



# SNS COLLEGE OF TECHNOLOGY

Coimbatore-35

An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## *DEPARTMENT OF MECHATRONICS*

# 19MCB303 – SENSORS AND SIGNAL PROCESSING

## UNIT 2 – ELECTROMECHANICAL SENSORS

### Capacitive Transducer & Ultrasonic Transducer

Mrs. P.KALAISELVI M.E.,(Ph.D.,)

ASSISTANT PROFESSOR,

DEPARTMENT OF MECHATRONICS,

SNSCT, Coimbatore.





# Syllabus



## UNIT-III

## ELECTRICAL MEASUREMENT

9

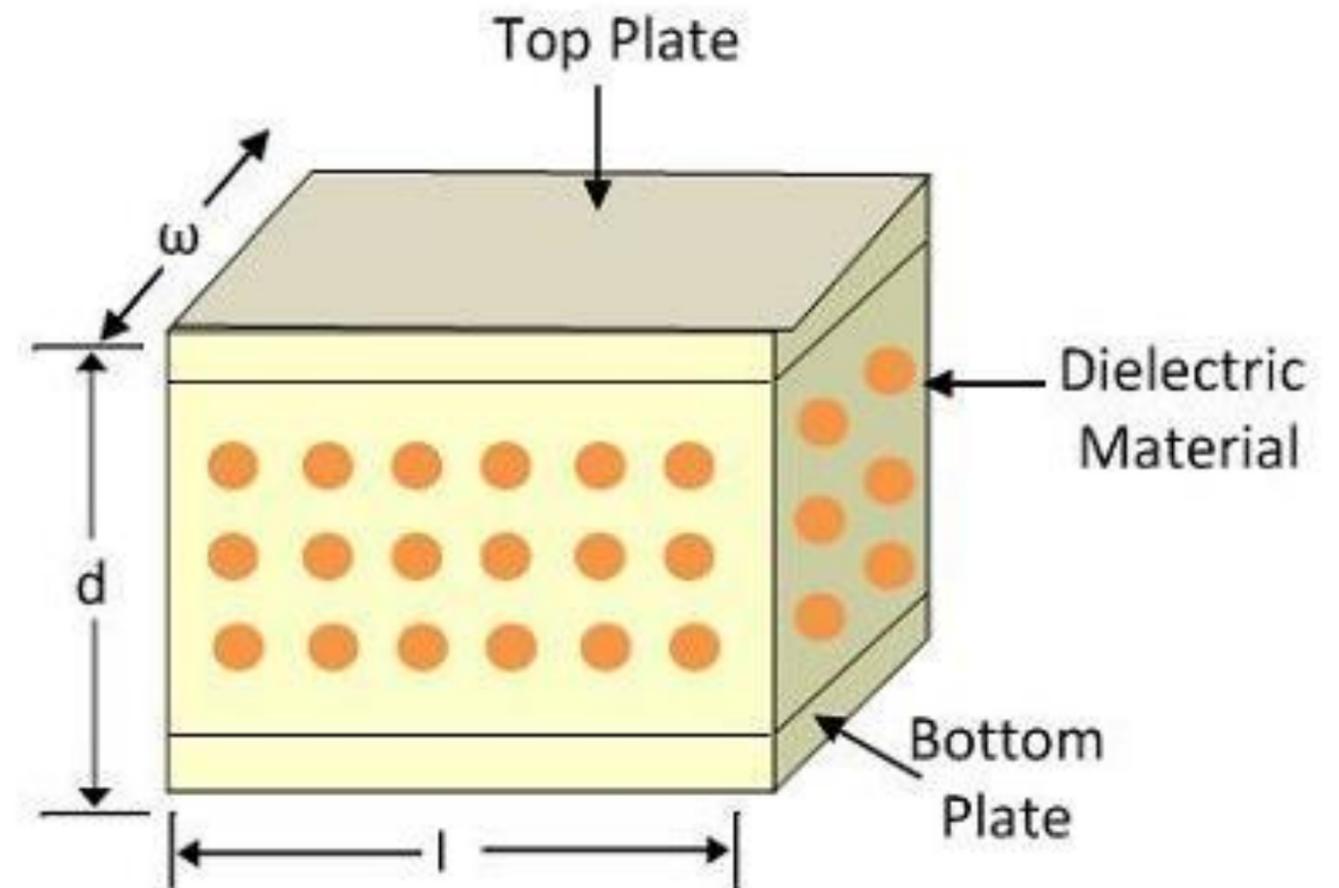
**Resistive transducers- Potentiometer-RTD- Thermistor - Thermocouple-Strain gauges-use in displacement, temperature, force measurement-Inductive transducer-LVDT- RVDT-use in displacement- Capacitive transducer - Piezoelectric transducer -Digital displacement transducers.**





## Capacitive Transducer

- ❑ The capacitive transducer is used for measuring the displacement, pressure and other physical quantities. The capacitive transducer contains two parallel metal plates.
- ❑ These plates are separated by the dielectric medium which is either air, material, gas or liquid.
- ❑ The capacitive transducer works on the principle of variable capacitances.





# Operation and Working

The equations below express the capacitance between the plates of a capacitor

$$C = \epsilon A/d$$

$$C = \epsilon_r \epsilon_0 A/d$$

Where A – overlapping area of plates in m<sup>2</sup>

d – the distance between two plates in meter

$\epsilon$  – permittivity of the medium in F/m

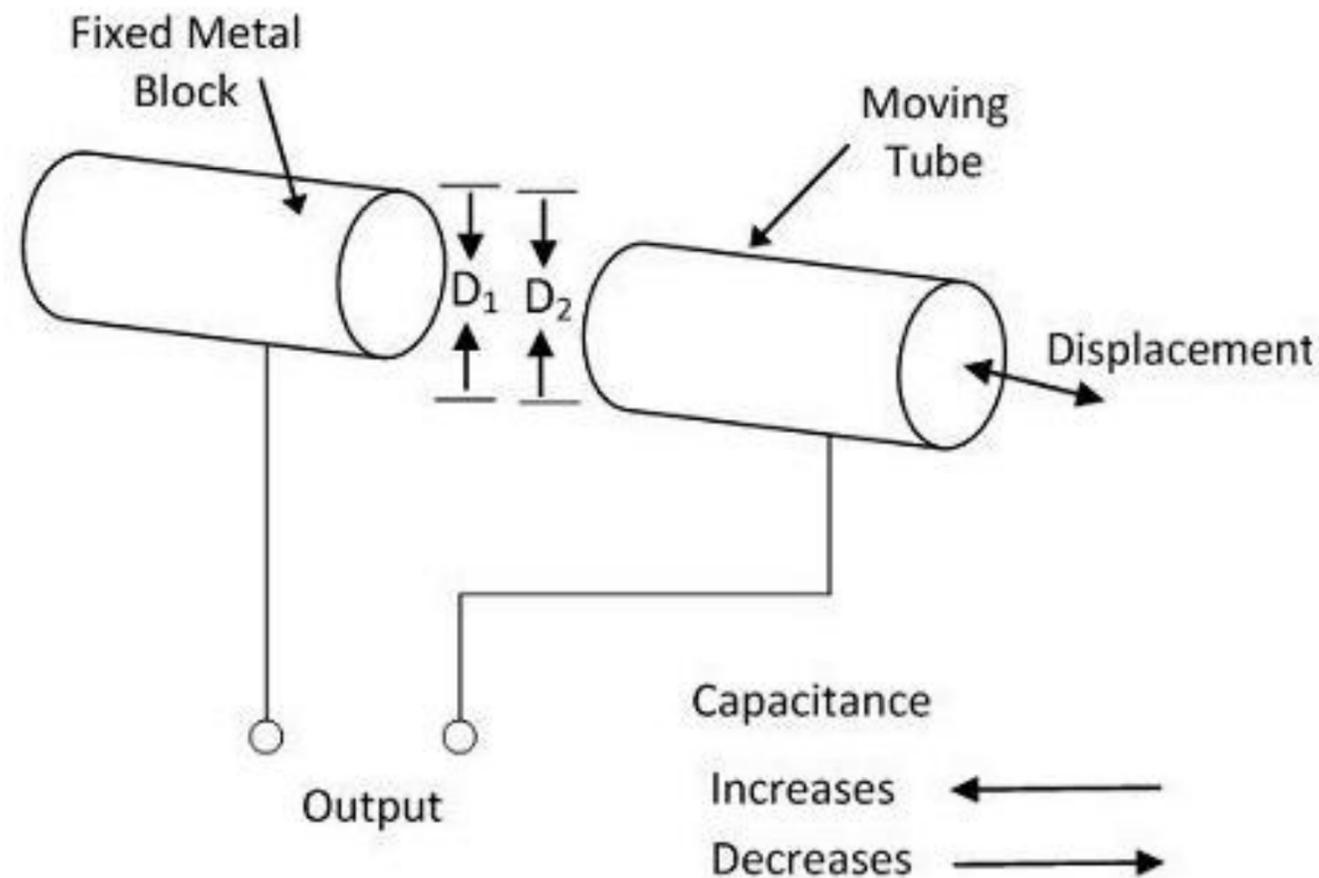
$\epsilon_r$  – relative permittivity

$\epsilon_0$  – the permittivity of free space



## *A transducer using the change in the Area of Plates*

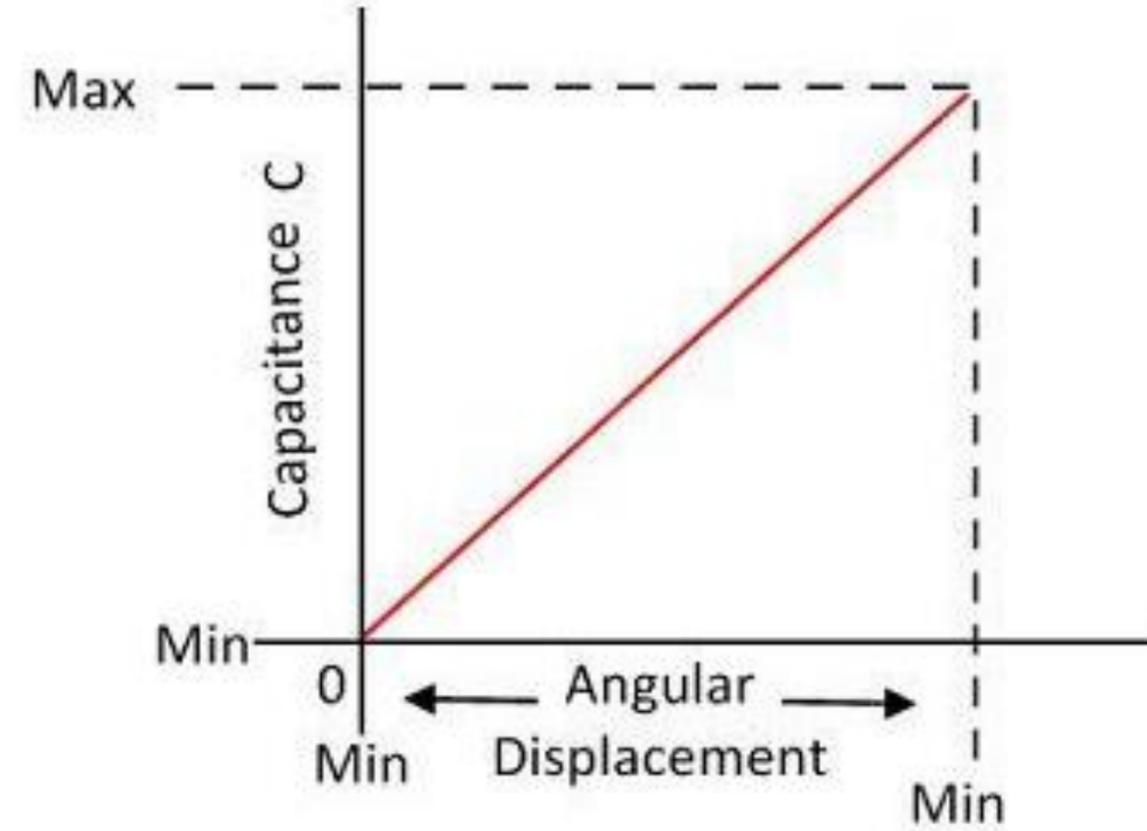
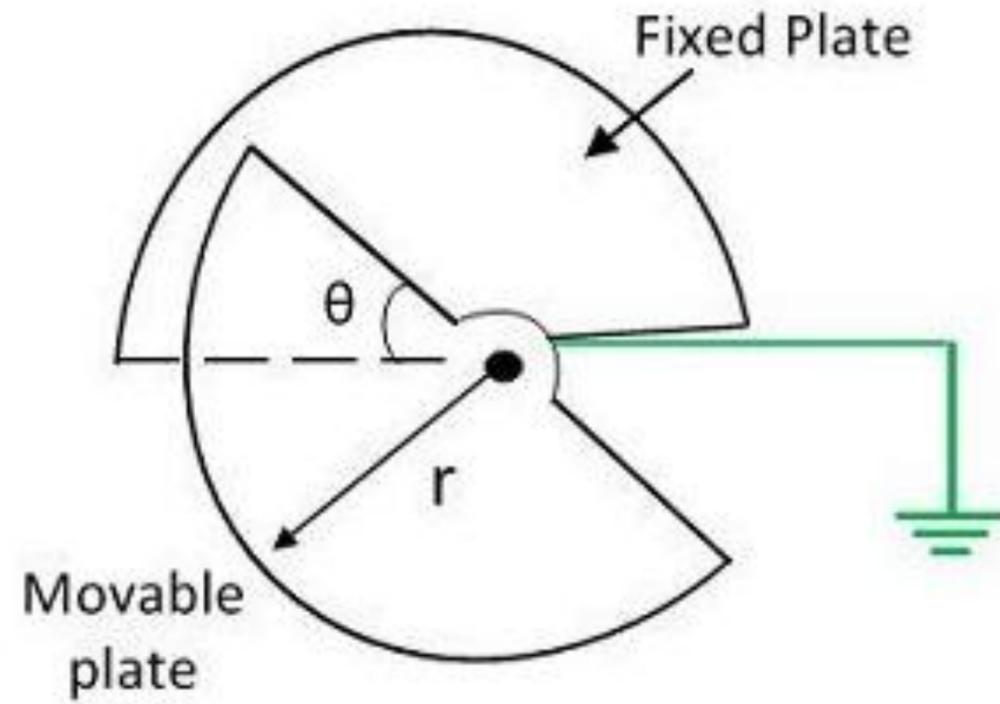
- capacitance is directly proportional to the area of the plates. The capacitance changes correspondingly with the change in the position of the plates.



$$C = \frac{\epsilon A}{d} = \frac{\epsilon x \omega}{d} F$$



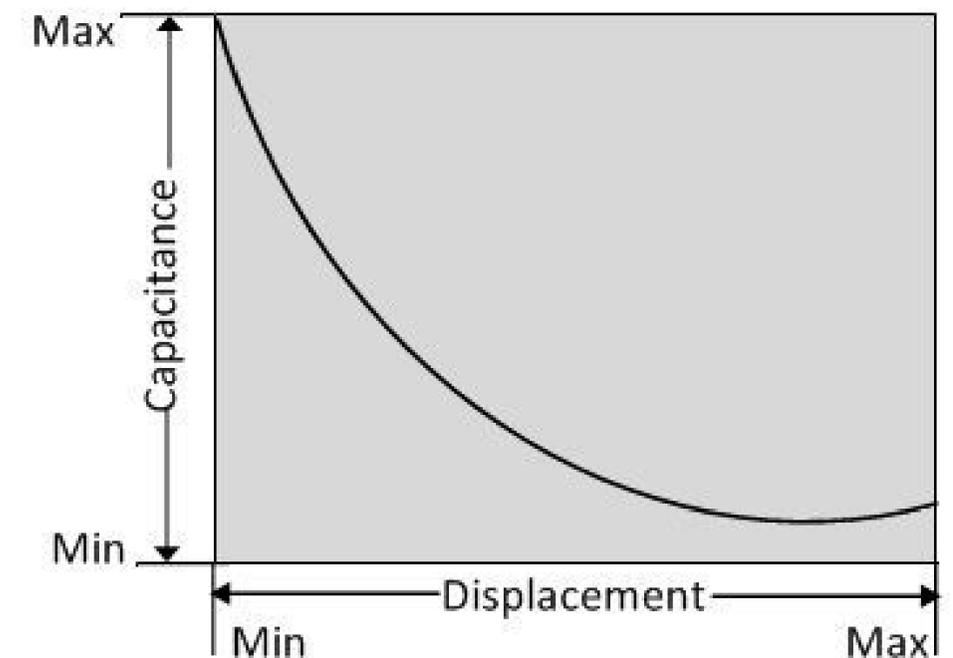
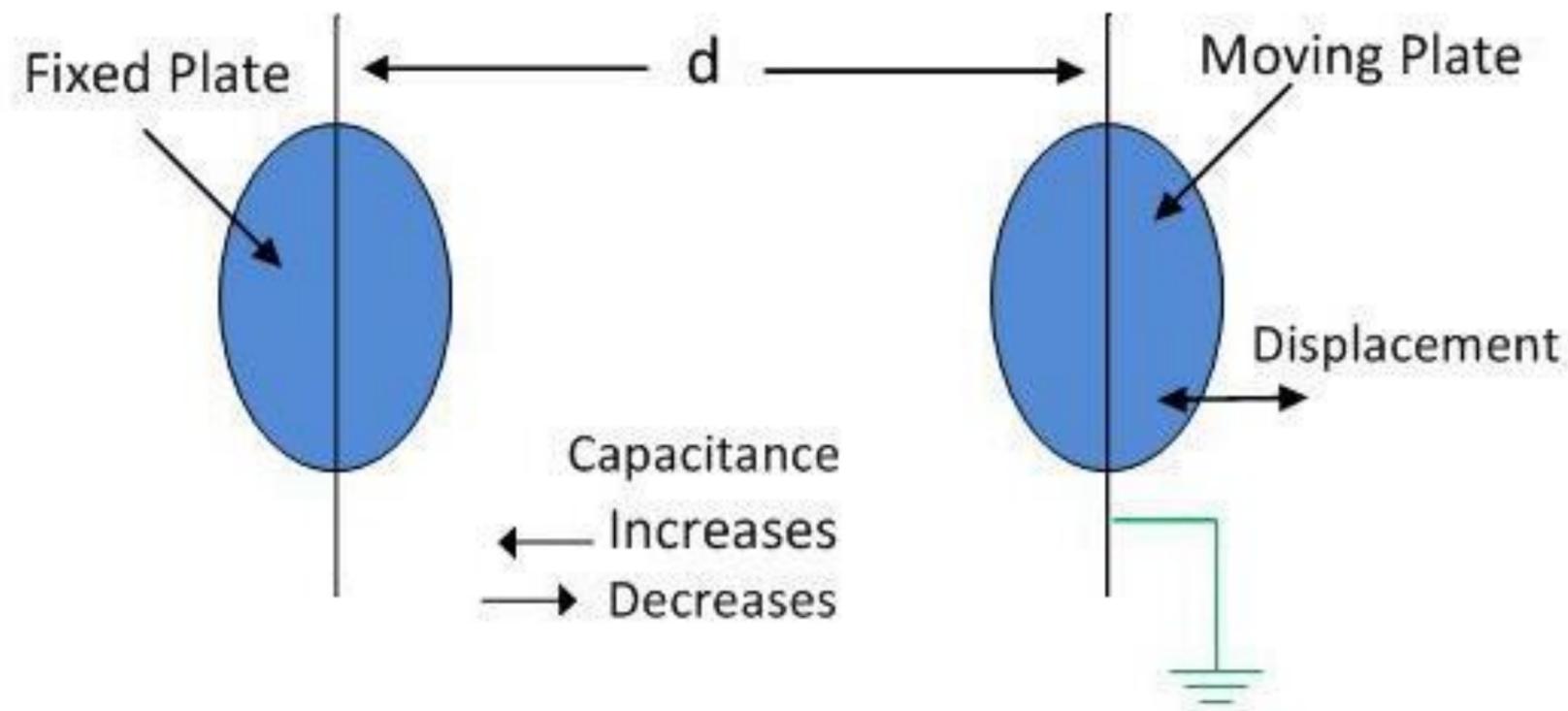
# Phasor Diagram





# *The transducer using the change in distance between the plates*

- The capacitance of the transducer is inversely proportional to the distance between the plates. The one plate of the transducer is fixed, and the other is movable. The displacement which is to be measured links to the movable plates.





## *Advantages*

- It requires an external force for operation and hence very useful for small systems.
- The capacitive transducer is very sensitive.
- It gives good frequency response because of which it is used for the dynamic study.
- The transducer has high input impedance hence they have a small loading effect.
- It requires small output power for operation.



## *Disadvantages*

- ❑ The metallic parts of the transducers require insulation.
- ❑ The frame of the capacitor requires earthing for reducing the effect of the stray magnetic field.
- ❑ Sometimes the transducer shows the nonlinear behaviours because of the edge effect which is controlled by using the guard ring.
- ❑ The cable connecting across the transducer causes an error.



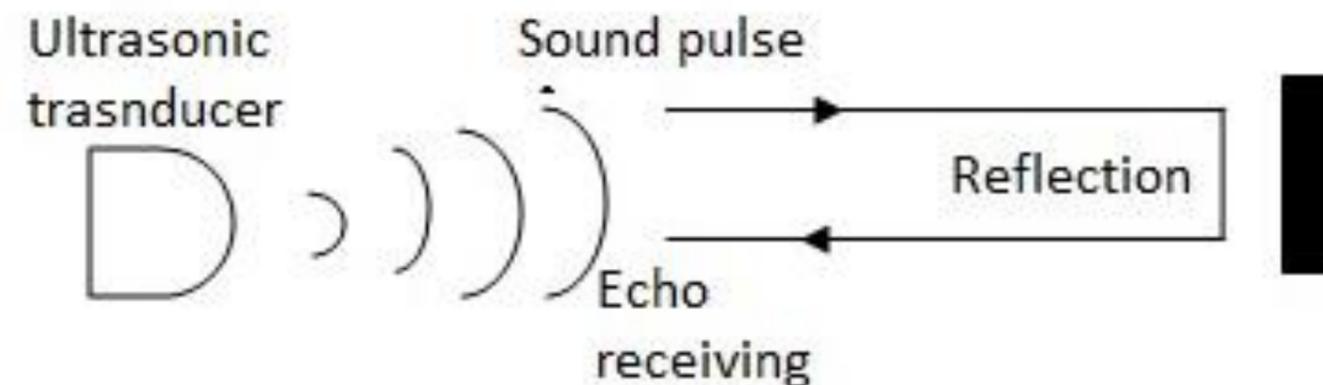
## *Uses*

- ❑ The capacitive transducer uses for measurement of both the linear and angular displacement. It is extremely sensitive and used for the measurement of very small distance.
- ❑ It is used for the measurement of the force and pressures. The force or pressure, which is to be measured is first converted into a displacement, and then the displacement changes the capacitances of the transducer.
- ❑ It is used as a pressure transducer in some cases, where the dielectric constant of the transducer changes with the pressure.
- ❑ The humidity in gases is measured through the capacitive transducer.
- ❑ The transducer uses the mechanical modifier for measuring the volume, density, weight etc.



# Ultrasonic Transducer

- ❑ An ultrasonic transducer is a device used to convert some other type of energy into an ultrasonic vibration. By these ultrasonic vibrations, this transducer measures the distance of the object. These are available in two types like active and passive
- ❑ The ultrasonic transducer is one type of sound-related sensor.
- ❑ These transducers send the electrical signals to the object and once the signal strikes the object then it reverts to the transducer.

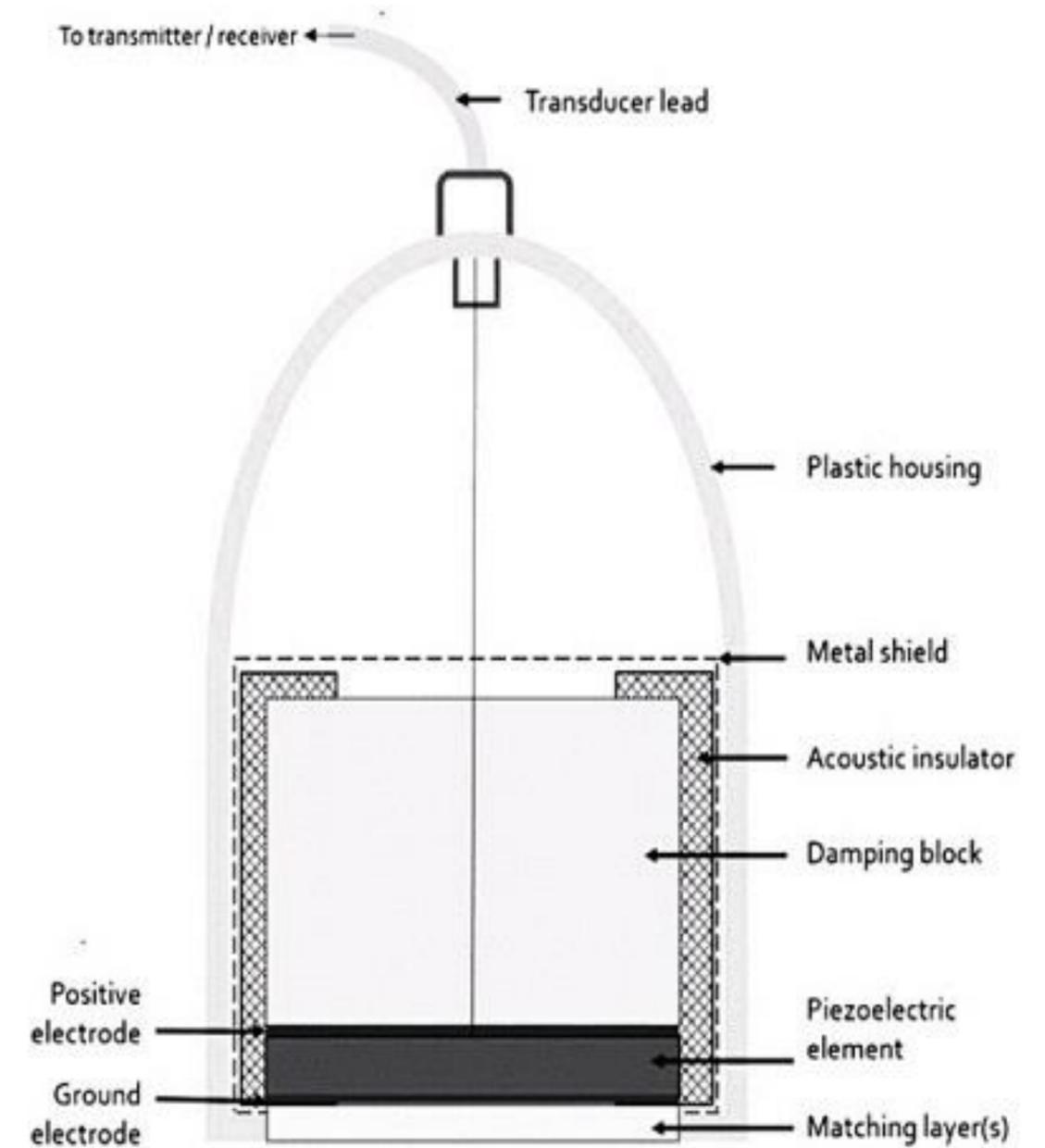




# Operation and Working



- ❑ The sound wave is produced when an electrical signal is applied to an ultrasonic transducer and it vibrates throughout the specified range of frequency.
- ❑ These sound waves travel and will send back the data of the transducer (or reflection of the transducer's echo) whenever any hurdle/interference appears. Hence the data is transformed into electrical signals.
- ❑ The transducer determines the time interval between the transmitted sound wave and the received echo signal. The ultrasonic transducer working principle is based on the transformation of one form of energy to another form.





## *Operation and Working*

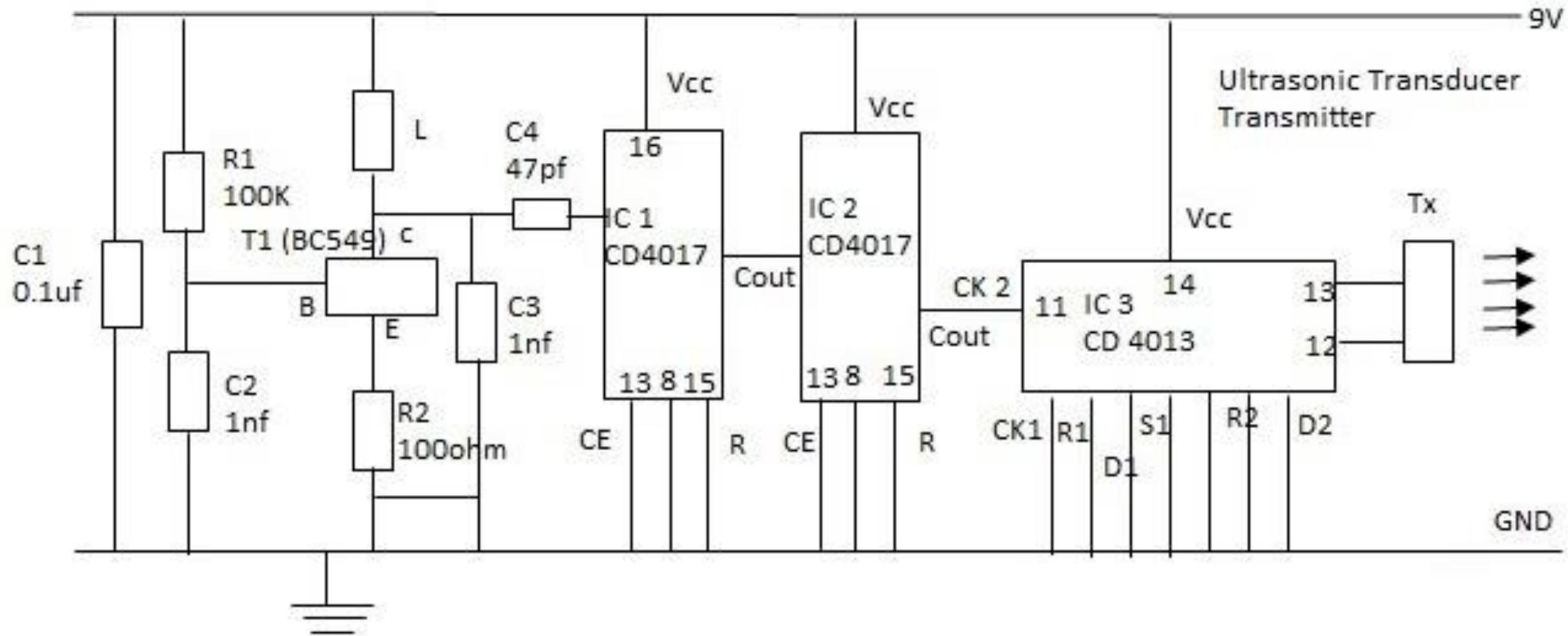
- ❑ At 40KHz, the ultrasonic pulse is transmitted by the ultrasonic transducer that travels through the air. This type of transducer is more preferred than any other infrared sensor because they are not influenced by dust, smote, black materials, etc. The ultrasonic transducers work efficiently in the suppression of noise distortion.
- ❑ To evaluate the distance, the ultrasonic transducers utilize ultrasonic waves. The formula to calculate the distance is given as,

$$D = \frac{1}{2} * T * C$$

- ❑ Where 'D' is the distance.
- ❑ 'T' gives the time gap between the transmitting and receiving of ultrasonic waves by the transducer
- ❑ 'C' is the sonic velocity

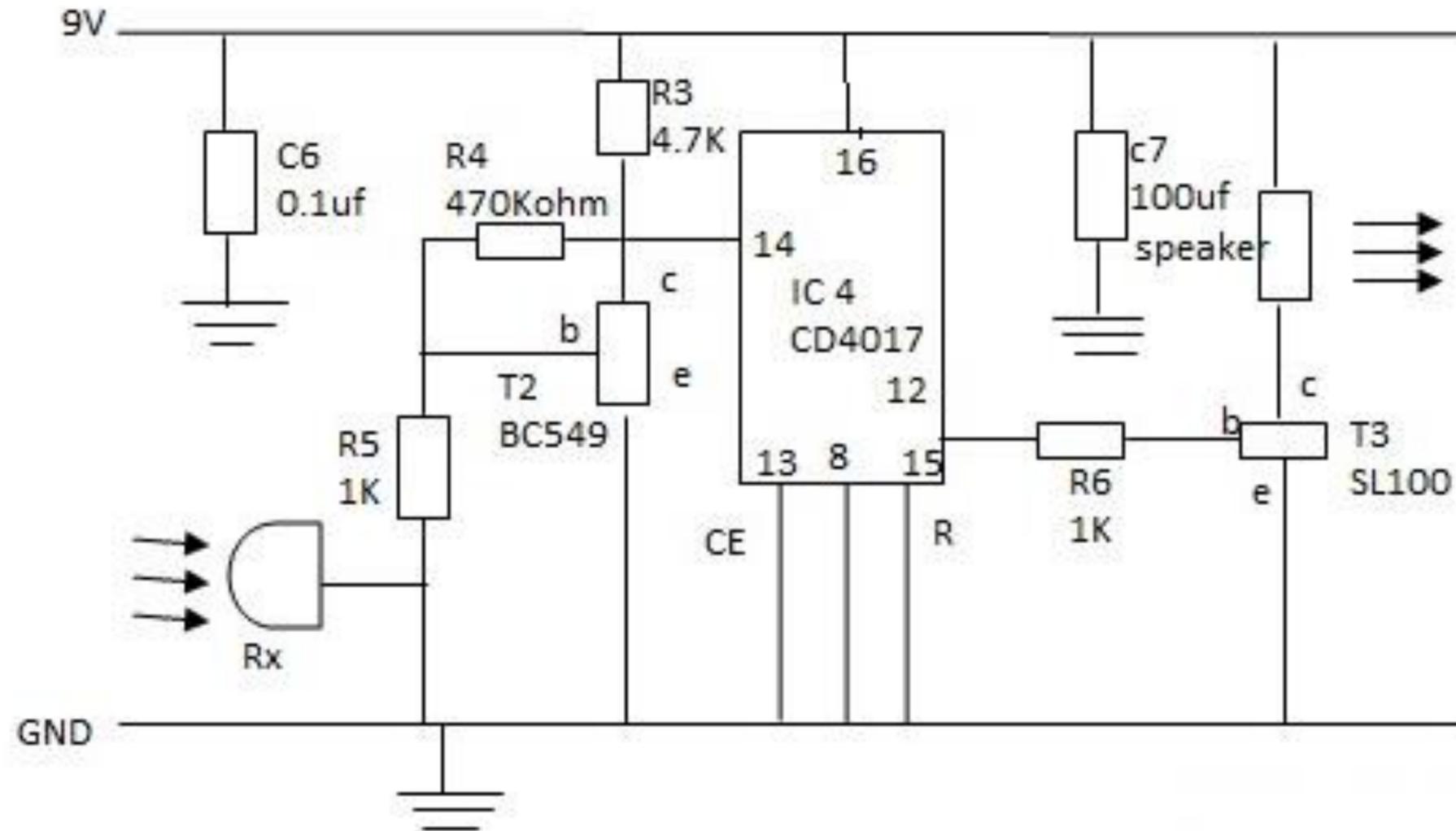


# Ultrasonic Transducer - Transmitter





# Ultrasonic Transducer - Receiver





## *Ultrasonic Transducer Types*



- ❑ **Linear Ultrasonic Transducers** – In this type of transducers, piezoelectric crystal arrangement is linear.
  
- ❑ **Standard Ultrasonic Transducers** – This type is also called as convex transducers. In this type, the piezoelectric crystal is in a curvy form. For in-depth examinations these are preferable.
  
- ❑ **Phased Array Ultrasonic Transducers** – Phased array transducers have a small footprint and low frequency. (its center frequency is 2 MHz – 7 MHz)



## *Advantages*

- ❑ These ultrasonic transducers can able to measure in any type of material. They can sense all types of materials.
- ❑ The ultrasonic transducers are not affected by temperature, water, dust or any.
- ❑ In any type of environment, the ultrasonic transducers will work in a good manner.
- ❑ It can measure in high sensing distances also.



## *Disadvantages*

- Ultrasonic transducers are sensitive to temperature variation. This temperature variation may change the ultrasonic reaction.
- It will face problems while reading the reflections from small objects, thin and soft objects.



# Application

- ❑ These transducers have many applications in different fields like industrial, medical, etc. These are having more applications because of ultrasonic waves. This helps find the targets, measure the distance of the objects to the target, to find the position of the object, to calculate the level also the ultrasonic transducers are helpful.
- ❑ In the medical field, the ultrasonic transducer is having the applications in diagnostic testing, surgical devices while treating cancer, internal organ testing, heart checkups, eyes and uterus checkups ultrasonic transducers are useful.
- ❑ In the industrial field, ultrasonic transducers have few important applications. By these transducers, they can measure the distance of certain objects to avoid a collision, in production line management, liquid level control, wire break detection, people detection for counting, vehicle detection and many more.



*Thank You*