MPHYEC-1F Measurement and Instrumentation

Unit 3 Notes (I)

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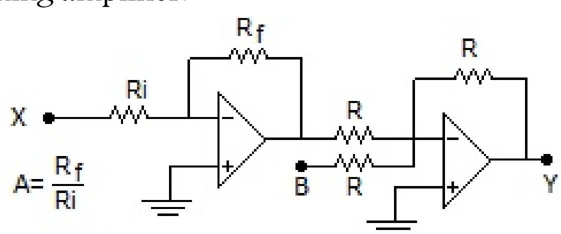
Scaling Sensor Outputs using OP AMP circuit

It is often necessary to derive from a signal available in voltage, millivot or microampere into a more relevant value such as m^3/hr, Deg C, etc. For example, if we are measuring temperature using a Thermocouple, the semsor output consists of an emf as a fraction of millivolt. What we would prefer is to get the reading directly in degree celsius instead of millivolts, which has been provided by the thermocouple. We could have another example in which we are using a piezoelectric pressure transducer whose output is a voltage, to give reading in PSI (Pounds per square inch).

In order to scale the output of the sensor we will need to know the functional relation between the available sensor output and the required output format. In most of the cases, if we are designing an apparatus to cover a limited range, then the linear relation [Y = A X + B] will be valid. The same equation will apply to almost all cases of data display and acquisition. Here, Y is the output in required format such as PSI for pressure, A is the slope or scale factor and B is the Offset.

An OP-AMP based circuit that would do this job is given below. It consists of an inverting amplifier followed by a summing amplifier.



Here, the input signal is X, the scale factor A is the ratio of the feedback resistance R_f and the input resistance R_i connected to the first OP AMP (at left) and the offset voltage is given as input B. The first OP AMP has been configured as an inverting amplifier. The output of the first amplifier is AX. The second OP AMP is a summing amplifier which adds an offset B to the output of the first OP AMP.

The values of A and B have to be obtained through a calibration process. To carry out this calibration, we need another instrument that gives standard measurement value, i.e. the required value (Y) pre calibrated in appropriate unit. We feed the same input simultaneously to the sensor as well as to the calibrating instrument. We note down the value of X which is the output of the sensor and Y which is the output of the calibrating instrument. This is repeated for a series of input values and a calibration curve is made by plotting Y against X. The curve in most cases is linear. The slope of this curve is A and its y intercept is B.

In some cases, such as a thermocouple working over a large temperature range, we would need a different functional relation [$Y = A + B X + C X^2$]. This is a parabolic relation. It requires an additional squaring operation. So the scaling circuit will be more complex in such case.