CREATION OF NATIONAL STANDARDS SET IN UKRAINE

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Abstract. The modern conditions and development prospects of electrical and magnetic quantities units standards in Ukraine, their comparisons with standards of other countries are considered.
Keywords: electrical and magnetic measurements, radio engineering, standard

1   THE DEVELOPMENT OF ELECTRICAL AND MAGNETIC UNITS STANDARDS

The technical base for reproducing and keeping of legalized units of electrical and magnetic quantities are state and other standards. Their creation and improvement is one of the premises of ensuring the unity of measurements in the country. It is important primarily to create a national system of reproducing the fundamental units of international system SI and the most aplicable in the country units SI specified by international standards ISO 31 and ISO 1000. (The national standard DSTU 3651 in Ukraine is the analogue of these standards).

Accepted in Ukraine a concept of creation of the standards base stipulates a step-by-step development of basic electrical and magnetic units standards. The first step is creation of volt standard based on Josephson effect and ohm standard based on Hall effect. Reproducing an ampere in accordance with the SI definition leads to inaccuracy near $(6 \div 8) \cdot 10^{-6}$ (standard deviation) and to further errors of reproduction of other electrical quantities. It is planed to realize the standard plant for reproducing of ampere size as a bridge-compensator with the use of state volt and ohm standards [1,2].

In 1998 in KSSRIM the works on creation of volt standard on multielement Josephson matrix with voltage 1 V were completed. The standard of the second on significance electrical units, ohm, is sheduled to create in two stages. On the first stage in 1997, the standard on the base of resistance measures was created and approved as state (national) standard. A group of Hall resistance measures $(6453.202 \; \Omega)$ and appropriate transfer measures were incorporated into its composition. The transfer measures provide a possibility of getting (while from the standard of other country) of Hall ohm size, its keeping and transfer to other measuring instruments. On the second stage, it is planed to create a plant for realization of quantum Hall effect which will be added to already existing primary standard devices.

State standards of alternating current voltage units, as well as electrical power, energy and power factor, are in UkrCSM in closing stages of creation [3]. The creation of the standards of high voltage units was finished in 1999 [4]. Standards of units of capacity and inductance are expected to create in 2000. The development of that system and its expensive equipment by accounting capacitor is not planed. But just today Ukraine has precise quadrature bridge which with the ohm standard allows to reproduce the capacity and inductance measures at an accuracy level sufficient for needs of Ukraine [1,5].

In the field of magnetic measurements Ukraine has a state standard of magnetic induction unit, tesla, within the most-used range $(0.05 \div 2)$ T. The standard is based on effect of nuclear magnetic resonance, and its metrological characteristics are at a level of best world analogues [1].

The main metrological features of existing standards of Ukraine in area of electrical and magnetic quantitiesare are brought in the Table 1, and creating system of units standards in this area is shown on Fig.1.

The works on creation of standards of units listed below will be finished in 2000-2004.

In KSSRIM:

direct current amperage 1 A $(S = (5 \div 10) \cdot 10^{-8}; \; \Theta = (2 \div 5) \cdot 10^{-7})$;

electromotive force and constant voltage in the range of $(1 \div 10)$ V $(S = 5 \cdot 10^{-9}; \; \Theta = 7 \cdot 10^{-9})$;

electrical voltage of alternating current in the range of $(0.1 \div 1)$ V on frequencies $(30 \div 1000)$ MHz $(S = 5 \cdot 10^{-4} - 5 \cdot 10^{-3}; \; \Theta = 5 \cdot 10^{-2} \div 1.5 \cdot 10^{-2})$.

In UkrCSM:

complex electrical resistance: R=(0,1 $\Omega \div$10 MΩ); Ñ=10^{-3} pF$\div$100 μF; L=1μÍ$\div$10 Í; tgδ=$10^{-5}\div$1; tgφ = $10^{-5} \div$ 1 on frequency f=1 kHz (S =1·$10^{-6}\div$2·10^{-4}; Θ=3·$10^{-5}\div$5·10^{-4});

Table 1. List of national standards and standard measures of electrical and magnetic quantities

Name and cipher of standard	Range of measurements	Error of reproduction	Place of location
Measurement of electrical and magnetic values			
State primary standard units of electromotive force and voltage of direct current DETU 08-03-98	0,01÷1	S=5·10^{-9} θ=1·10^{-8}	KSSRIM
State primary standard units of electrical resistance DETU 08-02-98	1; 100 Ω	S=3·10^{-8} θ=3·10^{-7}	KSSRIM
State primary standard units of electrical voltage of direct current DETU 08-04-99	1÷180 kV	S=(1-5)·10^{-5}	UkrCSÌ
State primary standard units of electrical voltage of alternating current DETU 08-05-99	1÷1.2·330√3 kV 50 Hz	S=(0.5-5)·10^{-4} θ=(0.5-2)·10^{-4}	UkrCSÌ
State primary standard units of magnetic inductions DETU 08-01-96	0,05-2 T	S=1·10^{-6} θ=3·10^{-6}	KSSRIM
Secondary standard units of voltage of alternating current SETU 08-89-01-98	0,001÷1000 V 10 Hz ÷ 30 MHz	S_Σ=0,0001-0,0003	UkrCSÌ
A plant for check of measuring instruments of magnetic field parameters	1·10^{-12}÷1·10^{-1} T 40÷20000 Hz	Δ_r= 0.2 %	Kharkiv SCSÌC
Group of master measures of electrical capacity HA11, GR, Ð 5050, Ð 597, ÊÌÅ-11	0,1 pF÷-1 μF; 1000 Hz	Δ_r=0.05-1,0 %	UkrCSÌ
Group of measures of inductance and mutual inductance 0187, Ð 5101-Ð 5115, Ð 5009	1·10^{-6}÷10 H 10 μH ÷10 mH	δ_r=0.03 %	UkrCSÌ
Kits of thermoelectrical converters of variable voltage PTT, ÒÏÏ, Ò300	3÷100 ìÀ 0.25 ÷25 À	δ_r=0.0005÷0.005 %	UkrCSÌ
Measure of tangent of angle of dielectrical losses ÂÒÓÏ-1Ì	1·10^{-7}÷1 20÷100 êHz	S=5·10^{-4}	UkrCSÌ
Kit of working standards of phase shift angle unit ÊÎÑ-ÔÀ1	0÷360^î; 0,001 Hz÷150 MHz	Δ=0.01-0.15^î	UkrCSÌ
Kit of working standards of power and power factor units on industrial and increased frequencies ÊÎÑ-ÌÊÌ5	0÷360^î -1≤ cos φ ≤1	Δ=1÷60`	UkrCSÌ
Electronic and radio engineering measurements			
State primary standard of amplitude modulation coefficient unit of high frequency oscillation DETU 09-02-96	0.1÷100 %	S=0.03% θ=(0.15-0.3) %	KSSRIM
State primary standard of frequency deviation unit of frequency modulated oscillations DETU 09-03-96	10 Hz ÷1ÌHz	S=5·$10^{-4}\Delta$f, θ=(0.5÷2.0)·$10^{-3}\Delta$f	KSSRIM
State special standard of power unit of electromagnetic oscillations in waveguide tracts DETU 09-04-96	1·10^{-3}÷1·10^{2} W 37.5÷178.6 GHz	S =(0.5÷1)·10^{-3}, θ=5·10^{-3}1·10^{-2}	KSSRIM
State primary standard of harmonics coefficient unit DETU 09-01-96	0.003÷100 % 10 Hz ÷200 kHz	Δ=±[(0.003-0.01)·k_h+ +(0.0003-0.003)] %	KSSRIM
Secondary standard of alternating current voltage unit SETU 08-27-01-98	30÷2000 MHz	S_Σ=0.07÷1.2 %	UkrCSÌ
Wattmeter of absorbed power on high frequencies Ì3-54	0.03÷17.85 GHz	δ_r=1.2 %	UkrCSÌ
Power measures of high frequency radiation in mobile waveguide ÌÂ-7, ÌÂ-11, ÌÂ-16, ÌÂ-23, ÌÂ-35	5.64÷37.5 GHz	δ_r=1 %	UkrCSÌ
Kit of measures of standing wave factor and	1÷18 GHz	δ_r=1÷2 %	UkrCSÌ

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| Name and cipher of standard	Range of measurements	Error of reproduction	Place of location
impedance ÝÊ-140, ÝÊ9-145, ÝÊ9-180			
Reflectometers ÐÎÍ-16, ÐÎÍ-17, ÐÎÍ-23, ÐÎÍ-28, ÐÎÍ-35, ÐÎÍ-48	3.94÷17.44 GHz	δ_r=0.7÷1,5 %	UkrCSÌ
Measures of Q-factor Q-0272-2 (3 units)	15÷600 units	δ_r=1.5÷7 %	UkrCSÌ
Measures of electrical capacity Å1-3	100÷1000 pF	δ_r=0.1 %	UkrCSÌ
Measure of electrical resistance Å1-5	1 Ω÷10 kΩ	Δ=0.006-30.0 Ω	UkrCSÌ
Plant for testing of meters of electromagnetic field intensity ÓÂÝÏ-1, ÓÌÏ-1, ÓÍÝÏ-1, ÓÎÏ-1	0,01÷1000 MHz	δ_r=2.3÷5 %	UkrCSÌ
Plant for testing of meters of energy flow density on superhigh frequencies Ï1-9	0.3÷39.65 GHz	δ_r=8 %	UkrCSÌ
Plant for testing of noise generators on superhigh frequencies	0.8÷37.5 GHz	δ_r=3.5÷5 %	UkrCSÌ
Time and frequency measurement			
Secondary standard of time and frequency units SETU 11-81-01-98	$1 \cdot 10^{-10} \div 1 \cdot 10^8$ s $1 \div 7 \cdot 10^{10}$ Hz	S=$5 \cdot 10^{-13}$ θ=$1 \cdot 10^{-12}$	UkrCSÌ
Notes: S - root-ìean-square deviation of result of measurements; Θ - nonexcluded systematic error; S_Σ - root-ìean-square deviation of measurements results under comparison with the national standard; Δ - limit of possible error (Δ - absolute, Δ_r – relative); δ - confidence error (δ – absolute, δ_r - relative).			
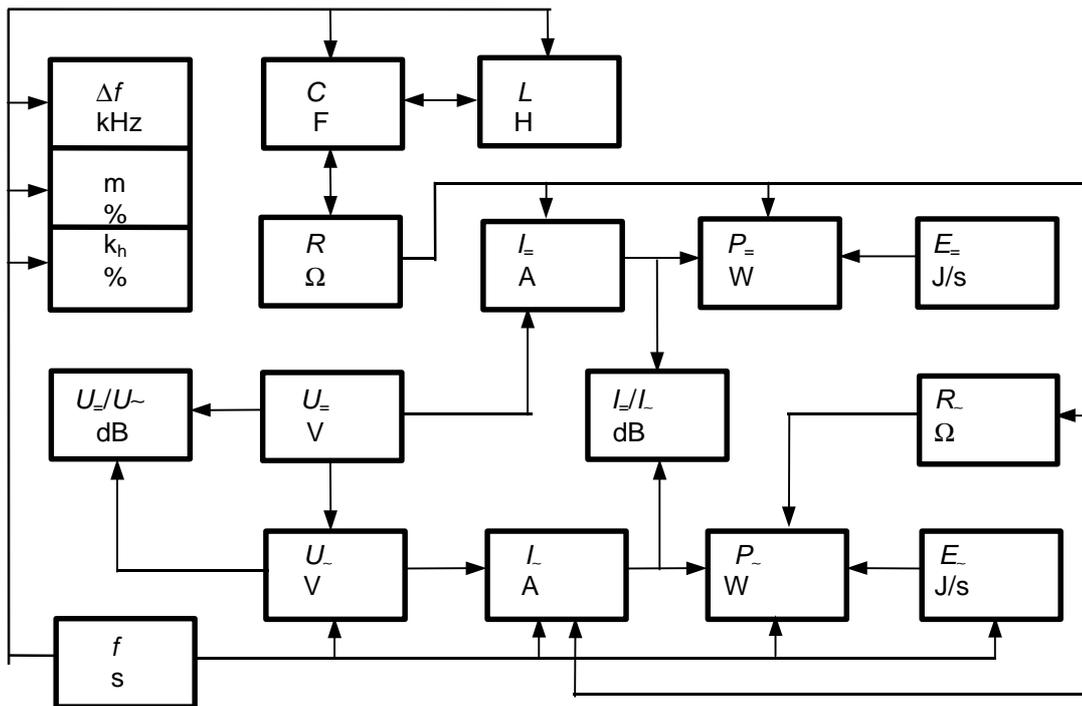
Figure 1. The creating system for reproducing of electrical and magnetic quantiteis units.

transformation factor of sinusoidal current in the range of (0,5÷5000) A on frequency 50 Ãö (S =$5 \cdot 10^{-6}$; Θ=$1 \cdot 10^{-4}$);

alternating current power in the range of $1 \cdot 10^{-3} \div 1 \cdot 10^{-1}$ A on frequencies 20 Hz÷20 kHz (S = (0.5÷5)$\cdot 10^{-4}$; Θ=(0.5-8.5)$\cdot 10^{-4}$);

electrical voltage of alternating current in the range of (0.1÷1000) V on frequencies (1÷30) MHz (S =(0.3÷1)$\cdot 10^{-3}$ Θ=(0.1÷2)$\cdot 10^{-3}$);

electrical power and energy in the ranges of (0,001÷50) A and (1÷600) V and power factor in the range of $\hat{E}_\rho$=1±0,5·f on frequencies (40÷65) Hz and f_ρ=40÷20000 Hz (S =(2÷5)$\cdot 10^{-4}$).

2   THE DEVELOPMENT OF THE UNITS STANDARDS IN RADIO

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ENGINEERING

There are long time traditions in the field of radio engineering measurements in Ukraine. Even in the time of former USSR KSSRIM was a leading organization in this area of measurements and kept 3 state standards of units: frequency deviation (Δf), amplitude modulation factor (m) and harmonics factor [6]. These standards are used for the calibration of measuring instruments employed in communication technique and other areas of radio engineering. The existing standard system is improved now with regard to the international standard IEC 27.

Measurement of the waveform parameters of composite electrical signals is based on measurement of the root-ìean-square deviation of voltage. The main integral characteristics of composite electrical signals are a total harmonic distortion (THD) and coefficient of harmonic (k_h). The calibrators of composite electrical signals are applied for calibration of distortion meters and characterized by high accuracy of signals parameters reproduction. In [7] the modern precise K2C-57 distortion calibrators is described. It is based on summation of the first and high harmonics and possess the high accuracy of test output signals shape, however the low fast-acting and the necessity to correct batchwise of test signal parameters. The calibrator form signals with certain THD value within the range which can be extended up to 0.001 % on condition the obtained value is corrected by mean the calculation of noice components.

The creation of standards of power unit on superhigh frequency (up to 40 GHz), phase shift angle between two voltages, as well as another parameters of radio signals is a priority problem of improvement of standards system in the field of radio measurements.

The works on creation of standards of units listed below will be finished in 2000-2004.

In KSSRIM:

attenuation of electrical voltage of alternating current within the range of (0÷110) dB on frequencies (0.01÷35) MHz (S =(2÷20)·10^{-3}; Θ=(2÷15)·10^{-3});
power of electromagnetic oscillations in square waveguide within the range of (1·10^{-3}÷1·10^{-2}) W on frequencies (5.64 ÷37.5) GHz (S =2·10^{-3}; Θ=(2÷3)·10^{-3});
wave resistance in coaxial waveguide 50 Ω within the range of frequencies 0.15÷18 GHz (S =(1÷10)·10^{-4}; Θ=(9÷60)·10^{-4});
complex reflecting factor in square waveguide 1,05÷2,5, φ=0÷360$^{\hat{i}}$ on frequencies 5.64÷37.5 GHz (S =(3÷8)·10^{-3}; Θ=(3÷12)·10^{-3});
phase shift angle between two voltages within the range of 0÷360$^{\hat{i}}$, 0.01÷10 V on frequencies 0,001 Hz÷1000 MHz (S =2·10^{-5}÷1·10^{-2}; Θ=(1÷2)·10^{-5});
powers of electromagnetic oscillations in coaxial waveguide within the range of 1·10^{-3}÷1·10^{-2} W on frequencies 0.15÷18 GHz (S =2·10^{-3}; Θ=(2÷8)·10^{-3});
spectral density of noise radiation power within the range of (1÷65) êÒi on frequencies (8.12÷37.5) GHz (S =5·10^{-5}; Θ=2·10^{-3}).

In UkrCSM:
energy flow density of electromagnetic radiation within the range of (2 ÷ 20) µW/cm^2 on frequencies (0,3 ÷ 39,65) GHz (S =0.2 dB; Θ=0.42 dB).

3   THE RESULTS OF INTERNATIONAL COMPARISONS

In 1996-1998 the comparisons of efficiency factor and reflectance module on the frequency 62 GHz in square waveguide section of thermistor heads of power units standards are conducted in BNM-LCIE (France, leading laboratory), NPL (Great Britain), NIST (USA) and KSSRIM. The comparisons were held by decision of Working group on radio frequencies (GT-RF) of Consulting committee on the electricity (CCE) and were organized on the circular scheme. It was received good coinciding the results.

Regretfully, at the present time the only possibility of participation of Ukraine in international standards comparisons is the participation in works of regional metrological organizations, mainly European. In 1996 UkrCSM conducted comparisons of electrical capacity 10 pF and 100 pF measures with similar measures of metrological organizations of seven European countries. The calibration one of the measures in PTB (Germany) confirms the hight stability of ukrainian standard measuring instruments in the measurements field of electrical capacity. The repeated calibration of measures mentioned above is prepared now.

4   CONCLUSION

Thereby, national standard system of electrical and magnetic quantities in Ukraine allows to decide

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a number of problems of metrological ensuring of electrical and magnetic measuring instruments, but requires a further development for bringing to better agreement with modern requirements in that field of measurements.

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