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INTERCOMPARISON OF PRECISION CURRENT SOURCES IN THE RANGE FROM 10 fA TO 10 pA BETWEEN PTB AND VNIIM

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Abstract

An intercomparison of precision current sources was carried out for currents between 10 fA to 10 pA. The current sources of both PTB and VNIIM were based on the principle of charging a capacitor using a linear voltage ramp [1],[2]. The relative deviation for the values of the sources were found to be between $2.8\cdot10^{-4}$ and $3.1\cdot10^{-3}$, depending on the current range.

Introduction

Measuring lowest currents in the pA- and sub-pA-range increasingly gains in importance in many fields such as, for example, semiconductor or medical instrumentation industries. Therefore, several metrology institutes operate or develop set-ups to calibrate picoamperemeters traceable to national standards. To validate our set-ups, a bilateral intercomparison between PTB and VNIIM was performed.

Measurements

The comparison was performed at PTB in June 2003 using two precision current sources: a) the PTB primary standard for small currents as described in [2] which is not easy to transport, and b) a compact and easily transportable current standard from VNIIM. The latter was calibrated before and after the comparison against the primary standard of VNIIM [3]. Both current sources were based on the principle of charging a capacitor C by a voltage V changing in time at a constant rate dV/dt. The output current of the source is then given by $I=C\cdot dV/dt$. While both current sources relied on the same principle, there was a difference in the voltage generators and in the capacitors used. The voltage generator of PTB used an analog technique to generate a linear voltage slope, whereas the generator of VNIIM used a digital technique. Furthermore, the capacitors of PTB and VNIIM were of completely different design. The comparison was performed using of a commercial picoamperemeter (Keithley Mod. 642) as a transfer standard. To eliminate any possible drift, the transfer standard was alternately fed by the current sources a), b), and then again a). Then, the calibration factors F_{PTB} and F_{VNIIM} shown in Table 1 were obtained by dividing each generated current by the corresponding reading of the transfer standard. It can be seen that the relative deviation of the calibration factors was between $2.8\cdot10^{-4}$ and $3.1\cdot10^{-3}$, depending on the current range. A detailed uncertainty analysis will be presented at the conference.

Table 1: Calibration factors F with their uncertainties u obtained by calibrating the transfer standard using the current sources of PTB and VNIIM. The factors F are calculated by dividing the generated current by the reading of the transfer standard.

Nominal current	Calibration factor F_{PTB}	Uncertainty u_{PTB} (95 %, k=2)	Calibration factor F_{VNIIM}	Uncertainty u_{VNIIM} (95%, k=2)
10 pA	0.99514	$1.3\cdot10^{-4}$	0.99594	$2.7\cdot10^{-4}$
- 10 pA	0.99864	$1.3\cdot10^{-4}$	0.99920	$2.7\cdot10^{-4}$
1 pA	0.99869	$3.8\cdot10^{-4}$	0.99841	$2.3\cdot10^{-3}$
-1 pA	0.99739	$3.8\cdot10^{-4}$	0.99768	$2.3\cdot10^{-3}$
100 fA	0.99928	$6.1\cdot10^{-4}$	0.99792	$8.6\cdot10^{-4}$
-100 fA	0.99931	$6.1\cdot10^{-4}$	0.99626	$8.6\cdot10^{-4}$
10 fA	1.0006	$3.1\cdot10^{-3}$	1.0018	$3.4\cdot10^{-3}$
-10 fA	0.9866	$3.1\cdot10^{-3}$	0.9859	$3.4\cdot10^{-3}$

References

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