Test systems for accuracy testing and calibration of low-power instrument transformers (LPITs) and LPIT-compatible electronic energy meters

The current trend for renewal of conventional energy metering equipment such as instrument transformers (scaling current and voltage converters) and energy meters results from the rapid development and global adoption of advanced digital technologies in energy sector. In this context, the corresponding aggregate of reference standards and procedures used for testing and metrological confirmation of such equipment also needs to be revised.

The test sets represented below will make it possible (along with other solutions) to provide the manufacturers of digital metering equipment of working class with the appropriate means for their servicing and full metrological support.

As regards electronic instrument transformers (low-power transformers or LPITs), their design and operation are regulated by IEC 60044-7 and IEC 60044-8.

The electronic transformers in their turn may have either analogue or digital output specified by IEC 61869-6, IEC 61869-10, IEC 61869-11, and IEC 61869-12 (specifies the requirements for electronic transformers with analogue output).

In spite of the fact that attention is mainly focused on the digital instrument transformers, it should be particularly emphasized that the analogue low-power transformers (LPITs, see Fig. 1) demonstrate a number of remarkable benefits and therefore are deemed to have a considerable application potential on the energy market. However there is one factor that essentially limits the implementation of LPITs and LPIT-compatible electronic meters with analogue input (Fig. 2). This is an almost complete lack of adequate test/calibration equipment which would be both easy-to-use and cost-effective.

The verification/calibration of LPITs and compatible electronic meters cannot be performed directly with use of conventional reference equipment, since the operating range of such meters and transformers is 0.1mV…10V, whereas the typical ranges for conventional transformers and meters are 1 A, 5 A, 100 V, and 220 V.

Fig. 1	Samples of complex (voltage/current) LPITs under test

Fig. 2	Samples of electronic meters with analogue input compatible with LPITs

That is why we have started a project on the design of the reference equipment with the operating ranges corresponding to the ranges of LPITs and compatible electronic meters (including the design of associated test/calibration procedures).

The specific objective of the project was to include the components of classical calibration systems applied to testing of conventional transformers and meters in the test set under development wherever possible, considering that such components present in great numbers in test/calibration labs. First of all this is related to reference transformers, test current and voltage sources and reference meters.

By now the required set of calibration equipment was successfully designed. Although intended for accuracy testing/calibration of a measuring channel consisting of electronic low-power instrument transformers and compatible energy meters, it includes the components of classical test systems to the maximum extent.

Principal diagrams of the test sets and the corresponding test procedures are briefly described below.

System for calibration of current LPITs

The test set is intended for accuracy testing/calibration of electronic low-power current instrument transformers up to 5 kA specified by IEC 60044-8 in laboratory conditions (Fig. 3).

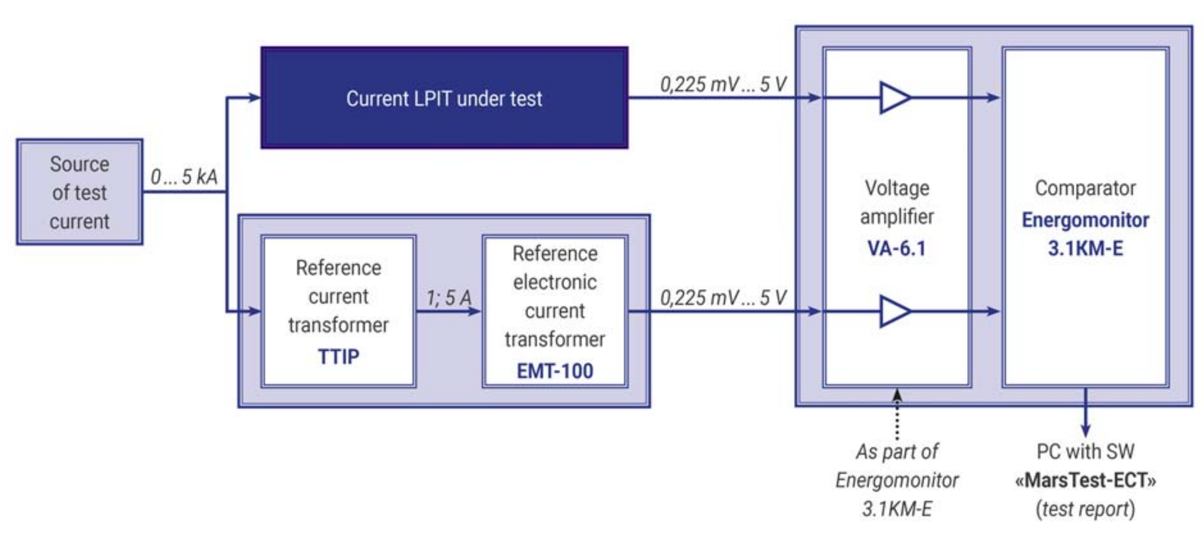

Fig. 3 Accuracy testing/calibration of current LPITs – Principal diagram

System for calibration of voltage LPITs

The test set is intended for accuracy testing/calibration of electronic low-power voltage instrument transformers 6 to 330 kV specified by IEC 60044-7 in laboratory conditions (Fig. 4).

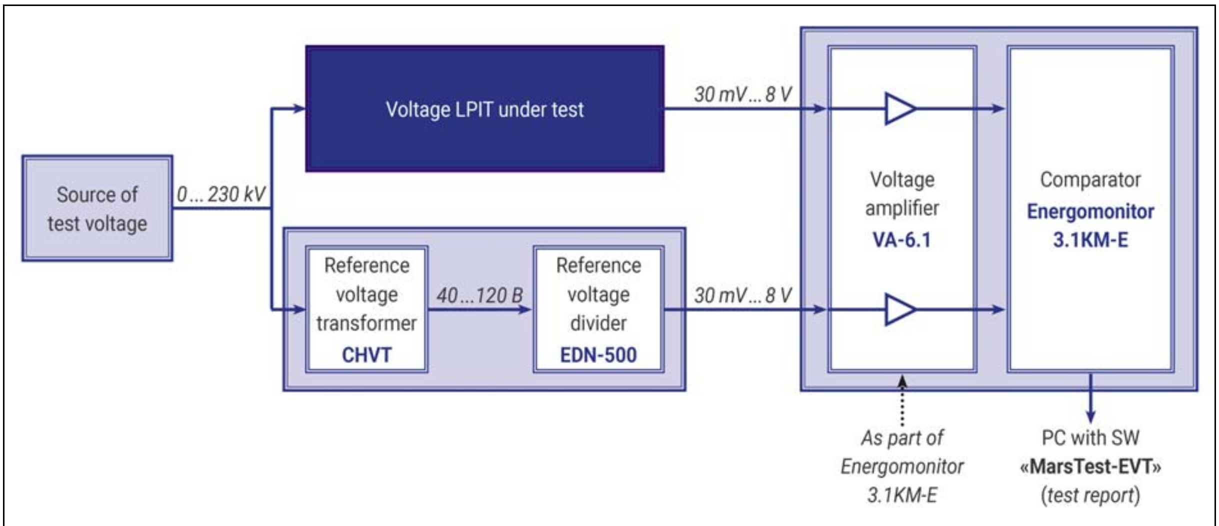

Fig. 4 Accuracy testing/calibration of voltage LPITs – Principal diagram

As shown in the diagrams above, in distinction to the classical schemes, these test schemes contain just two non-conventional modules: the reference electronic transformer EMT-100 and the reference voltage divider EDN-500. The test method implies comparison of two signals coming from the reference transformer and from the transformer under test. The ratio and phase errors of the transformer under test are determined on the basis of comparison results.

The electronic transformer is needed to convert the current coming from a conventional reference CT (rated at 1A and 5A) into an output voltage ranging from 1 mV to 10 V (acceptable for current LPITs). As regards the electronic voltage divider, it reduces the high voltage across the output of a conventional VT to an acceptable level of voltage LPITs.

The test sets have advantages as well as disadvantages. The equipment is suitable for laboratory conditions but absolutely unsuitable for field measurements in view of a large number of modules.

Thus to carry out accuracy testing/calibration of transformers in the field, the reference comparator MarsComp K-1000 was designed (Fig. 5).

Fig. 5 Reference Comparator MarsComp K-1000

This multifunctional instrument features a number of benefits:

- One and the same instrument performs 2 functions: it can be used to test/calibrate either current or voltage transformers
- As reference transformers, conventional CTs (1A, 5A) and conventional VTs (100 V, 100/√3 V) may be used.

This multifunctional instrument combines the following components: an electronic current transformer, electronic voltage dividers (based on programmable measuring amplifiers) and an analogue-to-digital comparator (Fig. 6).

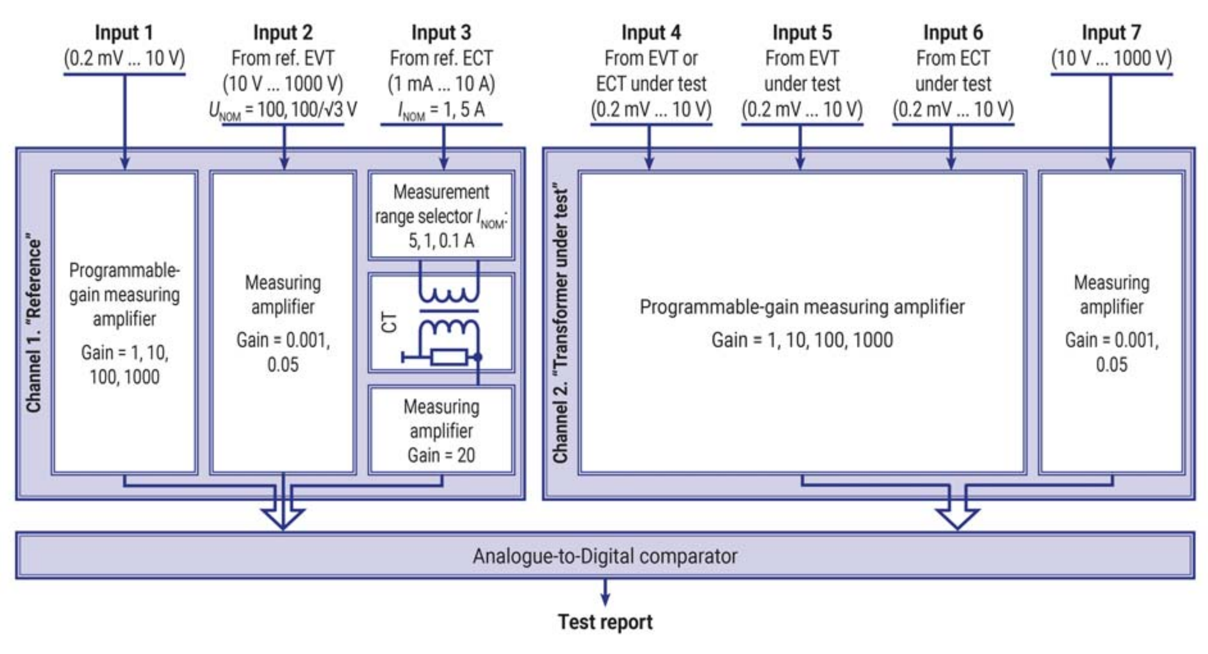

Fig. 6 MarsComp K-1000 – Block diagram

Sphere of application:

1. Accuracy testing and calibration (evaluation of ratio and phase errors) of the following instruments:

- Low-power voltage sensors (voltage LPITs) with AC voltage output ranging from 20 mV to 8 V specified by IEC 60044-7
- Low-power current sensors (current LPITs) with AC voltage output ranging from 20 mV to 8 V specified by IEC 60044-8
- Conventional voltage instrument transformers
- Voltage dividers, scaling measuring voltage devices.

2. Testing of frequency response and amplitude/frequency response performance of instrument voltage transformers by the method of injecting harmonics of order from 0.3 to 50 (from 15 to 2500 Hz) within a secondary voltage range from 0.08 to 840 V as well as by applying signals of various waveforms.

The test scheme is shown in Fig. 7.

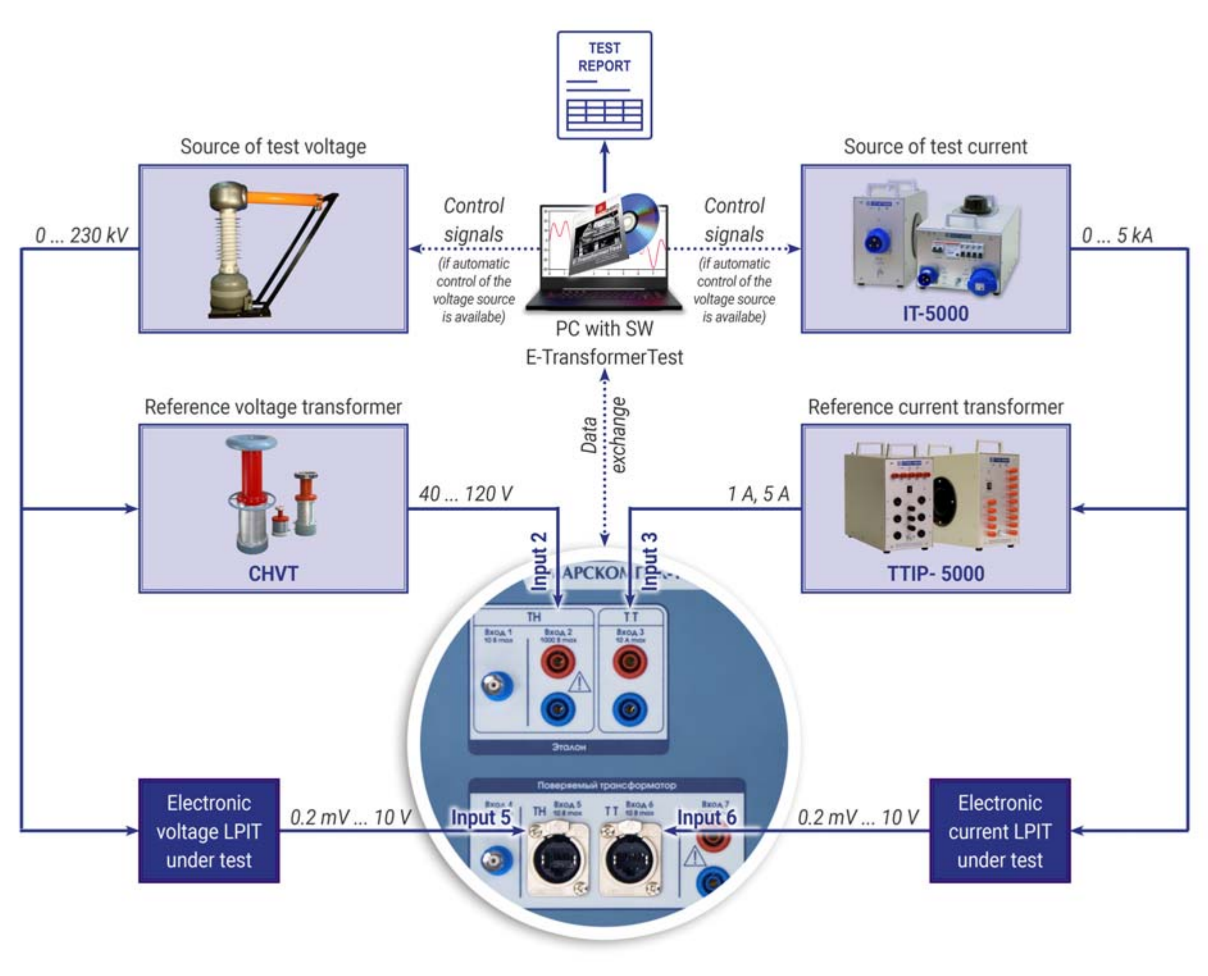

Fig. 7 Test scheme

As shown in the figure above, the test scheme includes test signal sources as well as current and voltage reference transformers.

Test procedures can be carried out automatically (controlled by the E-TransformerTest software) provided that the current and voltage signal sources have a function of automatic control.

The automatic control function is added to the existing current and voltage signal sources within the framework of designing the MarsComp K-1000: a prototype of the automated current source IT5000A (Fig. 8) has been developed, manufactured and presented to potential customers.

The IT5000A is a source of test current designed to work with a test system intended for testing /calibration of conventional transformers and LPITs compliant to IEC 60044-8 and IEC 60044-1. Among the options there is one with a built-in current sensor for measuring output currents within 50…6000 A in power networks rated at 50 or 60 Hz. The values of test current are set automatically under the control of the E-TransformerTest software (Fig. 9).

Fig. 8	IT5000A

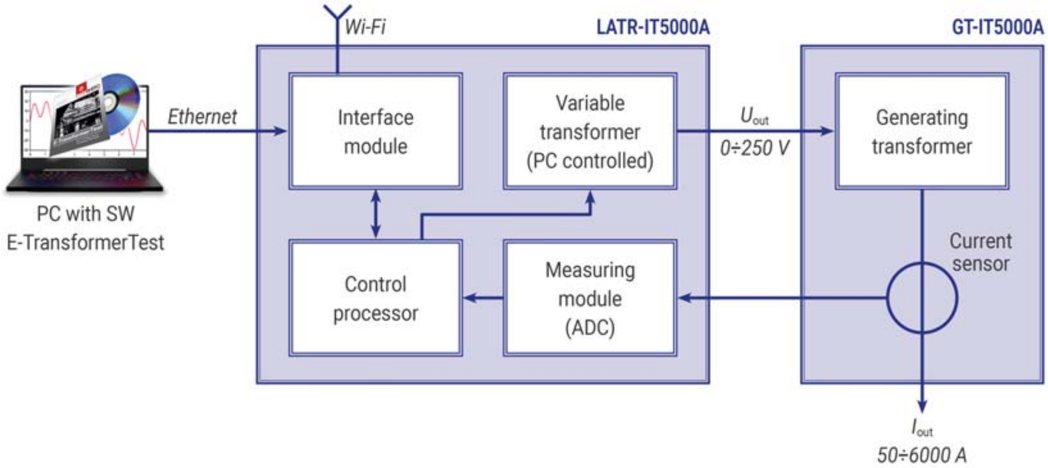

Fig. 9	IT5000A – Block diagram

The procedure for testing LPITs is easier than the one for conventional transformers, since in the first case there is no need to connect a burden set and to change burden values in the course of testing. This reduces the time of testing and simplifies the automatic control.

Considering the importance of accuracy testing of electronic transformers, it is reasonable to pay the same attention to testing LPIT-compatible electronic meters. The manufacturers of electronic transformers often complain that such meters are produced in small quantities (no more than 1% of the total number of currently produced conventional meters). As a result, application of LPITs in the sphere of energy metering is limited. The test system for accuracy testing/calibration of electronic (LPIT-compatible) meters MTS-ME 3.1KM-E is designed to solve the problem (Fig. 10).

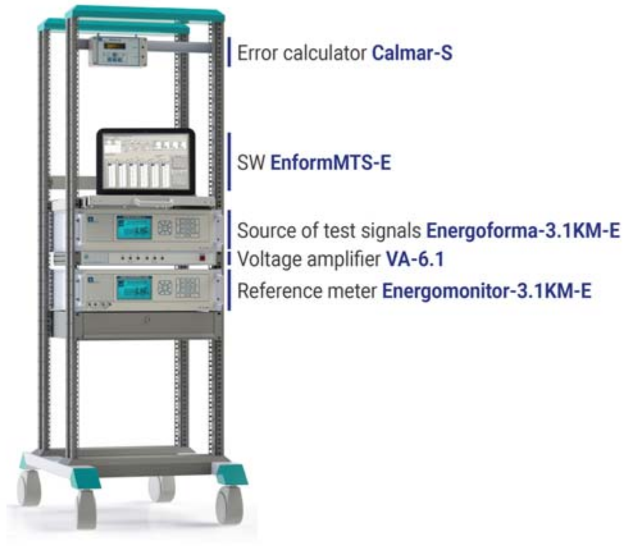

Fig. 10	Test system for calibration electronic energy meters

In distinction to test systems for testing conventional energy meters, in this setup the input/output signals are shifted to a range of 1 mV…10 V for both the source and the reference meter. The test current is supplied in the form of voltage signals to simulate the output of an electronic low-power current transformer.

The test method is classical since it uses the technique based on applying a reference meter. It consists of the following steps (Fig. 11):

- Test signals from the source are simultaneously supplied to the reference meter and to the meter under test
- The readings of the reference and tested devices along with the values of the error calculated by the pulse comparator are processed by the control software Enform MTS-ME, which then generates a test report.

The test system is intended for accuracy testing and calibration of electronic energy meters of accuracy class 0.2S (or less accurate) specified by the IEC 60044-XX standards.

The basic customers are: manufacturers of electronic meters, metrological labs and certification bodies.

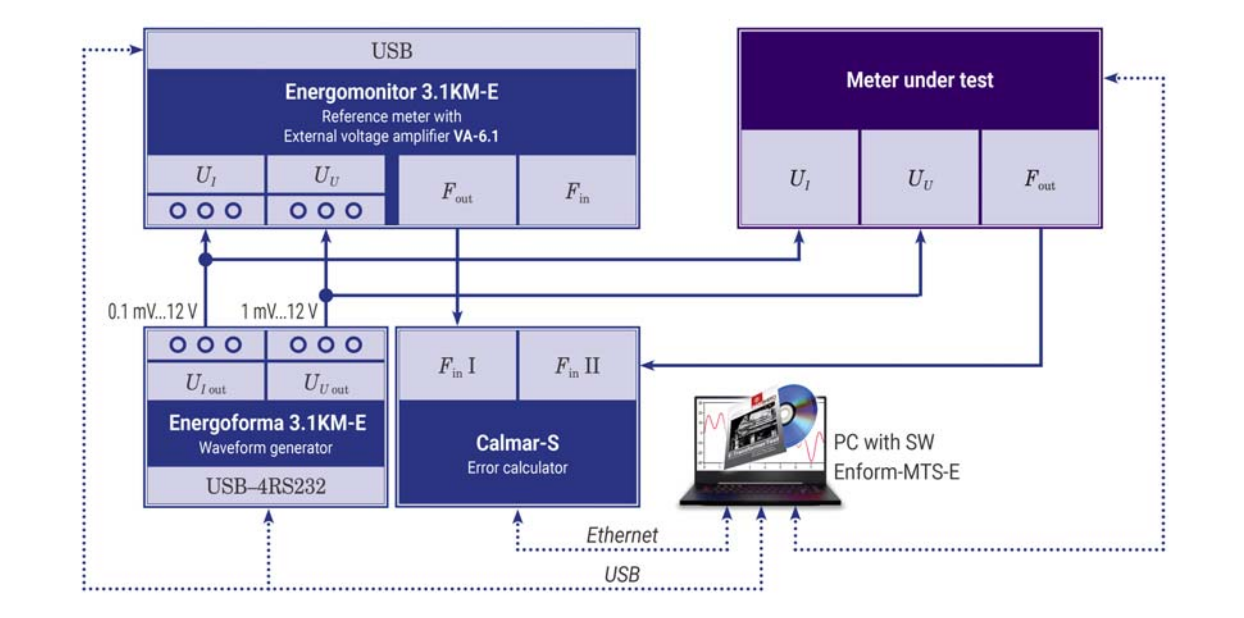

Fig. 11 Test system MTS-ME 3.1KM-E – Block diagram

Among other benefits, this test system features one interesting option: in addition to 50 Hz and 60 Hz, there is a fundamental frequency option of 400 Hz. This makes the system suitable for avionic and marine applications. It comes in two design versions: stationary and portable (Fig. 12).

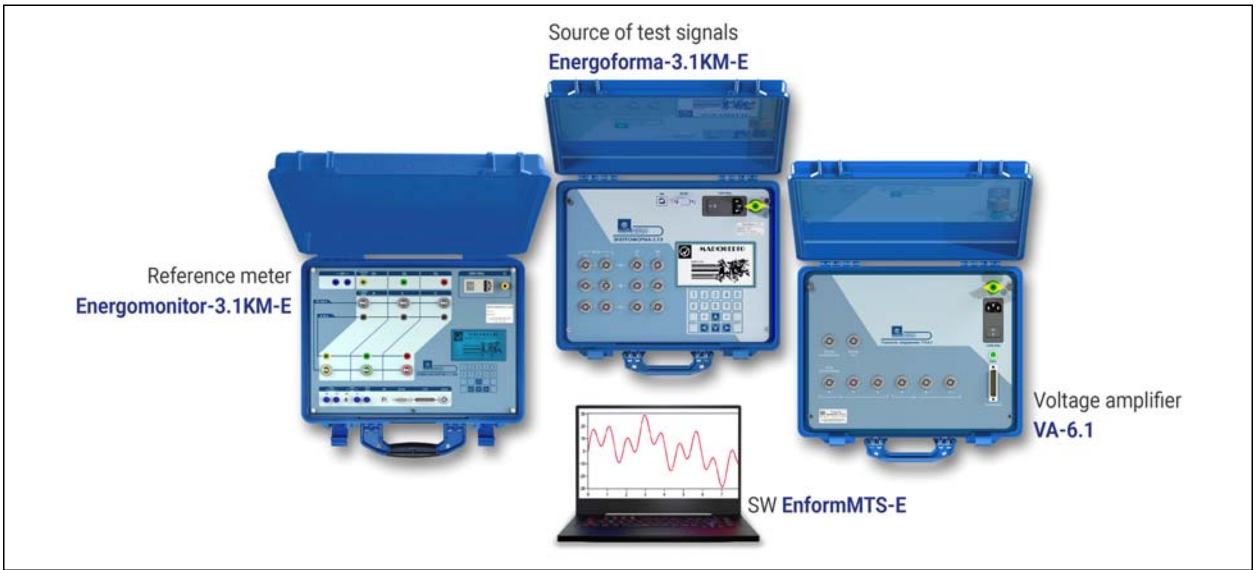

Fig. 12 Test system MTS-ME 3.1KM-E (portable version)

Conclusions

Considering the fact that LPITs and LPIT-compatible electronic meters typically have a calibration interval of about 8 years, right now the utility companies not pay much attention to the problems of their regular calibration. However, in the energy sector such equipment has been coming into use since 2016. That is why the time required for the development of calibration equipment, putting it into practical use and training the personnel is no more than 5 years. This period is quite sufficient to equip metrological labs with adequate test/calibration systems and test procedures for the whole lifecycle of LPITs and LPIT-compatible meters.