h)})$	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $ \cos \varphi = 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 $1.2U_N$
		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 $\pm(0.0002 U_N \cdot \sqrt{3})$	
21 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V $\pm 0.0005 U_N$	$0.5U_N$ 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 $\pm(0.0003 U_N \cdot \sqrt{3})$	
23 Positive sequence current of fundamental harmonic ($I_{1(1)}$), A	0 to I_N	Absolute, A $\pm 0.0002 I_N$	
24 Zero sequence current of fundamental harmonic ($I_{0(1)}$), A	0 to I_N	Absolute, A $\pm 0.0005 I_N$	

Table 3

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 $\pm 0.0003I_N$	
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 $1.7U_N$	$\pm[0.01+0.005(1.7U_N/U-1)]$ $\pm[0.015+0.005(1.7U_N/U-1)]$	U_N from 5 to 480 V $U_N \leq 2$ 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 $\frac{1}{4} T$, 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 4

**Measurement ranges and limits of permissible measurement errors for EM3.1KM-02
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, %	
		$\pm[0.01+0.002(1.2U_N/U-1)]$	U _N > 2 V
		$\pm[0.015+0.003(1.2U_N/U-1)]$	U _N ≤ 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 ·I _N) to 1.44(U _N ·I _N)	Relative, %	0.1U _N to 1.2U _N
			0.9 < cos φ ≤ 1.0
		$\pm 0.2^I; \pm 0.4^{II}; \pm 1.0^{III}$	0.01I _N to 0.05I _N
		$\pm 0.1^I; \pm 0.2^{II}; \pm 0.5^{III};$ $\pm 1.0^{IV}; \pm 2.0^V$	0.05I _N to 1.2I _N
			0.5 ≤ cos φ ≤ 0.9
		$\pm 0.25^I; \pm 0.5^{II};$ $\pm 0.15^I; \pm 0.3^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 4.0^V$	0.02I _N to 0.1I _N
		$\pm 0.15^I; \pm 0.3^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 4.0^V$	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 ≤ cos φ < 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 ·I _N) to 1.44(U _N ·I _N)	Relative, %	0.1U _N to 1.2U _N
			0.9 < sin φ ≤ 1.0
		$\pm 0.3^I; \pm 0.75^{II}; \pm 1.5^{III};$ $\pm 0.2^I; \pm 0.5^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 2.0^V$	0.02I _N to 0.05I _N
		$\pm 0.2^I; \pm 0.5^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 2.0^V$	0.05I _N to 1.2I _N
			0.5 ≤ sin φ ≤ 0.9
		$\pm 0.3^I; \pm 0.75^{II}; \pm 1.5^{III};$ $\pm 0.2^I; \pm 0.5^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 2.0^V$	0.02I _N to 0.1I _N
		$\pm 0.2^I; \pm 0.5^{II}; \pm 1.0^{III};$ $\pm 2.0^{IV}; \pm 2.0^V$	0.1I _N to 1.2I _N
		$\pm 0.3^I; \pm 0.75^{II}; \pm 1.5^{III};$ $\pm 2.5^{IV}; \pm 2.5^V$	0.2 ≤ sin φ < 0.5 0.1I _N to 1.2I _N
5 Apparent power (S), VA	0.01(U _N ·I _N) to 1.44(U _N ·I _N)	Relative, %	0.1U _N to 1.2U _N 0.01I _N to 1.2I _N
		$\pm 0.2^I; \pm 0.4^{II}; \pm 1.0^{III}$	S < 0.1S _N
		$\pm 0.1^I; \pm 0.2^{II}; \pm 0.5^{III}$ $\pm 1.0^{IV}; \pm 2.0^V$	0.1S _N to 1.44S _N
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute $\pm 0.02^I; \pm 0.02^{II}; \pm 0.05^{III};$ $\pm 0.05^{IV}; \pm 0.10^V$	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
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

Table 4

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
9 RMS of voltage harmonic of order h ²⁾ , $h = 2 \dots 50$ ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V $\pm 0.0005 U_N$	$U_{H,h} \leq 0.01U_N$
		Relative, % ± 0.05	$U_{H,h} > 0.01U_N$
10 RMS of voltage interharmonic of order m (frequency $m \cdot f_1$), $m = 0.5 \dots 50.5$ in 1.0 increments ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V $\pm 0.0005 U_N$	$U_{C,m} \leq 0.01U_N$
		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, %, $\pm 5 \%^I$; $\pm 10 \%^{II}$	$I_{H,h} > 0.01I_N$
12 RMS of current interharmonic of order m (frequency $m \cdot f_1$), $m = 0.5 \dots 50$ 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, % $\pm 5 \%^I$; $\pm 10 \%^{II}$	$I_{C,m} > 0.01I_N$
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 $1.2I_N$ $K_I(h) \geq 5\%$; $K_U(h) \geq 1\%$
		$\pm 2^I$; $\pm 2^{II}$	$h = 2 \dots 10$
		$\pm 10^I$; $\pm 10^{II}$	$h = 11 \dots 20$
		$\pm 20^I$; $\pm 20^{II}$	$h = 21 \dots 50$
14 Voltage harmonic of order h (in reference to fundamental harmonic); $h = 2 \dots 50$ [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % $\pm 0.003 \%$	$K_U(h) < 1.0$
		Relative, % ± 0.3	$K_U(h) \geq 1.0$
15 Current harmonic of order h (in reference to fundamental harmonic); $h = 2 \dots 50$ [$K_I(h)$], %	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, %: ± 0.003	$K_U < 1.0$
		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 ≥ 1.0
18 Active power of h^{th} harmonic; $h = 2 \dots 50$ ($P_{(h)}$), W	0.003 P_N to 0.1 P_N	Relative, %	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) = 1 \dots 40\%$ $K_U(h) = 1 \dots 40\%$
		$\pm 5.0^I$; $\pm 10.0^{II}$	$ \cos \varphi = 0.9 \dots 1.0$ $h = 2 \dots 50$
			$ \cos \varphi = 0.5 \dots 0.9$
		$\pm 5.0^I$; $\pm 10.0^{II}$	$h = 2 \dots 10$
		$\pm 10.0^I$; $\pm 20.0^{II}$	$h = 11 \dots 50$

Table 4

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
19 Positive sequence voltage of fundamental harmonic ($U_{1(l)}$), V	0 to U_N	Absolute, V $\pm(0.0002 U_H \times \sqrt{3})$	
20 Zero sequence voltage of fundamental harmonic ($U_{0(l)}$), V	0 to U_N	Absolute, V $\pm 0.0005 U_N$	$0.5U_N$ to $1.2U_N$ $K_{2U} < 15\%$; $K_{0U} < 15\%$
21 Negative sequence voltage of fundamental harmonic ($U_{2(l)}$), V	0 to U_N	Absolute, V $\pm(0.0003 U_H \cdot \sqrt{3})$	$0.5U_N$ 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 ($I_{1(l)}$, $I_{0(l)}$ and $I_{2(l)}$), A	0 to I_N	Absolute, A	
		$\pm(0.01I_N)^I$; $\pm(0.01I_N)^{II}$	$0.01I_N$ to $1.2I_N$
		$\pm(0.02I_N)^{III}$; $\pm(0.02I_N)^{IV}$	$0.05I_N$ to $1.2I_N$
24 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	$f = (f_{NOM} \pm 1)$ Hz $\Delta U/U \leq 20\%$; provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	$\pm[0.01+0.005(1.7U_N/U-1)]$ $\pm[0.015+0.005(1.7U_N/U-1)]$	$U_N = 5 \dots 480$ V $U_N \leq 2$ V
	$0.1U_N$ to $1.25U_N$	$\pm[0.015+0.005(1.25U_N/U-1)]$	$U_N = 800$ V

Notes:

1 Reactive power is calculated by 3 methods: cross-connection, geometrical and phase shift (voltage is shifted by $\frac{1}{4} T$, 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 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 5

Measurement ranges and limits of permissible measurement errors for EM3.1KM-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, % ±[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, % ±[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	Relative, % ±[0.05+0.01(1.44P _N /P-1)]	P _N = U _N · I _N cos φ = 0.2 ... 1.0
4 Reactive power and Reactive power of fundamental harmonic ¹⁾ (Q), Var	0.1I _N to 1.2I _N	Relative, % ±[0.1+0.02 (1.44Q _N /Q-1)]	Q _N = U _N · I _N sin φ = 0.2 ... 1.0
5 Apparent power (S), VA		Relative, % ±[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:		Absolute, degrees	
-phase voltages, degrees	0 to 360	±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 ±0.001 U _N	U _{H,h} ≤ 0.01U _N
		Relative, % ±0.1	U _{H,h} > 0.01U _N
10 RMS of voltage interharmonic of order m (frequency m·f ₁), m = 0.5...50.5 in 1.0 increments (U _{C,m}), V	0 to 0.15U _N	Absolute, V ±0.001 U _N	U _{C,m} ≤ 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 ±0.001 I _N	I _{H,h} ≤ 0.01I _N
		Relative, % ±0.05 %	I _{H,h} > 0.01I _N
12 RMS of current interharmonic of order m (frequency m·f ₁), m=0.5...50 in 1.0 increments (I _{C,m}), A	0 to 0.15I _N	Absolute, A ±0.001 I _N	I _{C,m} ≤ 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 ... 15 %
		±1.0	h = 2 ... 10
		±3.0	h = 11 ... 50

Table 5

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
		Absolute, % ±0.01	K _U (h) < 1.0
		Relative, % 1.0	K _U (h) ≥ 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) ≥ 1.0
16 Active power of h th harmonic; h = 2 ... 50 (P _(h)), W	0 to 0.05P _N	Absolute, W ±(0.00005P _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 1.1U _N
		Absolute, % ±0.003	K _U < 1.0
		Relative, % ±0.3	K _U ≥ 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 ≥ 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 ±(0,0004U _N × √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 ±(0.0006U _N · √3)	
23 Positive sequence current of fundamental harmonic (I ₁₍₁₎), A	0 to I _N	Absolute, A ±(0.0004I _N)	
24 Zero sequence current of fundamental harmonic (I ₀₍₁₎), A	0 to I _N	Absolute, A ±(0.001I _N)	
25 Negative sequence current of fundamental harmonic (I ₂₍₁₎), A	0 to I _N	Absolute, A ±(0.0006I _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₎ ≥ 0.02 I _N U ₁₍₁₎ , U ₂₍₁₎ , U ₀₍₁₎ ≥ 0.02 U _N

Table 5

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
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 mander-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 $\frac{1}{4} T$, 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 6

**Measurement ranges and limits of permissible measurement errors for EM3.1KM-05
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, % ±[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, % ±[0.1+0.01(I _N /I - 1)] ^I ±[0.2+0.02(I _N /I - 1)] ^{II} ±[0.5+0.05(I _N /I - 1)] ^{III} ±[1.0+0.05(I _N /I - 1)] ^{IV} ±[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 < cos φ ≤ 1.0
		±0.2 ^I ; ±0.4 ^{II} ; ±1.0 ^{III}	0.01I _N to 0.05I _N
		±0.1 ^I ; ±0.2 ^{II} ; ±0.5 ^{III} ; ±1.0 ^{IV} ; ±2.0 ^V	0.05I _N to 1.2I _N
			0.5 ≤ cos φ ≤ 0.9
		±0.25 ^I ; ±0.5 ^{II} ; ±0.15 ^I ; ±0.3 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±4.0 ^V	0.02I _N to 0.1I _N
		±[0.25+0.02(1.44P _N /P - 1)] ^I ; ±[0.5+0.05(1.44P _N /P - 1)] ^{II} ; ±[1.0+0.1(1.44P _N /P - 1)] ^{III} ; ±[2.0+0.1(1.44P _N /P - 1)] ^{IV}	0.2 ≤ cos φ < 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 ·I _N) to 1.44(U _N ·I _H)	Relative, %	0.1U _N to 1.2U _N
			0.9 < cos φ ≤ 1.0
		±0.3 ^I ; ±0.75 ^{II} ; ±1.5 ^{III} ; ±0.2 ^I ; ±0.5 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±2.0 ^V	0.02I _N to 0.05I _N
			0.05I _N to 1.2I _N
			0.5 ≤ sin φ ≤ 0.9
		±0.3 ^I ; ±0.75 ^{II} ; ±1.5 ^{III} ; ±0.2 ^I ; ±0.5 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±2.0 ^V	0.02I _N to 0.1I _N
		±0.3 ^I ; ±0.75 ^{II} ; ±1.5 ^{III} ; ±2.5 ^{IV} ; ±2.5 ^V	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
		±0.2 ^I ; ±0.4 ^{II} ; ±1.0 ^{II}	S < 0.1S _N
		±0.1 ^I ; ±0.2 ^{II} ; ±0.5 ^{III} ±1.0 ^{IV} ; ±2.0 ^V	0.1S _N to 1.44S _N
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute ±0.02 ^I ; ±0.02 ^{II} ; ±0.05 ^{III} ; ±0.05 ^{IV} ; ±0.10 ^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 6

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		± 0.03	$0.2U_N$ 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⁾ , $h=2\dots 50$ ($U_{H,h}$), 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 interharmonic of order m (frequency $m \cdot f_1$), $m = 0.5\dots 50.5$ in 1.0 increments ($U_{C,m}$), 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 interharmonic of order m (frequency $m \cdot f_1$), $m=0.5\dots 50$ in 1.0 increments ($I_{C,m}$), 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 harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) \geq 5\%$; $K_U(h) \geq 1\%$
		$\pm 2^I$; $\pm 2^{II}$	$h = 2 \dots 10$
		$\pm 10^I$; $\pm 10^{II}$	$h = 11 \dots 20$
		$\pm 20^I$; $\pm 20^{II}$	$h = 21 \dots 50$
14 Voltage harmonic of order h (in reference to fundamental harmonic); $h = 2 \dots 50$ [$K_U(h)$], %	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); $h = 2 \dots 50$ [$K_I(h)$], %	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 6

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
18 Active power of h^{th} harmonic; $h = 2 \dots 50$ ($P_{(h)}$), W	0.003 P_N to 0.1 P_N	Relative, %	0.2 U_N to 1.2 U_N 0.2 I_N to 1.2 I_N $K_I(h) = 1 \dots 40\%$ $K_U(h) = 1 \dots 40\%$
		$\pm 5.0^{\text{I}}$; $\pm 10.0^{\text{II}}$	$ \cos \varphi = 0.9 \dots 1.0$ $h = 2 \dots 50$
			$ \cos \varphi = 0.5 \dots 0.9$
		$\pm 5.0^{\text{I}}$; $\pm 10.0^{\text{II}}$	$h = 2 \dots 10$
		$\pm 10.0^{\text{I}}$; $\pm 20.0^{\text{II}}$	$h = 11 \dots 50$
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ± 0.20	0.5 U_N to 1.2 U_N
20 Positive sequence voltage of fundamental harmonic ($U_{1(l)}$), V	0 to U_N	Absolute, V $\pm(0.0004U_N \times \sqrt{3})$	
21 Zero sequence voltage of fundamental harmonic ($U_{0(l)}$), V	0 to U_N	Absolute, V $\pm 0.001 U_N$	0.5 U_N to 1.2 U_N $K_{2U} < 15\%$ $K_{0U} < 15\%$
22 Negative sequence voltage of fundamental harmonic ($U_{2(l)}$), 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 ($I_{1(l)}$, $I_{0(l)}$ and $I_{2(l)}$), A	0 to I_N	Absolute, A	
		$\pm(0.01I_N)^{\text{I}}$; $\pm(0.01I_N)^{\text{II}}$	0.01 I_N to 1.2 I_N
		$\pm(0.02I_N)^{\text{III}}$; $\pm(0.02I_N)^{\text{IV}}$	0.05 I_N to 1.2 I_N
24 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	$f = (f_{\text{NOM}} \pm 1)$ Hz $\Delta U/U \leq 20\%$; provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	0.1 U_N to 1.7 U_N	$\pm[0.02+0.005(1.7U_N/U-1)]$	U_N up to 480 V
	0.1 U_N to 1.25 U_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 $\frac{1}{4} T$, 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 7

Measurement ranges and limits of permissible measurement errors for EM3.1KM-10 (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 (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, % ±[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, % ±[0.1+0.01(1.44P _N /P-1)]	P _N = U _N · I _N cos φ = 0.2 to 1.0
4 Reactive power and Reactive power of fundamental harmonic ¹⁾ (Q), Var		Relative, %, ±[0.2+0.02(1.44Q _N /Q-1)]	Q _N = U _N · I _N sin φ = 0.2 to 1.0
5 Apparent power (S), VA		Relative, % ±[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 fundamental 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 ±0.002 U _N	U _{H,h} ≤ 0.01U _N
		Relative, % ±0.2	U _{H,h} > 0.01U _N
10 RMS of voltage interharmonic of order m (frequency m·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} ≤ 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 ±0.002 I _N	I _{H,h} ≤ 0.01I _N
		Relative, % ±0.1	I _{H,h} > 0.01I _N
12 RMS of current interharmonic of order m (frequency m·f ₁), m=0.5...50 in 1.0 increments (I _{C,m}), A	0 to 0.15I _N	Absolute, A ±0.002I _N	I _{C,m} ≤ 0.01I _N
		Relative, % ±0.1	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) = 2...15% K _U (h) = 2 ... 15 %
		±1.0	h = 2 ... 10
		±3.0	h = 11 ... 50

Table 7

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		0.2 U_N to 1.2 U_N 0.2 I_N to 1.2 I_N
		Absolute, % ± 0.05	$K_U(h) < 1.0$ $K_I(h) < 1.0$
		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 0.05 P_N	Absolute, W $\pm(0.0001P_N + 0.005P_{(h)})$	h = 2 ... 50 0.2 U_N to 1.2 U_N 0.2 I_N to 1.2 I_N $ \cos \varphi = 0.5 \dots 1.0$ $K_I(h) = 1 \dots 40\%$ $K_U(h) = 1 \dots 40\%$
16 Total Harmonic Distortion of voltage (THD $_U$) and Total Harmonic Distortion of current (THD $_I$), %	0 to 49.9		0.2 U_N to 1.2 U_N 0.2 I_N to 1.2 I_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	0.5 U_N to 1.2 U_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 $\pm 0.002 U_N$	0.5 U_N to 1.2 U_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	0.2 I_N to 1.2 I_N 0.2 U_N to 1.2 U_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 = ($f_{\text{NOM}} \pm 1$) Hz $\Delta U/U \leq 20\%$, provided that voltage waveforms are mean-der-like

Table 7

Measured parameter	Measurement 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, % ±[0.04+0.01(1.7U _N /U-1)]	U _N up to 480 V
	0.1U _N to 1.25U _N	Relative, % ±[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, % ±[0.04+0.01(1.2I _N /I - 1)]	I _N = 100 A
	0.1I _N to 1.5I _N	Relative, %, ±[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	±[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	±[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	±[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	±[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 hth harmonic equals h·f₁.

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 8

**Measurement ranges and limits of permissible measurement errors for EM3.1KM-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, % ± [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, % ±[0.1+0.01(I _N /I - 1)] ^I ±[0.2+0.02(I _N /I - 1)] ^{II} ±[0.5+0.05(I _N /I - 1)] ^{III} ±[1.0+0.05(I _N /I - 1)] ^{IV} ±[2.0+0.1(I _N /I - 1)] ^V	
3 Active power and Active power of fundamental harmonic (P), W	0.01(U _N ·I _N) to 1.44(U _N ·I _N)	Relative, %	0.1U _N to 1.2U _N
			0.9 < cos φ ≤ 1.0
		±0.2 ^I ; ±0.4 ^{II} ; ±1.0 ^{III}	0.01I _N to 0.05I _N
		±0.1 ^I ; ±0.2 ^{II} ; ±0.5 ^{III} ; ±1.0 ^{IV} ; ±2.0 ^V	0.05I _N to 1.2I _N
			0.5 ≤ cos φ ≤ 0.9
		±0.25 ^I ; ±0.5 ^{II}	0.02I _N to 0.1I _N
		±0.15 ^I ; ±0.3 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±4.0 ^V	0.1I _N to 1.2I _N
	0.2 ≤ cos φ < 0.5		
		±[0.25+0.02(1.44P _N /P - 1)] ^I ; ±[0.5+0.05(1.44P _N /P - 1)] ^{II} ; ±[1.0+0.1(1.44P _N /P - 1)] ^{III} ; ±[2.0+0.1(1.44P _N /P - 1)] ^{IV}	0.1I _N to 1.2I _N
4 Reactive power and Reactive power of fundamental harmonic ¹⁾ (Q), Var	0.01(U _N ·I _N) to 1.44(U _N ·I _N)	Relative, %	0.1U _N to 1.1U _N
			0.9 < cos φ ≤ 1.0
		±0.3 ^I ; ±0.75 ^{II} ; ±1.5 ^{III} ;	0.02I _N to 0.05I _N
		±0.2 ^I ; ±0.5 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±2.0 ^V	0.05I _N to 1.2I _N
			0.5 ≤ cos φ ≤ 0.9
		±0.3% ^I ; ±0.75% ^{II} ; ±1.5 ^{III} ;	0.02I _N to 0.1I _N
		±0.2 ^I ; ±0.5 ^{II} ; ±1.0 ^{III} ; ±2.0 ^{IV} ; ±2.0 ^V	0.1I _N to 1.2I _N
	0.2 ≤ cos φ < 0.5		
		±0.3 ^I ; ±0.75 ^{II} ; ±1.5 ^{III} ; ±2.5 ^{IV} ; ±2.5 ^V	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
		±0.2 ^I ; ±0.4 ^{II} ; ±1.0 ^{III}	S < 0,1S _H
		±0.1 ^I ; ±0.2 ^{II} ; ±0.5 ^{III} ±1.0 ^{IV} ; ±2.0 ^V	0.1S _N to 1.44S _N
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute ±0.02 ^I ; ±0.02 ^{II} ; ±0.05 ^{III} ; ±0.05 ^{IV} ; ±0.10 ^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 ±0.01	0.2U _N to 1.2U _N 0.2I _N to 1.2I _N

Table 8

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} ≤ 0.01U _N
		Relative, % ±0.2	U _{H,h} > 0.01U _N
10 RMS of voltage interharmonic of order m (frequency m·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} ≤ 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} ≤ 0.01I _N
		Relative, % ±5 % ^I ; ±10 % ^{II}	I _{H,h} > 0.01I _N
12 RMS of current interharmonic of order m (frequency m·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} ≤ 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 _U (h) ≥ 5%; K _I (h) ≥ 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) ≥ 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 _H до 1,2I _H ;
		Absolute, % ±0.05 ^I ; ±0.05 ^{II}	K _I (h) < 1.0
		Relative, % ±5.0 ^I ; ±5.0 ^{II}	K _I (h) ≥ 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 ≥ 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 ≥ 1.0

Table 8

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
18 Active power of h^{th} harmonic; $h = 2 \dots 50$ ($P_{(h)}$), W	0.003 P_N to 0.1 P_N	Relative, %	0.2 U_N to 1.2 U_N 0.2 I_N to 1.2 I_N $K_I(h) = 1 \dots 40\%$ $K_U(h) = 1 \dots 40\%$
		$\pm 5.0^{\text{I}}$; $\pm 10.0^{\text{II}}$	$ \cos \varphi = 0.9 \dots 1.0$
			$ \cos \varphi = 0.5 \dots 0.9$
		$\pm 5.0^{\text{I}}$; $\pm 10.0^{\text{II}}$	$h = 2 \dots 10$
		$\pm 10.0^{\text{I}}$; $\pm 20.0^{\text{II}}$	$h = 11 \dots 50$
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ± 0.20	0.5 U_N to 1.2 U_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 $\pm(0.002 U_N)$	0.5 U_N to 1.1 U_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	
		$\pm(0.01I_N)^{\text{I}}$; $\pm(0.01I_N)^{\text{II}}$	0.01 I_N to 1.2 I_N
		$\pm(0.02I_N)^{\text{III}}$; $\pm(0.02I_N)^{\text{IV}}$	0.05 I_N to 1.2 I_N
24 Flicker short-term severity, relative units	0.2 to 10	Relative, %, 5.0	$f = (f_{\text{NOM}} \pm 1)$ Hz $\Delta U/U \leq 20\%$, provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	0.1 U_N to 1.7 U_N	$\pm[0.04+0.01(1.7U_N/U-1)]$	U_N up to 480 V
	0.1 U_N to 1.25 U_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 $\frac{1}{4} T$, 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).			

2.4.3 Instruments of the Energomonitor–3.1KM x-x-xx1 modification meant for calibration of voltage instrument transformers (VTs) and current instrument transformers (CTs) determine electrical parameters in compliance with measurement ranges and limits of permissible measurement error specified in:

- Table 9 – for Energomonitor 3.1KM x-02;
- Table 10 – for Energomonitor 3.1KM x-05 and Energomonitor 3.1KM x-10.

Table 9

Measurement ranges and limits of permissible measurement errors of EM3.1KM-02 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} ± 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, %	
	±0.1999 %	±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 10

Measurement ranges and limits of permissible measurement errors of EM3.1KM-05 and EM3.1KM-10 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} ± 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, %	
	±0.1999 %	±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).			

2.4.4 Measurement results are averaged over averaging intervals selectable among 1.25 s, 2.5 s, 5 s, 10 s, 1 min, 15min and 30 min.

2.4.5 The EM 3.1KM measures, calculates and displays the following parameters (in addition to the parameters listed in Tables 1–10):

- Deviation of frequency from a user-specified value f_0 , Hz;
- Underdeviation or overdeviation of voltage from a user-specified value U_0 , V.

2.4.5.1 Frequency deviation is calculated as the difference between the measured frequency value f_m and the value f_0 , set in the EM 3.1KM.

2.4.5.2 Underdeviation $\delta U_{(-)}$ and overdeviation $\delta U_{(+)}$ of voltage from a value set by the user (U_0) are calculated from the formulae:

$$\delta U_{(-)} = [(U_0 - U_{m(-)}) / U_0] \cdot 100, \% \quad (1)$$

$$\delta U_{(+)} = [(U_{m(+)} - U_0) / U_0] \cdot 100, \% \quad (2)$$

where $U_{m(-)}$ stands for a measured voltage value lesser than U_0 , V;

$U_{m(+)}$ – stands for a measured voltage value greater than U_0 , V.

2.4.6 Additional measurement errors of the EM 3.1KM

2.4.6.1 Under the effect of self-heating, measurement error of the EM 3.1KM changes by no more than ½ of the declared permissible error limit.

2.4.6.2 On changing the input signal frequency by ± 5 % with respect to the nominal frequency f_{NOM} (50 or 60 Hz), measurement error of the EM 3.1KM changes by no more than ½ of the declared permissible error limit. On changing the input signal frequency by ± 15 % of f_{NOM} , measurement error of the EM 3.1KM does not exceed the declared permissible error limit.

2.4.6.3 On changing power supply voltage by ± 10 %, measurement error of the EM 3.1KM changes by no more than ½ of the declared permissible error limit.

2.4.6.4 Under the presence of harmonics in the current and voltage circuits [test conditions as specified in IEC 62053-22:2003], measurement error of the EM 3.1KM changes by no more than 200 % of the permissible error limit.

2.4.6.5 Under the presence of subharmonics in the current circuits [test conditions as specified in IEC 62053-22:2003], measurement error of the EM 3.1KM changes by no more than 300 % of the permissible error limit.

2.4.6.6 The EM 3.1KM has three channels for AC voltage measurements and three channels for AC current measurements. Crosstalk of the measurement channels causes changing of measurement error of the EM 3.1KM by no more than ½ of the declared permissible error limit.

2.4.6.7 Measurement error of the EM 3.1KM changes by no more than:

- ½ of the associated permissible error limit – on changing environment temperature from 20 to 15 °C and from 20 to 25 °C.
- Associated permissible error limit – on changing environment temperature from 20 to 10 °C and from 20 to 30 °C.

2.4.7 The EM 3.1KM has a pulse input for testing and calibration of electric energy meters.

2.4.7.1 The pulse input accepts signals from electric energy meters of electronic type with the pulse output characteristics as follows:

- Meter constant – from 1 to 999999999 pulses/(kW·h);
- Pulse amplitude – from 5 to 15 V;
- Pulse duration – at least 14 microseconds.

2.4.7.2 The pulse input supports connection of a scanning head (SH) or Pulse Former (PF) meant for testing of induction (disk type) meters.

2.4.7.3 Connection to the pulse input is available via connectors of two types: basic and coaxial (BNC).

2.4.8 The EM 3.1KM is provided with a frequency output generating pulse signal of frequency proportional to measured power.

2.4.8.1 The signal on the frequency output is a sequence of square pulses of voltage with characteristics as follows:

- Pulse duration – at least 10 microseconds;
- Polarity – positive;
- Logical 0 – $U_0 < 0.4$ V;
- Logical 1 – $U_1 > 4.0$ V;
- Load resistance – 10 kOhm as a minimum.

2.4.8.2 The EM 3.1KM is equipped with an additional frequency output generating pulse signal synchronously with the main frequency output.

The additional frequency output can be used as an “open collector” output, which has two states differing by output impedances:

Output impedance < 200 Ohm – “closed” state;

Output impedance > 50 kOhm – “open” state.

Maximal current that the output circuitry of the additional frequency output can sustain is 30 mA.

Maximal voltage on the output pins of the additional frequency output is 30 V.

The additional frequency output can also be used to generate pulses with amplitude of about 24 V (e.g., for testing reference-class energy meters not equipped with a frequency output but equipped with a pulse input).

2.4.8.3 Instrument constant of the EM 3.1KM, which depends on the active measuring range, is determined according to the formula:

$$C = [(144 \times 10^8) / (U_N \times I_N)] / F_D \quad (3)$$

where: C – instrument constant of the EM 3.1KM (for active power measurements – imp/kW·h; for reactive power measurements – imp/kVar·h; for apparent power measurements – imp/kVA·h);

U_N – value of nominal voltage set in the EM 3.1KM, V;

I_N – value of nominal current set in the EM 3.1KM, A;

F_D – division factor selected among 1 (no division), 2, 64, 1024 or 8192.

2.4.9 At the normal or operating conditions, the EM3.1KM is considered set for stable operation in 30 min after applying power. Its specifications are as declared from this point.

2.4.10 Time of continuous operation of the EM 3.1KM is maximum 16 hours. At least 15 min break is required before the next switching on.

2.4.11 EM 3.1KM supports data exchange with a personal computer (PC) via RS-232 and USB interfaces.

2.4.12 Logging function of the EM 3.1KM allows the following data to be recorded and stored (for further transfer to a PC) without rewriting:

- Test results for up to 100 electrical energy meters (up to 20 test points per each);
- Test results for up to 200 CTs and up to 200 VTs (up to 10 test points per each);
- Magnitudes and durations of voltage dips/swells; 80000 events may be recorded continuously before being overridden;
- Instantaneous values of 3 input phase voltages and 3 input phase currents taken directly from the ADC at 12.8 kHz. The memory size permits recording in this mode (called the oscilloscope mode) to last for 9 min without rewriting the data.

Measurement ranges and limits of permissible measurement errors of the EM 3.1KM when it makes measurements on dips/swells are specified in Table 11.

Table 11

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
Duration of voltage dip, s	From 0.02	Absolute, s ± 0.02	$f_1 = (f_{\text{NOM}} \pm 1) \text{ Hz}$
Voltage dip depth, %	From 10 to 100	Relative, % ± 10.0	
Voltage swell height (over-voltage factor), relative units	From 1.1 to 7.99	Relative, % ± 2.0	
Duration of voltage swell, s	From 0.02	Absolute, s ± 0.02	

2.4.13 The built-in real time clock provides a time stamp for every measurement being recorded into the internal memory of the EM 3.1KM.

Date / time in the clock are changeable. The clock's daily drift does not exceed ± 2 s; it is powered by a built-in battery with at least 2 years lifetime.

2.4.14 Power consumed by the EM 3.1KM together with the Transformer Calibration Switch (CTCS-3.1) from mains is 100 VA, or less.

2.4.15 Power consumed by each current measurement channel of the EM 3.1KM at a nominal input current (I_N) is 15 VA, or less.

Power consumption of each voltage measurement channel at a nominal input voltage (U_N) never exceeds 1VA.

Input impedance of the EM 3.1KM voltage circuitry:

1060 kOhm at a nominal voltage of 30, 60, 120, 240, 480, or 800 V;

176 kOhm at a nominal voltage of 1, 2, 5, or 10 V.

Power consumed by each input channel of the CTCS-3.1 at a nominal current (I_N) never exceeds 1 VA.

2.4.16 Overall dimensions, no more than:

485 × 450 × 140 mm – for the EM 3.1KM-S (Stationary) and EM 3.1KM-D (Desktop);

480 × 380 × 200 mm – for EM 3.1KM-P (Portable);

295 × 225 × 100 mm – for the CTCS-3.1.

2.4.17 Weight, no more than:

8 kg – for the EM 3.1KM-S (Stationary) and EM 3.1KM-D (Desktop);

10 kg – for the EM 3.1KM-P (Portable);

2.5 kg – for the CTCS-3.1.

2.5 Design and operation

2.5.1 The EM 3.1KM utilizes Analog-to-Digital Conversion (ADC) principles. Three-phase input voltages and currents are converted into digital codes from which arrays of sampled instantaneous values are created. The arrays are used by the EM 3.1KM firmware (FW) to make all programmed calculations with measured values.

The EM 3.1KM consists of the following functional blocks:

- Multi-range Input Current Converters;
- Multi-range Input Voltage Converters;
- Block of 6-channel ADCs (ADC Block);
- Data Processing Block (DTB);
- Measurement Range Selector;

- Power Supply Unit (PSU);
- Data Display;
- Keypad.

Based on error-compensated instrument current transformers, Input Current Converters convert input currents into proportional voltage signals.

Input Voltage Converters based on high-precision variable-gain inverting operational amplifiers scale input voltages to match inputs of the ADCs.

ADC Block converts output signals coming from the Input Current Converters, Input Voltage Converters and CTCS-3.1 into 18-bit codes (17 significant and 1 sign bit). The circuitry provides galvanic isolation between the ADC block and Data Processing block.

Data Processing Block is designed on the basis of a Texas Instruments signal processor and a FPGA available from Xilinx. Working under the operating firmware stored in the non-volatile EEPROM memory, DTB provides full control over the EM 3.1KM. In particular, DTB provides that calculations be done over the arrays of samples, the results be stored in flash memory and displayed on LCD screen, time be kept and intervals marked as per real-time clock, data exchange be supported with external devices (PCs), commands and data be received from operator's keyboard, pulse signals from the device under test be accepted etc.

Measurement Range Selector designed on a Xilinx field-programmable gate array (FPGA) produces control commands for the Multi-range Input Current/Voltage Converters and Transformer Calibration Switch CTCS-3.1 (supplied with the EM 3.1KM modifications meant for transformer testing).

PSU generates power supply voltages for all blocks and units of the EM 3.1KM.

Keypad and Data Display are both mounted on the front panel of the EM 3.1KM.

2.5.2 The Current Transformer Calibration Switch CTCS-3.1 is supplied with the EM 3.1KM intended for testing of instrument current transformers.

The CTCS-3.1 includes two error-compensated instrument current transformers and power supply unit. The CTCS-3.1 is connected to the CURRENT input connector of the EM 3.1KM.

2.5.3 The CURRENT input connector can also be used for connection of AC current probes.

3 PREPARING FOR OPERATION

3.1 Notes on Operating Conditions

3.1.1 **Caution!** If the Device has been moved from a cold environment (with ambient temperature below minus 5° C) into a warm one, it shall be left to stand for at least 4 hours at room temperature before applying power, to make sure that no condensation remains inside.

Warning! The Device shall not be used under the ingress of moisture inside its body.

3.1.2 Maximum value of AC voltage applied to the voltage inputs of EM 3.1KM must not exceed 120 % of its highest voltage measuring range.

3.1.3 Maximum value of input AC current must not exceed 120 % of the highest measuring range of the **current input in use**.

3.2 Unpacking

Check that the delivery package contains all parts specified in the Supply Agreement. Check to see if the manufacturer's seal is intact. Should anything in the package be found damaged, contact the supplier immediately.

The delivery package is specified in Table 2.1.

3.3 Preparing for operation

3.3.1 Controls and connectors

The following section covers operation of the EM 3.1KM controlled manually from the front panel display and keypad.

All functions of the EM 3.1KM can be controlled from the keypad and menu screens using the cursor. The keys on the keypad are described in Table 3.1.

Table 3.1

Key	Name and Function
0...9	Numeric keypad: used to type in numeric values
↑	Up arrow key: used to move the cursor up through menu items and to increase numeric values
↓	Down arrow key: used to move the cursor down through menu items and to decrease numeric values
←	Left arrow key: used to move the cursor to the left and to change numeric values
→	Right arrow key: used to move the cursor to the right and to change numeric values
ENT	Enter: used to open the selected screen, save values to the memory, or enable the selected mode
ESC	Escape: used to exit a mode or leave some current menu item for an upper level menu
F	Function: a hot key used to go to the Measuring range selection screen from the most of screens or menu items, or to enable/disable the mode of entering characters while specifying names of objects
.	Press to insert a symbol in the mode of entering characters while specifying names of objects

3.3.2 Making connections and turning on

Warning! To avoid electric shock, it is strongly recommended to connect (disconnect) the EM 3.1KM to the measured circuits when they are de-energized. Otherwise, connection (disconnection) to the measured circuits shall be carried out by qualified service personnel in compliance with local safety regulations in force.

Before making connections, inspect the cables. Ensure all joints are made properly to avoid overheating and excessively high resistance.

3.3.2.1 The EM 3.1KM has voltage input connectors (phase and neutral) and current input connectors. The phase current inputs are galvanically isolated from each other and from the voltage inputs.

3.3.2.2 Voltage and current measuring inputs of Energomonitor 3.1KM-S (stationary) and Energomonitor 3.1KM-D (desktop) (see Fig. 3.1) are located on the rear panel (Fig. 3.2). Input currents above 12 A are applied to separate inputs.

3.3.2.3 All measuring inputs of the Energomonitor 3.1KM-P (portable) are located on the front panel (Fig. 3.5).

3.3.2.4 The EM 3.1KM intended for testing of instrument current transformers is used in combination with the Current Transformer Calibration Switch CTCS-3.1. Connections of the CTCS-3.1 are shown in Fig. 3.3 and 3.4.

3.3.2.5 Turning on

As it is powered up, the EM 3.1KM turns on the display backlight and performs warm-up, initialization and initial configuration procedures. During the initialization, performance of every unit is checked and programs are loaded. At the conclusion (in 1...5 seconds), the “power up” screen containing manufacturer’s name and logo, device type, firmware version and serial number of the EM 3.1KM appears.

The EM3.1KM is considered set for stable operation in 30 min after applying power. Its specifications are as declared from this point.

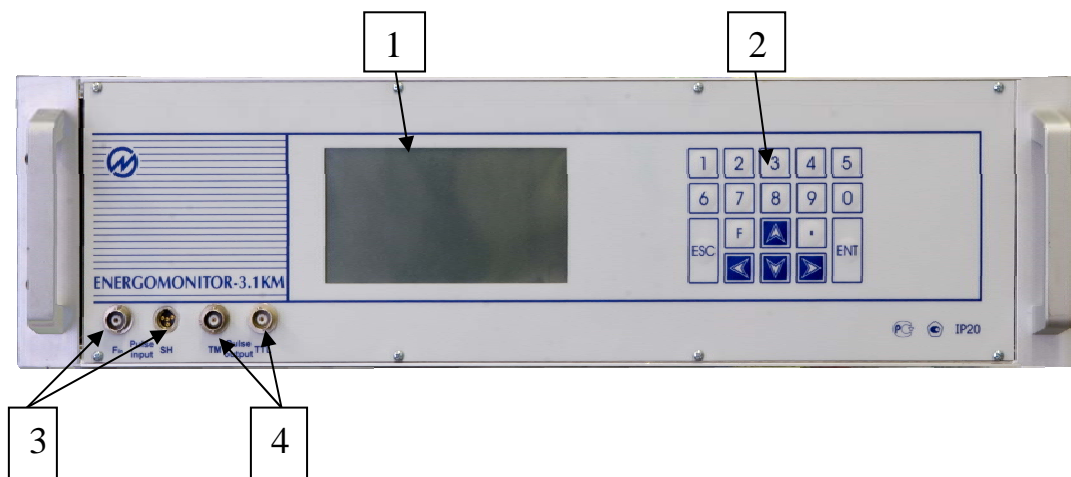


Fig. 3.1 Front panel of the EM 3.1KM –S (stationary)

1 — Graphic display;

2 — Keypad;

3 – "Pulse input" connectors: SH (for connecting Scanning Heads or Pulse Former) and F_{in} ;

4 – "Pulse output" connectors: TTL (produces TTL-compatible output signal of frequency proportional to power measured by the EM 3.1KM) and telemetry output TM (produces 24 V peak-to-peak voltage signal of the same frequency as generated on the main frequency output)

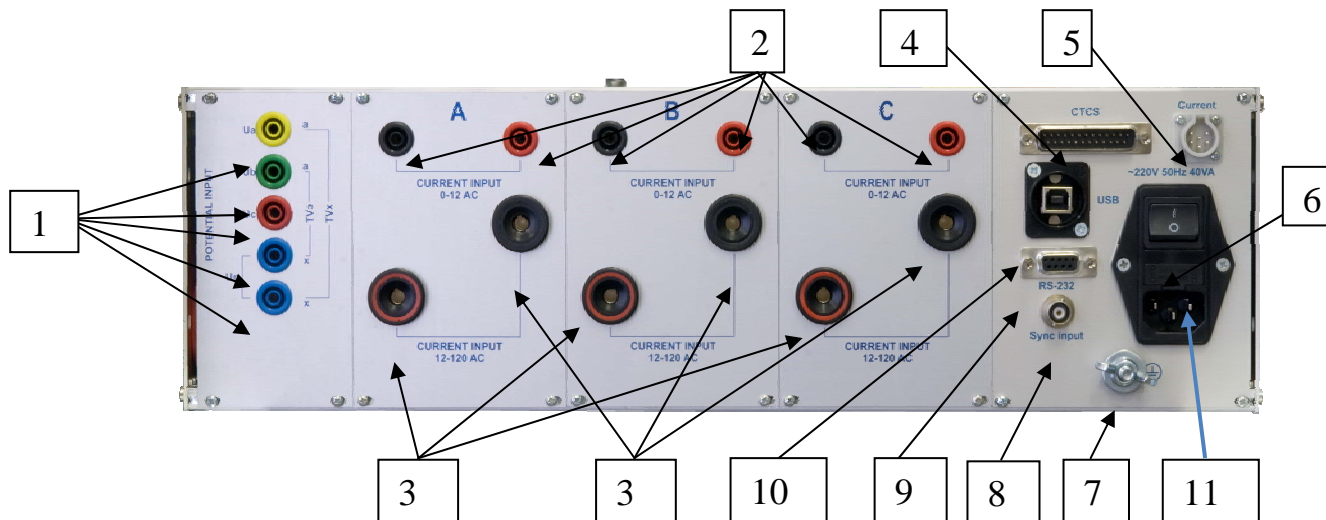


Fig. 3.2 Rear panel of the EM 3.1KM-S

- 1 — Voltage input connectors;
- 2 — Current input connectors for currents below 12 A;
- 3 — Current input connectors for currents above 12 A;
- 4 — CTCS port (transmits control signals to the Transformer Calibration Switch CTCS-3.1);
- 5 — CURRENT connector (to be linked to AC current probes or “Output” terminal of the CTCS-3.1);
- 6 — Mains switch, socket for mains cord;
- 7 — Ground terminal;
- 8 — Sync connector (to be linked to the Time Correction Module);
- 9 — RS-232 port;
- 10 — USB port;
- 11 — Fuses

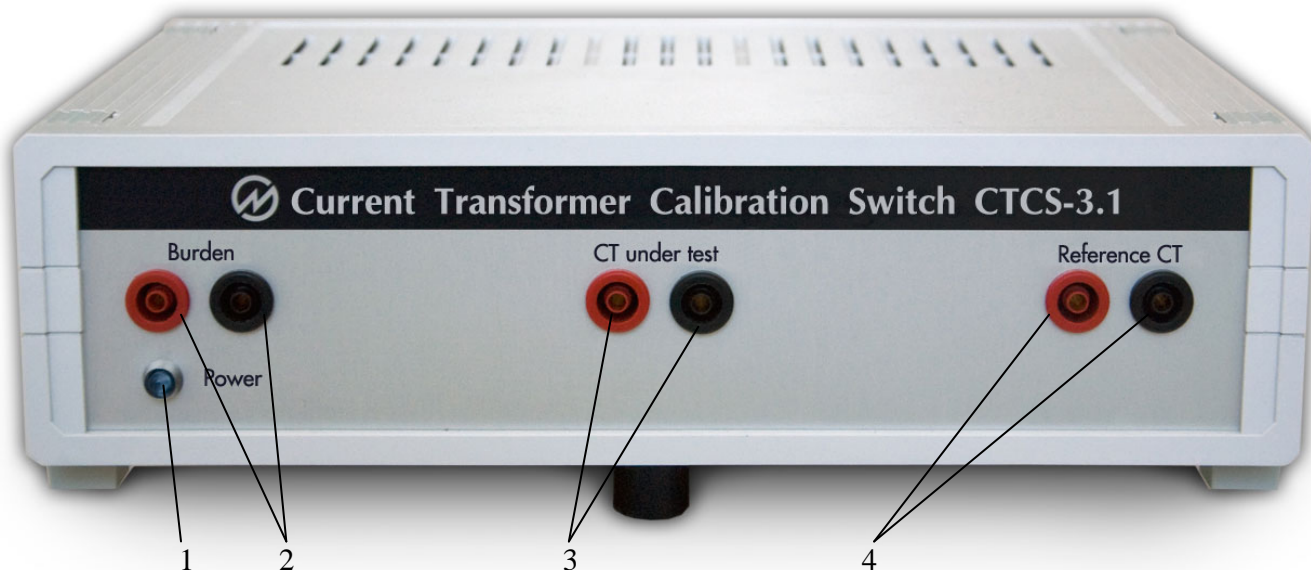


Fig. 3.3 Front panel of the CTCS-3.1

- 1 — Power indicator;
- 2 — Sockets for connecting CT under test burden;
- 3 — Sockets for connecting CT under test output terminals;
- 4 — Sockets for connecting Reference CT output terminals

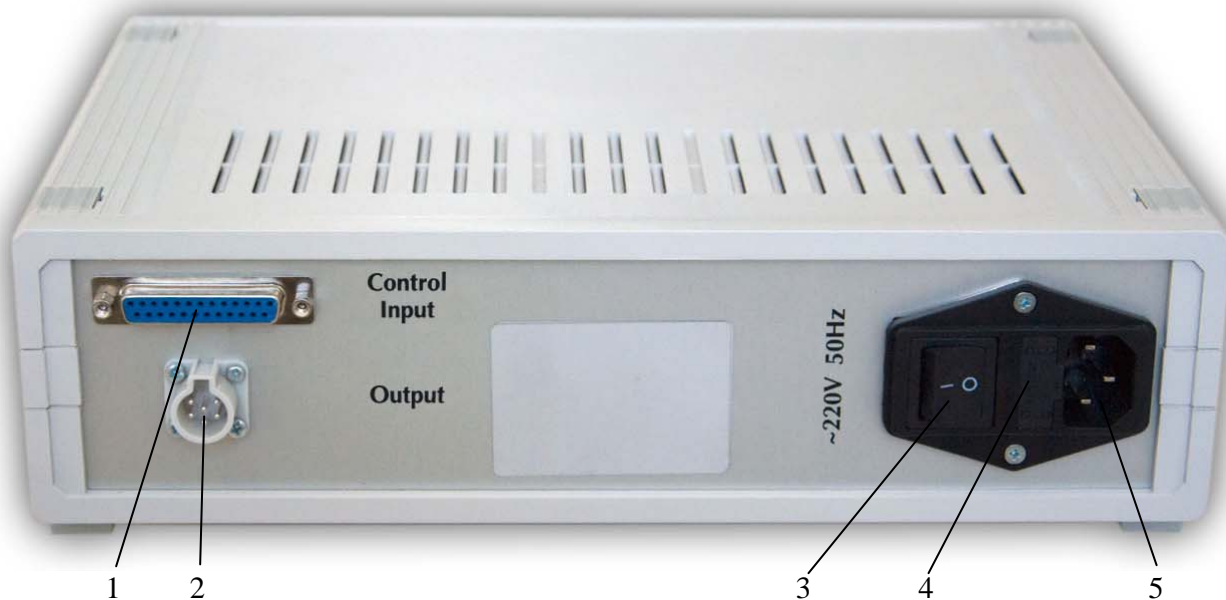


Fig. 3.4 Rear panel of the CTCS-3.1

- 1 – “Control Input” connector (to be linked to CTCS port of the EM 3.1KM);
- 2 – “Output” connector (to be linked to CURRENT connector of the EM 3.1KM);
- 3 – Mains fuses;
- 4 – Mains switch;
- 5 – Socket for mains cord

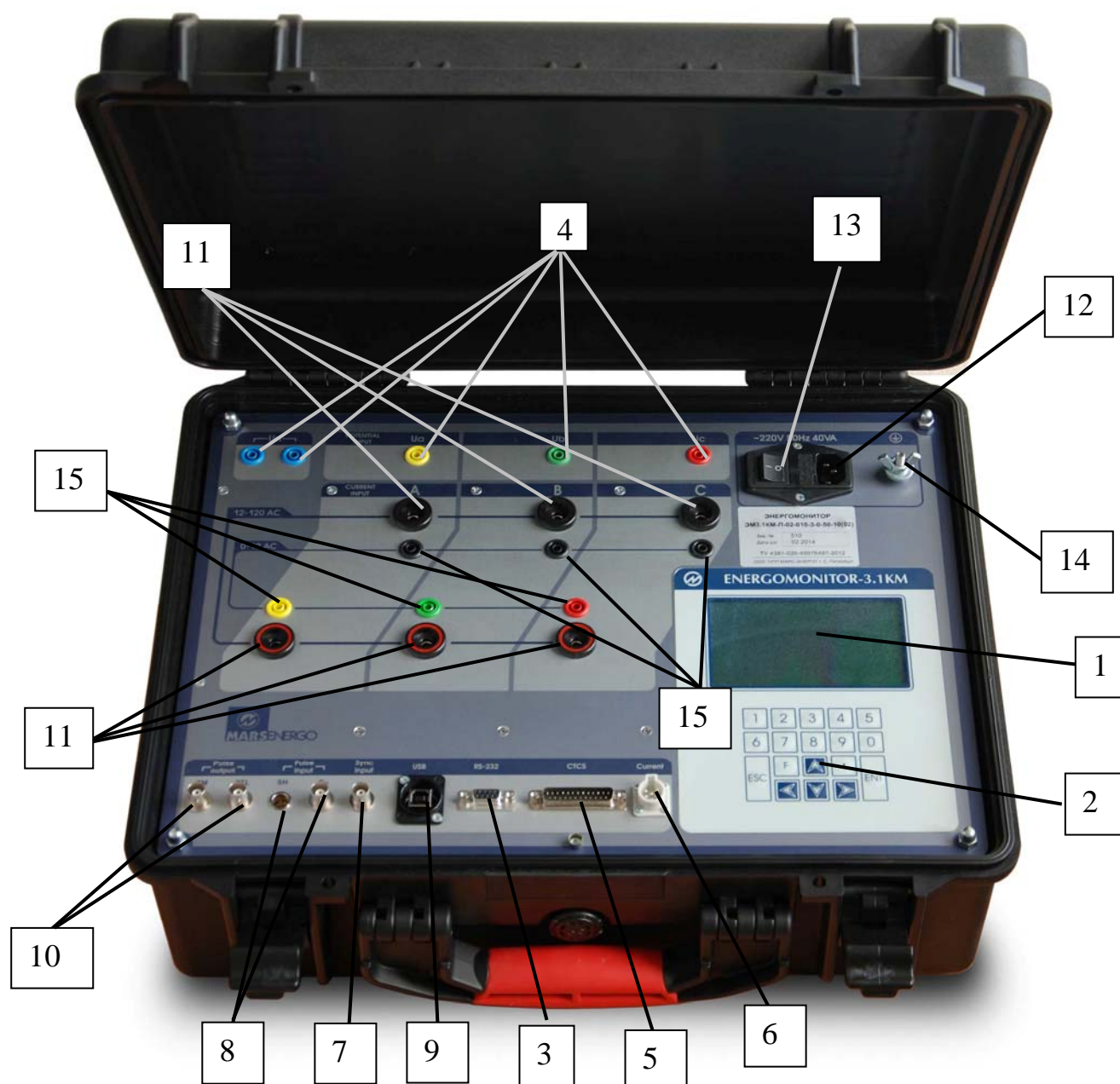


Fig. 3.5 The EM 3.1KM-P (portable)

- 1 – Graphic display;
- 2 – Keypad;
- 3 – RS-232 port;
- 4 – Voltage input connectors;
- 5 – CTCS port (transmits control signals to the Transformer Calibration Switch CTCS-3.1);
- 6 – CURRENT connector (to be linked to AC current probes or “Output” terminal of the CTCS-3.1);
- 7 – Sync connector (to be linked to the Time Correction Module);
- 8 – “Pulse input” connectors: SH (for connecting Scanning Heads or Pulse Former) and F_{in} ;
- 9 – USB port;
- 10 – “Pulse output” connectors: TTL (produces TTL-compatible output signal of frequency proportional to power measured by the EM 3.1KM) and telemetry output TM (produces 24 V peak-to-peak voltage signal of the same frequency as generated on the main frequency output);
- 11 – Current input connectors for currents above 12 A;
- 12 – Socket for mains cord;
- 13 – Mains switch;
- 14 – Ground terminal;
- 15 – Current input connectors for currents below 12 A

4 OPERATION

4.1 Operator interface and starting the work

4.1.1 The EM 3.1KM is a menu driven instrument. To navigate to a desired screen or menu item, six keys are used: "ENT", "ESC", "↓", "↑", "←", "→".

Regardless of the screen or mode active at the moment, current date and time are shown on the top of the display, while its bottom line shows active measurement ranges and circuit connection type.

4.1.2 When it is powered up, the EM 3.1KM performs self-testing, after which the welcome screen (Fig. 4.1.1) appears. Press ENT to get to the password entry screen (Fig. 4.1.2).

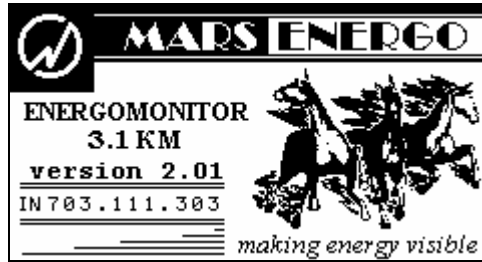


Fig. 4.1.1 Welcome screen

4.1.3 Menu options and configuration settings of the EM 3.1KM may be accessed at 3 levels, each one protected by password. The 1st and 2nd level passwords can be configured for use in operation. Data protected by the 3-rd-level password can only be accessed by the manufacturer.

The 1st level password is 8 digits in length; the 2nd level requires 9 digits.

Passwords set from the factory are:

- 1st (lower) level – 00000000 or no password (the menu is accessed on pressing ENT),
- 2nd (higher) level – 22222222 (nine digits).

4.1.4 The second screen displayed after applying power is the password entry screen shown in Fig. 4.1.2. No specific password is required for the first time (until configured otherwise).



Fig. 4.1.2 Password entry screen

Press ENT to go to the Circuit Connection screen (Fig. 4.1.3).

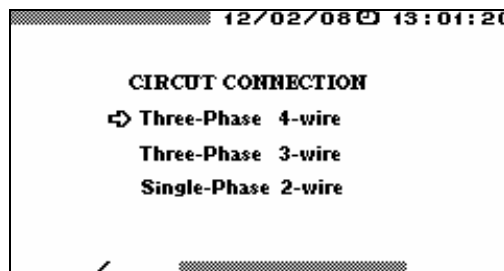


Fig. 4.1.3 “Circuit Connections” screen

Selecting the type of connection scheme is crucial to all calculations in the course of measurements. The EM 3.1KM can be connected to networks of three types:

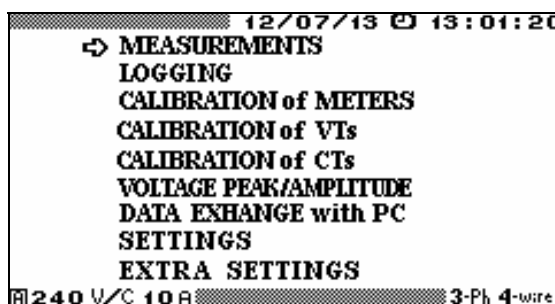
- 3-phase 4-wire,
- 3-phase 3-wire,
- Single-phase 2-wire.

When the EM 3.1K is connected to a 3-phase 4-wire network, it measures all phase voltage and current values necessary for further calculations (U_A , U_B , U_C , I_A , I_B , I_C).

When the EM 3.1K is connected to a 3-phase 3-wire network, it measures 2 line voltages and 2 phase currents (U_{AB} , U_{CB} , I_A , I_C).

When the EM 3.1K is connected to a single phase 2-wire network, it measures voltage and current in phase A only, as necessary for further calculations (U_A , I_A).

4.1. Each option of the main menu (pictured below) corresponds to a particular mode of operation or configuration procedure:

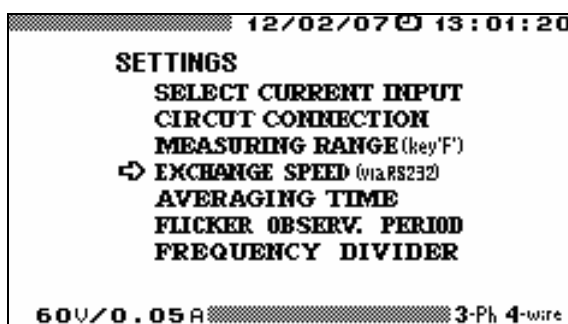


Press the arrow keys \downarrow and \uparrow to move the cursor through the menu options and press ENT to call up the selected option.

Note: The operator interface may be modified with respect to the order of displaying information. These changes do not affect the Device's accuracy and technical characteristics.

4.2 Settings menu

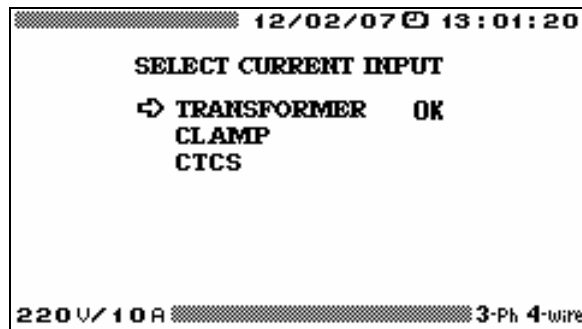
There are 7 options:



Press the arrow keys \downarrow and \uparrow to move the cursor through the menu options, press ENT to call up the selected option and press ESC to return to the main menu.

4.2.1 Selecting converters for current inputs

The SELECT CURRENT INPUT option determines the type of converters on the current measurement inputs of the EM 3.1KM. There are three options:



“Transformer” - selected when the internal current transformers (built into the EM 3.1KM current input circuitry) are used;

“Clamp” – selected when current measurements are made via AC current probes;

“CTCS” – selected when the EM 3.1KM is used as a comparator for calibration of current instrument transformers (CTs).

Press the arrow keys ↓ and ↑ to move the cursor through the menu options, press the ENT key to call up the selected option and press ESC to return to the main menu.

4.2.2 Circuit connection

CIRCUIT CONNECTION is a screen displayed at power up (see section 4.1, Fig. 4.2). The user also may enter the “Circuit Connection” screen and declare another connection type gently, not forcing the EM-3.3T1 power down and up.

Three phase 4-wire, three phase 3-wire, and single phase 2-wire connection types are available.

4.2.3 Selecting measuring range

The MEASURING RANGE screen is called up either by clicking on its name in the SETTINGS menu, or by pressing “F” hot key in the most of screens or menu items. The required ranges are selected with the arrow keys ↓, ↑ and ENT. Pressing the ESC key reverts back to the SETTINGS menu without saving changes.

Active voltage and current measurement ranges are represented on the bottom line of each screen (in the left corner).

If the measured voltage exceeds the limit of a currently active measuring range, an automatic swap is made for the highest possible voltage range.

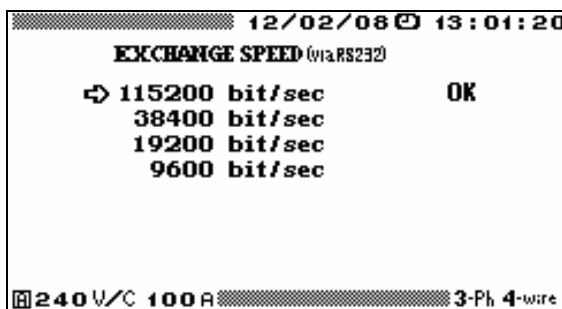
The EM-3.1K never makes swaps for lower ranges of current and voltage when the measured voltage or current drops below its active range limit.

4.2.4 Data transfer rate (via RS-232)

The EM 3.1KM supports data transfer to/from a PC via RS-232 at a speed of:

- 115200 bps;
- 38400 bps;
- 19200 bps;
- 9600bps.

The required value is selected with the keys ↓, ↑ and ENT.
 “OK” appears next to the selected speed.
 19200 bps is the default value.

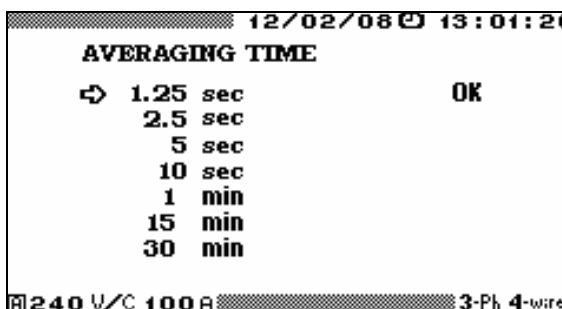


Pressing the ESC key reverts back to the SETTINGS menu without saving changes.

4.2.5 Averaging time

The AVERAGING TIME screen determines the period over which the sampled instantaneous values of currents and voltages are averaged. The following values are available: 1.25, 2.5, 5, 10 seconds and 1, 15, 30 minutes.

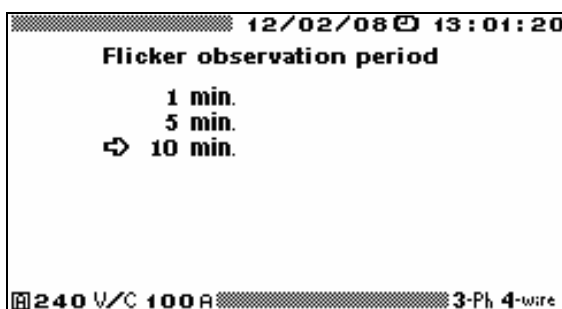
The required value is selected with the keys ↓, ↑ and ENT.
 “OK” appears next to the selected value.
 1.25 sec is set by default.



Pressing the ESC key reverts back to the SETTINGS menu without saving changes.

4.2.6 Flicker observation period

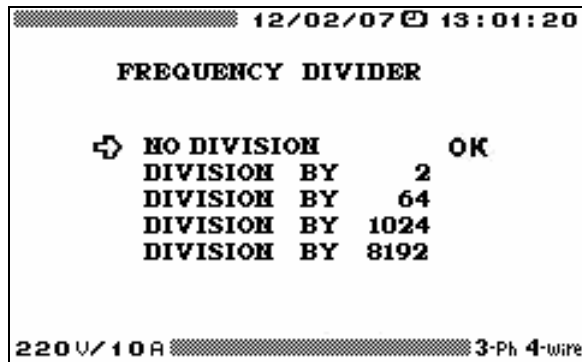
The EM 3.1KM calculates flicker short-term severity for measurement periods of 10 min, 5 min and 1 min.



The required value is selected with the keys ↓, ↑ and ENT.
 Pressing the ESC key reverts back to the SETTINGS menu without saving changes.

4.2.7 Frequency divider

The EM 3.1KM can also act as a frequency divider for pulse signals either coming to the frequency input F_{in} , or produced on its frequency output. The division ratio can be set to 2, 64, 1024, and 8192.

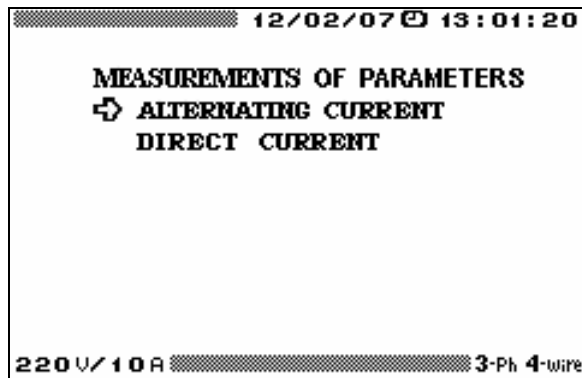


The required value is selected with the keys \downarrow , \uparrow and ENT. Pressing the ESC key reverts back to the SETTINGS menu without saving changes.

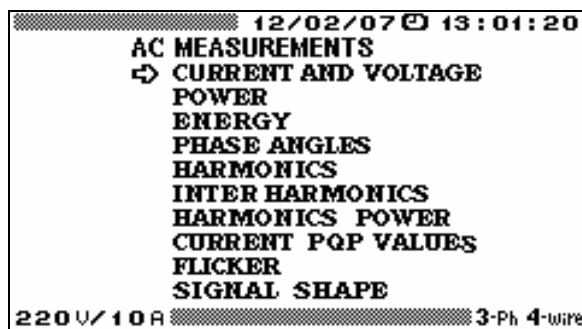
4.3 Measurements

Before making measurements, the EM 3.1KM is configured as described in section 4.2. Such settings as voltage and current measuring ranges and circuit connection type will be constantly displayed on the bottom line. The “Measuring range selection” function may be called up promptly from the most of modes, just by pressing “F” hotkey.

For the EM 3.1KM with DC current measurement function, on selecting the MEASUREMENTS option from the main menu, the screen shown below will appear.



Selection of the “ALTERNATING CURRENT” option calls up the screen where all AC-related measured parameters are listed:



The required option is selected with the keys \downarrow , \uparrow and enabled with ENT.

Pressing the ESC key reverts back to the previous menu.

Except for SIGNAL SHAPE, the measurement modes listed in the menu show actual values calculated in real time.

The PHASE ANGLES and all harmonic-related screens are updated with 1 Hz frequency.

Measurement results on the POWER and CURRENT AND VOLTAGE screens are updated as per averaging time preset in the AVERAGING TIME window of the SETTINGS menu.

Progress bar reflecting elapsed time in the course of averaging appears at the left top part of the screen (unless averaging time is set to 1.25 sec. default value).

4.3.1 AC measurements

4.3.1.1 Measuring currents and voltages

In this mode one screen is available (Fig. 4.3.1).

Pressing ESC returns you to the previous menu.

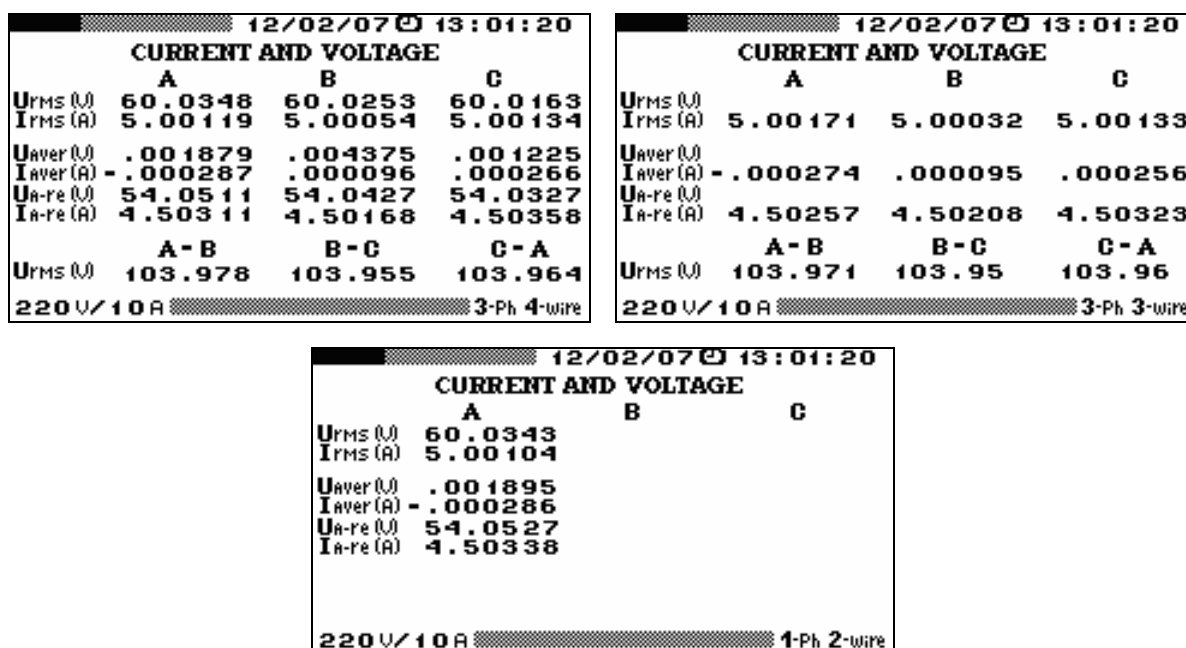


Fig. 4.3.1 CURRENT AND VOLTAGE screen for various circuit connections

Meaning of notations:

U_{RMS} (V) – RMS of phase voltages; RMS of line (phase-to-phase) voltages (for 3-phase 4-wire and 3-phase 3-wire networks);

I_{RMS} (A) – RMS of currents;

U_{AVER} (V) – average values (DC component) of phase voltages;

I_{AVER} (A) – average values (DC component) of currents;

U_{A-RE} (V) – average-rectified values of phase voltages;

I_{A-RE} (A) – average-rectified values of currents.

Note: The screen line showing average values of current is informative for technical service personnel only, as DC current component cannot pass through the input transformers and current clamps.

4.3.1.2 Measuring power

Selecting POWER mode from the MEASUREMENTS menu makes it possible to see three different screens named ACTIVE POWER (Fig. 4.3.2), REACTIVE POWER (Fig. 4.3.3) and APPARENT POWER (Fig. 4.3.4). Use \leftarrow , \rightarrow keys to cycle through these screens or $\langle 1 \rangle$, $\langle 2 \rangle$, $\langle 3 \rangle$ keys to select any particular one.

The pulse sequence of frequency proportional to the measured power of the type indicated in the header of this screen (active, reactive or apparent) is produced on the EM 3.1KM frequency output F_{out} .

Meaning of notations in the ACTIVE POWER screen:

$P(W)$ – active power values per each phase;

$P_{\Sigma}(W)$ – total active power for all phases (considering import and export directions of active energy transfer);

U_{RMS} , I_{RMS} and PF – RMS value of voltage (V), RMS value of current (A) and power factor per each phase;

$P_1(W)$, $P_2(W)$ – values of active power measured by Power meter 1 and Power meter 2 in case of 3 phase 3-wire configuration (Aron connection scheme);

PF_{Σ} – power factor for the whole three-phase system.

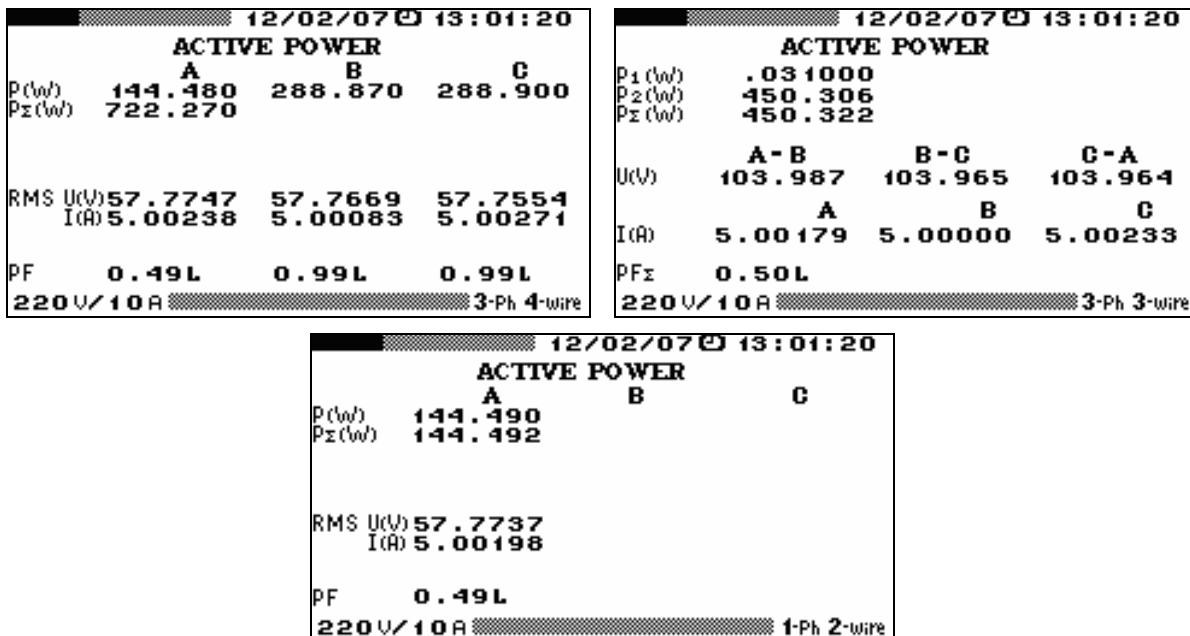


Fig 4.3.2 ACTIVE POWER SCREEN for various circuit connections

Meaning of notations in the REACTIVE POWER screen:

$Q = \sqrt{S^2 - P^2}$ – indicates per-phase values of reactive power calculated by the geometrical method, Var;

cross-con. – indicates per-phase values of reactive power calculated by the method of cross connection, Var;

$Q = UI \sin \varphi$ – indicates per-phase values of reactive power calculated by the phase-shift method (voltage is shifted by $\frac{1}{4} T$, where T is the fundamental period), Var;

$Q_{\Sigma}(Var)$ – total reactive power for all phases (considering import and export directions of reactive energy transfer).

NOTE! With \downarrow , \uparrow keys, the heading **At F-out:** ($\uparrow\downarrow$) can be placed above one of the reactive power calculation methods displayed, and the pulse sequence produced on F_{out} will reflect the exact total power Q_{Σ} obtained by the method selected.

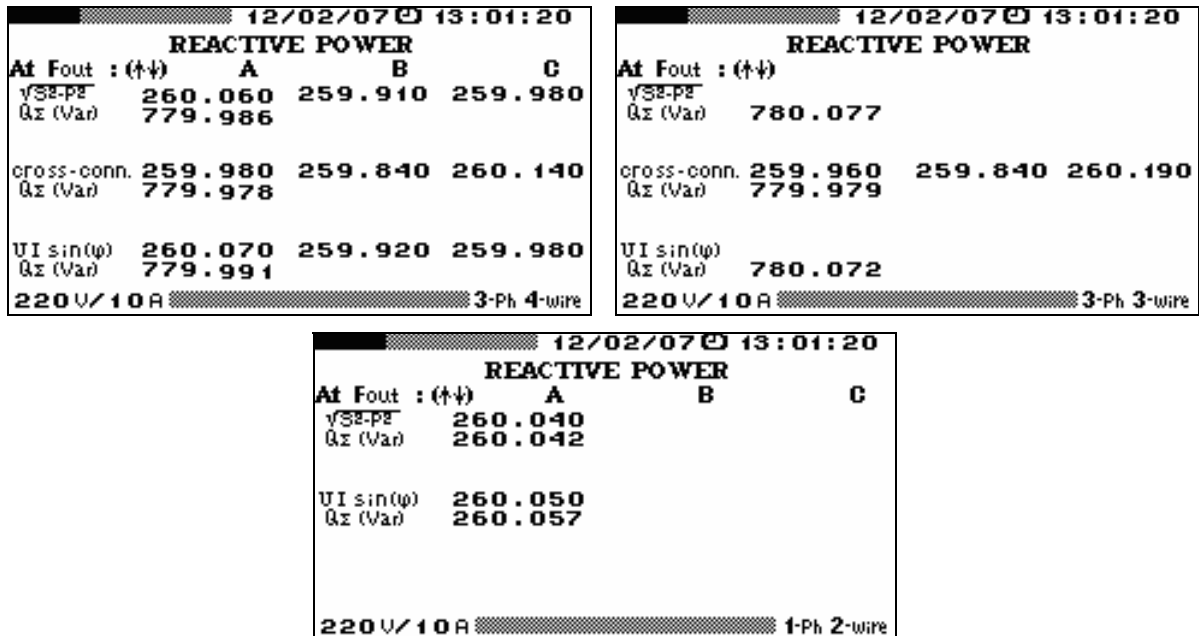


Fig 4.3.3 REACTIVE POWER SCREEN for various circuit connections

NOTES on Reactive Power

When calculation of reactive power values follows the phase shift method, instantaneous voltage values are multiplied by instantaneous current values displaced in phase by 90° .

The method of cross-connection takes the product of instantaneous values of phase current, and instantaneous values of line voltage (voltage between 2 different phases).

In theory, if a three-phase system is symmetrical and free of non-linear distortions, the reactive power would be of the same value, regardless of the calculation method. When the symmetry is broken within the system of voltage vectors ($U_{AB} \neq U_{BC} \neq U_{CA}$), the reactive power calculated with cross-connection method turns out different from what the other two methods give. Non-linear distortion makes the power calculated with the geometrical method differ from the other two. Thus, under real conditions the three values of reactive power are never precisely the same.

NOTE! When testing a reactive power meter, it is important to take into account its operation principle (geometrical, phase-shift, or cross connection).

Meaning of notations in the APPARENT POWER screen:

S (VA) – values of apparent power per each phase;

S_Σ (VA) – total apparent power for all phases;

P (W) – values of active power per each phase;

P_Σ (W) – total active power of the whole three-phase system (considering direction of active energy transfer);

$\sqrt{S^2 - P^2}$ – each-phase values of reactive power calculated by the geometrical method;

PF – each-phase values of power factor (for 3-phase 4-wire connection);

PF_Σ – power factor of the three-phase system (for 3-phase, 3-wire connection).

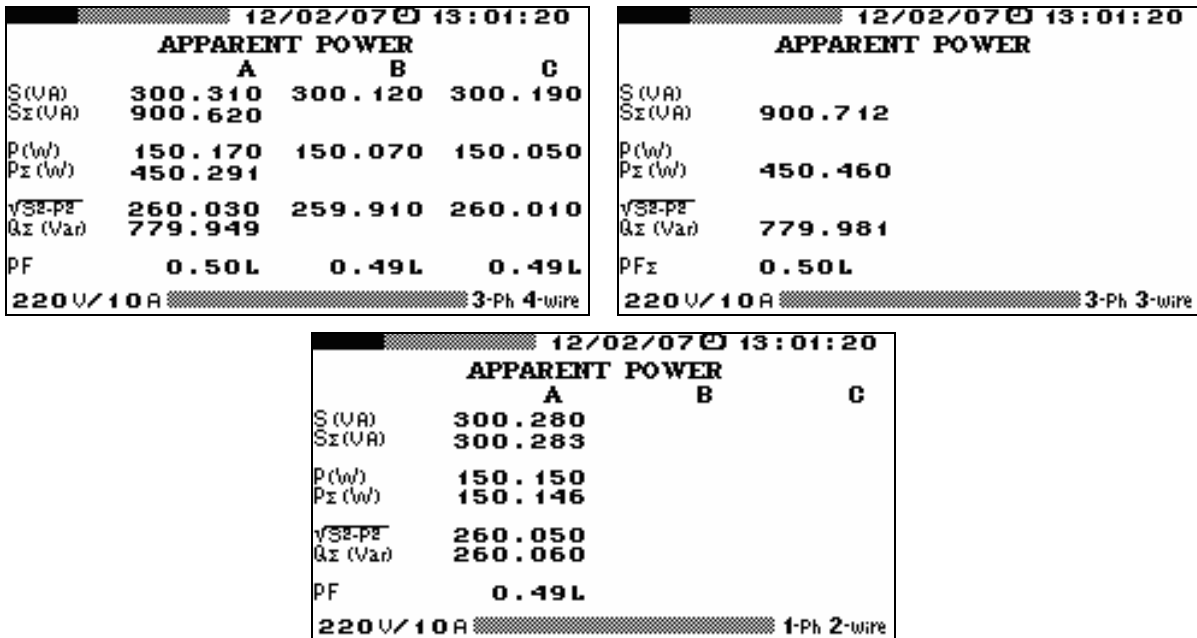


Fig. 4.3.4 APPARENT POWER SCREEN for various circuit connections

4.3.1.3 Measuring phase angles

The following phase angles are measured in degrees:

- $\angle U_{A1}-U_{B1}$ – between the 1st harmonics of phase voltages U_A and U_B ;
- $\angle U_{B1}-U_{C1}$ – between the 1st harmonics of phase voltages U_B and U_C ;
- $\angle U_{C1}-U_{A1}$ – between the 1st harmonics of phase voltages U_C and U_A ;
- $\angle U_{A1}-I_{A1}$ – between the 1st harmonics of voltage and current in phase A;
- $\angle U_{B1}-I_{B1}$ – between the 1st harmonics of voltage and current in phase B;
- $\angle U_{C1}-I_{C1}$ – between the 1st harmonics of voltage and current in phase C.

Phase angles in degrees are shown on the left part of the screen. Displayed on its right is a vector diagram (Fig. 4.3.5). It reflects the same phase relations (long vectors are voltages, and shorter vectors stand for currents).

To check phase rotation in three-phase systems, make sure that angles $\angle U_{A1}-U_{B1}$, $\angle U_{B1}-U_{C1}$, $\angle U_{C1}-U_{A1}$ are positive (clockwise rotation).

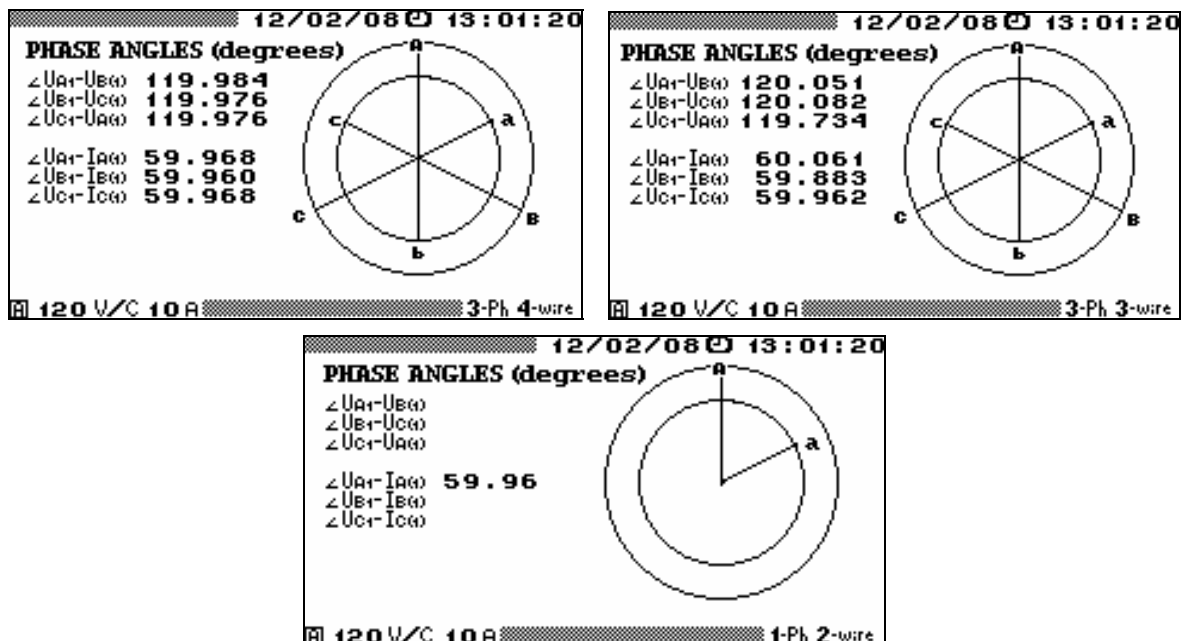


Fig. 4.3.5 PHASE ANGLES screen for different circuit connections

4.3.1.4 Measuring harmonics

In the HARMONICS mode, RMS of voltage and current fundamental components along with the contribution of higher harmonic components up to the 50th (harmonic ratio, % of fundamental) to the full signal as well as related data (THD_U and THD_I) are displayed.

Three-phase 4 wire connection: results are viewed on 6 screens (3 phase voltages and 3 phase currents).

The arrow keys \leftarrow , \rightarrow are used to cycle through the screens.

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics.

The numeric keys are used to select the desired screen directly: "1" – U_A, "2" – U_B, "3" – U_C, "6" – I_A, "7" – I_B, "8" – I_C.

Three-phase 3-wire connection: results are viewed on 6 screens (3 line voltages and 3 phase currents).

The arrow keys \leftarrow , \rightarrow are used to cycle through the screens.

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics

The numeric keys are used to select the desired screen directly: "1" – U_{A-B}, "2" – U_{B-C}, "3" – U_{C-A}, "6" – I_A, "7" – I_B, "8" – I_C.

Single-phase 2-wire connection: results are viewed on 2 screens (U and I).

The desired screen is selected with the arrow keys \leftarrow , \rightarrow or numeric keys ("1" – U, "6" – I).

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics

Meaning of notations in the HARMONICS screens (shown in Fig. 4.3.6):

U_{A1}; U_{B1} and U_{C1} – RMS of the fundamental (1st) harmonic of voltage in phases A, B and C (in volts);

F – frequency of the fundamental (1st) harmonic (Hz);

Numbers 1 to 50 – individual ratios of harmonics of order h (h= 1...50) as percentages of the fundamental voltage or current harmonic (U_{A1}, U_{B1}, U_{C1} or I_{A1}, I_{B1}, I_{C1}) respectively;

I_{A1}, I_{B1} and I_{C1} – RMS of the fundamental (1st) harmonic of current in phases A, B and C (in amperes);

THD_{UA}, THD_{UB}, THD_{UC} – Total Harmonic Distortion of phase voltages in phases A, B and C (in %);

THD_{UAB}, THD_{UBC}, THD_{UCA} – Total Harmonic Distortion of line (phase-to-phase) voltages for 3-phase 3-wire connection (in %);

THD_{IA}, THD_{IB}, THD_{IC} – Total Harmonic Distortion of phase currents in phases A, B and C (in %).

4.3.1.5 Measuring interharmonics

In the INTERHARMONICS mode, RMS of voltage and current fundamental components along with the contribution of interharmonic components from the 0.5th to 50.5th with 1.0 increments (interharmonic ratio, % of fundamental) to the full signal as well as related data (total interharmonic distortion of voltage TIHD_U and current TIHD_I) are displayed.

Three-phase 4 wire connection: results are viewed on 6 screens (3 phase voltages and 3 phase currents).

The arrow keys \leftarrow , \rightarrow are used to cycle through the screens.

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics

The numeric keys are used to select the desired screen directly: "1" – U_A, "2" – U_B, "3" – U_C, "6" – I_A, "7" – I_B, "8" – I_C.

Three-phase 3-wire connection: results are viewed on 6 screens (3 line voltages and 3 phase currents).

The arrow keys \leftarrow , \rightarrow are used to cycle through the screens.

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics

The numeric keys are used to select the desired screen directly: "1" – U_{A-B} , "2" – U_{B-C} , "3" – U_{C-A} , "6" – I_A , "7" – I_B , "8" – I_C .

Single-phase 2-wire connection: results are viewed on 2 screens (U and I).

The desired screen is selected with the arrow keys \leftarrow , \rightarrow or numeric keys ("1" – U, "6" – I).

The arrow keys \uparrow , \downarrow are used to scroll up and down to see all of 50 harmonics.

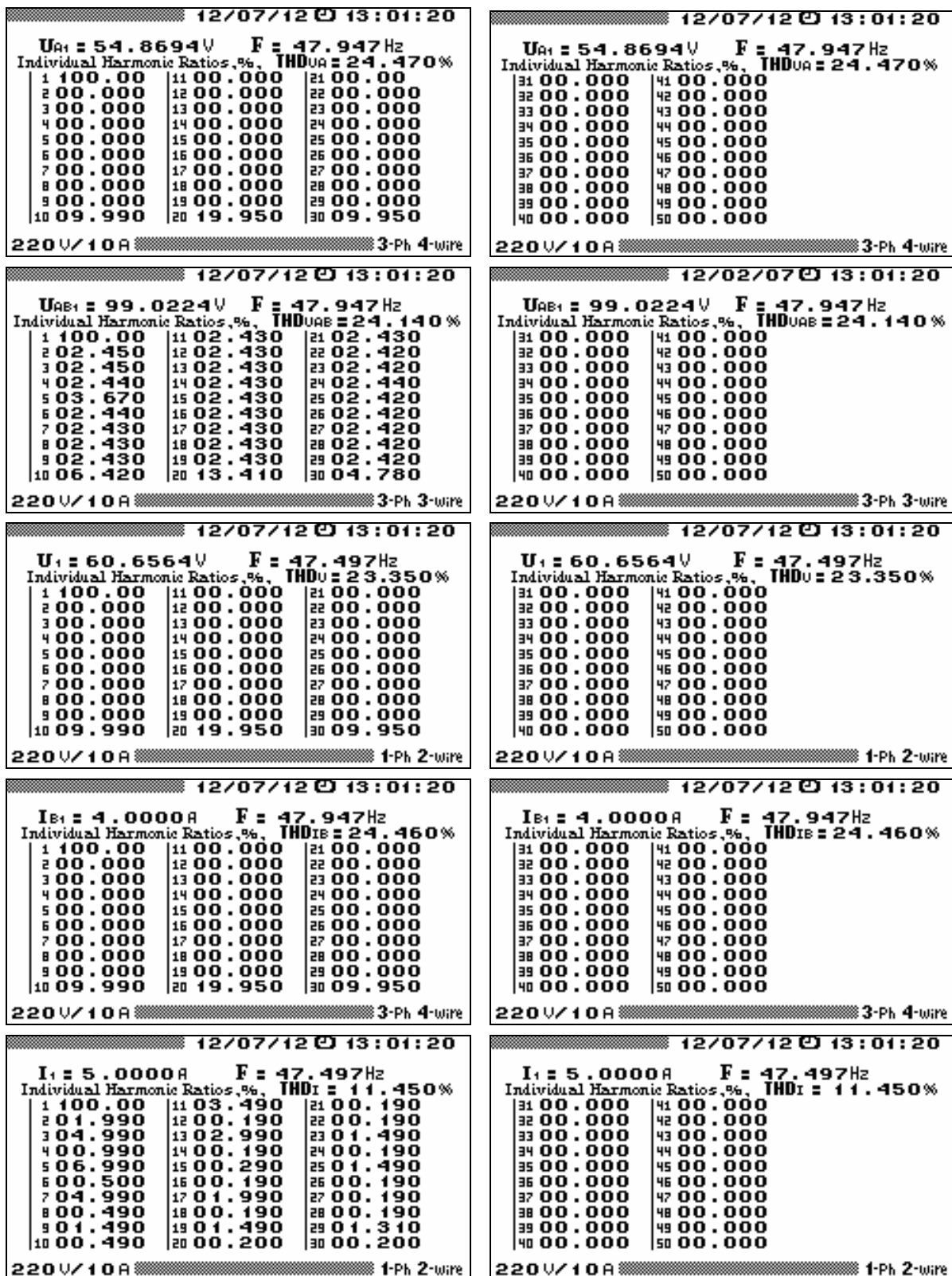


Fig. 4.3.6 View of HARMONICS screens showing current and voltage harmonics for different circuit connections

Meaning of notations in the HARMONICS screens (shown in Fig. 4.3.7):

U_{A1} ; U_{B1} and U_{C1} – RMS of the fundamental (1st) harmonic of voltage in phases A, B and C (in volts);

F – frequency of the fundamental (1st) harmonic (Hz);

Numbers 0.5 to 50.5 – individual ratios of interharmonics of order m (m= 0.5...50.5) as percentages of the fundamental voltage or current harmonic (U_{A1} , U_{B1} , U_{C1} or I_{A1} , I_{B1} , I_{C1}) respectively;

I_{A1} , I_{B1} and I_{C1} – RMS of the fundamental (1st) harmonic of current in phases A, B and C (in amperes);

TIHD_{UA}, TIHD_{UB}, TIHD_{UC} – Total Interharmonic Distortion of phase voltages in phases A, B and C (in %);

TIHD_{UAB}, TIHD_{UBC}, TIHD_{UCA} – Total Interharmonic Distortion of line (phase-to-phase) voltages for 3-phase 3-wire connection (in %);

TIHD_{IA}, TIHD_{IB}, TIHD_{IC} – Total Interharmonic Distortion of phase currents in phases A, B and C (in %).

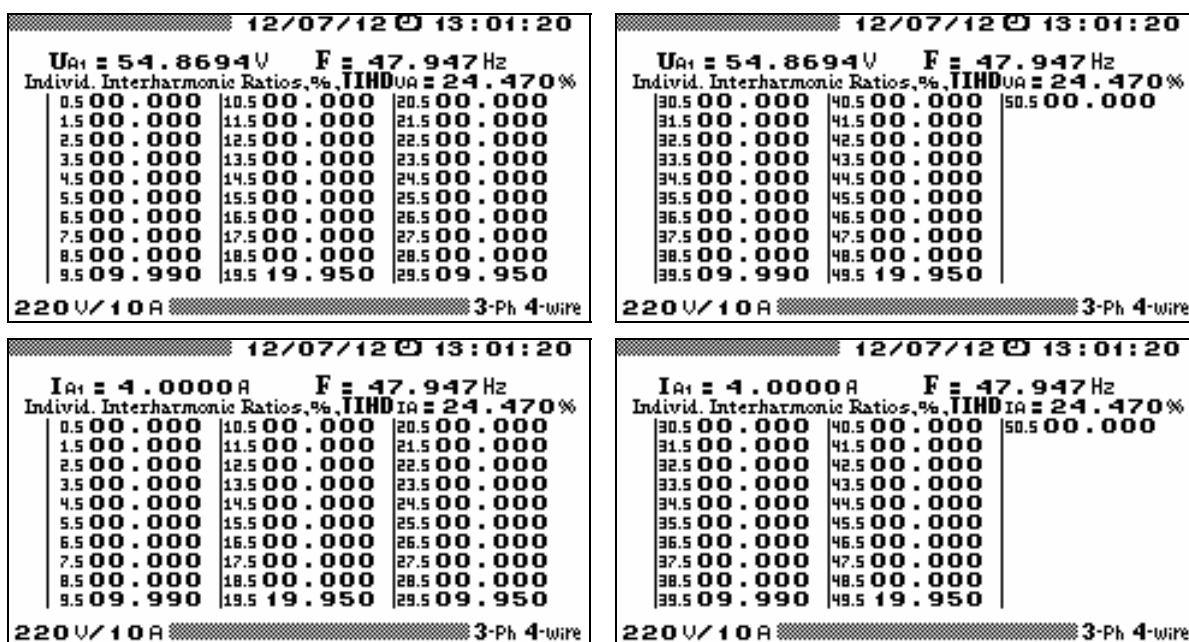


Fig. 4.3.7 View of INTERHARMONICS screens showing current and voltage interharmonics for different circuit connections

4.3.1.6 Power of harmonics

In the HARMONICS POWER mode, for three-phase measurement configurations, there are 3 screens:

Phase A, Phase B and Phase C related screens.

For single phase 2-wire configurations, 1 screen is available.

The arrow keys ←, → are used to cycle through the screens.

The arrow keys ↑, ↓ are used to scroll up and down to see all of 50 harmonics

The numeric keys are used to select the desired screen directly: "1" – Phase A, "2" – Phase B, "3" – Phase C.

Meaning of notations in the HARMONICS POWER screens (shown in Fig. 4.3.8):

P_i (W) – active power of a harmonic of order h, h = 1 ... 50, W;

$\angle U_i - I_i$ – phase angle between current and voltage harmonics of order h in the same phase, h = 1 ... 50, degrees.

Note. Each time the RMS value of voltage or current is found less than 1 % of its nominal range, the parameters are not calculated: zeroes (0) are displayed instead of measured values.

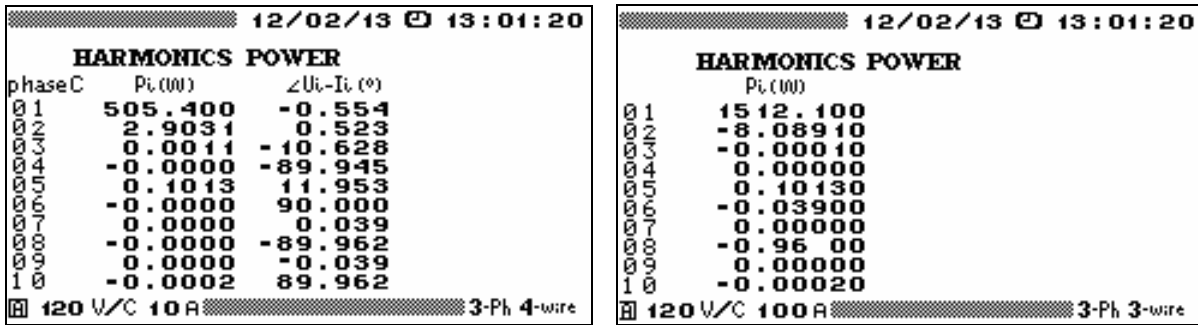


Fig 4.3.8 HARMONICS POWER screens for different circuit connections

4.3.1.7 Current PQP values

In the CURRENT PQP VALUES mode, “real-time” power quality parameters can be viewed on the screen as they are measured.

Meaning of on-screen notations:

- ΔF – deviation of frequency from a user-specified value f_0 , Hz (see section 2.4.5);
- $\delta U_{(-)}$ – underdeviation and $\delta U_{(+)}$ – overdeviation of voltage from a user-specified value U_0 , % of U_0 (see section 2.4.5);
- $U_{1(1)}$ – positive sequence voltage of fundamental harmonic, V;
- $U_{0(1)}$ – zero sequence voltage of fundamental harmonic, V;
- $U_{2(1)}$ – negative sequence voltage of fundamental harmonic, V;
- K_{2U} – negative sequence voltage ratio and K_{0U} – zero sequence voltage ratio, %;
- $I_{1(1)}$ – positive sequence current of fundamental harmonic, A;
- $I_{0(1)}$ – zero sequence current of fundamental harmonic, A;
- $I_{2(1)}$ – negative sequence current of fundamental harmonic, A;
- $U_{1(1)} \wedge I_{1(1)}$ – phase angle between positive sequence voltage and positive sequence current of fundamental harmonic, degrees;
- $U_{2(1)} \wedge I_{2(1)}$ – phase angle between negative sequence voltage and negative sequence current of fundamental harmonic, degrees;
- $U_{0(1)} \wedge I_{0(1)}$ – phase angle between zero sequence voltage and zero sequence current of fundamental harmonic, degrees.

The parameters are displayed on several screens cycled with \Leftarrow , \Rightarrow keys.

4.3.1.8 Flicker short-term severity

Flicker short-term severity is only determined for three-phase 4-wire and single-phase 2-wire configurations. The screen displays measured values of flicker short-term severity P_{st} as well as:

- Flicker observation period (1, 5 or 10 minutes);
- Time remaining to the end of the current P_{st} observation period.

Flicker measurement procedure starts on opening the Flicker screen. The first measured P_{st} value appears on the “real-time” screen with a delay of 2 minutes plus the Flicker observation period selected. Then P_{st} values are updated in Flicker observation periods.

4.3.1.9 Signal shape

In the SIGNAL SHAPE mode the EM 3.1KM plots waveforms of phase voltages and currents on its display (see Fig. 4.3.9). On entering the mode, the display shows voltage waveform in phase A with its RMS value to the right of the plot. By pressing the number keys "1", "2", "3", "6", "7", "8" you can make visible (or hide) the waveforms available (U_A , U_B , U_C , I_A , I_B , I_C respectively) with their RMS values.

Each displayed waveform/RMS couple reflects the moment of entering the mode. To get new waveforms, it is necessary to refresh the screen by pressing the ENT key.

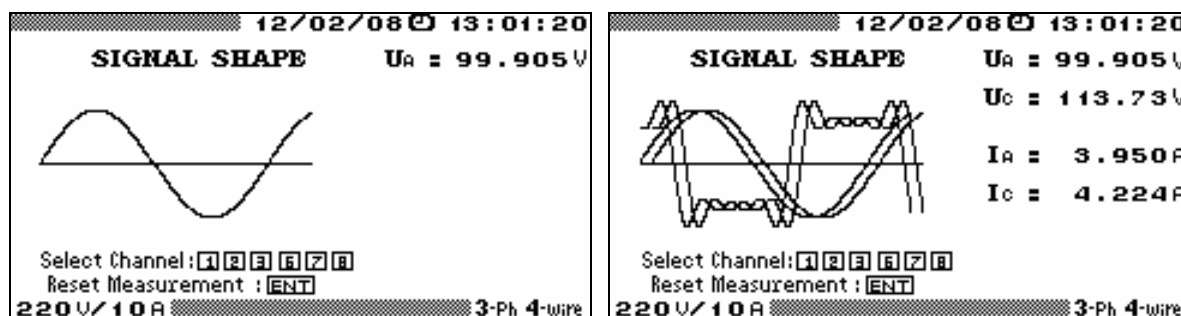


Fig 4.3.9 SIGNAL SHAPE screen

4.3.2 DC measurements

Selecting the DIRECT CURRENT option from the MEASUREMENTS menu brings up a screen with the following options:

GENERAL PARAMETERS
SIGNAL SHAPE
I - ZERO CALIBRATION

4.3.2.1 Zero calibration of current channels

Zero calibration (correction of characteristics of the current measurement channels) should be made before each start of DC measurements. It is useful to repeat the procedure from time to time while making DC measurements. It is recommended to carry out zero calibration after a considerable (greater than 5 °C) drop in ambient temperature.

Zero calibration is carried out only in the absence of input signals on the measurement inputs.

To make zero calibration, in the DC MEASUREMENTS menu enable the I-ZERO CALIBRATION option and press ENT to bring up the SELECT RANGE OF CURRENT screen with the list of all nominal (rated) currents available in this instrument. Select the value of nominal current related to the range of DC measurements required and confirm with ENT. Then follow on-screen instructions. On completing zero calibration, the mode is exited automatically.

If several ranges are required for making DC measurements, repeat zero calibration for all appropriate nominal values of current.

4.3.2.2 General DC parameters

Before making measurements, the EM 3.1KM is configured as described in section 4.2. Such settings as measuring ranges and circuit connection type will be constantly displayed on the bottom line. The "Measuring range selection" function may be called up promptly from the most of menus, just by pressing "F" hotkey.

On opening the GENERAL PARAMETERS screen from the DC MEASUREMENTS menu, the EM 3.1KM starts 3-channel DC measurements according to the selected measurement ranges. The display shows 3 values of power P(W), voltage U_{AVER} (V) and current I_{AVER} (A).

4.3.2.3 Signal shape

The mode is used to display shapes of current and voltage signals per 3 measurement channels. On entering the mode, the display shows voltage signal in phase A (U_A). By pressing the number keys "1", "2", "3", "6", "7", "8" you can make visible (or hide) the signal shapes available (U_A , U_B , U_C , I_A , I_B , I_C) with their respective values to the right of the graph.

Signals on the display reflect the moment of entering the mode. To get new signals, it is necessary to refresh the screen by pressing the ENT key.

4.4 Calibration of meters

4.4.1 CALIBRATION OF METERS mode

In the CALIBRATION OF METERS mode, the EM-3.1KM follows certain established methods and operates as an energy reference standard and pulse comparator. It provides for either performance testing or accuracy testing (calibration) of electric energy meters (class 0.05 or less accurate).

Meter-under-test measurement errors are recorded into the internal memory of the instrument. Error measurements taken from up to 200 meters (up to 10 test points per each meter under test) can be kept in the memory without rewriting. EmCounter software connects the EM 3.1KM with a PC and makes it possible to upload, save to files and view logs of test results, create and maintain databases of meters under test, automatically generate customer-specified calibration reports etc.

To test a meter with a pulse (“telemetry”) output, connect the pulse output of the meter-under-test to the Pulse Former via the manufacturer-supplied cable (the red wire is connected to (+) terminal, and the black one – to (-) terminal of the meter). Connect the Pulse Former to the pulse input (F_{in}) of the EM 3.1KM.

To test a meter with a pulse output ($U_1 = 3...15$ V, $U_0 = 0...0.4$ V), connect the meter-under-test pulse output with the pulse input (F_{in}) of the EM 3.1KM.

To test a meter with an optical pulse output, use the supplied scanning head SH-E, which is mounted onto the meter. The output of the scanning head is connected to the pulse input (F_{in}) of the EM 3.1KM.

To test an induction (disk type) meter, use the supplied scanning head SH-I, which is mounted onto the meter. The output of the scanning head is connected to the pulse input (F_{in}) of the EM 3.1KM

To bring up the METER CALIBRATION ENTRY screen with meter data (Fig. 4.4.1), enable the CALIBRATION OF METERS option from the main menu.

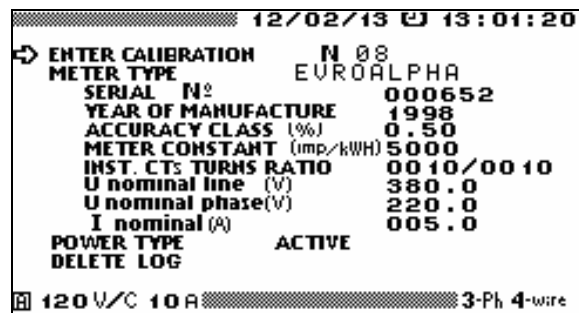


Fig. 4.4.1 METER CALIBRATION ENTRY screen

The following data on the meter to be tested can be specified here:

- Meter type, serial number, year of manufacture, accuracy class and meter constant;
- INST. CTs TURNS RATIO – turns ratio of external instrument current transformers; this field takes a value other than 1 only if the meter is tested together with external CTs as a whole unit;
- Nominal voltage and current of the meter under test;
- Type of power to be measured during testing / calibration: active, apparent, or reactive *).

* **If the meter to be tested is a Var·h (reactive energy) meter, the reactive power measurement method realized in this meter should be selected in this field.**

The DELETE LOG option may be used to delete old logs from the internal memory.

It is possible to quickly change an active measuring range in the EM 3.1KM by pressing 'F' hotkey.

On a startup, the EM 3.1KM will default to the settings specified before the last test procedure.

The METER TYPE option brings up the METER TYPE screen where one of the default names or names of meters configured earlier (including their specifications) can be called up for use in further test procedures (Fig. 4.4.2).

To select one of the meters configured earlier and stored in the library, put the cursor opposite to its name and press ENT. This will call up the meter name entry screen shown in Fig. 4.4.3 with the name of the selected meter displayed in the ENTER NAME field (on the top).

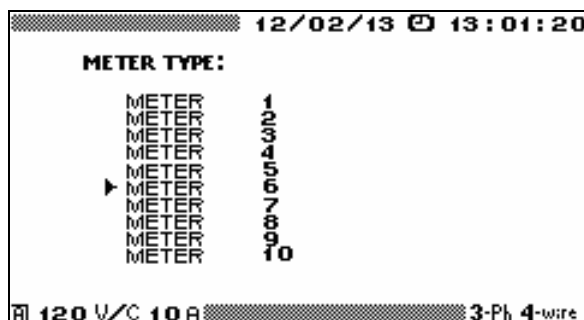


Fig. 4.4.2 METER TYPE screen



Fig. 4.4.3 Meter name entry screen

If no changes to the selected name are required, press ENT to confirm the selection and go to the METER CALIBRATION ENTRY screen (Fig. 4.4.1). The selected name of the meter will appear in the METER TYPE field along with its data in other fields.

If, however, you want to declare a new meter name, do not escape from the Meter name entry screen (Fig. 4.4.3), but use it to modify or replace the alphanumeric characters displayed in the ENTER NAME field (METER 6 in the above example).

Thus, if you want to change the meter name, proceed as follows:

1. Use \leftarrow , \rightarrow to position the cursor (Cursor 1) exactly under a character in the meter name you want to replace.

2. Press 'F' key to enter the character table and start selection of characters (as the prompt suggests on the screen) with another cursor (Cursor 2). Then use 'F' key to switch between Cursor 2 and Cursor 1.

3. Use ↓, ↑, ←, ⇒ to move Cursor 2 within the table of characters; place Cursor 2 under the character to be inserted in the meter name.
4. Press ‘.’ (the “dot” key on the keypad) to insert the character into the meter name.
5. If required, press ‘F’ key once again to enable Cursor 1 and select a new character to be replaced.
6. If you made a mistake while typing in the name, restart the procedure from point 1.
7. Character entry mode is not needed while typing in digits, not letters. Just press number keys on the keypad.
8. Press ‘ENT’ to save the new name and return to the upper-level screen (Fig. 4.4.1 in this case) with the new name on the top.

If you want to change other meter data in the METER CALIBRATION ENTRY screen (Fig. 4.4.1), position the cursor against the data field to be edited with the arrow keys ↓,↑ and press ENT to open an editing window. The meter characteristics changed this way will be recorded into the EM 3.1KM memory under that name.

The INST. CTs TURNS RATIO field represents primary current / secondary current ratio of external instrument current transformers (CTs) used together with the meter under test. When CTs are not used, one and the same value stands on both sides of the fraction sign, which means equal currents in primary and secondary windings.

The METER CALIBRATION ENTRY screen in conjunction with the METER TYPE screen allows the user to maintain a kind of a library in the internal memory with names and data on up to 10 meters. The dataset for each of 10 meters can be created either in the EM 3.1KM (as described above) or on a PC and then downloaded to the instrument.

On selecting the GO TO CALIBRATION N option, the screen shown in Fig. 4.4.4 will be displayed.

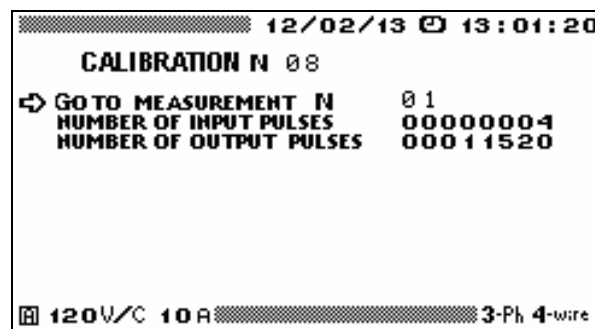


Fig. 4.4.4 CALIBRATION N screen

Meaning of on-screen fields:

- **NUMBER OF INPUT PULSES** – shows how many pulses (coming from the meter under test and reflecting common energy flow) the EM 3.1KM shall accept on its pulse output F_{in} to be able to calculate a reliable value of meter-under-test error. This value can be changed by the user;
- **NUMBER OF OUTPUT PULSES** – is the number of pulses that the EM-3.1KM is supposed to generate on its pulse output F_{out} while determining the error of the meter under test. Calculated automatically, this value is proportional to the amount of energy associated with the number of input pulses.

The EM 3.1KM calculates the recommended number of input and consequently output pulses, based on:

- Its own instrument constant;
- Meter’s accuracy class (specified in the METER CALIBRATION ENTRY screen);
- Instrument constant of the meter under test;
- Turns ratio of external CTs (if applicable);
- Division factor (1, 2, 64, 1024, or 8192).

▪ **GO TO MEASUREMENT N** – this field opens a screen where measurements related to this particular test procedure are launched and measurement results are viewed and saved (Fig. 4.4.5).

The screen displays actual RMS values of voltage and current, values of power factor and power of a certain type measured by both the meter and EM 3.1KM, and estimated time of error calculation.

NOTE! You may change (e.g. reduce) the NUMBER OF INPUT PULSES in the previous screen (Fig. 4.4.4), in order to reduce error calculation time. However, you must bear in mind that reducing this count makes the calibration procedure less accurate. Error determined at the reduced error calculation time may not fit the accuracy class of the meter under test.

12/02/13 13:01:20			
	A (A-B)	B (B-C)	C (C-A)
U_{ph} (V)	60.0326	60.0189	60.0116
I_{ph} (A)	5.00044	5.00048	5.00090
U_{line} (V)	103.961	103.949	103.961
PF	0.500L	0.500L	0.499L
PF_{Σ}			450.205
Pulse counting time (s)	6	P_{Σ} (W)	S_{Σ} (VA)
		Q_{Σ} (Var)	
ERROR (%)			
START MEASUREMENT N 0 1			in 00000004
			out 00011520
120 V/C 10 A 3-Ph 4-wire			

Fig. 4.4.5 METER CALIBRATION screen

To launch a measurement, select and enable the START MEASUREMENT option. At this point the prompt “Start measurement N __” turns to “Stop measurement N __”. The REMAINING TIME indicator starts showing time to finish. On completing the measurement, meter-under-test error is displayed (Fig 4.4.6).

Measurement being in progress can be stopped at any time by clicking on the STOP MEASUREMENT option, which will turn to SAVE MEASUREMENT. By clicking on “SAVE...” you may record the result into the log stored in the internal memory.

Before making the next measurement, you may change values of currents, voltages, PF, etc. applied to the meter-under-test and repeat measurement procedure with other test conditions.

12/02/08 13:01:20			
	A (A-B)	B (B-C)	C (C-A)
U_{ph} (V)	60.032	60.018	60.011
I_{ph} (A)	5.0004	5.0004	5.0009
U_{line} (V)	103.96	103.94	103.96
PF	0.50L	0.50L	0.49L
PF_{Σ}			450.205
Pulse counting time (sec)	6	P_{Σ} (W)	S_{Σ} (VA)
		Q_{Σ} (Var)	
ERROR (%)			
STOP MEASUREMENT N 0 1			00000004
REMAINING TIME (sec)			5
			00011520
120 V/C 10 A 3-Ph 4-wire			

Fig. 4.4.6 METER CALIBRATION screen (measurement in progress)

Press ESC to exit the mode and go to the previous screen.

Data on each meter calibrated are logged in the following format:

- Meter type or name;
- Serial number;
- Year of manufacture;
- Accuracy class;
- Meter constant C_{mt} ;
- Nominal voltage U_N (V) and current I_N (A);
- Actual power type;

- Turns ratio of external CTs;
- Date/time of calibration;
- Up to 10 records of calibration results.

Each record contains:

- Data on test signal applied to the meter while determining meter error;
- Calculated error.

The above information in the edited form is included in calibration reports. The reports can only be viewed on a PC.

4.4.2 Pulse former

The delivery set of the EM 3.1KM may contain the Pulse Former, an auxiliary device that can be used for calibration of electronic or induction (single- or three-phase) active or reactive energy meters instead of scanning heads SH-E and SH-I.

PF produces pulses which are applied to the frequency input of the instrument.

Manual mode

PF generates a pulse every time that the user presses the red button on its side. This may be the case when automatic scanning is impossible or inconvenient.

Connect PF to the frequency input (F_{in} connector) of the EM 3.1KM. In the METER CALIBRATION screen, launch a measurement by clicking on the START MEASUREMENT field. Repeatedly press the button on the Pulse Former each time the mark on the disk edge aligns with that on the meter's enclosure (or each time the LED flashes on an electronic meter). When the button is first pressed, the EM-3.1KM starts meter error calculation. Keep pushing the button until the result (calculated meter error) appears on the screen. This will happen when the actual count of your button-strokes runs into the recommended number of input pulses.

NOTE! It is necessary to consider an additional error introduced by operator's bias.

NOTE! When it takes less than 2 s for the meter to make one disk revolution (or one flash of its LED), it is recommended to use a scanning head (SH-E or SH-I).

Automatic mode

In the automatic mode, PF converts each pulse coming from a pulse (telemetry) output of the meter into another pulse that the EM-3.1KM can accept on its pulse input (F_{in}). To test a meter with an optical (telemetry) output, use the auxiliary "telemetry" (red/black) cable to connect PF to the pulse output of the meter. Plug the red lead into the meter's terminal marked "+ TM", and the black one – into another terminal marked "- TM".

4.5 Logging

To enable logging function, select the LOGGING option in the main menu. The logging screen looks like shown in Fig. 4.5.1. There are 3 options:

- Logging type;
- Nominal values of voltage (Unom. phase = 219.4 V, Unom. line = 380 V by default);
- “Start logging” command.

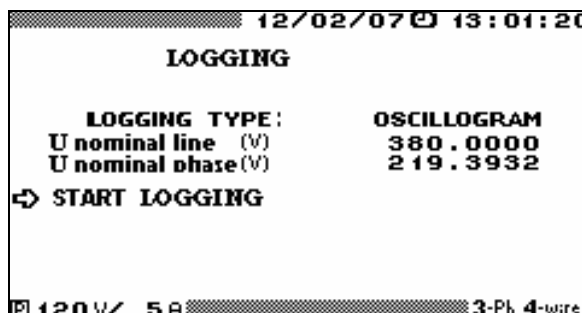


Fig. 4.5.1 LOGGING screen

On a startup the EM 3.1KM defaults to the settings specified in the LOGGING screen for the previous logging session.

To change nominal values of voltage, put the cursor opposite to the selected option and press ENT. Enter a new value using numeric keypad and the arrow keys \leftarrow , \rightarrow . Press ENT to save the new value in the memory, or press ESC to reject. Either of these actions will bring up the LOGGING screen. Should you change the setting for one of the nominal voltages (line or phase), the other will be recalculated automatically.

The LOGGING TYPE option makes it possible to select between the DIPS & SWELLS and OSCILLOGRAM logging modes (Fig. 4.5.2).

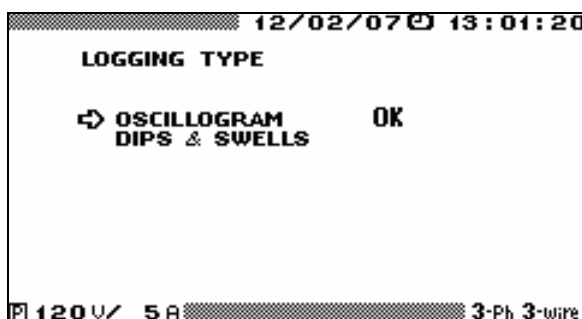


Fig 4.5.2 LOGGING TYPE options

DIPS & SWELLS logging function collects detailed data on each event (dip or swell) formatted as follows:

- Event type: dip or swell;
- Phase (A, B or C) affected by the event;
- Start time of the event;
- Event duration;
- Dip depth or swell height (as a percentage of nominal voltage).

The above information is kept in the internal memory and can only be viewed on a PC.

In the OSCILLOGRAM mode, the EM 3.1KM logs data (3 phase voltages and three phase currents) taken directly from the ADC at 12.8 kHz frequency. The information is recorded into the internal memory and can only be viewed on a PC. This method makes it possible to restore the original waveforms for each phase.

The memory capacity permits continuous logging of:

- 2000 events – in the DIPS & SWELLS mode;
- Data taken directly from the ADC during 2 1/3 minutes (in case of 3-phase connection) and during 7 minutes (in case of single-phase connection) – in the OSCILLOGRAM mode.

Logging is started by selecting and enabling the START LOGGING command in the LOGGING screen. As soon as you press ENT, the screen displays type of logging (as a header) and the STOP LOGGING command (Fig. 4.5.3).

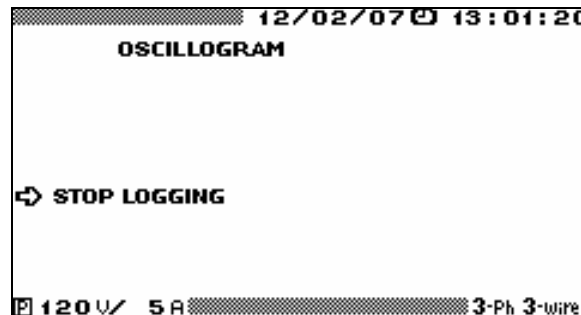


Fig. 4.5.3 STOP LOGGING screen

In this mode, the bottom line of the screen may contain one of the messages:

- “Waiting for start” (meaning that EM-3.1KM is about to start logging and initializes its non-volatile memory);
- “Logging” (which means logging is in progress).

It takes few seconds for the EM-3.1KM to initialize its internal memory and start data logging. The process stops when it either runs into end-of-memory, or is aborted by the user on enabling (and confirming) the STOP LOGGING command.

NOTE! When a new logging session is initiated, the EM 3.1KM erases all old data kept in its internal memory since the last session.

4.6 Calibration of voltage instrument transformers

4.6.1 General

The mode provides for either performance testing or accuracy testing (calibration) of voltage instrument transformers (VTs) according to certain established methods. VTs under test may be of 0.05 accuracy class or less accurate. In this mode, the EM 3.1KM operates as a comparator. Permissible limits of ratio and angle errors of the EM 3.1KM in this mode are specified in Tables 9 and 10.

Test results are recorded and stored in the internal memory. Each log may store results acquired from up to 200 VTs (up to 10 measurements per each VT). EmCalibrTrans software connects the EM 3.1KM with a PC and makes it possible to manage transformer data and test results, including automatic generation of customer-configurable test/calibration reports.

To bring up the screen with VT-under-test data (Fig. 4.6.2), enable the CALIBRATION OF VTs option from the main menu.

The following units are included in a typical VT test set (Fig 4.6.1):

- Adjustable High-Voltage source;
- Reference VT
- VT burden set;
- EM 3.1KM (comparator).

The adjustable High-Voltage Source provides voltage for high-voltage inputs (primary windings) of both Reference VT and VT under test. The secondary (low-voltage) windings of both VTs are connected to input terminals U_A and U_B of the EM 3.1KM, and secondary neutral terminals of both VTs are connected to the neutral terminal U_N of the EM 3.1KM (it has two U_N

terminals for convenience). The VT Burden set is connected to the secondary winding of the VT under test via separate cables.

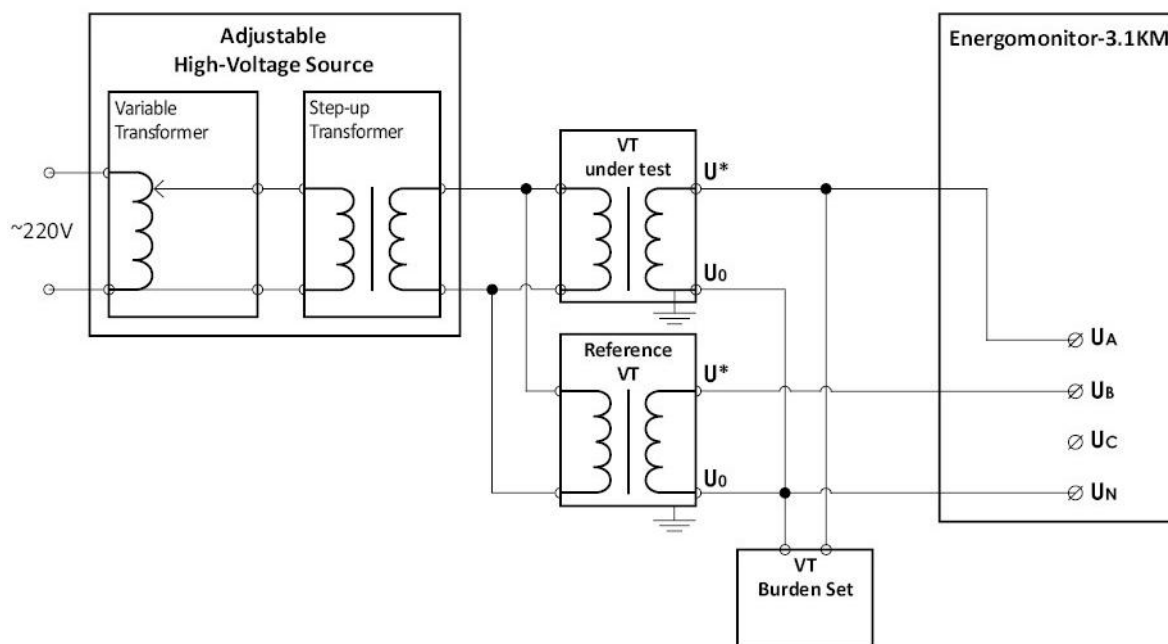


Fig 4.6.1 VT test set connection diagram

4.6.2 Setting up VT data

Before starting a calibration procedure, the VT-under-test data should be specified in the screen shown in Fig. 4.6.2.

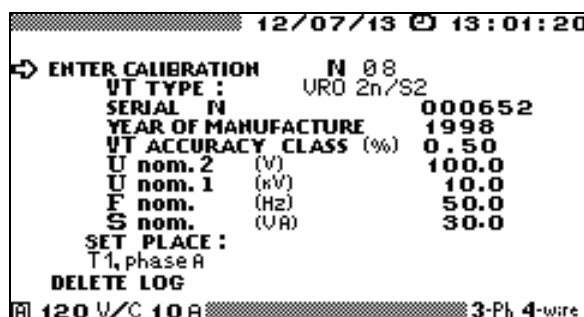


Fig. 4.6.2 VT-under-test data screen

Meaning of on-screen notations:

- VT type – type or name of the VT under test;
 - Serial N – its serial number;
 - Year of manufacture;
 - Accuracy class (%);
 - Unom. 2 (V) – nominal (rated) secondary voltage;
 - U nom. 1 (kV) – nominal (rated) primary voltage;
 - Fnom. (Hz) – nominal frequency;
 - Snom. (VA) – nominal value of apparent power taken for the transformer under test load;
 - Set place – location of the VT under test can be specified here;
 - Delete log – used to delete old logs from the internal memory.
- It is possible to quickly change an active measuring range in the EM 3.1KM by pressing 'F' hotkey.

On a startup, the EM 3.1KM will default to the settings specified before the last test procedure.

If you want to change VT under test data in the fields, position the cursor against the field to be edited with the arrow keys \downarrow, \uparrow and press ENT to open an editing window. Characteristics of the VT under test changed this way will be recorded into the EM 3.1KM memory under the name specified in the VT TYPE field.

If you want to enter a new transformer type (name) or make changes to an existing one, enable the VT TYPE field in the VT-under-test data screen, select the name to be modified from the list and click on it to open an editing window. Then follow the procedure for filling alphanumeric fields described in section 4.4.1 (p. 53-54) for electric energy meters.

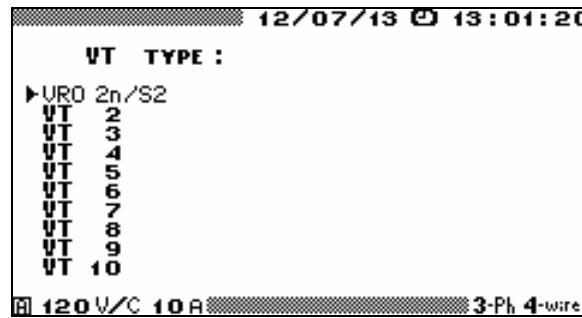


Fig. 4.6.3 VT TYPE screen

If you want to activate calibration procedure for one of the VTs existing in the list, select it, press ENT (this will bring up the screen where you can change its name) and press ENT once again to open the VT-under-test Data screen (Fig. 4.6.2) with the name of the selected VT on the top and its data in the fields.

The VT-under-test data screen in conjunction with the VT TYPE screen allows you to maintain a kind of a library in the internal memory with names and data on up to 10 VTs. The dataset for each of 10 VTs can be created either in the EM 3.1KM (as described above) or on a PC and then downloaded to the instrument.

NOTE! Before starting calibration procedure, do not forget to select nominal (rated) voltages for both Reference VT and VT under test. Click on the “U nom. 2” option (Fig. 4.6.2) to open the SELECT NOMINAL screen (Fig. 4.6.4) and set the required value.

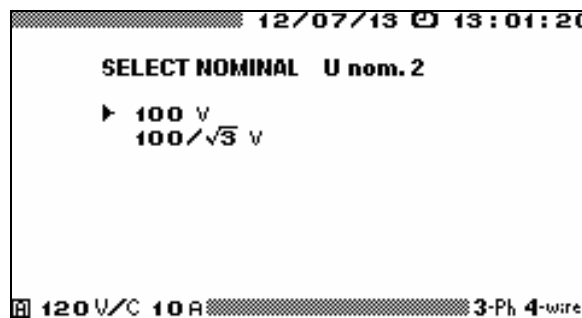


Fig. 4.6.4 Selecting nominal secondary voltage for Reference VT and VT under test

The SET PLACE field (Fig. 4.6.5) makes it possible to select one of 10 options stored in the library, or enter a new location data (including a phase to which the VT under test is connected).

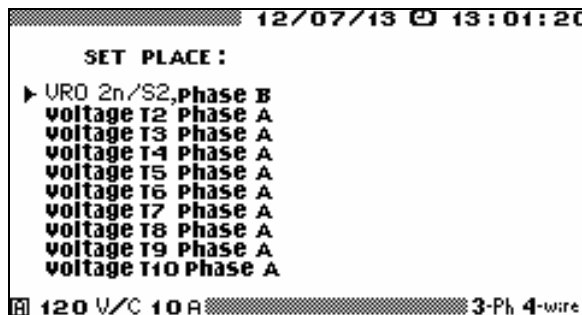


Fig. 4.6.5 Selecting VT under test location

If you want to enter a new location of the VT under test, or make changes to an existing one, select the location to be modified from the list and click on it to open an editing window. Then follow the procedure for filling alphanumeric fields described in section 4.4.1 (p. 53-54) for electric energy meters.

Alternatively, you may want to select any VT location existing in the list. Click on the desired VT location (this will bring up the screen where you can change its name) and press ENT once again to open the VT-under-test Data screen (Fig. 4.6.2) with the selected location data in the SET PLACE field.

Each of 10 locations present in this list can be created either in the EM 3.1KM (as described above) or on a PC and then downloaded to the instrument.

To start a calibration procedure, select the GO TO CALIBRATION N option from the VT-under-test Data screen (Fig. 4.6.2) and press ENT. The screen devoted to a certain calibration procedure will appear:

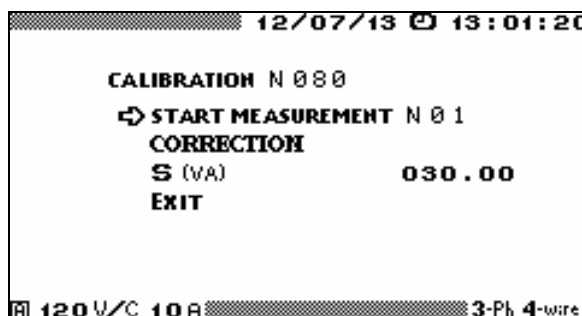


Fig. 4.6.6 “Actual calibration” screen

Calibration of VTs is carried out in 2 steps:

- 1 – Zero correction (compensation of differences in characteristics of voltage measurement channels);
- 2 – Calibration.

4.6.3 Zero correction

Zero correction shall be carried out in 30 min (or later) after applying power to the EM 3.1KM.

To start zero correction, in the VT-under-test data screen select GO TO CALIBRATION N, and then select GO TO MEASUREMENT N to display a screen shown below:

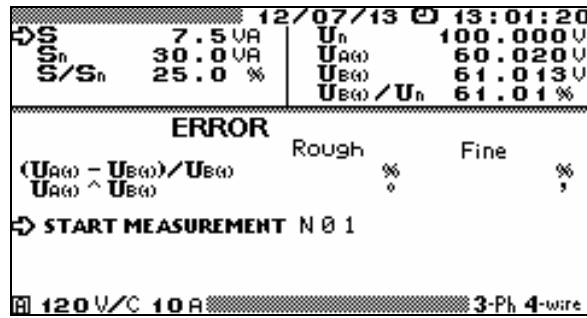


Fig. 4.6.7 Calibration data screen

Manually adjust the variable High-Voltage Source to obtain the required test voltage across primary windings of both Reference VT and VT under test by watching (and regulating) secondary voltage of the Reference VT (displayed as voltage in phase B $U_{B(1)}$ on the screen above).

Press ESC to return to the previous screen and select ZERO CORRECTION. The screen shown in Fig. 4.6.8 will appear. At this time, one and the same voltage taken from the output terminals of the Reference VT is applied to both voltage measurement channels (U_A and U_B) of the EM 3.1KM. The EM-3.1KM will carry out zero correction, namely it will electronically compensate both amplitude difference and phase shift between voltages in channels A and B.

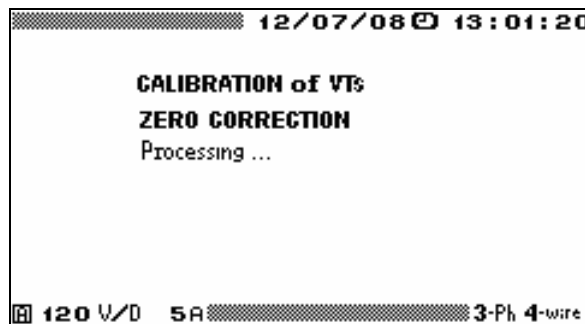


Fig. 4.6.8 Zero correction in progress

The ZERO CORRECTION mode is exited automatically. The differences in characteristics are recorded into the memory to be considered in further measurements.

To obtain the highest possible measurement accuracy, it is recommended to carry out zero correction after a considerable (greater than 5 °C) drop in ambient temperature and after each changing of voltage range.

4.6.4 Calibration of VTs

Before starting measurements, it is necessary to type in an actual value of apparent power that was selected on the Burden Set for the VT-under-test load (VA). This value will be printed in the test report.

To do this, select S (VA) in the “Actual calibration” screen shown in Fig. 4.6.6, press ENT to open an editing window and specify the required value.

To start calibration, click on GO TO MEASUREMENT N in the “Actual calibration” screen (Fig. 4.6.6). When done, voltage taken from the Reference VT is applied to U_B input, and voltage taken from the VT under test is applied to U_A input of the EM 3.1KM. The screen shown below will appear (Fig. 4.6.9):

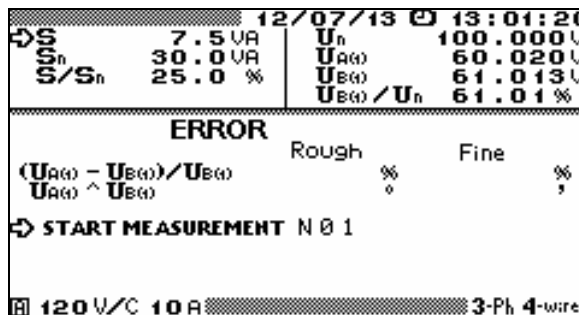


Fig. 4.6.9 “Calibration data” screen

Meaning of on-screen notations:

S – actual value of apparent power selected on the Burden Set for the VT-under-test load before this measurement (and typed in via the previous screen);

S_n – nominal value of apparent power of the VT under test specified as **S_{nom}** in the VT-under-test Data screen (Fig. 4.6.2);

S/S_n – apparent power of the VT under test as a percentage of the nominal apparent power;

U_n – nominal secondary voltage of the VT under test specified as **U_{nom}** in the VT-under-test Data screen (Fig. 4.6.2);

U_{A(1)} – RMS of fundamental harmonic of voltage across the secondary winding of the VT under test;

U_{B(1)} - RMS of fundamental harmonic of voltage across the secondary winding of the Reference VT;

U_{B(1)}/ U_n – secondary voltage of the reference VT as a percentage of the nominal voltage.

To launch a measurement, select and enable the START MEASUREMENT option. At this point, the prompt START MEASUREMENT turns to STOP MEASUREMENT.

The EM 3.1KM will determine and display the ratio and angle errors of the VT under test (Fig. 4.6.10).

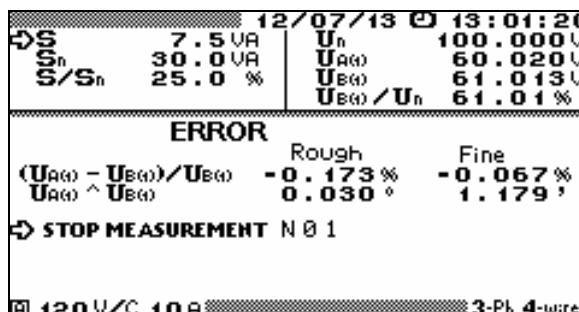


Fig. 4.6.10 “Calibration data” screen with calibration results

Well-determined or “Fine” (considering zero correction results) and “Rough” (without zero correction) VT-under-test errors are displayed as follows:

- Ratio error $\Delta f_U = \left[\frac{(U_{A(1)} - U_{B(1)})}{U_{B(1)}} \right] * 100, \%$;
- Angle error $\Delta \delta_U = U_{A(1)} \wedge U_{B(1)}$ (“Fine” error – in minutes, “Rough” error – in degrees).

Fine ratio and angle errors are considered representative within the ranges of $\pm 1^\circ$ for angle error and/or $\pm 2\%$ for ratio error.

When actual errors of the VT under test do not lie within these ranges, asterisks (*****) are displayed instead of "Fine" values. "Rough" error values shall be taken as calibration results in such a case.

Owing to zero correction, measurement in this mode is fairly accurate, as compared to other EM-3.1KM operating modes. To take the advantage of this, be sure to make zero correction before each measurement.

A measurement can be stopped at any time by clicking on the STOP MEASUREMENT option, which will turn to SAVE MEASUREMENT. By clicking on “Save...”, you can record the results into the memory.

Before the next measurement, you may change the actual value of apparent power S (VA) by selecting a new one on the Burden Set. Do not forget to type in the new value via the Actual calibration screen (Fig. 4.6.6). Then you can repeat the procedure with other test conditions.

Data on each VT calibrated are logged in the following format:

- VT type (name);
- Serial number;
- Year of manufacture;
- Accuracy class;
- Nominal value of frequency (Hz);
- Nominal primary voltage (kV);
- Nominal secondary voltage (V);
- Nominal value of apparent power (VA);
- Location (installation place);
- Connection phase;
- Date/time of calibration;
- Up to 10 records of calibration results; each record contains:
 - Actual value of apparent power of VT-under-test load (VA);
 - Test signal characteristics (RMS of fundamental harmonic of voltage across the secondary winding of VT under test $U_{A(1)}$, and Reference VT $U_{B(1)}$;
 - VT-under-test ratio error Δf_U and angle error $\Delta \delta_U$).

The above information in the edited form is included in each VT calibration test report. The reports can only be viewed on a PC.

4.7 Calibration of current instrument transformers

4.7.1 General

The mode provides for either performance testing or accuracy testing (calibration) of current instrument transformers (CTs) according to certain established methods. The CTs under test rated at 1A or 5A may be of 0.05 accuracy class or less accurate. In this mode, the EM 3.1KM operates as a comparator. Permissible limits of ratio and angle errors of the EM 3.1KM in this mode are specified in Tables 9 and 10.

Test results are recorded and stored in the internal memory. Each log may store results acquired from up to 200 CTs (up to 10 measurements per each CT). EmCalibrTrans software connects the EM 3.1KM with a PC and makes it possible to manage transformer data and test results, including automatic generation of customer-configurable test/calibration reports.

To bring up the screen with CT-under-test data (Fig. 4.7.2), enable the CALIBRATION OF CTs option from the main menu.

The following units are included in a typical CT test set (Fig 4.7.1):

- Adjustable Current source;
- Reference CT
- CT burden set;
- EM 3.1KM (comparator) complete with the Current Transformer Calibration Switch (CTCS).

The Adjustable Current source generates test current that passes through primary windings of both Reference CT and CT under test. Their secondary windings are connected to the respective inputs of the CTCS. The Burden Set provides an assortment of burdens for the CT under test.

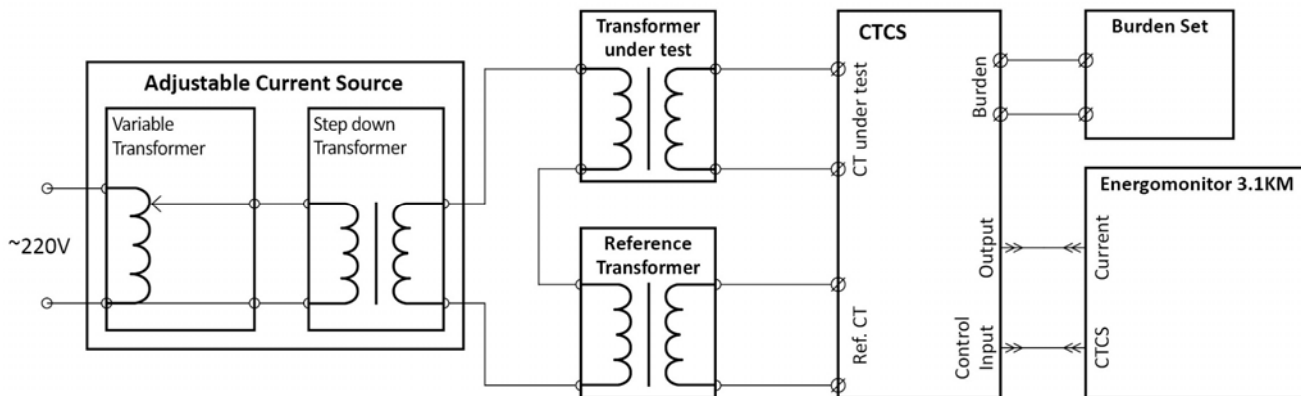


Fig 4.7.1 CT test set connection diagram

4.7.2 Setting up CT data

Before starting a calibration procedure, the CT under test data should be specified in the screen shown in Fig. 4.7.2.

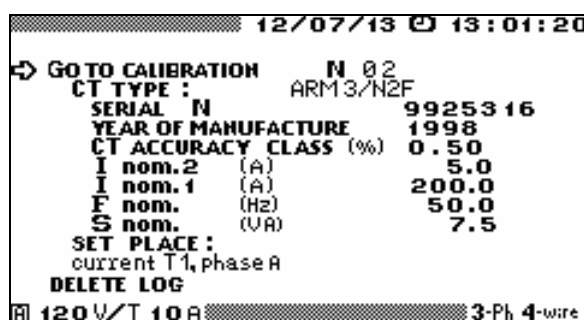


Fig. 4.7.2 CT-under-test data screen

Meaning of on-screen notations:

- CT type – type or name of the CT under test;
- Serial N – its serial number;
- Year of manufacture;
- Accuracy class (%);
- I nom. 2 (A) – nominal (rated) secondary current;
- I nom. 1 (A) – nominal (rated) primary current;
- Fnom. (Hz) – nominal frequency;
- Snom. (VA) – nominal value of apparent power taken for the transformer under test load;
- Set place – location of the CT under test can be specified here;
- Delete log – used to delete old logs from the internal memory.

It is possible to quickly change an active measuring range in the EM 3.1KM by pressing 'F' hotkey.

On a startup, the instrument will default to the settings specified before the last test procedure.

If you want to make changes to the CT under test data in the fields, position the cursor against the field to be edited with the arrow keys ↓,↑ and press ENT to open an editing window. The transformer characteristics changed this way will be recorded into the EM 3.1KM memory under the name specified in the CT TYPE field.

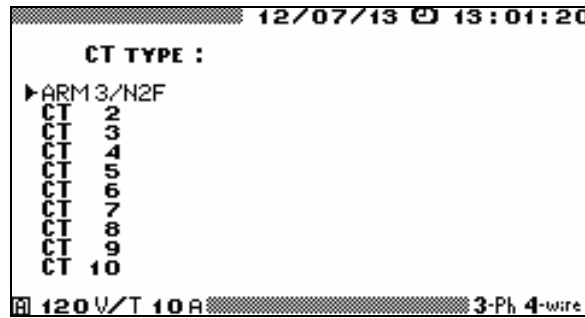


Fig. 4.7.3 CT type screen

If you want to enter a new transformer type (name) or make changes to an existing one, click on the CT TYPE field in the CT-under-test data screen, select the name to be modified from the list and click on it to open an editing window. Then follow the procedure for filling alphanumeric fields described in section 4.4.1 (p. 53-54) for electric energy meters.

If you want to activate calibration procedure for one of the CTs existing in the list, select it, press ENT (this will bring up the screen where you can change its name) and press ENT once again to open the CT-under-test Data screen (Fig. 4.7.2) with the name of the selected VT on the top and its data in the fields.

The CT-under-test data screen in conjunction with the CT TYPE screen allows you to maintain a kind of a library in the internal memory with names and data on up to 10 CTs. The dataset for each of 10 CTs can be created either in the EM 3.1KM (as described above) or on a PC and then downloaded to the instrument.

NOTE! Before starting calibration procedure, do not forget to select nominal (rated) secondary currents for both Reference CT and CT under test. Click on the “I nom. 2” option (Fig. 4.7.2) to open the SELECT NOMINAL screen (Fig. 4.7.4) and set the required value.

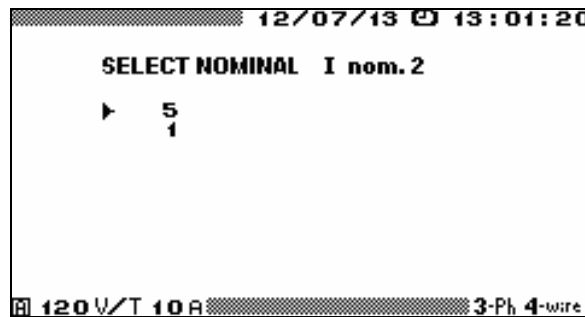


Fig. 4.7.4 Selecting nominal secondary current for Reference CT and CT under test

The SET PLACE field (Fig. 4.7.5) makes it possible to select one of 10 options stored in the library, or enter a new location data (including a phase to which the CT under test is connected).

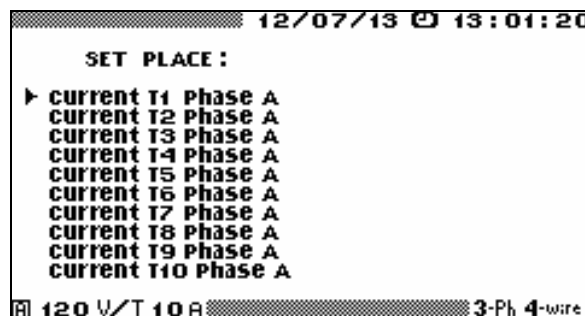


Fig. 4.7.5 Selecting CT-under-test location

If you want to enter a new location of the CT under test, or make changes to an existing one, select the location to be modified from the list and click on it to open an editing window. Then follow the procedure for filling alphanumeric fields described in section 4.4.1 (p. 53-54) for electric energy meters.

Alternatively, you may want to select any CT location existing in the list. Click on the desired CT location (this will bring up the screen where you can change its name) and press ENT once again to open the CT-under-test Data screen (Fig. 4.6.2) with the selected location data in the SET PLACE field.

Each of 10 locations present in this list can be created either in the EM 3.1KM (as described above) or on a PC and then downloaded to the instrument.

To start a calibration procedure, select the GO TO CALIBRATION N option from the CT-under-test Data screen (Fig. 4.7.2) and press ENT. The screen devoted to a certain calibration procedure will appear:

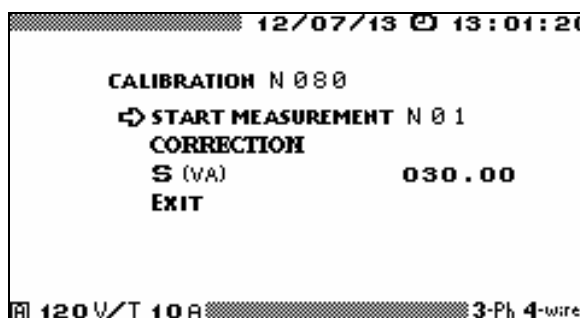


Fig. 4.7.6 “Actual calibration” screen

Calibration of CTs is carried out in 2 steps:

- 1 – Zero correction (compensation of differences in characteristics of current measurement channels of the EM 3.1KM and CTCS);
- 2 – Calibration.

4.7.3 Zero correction

Zero correction shall be carried out in 30 min (or later) after applying power to the EM 3.1KM.

NOTE! Circuitry of the Current Transformer Calibration Switch (CTCS) provides that the continuity of secondary circuits of both CTs is in no way affected by switching over modes or ranges.

NOTE! The EM 3.1KM selects operation modes and ranges for both channels of the CTCS automatically.

To start zero correction, in the CT-under-test data screen, select GO TO CALIBRATION N, then select GO TO MEASUREMENT N to display a screen shown below:

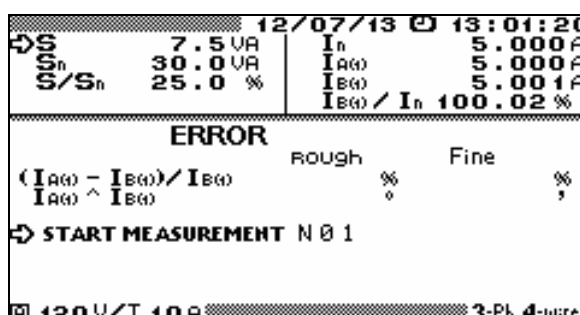


Fig. 4.7.7 Calibration data screen

Manually adjust the variable transformer of the Current Source to pass the required primary (test) current through primary windings of both Reference CT and CT under test by watching (and regulating) secondary currents of both CTs displayed as $I_{A(1)}$ (CT under test) and $I_{B(1)}$ (Reference CT) on the screen above.

Press ESC to return to the previous screen and select ZERO CORRECTION. The screen shown in Fig. 4.7.8 will appear. At this time, the current going through the secondary winding of the Reference CT is simultaneously applied to both channels of the CTCS. The EM 3.1KM will carry out zero correction, namely, it will electronically compensate both amplitude difference and phase shift between currents in these channels.

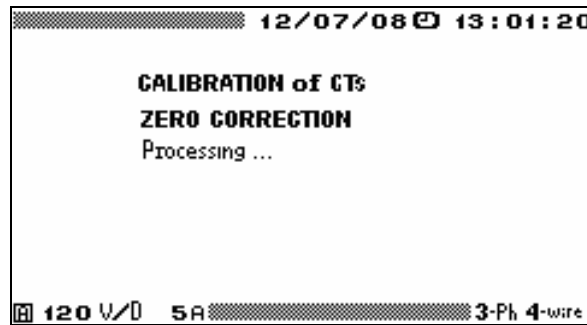


Fig. 4.7.8 Zero correction in progress

The ZERO CORRECTION mode is exited automatically. The differences in characteristics are recorded into the memory to be considered in further measurements.

To obtain the highest possible measurement accuracy, it is recommended to carry out zero correction after a considerable (greater than 5 °C) drop in ambient temperature and after each changing of current range.

4.7.4 Calibration of CTs

Before starting measurements, it is necessary to type in an actual value of apparent power that was selected on the Burden Set for the CT-under-test load (VA). This value will be printed in the test report.

To do this, select S (VA) in the “Actual calibration” screen shown in Fig. 4.7.6, press ENT to open an editing window and specify the required value.

To start calibration, click on GO TO MEASUREMENT N in the “Actual calibration” screen (Fig. 4.7.6). The screen pictured below will appear:

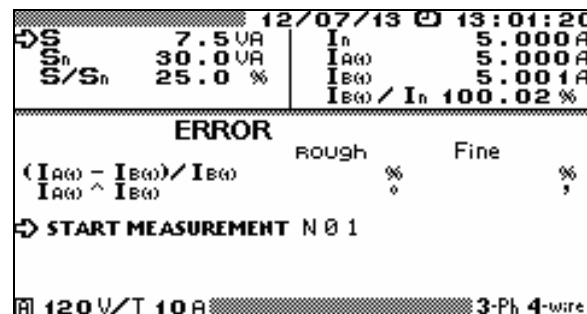


Fig. 4.7.9 Calibration data screen

Meaning of on-screen notations:

- S – actual value of apparent power selected on the Burden Set for the CT-under-test load before this measurement (and typed in via the previous screen);
- S_n – nominal value of apparent power of the CT under test specified as **S_{nom}** in the CT-under-test Data screen (Fig. 4.7.2);

- S/S_n – apparent power of the CT under test as a percentage of the nominal apparent power;
- I_n – nominal secondary current of the CT under test specified as I_{nom} in the CT-under-test Data screen (Fig. 4.7.2);
- $I_{A(1)}$ – RMS of fundamental harmonic of current in the secondary winding of the CT under test;
- $I_{B(1)}$ – RMS of fundamental harmonic of current in the secondary winding of the Reference CT;
- $I_{B(1)} / I_n$ – secondary current of the reference CT as a percentage of the nominal current.

To launch a measurement, select and enable the START MEASUREMENT option. At this point, the prompt START MEASUREMENT turns to STOP MEASUREMENT.

The EM 3.1KM will determine and display the ratio and angle errors of the CT under test (Fig. 4.7.10).

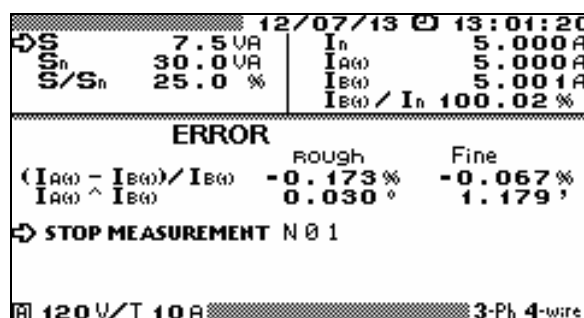


Fig. 4.7.10 Calibration data screen with calibration results

Well-determined or “Fine” (considering zero correction results) and “Rough” (without zero correction) CT-under-test errors are displayed as follows:

- Ratio error δ_{fi} : $\left[\frac{(I_{A(1)} - I_{B(1)})}{I_{B(1)}} \right] * 100, \%$
- Angle error $\Delta\delta_i$: $I_{A(1)} \wedge I_{B(1)}$, (“Fine” error – in minutes, “Rough” error – in degrees).

Fine ratio and angle errors are considered representative within the ranges of $\pm 1^\circ$ for angle error and/or $\pm 2\%$ for ratio error.

When actual errors of the CT under test do not lie within these ranges, asterisks (*****) are displayed instead of "Fine" values. "Rough" error values shall be taken as calibration results in such a case.

Owing to zero correction, measurement in this mode is fairly accurate, as compared to other EM-3.1KM operating modes. To take the advantage of this, be sure to make zero correction before each measurement.

A measurement can be stopped at any time by clicking on the STOP MEASUREMENT option, which will turn to SAVE MEASUREMENT. By clicking on “Save...”, you can record the results into the memory.

Before the next measurement, you may change the actual value of apparent power S (VA) by selecting a new one on the Burden Set. Do not forget to type in the new value via the Actual calibration screen (Fig. 4.7.6). Then you can repeat the procedure with other test conditions.

Data on each CT calibrated are logged in the following format:

- CT type (name);
- Serial number;
- Year of manufacture;
- Accuracy class;
- Nominal value of frequency (Hz);
- Nominal primary current, (A);
- Nominal secondary current (A);
- Nominal value of apparent power (VA);

- Location (installation place);
- Connection phase;
- Date/time of calibration;
- Up to 10 records of calibration results; each record contains:
 - Actual value of apparent power of CT-under-test load (VA),
 - Test signal characteristics (RMS of fundamental harmonic of current in the secondary winding of CT under test $I_{A(1)}$, and Reference CT $I_{B(1)}$, A;
 - CT-under-test ratio error (δ_{fi}) and angle error ($\Delta\delta_i$).

The above information in the edited form is included in each CT calibration test report. The reports can only be viewed on a PC.

4.8. Voltage Peak/Amplitude

In the VOLTAGE PEAK/AMPLITUDE mode, the EM 3.1KM measures amplitude and peak values, as applied to AC voltages of up to 500Hz frequency, across its one / three channels (including differential channel).

The mode includes three functions:

- PEAK DETECTOR;
- AMPLITUDE DETECTOR;
- AVERAGE AMPLITUDE.

Selectable parameters:

- Time constant for the AMPLITUDE DETECTOR mode;
- Time of bounce suppression for the AVERAGE AMPLITUDE mode;
- Selection of scaling factors.

The VOLTAGE PEAK/AMPLITUDE screen is shown in Fig. 4.8.1.

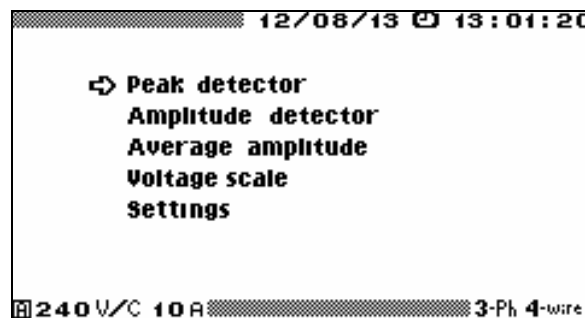


Fig. 4.8.1 VOLTAGE PEAK/AMPLITUDE menu

4.8.1. Peak detector

The PEAK DETECTOR function meant for detection of maximum and minimum values of a signal for the user-defined period is a programmatic (firmware-based) version of a peak detector instrument (its operation principle is schematically shown in Fig. 4.8.2 and 4.8.3).

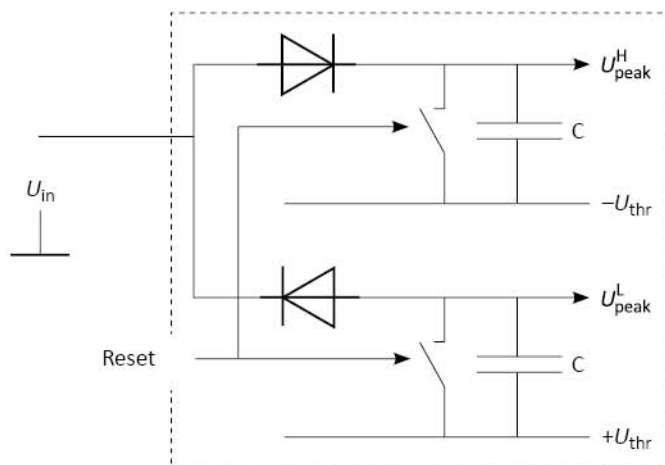


Fig. 4.8.2 Operation principle of the PEAK DETECTOR mode

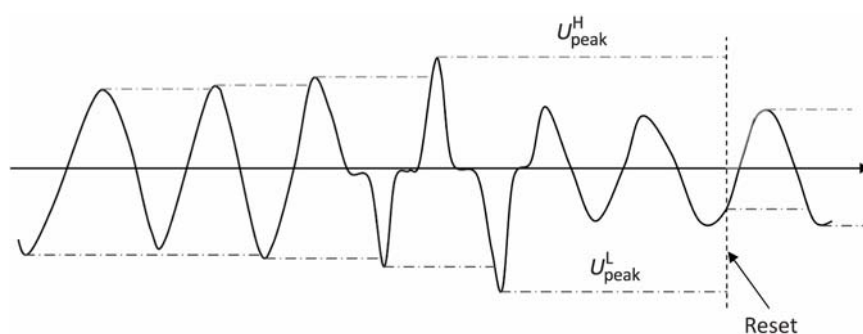


Fig. 4.8.3 Signal processing in the PEAK DETECTOR mode

Meaning of notations in the figures:

U_{in} — input voltage;

f_s — sampling rate (12.8 kHz);

Reset — signal that enables reset of captured data, selectable among 1.25; 2.5; 5 or 10 s (generated according to the AVERAGING TIME value selected in the SETTINGS menu);

U_{peak}^H — maximum recorded value of voltage;

U_{peak}^L — minimum recorded value of voltage;

C — memory cell of the firmware-based peak detector;

$-U_{thr}$ — minimum threshold voltage;

$+U_{ths}$ — maximum threshold voltage.

12/03/13 13:01:20			
Peak detector			
	A	B	C
temp+	84.90 V	84.89 V	84.87 V
Peak+	84.90 V	84.89 V	84.87 V
/√2	60.03 V	60.03 V	60.01 V
temp-	-84.93 V	-84.91 V	-84.91 V
Peak-	-84.93 V	-84.91 V	-84.91 V
/√2	-60.05 V	-60.04 V	-60.07 V
RMS	60.02 V	60.01 V	60.00 V
240 V/D 5A 3-Ph 4-wire			

Fig. 4.8.4 Peak values displayed in the PEAK DETECTOR mode

The PEAK DETECTOR mode includes 1 screen shown in Fig. 4.8.4.

Meaning of on-screen notations (3-phase 4-wire configuration):

- Temp-; Temp+ — actual (temporary) peak values of voltage (both polarities) across three channels;

- Peak-; Peak+ — peak values of voltage (both polarities) captured for the previous averaging interval across three channels;

- $/\sqrt{2}$ — peak values of voltage (both polarities) captured for the previous averaging interval across three channels divided by $\sqrt{2}$;
 - RMS — RMS values of voltage across three channels.
- For a single-phase configuration**, the PEAK DETECTOR screen displays the same parameters for one channel (phase A).

4.8.2. Amplitude detector

The AMPLITUDE DETECTOR function is a programmatic (firmware-based) version of the corresponding analogue instrument (its operation principle is schematically shown in Fig. 4.8.5 and 4.8.6).

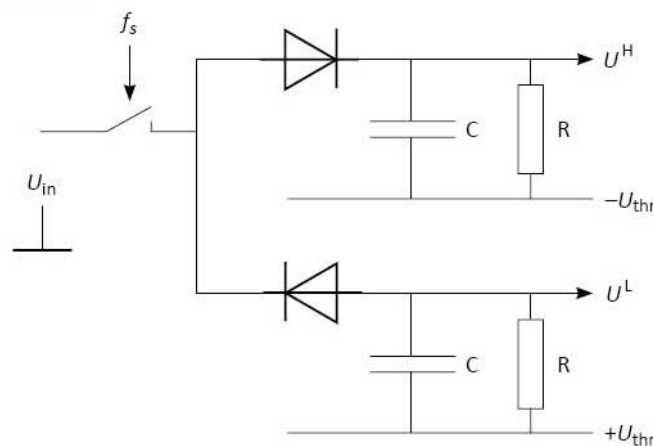


Fig. 4.8.5 Operation principle of the AMPLITUDE DETECTOR mode

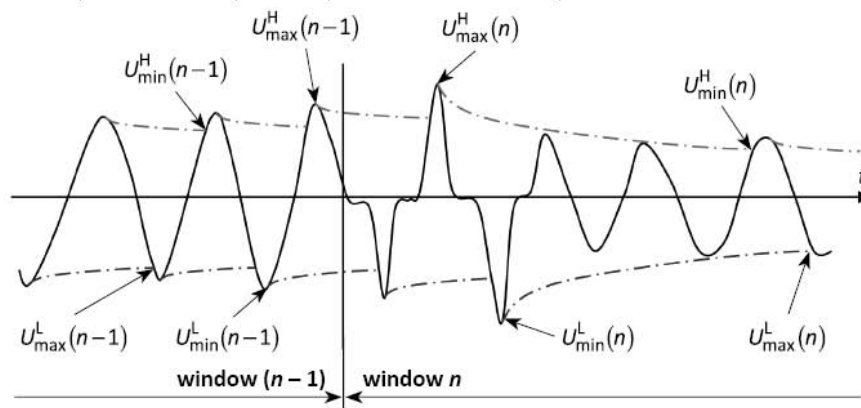


Fig. 4.8.6 Signal processing in the AMPLITUDE DETECTOR mode

Meaning of notations in the figures:

- U_{in} — input voltage;
- f_s — sampling rate (12.8 kHz);
- U^H — values of upper envelope curve of voltage;
- U^L — values of lower envelope curve of voltage;
- $\tau = RC$ — time constant (selectable within 0.02 to 100 s range);
- $-U_{thr}$ — minimum threshold value of voltage;
- $+U_{thr}$ — maximum threshold value of voltage.

The following values of voltage are calculated within a time interval (time window) of 0.16 s:

U_{\max}^H — maximum value of upper envelope curve of voltage;
 U_{\min}^H — minimum value of upper envelope curve of voltage;
 U_{\max}^L — maximum value of lower envelope curve of voltage;
 U_{\min}^L — minimum value of lower envelope curve of voltage.

$$\bar{U}_H = \frac{U_{\max}^H + U_{\min}^H}{2}, \quad \bar{U}_{H2} = \frac{U_{\max}^H + U_{\min}^H}{2\sqrt{2}},$$

$$\bar{U}_L = \frac{U_{\max}^L + U_{\min}^L}{2}, \quad \bar{U}_{L2} = \frac{U_{\max}^L + U_{\min}^L}{2\sqrt{2}}.$$

Then the values calculated for \bar{U}_H , \bar{U}_{H2} , \bar{U}_L , \bar{U}_{L2} are averaged over 1.25; 2.5 or 5 s interval (according to the AVERAGING TIME value specified in the SETTINGS menu) and displayed. Parameter τ corresponds to a time constant of the programmatically realized RC circuit. Thus, by selecting the value of the time constant (via the “Settings” option of the VOLTAGE PEAK/AMPLITUDE menu), you can achieve the balance between the rate of tracking of amplitude values and dynamic (discharge related) measurement error.

In the AMPLITUDE DETECTOR mode two screens are available (Fig. 4.8.7) — amplitude values measured across the basic three channels and across the differential channel. The screens are selected with the arrow keys \leftarrow , \rightarrow keys or "1" and "2" numeric keys.

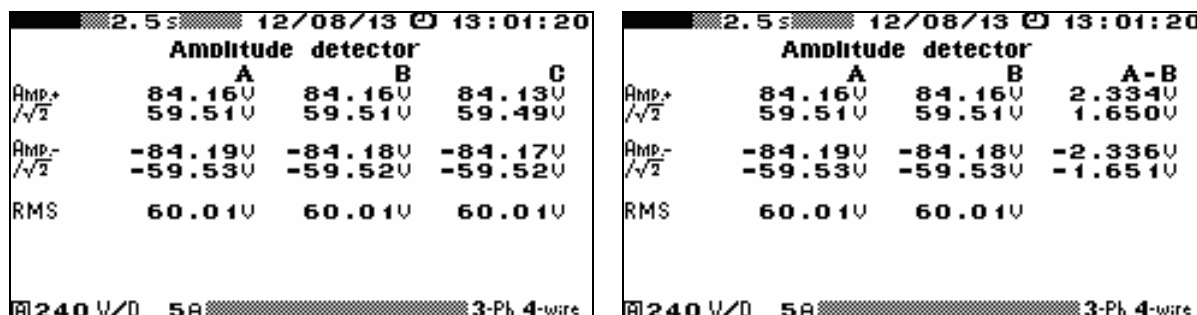


Fig. 4.8.7 Amplitude values measured in the AMPLITUDE DETECTOR mode

Meaning of on-screen notations (3-phase 4-wire configuration):

- Amp-; Amp+ — amplitude values of voltage (both polarities) across three channels;
- $/\sqrt{2}$ — amplitude values of voltage (both polarities) across three channels divided by $\sqrt{2}$;
- RMS — RMS values of voltage across three channels;
- Amp-; Amp+ (channel A-B) — amplitude values of voltage (both polarities) across the differential channel A-B;
- $/\sqrt{2}$ (Channel A-B) — Amplitude values of voltage (both polarities) across the differential channel A-B divided by $\sqrt{2}$.

For a single-phase configuration, the AMPLITUDE DETECTOR screen displays:

- Amplitude values of voltage (both polarities);
- Amplitude values of voltage (both polarities) divided by $\sqrt{2}$;
- RMS of voltage.

4.8.3. Average amplitude

The AVERAGE AMPLITUDE function is a firmware-based version of the analogue circuit shown in Fig. 4.8.8.

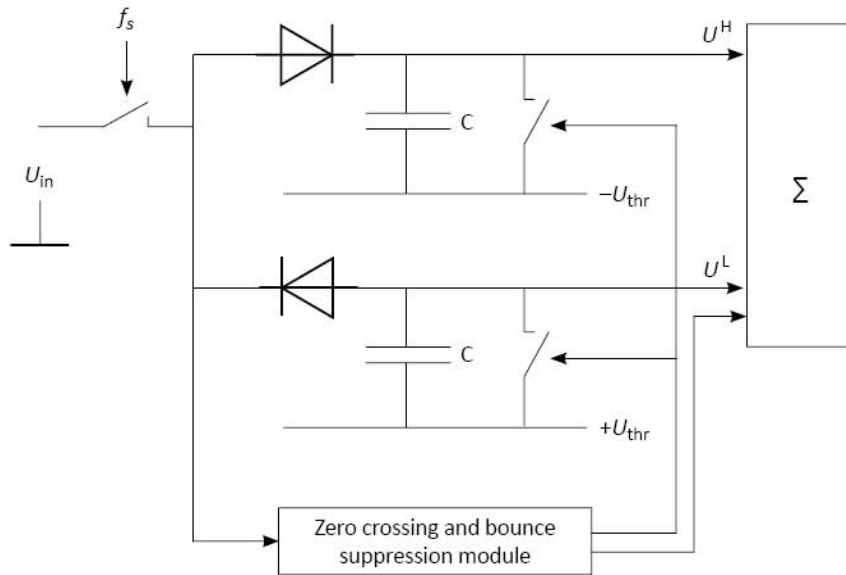


Fig. 4.8.8 Operation principle of the AVERAGE AMPLITUDE mode

Meaning of notations in the figures:

- U_{in} — input voltage;
- f_s — sampling rate (12.8 kHz);
- U^H — values of upper envelope curve of voltage;
- U^L — values of lower envelope curve of voltage;
- $-U_{thr}$ — minimum threshold value of voltage;
- $+U_{thr}$ — maximum threshold value of voltage.

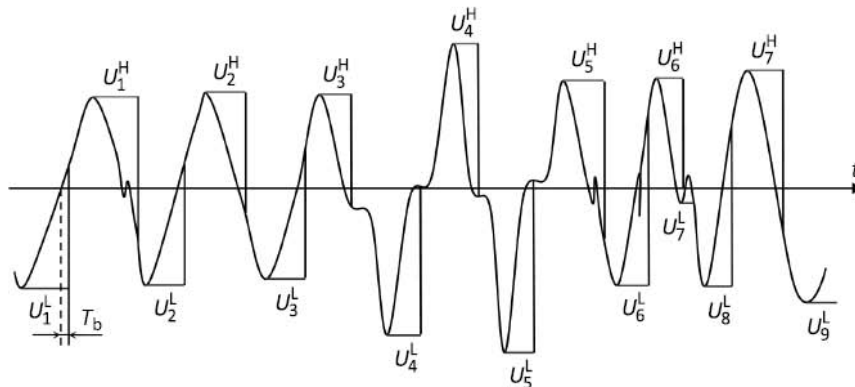


Fig. 4.8.9 Signal processing in the AVERAGE AMPLITUDE mode

- U_i^H — values of upper envelope curve;
- U_i^L — values of lower envelope curve;
- T_b — time of bounce suppression

In case of a **bipolar signal** (polarity periodically becomes positive or negative, see Fig. 4.8.9), EM 3.1KM measures a maximum value on each positive half-period of voltage signal and a maximum value (in absolute magnitude) on each negative half-period, records each measured value into the memory and calculates a value of average amplitude (separately for signals of positive and negative polarity) over a time gate of 160 ms.

Then the average amplitude values are averaged once again over a user-selected period (1.25, 2.5 or 5s).

Parameter T_b (the user-specified “time of bounce suppression”) determines a time interval within which EM 3.1KM ignores changes in signal polarity to suppress voltage fluctuations about zero (if present). T_b is selected within 0.2...100 ms range (via the “Settings” option of the VOLTAGE PEAK/AMPLITUDE menu).

In case of a **unipolar signal** (there are no changes in signal polarity during the specified averaging time (1.25, 2.5 or 5s) or the changes are within T_b interval), EM 3.1KM records the maximum signal value for positive signal or the maximum signal value (in absolute magnitude) for negative signal detected within each 160 ms gate.

Then the unipolar voltage values recorded into the memory at 160 ms intervals are sequentially passed for averaging over 1.25, 2.5 or 5 s intervals and displayed in the corresponding screen fields. At this time, the screen fields related to undetected polarity display zeroes.

$$\bar{U}_H = \frac{1}{K} \sum_{i=1}^K U_i^H, \quad \bar{U}_{H2} = \frac{1}{\sqrt{2}K} \sum_{i=1}^K U_i^H,$$

$$\bar{U}_L = \frac{1}{M} \sum_{i=1}^M U_i^L, \quad \bar{U}_{L2} = \frac{1}{\sqrt{2}M} \sum_{i=1}^M U_i^L.$$

The operation algorithm is pictured in Fig. 4.8.9.

In the AVERAGE AMPLITUDE mode 2 screens are available (Fig. 4.7.10). They represent amplitude values measured across the basic three channels and across the differential channel. The screens are selected with the arrow keys \leftarrow, \rightarrow or "1" and "2" numeric keys.

Average amplitude			
	A	B	C
Amp+ /√2	84.89V	84.88V	84.86V
	60.02V	60.02V	60.00V
Amp- /√2	84.91V	84.90V	84.89V
	60.04V	60.03V	60.03V
RMS	60.02V	60.01V	60.01V

Average amplitude			
	A	B	A-B
Amp+ /√2	84.88V	84.87V	2.336V
	60.02V	60.01V	1.652V
Amp- /√2	84.91V	84.90V	2.343V
	60.04V	60.03V	1.656V
RMS	60.02V	60.03V	

Fig. 4.8.10 Amplitude values measured in the AVERAGE AMPLITUDE mode

Meaning of on-screen notations (3-phase 4-wire configuration):

- Amp-; Amp+ — amplitude values of voltage (both polarities) across three channels;
- $/\sqrt{2}$ — amplitude values of voltage (both polarities) across three channels divided by $\sqrt{2}$;
- RMS — RMS values of voltage across three channels;
- Amp-; Amp+ (channel A-B) — amplitude values of voltage (both polarities) across differential channel A-B;
- $/\sqrt{2}$ (Channel A-B) — amplitude values of voltage (both polarities) across differential channel A-B divided by $\sqrt{2}$.

For a single-phase configuration, the AVERAGE AMPLITUDE screen displays:

- Amplitude values of voltage (both polarities);
- Amplitude values of voltage (both polarities) divided by $\sqrt{2}$;
- RMS of voltage.

4.8.4. Voltage scaling factors

In the VOLTAGE PEAK/AMPLITUDE mode, the EM 3.1KM displays measured values considering scaling factors (turns ratios) of external voltage dividers.

The scaling factors can be specified separately per each channel within 0.00001 to 99999.99999 range in 0.00001 increments (Fig. 4.8.11).

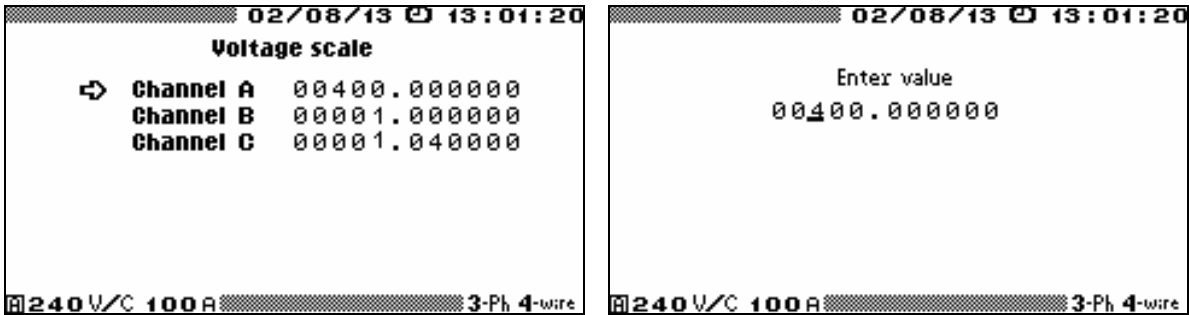


Fig. 4.8.11 Specifying scaling factors

All values measured in the VOLTAGE PEAK/AMPLITUDE mode are automatically displayed in appropriate measurement units (V, kV, or MV).

Voltage measured across the differential channel is also displayed considering scaling factors:

$$U_{A-B} = K_A \cdot U_A - K_B \cdot U_B.$$

4.8.5. Settings

In the VOLTAGE PEAK/AMPLITUDE, mode 2 parameters are selectable:

- Time of bounce suppression (AVERAGE AMPLITUDE submenu);
- Time constant (AMPLITUDE DETECTOR submenu).

4.8.5.1. Time of bounce suppression

In the AVERAGE AMPLITUDE mode (see section 4.8.3), time of bounce suppression T_b represents a time interval within which the EM 3.1KM ignores changes in signal polarity to suppress voltage fluctuations about zero (if present).

T_b can be selected within 0.02 to 100 ms range in 0.01 increments (Fig. 4.8.12).

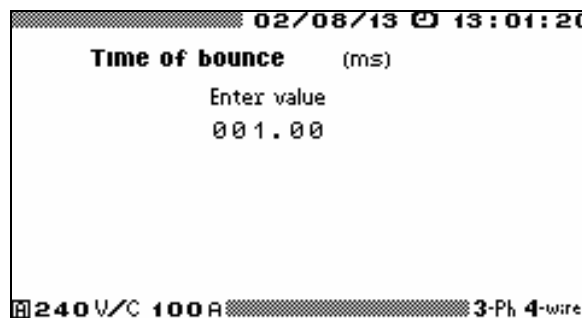


Fig. 4.8.12 “Time of bounce suppression”, AVERAGE AMPLITUDE

If no changes in signal polarity have occurred during 160 ms, or the signal has changed its polarity within T_b interval, and thus such changes have not been registered, the EM 3.1KM memorizes amplitude values measured on the unipolar part of signal curve.

4.8.5.2. Time constant

τ is the parameter that corresponds to a time constant of programmatically realized RC circuit (see section 4.8.2). Thus, by selecting the value of the time constant, you can achieve the balance between the rate of tracking of amplitude values and dynamic (discharge related) measurement error.

τ is selectable within the range of 0.02 to 100 in 0.01 increments (Fig. 4.8.13).

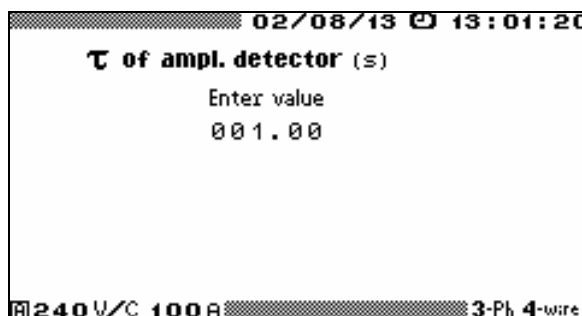


Fig. 4.8.13 “Time constant”, AMPLITUDE DETECTOR

4.9 Data Exchange with PC

4.9.1 The following ports are available:

- USB (recommended),
- RS-232.

The port is enabled by selecting its option in the DATA EXCHANGE with PC screen of the main menu. Selection is confirmed by pressing ENT.

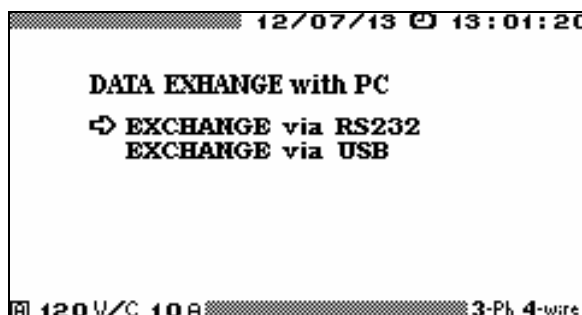


Fig. 4.9.1 DATA EXCHANGE screen

To connect the EM 3.1KM to a PC via USB, use the USB A-male / USB B-male cable from the delivery package.

To connect the EM 3.1KM to a PC via RS-232, use the RS-232 null modem cable from the delivery set. Do not forget to select the required data transfer rate (EXCHANGE SPEED option of the SETTINGS menu, see section 4.2.4 of this manual).

A software package that supports EM 3.1KM / PC data exchange / processing shall be previously installed on the PC.

4.10 Extra Settings

The number of options accessible from the EXTRA SETTINGS menu depends on the level of password typed-in at power up.

The first-level password gives access to:

- PASSWORD CHANGING
- LANGUAGE
- ABOUT
- RESTART

The second-level password expands the options up to:

- PASSWORD CHANGING
- LANGUAGE
- ABOUT
- RESTART
- CLOCK
- MEMORY

4.10.1 Password changing

The level of the password being changed corresponds to that entered at the latest power up. Enter a new one with number keys and press ENT. Confirm your password by typing it in again and press ENT.

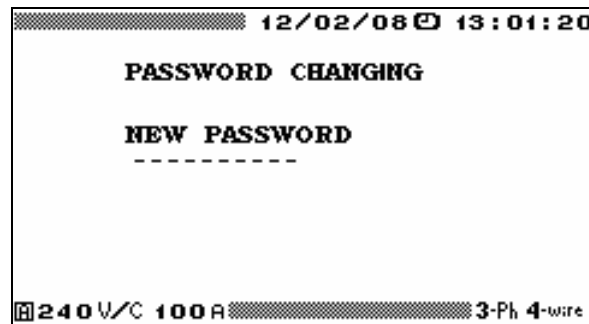


Fig. 4.10.1 Password entry screen

On accepting this change, the EM 3.1KM takes you back to the SETTINGS screen. Press ESC to return to the SETTINGS screen without saving changes.

4.10.2 Language

Selecting the LANGUAGE option brings up the screen pictured below. The arrow ↓, ↑ and ENT keys are used to select the language. “OK” appears next to the value selected

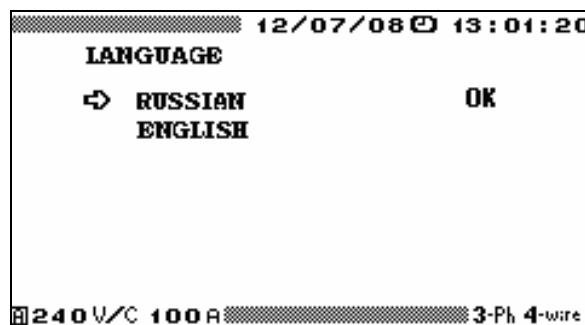


Fig. 4.10.2 Language

4.10.3 About

The option is used for product identification.

The display contains:

Identification code;

Firmware version (e.g. 2.01),

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

PROG CRC — Cyclic Redundancy Checksum for the firmware module;

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

4.10.4 Restart

The option is used to reset the EM 3.1KM firmware to the “soft off” state without removing power. This may be needed, for example, to quickly access the menu with the 2nd level password.

4.10.5 Clock setting

The menu can only be accessed with the 2nd level password. It consists of 2 options:

CLOCK SETTING — used to set new values for current date/time of the internal clock;

CLOCK CALIBRATION — used in calibration of the EM 3.1KM; in this mode, the screen displays current date and time up to seconds, while the EM 3.1KM generates pulses with 1 s repetition period on its frequency output F_{out} .

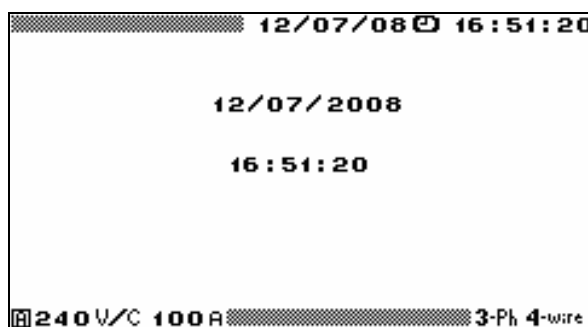


Fig. 4.10.3 CLOCK CALIBRATION screen

Press ESC to return to the CLOCK submenu.

4.10.6 Memory

The menu pictured in Fig. 4.10.4 can only be accessed with the 2nd level password.

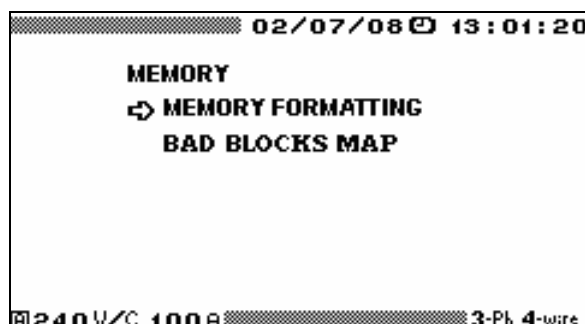


Fig. 4.10.4 MEMORY screen

The MEMORY FORMATTING option is used to delete logs from the internal memory. The function deletes logs of all types upon on-screen confirmation: press the decimal point (□) key to confirm deletion, or ESC to reject.

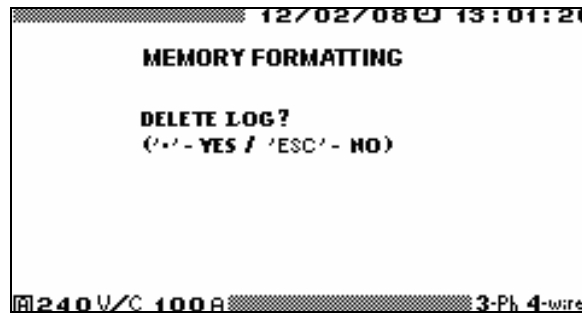


Fig. 4.10.5 MEMORY FORMATTING screen

When the operation is finished, the EM-3.1KM returns to the MEMORY submenu automatically.

The BAD BLOCKS MAP option is enabled to display addresses of bad blocks detected in the internal memory.

5 USER MAINTENANCE

5.1 Maintenance is the care and servicing that the user provides for keeping the equipment operational over its life cycle.

5.2 Every maintenance operation shall meet safety requirements described in this manual.

5.3 Routine maintenance includes self-testing, cleaning the display and keyboard with a damp cloth, cleaning the oxidized contacts and checking reliability of their fixing.

5.4 Troubleshooting

Fault	How to solve the problem
1 The EM 3.1KM is not turned on.	Replace the fuse.
2 No connection between the EM 3.1KM and PC	Check communication (data exchange rate and COM port) settings both in the EM3.1KM and PC.

6 STORAGE CONDITIONS

6.1. Storage conditions of the EM 3.1KM shall comply with National Standard GOST 15150-69.

6.2. The Device shall be stored in the manufacturer's package and in a heated storeroom.

Storage conditions in the manufacturer's package:

Ambient temperature 0 to 40 °C;
Relative humidity 80 % at 35 °C.

Storage conditions without the package:

Ambient temperature 10 to 35 °C;
Relative humidity 80 % at 25 °C.

6.3. The storeroom should be free from current-conductive dust, acid or alkali fumes and other aggressive substances.

7 TRANSPORTATION

The EM 3.1KM shall be transported packed in the manufacturer's box. The EM 3.1KM can be transported in any enclosed vehicle including air-tight heated plane cargo compartment.

Ambient conditions allowed during transportation:

Ambient temperature -50 to 50 °C;
Relative humidity 95 % at 25 °C.

8 MARKING AND SEALING

8.1 Marking of the device

8.1.1 Panels of the EM 3.1KM bear:

- Model name (Energomonitor 3.1KM);
- Manufacturer's trade mark;
- Protection rating IP20;
- Power supply type and nominal power supply voltage;
- Marking of input and output connectors.

8.1.2 The manufacturer's nameplate contains:

- Model name;
- Serial number;
- Date of manufacture (month and year).

8.2 Marking of the transportation box

8.2.1 Side and face walls of the transportation box bear handling symbols "Fragile", "Keep dry" and "Top".

8.3 Sealing

8.3.1 The seal is installed:

- For stationary and desktop modifications — in the hole of a fastening screw on the rear panel;
- For portable modifications — in the hole of a fastening screw on the front panel.

8.3.2 After opening the Device for repair, the seal should be reinstalled by authorized Service Companies only.

9 WARRANTY

9.1. All products of MARS-ENERGO are warranted against defects in manufacture or material **for a period of 2 (two) years** from the date of purchase from MARS-ENERGO. Warranty period for the batteries is 6 (six) months from the date of purchase from MARS-ENERGO. Equipment believed to be defective may be sent within the warranty period to MARS-ENERGO for inspection (Warranty Claim enclosed, transportation prepaid). If the inspection by MARS-ENERGO confirms that the product is defective, it will be repaired or replaced (at MARS-ENERGO option) at no charge, within the underlisted limitations (paragraph 9.3), and returned prepaid to the location specified in the buyer's Warranty Claim. All replaced parts become the property of MARS-ENERGO.

Conditions

9.2 In the event of any Device's failure or defect in manufacture or material during the warranty period (provided that the transportation, storage and operating conditions outlined in this Manual are fulfilled), send the Device to MARS-ENERGO along with the sales invoice or other proof of Device's ownership and date of purchase. If the documents outlined in the previous section are absent, the warranty period is calculated from the date of Device manufacture.

MARS-ENERGO retains the right to reject a warranty claim, if the documents listed in the previous section are filled out incompletely, incorrectly or illegibly. This warranty will not be applicable for the Devices whose serial number has been altered, removed or made illegible.

This warranty will not be applicable for damages to your Device caused during shipment to and from MARS-ENERGO location.

This warranty will not be applicable:

- 1) For parts requiring regular maintenance or replacement due to natural wear;
- 2) For consumable parts (parts, the nature of which is to become worn or depleted with use, such as batteries);
- 3) For damages to the Device caused by:
 - a) Any use other than correct use described in the User manual including:
 - Handling the Device resulting in mechanical damages, cosmetic defects, Device modification, or damages to the LCD;
 - Damages caused by incorrect installation;
 - Damages caused by any maintenance other than correct maintenance described in the User manual;
 - Damages caused by installation and use inconsistent with the technical and safety standards in force in the country where the Device has been installed and used;
 - b) Damages caused by computer virus infection or by use of software not supplied by MARS-ENERGO, or damages caused by incorrect software installation;
 - c) Damages caused by condition or defects of a system or its elements with which or as part of which the Device was used, excluding the other MARS-ENERGO products intended for use with the Device;
 - d) Damages caused by accessories or ancillary equipment not made or authorized by MARS-ENERGO with respect to their type, condition or characteristics;
 - e) Damages caused by repairs or attempts to repair the Device executed by an unauthorized person or company;
 - f) Damages caused by adjustments or modifications made to the Device without prior written consent of MARS-ENERGO;
 - g) Damages caused by negligent handling;
 - h) Damages caused by accidents, fire, ingress of liquids, chemicals or other materials, flood, vibration, heat, improper ventilation, variations of supply voltage, improper power supply or input voltage, electrostatic discharge including lightning, or any other impacts or external actions beyond the reasonable control of MARS-ENERGO and not covered by the technical documentation for the Device.

The present warranty only covers hardware failures. This warranty does not cover failures of software (produced either by MARS-ENERGO or by other manufacturers), which are the subject of express or implied end user license agreements, separate warranties, or exclusions.

9.3 MARS-ENERGO establishes the lifetime for the products outlined above (excluding the batteries) of 4 (four) years from the date of purchase from MARS-ENERGO. Lifetime period for the batteries is 2 (two) years from the date of purchase from MARS-ENERGO. *Please note that warranty period and lifetime differ from each other.*

9.4 It is highly recommended to make a backup copy of the data from the Device's internal memory and store it on another (external) media. MARS-ENERGO shall in no circumstances be liable for any direct or indirect damages or losses, whether incidental, consequential or otherwise, including but not limited to loss of profits, loss of use or any deletion, corruption, destruction or removal of data, disclosure of confidential information or infringement of privacy, data recovery expenses, losses arising out of interruption of commercial, production or other activities based on use or loss of use of the Device.

Manufacturer's address (for warranty claims):

Mars-Energo

V.O. 13 Line, 6 - 8, office 41H, St. Petersburg, Russia. A
Tel/Fax: (812) 327-21-11, (812) 331-87-35 (812) 334-72-41
E-mail: mail@mars-energo.ru
www.mars-energo.com

Manufacturer's address (Production and Service departments):

V.O. Kozhevennaja Line, 29-5, Saint-Petersburg, Russia, 199106
Tel/Fax: (812) 309-02-06
E-mail: service@mars-energo.ru

10. PACKING FORM

Multifunctional reference standard Energomonitor-3.1KM _____
N_____

The aforesaid equipment has been packed by MARS-ENERGO in compliance with the Technical Requirements in force.

Packer signature: _____ (*Initials and Name*)

Date: _____

11. ACCEPTANCE FORM

Multifunctional reference standard Energomonitor-3.1KM _____
N_____

The aforesaid equipment has been manufactured in compliance with Technical Specifications TS 4381-026-49976497-2012 and conforms to the Technical Requirements in force.

Head of Quality Control Department: _____ (*Initials and Name*)

Corporate Seal:

Date: _____

Date of sale: _____

(*Corporate Seal*) _____ (*Initials and Name*)

12. WARRANTY CLAIM

In the event of any Device's failure or defect in manufacture or material during the warranty period (provided that the transportation, storage and operating conditions outlined in this Manual are fulfilled), send the Device to MARS-ENERGO along with the Warranty Claim containing the following information:

- 1) Device's Model and Serial number;
- 2) Date of manufacture;
- 3) Date of putting the Device into operation;
- 4) Condition of the manufacturer's seals (in place, destroyed, absent). See section 8 for the location of the seals.
- 5) Description of the failure or defect;
- 6) Buyer details (Company name, address, etc., including name and phone number of whom the reply may concern).

Find the Device's Serial number and Date of manufacture on the nameplate located on the lower panel.

13. CALIBRATION

Energomonitor 3.1KM N _____

Calibration procedures shall be carried out in compliance with the calibration methods established by D.I. Mendeleev Institute for Metrology (VNIIM, Saint-Petersburg, Russia). The Device undergoes primary post-manufacture calibration, and then it is calibrated after each repair. Regular calibration is performed during operation. A period of two calendar years is considered maximum time between calibrations.

Date of Calibration	Type of Calibration	Calibration Results	Calibrator's Signature, Initials and Name