NEW LOW-VOLTAGE STANDARDS IN THE DC TO 1 MHz FREQUENCY RANGE

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Summary Abstract

Several new techniques for measuring the rms value of 1 to 600-mV signals have been developed and compared to existing thermal transfer standards. Differences between the techniques at 100 mV are typically within ±20 ppm in the audio-frequency range and within ±100 ppm out to 1 MHz.

Introduction

Standards for ac voltage rely on the ac-dc difference of thermal voltage converters (TVCs) which have uncertainties of <1 part per million (ppm) in the audio-frequency range to <100 ppm out to 1 MHz. However, existing TVCs have a lower limit of about 100 mV (most commercial converters are limited to 500 mV). At 100 mV and below, micropotentiometers have been used as 0.1% standards for a number of years.

Recent measurements indicate that a properly designed micropotentiometer, often referred to as a μpot, may be substantially more accurate than previously thought in the dc to 1 MHz frequency range.

New Developments

A new high input-impedance thermal transfer standard (TTS) has been used to intercompare various low-voltage measurement techniques with a resolution approaching 1 ppm. The TTS uses wideband amplification to scale signals between 1 and 600 mV up to levels that can be measured by a thermal sensor [1]. The ac-dc differences of the TTS at 100 mV were determined between 20 Hz and 1 MHz by comparing it to a specially designed thermal voltage converter with a nominal input voltage of 250 mV. The TTS was then used as a transfer standard to calibrate two μpots with different terminating resistors. The ac-dc differences of the TVC and the corrected differences of the TTS and the μpots are given in the table below.

A calculable digitally synthesized source (DSS) [2] has been modified to generate 1 to 100 mV signals from dc to 5 kHz. The DSS uses a look-up table and two digital-to-analog converters to produce a precise stepped sine wave, which can be characterized using a dc voltmeter. The ac-dc differences of the DSS (as measured by the TTS) are also given in the table below.

AC-DC Differences at 100 mV (ppm)

Freq.	TVC	TTS	μpot-1	μpot-2	DSS
20 Hz	28	43	-1	-7	-7
1 kHz	-5	8	-1	-6	0
20 kHz	-2	-7	-5	-10	
50 kHz	-7	13	-9	-15	
100 kHz	-21	32	-1	-11	
1 MHz	259	-28	79	-12	

The new low-voltage measuring instruments and their sources of error will be described in detail in the final paper. Additional measurements down to 1 mV using these instruments will be included, and other techniques and instruments for measuring low levels (resistive and inductive voltage dividers, and digital multimeters) will be discussed.

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Conclusions

The new low-voltage thermal transfer standard has made it possible to intercompare thermal converters, micropotentiometers, and a digitally synthesized source to a precision of 1 ppm. The results indicate that micropotentiometers are inherently more accurate transfer devices in the dc to 1 MHz frequency range than low-voltage TVCs.

References

1. L.L. Szepesi, "Recent Developments on Solid State Thermal Voltage Converters," pp. 9-13 of the conference record, Measurement Science Conference, 1986.

2. N.M. Oldham, P.S. Hetrick, and Xiangren Zeng, "A Calculable, Transportable Audio-Frequency AC Reference Standard," IEEE Trans. Instrum. Meas., vol. 38, no. 2, pp. 368-371, April 1989.