

A Current Comparator Bridge for the Measurement of AC Resistance up to 100 kHz

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Introduction

In order to extend the frequency range of the NPL Audio Frequency Wattmeter it has become necessary to characterise the AC/DC difference and time constant of current shunts used for measuring current at frequencies up to 100 kHz. Similar AC resistance measurements are also used for other purposes such as the measurement of AC currents in a coil. Conventional twisted-pair resistance bridges are unsuitable at such frequencies and so a coaxial arrangement is required.

The resistors used for current measurement either have the resistor as part of the inner of the coaxial line or, as here, the resistor is connected between the inner and outer of the coaxial line. This paper describes suitable standards of the latter kind and the construction of a bridge to measure them.

Resistance Standards

The current shunts used with the Audio Frequency Wattmeter are constructed by connecting low-power metal-film resistors in parallel between two copper plates as described by Laug [1]. One plate is connected to the inners of a pair of coaxial UHF connectors, and the other to the outers. One connector acts as the current terminals, the other as the potential terminals.

The standard resistor developed for use with the current comparator bridge is constructed differently, in such a way that the frequency dependence is calculable. A 1 ohm resistor has been made whose AC value at 100 kHz is calculated to differ by less than 10 ppm from the DC value.

Current Comparator Bridge

The current comparator bridge shown in Fig. 1 is used instead of the more usual potential bridge based on the ratio of a transformer. The current comparator consists of three screened windings on a toroidal core. One 100 turn, A, is tapped at 99 and 100 turns and the other, B, at 10, 20, 50 and 100 turns. There is also a 300 turn detector winding. The current through the windings A and B are provided by the independently adjustable outputs of a two-channel source via separate isolating transformers. These transformers and the comparator are mounted in a metal box. The A and B windings emerge via triaxial cables. The inner screens of the triaxial cables, shown as broken lines, are connected to one end of A and B, as shown, so that they have the same potential as the conductors inside them. This

ensures that cable capacitance does not affect the measurement. The separately-screened detector winding is outside the screens of the two 100 turn windings.

The 99 turn tapping on winding A enables the off-balance indications of the detector to be calibrated. The tapings on winding B allow different resistor values to be measured.

The separate detector transformer D consists of a high-permeability toroidal core surrounding the inner coaxial conductor. The 10 turn transformer detector winding around the core is connected to D_2 and is completely screened from the inner conductor. The potential coaxial connectors of the coaxial resistors are directly connected to the terminals of D. The current coaxial connectors of the resistors are connected to the appropriate output tapings of the current comparator. The inner screen of the triaxial cable is terminated as close to the coaxial connection to the resistor as possible.

Measurement method

R_A is driven from the 100 turn tapping, and R_B from the tap of winding B appropriate for the nominal ratio of the resistor. The magnitude and phase difference of supplies A and B are adjusted to produce zero flux in the core of the comparator transformer as indicated by a null of the detector D_1 . The ratio of the currents passing through the two resistors are then in inverse proportion to the number of turns in which the currents are flowing. The indication of the linear detector D_2 is proportional to the small difference in the voltage produced across the two resistors.

This indication of D_2 , which is proportional to the difference in the departures of the two resistors from their nominal value, can be calibrated using the 99 turn tapping of winding A because this will generate a 1% change in the current ratio.

The time constant of the resistor can be calculated from the phase difference between the supplies, with a small correction for the phase error of the transformer. This phase error can be measured by reversing the positions of nominally identical resistors.

Acknowledgements

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References

- [1] O.L.Laug, "A wide band transconductance amplifier for current calibrations", IEEE Trans. Instrum. Meas. vol IM-34, pp.639-643, Dec 1985

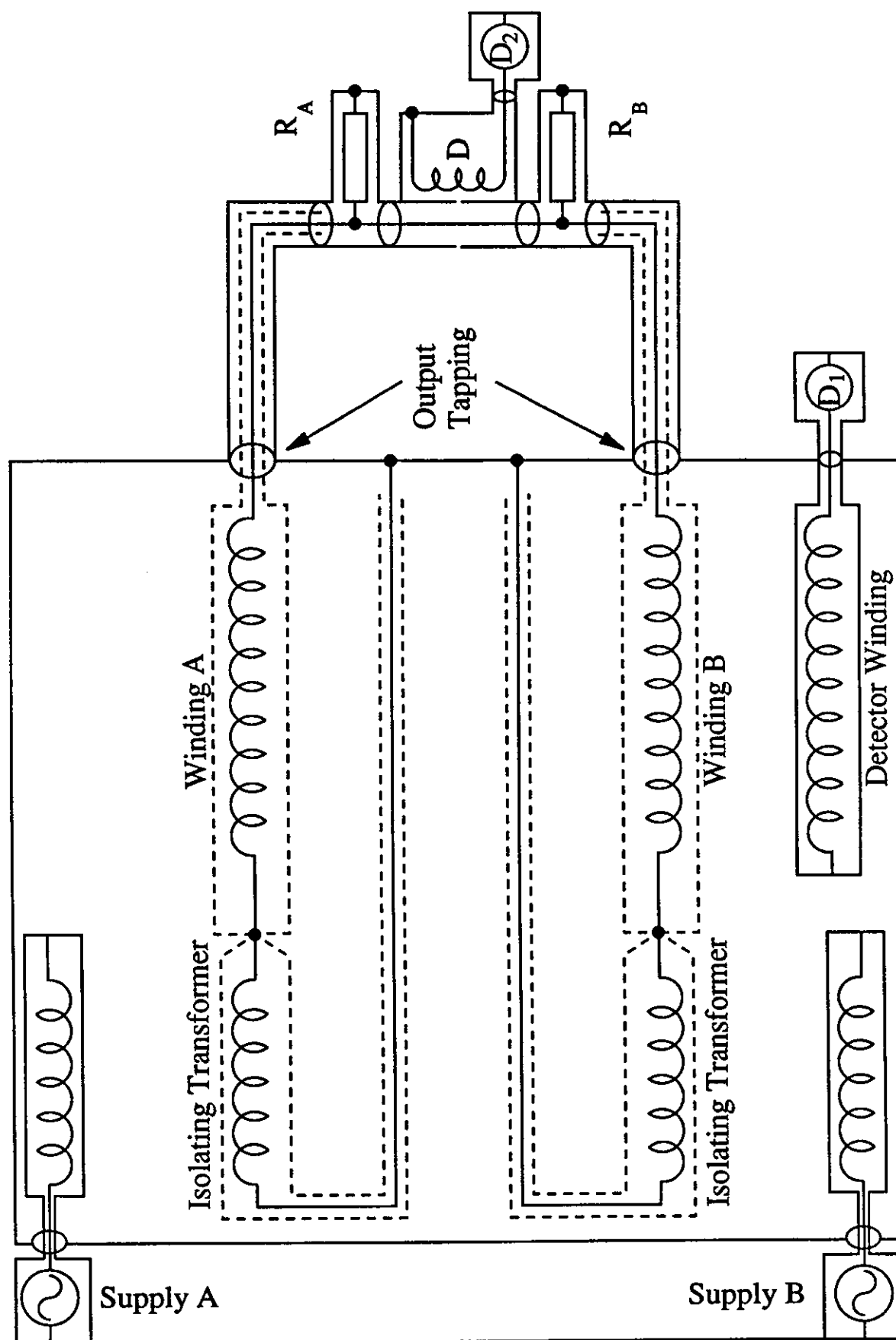


Figure 1