TRANSDUCERS

An instrumentation circuit or system generally consist of three elements

1. An input device
2. Processing circuit (Signal conditioning)
3. An output device

Input device receives quantity under measurement and gives proportional electrical signal to the processing circuit, here signal is amplified, filter, modified to a acceptable format and then provide to the output. In this process the input quantity in most of cases is non electrical and therefore convert it into electrical signal for this device required is called as transducer.

Transducer is defined as a device which converts one form of energy into another form. A transducer perform transfer action so it is sometimes called as sensor, the term sensor is used when it senses the input signal.

Classification of transducer - The transducer may be classified according to their application, method of energy conversion, nature of output etc. As, according to activity and According to working principle.

According to activity – 1) Passive Transducer (Externally powered)

2) Active transducers (Self Generated)

1) Passive Transducer (Externally powered) – A transducer which requires external power to produce change in electrical quantity is called as passive transducer or externally powered transducer.

Example - LDR, thermistor, strain gauge, capacitive transducer, hygrometer (to measure humidity), galvanometer, photoconductive cell etc

2) Active transducer (Self Generated) – A transducers capable of generating electrical signal directly in response to the physical parameter and which does not required any external power source for its operation is known as active transducers or self generated transducers.

Example - Solar cell (Photo voltaic cell), piezo electric crystal, thermocouple etc.

According to working principle –

1) Mechanical transducers (LVDT, Capacitive transducers, Strain gauge etc)

2) Magnetic transducers (Induction coil, earth coil etc)

3) Radiation transducers (Photo cell, LDR, LED etc)

4) Thermal transducers (Thermistor, thermo couple, thermopile etc)

Selection of transducers – Selection of appropriate transducer is most important step in obtaining accurate results. While selecting transducers we must consider following parameters-

Transducers type

Transducers Specification

Transducers Compatibility

1) ***Transducers type*** – This point is very basic because we must know that which non electrical quantity is received by the system. By using this knowledge we can select transducer group and type.
2) ***Transducers Specification*** – After selecting group, it is essential to know its physical parameters like size of transducers, shape, package, its diameter, height etc and technical parameters like operating temperature range, minimum and maximum range, sensitivity, limitations, graphical analysis etc.
3) ***Transducers Compatibility*** – The environmental conditions like temperature, acceleration, shock, and vibrations should affect the accuracy of instrument. It also include electrical parameters like impedance matching, insulation resistance, tolerance etc. therefore while designed a system with maximum accuracy and to increase standard of system these parameters will help us.

Thermistor- Thermistor means thermally sensitive resistor, the resistor whose resistance varies with temperature. It is passive transducer that is external power is required for its operation

Principle – Thermistor is a transducer which changes its resistance when its temperature changes.

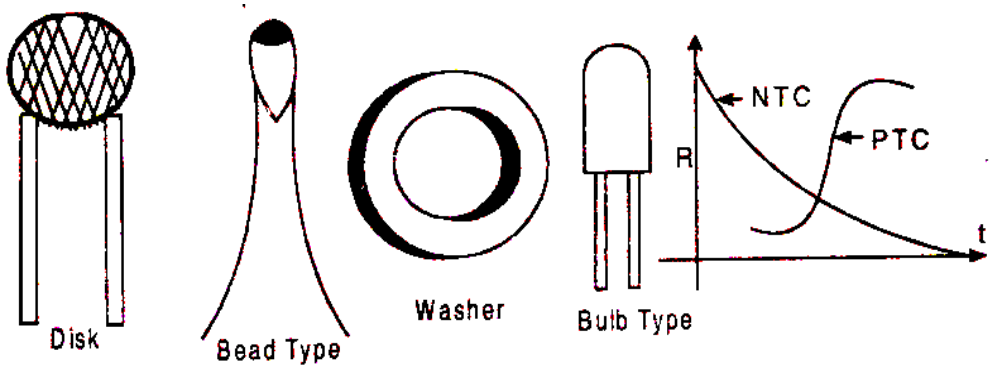
Construction – Thermistor is a semiconductor device basically of two types-

1) Negative Temperature Coefficient (NTC)
2) Positive Temperature Coefficient (PTC)

Thermistor are composed of sintered mixture of metallic oxides like iron, manganese, nickel, cobalt, copper etc. then they can be obtained in different shapes and size like disc, bead, rod, bulb, washers etc. with diameter of about 1.5 mm to 2 cm.

Temperature range - -100^0C to 300 ^{0}C

Resistance range – 0.5 ohm to 100 mega ohm



Applications – 1) In medical instrumentation

2) Temperature controlled soldering iron

3) In flow meter and in gas detector

4) In furnace to control temperature

5) In medical heating pad

6) Temperature regulators

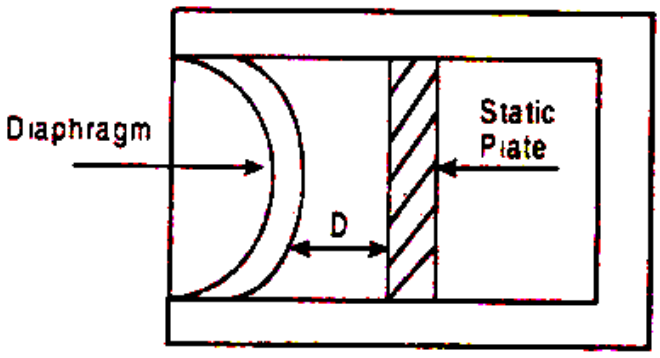
Capacitive Transducer – This is a pressure transducer also known as displacement transducer. It detects small change in pressure.

Principle – It is based on principle of capacitance produce by parallel plate capacitor because,

$$C = \frac{A\varepsilon}{d} \text{ Therefore C } \propto \frac{1}{d}$$

Construction - It consist of parallel plate capacitor fixed in an insulating container. One plate is fixed known as static plate and other plate is movable, flexible plate known as diaphragm both plates are separated by dielectric medium air and pressure which is to be measured is applied on the diaphragm.

Working – When pressure is applied on diaphragm, it moves towards static plate and distance between plates is reduced. Since capacitance is inversely proportional to distance causes electrical change, it can be connected to oscillator circuit to produce change in frequency.



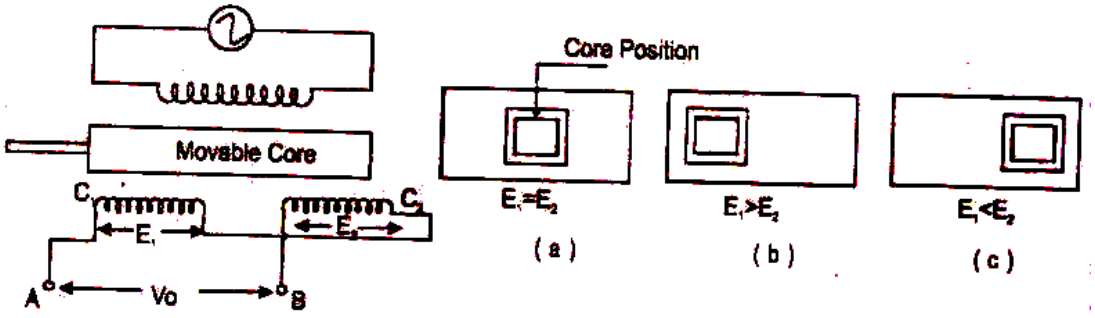
Advantages and disadvantages –

1) Easy construction and low prize
2) Used to measure static and dynamic pressure
3) Its accuracy may be affected by change in temperature
4) It causes invisible error due to capacitance produced by its long leads

Linear Variable Differential Transformer (LVDT) – This is a pressure type of transducer also known as displacement transducer, used to measure pressure, force, position as well as in control system. It is known for its great accuracy, high stability and fine resolution.

Principle –The differential voltage between two secondary windings of transformer is varied when magnetic core changes its position due to applied force.

Construction – Basically LVDT is a transformer consist of single primary winding and two opposite and equal secondary windings connected in series but in opposite direction so that vector sum of induced voltage opposes to each other.



Working –When the core is at center or when no force is applied, equal and opposite e.m.f is induced in both coils which will cancel each other Therefore $V_0 = V_1 - V_2 = 0$

When core is displaced towards left by applying force more e.m.f is generated in coil 1 than that of coil 2, hence $E_1 > E_2$. The differential voltage produced is directly proportional to the applied force.

When core is displaced towards right by applying force more e.m.f is generated in coil 2 than that of coil 1, hence $E_2 > E_1$. The differential voltage produced is directly proportional to the applied force.

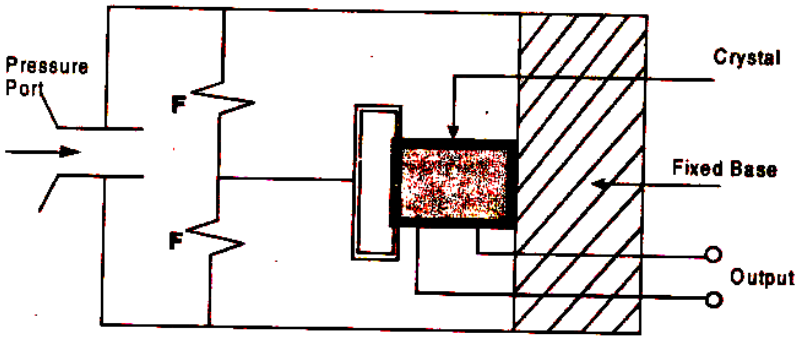
Advantages and disadvantages –

1) LVDT is very sensitive
2) Maximum operating temperature range
3) Great accuracy, high stability and fine resolution
4) Big in size and expensive

Applications – In accelerometer and in servo mechanism.

Piezo electric transducer - Certain crystals like Rochelle salt (Na, K, tartrarate), quartz, tourmaline possess the ability to generate electric potential when subjected to pressure or conversely changes its shape when subjected to voltage this property is known as piezo electric effect.

In order to sense force or pressure a crystal is placed between solid fixed base and movable part. The pressure to be sensed is applied through an input space known as pressure port, the crystal produces proportional potential difference across its opposite surface by producing electric charge. The output is proportional to the input pressure.



Advantages and disadvantages –

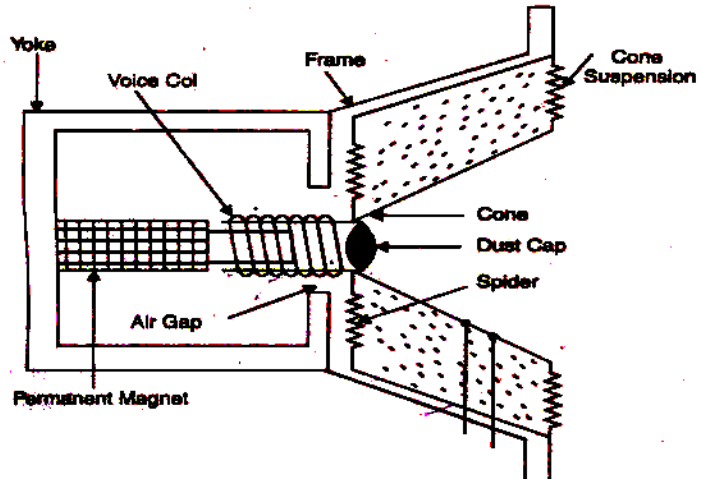
1) Very small size of crystal
2) Hard and stable for high temperature
3) Cannot used for measurement of static pressure

Application – In crystal microphone and in phonograph pick up cartridge.

Loud speaker – It is electro - acoustic (sound) or electromagnetic transducer that converts electrical energy into sound. It is active transducer.

Principle – When audio electric current is passed through coil placed in strong magnetic field starts vibrating along with diaphragm which produces sound wave by means of air vibrations.

Construction and working – The loud speaker consists of following parts - Permanent magnet, Voice coil, Spider, Diaphragm, Dust cap, Frame etc.

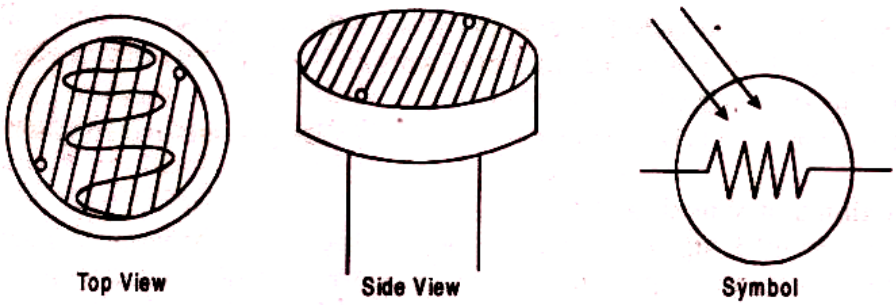


A voice coil is made up of few turns of wire wound on insulating material it is suspended between magnetic poles to which paper cone is attached with the help of spider. Spider is made up of special cloth fixed on the coil from one side and speaker frame on other side its purpose is to keep coil at the center. Diaphragm or cone is made up of special paper normally in black color; the cone is a vibrating element which produces sound wave. A strong magnetic field is necessary for operation of dynamic speaker therefore strong permanent magnet made up of alloy of Al, Ni, Co called 'Alnico' is used in between it the voice coil is suspended. Adjust cap is used to collect dust particles. Along with this loud speaker consist of yoke and frame.

Light Dependent Resistor (LDR) or Photoconductive transducer or Photo resistive transducer – LDR is a passive transducer because with the help of external signal it changes its output.

Principle - **When** a photosensitive material is exposed to light it changes its resistance or conductance, the incident light may be visible or invisible.

Construction – A photoconductive material like CdS, CdSe, and PbSe is deposited on insulating surface in the form of zigzag wire and top side is covered with glass window to receive light and two electrodes are taken out for external connections.



Working – When LDR receives light its conductivity increases causes decrease in resistance (few 100 ohms). In dark condition the conductivity of LDR decreases and hence its resistivity increases and its value is near about few hundred kilo ohms.

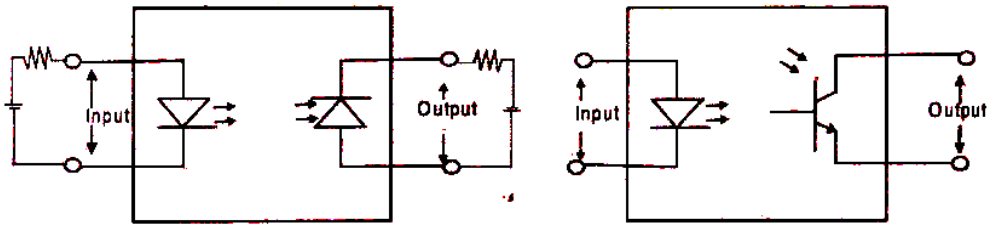
Advantages and disadvantages –

1) Small size and low cost
2) High sensitivity
3) Large response time

Applications – In counter, Lux meter, Burglar alarm, Photo relay.

Opto - coupler (Opto - isolator) – It produces electrical separation (isolation) between input and output circuit without any physical contact.

As name suggest, it is light activated and combine device consist of two photo transducer 1) Light Emitting Diode (LED) & 2) LDR or photo diode



Working – When input voltage is given to opto coupler, it conducts LED and emits light this light falls on photo diode and produces output current that is output varies if input signal is varies. It uses visible and infra red LED and output is taken using photodiode or photo transistor. Both input and output are connected with external batteries to produce electrical current.

Gas Sensor - Gas sensors are used I many industries for variety of applications also known as gas analyzers which sense and measure the concentration of gas.

Types of gas sensor –

1) Thermistor type
2) Catalytic or calorimetric type – To measure heat evolved during catalytic oxidation
3) Paper tape type – Paper tape is impregnated with specific reagent, which reacts with gases showing change in color
4) Electrochemical type gas sensor – Two electrodes are separated by electrolyte. The air which is to be tested is passed through permeable membrane. Due to toxic gas present in air it produces ions, results in potential difference produced at output.

5) Piezo electric gas sensor – Crystals are coated with abso9rbant layer which absorb gas, by sensing gases it changes its resonance frequency. The frequency is calibrated in terms of gaseous %
6) Catalytic gate FET – These are FET with gate sensitive to hydrogen ions. Used to measure hydrogen concentration.

Applications –

1) To detect % of certain gas present in air
2) In fire detection and prevention system
3) For indication of gases like CO, hydrogen sulphide, chlorine, etc. when concentration exceeds certain limit
4) To sense the pollutant gases level and to measure the % of oxygen in air
5) In monitoring the inflammable gases to avoid their concentration.