PERFORMANCE EVALUATION OF A NEW AUDIO-FREQUENCY POWER BRIDGE

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Abstract

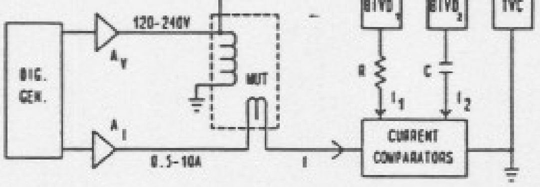
Several techniques for measuring active and reactive power in the 50 Hz to 20 kHz frequency range are described. These approaches were developed to evaluate a new high-accuracy, audio-frequency power bridge that is based on ac voltage and impedance measurements.

Introduction

Standards for ac power are based on impedance bridge [1], thermal [2], and sampling [3] techniques. However, these standards are normally limited to power frequencies (50 Hz to 1 kHz). New energy sources, such as photovoltaic systems, operate more efficiently by converting dc to ac power at frequencies up to 20 kHz. The power bridge described, in part, in [4] was designed to support measurements of these systems.

Power Bridge

A simplified diagram of this power bridge is shown in the figure below. The wattmeter under test (MUT) is supplied by a dual channel digital generator followed by power amplifiers (A_V and A_I). The test voltage is scaled to 10 V (with a two-stage voltage transformer) where it is measured using a thermal voltage converter (TVC).



Reference currents I_1 and I_2 are established using binary inductive voltage dividers (BIVD$_1$ and BIVD$_2$) and impedances R and C. The test current I is compared to the sum of I_1 and I_2 using a current comparator. The active power applied to the wattmeter is a function of the measured voltage and R. The bridge consists of components that can be individually characterized, but instrumentation to evaluate the entire system to uncertainties of ±200 parts per million (ppm) at 20 kHz is not available. Thus, several techniques were devised for this purpose.

Sampling Wattmeter

A high-precision sampling wattmeter was constructed using two sampling digital voltmeters. The test voltage (120 V) was scaled to 0.5 V using a resistive divider and the current (5 A) was also scaled to 0.5 V using a 0.1-ohm shunt. These low-level signals were then simultaneously sampled over a whole number of periods and the power was computed as the average value of the products of the sample pairs [3]. This technique proved to be particularly useful at zero power factor where the bridge errors could be separated from the sampling wattmeter errors.

Digital Source

A dual-channel digitally synthesized source was used to verify measurements at zero power factor. The inherent phase linearity of such a source has been shown to be well within ±100 microradians in the audio-frequency range. Precise phase shifts from $+\pi/2$ to $-\pi/2$ radians (zero power factor lead and lag) are made by simply changing the starting address of one of the memories that stores the sampled waveform.

Thermal Converters

At unity power factor the power is simply the product of the rms voltage and current (a 1000-microradian error in phase angle causes less than 1 ppm error in power). Therefore, conventional thermal converter techniques may be used to measure the test voltage and current directly.

Conclusions

Modifications have been made to an audio-frequency power bridge to improve its performance. The bridge has been evaluated up to 20 kHz using various techniques which indicate that its uncertainties are within the expected ±200 ppm for active power. Details of the bridge modifications and the three measurement techniques employed will be included in the final paper.

References

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