External sound card based practical Johnson noise thermometer

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In this paper, the design of a practical Johnson noise thermometer is presented. Theory of operation is similar to that presented in [1]. The main difference lies in the different injection of the reference signal into the system. The presented design uses a wideband transformer with a transformation ratio of 15625:1 for injecting reference signal instead of resistors, similar to the one in [2]. The reference signal is an optimized multisine signal with low crest factor [3]. This is important because this type of signal makes better use of the available dynamic range and minimizes distortion. The analog part of the thermometer is completely galvanically isolated from the rest of the measurement system including the analog-to-digital converter (ADC) and the digital-to-analog converter (DAC). A sound card was selected for ADC and DAC. The selected sound card (RME ADI 2 Pro FS R BE) has all the characteristics necessary for measuring the voltage ratios. The reference signal of the DAC was measured with a multimeter (HP 3458A) to account for the non-ideal voltage reference of the sound card. The thermometer's probe is designed to withstand temperatures of 300 °C. The analog front end consists of two amplifiers of the same design, but separated from each other. This separation includes different battery power supplies, enclosures, cables from the sensor and cables to the DAC. The system can measure Johnson noise up to 300 kHz, which is limited by the sampling frequency of the sound card. The analog front end is intentionally limited to a bandwidth of 1 MHz to minimize amplification of EM interferences. Preliminary measurement results of the presented measurement system prototype will be presented in the final version of the paper. The presented study is part of research project No. J2-1721 - New generation of industrial Johnson noise thermometers. The authors thank the Slovenian Research Agency for financial support.

References

[1] P. Bramley, D. Cruickshank, and J. Pearce, “The Development of a Practical, Drift-Free, Johnson-Noise Thermometer for Industrial Applications,” International Journal of Thermophysics, vol. 38, no. 2, p. 25, Dec. 2016
[2] L. Callegaro, V. D’Elia, M. Pisani, and A. Pollarolo, An absolute Johnson noise thermometer. 2009
[3] E. Van der Ouderaa, J. Schoukens and J. Renneboog, "Peak factor minimization of input and output signals of linear systems," in IEEE Transactions on Instrumentation and Measurement, vol. 37, no. 2, pp. 207-212, June 1988, doi: 10.1109/19.6053.