

# About the power standards calibration in the National Institute of Metrology, Romania

Ioana Odor<sup>1</sup>, Dorin Flaminzeanu<sup>2</sup>, Cornel Baltateanu<sup>3</sup>, Dan Mihai Stefanescu<sup>4</sup>

<sup>1</sup>National Institute of Metrology, Sos. Vitan-Barzesti, No.1, sector 4, Bucharest, Romania, [ioana.odor@inm.ro](mailto:ioana.odor@inm.ro)

<sup>2</sup>National Institute of Metrology, Sos. Vitan-Barzesti, No.11, sector 4, Bucharest, Romania, [doru.flaminzeanu@inm.ro](mailto:doru.flaminzeanu@inm.ro)

<sup>3</sup>National Institute of Metrology, Sos. Vitan-Barzesti, No.11, sector 4, Bucharest, Romania, 0213345060/ext.177

<sup>4</sup>Romanian Measurement Society, Sos. Vitan-Barzesti, No.11, sector 4, Bucharest, Romania, [stefidanro@yahoo.com](mailto:stefidanro@yahoo.com)

**Abstract:** The paper presents the way in which the Electrical Laboratory from the Romanian Bureau of Legal Metrology – National Institute of Metrology is managing all its capabilities to assure the traceability to SI for the references for electrical power and energy from the utilities and from the manufacturers of watt-hour-meters. The activity described in this paper is performed by using digital equipments, as well as a very accurate analogical power converter, in accordance with the international recognized methods (IEC, IEEE, EA) for calibrating power and energy meters. Till 2006, this activity of calibration was performed only for sinusoidal conditions, following documented procedures and established uncertainty budget under the quality system of the National Institute of Metrology, Romania. So, the laboratory declared the CMCs for AC power single phase and three phases in the Appendix C of The BIPM key comparison database phase. During the last year, for the first time in Romania, new activities are developed for the calibration of power standards and energy meters under non-sinusoidal conditions, and some of them are present in this paper.

## 1. Introduction

The activity of calibrating power standards is a main part of the Electrical Laboratory of the National Institute of Metrology, Romania, supplying the traceability to SI for a lot of reference standards from the local metrological laboratories (utilities, manufacturers of watt-hour meters, dealers and users of power analyzers, etc.). Although, till now, the laboratory did not realized a reference standard for electrical power based on the sampling procedure, as used in several EUROMET laboratories, it owns traceable to SI digital standards and its calibration and measurement capabilities are ordinarily available to the customers of the institute through services of calibration and measurement [1]. The paper presents the traceability to SI of reference standards of the Electrical Laboratory of the National Institute of Metrology, Romania, as well as the measuring methods used by this laboratory to calibrate power and energy standards under sinusoidal and non-sinusoidal conditions.

## 2. Reference and working standards

In the last 10 years, in the frame of different national or European Programs, the National Institute of Metrology was supplied with several reference standards, in order to provide technical basis for agreements negotiated for international trade, commerce and regulatory affairs. Such standards are presented below:

Table 1. Standards for electrical power and energy used in the National Institute of Metrology, Romania

Standard	Type/ producer	Technical specifications					Used for
		V [V]	I [A]	f [Hz]	$\phi$ [°]	U [ $10^{-6}$ ] (k=2)	
Power converter	C 1-2 / HEG-EMH Germany	120	5	45...65	0...90	20	Calibration under sinusoidal conditions
Three phase digital comparator	KOM 200.3/ EMH- Germany	60...480	.005...120	45...65	0...360	80	
Static three phase standard power meter	PRS 200.3/ EMH- Germany	60...480	0.005...120	45...65	0...360	80...150	
Three phase power standard (calibrator)	6100A /6101A / Fluke – UK	16...1000	.25...80	50...4500	0...360	45...250	Calibration under non -sinusoidal conditions

For performing calibrations under sinusoidal conditions, the laboratory uses as reference standards for electrical power an analogical converter [2] and a digital three-phased comparator [3], both traceable to SI by periodically calibration against the standards from PTB – Germany [4]. The two standards are also compared each other, every four months, under the quality system of the institute.

For performing calibrations under non-sinusoidal conditions, the laboratory uses as reference a three-phased power standard, type Fluke 6100A/6101A [5], traceable at SI by periodically calibration against the standards of the producer's UKAS accredited laboratory [6]. Using this three-phased standard with injection of voltage and current harmonics, the laboratory is now elaborating the procedure of calibrating power standards, electricity meters and power analyzers under non-sinusoidal conditions.

### 3. Calibration method

#### 3.1. Calibrating method under sinusoidal conditions

In Figure 1 and Figure 2 are shown the block diagrams of the calibration sets-up, as they are used in the Electrical Laboratory, to perform the direct comparison of the unit under test (UUT) against the standard.

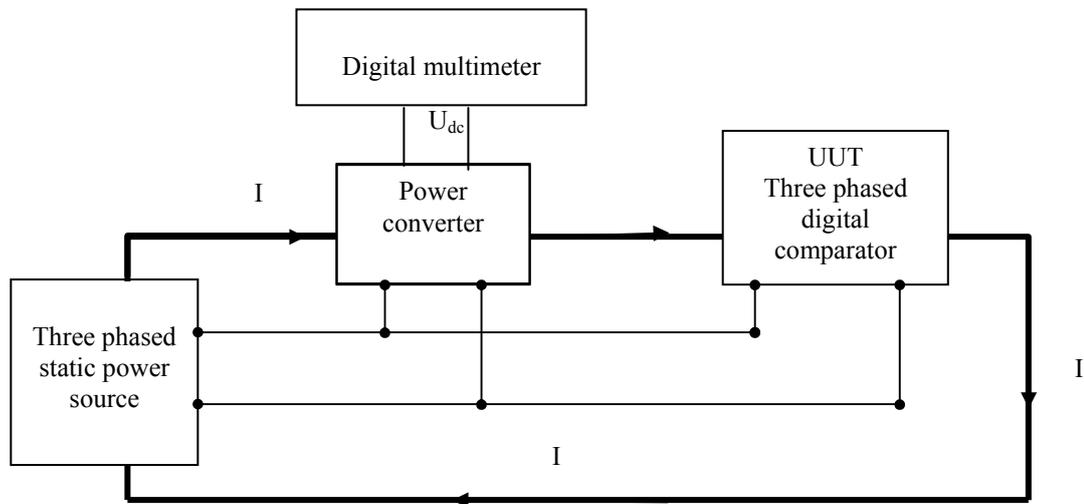


Figure 1. Bloc diagram of the comparison set-up between each phase of the digital comparator, type KOM 200.3, against the single-phase analogical converter power/voltage, type C1-2 ( $U_{d.c.} = k \cdot P = k \cdot U \cdot I \cdot \cos \varphi$ )

In May 2005 the Electrical Laboratory of the National Institute of Metrology, Romania, has participated in the Key Comparison Supplementing CCEM-K5 comparison, EUROMET.EM-K5.1 [7], on AC Power, at  $f = 50$  Hz, with pilot laboratory the National Metrology Institute of Turkey [8]. A power converter, type C1-2, provided by PTB-Germany, and was used as traveling standard.

The measurements were performed under a PC controlled program for the five points of measurement ( $U = 120$  V,  $I = 5$  A,  $\cos \varphi = 1$ ;  $0.5$  i/c;  $0.01$  i/c), as established in the comparison protocol. The power source, type SPE 100.3, supplied the voltage and current circuits of the two standards, as shown in Figure 1, and a digital multimeter, type Fluke 8508 [9], was used to measure the d.c. output voltage of the power converter C1-2. The multimeter was traceable at SI through an unbroken chain of comparisons to the UME-Turkey laboratory, all having stated uncertainties. The errors and the uncertainties of the measurements, were estimated by the laboratory in compliance with EA Documents [10], and will be published in the final report of the Key Comparison, on the BIPM site [11].

To perform calibration for the mono-phase or three-phase power reference standards, with the limits of the errors of  $\pm (0.02 \% \dots 0.05 \%)$ , as those manufactured by international companies as Radian Research, Inc., Zera GmbH, MTE/EMH Energie-Messtechnik GmbH, Schlumberger, the laboratory uses the calibration set-up presented in Figure 2. The current and the voltage circuits of the digital comparator and of the UUT are supplied by the three-phased power source, with established values for the measuring points ( $U$ ,  $I$ ,  $\cos \varphi$ ), following documented procedures, in accordance with the requirements of the IEC norms and the technical specifications of the UUT. As, in December 2006, through a national program of excellence, the laboratory was supplied with a complete version of the dedicated software CamCal, now it becomes possible to perform a larger number of automatic repetitive measurements for each programmed point ( $U$ ,  $I$ ,  $\cos \varphi$ ), in the same environmental conditions and without the operator bias. This new possibility decreases the value of the standard deviation of the mean of the errors with about  $5 \times 10^{-6}$ , but the value of the uncertainty of the

measurements performed as shown in Figure 2 is mainly determined by the expanded uncertainty,  $U = 80 \times 10^{-6}$ , at a level of confidence of 95 % ( $k = 2$ ), declared in the calibration certificate of the three-phased digital comparator, issued from PTB.

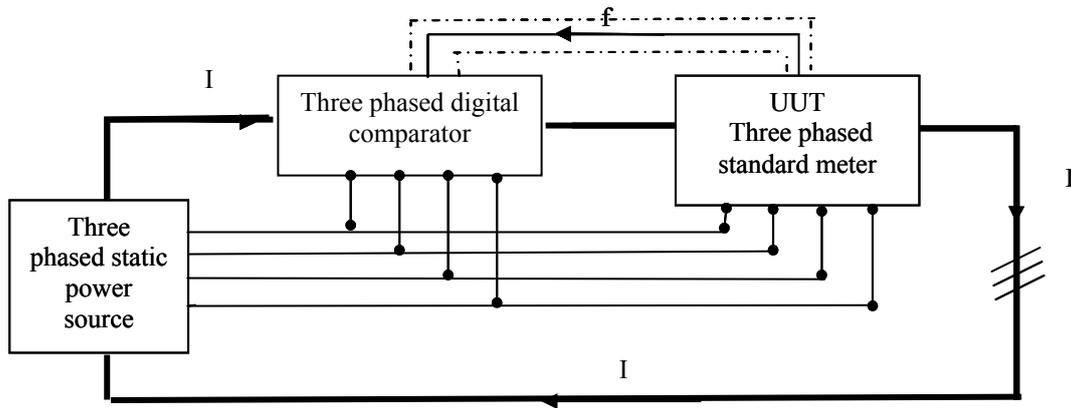


Figure 2. Bloc diagram of the calibration set-up under non-sinusoidal condition for the three phased digital standard meter, type PRS 200.3, against the digital comparator, type KOM 200.3

The values of the uncertainty of the measurements, stated in the calibrating certificates for the electrical power and energy standards, issued by the Electrical Laboratory from the National Institute of Metrology, Romania, are estimated according to the Guide to the Expression of Uncertainty in Measurement (GUM) and the equivalent Romanian Norm SR ENV 13005:2003.

In Table 2, are given values of the expanded uncertainty at a coverage probability of 95 %, estimated by for the calibration of some electrical power standards, used as references, in the metrological laboratories of the regional utilities, for testing energy meters from the internal energy market.

Table 2. Values of the extended uncertainties ( $k = 2$ ), estimated for different power standards calibrated in the Electrical Laboratory of the National Institute of Metrology, Romania

Type of power standard	Limits of the errors from the technical specification of the standard	Extended uncertainty ( $k = 2$ ) declared in the calibration certificate
RM-11 / Radian Research Inc.	$\pm 0.01 \%$	0.015 %
SRS 200.3 / EMH GmbH	$\pm 0.02 \%$	0.015 %
PRS 1.3 / EMH GmbH	$\pm 0.02 \%$	0.015 %
SM 3050 / Schlumberger	$\pm 0.05 \%$	0.025 %
TVE 104/3 Landis & Gyr	$\pm 0.05 \%$	0.025 %
MTE ZVE 3-10 / EMH GmbH	$\pm 0.05 \%$	0.025 %

### 3.2. Calibrating method under non-sinusoidal conditions

The developing of the Romanian energy market induced the necessity of more and more accurate measurements of the electricity quantity as well as the attributes of the electrical power (parameters of quality), in the places of the grid/net where electricity is sold and bought. Buyers obviously are interested to ensure they are getting the spot goods they paid for, and the distributors are very interested to ensure that power supplied does not adversely affect the integrity of their network.

As shown in [14], beginning from the nineties, the laboratory was frequently asked to perform calibration of power measuring instrumentation under non-sinusoidal conditions, but the lack of a stable power source with voltage and current harmonics injection determined the staff to deny their competence in such complex metrological activities.

In December 2005, through a technical project sustained by the Romanian Bureau of Legal Metrology, the Electrical Laboratory obtained a three-phased power standard with voltage and current harmonics injection, traceable to SI by calibration at the manufacturers UKAS accredited laboratory.

Towards of the dissemination of the unit for electrical power (watt) under non-sinusoidal conditions to all the instrumentation used in the electrical network, the calibrations of the digital power standards used as references in the regional utilities laboratories, shall be performed according to the requirements of the International Norms issued by OIML and the IEC – TC 13 “Electrical energy measurement, tariff- and load control” concerning the influences of voltage and current harmonics on the measured power.

So, the three-phase reference standard for electrical power and energy of the National Institute of Metrology, Romania, a digital comparator, type KOM 200.3, was calibrated at PTB under non-sinusoidal conditions against another comparator, type KOM3003, and the results are processed in the calibration certificate number 2859PTB06. A similar calibration was performed in our national laboratory by calibrating the working power standard meter, type PRS 200.3, against the digital comparator. The calibration set-up used was this from Figure 2, but the voltage and current circuits of the two standards to be compared were supplied by the three-phase power source type Fluke 6100A/6101A. Some results of this calibration are given in Table 3.

Table 3. Calibration results

Values of the electrical quantities supplied by the three phase power source, type FLUKE 6100A/6101A, according to the requirements of IEC 62052-11:2003 and IEC 62053-21:21:2003	Three phase static standard meter, type PRS 200.3 (4W)	
	E ( $\times 10^{-6}$ )	U ( $\times 10^{-6}$ ) for k = 2
f = 53 Hz; U = 110V ; U <sub>5</sub> = 10 % U; I = 5 A; I <sub>5</sub> = 40 %* I 3*110 V / 191 V	1	84
	0.5i	120
	0.5c	- 57
f = 53 Hz; U = 230 V ; U <sub>5</sub> = 10 % U; I = 5 A; I <sub>5</sub> = 40%* I 3*230 V / 398 V	1	130
	0.5i	74
	0.5c	- 91

But, the new standard will be used in the Electrical Laboratory to develop specific procedures to perform activities of testing/calibrating electrical instrumentation (mono or three phased power analyzers), according with the requirements of the international norms [12], [13] and [14], as shown in [15]. The calibration set-up for such activities is shown in Figure 3.

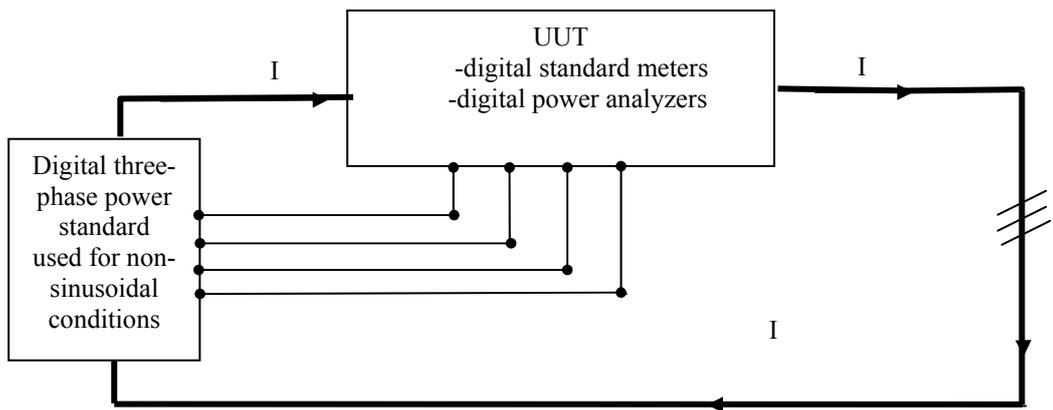


Figure 3. Bloc diagram of the calibration set-up for the digital instrumentation, against the three-phase power standard with voltage and current harmonics injection

According the requirements of [14], the parameters that has to be calibrated for a power analyzer are: Voltage level (rms), Frequency (Hz), Flicker (P<sub>ST</sub>), Harmonic Distortion (THD), Harmonic level (%), Unbalance (%), Voltage dips, swells and interruptions, detection and evaluation (depth and duration).

During this year, in the frame of the program named “The Maintenance of the National and Reference Standards from Romania”, economically sustained by the Romanian Bureau of Legal Metrology, specific procedures and working instructions for calibrating power analyzers will be elaborated by the staff of the laboratory. All these procedures will use computers and dedicated software, as CamCal from EMH GmbH, Met/Cal from Fluke or LabView from National

Instruments, to perform automated measurements, to create databases and to estimate the errors and the uncertainty of the measurements.

#### 4. Conclusions

The National Institute of Metrology, Romania, has developed the activity of the Electrical Laboratory by the purchase of power standards traceable to SI through calibrations at EUROMET laboratories, as well as by the elaboration and implementation of the specific procedures concerning the calibration of electrical power standards under sinusoidal conditions. Also, the laboratory has declared its CMCs in the domain of electrical power and energy [16]. During 2005 it has participated in the Key Comparison Supplementing CCEM-K5 comparison, EUROMET.EM-K5.1 [7].

With specialized staff and environmental conditions complying with the requirements of ISO/CEI 17025:2005, the Electrical Laboratory has as main goal for 2007 to obtain the accreditation certificate, issue from an European Accreditation member body, for the activity of calibration in the field of electrical power under sinusoidal conditions.

In the next year, after editing all the specific procedures and working instructions for the activity of calibration in the field of electrical power under non-sinusoidal conditions, the Electrical Laboratory will have to participate in an international comparison, to confirm the budget of uncertainties established for such measurements and to sustain the future possible enlarged CMCs.

All the attention given by the Romanian Bureau of Legal Metrology and the National Institute of Metrology, Romania, to the activities concerning the calibration under sinusoidal and non-sinusoidal conditions of the electrical power instrumentation (standards, meters, analyzers) is necessary to ensure accurate sale of power on the energy market.

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