SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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

Redesigning Common Mind & Business Towards Excellence

Build an Entrepreneurial Mindset Through Our Design Thinking FrameWork

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 23EET206 CONTROL SYSTEMS AND INSTRUMENTATION

II YEAR ECE /III SEMESTER

Unit 4- Electronic Instruments & Transducers

Topic 6 : Displacement Transducer

TRANSDUCER

- **A transducer** is a device that transforms energy from one form to another, commonly used in sensing, measurement, and control applications.
- It can convert signals such as pressure into displacement or sound into electrical signals, facilitating interpretation and analysis.

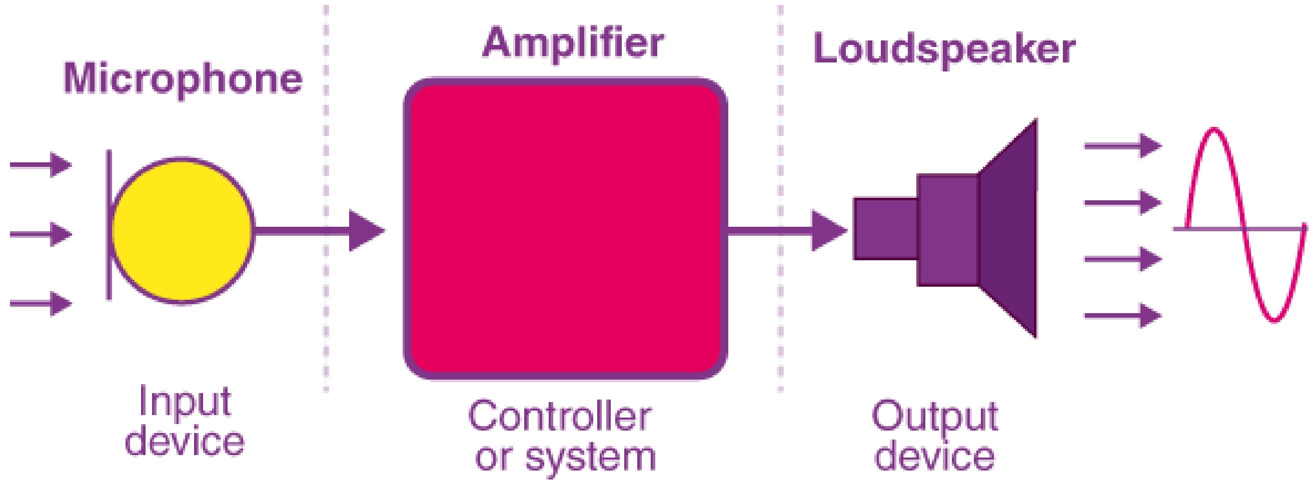
Sensing Element

It is the part of a transducer that responds to the physical sensation. The response of the sensing element depends on the physical phenomenon.

Transduction Element

The transduction element of the transducer converts the output of the sensing element into an electrical signal. The transduction element is also called the secondary transducer.

TRANSDUCER



INPUT TRANSDUCER

OUTPUT TRANSDUCER

Aspect	Sensor	Transducer
Function	Detects changes in environment and converts them into electrical signals	Converts one form of energy into another, including electrical signals
Scope	Specialized for measuring specific physical quantities	Broader range of applications beyond sensing, including actuation and control
Examples	Temperature sensor, pressure sensor, motion sensor	Microphone, loudspeaker, accelerometer
Typical Output	Electrical signals	Various forms of energy
Application	Monitoring and measuring physical parameters	Actuation, control, and signal conversion in various systems

DISPLACEMENT TRANSDUCER

- A displacement transducer is a device that converts mechanical motion or vibrations into electrical signals, or vice versa. They are also known as position sensors and are used in a variety of applications.
- A displacement transducer, or DT, is an electrical transducer used in measuring linear position.
- Linear displacement is the movement of an object in one direction along a single axis. Measuring displacement indicates the direction of motion.
- The output signal of the linear displacement sensor is the measurement of the distance an object has traveled in units of millimeters (mm), or inches (in.), and can have a negative or positive value.
- Precision manufactured displacement transducers are mounted on most modern product lines for automatic gaging in sorting, “go-no go” applications, and quality opera

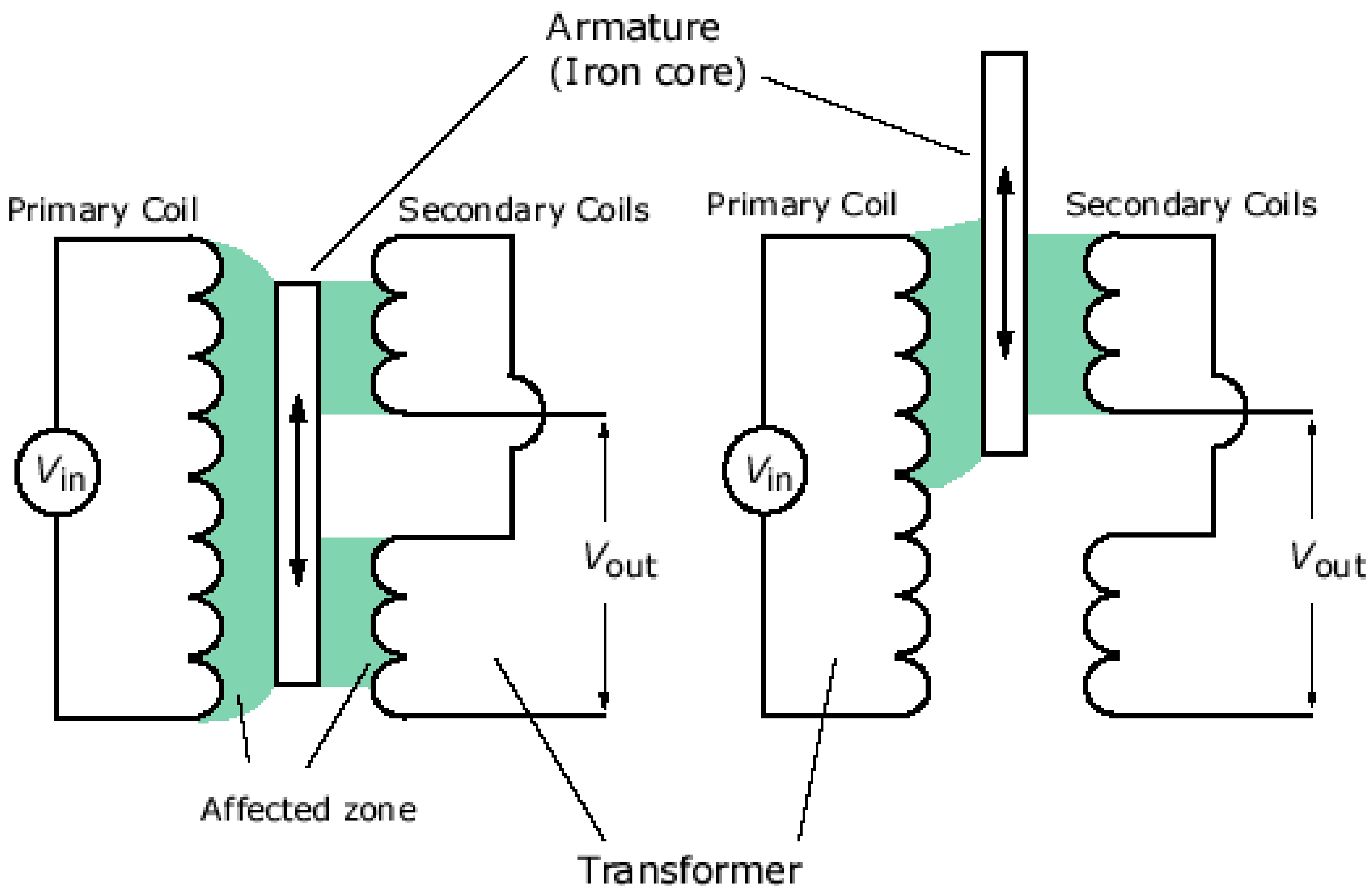
TYPES OF DISPLACEMENT TRANSDUCER (Conversion Principle)

- Electromagnetic
- Magnetoelectric
- Inductive
- Electrostatic

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

- It converts the Linear motion into an electrical signal using an inductive transducer. Due to its superior sensitivity and accuracy over other inductive transducers, the LVDT is extensively used in many different fields.
- For measuring linear distance, the linear variable differential transformer (LVDT) is a precise and trustworthy tool. Today, LVDTs are used in computerized manufacturing, robotics, avionics, and machine tools, combining research facilities, high-level analysis, and analysis to detect damage caused by massive rock deformation or other movements in the subgrade of old buildings or structures. physical structure.
- This method is used to try to detect failure in concrete slopes and warn or correct the condition. One of the special problems with historical buildings is that they can easily be damaged by small deformations in the long run.

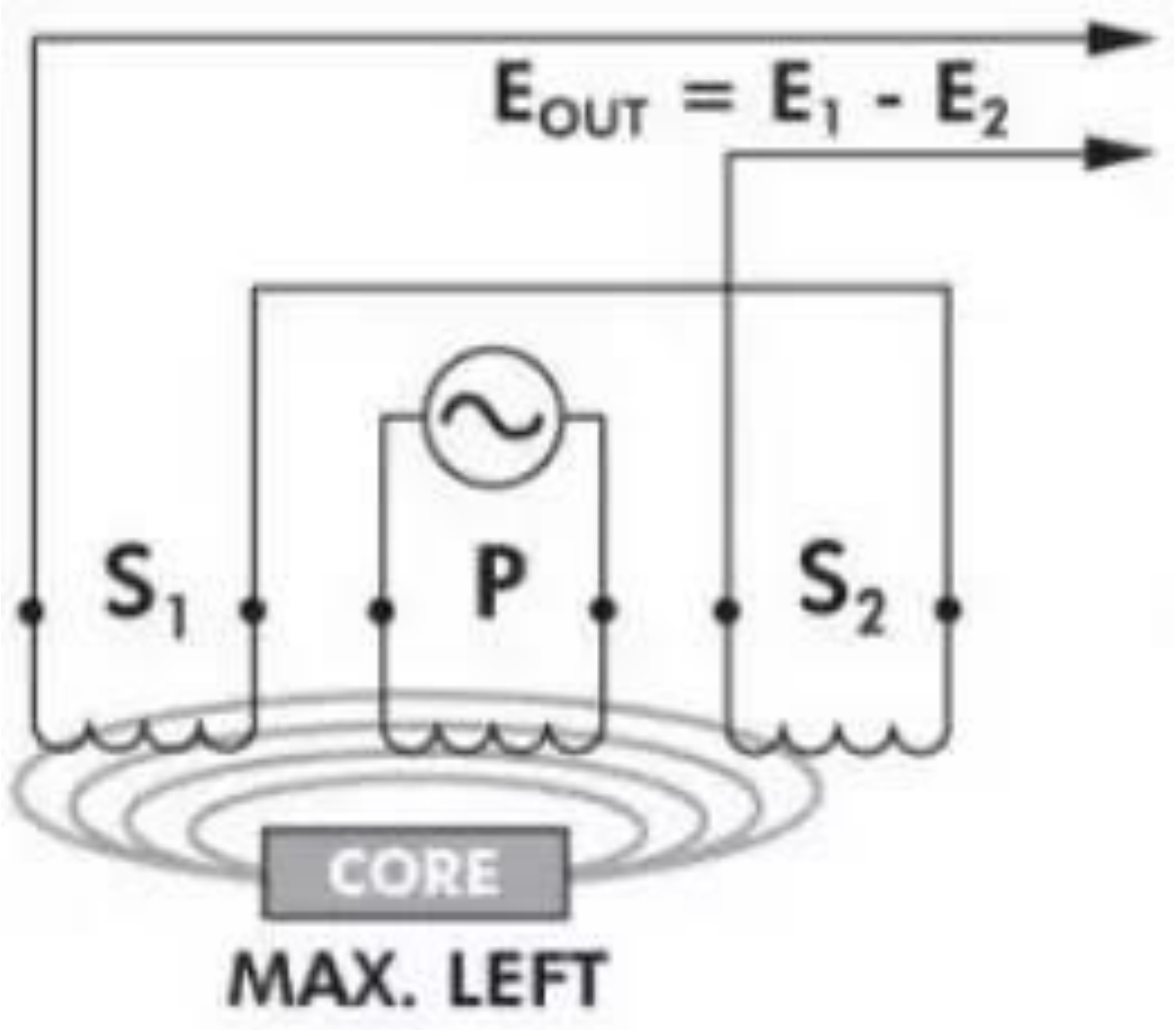
LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)



- The transformer and LVDT share a similar construction. It consists of one primary winding(P) and two secondary windings (S1 & S2). The primary and secondary windings are bounded by a hollow cylinder, known as the former. The primary winding is at the center and the secondary windings are present on both sides of the primary winding at an equal distance from the center. Both the secondary windings have an equal no. of terms and they are linked with each other in series opposition, i.e. they are wounded in opposite directions, but are connected in series with each other.
- The entire coil assembly remains stationary during distance measurement. The moving part of the LVDT is an arm made of magnetic material.

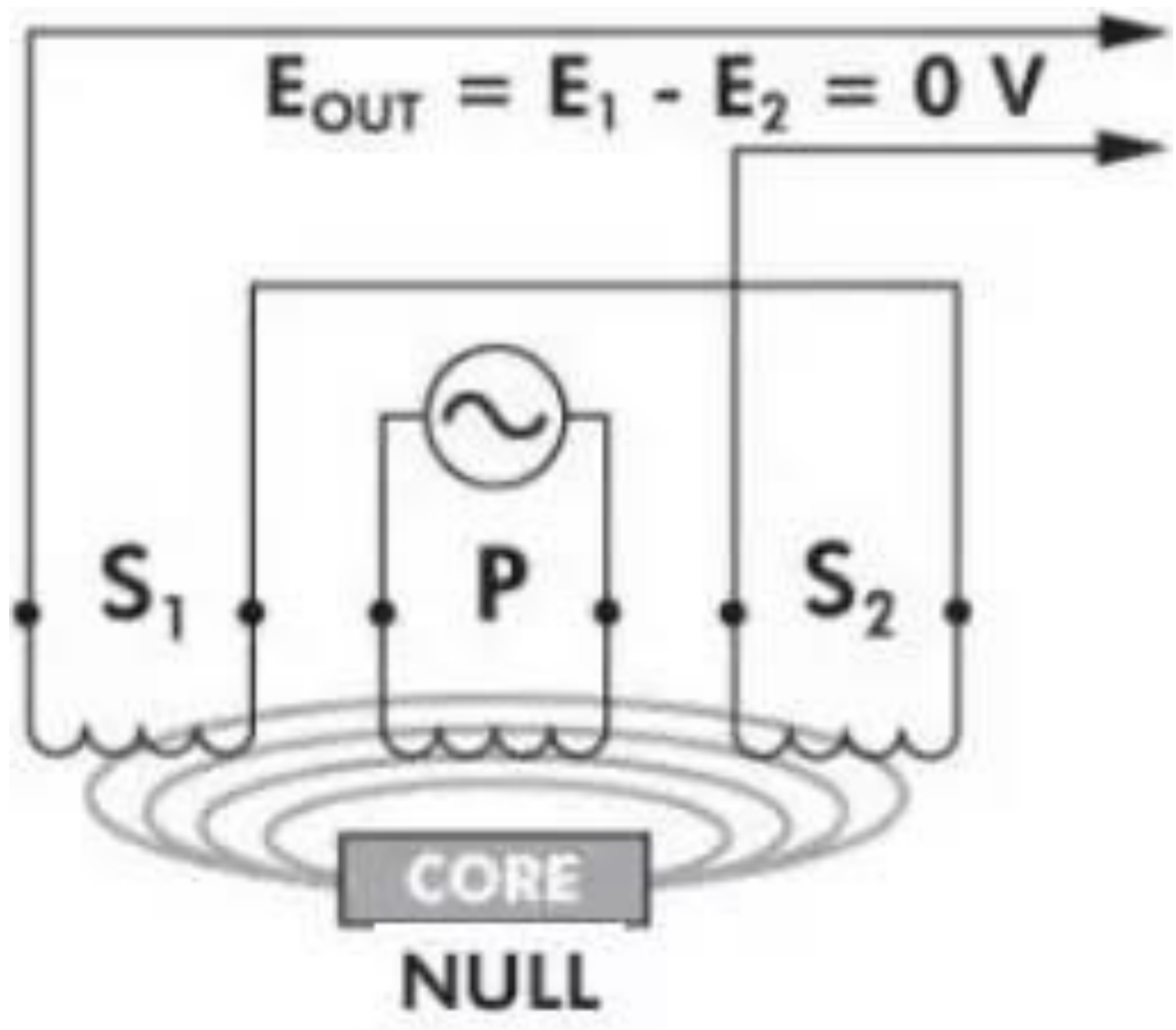
CASE 1: CORE MOVES TOWARDS S1

When the core of LVDT moves toward Secondary winding **S1**. Then, in this case, the flux linkage with **S1** will be more as compared to **S2**. This means the emf induced in S1 will be more than the induced emf in **S2**. Hence **E1>E2** and Net differential output voltage **E0 = E1 – E2** will be positive. This means the output voltage **E0** will be in phase with the primary voltage.



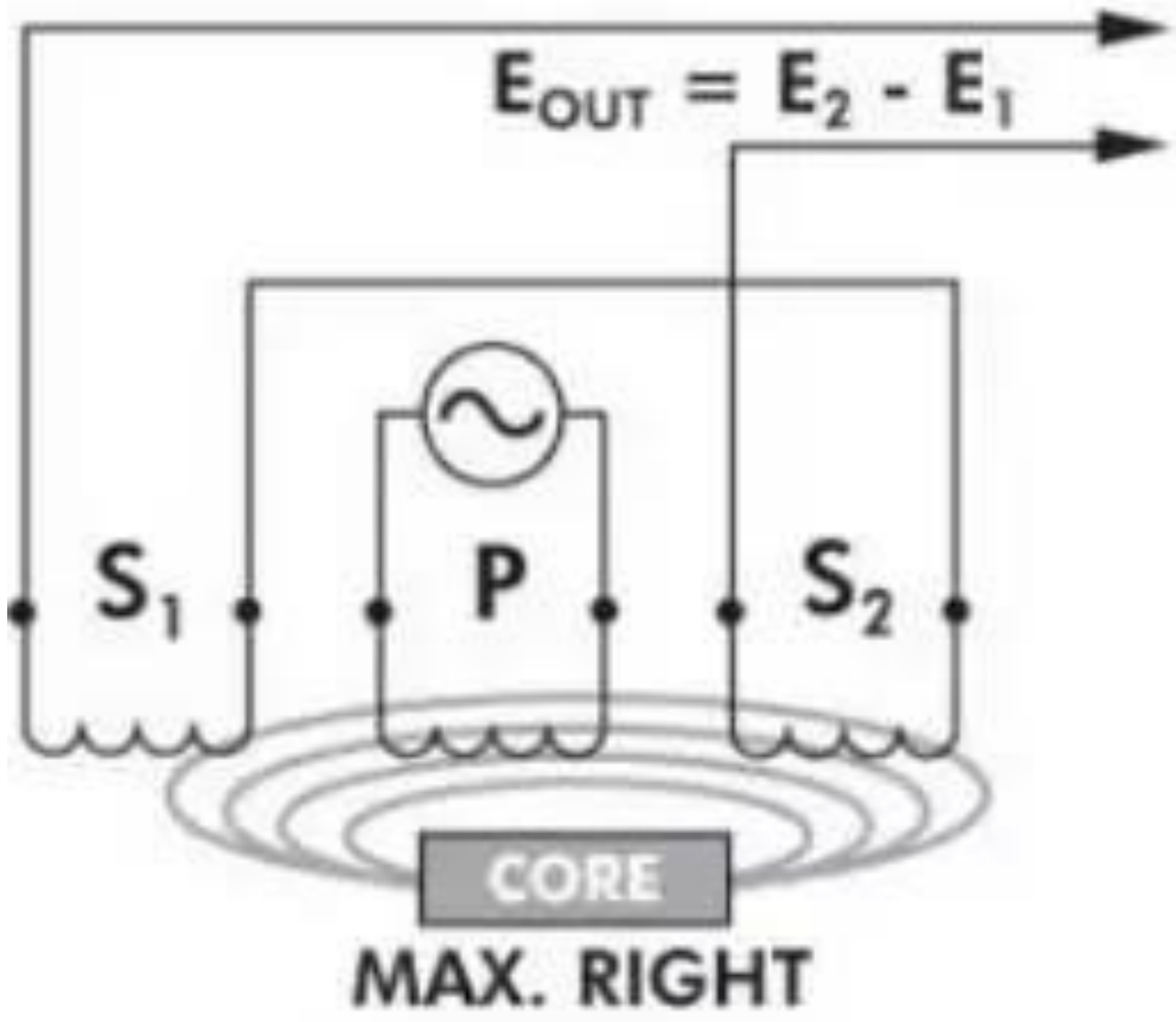
CASE 2: CORE AT NULL POSITION

When the core is at the null position then the flux linkage with both the secondary windings will be the same. So the induced emf **(E1 & E2)** in both the windings will be the same. Hence the Net differential output voltage **E0 = E1 – E2** will be zero **(E0 = E1 – E2 = 0)**. It shows that no displacement of the core.



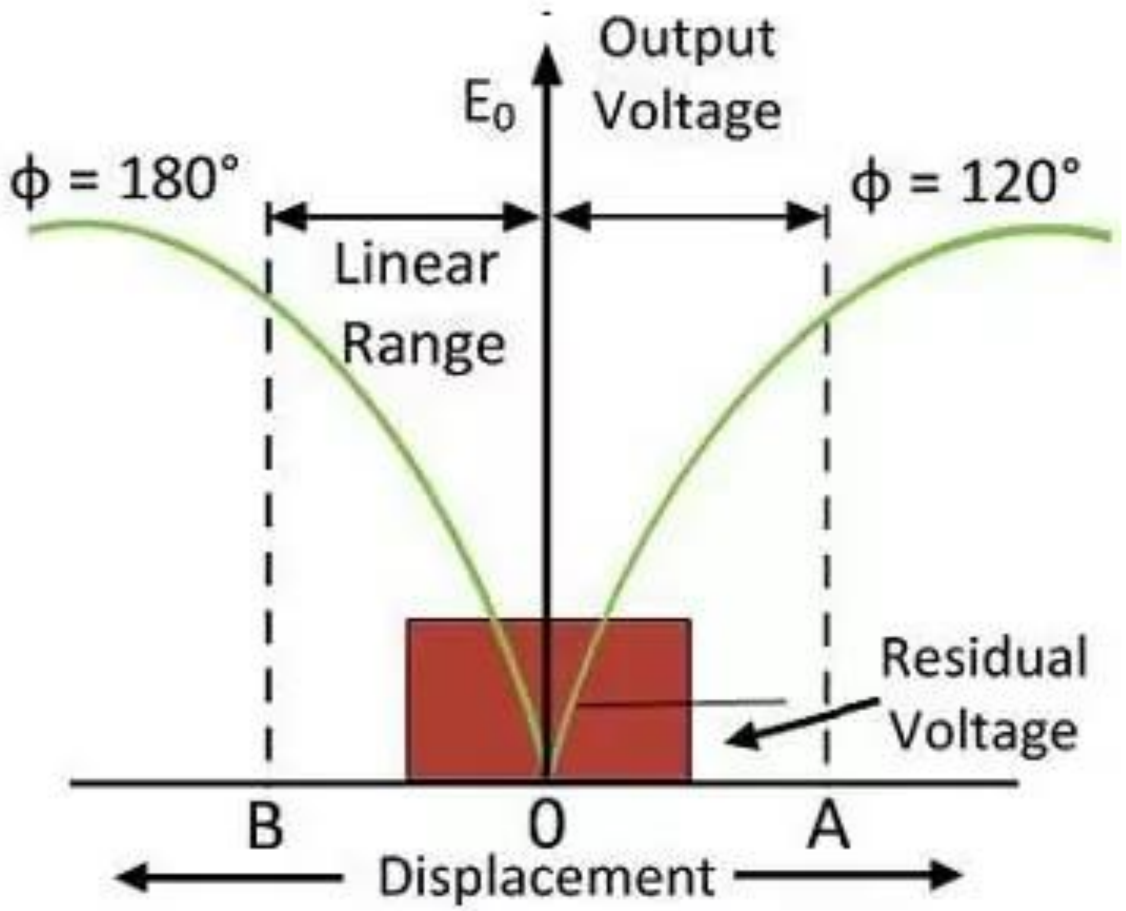
CASE 3: CORE MOVES TOWARDS RIGHT

When the core of LVDT moves toward Secondary winding **S2**. Then, in this case, the flux linkage with **S2** will be more as compared to **S1**. It means the emf induced in S2 will be more than the induced emf in S1. Hence **E2>E1** and Net differential output voltage **E0 = E1 – E2** will be negative. It means the output voltage **E0** will be in phase opposition (**180** degrees out of phase) with the primary voltage.



LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

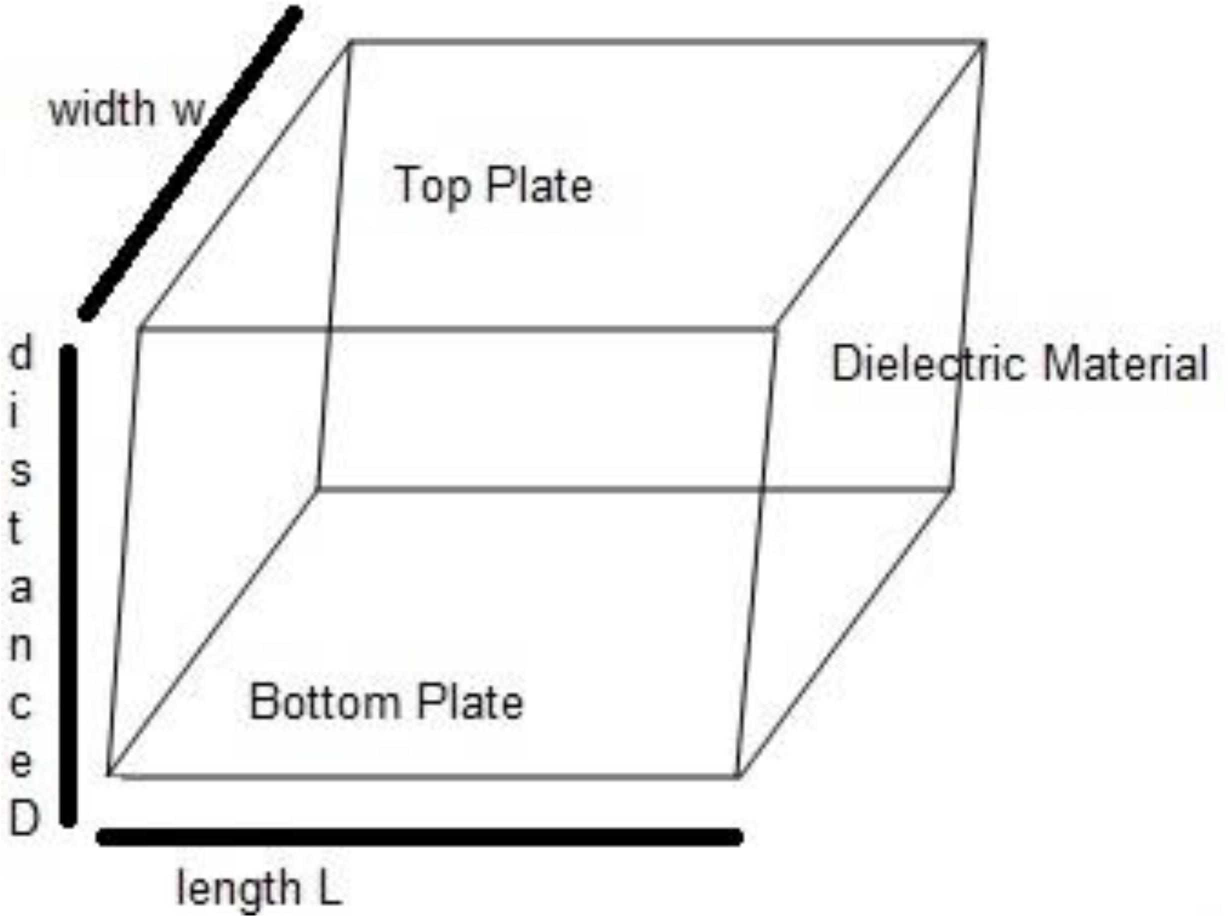
- The direction of the movement of an object can be identified with the help of the differential output voltage of LVDT.
- The amount or magnitude of displacement is proportional to the differential output of LVDT. The more the output voltage, the more will be the displacement of the object.
- If we take the core out of the former then the net differential of the output of LVDT will be zero.
- In fact corresponding to both cases, whether the core is moving either Left or Right to the Null position. Then the output voltage will be increased linearly up to 5mm from the Null position and after 5 mm output E0 will be non-linear.



CAPACITANCE TRANSDUCER

- **Capacitive displacement sensors** are "non-contact devices capable of high-resolution measurement of the position and/or change of position of any conductive target".
- They are also able to measure the thickness or density of non-conductive materials.
- Capacitive displacement sensors are used in a wide variety of applications including semiconductor processing, assembly of precision equipment such as disk drives, precision thickness measurements, machine tool metrology and assembly line testing. These types of sensors can be found in machining and manufacturing facilities around the world.

CAPACITANCE TRANSDUCER



The capacitance of the variable capacitor can be measured by this formula.

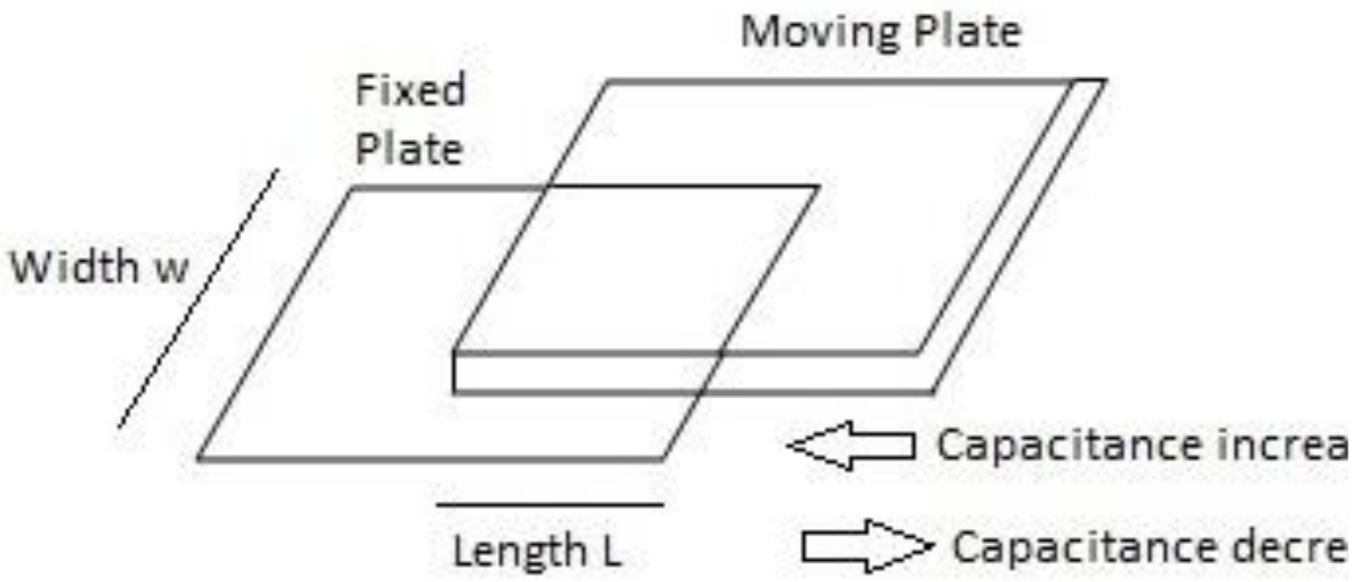
$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

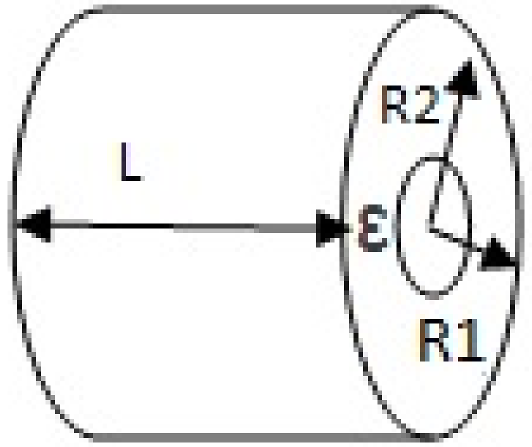
C indicates the capacitance of the variable capacitance
ε_o indicates the permittivity of free space
ε_r indicates the relative permittivity
A indicates the area of the plates
D indicates the distance between the plates

CAPACITANCE TRANSDUCER

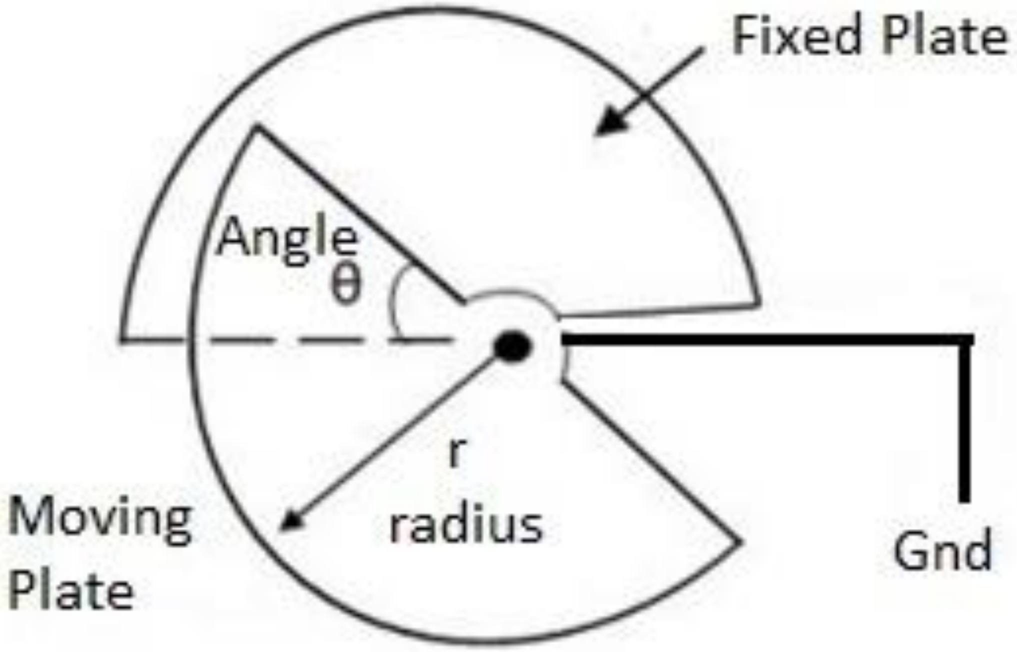
- The variable capacitance value is dependent on four important parameters. They are the distance between the plates of the variable capacitor, occupying area of the plates, permittivity of the free space, relative permittivity and dielectric material. These parameters can be varying the capacitance value of the variable capacitor.
- Change in dielectric constant can vary the capacitance of this transducer.
- The area of the plates of these transducers can vary its capacitance value.
- Distance between the plates can vary the transducers' capacitance value. This method is mostly used. In this method, the dielectric medium and area of the plates are kept constant. When the plates are moving then the distance is varied and this results in the changing of the capacitance of the capacitive transducer.

CHANGING AREA OF THE PLATE

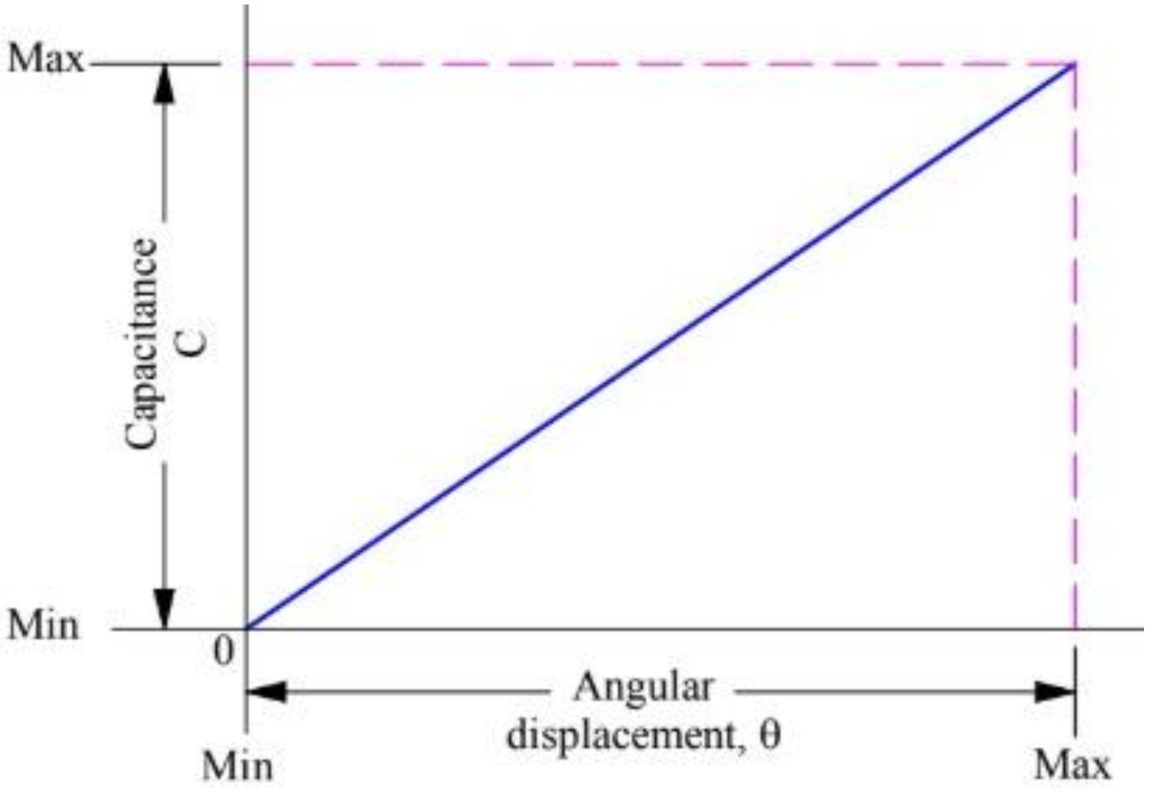




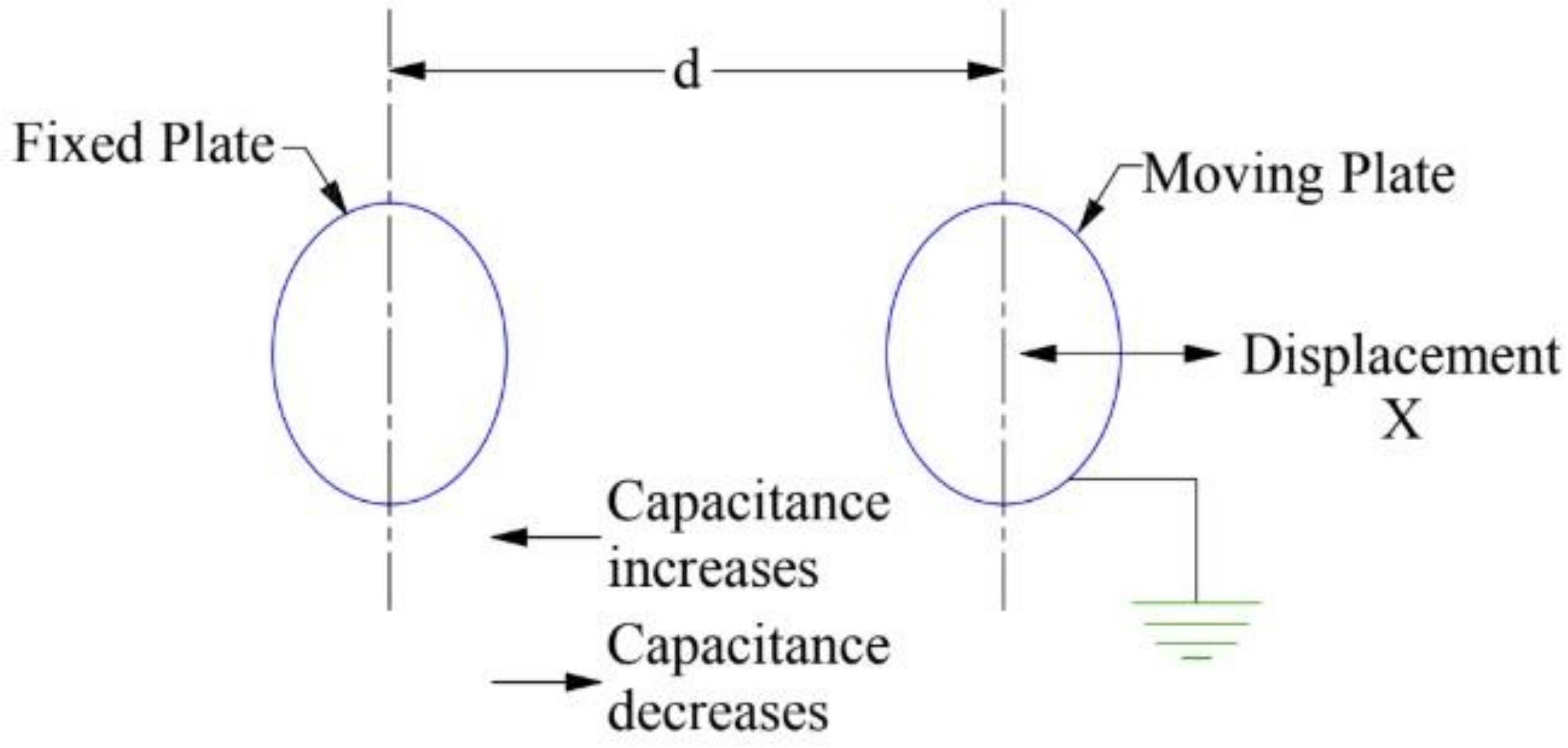
$$C = \frac{2*Pi*\varepsilon_o*\varepsilon_r*L}{\text{Log }(R2/R1)}$$



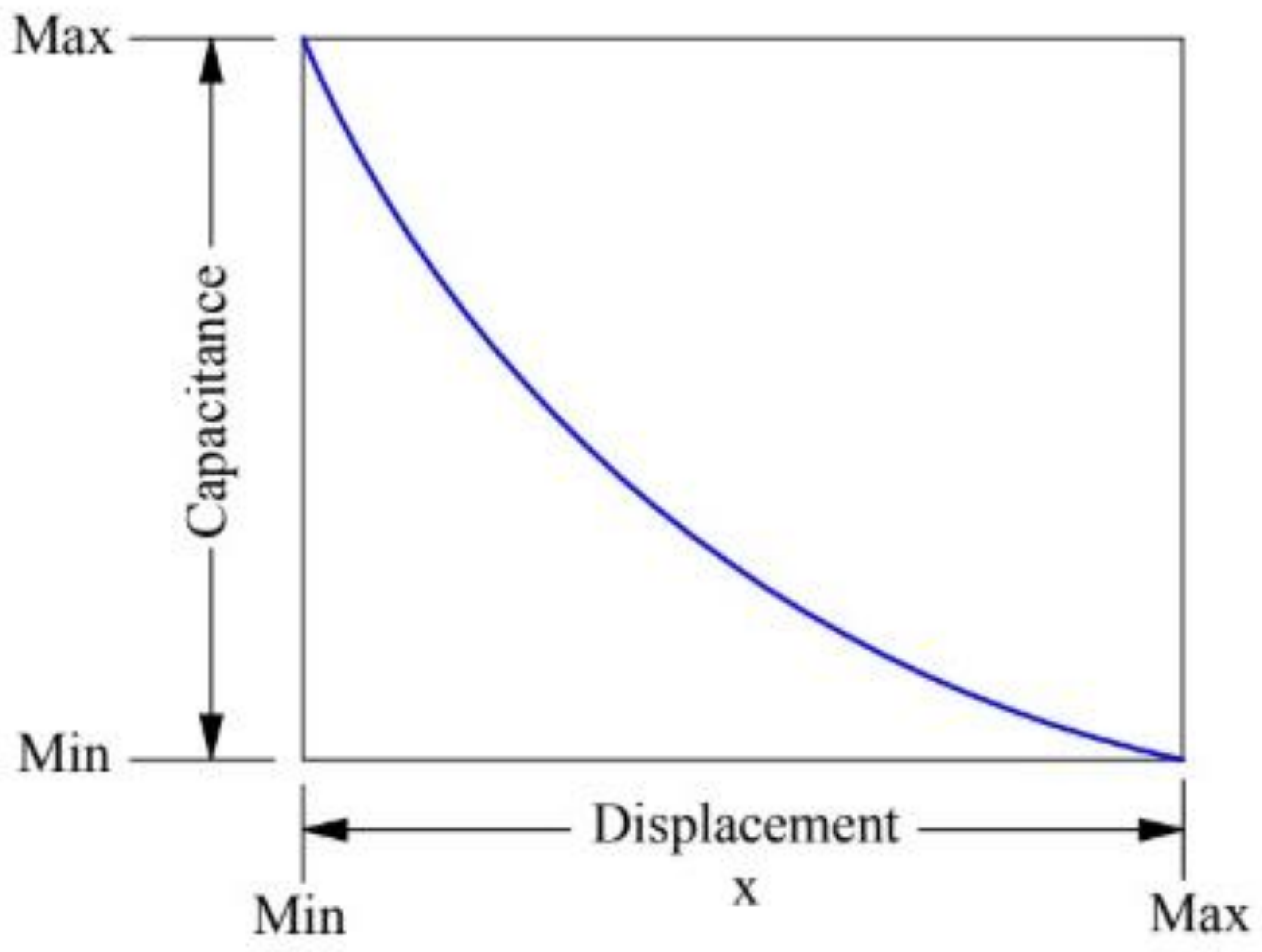
$$C = \frac{\varepsilon \theta r^2}{d}$$



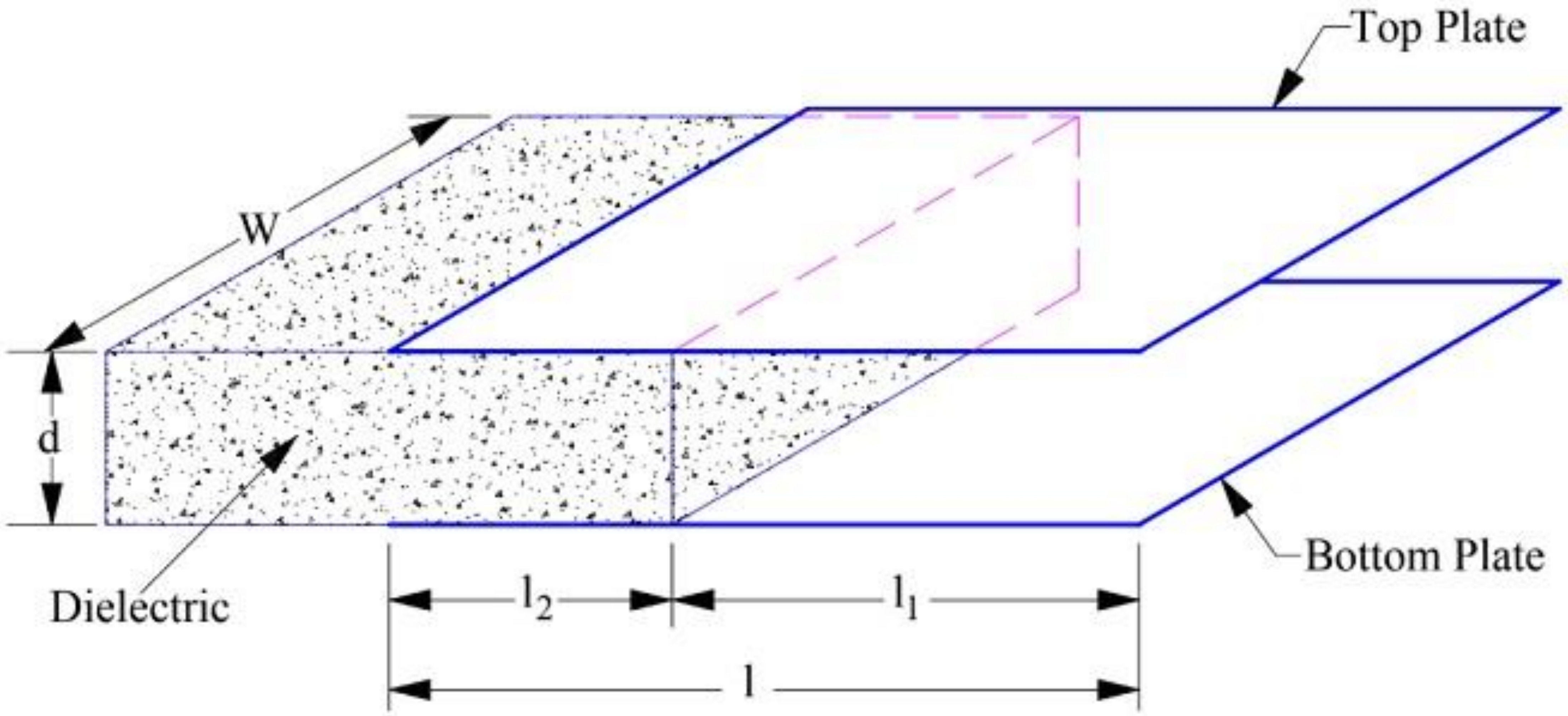
CHANGING THE DISTANCE BETWEEN THE PLATES



$C = \varepsilon A/x$



CHANGING THE DIELECTRIC CONSTANT



$$C = \frac{\varepsilon_0 W}{d}[l_1 + \varepsilon_r l_2]$$

References

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2. Sawhney A K., "Course in Electrical, Electronic Measurements and Instrumentation", Shree Hari Publications, 2021(Unit IV-V).
3. Patranabis D, "Principles of Industrial Instrumentation", Mc-Graw Hill Education, 3rd Edition, 2017 (Unit IV-V).

Thank You