Abstract

A high precision digital voltmeter can be used to measure the ratio of 1 V to 10 V very accurately. Preliminary tests of calibrating 10-V Zener references from a 1-V Josephson array standard indicate that an accuracy with an uncertainty of several parts in 10^6 is possible.

Introduction

There is currently a transition from 1.018 V Weston cells to 10-V Zener reference standards taking place in the metrology community. To avoid the situation of maintaining or transferring two representations of the volt, one at 1.018 V and another at 10 V, there is an increasing need to measure 1:10 V ratios accurately. Josephson array voltage standards are becoming more commonplace, but the availability of 10-V Josephson arrays may be irregular for some time. Therefore a method of stepping up to the 10-V level would be especially advantageous to 1-V array users. Procedures relying on resistive dividers can be fairly accurate, but have a large number of uncertainty components [1-2]. High precision digital voltmeters (DVMs) have recently been introduced, which have extremely good linearity specifications. This linearity may also be stable for long periods of time. Thus, DVMs may provide both a cost and time effective solution for 1:10 V ratio requirements. Toward this end, we investigated the accuracy of using a 1-V array with an 8 1/2 digit voltmeter in making the transition from the 1-V level to the 10-V level of a Zener reference standard.

Results and Discussion

The key test of the technique described here is the comparison of the voltage of the 10-V Zener reference standard calculated from the ratio measurements taken with the digital voltmeter with the actual voltage determined by the Josephson array. The calculated voltage of the 10-V Zener reference is given by
where \( V \) is the voltage. The subscripts refer to the nominal voltages of the Zener references, and the terms in parentheses refer to the instruments used to measure the voltage of the Zener reference. The term in the brackets is essentially the gain correction for the digital voltmeter.

Performing the calculation given by Eq. (1) for measurements described above yielded a deviation from 10 V nominal value for \( V_{10} \) of -2.068 ± 0.036 ppm. When compared with the voltage measured with the 10-V Josephson array, -2.081 ± 0.006 ppm, the relative error between these two values is only 0.013 ± 0.037 ppm. For these short-term special tests, this random uncertainty is similar to the NIST 10-V calibration service [4]. Similar results, but with less precision due to fewer repeated measurements, have been obtained for several other Fluke Zener reference standards.

From the small relative error reported above, these preliminary results indicate it is indeed possible to achieve an accurate calibration of a 10-V Zener reference standard by voltage ratio techniques using a high-precision digital voltmeter, especially from 1-V Josephson array measurements. This demonstrates that linearity corrections and impedance loading of the digital voltmeter may be minimal. Additional measurements with other voltmeters and Zener references are needed in order to verify the applicability of this technique. Also, since measuring the gain of the DVM directly with the array is possible, this will be investigated as a way to indicate possible systematic errors from severe nonlinearities. Whether nonlinearities on the 1-V range are precisely the same on the 10-V range will be examined closely. It is expected that these additional measurements will yield positive results, which will allow a relatively easy and inexpensive technique for calibrating 10-V Zener reference standards to within a few parts in \( 10^8 \), especially with a 1-V Josephson array standard.

References


