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A TWO-CHANNEL CURRENT MEASURING SYSTEM FOR MEASURING LEAKAGE CURRENT IN HIGH DIRECT VOLAGE MEASUREMENTS

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Abstract

This paper describes the design and implementation of a high resolution current measuring system for measuring leakage currents in high voltage dividers for dc.

Introduction

Many NMI and Calibration Laboratories use Park-type resistor dividers to measure high direct voltage [1]. Such dividers are designed to keep both surface and bulk leakage currents low so that their effect on the measurement of voltage is small compared with the estimated uncertainty of that measurement. It is desirable that this should be verified as part of the maintenance of the measuring system under the Quality System.

The approach adopted here is similar to that used on the dividers at the UK end of the France-UK high direct voltage link [2], that is, comparative measurements of the current into the high voltage end of the high voltage arm with the current out of the high voltage arm. For clean, new, dividers constructed of uniform materials and having a shielded low voltage arm (the grounded shield collects the leakage current) this difference is equal to the leakage current. For an aged divider with some surface contamination, some of the leakage current may flow back into the high voltage resistor and this possibility must be considered: however, this amount will be second order.

The uncertainty of high direct voltage measurements made at INMS is 20 μV/V: a target resolution of 0.0001% was set. An influencing factor was to reach this target using equipment with a proven history where feasible.

Current Measuring System

The current measurement system consists of two measurement channels: each channel comprises a current–to-voltage converter, four parallel differential input ADC, a 10 V reference for offset measurements, and a fibre optic link to a remote computer where the measured data is stored for later analysis. Because both channels are isolated, it is possible to interchange the systems to eliminate the effects of any residual bias on the comparison.

Current-to-Voltage Converters. Precision resistors were used as voltage-to-current converters. One is used to replace the usual low voltage arm and the other is mounted on a shielded platform at the high voltage input. Standard resistance boxes provide the elements for Hamon resistors: by selecting the number of parallel resistors it is possible to obtain an output of about 10 V for the current corresponding to a selected high voltage. A range of high voltage inputs can be covered using various combinations of resistors available in the laboratory.

Differential input ADC. While it would have been possible to mount a precision meter on the shielded platform, operated it with a custom built power supply, and read it with a fibre optic system, it would have been more cumbersome and costly than using ADC. However, no ADC with sufficient accuracy or resolution were available. This lead to the choice of differential inputs used with a 10 V reference connected to one side (two battery operated references were available in the laboratory). The ADC selected had an input impedance of ≥ 1GΩ, a resolution of 16 bits and a specified accuracy of 0.1% (sic). Four channels were specified with gains of 1, 100, 300, and 1000. All channels can be used in parallel(digitization is simultaneous, reading over the link is sequential) or just selected channels may be connected. Gain 1 can be used for inputs from 0 V to 10 V, gain 100 from 9.9 V to 10 V, gain 300 from 9.97 V to 10 V, and gain 1000 from 9.99 V to 10 V: this gives a versatile system that can be adapted to the stability of the high voltage source. The system is battery operated with a working time of about 4 hours and a charging time of 16 hours.

Reference Voltage. The reference sources are two Fluke 732A sources.

Fibre Optic Link and interface. The fibre optic link comprises separate cables, one to carry instructions to the ADC and one to carry the data back to the computer. The interface is USB2 operating in the high speed mode.

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Calibration

The resistances of each setting of the current–to-voltage converters were calibrated against a reference standard using an HP3458A. The voltage references were calibrated against the laboratory reference standard. Each complete channel was calibrated using a Datron 4808 which was calibrated against the laboratory reference standard. All calibrations were performed before and after each period of work.

Acknowledment

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