

Johnson Noise Thermometry in the Range 505 K to 933 K using Resistance-based Scaling

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The International Temperature Scale of 1990 (ITS-90) [1] is an artifact-based temperature scale designed to approximate thermodynamic temperature. The existence of thermodynamic errors in the ITS-90 have been known since its adoption, but these have only recently been quantified by primary thermodynamic methods such as acoustic gas thermometry for $T < 510$ K [2]. Johnson Noise Thermometry (JNT) is another primary method which can be applied over wide temperature ranges. NIST is currently using JNT to determine the deviations of ITS-90 from thermodynamic temperature in the range 505 K to 933 K, overlapping ranges of both acoustic gas-based and radiation-based thermometry. These data on ITS-90 deviations will allow the highly accurate acoustic gas-based data at lower temperatures to be linked with the higher-temperature radiation-based data, forming the basis for a new International Temperature Scale with greatly improved thermodynamic accuracy.

Advances in digital electronics have now made viable the computationally-intensive and data-volume-intensive processing required for JNT using noise voltage correlation in the frequency domain. We have used resistance-based scaling techniques in a switched-input digital correlator operating at balanced noise power. Data are derived from Ni-Cr elements in 5-wire quartz-insulated noise probes which are compared directly to standard platinum resistance thermometers. The reference noise power spectra are obtained from a set of known resistance-temperature products at $T < 400$ K. Statistical uncertainties under $100 \mu\text{K/K}$ are achievable by fitting the effects of transmission-line time constants over bandwidths as large as 900 kHz.

[1] H. Preston-Thomas, *Metrologia* **27**, 1990, pp. 3-10, *ibid.*, p. 107 (erratum).

[2] Strouse, G.F., Defibaugh, D.R., Moldover, M.R., and Ripple, D.C., in "Temperature: Its Measurement and Control in Science and Industry; Volume VII; 8th International Temperature Symposium, Chicago IL, Oct. 21-24, 2002," edited by D.C. Ripple, pp. 31-36, AIP Confer. Proc. CP684 (2003).