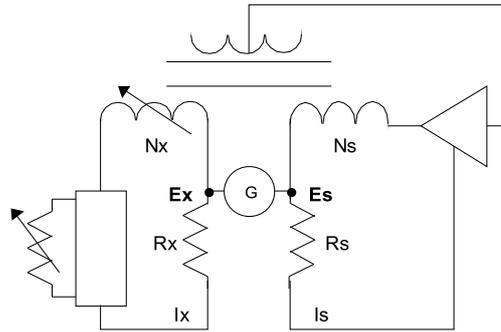# MEASUREMENT OF RESISTANCE RATIOS – TWO TECHNIQUES

CURRENT RATIOS: DIRECT CURRENT COMPARATOR – DCC

Passing known ratios of current through each pair of resistors until the voltage drop developed across each resistor is the same
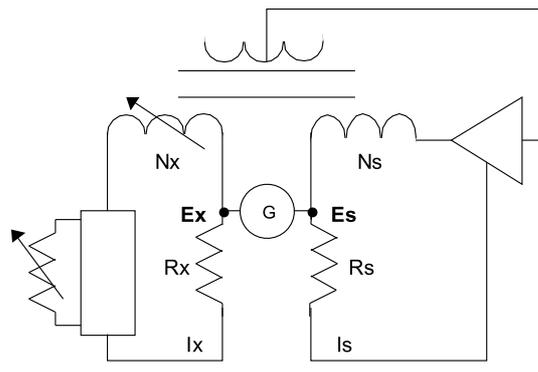
$$Ex = Es$$
$$Rx = Nx/Ns \ x \ Rs$$

CURRENT COMPARATOR INTRODUCTION

Block Diagram & Theory

$$IsNx = IxNx, \ Ix/Is = Nx/Ns \ and \ Rx/Rs = Is/Ix \ = Nx/Ns$$

$$Then \ Rx = (Nx/Ns)Rs$$

Where:
  Ix – master current source
  Is – Slave or variable current source
  Nx – variable primary windings
  Ns – fixed slave winding
  D – ampere turn balance peak detector
  Rx – unknown resistor being measured
  Rs – known or standard resistor.
  Nv – voltage detector

RESISTANCE MEASUREMENT

The resistance of the measurement is defined as the voltage difference between the potential terminals divided by the currents passing through the current terminals. Measuring the current ratio when the voltages across the resistors are equal compares the resistors. Since the ampere-turn ratio in the current comparator depends only on the turn's ratio, turns cannot be lost or gained, this represents a fundamental measurement standard and the error can be defined as

$$\text{Ratio Error} = e_p$$

The two resistors to be compared, Rx & Rs, are supplied from different current sources and the ratio of the two currents is measured when the voltage drops across the two resistors are equal.

The peak detector circuit of the current comparator is then used to maintain an ampere-turn balance between the primary and secondary windings. Zero flux core condition in the current comparator is sensed by the flux detector (D) and fed back to control the Is current.

The slave current source (Is) is adjusted by changing the primary turns until a voltage balance across the two resistors is obtained. The master current source (Ix) is fixed at a level dependent on the desired sensitivity and the required power level for Rx. The current (Is) is adjusted to obtain a voltage balance across the two resistors as indicated by the nanovolt detector (nV). The CPU monitors the nV voltage and adjusts the Nx turns automatically to maintain zero volts difference across the two resistors.

When balance indicates zero flux**:**

$$\text{Is Ns} = \text{Ix Nx}$$

And

$$\frac{\text{Is}}{\text{Ix}} = \frac{\text{Nx}}{\text{Ns}}$$

$$\text{Ratio} = \frac{\text{Rx}}{\text{Rs}} = \frac{\text{Is}}{\text{Ix}} = \frac{\text{Nx}}{\text{Ns}}$$

$$\text{Rx} = \frac{\text{Nx}}{\text{Ns}} \text{ x Rs}$$

At balance and under four terminal conditions there is no current flowing in the potential leads. In the DCC Resistance Bridge, there is no need for current accuracy because of the

master slave relationship and automatic ampere-turn balance.

VOLTAGE RATIOS: BINARY VOLTAGE DIVIDER – BVD

Passing a current through two or more resistors in series and measure the ratio of voltages developed across the resistors

$$R = \frac{Rx}{Rs} = \frac{V1 - V2}{V3 - V4} = \frac{V1/E - V2/E}{V3/E - V4/E} = \frac{r1 - r2}{r3 - r4}$$
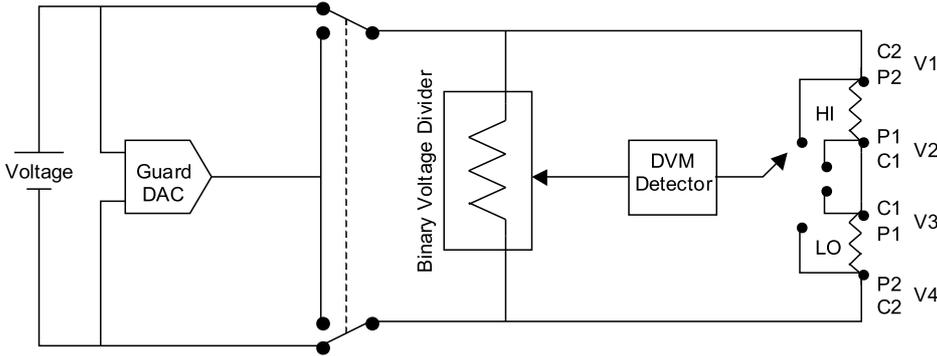
In both the BVD method and the DCC method, at balance no current flows in the measuring leads. Lead resistance is therefore unimportant when using four terminal connections. In the potentiometric method resolution and accuracy are limited by (and cannot be better than) the stability of the DVM detector. The BVD bridge method suffers from the disadvantage that when scaling resistors in decade steps the same current must be passed through both resistors and the greatest power is dissipated in the largest resistor. This limits the dynamic range for sub ppm measurements for the BVD to 1000 ohms and higher. In the DCC method the greatest power is dissipated in the smallest resistor and the dynamic range for sub ppm measurements is limited by the current noise of the DCC comparator to 10,000 ohms and less. The DCC method also suffers from the disadvantage of using 2 terminal measurements above 10,000 ohms.