

Comparison of the Josephson Voltage Standards of the NIST and the BIPM (part of the ongoing BIPM key comparison BIPM.EM-K10.b)

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The story

A comparison of the 10 V Josephson array voltage standard of the Bureau International des Poids et Mesures (BIPM) was made with that of the National Institute of Standards and Technology (NIST), USA, in March 2009. For this exercise, three different measurement methods were carried out: the two different options of the [BIPM.EM-K10.b](#) comparison protocol as well as the measurement protocol applied by NIST. The results of both participants are in very good agreement and the overall relative standard uncertainty is 9.5 parts in 10¹¹.

The alternative protocol with automatic data acquisition used by NIST was developed to reduce the significant manual operation required by the BIPM protocols. The higher level of automation allows reasonable collection of a substantially increased number of measurement points, which enables the study of additional subtle effects that can affect the results of voltage measurements such as pressure dependent effect and impact of 1/f noise floor of the null detector. This comparison has demonstrated that the alternative protocol used by NIST gives measurements in complete agreement with the BIPM protocols.

The feedback: a letter from Dr Yi-hua Tang, NIST, to Prof. A. Wallard, BIPM Director

07 April 2009

Dear Prof. Wallard,

I am sure Stéphane Solve and Régis Chayramy have given you a report on our successful NIST-BIPM JVS direct comparison that was carried out in the NIST DC Volt Lab in Gaithersburg, Maryland from March 20, 2009 to March 26, 2009. I would also like to give you a brief report from my own perspective.

During the week that Stéphane and Régis were in my lab, we performed a number of comparisons using the [BIPM protocols Option A and Option B](#). The analysis for the Option B protocol indicates the difference between the NIST Compact JVS (CJVS) and the BIPM JVS was -0.07 nV at 10 V with a combined standard uncertainty of 1.2 nV.

This is one of best results from the BIPM comparisons with many NMIs over the years. The analysis for the Option A protocol indicates the difference between the NIST Compact JVS (CJVS) and the BIPM JVS was -1.53 nV at 10 V with a combined standard uncertainty of 1.1 nV.

BIPM has played a critical role in supporting NMIs to maintain an internationally consistent voltage standard by making many key comparisons around the world. The recent BIPM-NIST comparison will have a positive and significant impact on future SIM regional comparisons such as the NIST direct JVS comparison with INMETRO of Brazil in June 2009. BIPM carried out a direct JVS comparison with INMETRO in early 2006, but unfortunately the result of that comparison was not satisfactory. I hope the comparison between NIST and INMETRO this coming June will be successful. There are probably more than 60 JVS systems in operation around the world, mostly owned by NMIs. It is a daunting task to make sure these systems are operated properly. In my opinion, it is important for BIPM to continue its comparisons with other NMIs. My own experience with US industrial and other government labs has verified that this type of comparison can be used to verify the software and hardware of these systems, and also be used as a diagnostic tool.

At NIST we are also working on developing various JVS comparison protocols to support US industry and other government labs. I am glad that we had an opportunity to demonstrate for Stéphane and Régis the recent automatic protocol for the JVS comparison. The advantage of using the automatic protocol for the JVS comparison is that it improves the efficiency of data acquisition with comparable uncertainty as using the manual operation. Although the results from the automatic measurements will not be used in the final BIPM.EM.K10.b report, I am pleased that the results from this alternative protocol are consistent with those obtained from using the BIPM protocols.

Stéphane, Régis and I also discussed opportunities for future voltage metrology collaborations. While we used mature protocols and techniques for the BIPM-NIST comparison, we also believe that there are still issues, such as thermal fluctuation during the comparison, that need to be studied. In addition, NIST is making progress in the construction a 10 V programmable JVS. We believe this new JVS system will have a big impact on voltage metrology in the next few years. This could provide a new opportunity for collaboration between NIST and BIPM to determine the role of the 10 V PJVS in future JVS comparisons.

With best regards,
Yi-hua

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