TRANSPORTABLE LOWEST DC CURRENT STANDARD

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Abstract

A new compact transportable lowest current standard for the range from 1 fA to 1 nA was made in VNIIM.

Introduction

A new compact transportable lowest dc current standard for the range from 1 fA to 1 nA was made in VNIIM. It is based on the principle of condenser charging previously realized in the National Standard of Russia [1]. In this case value of the reproduced current is defined by equation $I = C \cdot dV/dt$, where C- capacitance of condenser; V – voltage with linear variations within the time interval t. For the realization of the ratio dV/dt, the digital ramp voltage measure (DRVM) is used. The principle of the DRVM is based on the transformation of digital signals produced by a special controller into the ramp voltage. In this case the height of the voltage step does not exceed 1 mV.

Features

The transportable standard makes it possible to reproduce currents in the range from 1 fA to 1 nA. The output voltage of DRVM can rise or decrease in a linear way for the range 0 to 24 V in the automatic mode. The duration of the ramp voltage reproduction may be specified in the interval up to 2000 s.

Table 1: The nominal values of air condenser capacitance used in differentiators and the corresponding values of the reproduced currents. The range of steepness ramp voltage values is between 1 and 100 mV/s, and it may be smoothly regulated in this range with a discontinuity of 1 mV/s.

Nominal value of condenser capacitance of differentiating block, pF	Range of the reproduced current, A
1	$1 \cdot 10^{-15} - 1 \cdot 10^{-13}$
10	$1 \cdot 10^{-14} - 1 \cdot 10^{-12}$
100	$1 \cdot 10^{-13} - 1 \cdot 10^{-11}$
1000	$1 \cdot 10^{-12} - 1 \cdot 10^{-10}$
10000	$1 \cdot 10^{-11} - 1 \cdot 10^{-9}$

Power consumption (at 15 V) - maximum: 0.38 VA
Overall dimensions of standard blocks:

DRVM	90x170x35 mm
The case for standard	265x320x76 mm
Weight of the standard	2.5 kg

Table 2: The output resistance of standard depending on the current range

Range of the reproduced current, A	Output resistance, Ω
$1 \cdot 10^{-15} - 1 \cdot 10^{-11}$	Not less than 10^{14}
$1 \cdot 10^{-11} - 1 \cdot 10^{-9}$	Not less than 10^{12}

Design

of the physical configuration of the transportable standard blocks is shown on the Fig.1.

Fig.1. General type of transportable standard

On the face panel of DRVM the information screen and the buttons to capture the necessary parameters are placed, the value of reproduced ramp voltage in the digital mode being displayed on the screen.
The differentiating blocks consist of filters to smooth the steps of ramp voltage and of the air condensers having constant capacitance. The condensers with the sapphire insulation are used for the range of current from 1 fA to1 pA, and those with the polystirol insulation are used for the range of current from 10 pA to 1 nA.
The DRVM is powered by 9 to 15 V DC voltage.

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Calibration

Metrological performance of the transportable standard was studied using the Russian National Standard of the DC current unit. The transfer of the size of the unit of current from the National Standard to the transportable standard was carried out through the direct comparison using the zero compensation method.

The mean value of the current of both polarities was defined for 100 s, i.e. from 2 to 18 measurements were made during one cycle of the realization of the unit of current. At the same time it was determined that the relative extended uncertainty (95%, k=2) of the average value of current for ranges from 1 fA to 1 nA was within the range from $1 \cdot 10^{-2}$ to $4 \cdot 10^{-4}$ for steepness of ramp voltage 10 mV/s.

Investigations of transportable standard stability were carried out, showing that the change in the reproduced value of current during 6 month was inside the range of the mentioned uncertainties, which supports the possibility to use the transportable lowest DC current standard for comparisons of the primary standards in this field of measurements.

Conclusion

The new compact transportable standard was used in the comparisons of the National Standards of Russia and Germany, and the obtained results proved the reliability of the abovementioned metrological performance [2]. It is expedient to use this transportable standard for international comparisons.

References

[1] Katkov A.S., Pavlov O.M., Galakhova O.P., Koltik E.D. "Primary Standard of Current Developed of VNIIM", *2ND International Symposium on Electromagnetic Metrology (2ND ISEM'93), Beijing, September 6-8,* pp.47-48, 1993.

[2] G.-D. Willenberg, H. N. Tauscher, O.M. Pavlov, I.V. Korotkova, "Intercomparison of Precision Current Sources in the Range from 10 fA to 10 pA Between PTB and VNIIM", will be published at CPEM 2004.