The paper summarizes results of two international comparisons relating ac-dc voltage transfer standards of the National Research Council of Canada (NRC) to the standards of VSL, PTB and NIST. The first comparison was part of the CCE 92-05 Intercomparison of AC-DC Voltage Transfer Standards at HF (1-50 MHz), designated as a key comparison, with results published before NRC participation [1]. The second comparison was carried out using a calorimetric thermal voltage converter of NRC design. Results of comparisons conducted so far show very good agreement between NRC and the three other NMIs in the frequency range from 10 Hz to 100 MHz.

Abstract

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Introduction

Several techniques are used to realize ac-dc transfer standards in the frequency range above the range of Multijunction Thermal Converters (MJTC). The popular standards used at HF frequencies are coaxial calorimeters or a coaxial assembly of a resistor and an UHF vacuum junction thermal voltage converter as a calculable thermal converter. At NRC the highest accuracy HF ac-dc transfer standard is realized in the form of a Calorimetric Thermal Voltage Converter (CTVC) of an in-house design, [2, 3]. The LF ac-dc difference of the CTVC is determined by comparison with a MJTC, where the frequency characteristic of the converter is calculated theoretically. The purpose of the NRC participation in the international comparisons reported in this paper was to confirm and verify the correctness of this approach.

The first comparison, part of CCE 92-05 Intercomparison of AC-DC Voltage Transfer Standards at High Frequencies (1-50 MHz), was piloted by VSL and used a VSL designed standard. The second comparison, piloted by NRC, uses CTVC as the travelling standard and was conducted over the frequency band from 10 Hz to 100 MHz. Its additional goal was to test the CTVC as a possible travelling standard for future NORAMET or SIM comparisons.

Each of the NMIs participating in the comparison derives its HF ac-dc transfer standard independently. VSL [4] and NIST [5] use a calculable coaxial resistor connected in series with an UHF-type vacuum junction thermal converter. However, the NIST sampling voltmeter will also be used in CTVC measurement [6]. At PTB, from 10 Hz to 1 MHz a MJTC [7] is used. At higher frequencies a coaxial dual dry-load calorimeter serves as the primary standard [8].

NRC Participation in CCE 92-05 Intercomparison

During this highest accuracy comparison two travelling standards were used: VSL Calculable HF ac-dc transfer standard (TS-HF) and a commercial converter, Fluke model A55, TS-A55. The TS-HF converter was a 5 mA, 4 V converter equipped with a type-N male input connector. The TS-A55 converter was a commercial 5 mA, 3 V converter with a GR874 input connector. Both converters were measured at NRC in September 1998. Fig.1 shows the ac-dc difference of the TS-HF converter, as determined by VSL, the pilot laboratory, and NRC. The base value in Fig.1 is the mean value of the comparison, as reported in [1]. Very good agreement between the two laboratories should be noted; at 100 MHz the difference in the measured ac-dc difference was less than 1.5x10⁻² μV/V, significantly less than the combined uncertainty of the two laboratories (11x10⁻², k=1). A similarly good agreement between VSL and NRC was achieved when TS-A55 was measured using an
asymmetrical Tee (N/NGR874) supplied by the pilot laboratory. However, results obtained using NRC asymmetrical Tee were significantly different from VSL results, approximately 22×10² μV/V, which prompted investigation of the parameters of the asymmetrical Tees. These tests, which will be reported separately, confirmed that the differences are due to the asymmetrical Tee design.

**Calorimetric Thermal Voltage Converter**

The NRC calorimetric converter has been designed with an internal Tee. One arm of the Tee, a short coaxial line, is terminated by a microwave rod resistor. Energy dissipated in this resistor raises its temperature above the temperature of the enclosure. The resistor temperature is measured by a 100-junction copper-constantan thermopile. To the other arm of the Tee is soldered the center pin of the type-N connector, used to attach a converter under test. The input test voltage is applied to an SMA type connector connected to the center of the Tee by a copper plated stainless steel tube.

The CTVC is mechanically and electrically stable and not easily damaged by overloading. However, it is relatively more difficult to measure than a regular TVC due to its small output voltage, 4.5 mV at 1 V, long time constant (15 s) and a close coupling of the cold junctions of the thermopile to the enclosure. The experience of this comparison has shown that it usually requires modifications in the ac–dc automatic comparator software and a close attention to the good thermal insulation from the ambient. Consequently, the standard deviation of a typical test was much higher than in tests of a MJTC, in the range of a few μV/V.

Three of four laboratories have finished testing the CTVC. Some of the measurements performed, up to 1 MHz, are presented in Fig. 2 as a deviation from the average of the values of the four (three above 0.1 MHz) laboratories. The results shown mirror results from the LF comparison CCE 92-2 [7], differences between the two comparisons can be attributed to the inherently less precise CTVC measurements. The final results will be presented at the Conference.

**Summary and Conclusions**

The comparisons performed so far show good agreement between the NRC, VSL, PTB and NIST ac–dc transfer standards in the whole frequency band. The experience in using the CTVC as the travelling standard showed thus far its very good stability and repeatability. However, it's the outer enclosure should be redesigned to better insulate active part of the CTVC from the ambient.

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**References**


