Robotics
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Lecture – 33
Sensors (Contd.)

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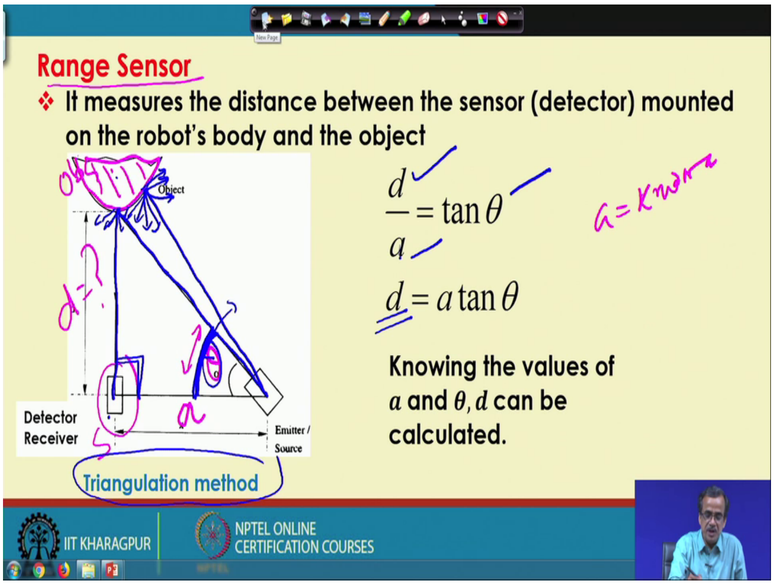

Now, we are going to discuss, the working principle of a Range Sensor. Now this range sensor is generally used, just to find out the distance between the object and this particular sensor. Now, supposing that so this is actually the detector or the sensor. Say this particular detector or the sensor is mounted on the robotic link or a robotic joint. And I am just going to ensure the collision free movement of that particular joint with the obstacle.

Now, supposing that this is the obstacle. So, this obstacle actually I am just trying to find out so what is the distance between so this particular obstacle, so this is the obstacle and or the object and this is actually the sensor or the detector or the receiver. So, I am trying to find out what is the distance between this particular object or the obstacle and the sensor or the detector. So, this d, I will have to find out d is equals to what ok.

Now, here actually on the PPT, I will have to make one correction. So, this particular angle, it is not alpha, let us write the angle is theta. And this particular distance is say a in place of x ok. Now, here we have got there is a light source or a detect or an emitter.

Now, this particular angle theta, so it can be varied. So I can vary this particular angle theta. Now, supposing that I know the distance between the sensor and this particular light source or the emitter, so this distance is known that is a is known ok, so a is known and theta is actually it is a variable and I am just going to vary this particular theta.

Now, by varying theta, so I will be getting, so different type of responses here in this particular the sensor. For example, say if I use a higher value of this particular theta say for example, I am using a higher value and this light is going to fall here. So, this is the light source; so, light is going to fall here. And this is not a very smooth surface. So, what will happen is, so this particular light there will be some reflection here. So, this type of reflected beams will be getting and it is not a very smooth surface, so I may not get a very bright spot with the help of this detector.

Now, you just go on varying this particular theta. The moment theta becomes this equal to this, there is a possibility that I will be getting this type of beam; and here there will be some reflection this side that side; but there is a possibility, I will be getting a very bright spot here with the help of this particular the sensor. The moment you got a very bright spot with the help of this particular sensor ok, it is more or less correct that this particular angle is your 90 degree and this angle theta we can measure ok.

And if you can measure this particular angle theta, that means your so I am getting very good reflection here ok, and this angle is 90 degree. I know this particular theta, so very easily I can find out, because d divided by a; so, d, I am going to determine. So, d divided by a is nothing but tan theta, tan theta I can measure, a is known. So, very easily I can find out d that is the distance between the sensor and this particular the obstacle.

Now, let me let me repeat that particular example once again. Suppose, if this is the robotic joint; so, here I am just going to put that particular sensor. And I want to make this particular joint collision free and supposing that, I have got one object here. So, it is come very near to this particular object, so I will have to find out the distance between the object and this particular the joint. So, this type of sensor I can use just to find out the distance between your so this sensor and this object or the obstacle.

Now here I can use a light source; I can also use some sort of sound source. And this method is a very popularly known as the triangulation method. So, in range sensor, we use some sort of the triangulation method. It is very simple. And using this very simple mathematics, we can find out the distance between the obstacle and this particular the sensor, which is mounted on the body of this particular the robot ok. This is the working principle of your the range sensor.

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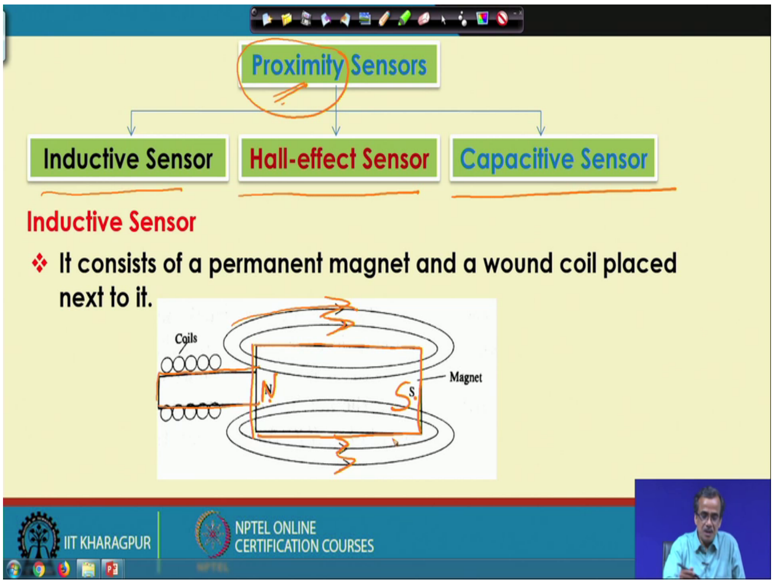

Now, I am going to discuss the proximity sensor; and these proximity sensors are very frequently used. For example, say we have got three popular types of sensor, proximity sensor; one is called the inductive sensor; we have got the hall-effect sensor and we have got the capacitive sensor. Now, let me try to explain the working principle of this particular the inductive sensor. Now, by proximity we mean, it is the closeness ok. So, what is the how much closeness we are going to consider between the sensor and this particular object.

So, proximity means it is actually the closeness. So, this inductive sensor the working principle is very simple. So, here we use one permanent magnet, supposing that this is the permanent magnet. And this is the North Pole, and this is the South Pole of the magnet. And this is the extended version of this particular the magnet say ok. And on the extended version, so we put some coils for current flow. So, we have got some electric coils wires for current flow.

Now, this is the North Pole and this is the South Pole. So, the magnetic lines of force will pass through pass from will come from come out from North Pole and it will move through the South Pole outside that particular magnet; and inside the magnet, it will be from South Pole to north pole. So, this is actually the direction of the lines of forces. So, these are the direction of lines of forces ok. These are all fundamentals all of us we know. And this is a permanent magnet ok. Now, so this will have some lines of forces, it will have some magnetic flux. Now, let us see what happens like if I just bring one ferromagnetic material or the magnetic material closer to this particular inductive sensor. This is nothing but the inductive sensor.

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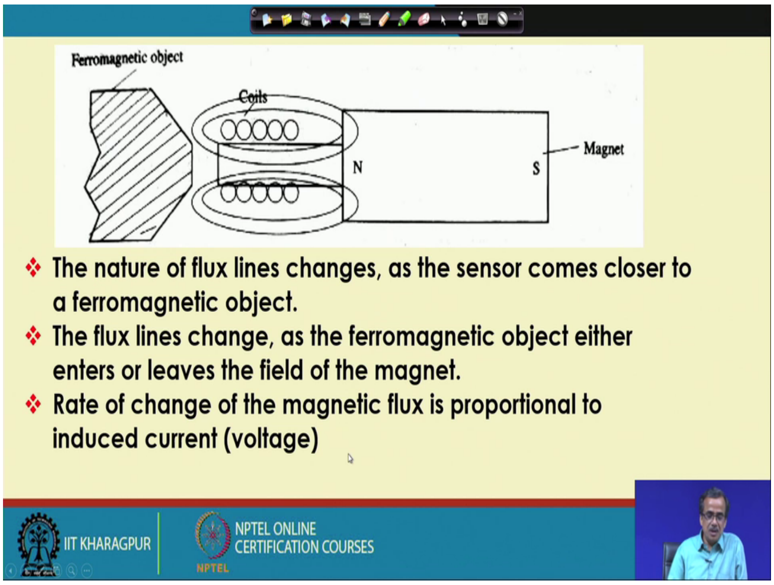

Now, so this is the ferromagnetic object which is brought very near to this particular your sensor. So, this is actually the inductive sensor. And this is the ferromagnetic object. The movement we bring this particular ferromagnetic object very near to the, this inductive sensor, what will happened to this the magnetic lines of forces, the magnetic lines of forces will be deflected.

So, previously the magnetic lines of forces were here ok; it was shown here. Now there will be shifting of the magnetic lines of forces; and there will be change of magnetic flux. Now, this particular the rate of change of magnetic flux is proportional to the induced voltage or the induced current. So, due to this change in magnetic flux, what will happen there will be some induced voltage and there will be some current flow through these particular coils. So, we have got the coils through which the current will flow, and due to this induced voltage there will be some current flow ok. So, and this particular voltage or this current, we can we can we can measure.

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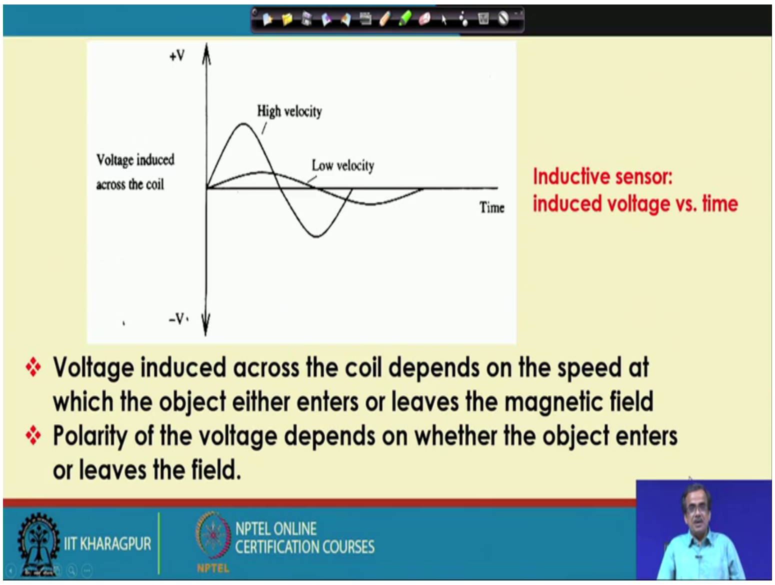

So, let us see the way it works. Now, supposing that say I have got, so this is actually let me just see this particular paramagnetic object. So, this is stationary. So, inductive sensor is say stationary. And this ferromagnetic object is brought near to the inductive sensor and or it is actually thrown away from this particular the inductive sensor. The moment it is brought near to this particular ferromagnetic object, near to this inductive sensor, there will be some amount of your the voltage induced. And you will be getting the voltage induced like this.

For example, if I plot the induced voltage with time, supposing that the ferromagnetic object is brought near to the inductive sensor with high speed. So, if it is brought with high speed, so there is a possibility so I will be getting this type of plot for this induced voltage. Now, this positive site as if the ferromagnetic object is brought near to the inductive sensor. And the moment it is thrown away from the inductive sensor, so it will be getting this particular the negative induced voltage ok.

Now, once again let me repeat if this particular ferromagnetic object is brought at high speed, so I will be getting this type of plot for the induced voltage. But, if it is brought at low speed, there is a possibility I will be getting this type of plot for this induced voltage with time ok. So, the nature of the induced voltage will be changing, and it depends on the speed with which I am just going to bring that particular ferromagnetic object near to the inductive sensor; or I am throwing away this ferromagnetic object from the inductive sensor. So, depending on this particular speed will be getting the different types of voltage distribution.

Now, here if I just concentrate on this type of the induced voltage distribution, I will be getting its amplitude. And if I consider this type of distribution, I will be getting the different amplitude that means, I will be getting high amplitude value for this induced voltage. If it is moving with a high speed and if it is moving with low speed, then I am I will be getting low amplitude for this particular the distribution of voltage. Now, once again let me repeat corresponding to the high speed I will be getting high amplitude that means, corresponding to the high speed.

Now if I consider a fixed time, I am plotting here with time. So, if I consider a fixed time, and if the ferromagnetic object, if this is the inductive sensor and this is the ferromagnetic object. Now, if it is moving with high speed towards the ferromagnetic object, so at the fixed instant of time a for at the fixed duration, so it will come more closer to this particular inductive sensor compared to the situation, whenever it was moving with slow speed.

Now, once again let me repeat if the time duration is same say delta t or t if it is the same, so time is the same. And now, once again I am repeating for the same time. So, this is the fixed position of the inductive sensor, and it is moving with high speed. So, in the same duration, so it will be coming more closer to this particular the inductive sensor compared to the situation, whenever it is moving with the slow speed. So, whenever it is moving with the slow speed, the distance between the sensor and the object will be more; and whenever it is moving with high speed, the distance between the object and the sensor will be small. The same thing is actually is coming here in the calibration curve.

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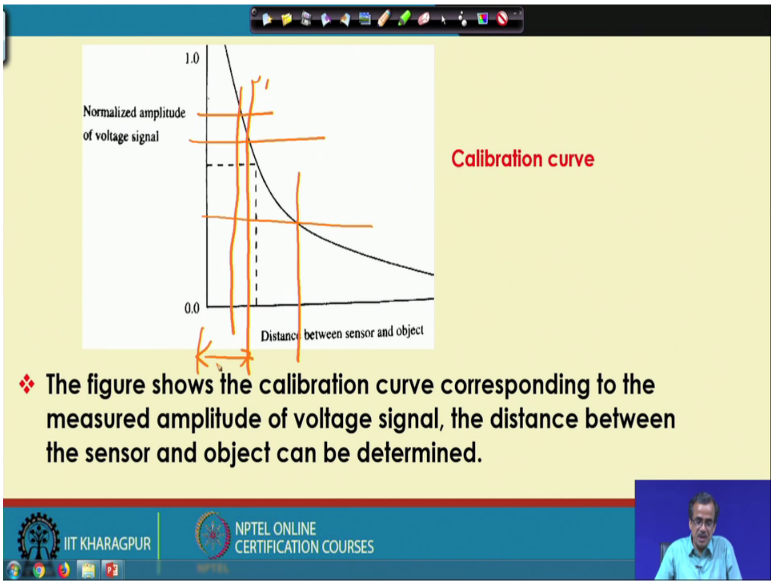

Now, this is the calibration curve. Now, whenever we are getting the higher amplitude that means, the ferromagnetic object is moving with high speed, it is come very near to the inductive sensor ok. Now, in that case corresponding to the high amplitude, so I will be getting smaller or the distance between the sensor and the object and corresponding to the lower amplitude, so I will be getting the larger distance between the sensor and this particular the object; now if this particular calibration curve is known, and if I can measure the normalized amplitude or the voltage signal.

Now, why this is the normalized, because in the scale of 0 to 1, I want to represent so, this normalize amplitude of voltage signal if we can measure, then very easily I can find out what should be the distance between your object and this particular your the sensor ok. So, this is the way actually we can use the inductive sensor, just to find out like what should be the distance between the sensor and this particular the object. Now this is the way actually one inductive sensor is working. Now, this sensor is suitable only for the magnetic material; this is not going to work for the non-magnetic material.

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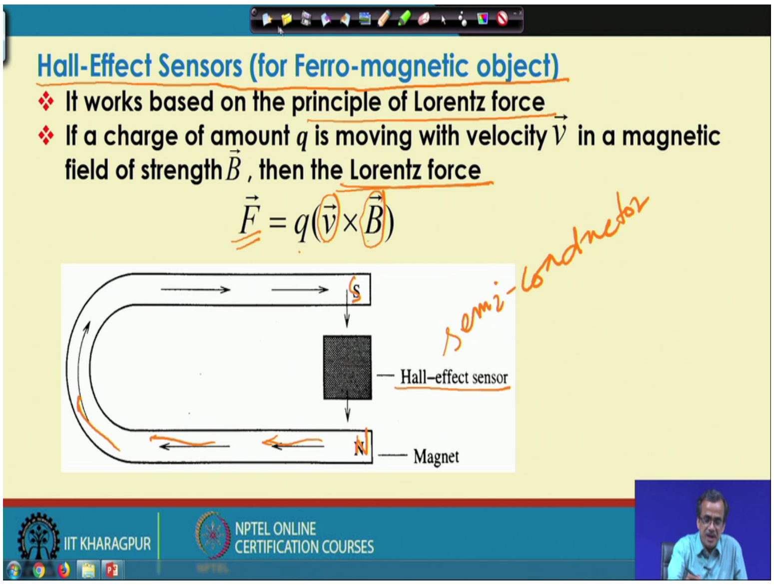

Now, I am just going to discuss another very popular the sensor that is called the hall-effect sensor. And this is also suitable only for the ferromagnetic material; this is not suitable for the non-magnetic material. And this particular hall-effect sensor is very frequently used in the vertex.

Now, it is working principle is based on the principle of your the Lorentz force. Now supposing that an amount of charge q is moving with velocity v in a magnetic field of strength B, then it will be subjected to one force that force is known as the Lorentz force ok. Now this Lorentz force is nothing but F is q multiplied by v cross B; v is nothing but the velocity, so this is the vector; and B is nothing but the strength of the magnetic field that is also a vector. So, we find out the cross product that is v cross B multiplied by the amount of charge that is q that is nothing but the Lorentz force.

Now, this particular principle, in fact we are going to use here to develop the hall-effect sensor. Now supposing that this is once again a permanent magnet say you type say permanent magnet, this is the North Pole, and this is actually the South Pole, North Pole and South Pole, so will be getting the magnetic lines of forces like this. Now supposing that so in between the North Pole and South Pole, supposing that I am just going to put one hall-effect sensor now what is a hall-effect sensor, the hall-effect sensor is nothing but one semi-conductor material say silicon. So, this is nothing but a semi-conductor material.

Now, this semi -conductor material or say silicon or having some free electrons, the moment we put the semi-conductor material in between the North and South Pole, and within the influence of this magnetic lines of forces, there will be some amount of voltage induced in the your semi-conductor material or this hall-effect sensor ok.

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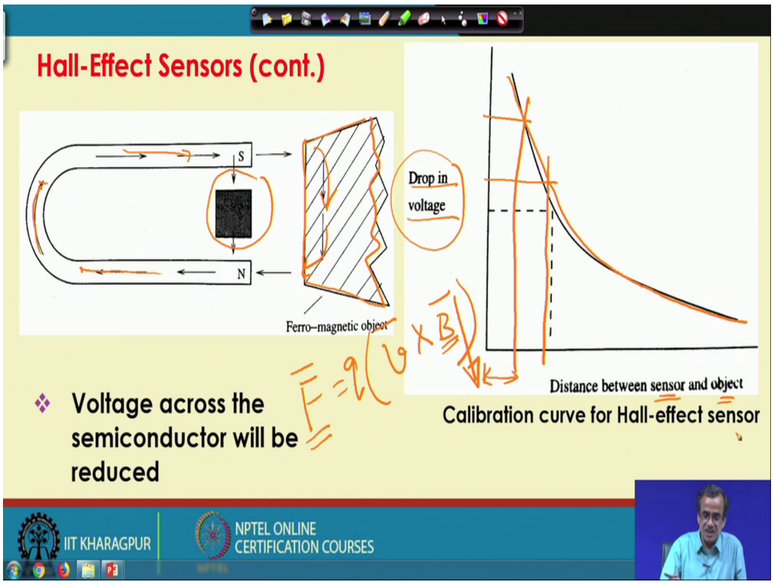

Now, actually what happens, the moment we just bring one magnetic object near to that. Supposing that this is the magnetic object, which has been brought near to that particular your the hall-effect sensor ok. So, this is the hall-effect sensor. Now, what will happen is, so this is a ferromagnetic material. And we have got the permanent magnet here, this is the North Pole, this is the South Pole. So, the magnetic lines of forces will pass through this, pass through this. And here as this is the magnetic material, some of the lines of forces will pass through this particular the ferromagnetic object.

And due to that actually what will happen is, the strength of the magnetic field here will be reduced. And the Lorentz force F is nothing but q multiplied by v cross B. Now, here actually due to the presence of this particular ferromagnetic object, the strength of the magnetic field will be reduced, the strength of B will be reduced. Then what will happen to the Lorentz force, the Lorentz force is also going to be reduced.

And consequently, the amount of induced voltage here in this semi-conductor material is going to be reduced, and there will be some drop in voltage. So, when this particular material was not there in front of the senor, there was some induced voltage. And whenever it is coming, there is some change in induced voltage, truly speaking there is some drop in induced voltage. And this particular drop in induced voltage can be measure with the help of voltmeter or multimeter.

And if I know this particular calibration curve, so this particular calibration curve is known. And if I know the drop in voltage, I can find out the distance between the sensor and this particular the object. Now, if this particular object comes very near to the sensor what will happen to the drop in voltage, the drop in voltage is going to increase, and the distance between the sensor and the object that will be reduced.

And this is the way by measuring the drop in voltage, I can find out the distance between the sensor and this particular the object. This is the working principle of this particular the hall-effect sensor. And this is also very popular in robotics. But, the main drawback is your these sensors like inductive sensors, then comes your hall-effect sensors. These are not suitable for the non-magnetic material.

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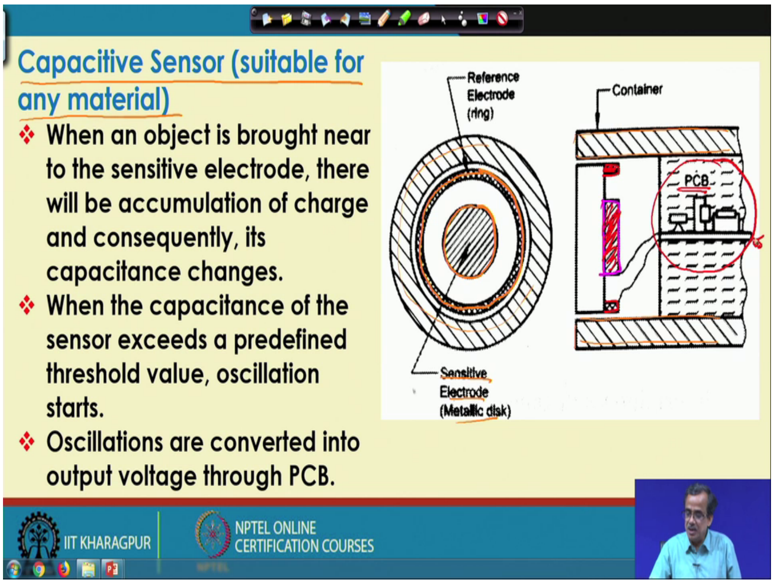

Now, I am just going to discuss the working principle of another sensor that is called the capacitive sensor, it is suitable for any material, whether it is magnetic or nonmagnetic, so this particular sensor is going to work. Now, let us try to understand the construction details fast, it is very simple. Supposing that we have got a container here, so this is this shows this view, this shows the container, it is just like cylindrical container sort of thing. So, this is another view, so this is the container ok. So, this shows actually another view.

So, we have got the cylindrical container, and here we have got one sensitive electrode, and that is nothing but a metallic disc. This is a very thin metallic disc. And we have got one reference electrode, which is nothing but a ring. So, this reference electrode is nothing but a ring. So, this is nothing but a ring, and this is the reference electrode. And we have got your the sensitive electrode. And this is nothing but is your sensitive electrode.

So, this is the sensitive electrode; and it is very thin and lightweight. If you see in this particular view, so this sensitive electrode is shown here, so this is nothing but the sensitive electrode. And the reference electrode is nothing but is your so this is nothing but the reference electrode ok. Now this reference electrode is kept fixed, but this sensitive electrode there could be some oscillation. Now, let us try to find out the reason behind this particular oscillation. Now as I told that this particular sensitive electrode is a thin metallic disc, and very lightweight the moment we bring any object in front of so this particular the thin metallic disc. So, what will happen is your there will be some amount of charge accumulated.

And due to this particular accumulation of charge is capacitance is going to change. And the moment its capacitance exceeds the threshold value, then oscillation starts. So, there will be some sort of oscillations here. And this particular the charge is due to some sort of static electricity sort of charge. And there will be some oscillation as we told. And the sensitive electrode there will be some oscillation, but in the reference electrode is fixed. So, with respect to the fixed electrode the reference electrode, there will be some oscillation in the your the sensitive electrode or the metallic disc.

Now, let me let me repeat little bit. Now, here if you see so this particular sensitive electrode is a very thin and lightweight, and a object is brought very near to that the moment is it is brought very near to that sensitive electrode. What will happen is, there will be some amount of charge accumulation static electricity sort of charge accumulation. And due to this accumulation, the capacitance of this particular the metallic disc is going to increase. And the moment it exceeds, the threshold value of capacitance there will be oscillation.

And as I told that this reference electrode is fixed, but this sensitive electrode there will be some oscillation. So, with respect to fixed, there will be some oscillation. Now, this oscillation is converted into some output voltage here with the help of some electronic circuit some printed circuit board. And with the help of this printed circuit board, so output side will be getting some output voltage, but the input site the inputs will be some sort of oscillations.

And here there are some electronic circuits, and this is the printed circuit board, and this output voltage can be measured with the help of your voltmeter or multi meter. So, we can find out so by measuring this particular actually your the change in capacitance or change in output. In fact, so we can determine the distance between your the sensor, and this particular the object.

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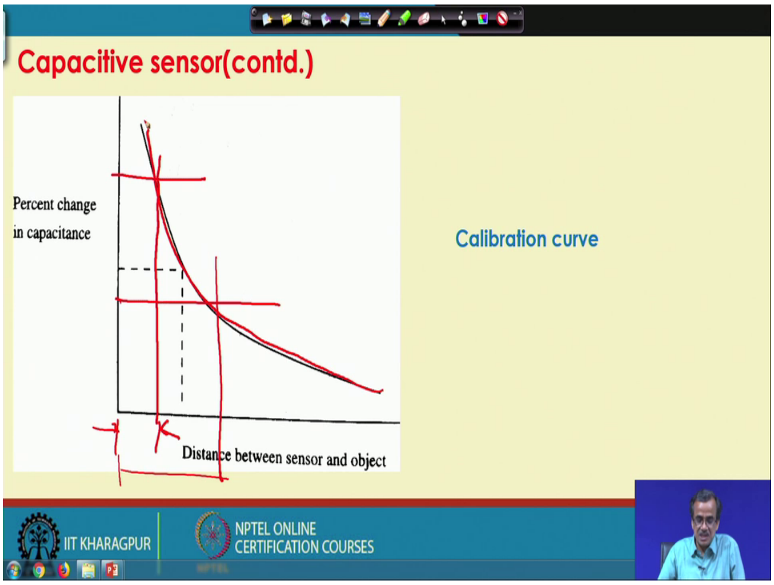

Now, as I told the moment that object is brought near to that particular sensor, there is capacitance is going to be changed due to the accumulation of charge. Now, supposing that the amount of charge accumulation is more, so if this is the percentage change in capacitance. If it is more then what will happen? The object has come very near to the sensor. So, this is the distance between the sensor, and this particular the object.

And supposing that the percentage change in capacitance is less that means, your objects is far from this particular your the sensor. So, and this is the calibration curve. And knowing this particular calibration curve, and knowing the percentage change in capacitance, we can find out the distance between the sensor and this particular the object. So, this is the way we can determine the distance between sensor and object using the capacitive sensor.

Thank you.