EXPERIMENTAL DESCRIPTION

A set of four Fluke 732B travelling Zener standards[2] was measured at 10 V against JVSs at NIST and LMA using MAP procedures. NIST received the Zener standards on May 27, 1999. The first round of measurements at NIST was carried out from May 29 through June 7. LMA performed its measurements between June 10 and June 21. NIST started its second round of measurements on June 23 and finished the intercomparison on June 30, 1999. All the shipments were handled by overnight express delivery. For a single point measurement of a Zener output, an integration time of 100 seconds was used for averaging at NIST, and 20 seconds at LMA. An established procedure was used to minimize the thermal voltages existing in the wires and contacts between the scanner and Zener standards. Each Zener output was measured consecutively twice, once normally and once with the positive and negative outputs reversed. Four low-thermal reversing

Measurement Assurance Program for an Intercomparison of Josephson Voltage Standards between NIST and Lockheed Martin Astronautics.

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ABSTRACT

An intercomparison of 10 V Josephson voltage standards (JVS) between NIST and Lockheed Martin Astronautics (LMA) using four travelling Zener standards will be presented. The main purpose of the intercomparison was to establish traceability of LMA's JVS to the U.S. national representation of the SI volt for the 1999 JVS Interlaboratory comparison organized by the National Conference of Standard Laboratories (NCSL). The secondary purpose was to test the technique of applying pressure corrections in order to improve the uncertainty of the comparison. A Measurement Assurance Program (MAP) protocol was adopted for the intercomparison. The MAP procedure, measurement methods, uncertainty analysis and intercomparison results will be discussed.

INTRODUCTION

An intercomparison of the JVS between NIST and LMA was carried out from May 28, 1999 to June 30, 1999. The main purpose of the intercomparison was to establish traceability of LMA's JVS to U.S. national representation of SI volt for the JVS intercomparison organized by the NCSL. In the past, the environmental effects to Zener standards due to pressure, temperature were not corrected based on independent determinations of these effects. Rather, the environmental effect such as from pressure was treated as a fit parameter in the data analysis [1]. The second purpose of the NIST-LMA intercomparison is to test the technique of pressure correction for travelling Zener standards in order to improve the uncertainty of the comparison.

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[1] Lockheed Martin Astronautics (LMA) is now Lockheed Martin Space Systems Company – Astronautics Operations (LMAO).

where $V_i(LMA)$ is the i^{th} measurement by LMA, $V_i(predict)$ is the i^{th} calculated Zener value at the time when the LMA measurement was taken using the NIST drift rate, and 12 is the total number of paired measurements made by LMA. The difference between LMA and NIST for each travelling Zener standard is listed in the last row of Table 3. The mean difference of the four standards is found to be 0.059 µV. Finally, the uncertainty components [2] of the intercomparison were evaluated and the results are listed in Table 3. The Type A uncertainties of NIST and LMA were calculated based on the residuals relative to the LSS fit line. The total Type A uncertainty for each Zener is the root-sum-square (RSS) of NIST and LMA Type A measurement uncertainties. There was a Type B uncertainty contribution from the pressure coefficient measurements. The uncertainty, u_P, due to the pressure difference between NIST and LMA is given by Eq.(3)

$$u_P = u_{Cp}\,(P_{NIST} - P_{LMA}) \qquad (3)$$

where u_{Cp} is the standard uncertainty of the pressure coefficient measurements whose results are listed in Table 1, and P_{NIST} and P_{LMA} are the mean pressures at NIST and LMA respectively, during the time the respective measurements were taken. This Type B uncertainty contribution is listed in Table 3 for each Zener standard.

	Z1	Z2	Z3	Z4
NIST Type A	0.024	0.031	0.021	0.013
NIST Type B	0.007	0.007	0.007	0.007
LMA Type A	0.038	0.026	0.021	0.012
LMA Type B	0.034	0.034	0.034	0.034
Type B due to C_p	0.007	0.006	0.007	0.007
LMA – NIST	0.090	-0.014	0.226	-0.064

Table 3. The difference between LMA and NIST, and uncertainty budget, all in µV.

The combined standard uncertainty, u_c, of the LMA-NIST comparison is derived from several estimated components listed in Table 4 along with their associated degrees of freedom, υ_i. The combined variance of the results and the effective degrees of freedom are derived using the Welch-Satterthwaite formula, [3].

Source	Uncertainty (µV)	υ_i
Pooled Type A of NIST, u_A^{NIST}	0.023	15
Pooled Type A of LMA, u_A^{LMA}	0.026	11
Standard deviation of mean of four Zener differences $u_B^{LMA\text{-}NIST}$	0.064	3
Type B uncertainty from NIST, LMA JVS systems and pressure, $u_B^{LMA,\,NIST,\,pressure}$	0.035	∞

Table 4. Uncertainty Summary of NIST-LMA intercomparison

The pooled Type A uncertainty for the LMA and NIST measurements are calculated using Eq. (4).