Measurement Systems

Lecture-18
Introduction

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Measurement

Measurement is the act or the result of a qualitative comparison between predefined standards and unknown magnitude. There are two basic requirements for the measurements such as:

(i) The standard which is used for comparison must be accurately defined and commonly
accepted.

(ii) The procedure and apparatus employed for obtaining comparison must be produce.

Functional elements of measuring system

A generalized 'Measurement System' consists of the following:

1. Basic Functional Elements, and
2. Auxiliary Functional Elements.

Basic Functional Elements

Basic Functional Elements are those that form the integral parts of all instruments. They are the following:

(a) Transducer Element that senses and converts the desired input to a more convenient and practicable form to be handled by the measurement system.

(b) Signal Conditioning or Intermediate Modifying Element for manipulating / processing the output of the transducer in a suitable form.

(c) Data Presentation Element for giving the information about the measurand or measured variable in the quantitative form.

Auxiliary Functional Elements

Auxiliary Functional Elements are those which may be incorporated in a particular system depending on the type of requirement, the nature of measurement technique, etc. They are:

(a) Calibration Element to provide a built-in calibration facility.

(b) External Power Element to facilitate the working of one or more of the elements like the transducer element, the signal conditioning element, the data processing element or the feedback element.

(c) Feedback Element to control the variation of the physical quantity that is being measured. In addition, feedback element is provided in the nullseeking potentiometric or Wheatstone bridge devices to make them automatic or self-balancing.

(d) Microprocessor Element to facilitate the manipulation of data for the purpose of simplifying or accelerating the data interpretation. It is always used in 15 conjunctions with analog-to-digital converter which is incorporated in the signal conditioning element.

Classifications of the measuring instruments

- Measuring instruments are classified based on their applications, mode of operation, manner of energy conversation, nature of output signal.
  - **(i) Deflection and Null type instruments**
  - **(ii) Manually operated and Automated type**
  - **(iii) Analog And Digital Instruments**
  - **(iv) Dumb and Intelligent Types**

(i) Deflection and Null type instruments

In a Deflection type system, the quantity to be measured produces an effect either in the form of a voltage or a current. This effect is then utilized to produce a torque that causes a mechanical deflection. With the help of a spring system, this torque is countered by a restoring torque that increases with the increase in deflection. When the torques involved achieves a state of equilibrium, the pointer comes to a standstill. Now by equating the torques involved in a mathematical equation, a relation can be obtained between the cause and the deflection in terms of device constants and thus the Instrument can be calibrated. A prime example of this type of system is the PMMC (Permanent Magnet Moving Coil) Instruments.

- In a Null type Instrument, the quantity to be measured produces an effect that is compared with an already calibrated effect of another system. It is achieved with the help of a sensitive galvanometer that shows a deflection for any amount of difference between the effect to be measured and the already calibrated effect. By manual or automatic control, the calibrated effect is varied until it becomes equal to the effect produced by the measuring instrument. When such a state is reached, the galvanometer shows no deflection at all and quantity is successfully measured. A prime example of this system is the Wheatstone bridge used for the measurement of electrical resistance.

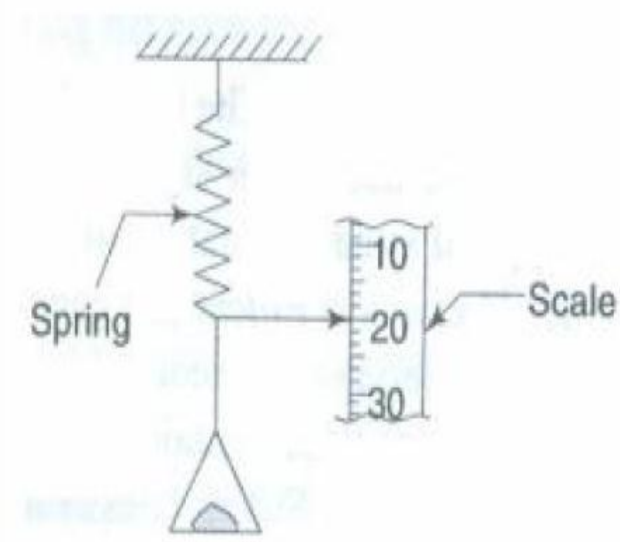


Figure:-A typical spring balance – A deflection type weight measuring instrument

Advantages of Null Types Instrument

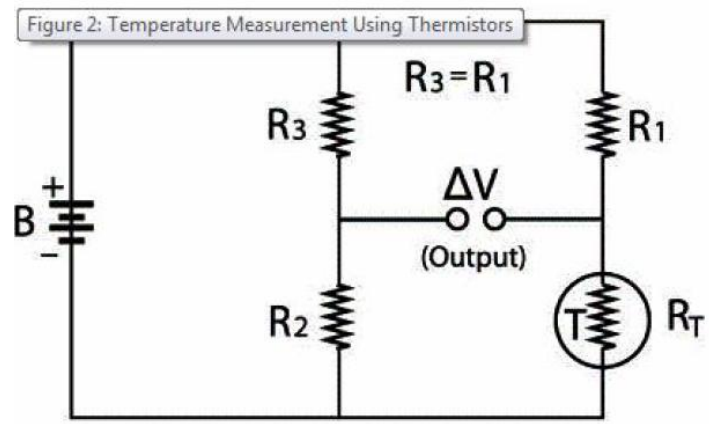
- The following are the advantages of the null type instruments.

  1. The accuracy of the null type instrument is high. This is because the opposing effect is measured with the help of the standards which have a high degree of accuracy.

  2. The null type instrument is highly sensitive. In null type instrument, the balanced quantity is measured out. The detector has to cover a small range around the balanced point and hence it is highly sensitive. Also in null type instrument, the detector need not be measured it has only to detect the presence and direction of unbalance and not the magnitude of unbalance.

(ii) Manually operated and Automated type

- The instrument which requires the services of human operator is a manual instrument. The measurement of temperature by a resistance thermometer incorporating a Wheatstone bridge in its circuit is manual in operation as it needs an operator for obtaining the null position. The instrument becomes automatic when the human operator is replaced by an auxiliary device incorporated in the instrument. For example, the temperature measurements by mercury-in-glass thermometer are automatic as the instrument indicates the temperature without requiring any manual assistance. Automatic instruments are proffered because of their fast dynamic response and low operational cost.



(iii) Analog And Digital Instruments

- The signals of an analog unit vary in a continuous fashion and can take on infinite number values in a given range. Wrist watch, speedometer of an automobile, fuel gauge, ammeters and voltmeters are examples of analog instruments. Signals varying in discrete steps and taking on a finite number of different values in a given range are digital signals and the corresponding instruments are of digital type. for example, the timers on a scoreboard, the calibrated balance of a platform scale, and odometer of an automobile are digital instruments.
- The digital instruments convert a measured analog voltage into digital quantity which is displayed numerically, usually by neon indicator tubes. the output may either be a digit for every successive increment of the input or be a coded discrete signal representative of the numerical value of the input. the digital devices have the advantage of high accuracy high speed and the elimination of human operational errors. however, these instruments are unable to indicate the quantity which is a part of the step value of the instrument. the importance of the digital instrumentation is increasing very fast due to the applications of the digital computers for data handling, reduction and in automatic controls. apparently it becomes necessary to have both analog-to-digital converters at input to the computers and digital-to-analog converters at the output of the computers.

(iv) Dumb and Intelligent Types

- A dumb or conventional instrument is that in which the input variable is measured and displayed, but the data is processed by the observer. For example, a Bourdon pressure gauge is termed as a dumb instrument because though it can measure and display a car tyre pressure but the observer has to judge whether the car tyre air inflation pressure is sufficient or not. Currently, the advent of microprocessors has provided the means of incorporating Artificial ntelligence (AI) to a very large number of instruments. Intelligent or smart instruments process the data in conjunction with microprocessor (μP) or an on-line digital computer to provide assistance in noise reduction, automatic calibration, drift correction, gain adjustments, etc. In addition, they are quite often equipped with diagnostic subroutines with suitable alarm generation in case of any type of malfunctioning.
- An intelligent or smart instrument may include some or all of the following:

☐ The output of the transducer in electrical form.

☐ The output of the transducer should be in digital form. Otherwise it has to be converted to the digital form by means of analog-to-digital converter (A-D converter).

☐ Interface with the digital computer.

☐ Software routines for noise reduction, error estimation, self-calibration, gain adjustment, etc.

☐ Software routines for the output driver for suitable digital display or to provide serial ASCII coded output.