UNIT – 1

SCIENCE OF MEASUREMENT AND TRANSDUCERS

Classification and Characteristics of Transducers

Transducer

- A transducer is defined as a device that receive energy from one system and transmits it to other, often in a different form
- The energy transmitted by these systems may be electrical, mechanical, optical, or acoustical
- Basically, there are two types of transducers:

  (a) Electrical Transducer (b) Mechanical Transducer

  (Manometer, Turbines, Spring, Diaphragm, etc.)

Electrical Transducer:

- The transducer may be thought of consisting of two parts:

  (i) Sensing Element, (ii) Transduction Element
- **Sensing Element** responds to a physical phenomenon or a change in physical phenomenon
- **Transduction Element** transforms the output of a sensing element to an electrical output

Electrical Transducer (-contd.)

- In other words, an electrical transducer is a sensing device by which the physical, mechanical, or optical quantity to be measured be transformed directly by a suitable mechanism into an electrical voltage/current proportional to the input measured
- The output may be analog, digital, or frequency modulated

- The important parameters relating to an electrical transducer are as follow:

(a) Linearity: The relationship between a physical quantity and the resulting electrical signal must be linear.

(b) Sensitivity: Sensitivity is defined as the electrical output per unit change in the physical quantity (e.g. v/^{o}c for a temperature sensor). High sensitivity is generally desirable for a transducer.

(c) Dynamic range: The operating range of the transducer should be wide enough to permit its use under a wide range of measurement conditions.

Advantages of Electrical Transducer

(d) Repeatability: The input/output relationship for a transducer should be predictable over a long period of time. This ensures reliability of operation.

(e) Physical size: The transducer must have minimal weight and volume, so that its presence in the measurement system does not disturb the existing conditions.

Advantages of Electrical Transducers:

- The main advantages of electrical transducers (conversion of physical quantity into electrical quantities) are as follow:

(i) Electrical amplification and attenuation can be easily done

(ii) Mass inertia effects are minimized

(iii) Effects of friction are minimized

(iv) The output can be indicated and recorded remotely at a distance from the sensing medium

Classification of Transducers

(v) The output can be modified (pulse conversion/frequency conversion, modulated, or amplified) to meet the requirements of the indicating or controlling units

(vi) The signal can be conditioned or mixed to obtain any combination with outputs of similar transducers or control signals

(vii) The electrical or electronic signal can be controlled with a very small power level

(viii) The electrical output can be easily used, transmitted, and processed for purpose of measurement

Classification of Transducers:

- The transducers may be classified:

  (i) On the basis of transduction principle (ii) As primary and secondary transducers (iii) As passive and active transducers (iv) As analog and digital transducers (v) As transducer and inverse transducers

Classification of Transducers (-contd.)

On the Basis of Transduction Principle:

- Depending upon how they convert the input quantity into resistance, inductance, or capacitance; the transducers are called resistive, inductive, or capacitive respectively
- They may also be classified as piezoelectric, thermoelectric, magnetorestrictive, electrokinetic, & optical, etc.

Primary and Secondary Transducers:

- In most of the measurement systems, there is a suitable working combination wherein a mechanical device acts as a primary detector (transducer) and the electrical device acts as the secondary transducer with mechanical displacement serving as the intermediate signal

Passive and Active Transducers:

- Passive transducers derive the power required for transduction from an auxiliary power source
- They also derive part of the power required for conversion from the physical quantity under measurement

Classification of Transducers (-contd.)

- In the absence of external power, the transducers can not work and hence are called passive (externally powered) transducers, e.g. resistive, inductive, and capacitive transducers
- On the other hand, active transducers are those which do not require an auxiliary power source to produce their output
- They are also known as self generating type since they develop their own voltage or current output
- The energy required for production of output signal is obtained from the physical quantity being measured, e.g., thermocouples, photovoltaic cells, and piezoelectric crystals etc.

Analog and Digital Transducers:

- Analog transducers convert the input physical quantity into analog output which is a continuous function of time, e.g., a strain gauge, an LVDT, a thermocouple, or a thermistor etc.
- On the other hand, the digital transducers convert the input quantity into an electrical output which is in the form of pulses, e.g., photocell

Classification of Transducers (-contd.)

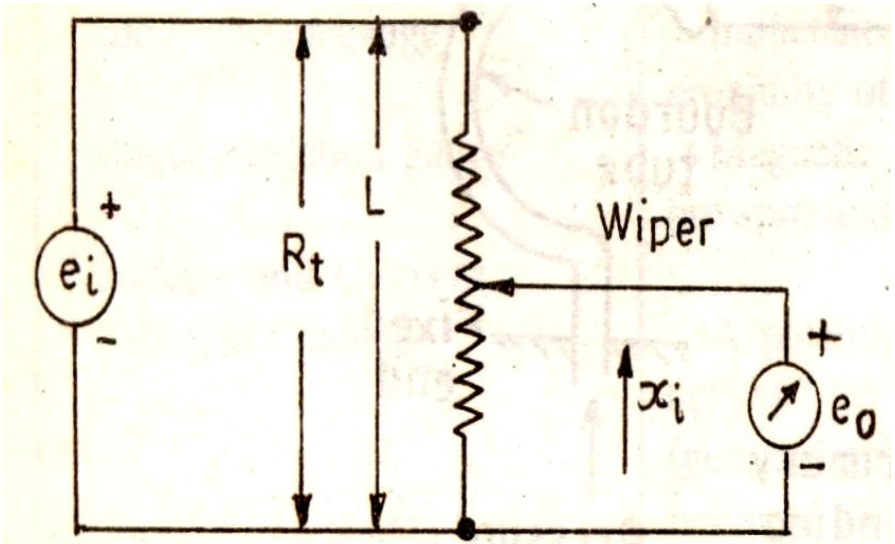

Fig. 25.28. Linear potentiometer (POT), a passive transducer

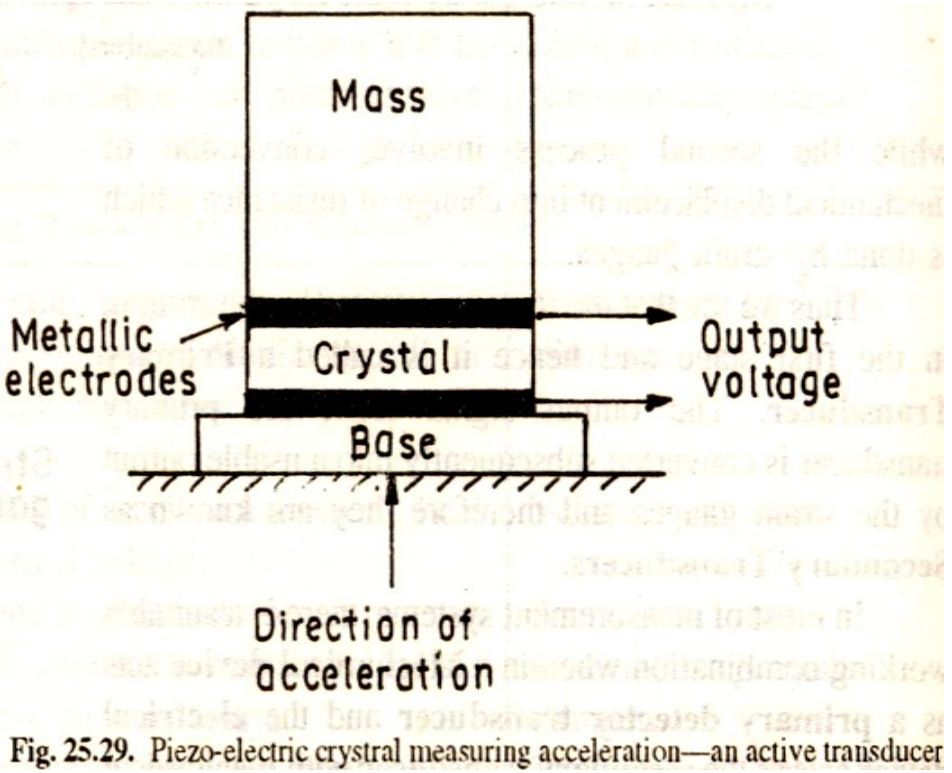

Fig. 25.29. Piezo-electric crystral measuring acceleration—an active transducer

Selection of Transducer

Transducers and Inverse Transducers:

The transducers may be broadly defined as the devices which convert a non-electrical quantity into an electrical quantity and the inverse transducers are defined as the devices which convert an electrical quantity into a non-electrical quantity

Selecting a Transducer:

- The transducer has to be physically compatible with its intended application. The following features should be considered while selecting a transducer:

(i) Operating Range – chosen to maintain range requirement and good resolution

(ii) Sensitivity – chosen to allow sufficient output

(iii) Frequency Response and Resonant Frequency – flat over the entire desired frequency range

Selection of Transducer (-contd.)

(iv) Accuracy – repeatability and calibration error as well as errors due to sensitivity to other stimuli should be minimum

(v) Electrical Parameters – length and type of cable required, SNR when combined with amplifiers etc.

(vi) Usage and Ruggedness – Ruggedness both of mechanical and electrical intensities versus size and weight

(vii) Environmental Compatibility – temperature range, pressure, corrosive fluids, shocks, size, interaction and mounting restrictions

(viii) Loading Effects – transducer should have a high input impedance and a low output impedance to avoid loading effects