Electrical Measurement and Electronic Instruments
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Lecture - 07
Electrostatic Instrument

So, we shall talk about another type of instruments which is called Electrostatic Instruments. Previously you would recall that we have talked about electrodynamic instruments and then the name automatically suggests that there must be something called electrostatic instruments because, there is something electro dynamic. So, why should there be not something called electrostatic? So, let us see the working principle of this instrument.

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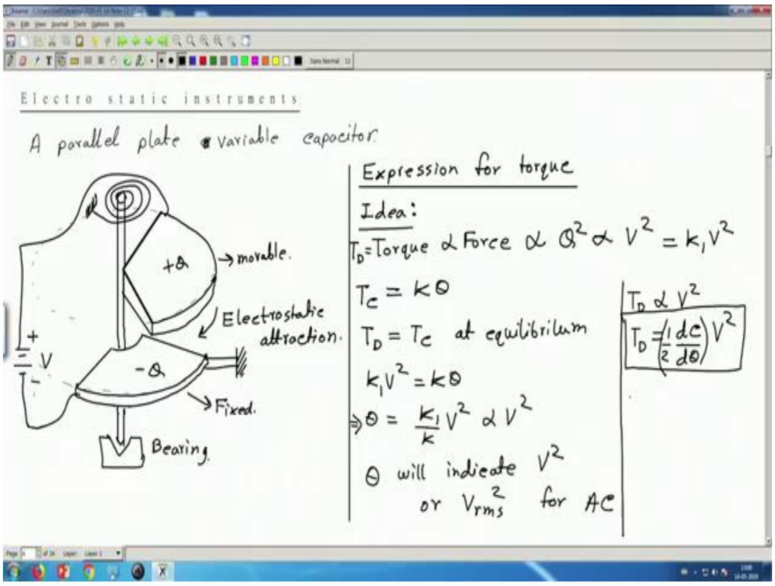

This instrument is basically a set of a parallel plate capacitor, parallel plate variable capacitor. So, it has pair of parallel plates, which may be like this, maybe I have one plate here. So, this is one plate and see this is attached to a spindle which can rotate. So, this spindle can rotate on a bearing. So, this is bearing. And below this we have another plate which is like this, let me bring these two plates bit closer. And this plate is not attached to this spindle. So, this second plate is not attached to this spindle.

So, let me it is it from here; so, this is not attached to this spindle. This may be attached to the frame of the instrument. So, this is fixed, this is movable and these two plates can have some common overlapping area because this one can turn, and this is fixed. So, let me be maybe I can demonstrate you this.

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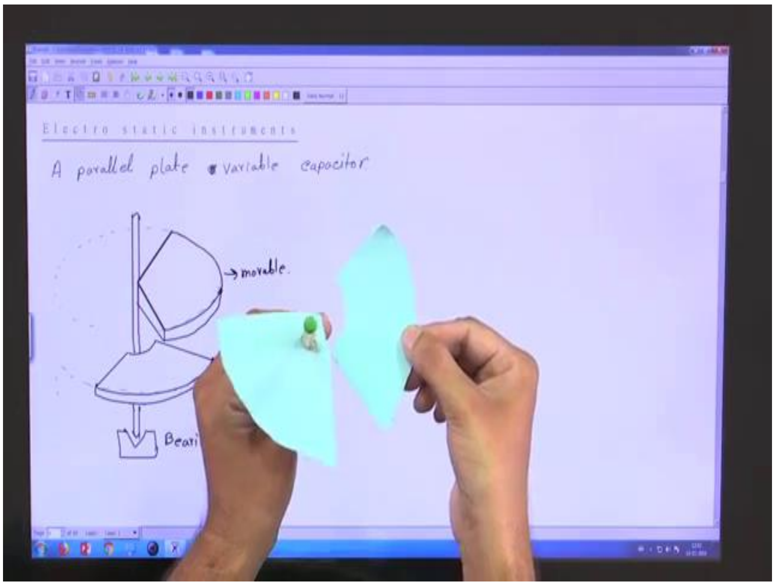

So, we may go to the overhead camera. So, let me take two plates let me make two metallic plates, although this is paper just paper now, but assume this is metal and one of them is attached to a spindle like this, this can turn. And I have another plate which I hold in my hand and this one, this plate cannot turn. So, one plate can turn another cannot turn and as it turns, you see the overlapping area between them changes. Here we have maximum overlap, here no overlap and here partial overlap so, this is the arrangement.

Now, what will happen if I apply a voltage between these two between these two plates? So now, this is positive, and this is negative side. So, plus charge will accumulate here and minus charge will accumulate here. So, this also acts like a parallel plate capacitor and then, this plus and minus charges they will attract each other. So therefore, this movable plate we will try to come closer to this fixed plate due to attraction. And, what kind of attraction? This is electrostatic attraction between two charged plates; that is why this instrument is called electrostatic instrument.

The previous instrument which we call electrodynamic instrument, there the force of attraction was between a current carrying conduct conductor, so there the charge was movable. So, that is why that was electro dynamic force, here it is electrostatic force. So, then due to this force this movable plate will come closer to this fixed plate, and if I now attach a spring as always to stop or to hold back this movable plate, then depending on the force of attraction the amount of movement will be determined. So, this is called electro static instrument once again. So normally we would like to find out the equation or expression for torque.

$$T_D \; \alpha \; Q^2 \; \alpha \; V^2 = KV^2$$

$$T_C = K\theta$$

$$\text{At equilibrium, } T_C = T_D$$

$$T_D \; \alpha \; \theta = \frac{K_1}{K_2} V^2 \; \alpha \; V^2$$

$$T_D = \left(\frac{1}{2}\frac{dC}{d\theta}\right) V^2$$

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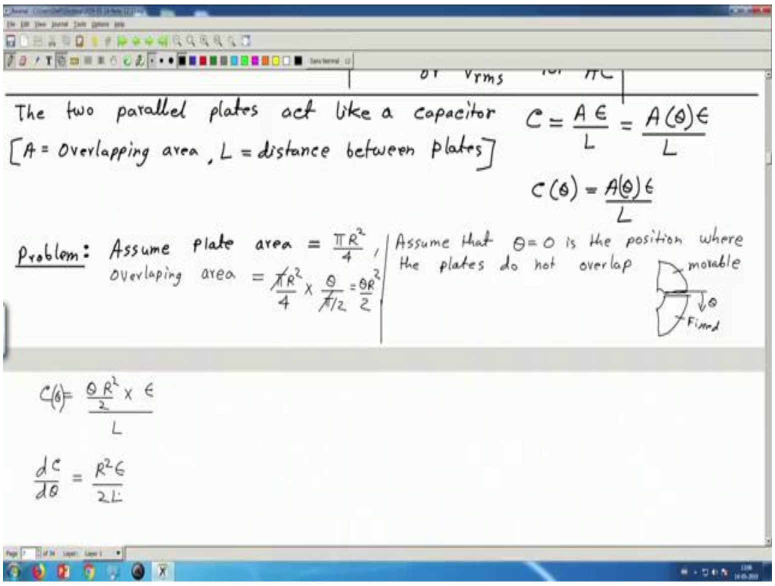

So, we know that there is so, these two plates, these two parallel plates act like a capacitor. The two parallel plates act like a capacitor and you can find the expression of the capacitance C;

$$C = \frac{AE}{L} = \frac{A(\theta)\varepsilon}{L}$$

$$C(\theta) = \frac{A(\theta)\varepsilon}{L}$$

So, this overlapping area A, changes as this movable plate rotates. So, we can write A as a function of theta.

$$C(\theta) = \frac{\frac{\theta R^2}{2}\varepsilon}{L}$$

$$\frac{dC}{d\theta} = \frac{R^2\varepsilon}{2L}$$

So, this is the meaning of this equation, we have not proved this equation in this video, but we should understand the meaning of this expression. And maybe we can do a very quick exercise. So, assume that these are quarter circles, both these plates are quarter circles. So, the total plate area will be how much?

$$Plate\ Area = \frac{\pi R^2}{4}$$

So, this is the total area and overlap. So therefore, overlapping area will be, so assume that theta equal to 0 is the position where, the plates do not overlap, their edges are side by side if that is the case. So, like so, theta equal to 0 is the position when we have one plate here and another plate here. So, exactly no overlap, 0 overlap see and then say this is fixed, this is movable, and this can move.

$$Overlaping\ Area = \frac{\pi R^2}{4} \times \frac{\theta}{\left(\frac{\pi}{2}\right)} = \frac{\theta R^2}{2}$$

So, this is very simple. So, here we have talked about this equation and we have tried to understand this equation, but we have not yet proved this equation.

Thank you!