THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

RESEARCH DIVISION REPORT

To Mr. J.R. Leslie
Manager
Electrical Research Dept

CURRENT AND VOLTAGE TRANSDUCERS FOR THE LOW-LEVEL INSTRUMENTATION SYSTEM

O.W. Iwanusiw

Described in this report is a multiplexing circuit that provides one output proportional to the applied voltage and another proportional to the current in a high-voltage circuit. The multiplexing equipment is called a CVT in this report, short for current and voltage transducer.

The report briefly describes various configurations of the CVT, pointing out advantages and disadvantages of each. Areas requiring research are identified and recommendations are made regarding further work in this field.

The CVT

The simple configuration of the CVT is shown in Figure 1. It consists of two capacitive dividers, C1-C2 and C3-C4 having identical ratios, and an impedance Z. It can be shown that the output of the C1-C2 divider is proportional to the applied voltage V, and that the differential voltage between the two dividers is proportional to the voltage drop IZ, or to the current I if Z is known.

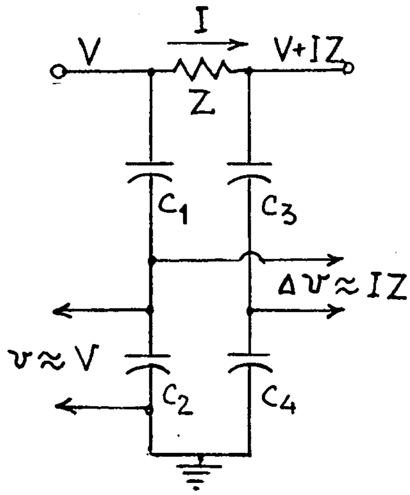

Figure 1.

For many applications it will be desirable to use a pure resistance for Z. For some applications it may be desirable to use Z_L for Z, where Z_L is an impedance proportional to the impedance of a particular line. In the latter, an output proportional to IZ_L is obtained. This output can be used directly as an input to an electronic distance relay.

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Some of the problems facing the CVT as shown above are:

a) large IZ product is required,

b) the voltage proportional to current is very sensitive to relative changes of the ratios of the two capacitive dividers,

c) equipment exhibiting very high common mode rejection must be used for extracting the voltage proportional to current.

Successive improvements or modifications have been made to the circuit, and are shown in Figures 2 to 5.

A current transformer (T) is used in Figure 2 to increase IZ without adding much impedance to the primary circuit. A further improvement, that of a centre-tapped transformer (or a centre-tapped impedance) is shown in Figure 3. The main advantage of this circuit is its symmetry or balance, and the resulting cancellations of some loading errors. It requires the capacitance of the two dividers to be the same. The signal proportional to voltage is the average output of the two dividers, for this configuration.

Figure 4 uses different dividing ratios for the current and voltage signals. In this manner the signal proportional to current can be made less affected by the ratio of the capacitors C1-C2 and C3-C4, but more affected by the common mode rejection of the equipment used to extract the signal. The signal proportional to voltage is obtained directly across Cp, and no averaging is required as in Figure 3.

Figure 5 appears to be the ultimate, at least from the theoretical viewpoint. The signal proportional to current is available with little or no common mode voltage, and its level can be readily set by the ratio of (C1 + C3) to C_s. A practical realization of Figure 5 may be difficult. The circuit depends on the centre-tapped inductance (L) to be of very large value. The circuit is also very sensitive to the relative changes of capacitors C1 and C3.

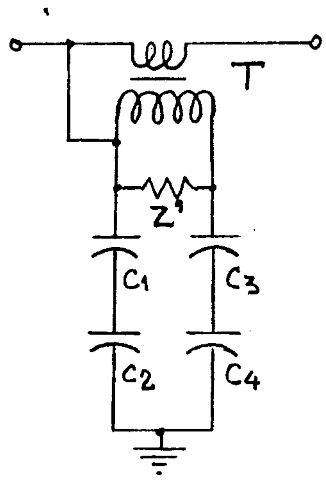

Figure 2

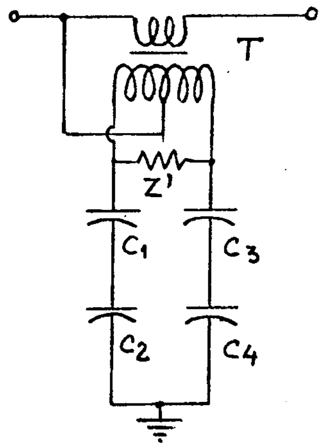

Figure 3

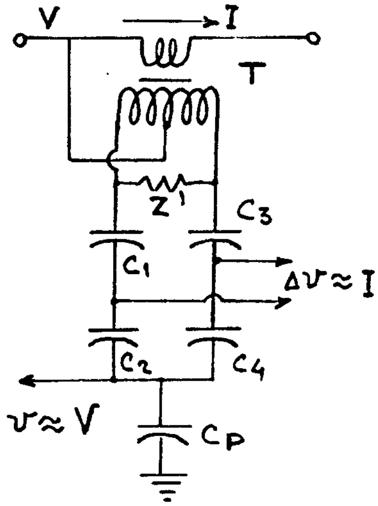

Figure 4

Carrier Coupling

Theoretically, the CVT's described here could be readily used for coupling high-frequency carrier signals to the high-voltage line. The requirement would be a coupling inductance at the ground end of the CVT, as shown in Figure 6. The signal proportional to the voltage would then have to be obtained, differentially, across capacitor C_P, as shown.

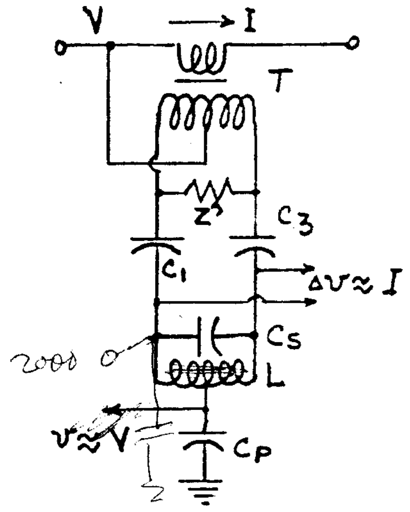

Figure 5

In practice, this coupling may be more difficult to obtain. Capacitors C1 and C3 are estimated to be in the range of 100 to 1000 pF. This value of capacitance may be rather small for certain carrier frequencies.

It is anticipated that component values optimised for the current and voltage signals may not be optimum for carrier coupling.

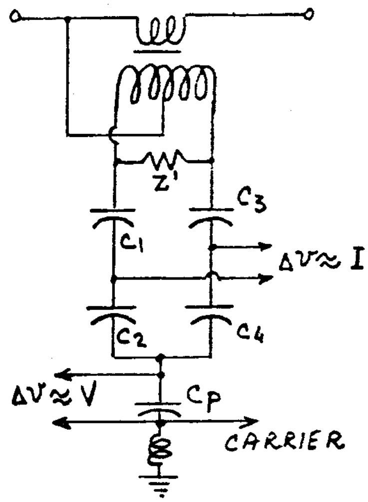

Figure 6

Advantages and Disadvantages

The advantage of the CVT is its ability to provide a voltage and current signal compatible with the low-level instrumentation system, and to do so at a reasonable price. It was estimated that a CVT may cost about $5000 for 230 kV in production quantities. This compares quite favourably with $5000 for a conventional current transformer, $2500 for a capacitive voltage transformer, or $5000 for a magnetic voltage transformer.

The designers of protective systems may find it advantageous to have both current and voltage measuring capabilities at locations where they have only current or voltage at the present time. For example, they may find it advisable to supply line relays with current signals from the line, (rather than summing two bus currents), perhaps even with IZ, as has been suggested earlier.

The disadvantage of the CVT is its sensitivity to variations of component values. Changes in capacitance or ratios will cause the voltage signals to be partially converted to current signals, hence causing errors (common mode to normal mode signal conversion). Another disadvantage is the necessity of having active equipment operating in the undesirable ambient both with respect to temperature and electrical noise.

Recommended Work Areas

To fully evaluate the CVT it is desirable to determine which configuration and the range of component values will be optimum for the quality of components and equipment available at the present time.

The success of the CVT depends on active circuitry. The reliability of this circuitry and the firm availability of power to operate it is of prime importance and should be investigated.

Since the major errors in the CVT are expected to occur due to drift of components, automatic or semi-automatic means of correcting for these drifts should be investigated.

Since we have difficulties in obtaining quotations for current transducers for further work on the low-level instrumentation system, it is recommended that a set of CVT's be procured and tested as soon as possible.

Submitted:

O.W. Iwanusiw
Engineer - Instrumentation
Instrumentation & Standards Section

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