
BIPM.EM-K10 (INRIM 2026)

DC voltage, Josephson standards

KEY COMPARISON

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Comparison of the Josephson Voltage Standards of the INRiM and the BIPM

(part of the ongoing BIPM key comparison BIPM.EM-K10.a and b)

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Abstract. A comparison of the Josephson voltage standards (JVSs) of the Bureau International des Poids et Mesures (BIPM) and the Istituto Nazionale di Ricerca Metrologica (INRiM), Italy, was carried out in March 2026 at the level of 1 V and 10 V. For this comparison, the transportable JVS of the BIPM was brought to INRiM. For this exercise, options I and II of the BIPM.EM-K10 comparison protocol were applied. Option I required the BIPM to provide a reference voltage for measurement by INRiM using its Josephson standard with its own measuring device. Option II required INRiM to provide a reference voltage for measurement by the BIPM using its JVS together with an analog detector and associated measurement loop.

The final results were in excellent agreement with a relative voltage difference of a few parts in 10^{11} and a total combined relative standard uncertainty of a few parts in 10^{10} at 1 V and a few parts in 10^{11} at 10 V.

1. Introduction

Within the framework of CIPM MRA key comparisons, the BIPM performed a direct Josephson voltage standard (JVS) comparison with INRiM, Italy, in March 2026.

The BIPM PJVS (Programmable Josephson Voltage Standard) was transported by road to INRiM, Torino, Italy, where an on-site direct comparison was carried out from 25 March to 1 April 2026. The comparison followed the technical protocols for the options I and II of the BIPM.EM-K10 comparisons. The comparisons required the INRiM to measure the voltage of the BIPM transportable PJVS using its own measurement chain for option I and the BIPM to measure the voltage of the INRiM PJVS using its measurement loop where an analogue voltmeter was used as a detector for option II.

For both protocol options, the BIPM and the INRiM arrays were kept floating from ground. The BIPM PJVS was biased in such a way to provide exactly the same quantum voltage as the one generated by the INRiM PJVS for each polarity: As a consequence, the voltage difference never exceeds the amplitude of the residual thermal Electromotive Forces (EMFs) which are ranging between 600 nV and 990 nV with an average of 700 nV.

This article describes the technical details of the experiments carried out during the comparison.

2. Comparison equipment

2.1 The BIPM PJVS

The BIPM traveling quantum voltage standard is a Programmable Josephson Voltage Standard (BIPM-PJVS), which is composed of a cryoprobe that can carry a liquid helium version of the 2 V or 10 V SNS NIST programmable array [1-2]. In the present exercise, only the 10 V array was operated. The voltage across the array is controlled by a dedicated microwave source ($f=18$ GHz) and a dedicated bias source. The array must be cooled down in a bath of liquid He, the temperature of which is determined by the atmospheric pressure. The PJVS was operated with the NIST bias source (JVS-650) and associated software (*iPJVS Core 2021-v1208*) at all voltages. The BIPM traveling quantum voltage standard is flexible and can be modified to limit the errors, when identified, introduced by the participant's electromagnetic environment and possible systematic errors and noise due to grounding effects and/or AC capacitive coupling effects. For instance, the BIPM-PJVS is electrically floating with no connection to earth potential, but its low potential side can be grounded whenever necessary. The series resistance of each of the precision measurement leads is 2.5 Ω , and their leakage resistance to earth is 80 G Ω .

For the option II comparison measurement, the BIPM used an EM-N11 analog nanovoltmeter, its associated input reversal switch and the control software, designed by the BIPM, to measure the voltage difference between the two quantum voltage standards.

2.2 The INRiM PJVS

At INRiM, the reference standard for DC voltage is a 10 V Programmable Josephson Voltage Standard (PJVS) [3] fabricated by *Supracon AG* and computer-controlled with the *AC-SupraVOLTcontrol* software [4] The software allows the user to check the array performances as well as to generate programmable DC quantum voltages and run automated DC voltage calibrations, including direct comparison with another Josephson standard.

The PJVS device is mounted at the lower end of a cryoprobe for operation in liquid helium. The voltage across the array is controlled by means of a floating-ground multi-channel DC bias source

and a portable microwave source whose frequency can be tuned from 69.5 GHz to 70.5 GHz in steps of 1 kHz. A Keithley 2182A nanovoltmeter is used to verify array performance (critical current, step flatness) and to serve as a null detector for the calibration of DC voltage sources. A software-controlled low-thermal EMF scanner is used to automatically implement the necessary electrical connection between the PJVS, null detector, and device under test, as well as to perform the polarity reversals necessary to cancel offset voltages in the measurement circuit.

The main specifications of the PJVS array are a critical current $I_c = 8$ mA at 4.2 K and a step width larger than 1 mV with an RF power of about 60-80 mW.

2.3 Grounding configuration

Prior to performing any measurement of the voltage difference between the two PJVS, the stability of the measurement setup was checked by measuring the Quantum Locking Range (QLR) of each PJVS while being connected in the measurement setup.

All along the comparison, the BIPM PJVS was very stable, exhibiting a critical current of $I_c = 5.8$ mA and a QLR varying from $\Delta I = 1.48$ mA to $\Delta I = 1.58$ mA whatever the tested grounding configuration.

For historical reasons, the INRiM PJVS was installed in a shielded room. The capabilities of this equipment were never used since the door has never been closed during the time of the comparison. Nevertheless, the PJVS mains power was distributed through the shielded room associated designed filter. In addition, the 10 MHz reference signal, provided by the INRiM Time and Frequency Department was provided through a feed-through BNC adaptor forcing the potential of the Faraday cage to the reference potential of the 10 MHz reference signal.

Since the INRiM PJVS was perturbed by the interferences of the measurement setup, losing its quantum behaviour and introducing a sloped step within the QLR, we decided not to use the shielded room mains power supply as well as the BNC connector for the distribution of the 10 MHz reference signal. We also added an isolation transformer on the 10 MHz reference signal upstream of its distribution to the two PJVS.

The stability on the INRiM quantum voltage standard was recovered when the outer of the 10 MHz reference signal was connected to the selected reference ground point: Earth potential of the

mains. The dewars were also grounded but the shielding of the connection cables in the measurement setup needed to be left at a floating potential: the reason relies on the fact we did not succeed to get rid of a small leakage current between the reference potential points of the two setups despite being connected to the same Earth potential reference point. The only way to suppress the small leakage was to interrupt the continuity of the shielding of the connection cables. Within these conditions, we could perform the comparison in excellent conditions.

It was however required to check the quantization of the INRiM PJVS quite often since its quantization was lost from time to time whose rational explanation couldn't be found.

3. Comparison procedures: - Option I at the 10 V level

For comparison Option I the voltage output of the BIPM PJVS is connected to the participant's measurement setup. The INRiM measurement setup is equipped with a scanner providing three different possible inputs. All the measurements were performed on the channel A of the scanner.

After the BIPM PJVS was set up and checked for trapped flux, the array was biased to the same voltage as the INRiM PJVS. The BIPM PJVS offers the flexibility that its output voltage can be accurately adjusted to the one generated by the participant. In the present case, the BIPM JVS was biased to the same voltage as the INRiM PJVS $U = 9.999\,977\,422\text{ V}$. This corresponds to a selection of 264 260 Josephson junctions of the BIPM array, biased at $f = 18.300\,035\,050\text{ GHz}$.

3.1 Results at the 10 V level

The reference ground of the chassis of the instruments that constituted the BIPM PJVS was connected to the laboratory ground potential. The BIPM standard was connected in series-opposition with the INRiM PJVS at the input of the scanner normally used to select the secondary standard to be calibrated (channel A). In this comparison scheme (option I), the INRiM PJVS measurement set-up was used to measure the BIPM transportable PJVS voltage as if it were a Zener voltage standard. During the comparison, only the biases of the two arrays were reversed (no mechanical switch reversal). The polarity reversal was typically completed in less than 5 s.

The EMF differences between the BIPM PJVS and the INRiM PJVS array were measured using a digital nanovoltmeter *Keithley 2182A* operated on its 10 mV range and processed in real-time with the Supracon data acquisition and calculation software operated in “Comparison Mode”.

Eight data points were taken consecutively - with the simple mean value being considered as the result of one series. Each individual data point represents the mean of 40 measurements (20 in positive and 20 in negative polarity). The nanovoltmeter input was shorted before each polarity reversal and restored right after. Each series lasted about 15 minutes.

Frequency and power of the microwave irradiating each PJVS array were set to maximize the quantum operating margins and were kept fixed throughout the whole on-site comparison.

Remark: The number of data points per series couldn't exceed 8 and this is why each data point was performed with the maximum number of individual measurements. Later on, for the 1 V comparison, we discovered that it could be possible to directly enter the number of measurements manually.

The result of the first series of 8 individual points $(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = 0.64 \times 10^{-10}$ was obtained with an experimental standard deviation of the mean of 2.29×10^{-10} .

As a follow-up of this excellent agreement, 6 more series of 8 individual points were measured. All of them are represented on Figure 1.

The result of the comparison at 10 V is calculated as the average of all the measurement points (56 in total) and the corresponding Type A uncertainty is calculated as the standard deviation of the mean of the complete sample. This gives:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -0.38 \times 10^{-10} \text{ with a relative Type A uncertainty of } 0.85 \times 10^{-10}.$$

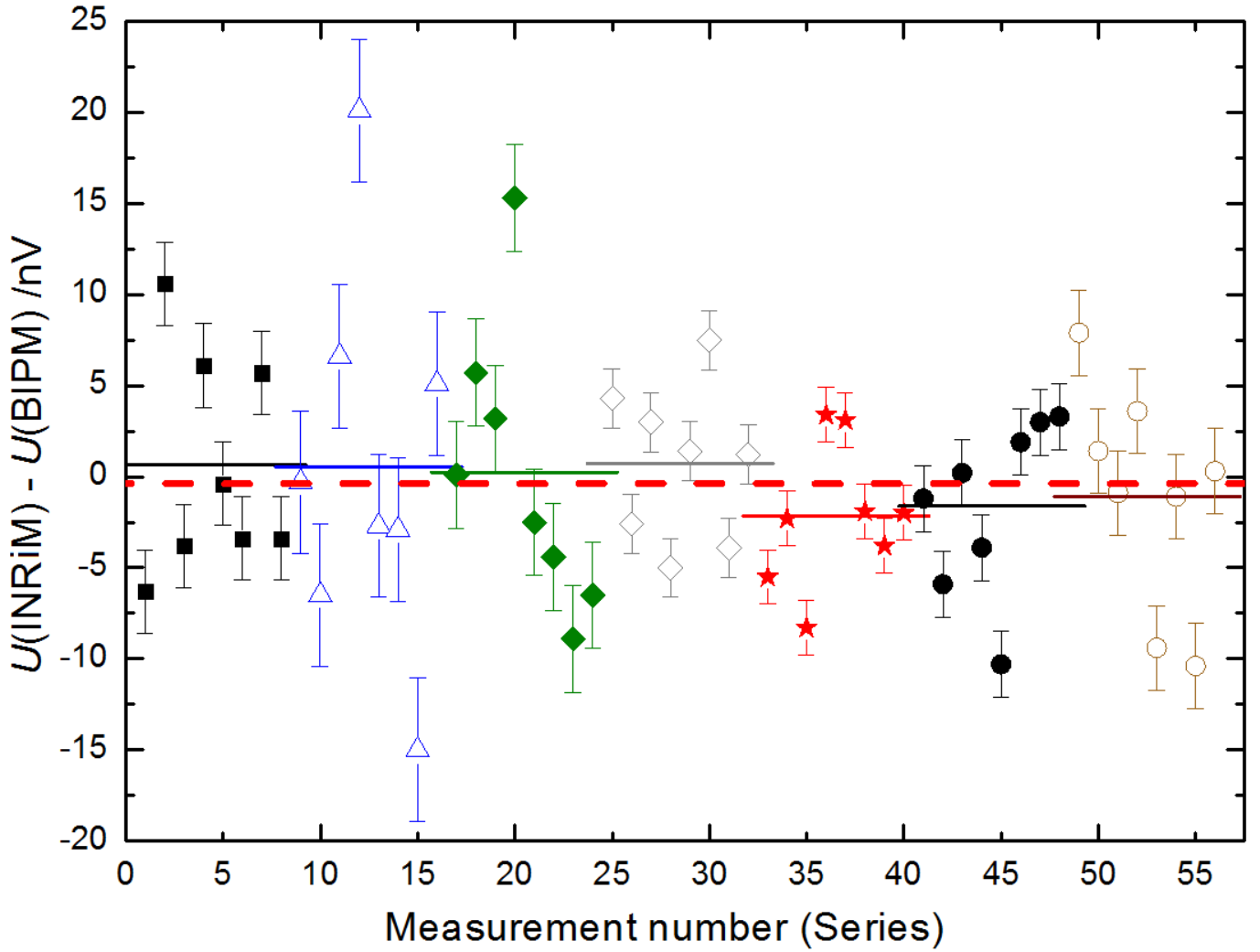


Figure 1: Individual results obtained to calculate the result of the option I comparison scheme at the level of 10 V: The solid lines represent the mean value of each of the 7 series, the red dashed line (— —) represents the simple mean of all the series representing a total of 56 individual points.

3.2 Results at the 1 V level

After the BIPM PJVS was checked for trapped flux, the array was biased to the same voltage as the INRiM PJVS $U = 1.000\,012\,265\text{ V}$. This corresponds to a selection of 26 425 Josephson junctions of the BIPM array, biased at $f = 18.300\,300\,818\text{ GHz}$.

A first series of 10 individual points was performed while the BIPM PJVS output connected to channel A of the INRiM measurement setup.

The result of this first series $(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -0.31 \times 10^{-9}$ was obtained with an experimental standard deviation of the mean of 1.33×10^{-9} .

As a follow-up of this excellent agreement, an additional series of 10 individual points was performed. All of them are represented on Figure 2.

The result of the comparison at 1 V (Option I) is calculated as the average of all the measurement points (20 in total) and the corresponding Type A uncertainty is calculated as the standard deviation of the mean of the complete sample. This gives:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = 0.4 \times 10^{-10} \text{ with a relative Type A uncertainty of } 0.98 \times 10^{-9}.$$

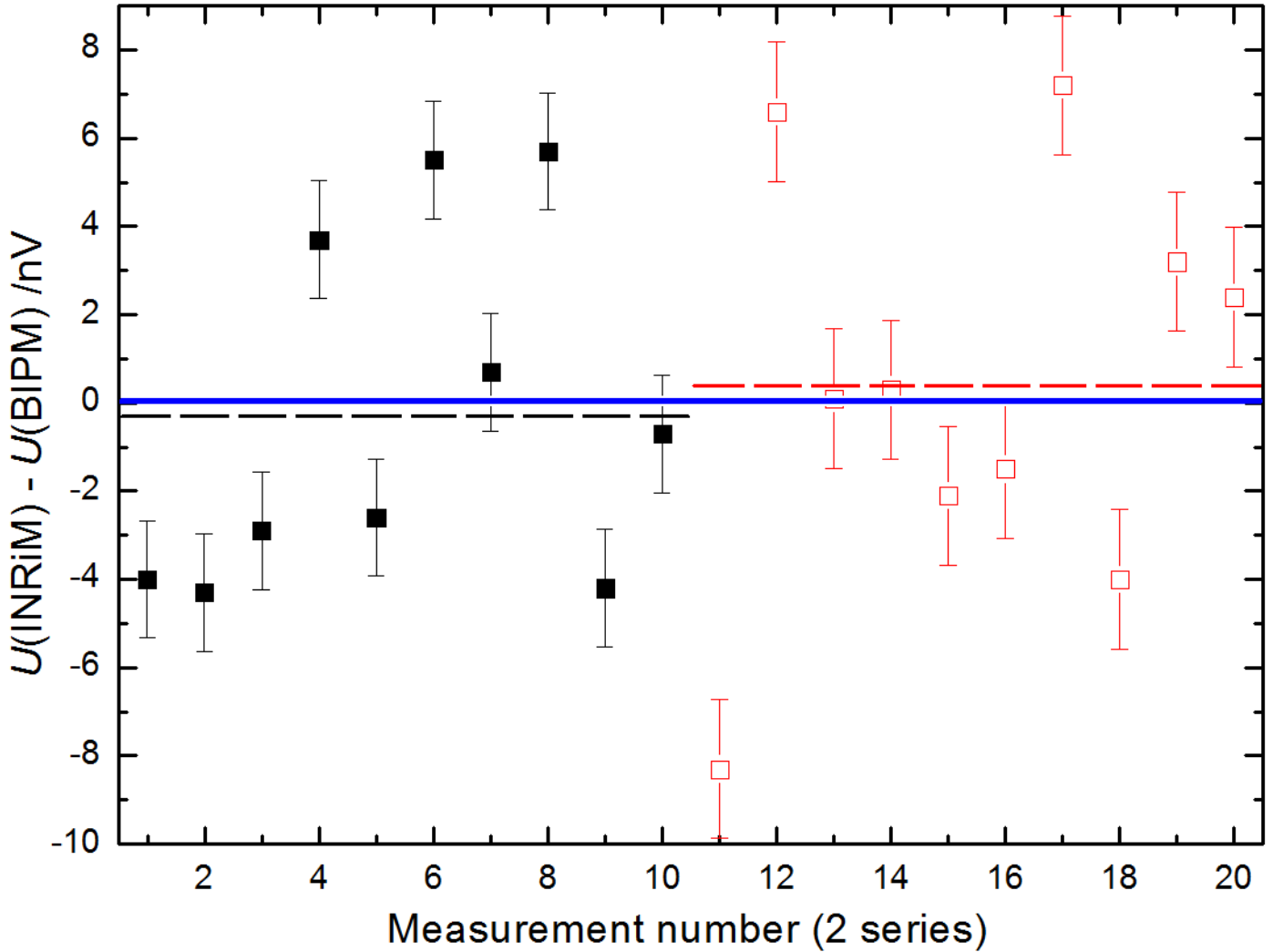


Figure 2: Individual results obtained to calculate the result of the option I comparison scheme at the level of 1 V: The dashed (— —) lines (black and red) represent the mean value of each of the 2 series, the blue solid line represents the simple mean of the two series representing a total of 20 individual points.

This comparison result showed that the two standards were in excellent agreement. Therefore, during the remaining period dedicated to the comparison, experiments were performed to investigate on the QLR limits and the leakage resistance of the measurement setup.

4 Leakage Resistance

BIPM and INRiM measured the leakage resistance at the output measurement leads independently and the corresponding values are reported in Section 7. In order to emphasise any possible leakage current between the two primary voltage standards we decided to carry out an experiment where we artificially modified the line resistance between the two PJVS.

4.1 Measurement setup

The measurement setup is presented on Figure 3. The insertion of R between the two positive polarities of the PJVS artificially increases the line resistance which is normally equal to $(2r_{\text{INRiM}} + 2r_{\text{BIPM}})$. Hence, the line resistance increases such as the corresponding voltage error due to the leakage effect [5,6]. The leakage resistance of each PJVS system is represented symbolically on the figure as R_L (INRiM) and R_L (BIPM).

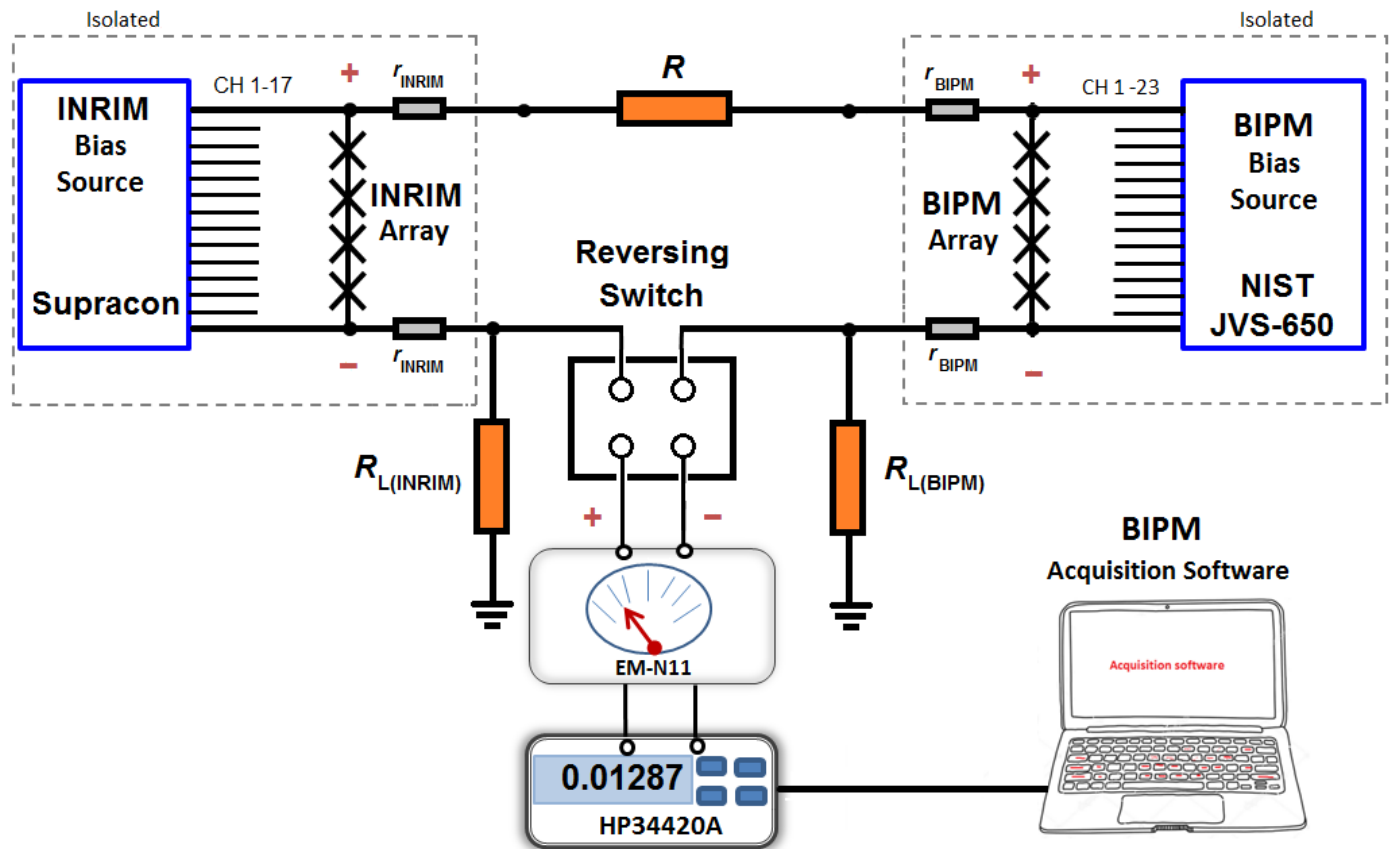


Figure 3: Schematic setup of the investigation on the total leakage resistance of the measurement setup at the level of 10 V. R is the additional resistance placed in between the positive polarities of the output measurement leads. R_L (INRiM) and R_L (BIPM) are the leakage resistances and $(2r_{\text{INRiM}}, 2r_{\text{BIPM}})$ are the line resistances of each PJVS output measurement leads.

4.2 Results

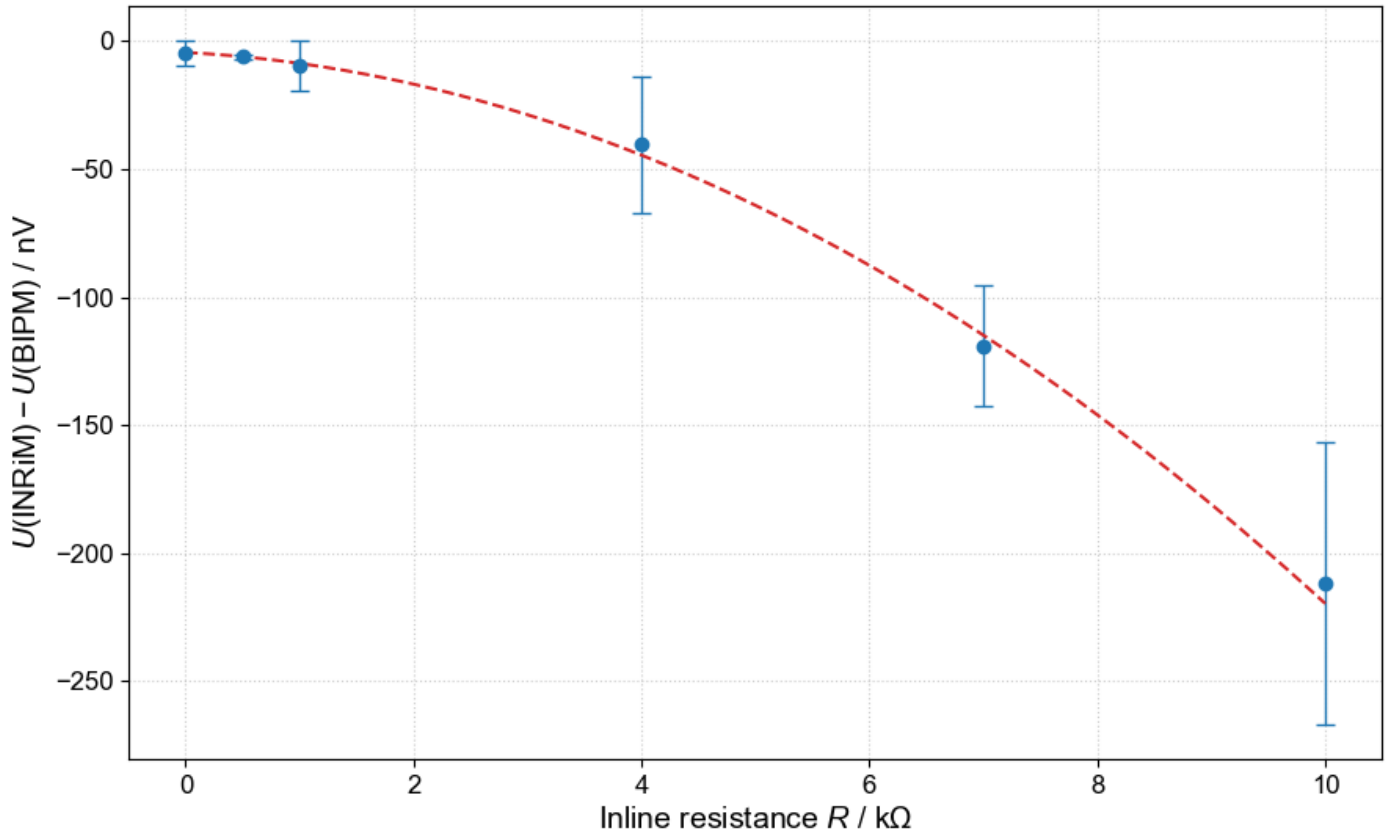


Fig. 4: Results of the investigation on the leakage resistance presented as the voltage difference between the two PJVS as a function of the value of the additional resistance inserted between the two high potential terminals of the quantum standards.

The results (Figure 4) give an idea of the total voltage error due to leakage from the equation of the parabolic fit of the data:

$U(\text{INRiM}) - U(\text{BIPM}) = -2 \times 10^{-6} \times R^2 - 3.3 \times 10^{-3} \times R$. Considering the values of $2r_{\text{INRiM}}$ and $2r_{\text{BIPM}}$, and taking $R = 2r_{\text{INRiM}} + 2r_{\text{BIPM}}$ the residual voltage error due to leakage to ground is $U(\text{INRiM}) - U(\text{BIPM}) = -0.03$ nV giving a higher voltage error due to the leakage on the INRiM PJVS. This value is nonetheless coherent with the uncertainty on leakage error given in Table 1 (0.04 nV). However, it is impossible to specifically identify whether the leakage path to ground is to electronics and power supply of the bias sources (BIPM or INRiM) or to the measurement leads. It is most probably a combination of all possible leakage to ground. The individual leakage resistance of each PJVS was determined aside this experiment.

5. Quantum Locking Range of the PJVS

5.1 Description of the measurements.

In order to investigate on the quantization of each Quantum Voltage Step, we determined the *Quantum Locking Range* (QLR), i.e. the interval of biasing current over which we can consider the 10 V Josephson voltage step to be quantized.

This investigation was carried out in the comparison mode, by changing the biasing current on one PJVS and measuring the voltage difference between the two standards (at least 3 measurement points in a row). In fact, the QLR of a PJVS on its own (without being connected to any external instrument) is much larger. Any additional instrument connected to the output measurement leads brings electrical noise to the PJVS and therefore shrinks the QLR.

5.2 Results of the QLR.

Once the experiment was performed on one PJVS, it was repeated on the other one as shown in Figure 5 with blue squares for the INRiM and red disks for the BIPM.

The two PJVS exhibited a very similar and broad QLR of 1.2 mA for the INRiM and 1.4 mA for the BIPM demonstrating an excellent behaviour of the two PJVS in the comparison mode.

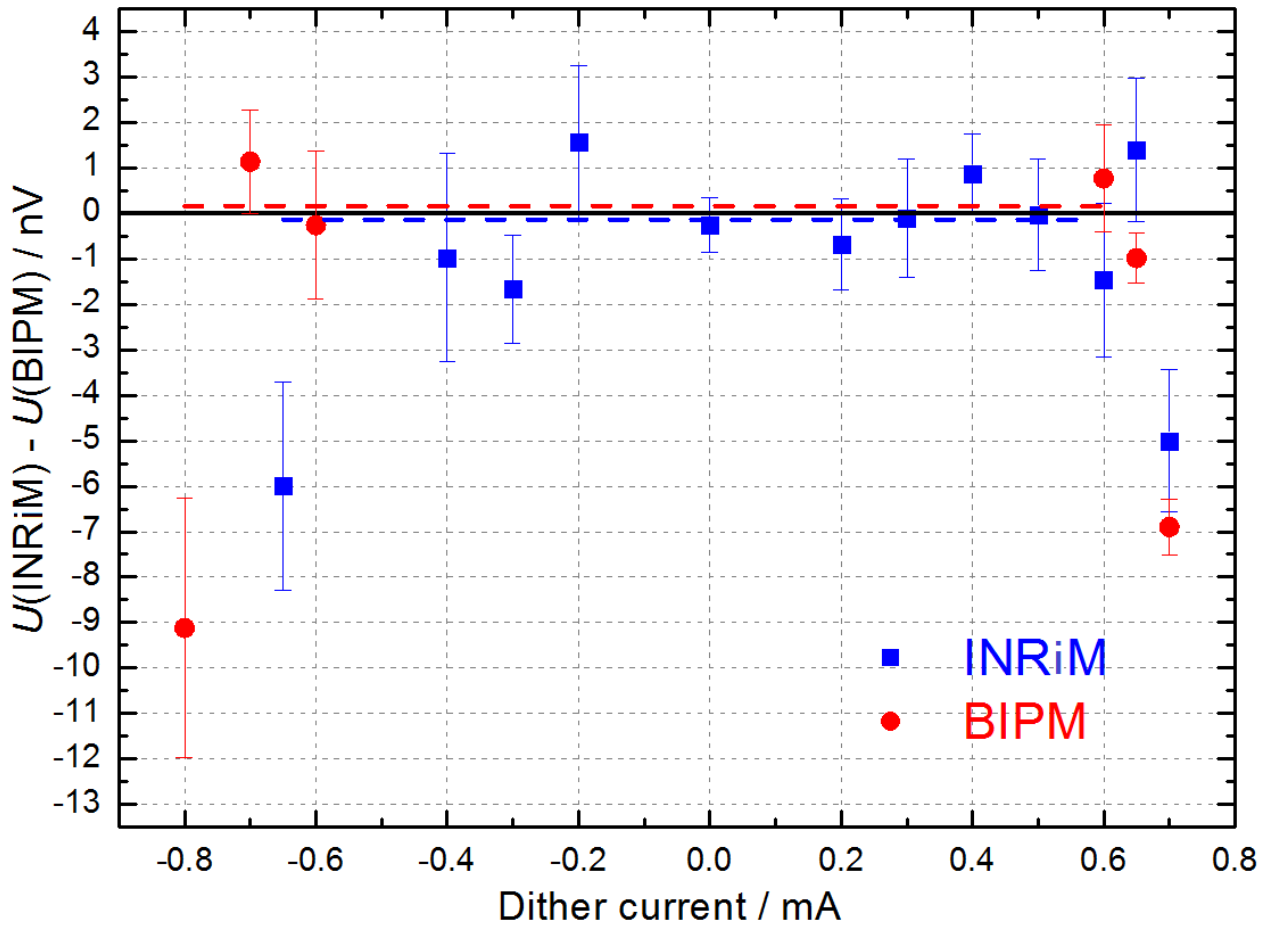


Figure 5: Quantum Locking Range (QLR) of the INRiM (blue squares) and the BIPM (red disks) presented as the voltage difference between the two PJVS as a function of the dither current applied on the biasing current from the central biasing point (represented by 0 mA on the X-axis).

6. Comparison procedures - Option II

6.1 Measurement set-up

The option II comparison protocol for DC direct comparison has been designed to achieve the lowest Type A uncertainty on the voltage difference between the participants using an analog nanovoltmeter EM-N11 which offers a lower internal noise than a digital nanovoltmeter (Cf. Figure 6). The grounding configuration of option I as well as the generated voltage are the same.

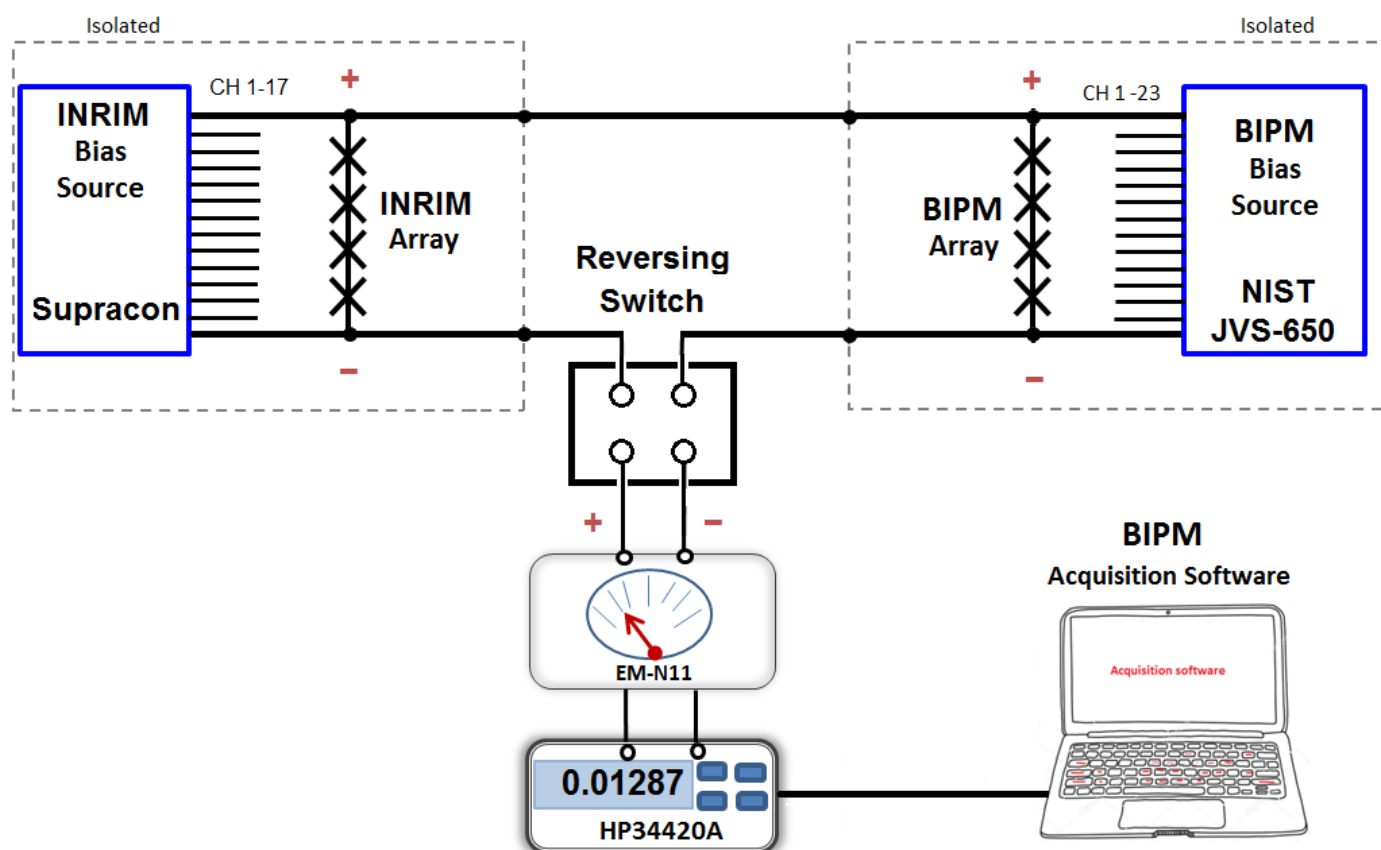


Figure 6: Measurement setup used for the Option II (1 V and 10 V DC). The switch which reverses the nanovoltmeter input has an “open position” (not represented)

The measurement loop was such that both positive polarities of the arrays were connected together but a nanovoltmeter EM N11 was placed between the two negative polarities of the arrays. The “High” of the nanovoltmeter was connected to the INRiM array and to the BIPM array alternatively during the acquisition process. The equipment included a voltage divider to prevent the detector from overload if both systems were no longer on the same selected voltage (frequency mismatch or trapped magnetic flux). The voltage divider is made from a low thermal EMFs switch for which the corresponding leakage resistance is higher than 5×10^{11} ohms (on ratio 1/1). The measurement software was changed and followed the process for one measurement point presented here:

- 1- Positive array polarity and reverse position of the detector;
- 2- 500 data readings acquisition;
- 3- Positive array polarity and normal position of the detector;
- 4- 500 data readings acquisition;
- 5- Negative array polarity and reverse position of the detector;
- 6- 500 data readings acquisition;

- 7- Negative array polarity and normal position of the detector;
- 8- 500 data readings acquisition;
- 9- Negative array polarity and reverse position of the detector;
- 10- 500 data readings acquisition;
- 11- Negative array polarity and normal position of the detector;
- 12- 500 data readings acquisition;
- 13- Positive array polarity and reverse position of the detector;
- 14- 500 data readings acquisition;
- 15- Positive array polarity and normal position of the detector;
- 16- 500 data readings acquisition.

After each polarity reversal 5 seconds elapsed before beginning the data acquisition in order to limit the amplitude of the effects of filter capacitor discharge. The total elapsed time for one measurement point is about 3 minutes.

6.2 Results at the 10 V level

A total of 20 individual measurement points were performed at the 10 V level: two series of 10 points on the range 3 μ V. Since the agreement was excellent, no further measurements were required (Cf. Figure 7).

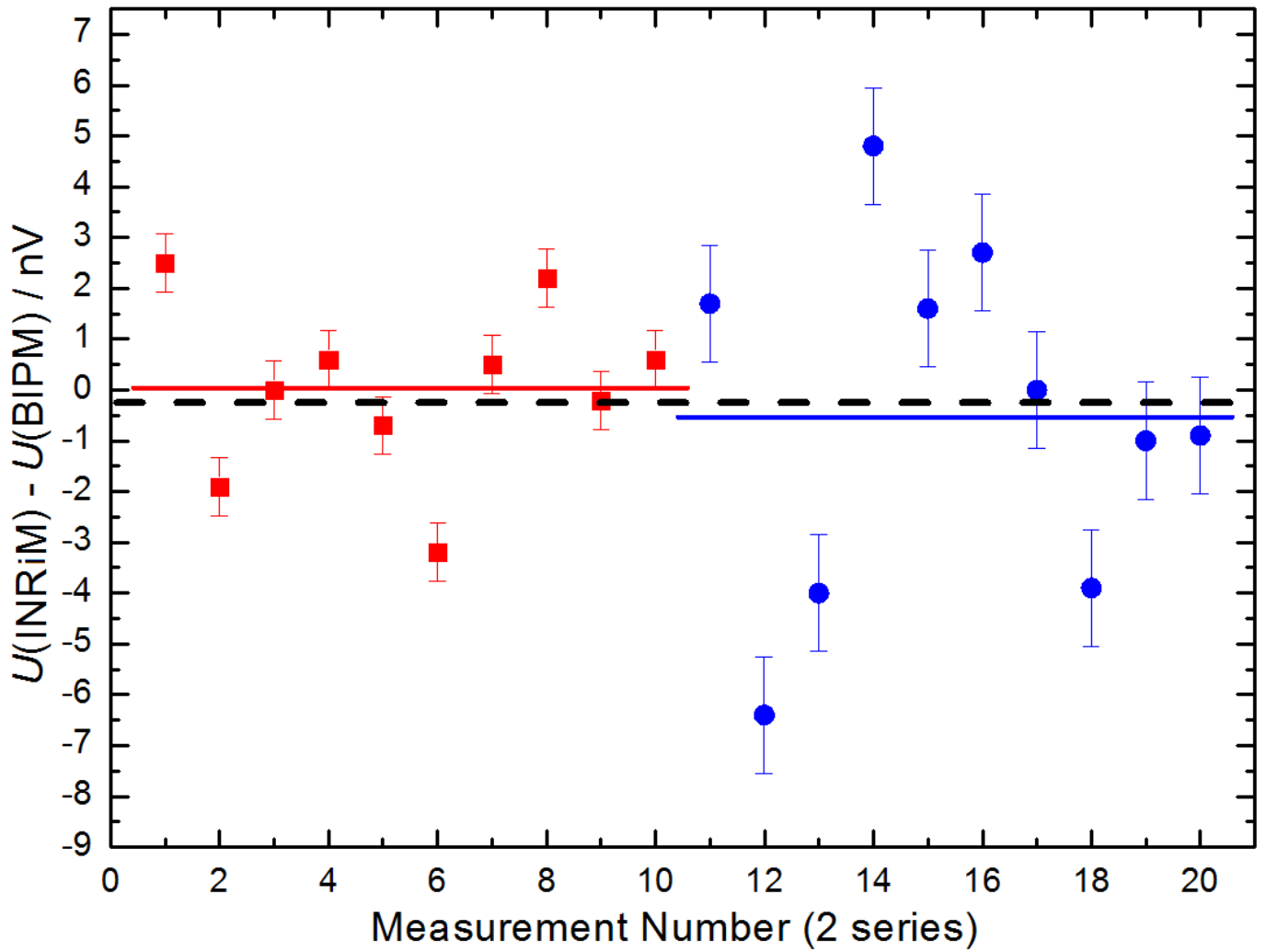


Figure 7: Individual results obtained with the Option II comparison protocol at the 10 V level. The uncertainty bars represent the standard deviation of the mean of each complete series (2 in total).

The result of the comparison at 10 V (Option II) is calculated as the average of all the measurement points (20) and the corresponding Type A uncertainty is calculated as the standard deviation of the mean of the complete sample. This gives:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -0.25 \times 10^{-10} \text{ with a relative Type A uncertainty of } 0.61 \times 10^{-10}.$$

6.3 Results at the 1 V level

The PJVS voltages were adjusted to 1 V (see Option I) and 3 series (34 individual points) were carried out within the following conditions (Cf. Figure 8):

- 1- 11 individual points performed on the 3 μV range of the EM-N11;
- 2- 13 individual points performed on the 1 μV range of the EM-N11;
- 3- 10 individual points performed on the 3 μV range of the EM-N11.

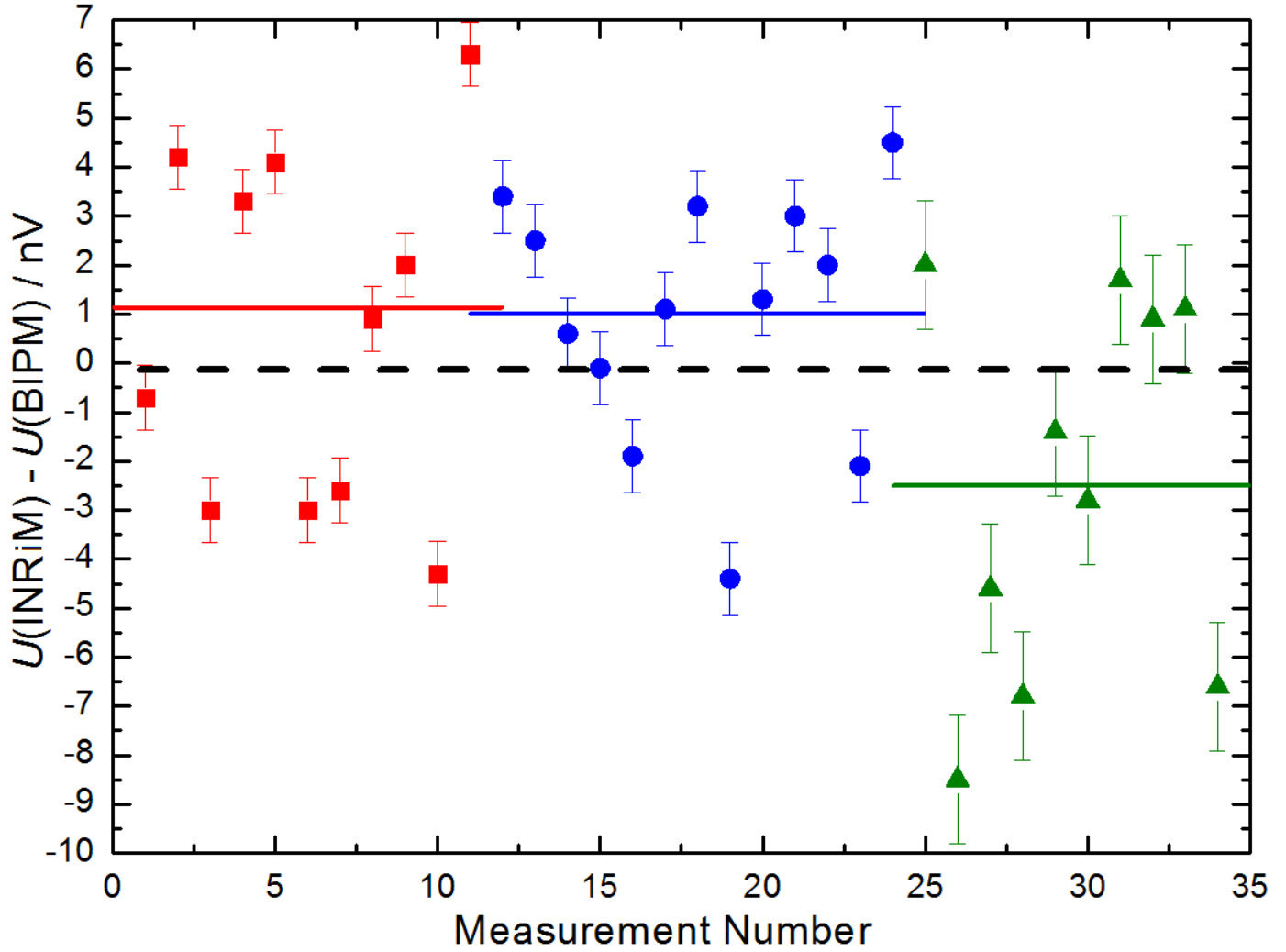


Figure 8: Individual results obtained using the Option II comparison protocol at the 1 V level. The uncertainty bars represent the standard deviation of the mean of each complete series (3 in total).

The result of the comparison at 1 V (Option II) is calculated as the average of all the measurement points (34) and the corresponding Type A uncertainty is calculated as the standard deviation of the mean of the complete sample. This gives:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -1.4 \times 10^{-10} \text{ with a relative Type A uncertainty of } 6.3 \times 10^{-10}.$$

7. Uncertainties and results

7.1 Option I - Type B Uncertainties

The sources of Type B uncertainty (Table 1) are: the frequency accuracy of the RF synthesiser, the leakage currents, and the detector gain and linearity. Most of the effects of detector noise and frequency stability are already contained in the Type A uncertainty. The effect of residual thermal EMFs (i.e. non-linear drift) and electromagnetic interferences are already contained in the Type A uncertainty of the measurements because both array polarities were reversed during the measurements. Uncertainty components related to RF power rectification and sloped Shapiro voltage steps are considered negligible because these were clearly identified and an adjustment of the biasing parameters eliminated the effects when they occurred.

	Type	Relative uncertainty*	
		BIPM	INRiM
Frequency offset ^(A)	B	3.2×10^{-12}	8.2×10^{-12}
Leakage resistance ^(B)	B	1.8×10^{-11}	2.3×10^{-11}
Detector ^(C)	B		7.0×10^{-14}
Total (RSS)	B	3.05×10^{-11}	

Table 1: Estimated Type B relative standard uncertainty components (Option I)

*see the text below for explanation.

^(A) As both systems referred to the same 10 MHz frequency reference, only a Type B uncertainty from the frequency generated by the respective RF sources is included. The 10 MHz signal used as the frequency reference for the comparison was distributed from the time and frequency laboratory and was locked to the main atomic clocks of INRiM.

The BIPM PJVS RF synthesiser frequency has an accuracy better than 0.01 Hz. We degrade this accuracy by 10 and apply a rectangular statistical distribution to the value. The relative uncertainty for the offset of the frequency can be calculated from the formula:

$$u_f = (0.1/\sqrt{3}) \times (1/18) \times 10^{-9} = 3.2 \times 10^{-12}.$$

According to the specifications, the accuracy of the INRiM 70 GHz synthesizer is the same as that of the external 10 MHz reference, although its resolution is 1 mHz. To remain conservative, a rectangular distribution with a half width of 1 Hz is assumed. Hence, the relative uncertainty for the offset of the frequency can be calculated from the formula:

$$u_f = (1/\sqrt{3}) \times (1/70) \times 10^{-9} = 8.2 \times 10^{-12}.$$

^(B) If a rectangular statistical distribution is assumed then the relative uncertainty contribution of the leakage resistance R_L can be calculated as: $u_L = (1/\sqrt{3}) \times (2r / R_L)$ [7]. For INRiM, the related variables were line resistance $r = 1 \Omega$ and $R_L = 5 \times 10^{10} \Omega$. This value for the isolation resistance includes all the cables from the array to the DVM as well as the scanner used in the measurement loop. In the case of the BIPM, $r = 2.5 \Omega$ and $R_L = 8 \times 10^{10} \Omega$.

^(C) A Keithley 2182A served as the null detector with the correction of (140 ± 1) ppm on its 10 mV range. The uncertainty on the gain has been obtained from the standard deviation of the mean of 10 measurements of the gain performed at different times after the comparison using the dedicated function of the *AC-supraVOLTcontrol* software. As the voltage read by the null detector was always below 700 nV, given by the maximum remaining thermal EMFs between the two PJVS, the uncertainty due to the detector after correction can be calculated as:

$$u_d = 1 \times 10^{-6} \times 700 \text{ nV} = 7.0 \times 10^{-13} \text{ V}. \text{ So, the relative uncertainty at 10 V is } 7.0 \times 10^{-14}.$$

7.2 Option II - Type B Uncertainties

The sources of Type B uncertainty for the option II are listed in Table 2.

Only the detector and associated software change compared to Option I.

	Type	Relative uncertainty	
		BIPM	INRiM
Frequency offset	B	3.2×10^{-12}	8.2×10^{-12}
Leakage resistance	B	1.8×10^{-11}	2.3×10^{-11}
Detector ^(D)	B	2×10^{-13}	
Total (RSS)	B	3.05×10^{-11}	

Table 2: Estimated Type B relative standard uncertainty components (Option II).

(D) The uncertainty on the accuracy of the nanovoltmeter is calculated from the difference between the nominal calibration factor and the measured one. The difference is applied to the maximum voltage difference measured by the N11 on the 3 μ V range and is equal to: $u_D = 0.25$ nV.

An EM N11 served as the null detector on the 3 μ V range at 10 V and on the 3 μ V and 1 μ V ranges at 1 V. Although the two PJVS were exactly set to 10 V, the maximum remaining thermal EMFs between the two standards, of amplitude 700 nV were measured by the nanovoltmeter. The gain correction was not measured since it is insignificant to be applied to the readings. The uncertainty on the gain is about 5×10^{-6} according to our experience with this type of nanovoltmeter [6]. We apply this uncertainty to the maximum measured voltage considering a rectangular statistical distribution: the standard uncertainty of the detector can then be calculated as:

$u_d = 5 \times 10^{-6} \times 700 \times 10^{-9} \text{ V} / \sqrt{3} = 2.02 \times 10^{-12} \text{ V}$. Therefore, the relative uncertainty at 10 V is 2.02×10^{-13} .

8. Discussion and conclusion

The comparison was carried out in the INRiM Quantum Voltage Standard Laboratory where an excellent stability was achieved on both PJVS from the start of the comparison despite the presence of some random electromagnetic interference in the shielded room. These interferences had no impact on the BIPM PJVS but affected the quantization of the voltage output of the INRiM PJVS. No rational explanation could be stated but our investigations showed that the insulation resistance between the potential of the outer connector of the bias cables to the INRiM probe were perfectible as if a cable would create an intermittent short-circuit. The consequence was a loss of quantization of the PJVS voltage. When the INRiM array was properly biased, the comparison results exhibited an excellent agreement as it can be seen from the final results where the total combined uncertainty is the quadratic combination of the Type A uncertainty and the Type B uncertainties:

At 1 V:

The result using option I, expressed as the relative difference between the values attributed to the 1 V BIPM PJVS by the INRiM PJVS measurement set-up (U_{INRiM}) and by the BIPM (U_{BIPM}) is:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = 4.0 \times 10^{-11} \quad \text{and} \quad u_c / U_{\text{BIPM}} = 9.8 \times 10^{-10},$$

where u_c is the total combined standard uncertainty.

The result using option II, expressed as the relative difference between the values attributed to the 1 V INRiM PJVS by the BIPM PJVS measurement set-up (U_{BIPM}) and the INRiM (U_{INRiM}) is:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -1.4 \times 10^{-10} \quad \text{and} \quad u_c / U_{\text{BIPM}} = 6.3 \times 10^{-10},$$

where u_c is the total combined standard uncertainty.

At 10 V:

The result using option I, expressed as the relative difference between the values attributed to the 10 V BIPM PJVS by the INRiM PJVS measurement set-up (U_{INRiM}) and the BIPM (U_{BIPM}) is:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -3.8 \times 10^{-11} \quad \text{and} \quad u_c / U_{\text{BIPM}} = 9.0 \times 10^{-11},$$

where u_c is the total combined standard uncertainty.

The result using option II, expressed as the relative difference between the values attributed to the 10 V INRiM PJVS by the BIPM PJVS measurement set-up (U_{BIPM}) and the INRiM (U_{INRiM}) is:

$$(U_{\text{INRiM}} - U_{\text{BIPM}}) / U_{\text{BIPM}} = -2.5 \times 10^{-11} \quad \text{and} \quad u_c / U_{\text{BIPM}} = 6.8 \times 10^{-11},$$

where u_c is the total combined standard uncertainty.

Both the results of Option I and II are published in the KCDB; however, the best ones are selected as degrees of equivalence which would be the results of Option I for the 1 V level and Option II for the 10 V level.

The Degrees of equivalence are stated in Table 3.

Nominal Voltage / V	1	10
Relative Difference / 10^{-11}	4	-2.5
Relative Total Expanded Uncertainty ($k=2$) / 10^{-11}	196	14

Table 3: Degrees of equivalence INRiM - BIPM for the DC comparison at 1 V and 10 V.

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