

## **USER GUIDE**

Applying reference standards Energomonitor 3.3T1 or Energomonitor 3.1KM for on-site testing of energy meters installed on a power line above 1 kV without disconnection of the meters from their current and voltage measurement circuits

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## INTRODUCTION

This User Guide describes the procedure of applying reference standards Energomonitor 3.3T1 or Energomonitor 3.1KM (the EM below) for on-site testing of energy meters installed on a power line with nominal voltage above 1 kV without disconnection of the meters from measured circuits. The power measured by the energy meters ranges from  $0.01 I_N \cdot U_N$  to  $1.5I_N \cdot 1.2U_N$ , where  $I_N$  is the nominal (rated) current, and  $U_N$  is the nominal (rated) voltage of the meter.

This User Guide covers testing of meters that measure active or reactive energy in single-phase or three-phase circuits provided that the current flowing through the circuit is no less than 20% of the rated current of the meter.

The test procedure makes it possible to:

- Verify that connection of the meter to the measured circuits was made correctly
- Check that the parameters of instrument current transformers, if a whole unit consisting of a meter together with a CT or CTs (the [Meter + CT] below) is tested, were specified correctly
- Check that software settings were specified correctly
- Determine the meter-under-test error (related to the reference value) in measuring an actual value of electrical power.

The possibility to measure electrical power without disconnection of meters from measured circuits is provided by the contactless current sensors (clamp-on CTs) included in the scope of supply of the reference standard (EM3.1KM or EM3.3T1C).

The test procedure covers testing of a single / three-phase energy meter together with a CT / CTs or a single / three-phase energy meter only (the tested unit below).

An example of the [meter + CT] unit is shown in Fig. 1.

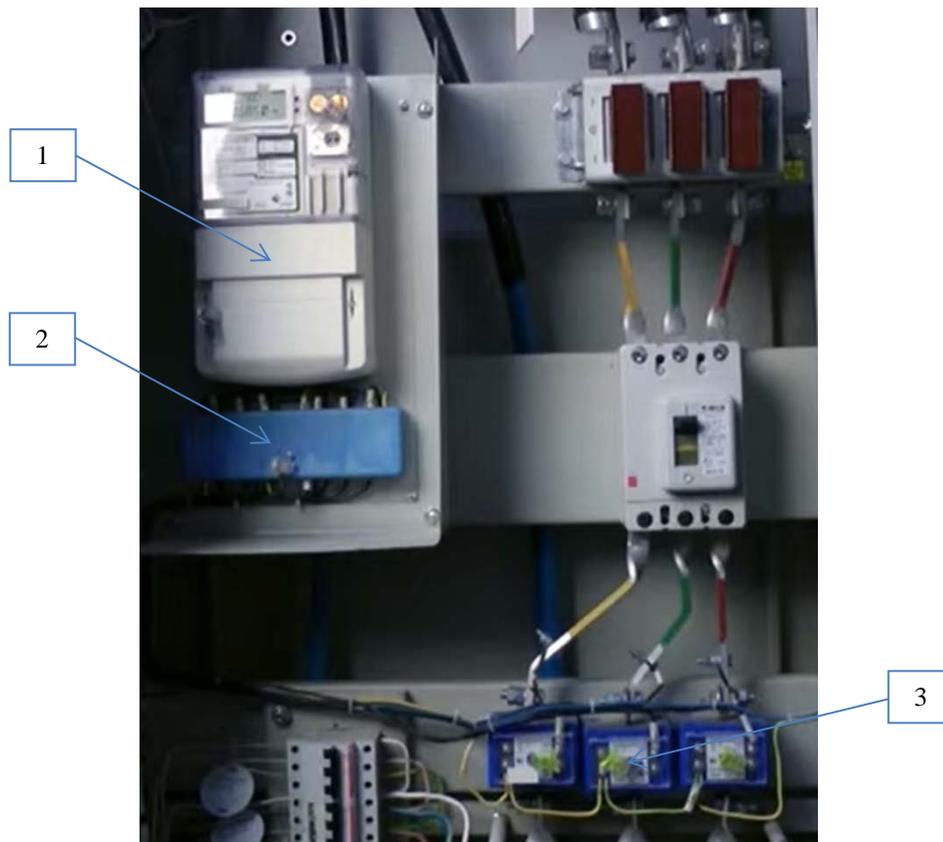


Fig. 1 (Meter +CT) unit

1. Energy meter (type A1805, rated input current 5 A, rated phase voltage 220 V, meter constant = 5000 imp per kW·h)
2. Sealed terminal block
3. Set of CTs (rated primary current 150 A)

## 1. PREPARING FOR TESTING

1.1 Before testing the [meter] or [meter +CT] unit, it is necessary to:

1.1.1 Enter the information on the [meter] or [meter + CT] unit in the test report (given in Appendix A)

1.1.2 Enter the results of visual inspection and test conditions in the test report

1.1.3 Prepare the EM for work in accordance with its User Manual (the preparation is briefly described below).

The EM (the Energomonitor 3.3T1 is taken as an example) together with the corresponding test kit is shown in Fig. 2.



Fig. 2 Reference Standard Energomonitor 3.3T1 with its meter test kit

The meter test kit includes voltage test leads, current clamps (clamp-on CTs) rated at various currents, a scanning head (mounted on the holder) for detecting optical pulses from the meter, and a pulse former for transmitting electrical pulses from the meter.

Step 1: Connect the voltage test leads to the voltage measurement inputs of the EM3.3T1 in accordance with their wiring colour codes for phases A (L1), B(L2), C(L3), and N (neutral).

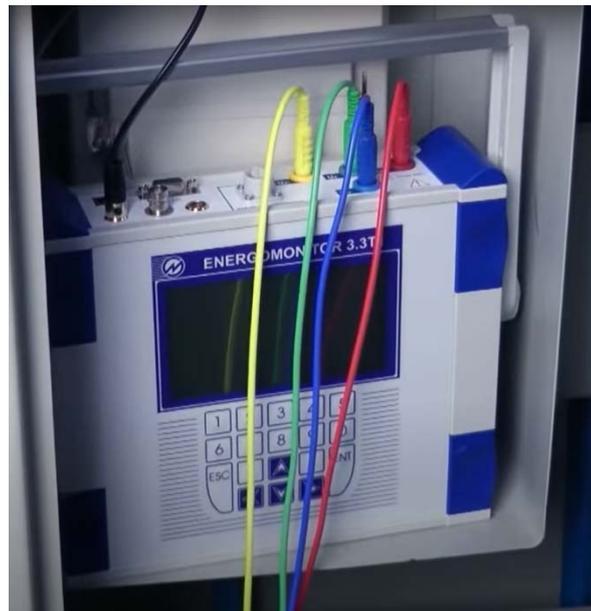


Fig. 3 Connecting voltage test leads to the EM

Step 2: Connect the output of the current clamps to the current measurement input of the EM3.3T1. The current clamps should be rated for a current no less than the rated primary current of the CTs included in the [meter +CT] unit. The principles of selecting current clamps are described in detail below (see section 1.1.4).



Fig. 4 Connecting output of current clamps to the EM

**Step 3:** To test a meter with optical pulse (LED) output, connect the output of the Scanning Head SH-E to the pulse input “Fin” of the EM.

To test a meter with electrical pulse output, connect the pulse (TM) output of the tested meter to the pulse input “Fin” of the EM via the Pulse Former (PF) included in the scope of supply.

**Step 4:** Turn on the EM.

**Step 5:** Select the type of meter connection on the display of the UM.

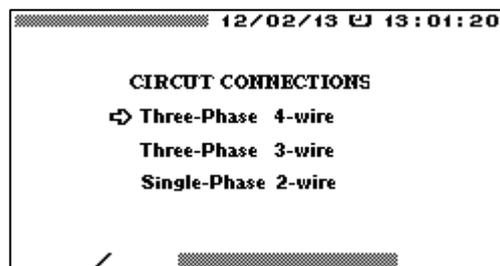


Fig. 5 “Circuit connections” screen

For our example we have selected the 3-phase 4-wire connection.

**Step 6:** By pressing the “F” key bring up the screen for selecting current measuring ranges. Set the current measuring range in the EM3.3T1 to the value that corresponds to the rated current of the current clamps.

#### 1.1.4 Connect the tested unit to the EM

**Step 1:** To measure current, position the current clamps around the primary wires of the CTs of the [meter +CT] unit, or around the input current wires of the [meter].

The current clamps are positioned in accordance with the “Source → Load” arrow embossed on the clamps (the pointer shows in which way the power is transmitted) and in accordance with the marking of phases (A (L1), B (L2), and C (L3)).



Fig. 6 Current clamps clamped around the primary wires of the CTs

The rating of current clamps is selected in accordance with the reasons described below:

*For the [meter + CT] unit:* Use the current clamps rated at a current which is equal to the rated primary current of the CT used with the tested meter. Clamp them around the primary wires of the CTs.

*For the [meter] only (or for the [meter +CT] if the primary circuit of the CT is at a voltage of above 0.6 kV):* Use the current clamps with the rated (nominal) current  $I_N=10$  A (which are clamped around the secondary wires of the CTs or around the wires connected to the current inputs of the tested meter).

**WARNING!** You must not connect current clamps to the current carrying circuits which are at any voltage above 600 V.

**Step 2:** To measure voltage, connect the crocodile clips on the ends of the voltage test leads to:

- The corresponding phases on the primary side of the CTs when testing the [meter +CT] unit
- The voltage inputs of the tested meter when testing the [meter] without CTs.

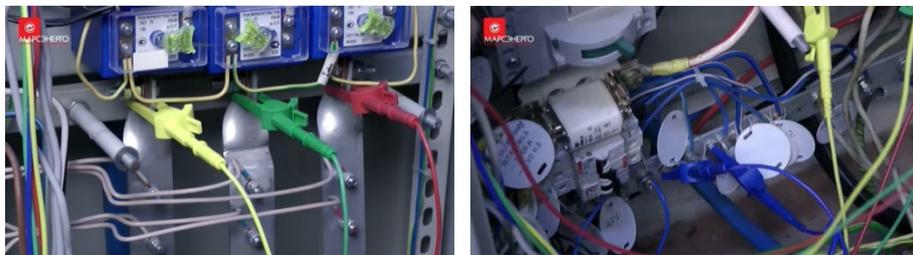


Fig. 7 Crocodile clips connected to the phase inputs on the primary side of the CTs and to the neutral terminal

## 2. CHECKING THAT TESTED UNIT IS CONNECTED CORRECTLY

### 2.1 Analysing phase angles

From the menu of the EM select the “Measurement” → “Phase angles” option and analyse the measurement results.

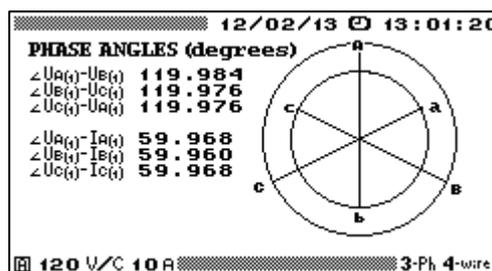


Fig. 8 “Phase angles” screen

The tested unit is correctly connected to the measured circuit if:

- Phase rotation is correct (ABC)
- Phase shifts between phase voltages are close to  $120^\circ$
- Phase shifts between voltage and current in the same phase are within ( $+90^\circ$  to  $-90^\circ$ )

range.

Make a proper record in the test report.

## 2.2 Analysing power

From the menu of the EM select the “Measurement” → “Power” option and analyse the measured values on the “Active power” screen.

| 12/02/07 13:01:20 |         |             |         |
|-------------------|---------|-------------|---------|
| ACTIVE POWER      |         |             |         |
|                   | A       | B           | C       |
| P (W)             | 144.480 | 288.870     | 288.900 |
| Pz (W)            | 722.270 |             |         |
| RMS U(V)          | 57.7747 | 57.7669     | 57.7554 |
| I (A)             | 5.00238 | 5.00083     | 5.00271 |
| PF                | 0.49L   | 0.99L       | 0.99L   |
| 220 V/10 A        |         | 3-Ph 4-wire |         |

Fig. 9 “Active power” screen

The tested unit is correctly connected to the measured circuit if:

- The sign of measured active power values in all 3 phases is the same: “+” if the power is transmitted in a forward direction (power consumption), and “-” if the power is transmitted in opposite direction (power generation).

- The measured values of current in any phase lie within a range of 10% to 150% of the rating of the current clamps. For example, if the current clamps in use are rated at 10A, this range equals 1A to 15A.

Record the values of each phase active power, voltage and current to the test report.

## 3. PREPARING FOR ACCURACY TESTING

3.1 Mount a holder with a scanning head onto the tested meter or connect the frequency (TM) output of the meter with the frequency input Fin of the EM via the pulse former PF.



Fig. 10 Connecting tested meter to the EM via PF

When connecting the tested meter to the EM via the pulse former PF, the red wire of the PF is connected to the “plus” terminal, and the black one – to the “minus“ terminal of the meter.

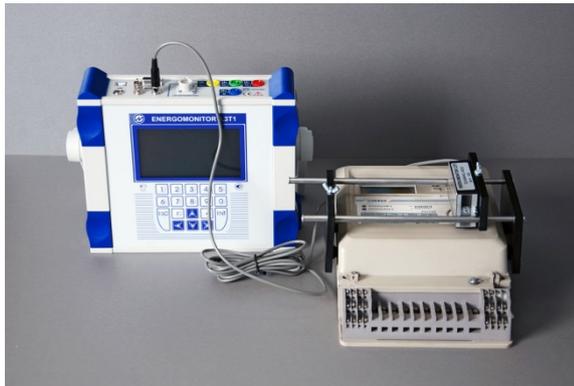


Fig. 11 Scanning head SH-E mounted onto the meter  
and connected to the frequency input of the EM

3.2 As soon as the SH-E is installed, by rotating the knob on the scanning head, adjust its LED so that it flashes in time with the pulse-generating LED of the meter.

3.3 Select the “Calibration of meters” option from the menu of the UM.

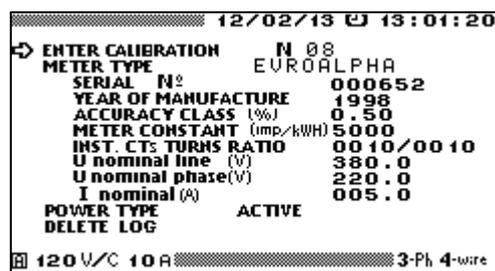


Fig. 12 “Calibration of meters” screen

Specify the parameters of the meter or the parameters of the [meter + CT] unit by typing symbols on screen or from a PC running the corresponding program of the Energomonitoring family. The parameters to be entered are as follows:

- Type, serial number, and year of manufacture of the tested meter (to be present in the test report)
- Accuracy class of the meter
- Meter constant
- Turns ratio of the instrument current transformers as part of the [meter + CT] unit, which is entered as a primary (e.g., 150 A) to secondary (e.g., 5 A) current ratio (150/5). If the meter is tested without CTs, the turns ratio must equal 1 (e.g. 10/10).
- Rated voltage and current of the meter (to be present in the test report)
- Type of the power measured by the meter (active or reactive).

3.4 Open the meter error calculation screen by selecting the upper option (“Enter calibration No...”). First of all, you will see the screen shown below:

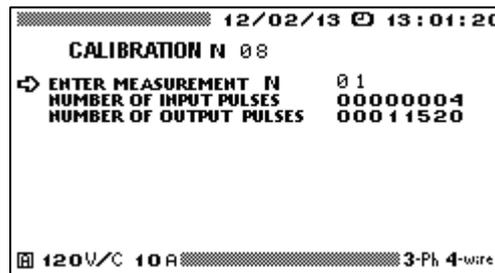


Fig. 13 “Number of pulses” screen

The pulse count fields have the following meaning:

- "Number of input pulses" shows how many pulses (coming from the tested meter and reflecting common energy flow) the EM shall accept on its pulse input Fin to be able to calculate a reliable value of meter-under-test error
- "Number of output pulses" is the number of pulses to be generated by the EM on its pulse output Fout and proportional to the amount of energy to be measured by the EM during calculation of meter error.

The number of input pulses (pulses from the meter under test) displayed in the window is calculated by the EM on the basis of the instrument constant of the EM, accuracy class of the meter under test, instrument constant of the meter and CTs turns ratio (if applicable).

To improve the accuracy of meter error calculation, you can increase the number of input pulses (pulses from the meter) by entering a new value in the corresponding field. However, the number of input pulses should not be decreased.

3.5 Select the option “Enter measurement No...” to open the screen for controlling meter error calculation.

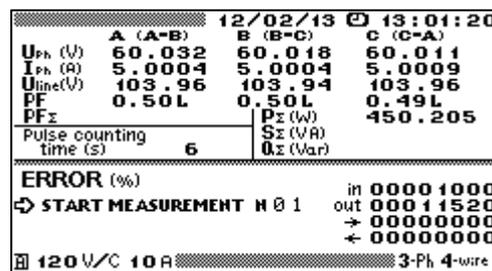


Fig. 14 “Meter error calculation” screen

Here we can see actual values of current, voltage, power factor, power of the type measured by the reference and tested devices, and the calculated time over which the meter error will be calculated (“pulse counting time”). If you increase the number of input pulses in the previous window, the pulse counting time will be increased accordingly.

**NOTE! Before you start measurements, make sure that the actual values of phase currents (as shown in Fig. 14) are within the range of 20...120% of the rated current, and the values of power factor (PF) are no less than 0.5.**

#### 4. PERFORMING MEASUREMENTS

4.1 Activate the option “Start measurement No...”. At this point, the accumulation of pulses for error calculation will start. On finishing the process, the calculated error of the tested unit  $\delta_{\bar{n}i}$  (resulted from the  $i^{\text{th}}$  measurement) will be displayed in the ERROR (%) field. At the same time, the EM starts a new error calculation cycle. You can stop it (if necessary) by clicking on “Stop measurement” and record the error value in the test report.

4.2 Repeat the measurements at least 7 times. Record the results in the test report.

5.1. Determine the arithmetic mean over recorded 5 values of meter error  $\delta_{\bar{n}i}$  (excluding the maximum and minimum values) according to the formula:

$$\bar{\delta}_{\bar{n}} = \frac{1}{n} \sum_{i=1}^n \delta_{\bar{n}i}, \text{ where}$$

$\delta_{\bar{n}i}$  is the error of the tested unit resulted from the  $i^{\text{th}}$  measurement.

Record the arithmetic mean value in the test report.

5.2. Determine the standard deviation of the test results  $S_{\delta}$  according to the formula:

$$S_{\delta} = \sqrt{\frac{1}{(n-1)} \cdot \sum_{i=1}^n (\delta_{\bar{n}i} - \bar{\delta}_{\bar{n}})^2}$$

If the value of the standard deviation  $S_{\delta}$  does not exceed 0.5%, the test result  $\bar{\delta}_{\bar{n}}$  is considered credible. If not, the measurements described in section 4 should be repeated.

5.3 Test results may be recorded according to a template given in Appendix A.

**Appendix A**  
(recommended)

**Test report No \_\_\_\_\_**

dated \_\_\_\_\_ (on \_\_\_\_\_ pages)

Representatives of the customer \_\_\_\_\_  
\_\_\_\_\_

**1 Purpose:**

Determining relative measurement error of the tested unit consisting of a 3-phase electrical energy meter and instrument current transformers connected to a circuit rated at 0.4 kV without disconnecting the measurement unit from the circuit.

**2 Identification information on the metering point**

Location (address): \_\_\_\_\_

Place (Metering point): \_\_\_\_\_

Power supply centre: \_\_\_\_\_

**Information on the components of the measurement unit**

| Name                       | Electrical energy meter | CT - A | CT- B | CT - C |
|----------------------------|-------------------------|--------|-------|--------|
| Type                       |                         |        |       |        |
| Serial No                  |                         |        |       |        |
| Year of manufacture        |                         |        |       |        |
| Verification date          |                         |        |       |        |
| Accuracy class             |                         |        |       |        |
| Rated voltage, V           |                         | -      | -     | -      |
| Rated primary current, A   | -                       |        |       |        |
| Rated secondary current, A |                         |        |       |        |
| Maximum current, A         |                         | -      | -     | -      |

|                                   |  |   |   |   |
|-----------------------------------|--|---|---|---|
| Type of measured energy<br>(P, Q) |  | - | - | - |
|-----------------------------------|--|---|---|---|

### 3 Time of testing

From \_\_\_ h \_\_\_ min "\_\_\_" \_\_\_\_\_ 20\_\_\_ till \_\_\_ h \_\_\_ min "\_\_\_" \_\_\_\_\_ 20\_\_\_

### 4 List of reference instruments

| Name               | Type                | Serial No, year of manufacture | Calibration Certificate number and date |
|--------------------|---------------------|--------------------------------|---|
| Reference standard | Energomonitor 3.3T1 |                                |   |
|                    |                     |                                |   |

### 5 Test conditions

Ambient temperature \_\_\_\_\_ °C

## 6 Measurement and calculation results

#### 6.1 Visual inspection

##### 6.1.1 State of the meter:

Enclosure \_\_\_\_\_

Presence of seals \_\_\_\_\_

##### 6.1.2 State of CTs:

Enclosure \_\_\_\_\_

Presence of seals \_\_\_\_\_

#### 6.2 Checking that the tested unit is connected correctly

| Phase rotation | Phase A |       |             | Phase B |       |             | Phase C |       |             |
|----------------|---------|-------|-------------|---------|-------|-------------|---------|-------|-------------|
|                | U (V)   | I (A) | Angle (U^I) | U (V)   | I (A) | Angle (U^I) | U (V)   | I (A) | Angle (U^I) |
| Direct         |         |       |             |         |       |             |         |       |             |

#### 6.3 Determining measurement error of the tested unit

Meter constant: \_\_\_\_\_ pulses/kW•h

CT turns ratio ( $I_{pr}/I_{sec}$ ): \_\_\_\_\_/\_\_\_\_\_ (if applicable)

Power type: active/reactive

Readings of the EM-3.3T1:

| Number of the measurement (i) | Measurement ERROR readings of the EM: $\delta_{ni}$ – relative error of the tested unit in measuring electrical power (energy), % | Measurement ERROR values taken for calculation of the arithmetic mean (at least 5 values), %<br>See section 5 of this User Guide |
|-------------------------------|---|--|
| 1                             |   |  |
| 2                             |   |  |
| 3                             |   |  |
| 4                             |   |  |
| 5                             |   |  |
| 6                             |   |  |
| 7                             |   |  |
|                               |   |  |

Number of measurements n= \_\_\_\_\_

### 7. Calculation results

$$\bar{\delta}_n = \frac{1}{n} \sum_{i=1}^n \delta_{ni} = \text{_____} \% \text{ (arithmetic mean)}$$

Standard deviation:

$$S_\delta = \sqrt{\frac{1}{(n-1)} \cdot \sum_{i=1}^n (\delta_{ni} - \bar{\delta}_n)^2} = \text{_____} \%$$

The value of standard deviation  $S_\delta$  meets (does not meet) the requirements stated in section 5 of this User Guide.

### 8. Conclusion

The value of the measurement error of the tested unit  $\bar{\delta}_n$  meets (does not meet) the requirements of

\_\_\_\_\_.

Testing performed by \_\_\_\_\_

Representatives of the customer \_\_\_\_\_