AUDIO-FREQUENCY ANALYSIS OF INDUCTIVE VOLTAGE DIVIDERS BASED ON STRUCTURAL MODELS

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Abstract: A Binary Inductive Voltage Divider (BIVD) is compared with a Decade Inductive Voltage Divider (DIVD) in an automatic IVD bridge. New detection and injection circuitry was designed and used to evaluate the IVDs with either the input or output tied to ground potential. In the audio frequency range the DIVD and BIVD error patterns are characterized for both in-phase and quadrature components. Differences between results obtained using a new error decomposition scheme based on structural modeling, and measurements using conventional IVD standards are reported.

Introduction

Inductive Voltage Dividers are inherently extremely linear devices. Methods for determining IVD linearity have been described in the literature. A new method has been developed in which IVDs with different structures were intercompared and the measurement data were fitted to models that describe each of the divider structures to give the linearity of each IVD [1]. This approach requires a priori knowledge of the IVD error patterns. Results of measurements made over the audio frequency range using classical methods and the new modeling method are compared.

Balance Circuit

In the IVD bridge a balance circuit compares the IVD output voltages and injects the appropriate signal to balance the detector reading. To minimize the influence of the detection circuitry on the measurement, a novel balance circuit was designed. The design was inspired by Thompson's "difference transformer" described in [2]. The simplified balance circuit is shown in Fig. 1. When used with the IVD output taps driven to virtual ground, the detection transformer consists of a single layer of coaxial cable wound on a toroidal core. At the midpoint of this winding the outer conductor was broken and the detector and injector were connected providing a ground point at the middle of the structure. This design minimized the effects of capacitive loading. For measurements made with the IVD inputs grounded, the detection transformer was constructed using a twisted pair of coaxial cables wound on the core so that the tap-to-tap connection could be guarded from the grounded detector.

IVD Errors in the Audio Frequency Range

The new balance circuit was incorporated into the automatic IVD bridge described in [3] which was then used to measure the voltage difference between a BIVD and a commercial automatic DIVD over the audio frequency range up to 20 kHz.

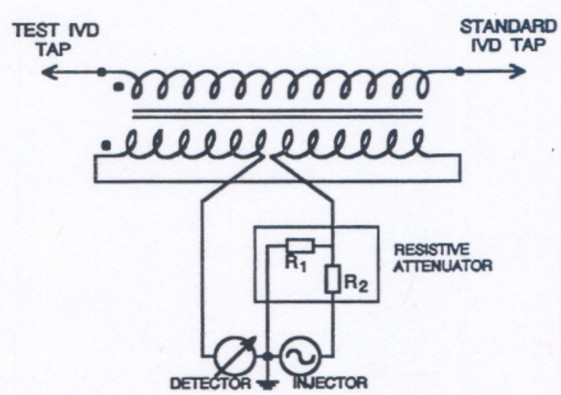

Fig. 1. Simplified scheme of the balance circuit.

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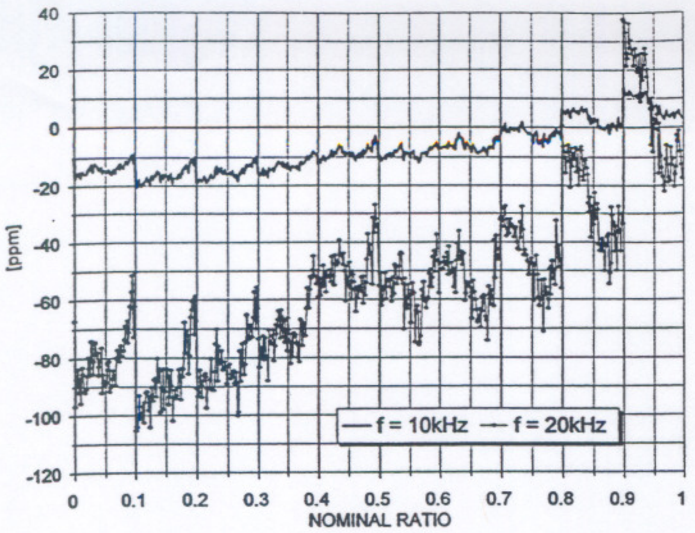

Fig. 2a. DIVD in-phase errors.

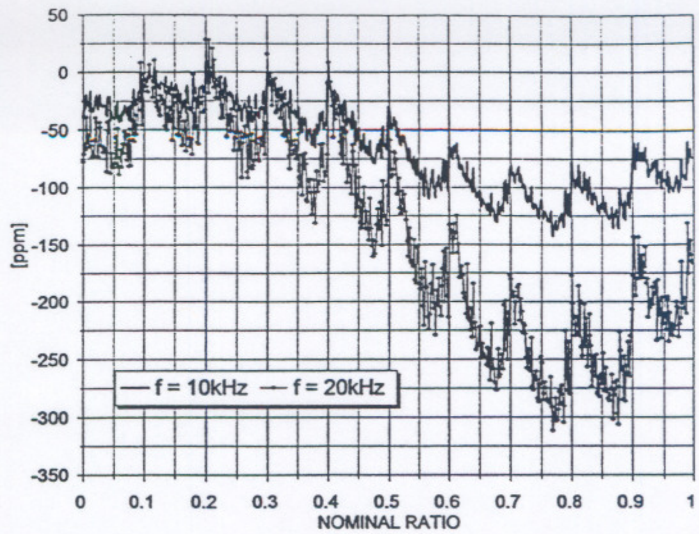

Fig. 2b. DIVD quadrature errors.

The error decomposition method proposed in [3] was used to analyze the IVD errors. This method is based on modeling the structure of the tested devices with orthogonal vectors to determine the linearity of the IVDs. DIVD in-phase and quadrature errors determined by this method at 10 and 20 kHz are shown in Fig. 2a and 2b respectively.(Note the difference in scales).

At 1 kHz, the DIVD in-phase errors were computed using the decomposition method and also measured at 10 cardinal points using a standard decade IVD calibration system [4]. These are shown in Fig 3. The estimated measurement uncertainty of that standard system is ± 0.5 parts per million (ppm), while the 2σ uncertainty of the error decomposition method calculated from the residuals is 0.07 ppm.

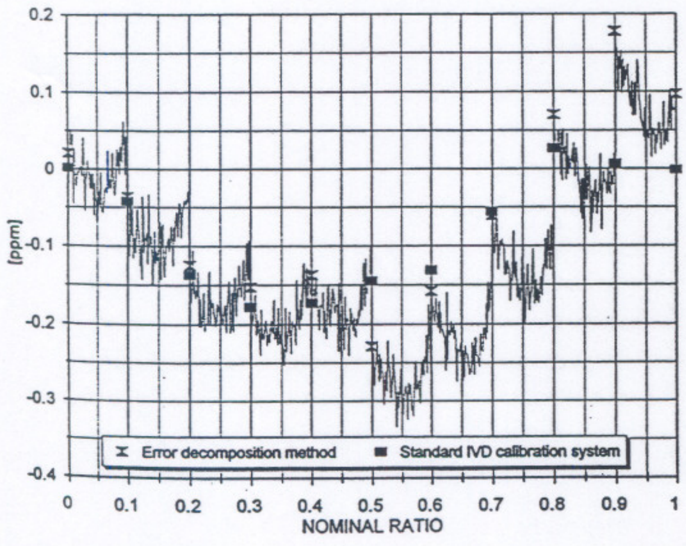

Fig. 3. DIVD in-phase errors at 1kHz.

The errors at ratios other than the cardinal points are significant. Since IVDs may be used at any ratio, test points should be selected in such a way that these errors can be estimated. This will be described in more detail in the final paper.

Acknowledgements.

This project was partially funded under NASA contract NAS 3-25370. The authors thank Robert Palm for his assistance in the fabrication of system components and Gerard Stenbakken for his valuable contributions to the structural model development. Thanks go to Charles Levy for providing data used in the error comparison.

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