**Bilateral Comparison of 1 Ω and 10 kΩ resistance standards between the JV and the BIPM, June 1997**

by D. Bournaud*, T. Sørsdal** and T.J. Witt*

*Bureau International des Poids et Mesures, F-92312 Sèvres Cedex
** Justervesenet, Fetveien 99, 2007 Kjeller, Norway

Comparisons of the reference standards of resistance of the BIPM and the JV were carried out at the 1 Ω and 10 kΩ values. Two 1 Ω and two 10 kΩ standard resistors were brought from the JV to the BIPM and measured from 4 June to 30 June, 1997. The BIPM values are referenced to $R_{K-90}$ realized with the BIPM quantum Hall resistance standard via a group of reference resistors. The type B uncertainty for this step is 1.5 parts in $10^8$. The JV values are referenced to $R_{K-90}$ via extrapolation from the results of previous calibrations at the BIPM.

Table 1 lists the results of the comparison at 1 Ω. Details of the JV values and uncertainties are contained in the letter of Tore Sørsdal of 11 November 1997 supplemented by an e-mail message of 19 November 1997. Details of the BIPM results are reported on Calibration Certificates number 53 and 54 of 27 November 1997. The final result is calculated from the mean of the results obtained from the two travelling standards. From usual uncertainty propagation analysis, the type A variance of this value is the sum of the type A variances of the travelling standards divided by the square of the number of travelling standards. The total variance of the result is the sum of (1) the type A variance, (2) the type B variances and (3) the variance deduced from the transfer uncertainty.

The final results of the 1 Ω comparison are presented as the difference between the value assigned to a 1 Ω standard by the JV, $r_{JV}$ and that assigned by the BIPM, $r_{BIPM}$ on the reference date. This gives

$$r_{JV} - r_{BIPM} = 27\ \text{n}\Omega; \qquad u_c = 62\ \text{n}\Omega, \text{ on } 1997/06/15,$$

where $u_c$ is the combined type A and type B standard (1-σ) uncertainty from both laboratories.

Table 2 lists the results of the comparison at 10 kΩ. Details of the JV values and uncertainties are contained in the letter of Tore Sørsdal of 11 November 1997 supplemented by an e-mail message of 19 November 1997. Details of the BIPM results are reported on Calibration Certificates number 55 and 56 of 27 November 1997. The final result is calculated from the mean of the results obtained from the two travelling standards. From usual uncertainty propagation analysis, the type A variance of this value is the sum of the type A variances of the travelling standards divided by the square of the number of travelling standards. The total variance of the result is the sum of (1) the type A variance, (2) the type B variances and (3) the variance deduced from the transfer uncertainty.

The final results of the 10 kΩ comparison are presented as the difference between the value assigned to a 10 kΩ standard by the JV, $R_{JV}$ and that assigned by the BIPM, $R_{BIPM}$ on the reference date. This gives

$$R_{JV} - R_{BIPM} = 120\ \mu\Omega; \qquad u_c = 670\ \mu\Omega, \quad \text{on } 1997/06/16,$$

where $u_c$ is the combined type A and type B standard (1-σ) uncertainty from both laboratories.

The results of these comparisons are excellent. Previous experience leads us to expect transfer uncertainties of the order of 5 parts in $10^8$ for these types of standard resistors.

Table 1. Results of the comparison at 1 Ω.

| | | | |
|---|---|---|---|
| | 1870737 | 64179 | |
| Mean date (yy/mm/dd) | 97/6/15 | 97/6/15 | |
| JV value, $R_{JV}$ / Ω | 0.999 992 139 | 0.999 998 813 | |
| JV relative uncorrelated unc. (A&B) $\times 10^8$ | 3.7 | 3.0 | $p$ |
| JV relative correlated unc. (B) $\times 10^8$ | 5.2 | 5.2 | $q$ |
| JV relative unc. (A&B) $\times 10^8$ | 6.4 | 6.0 | $s$ |
| | | | |
| BI value, $R_{BI}$ / Ω | 0.999 992 099 | 0.999 998 798 | |
| BI relative unc. (A) $\times 10^8$ | 0.04 | 0.08 | $t$ |
| BI relative unc. (B) $\times 10^8$ | 1.5 | 1.5 | $v$ |
| BI relative unc. (A&B) $\times 10^8$ | 1.5 | 1.5 | |
| | | | |
| $[(R_{JV}-R_{BI})/R] \times 10^8$ | 4.0 | 1.5 | |
| Mean $[(R_{JV}-R_{BI})/R] \times 10^8$ | 2.7 | | |
| Rel. unc. of transfer $\times 10^8$ | 1.77 | | $x$ |
| | | | |
| Total unc. of comparison $\times 10^8$ | 6.2 | | See note a. |

Note a. The total uncertainty of the comparison is calculated from

$$u_c = \sqrt{x^2 + q^2 + \left(\frac{(p^2{}_{37} + p^2{}_{79})}{2^2}\right) + v^2 + \left(\frac{(t^2{}_{37} + t^2{}_{79})}{2^2}\right)}$$

This assumes correlation between the type B components of the JV uncertainty component due to the extrapolation of previous calibration results to the measurement mean date.

Table 2. Results of the comparison at 10 kΩ.

| | 25036 | 224102 | |
|---|---|---|---|
| Mean date (yy/mm/dd) | 97/6/15 | 97/6/15 | |
| JV value, $R_{JV}$ / Ω | 10 000.000 71 | 10 000.002 56 | |
| JV relative unc. (A) $\times 10^8$ | 2.8 | 2.8 | *p* |
| JV relative unc. (B) $\times 10^8$ | 6.0 | 6.0 | *q* |
| JV relative unc. (A&B) $\times 10^8$ | 6.6 | 6.6 | |
| | | | |
| BI value, $R_{BI}$ / Ω | 10 000.000 69 | 10 000.002 33 | |
| BI relative unc. (A) $\times 10^8$ | 0.07 | 0.06 | *t* |
| BI relative unc. (B) $\times 10^8$ | 1.5 | 1.5 | *v* |
| BI relative unc. (A&B) $\times 10^8$ | 1.5 | 1.5 | |
| | | | |
| $[(R_{JV}-R_{BI})/R] \times 10^8$ | 0.2 | 2.3 | |
| Mean $[(R_{JV}-R_{BI})/R] \times 10^8$ | 1.2 | | |
| Rel. unc. of transfer $\times 10^8$ | 1.47 | | *x* |
| | | | |
| Total unc. of comparison $\times 10^8$ | 6.7 | | See note a. |

Note a. The total uncertainty of the comparison is calculated from

$$u_c = \sqrt{x^2 + q^2 + \left(\frac{(p^2{}_{36} + p^2{}_{102})}{2^2}\right) + v^2 + \left(\frac{(t^2{}_{36} + t^2{}_{102})}{2^2}\right)}$$

This assumes correlation between the type B uncertainty components.