METHODS OF UNCERTAINTY REDUCTION IN THE CALIBRATION OF NORMAL ELEMENTS

Tolmach Halyna
Metrological Center of Military Standards Armed Forces of Ukraine, Ukraine

To ensure accurate reproduction and preservation of electromotive force (EMF) and constant voltage units in metrology, a standard measure of constant voltage called a normal element is utilized. Normal elements are extensively used both as standard voltage measures of the 1st and 2nd orders and as national standard measures in various countries. For instance, in Ukraine, the national standard for constant voltage includes a group measure comprising 12 normal elements.

The primary advantage of employing normal elements lies in preserving constant voltage units with very low «drift», a feat not currently achieved by superior solid-state measures in production. However, the utilization of normal elements entails certain specifics: normal elements must be thermostated at a temperature of 20^0C ± 0.01^0C, transported, and utilized solely in the vertical position, as an inclination exceeding 30^0 leads to alterations in the stored voltage value. Additionally, normal elements possess low load capacity, allowing them to be loaded for no more than 1 minute per day with a resistance of 10^9 Ohms. Therefore, using standard calibration methods employing comparators or potentiometers with high input resistance allows only one measurement per day. For instance, during the certification of normal elements of the 2nd order, the uncertainty component of type B, arising from result instability (random component), equals 1.4 μV.

One approach to reduce uncertainty in the calibration of normal elements is realization of the replicate measurements. However, standard means do not allow this. Nevertheless, multimeters with an input resistance exceeding 10^{10} Ohms are currently available. One such multimeter is the HP34420A (or its analogs, such as Keysight 34420A), with an input resistance of 10^{10} Ohms, enabling up to 30 automated measurements in 1 minute. Subsequently, mathematical processing of measurement results, specifically finding the root mean square deviation (RMSD), or processing the result of uncertainty of type A, can be performed. Thus, the random component of the conducted measurements is removed from the uncertainty budget of type B. For instance, during the certification of normal elements of the 2nd order, the random component equals 1.4×10^{-6}, but with replicate measurements, this figure can be reduced to 5×10^{-7}.

Therefore, by realization of the replicate measurements using the high-precision multimeter HP34420A (Keysight 34420A), it is possible to significantly reduce the uncertainty result of calibrating normal elements.

References:

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3. Keysight Technologies. (n.d.). Keysight 34420A NanoVolt/Micro-Ohm Meter.