Embedded System Design with ARM
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Lecture – 17
Output Devices, Sensors and Actuators (Part III)

We continue with our discussion on Sensors and Actuators. So, in this lecture we shall be talking about some more kinds of sensors and also actuators.

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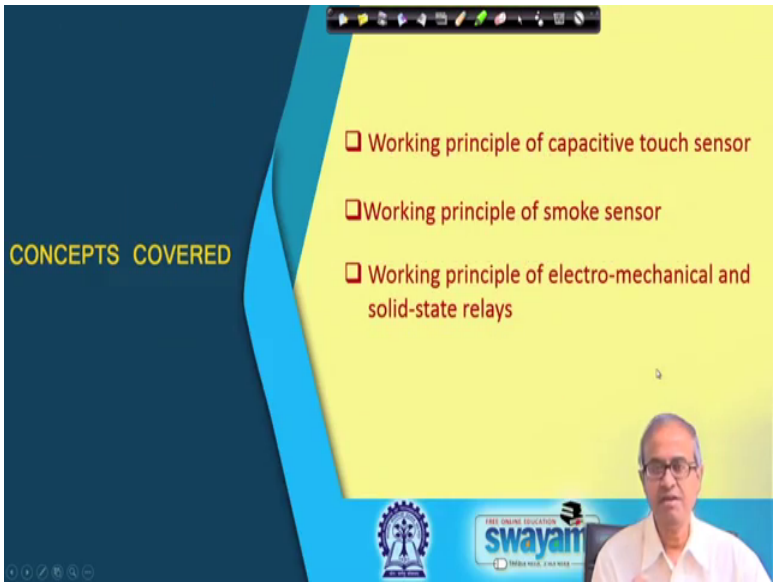

Specifically, we shall be talking about capacitive touch sensor as an input device, smoke sensor also as an input device you can sense whether there is a smoke a particular kind of smoke or gas, and then we shall be talking about relays; the different kinds of relays.

First let us talk about capacitive touch sensor which can detect physical touch well we are all familiar with many of the touch activated devices means our mobiles are touch sensitive. We use our fingers to navigate on this screen; there are many other input devices where you can touch the screen and feed our input there is no separate keyboard right. This is one technology the capacitive touch sensing using which I can implement such kind of a sensing device.

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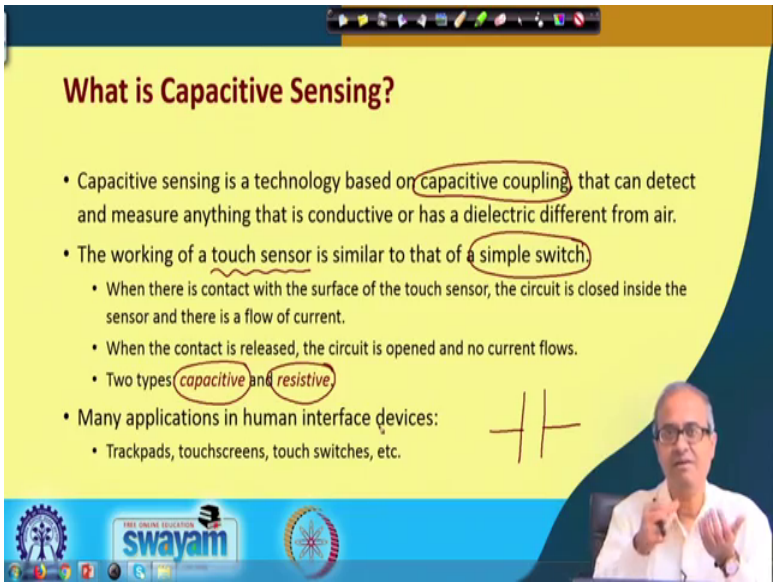

Now, first let us see what this capacitive sensing is all about. This is basically a technology based on something called capacitive coupling. So, what is a capacitance? When two materials are parallel plates are brought close together, there will be a capacitance? Now when you bring your finger close to a material your finger and that material will also form some kind of a capacitance because there will some moisture, in your finger your body is also conductive. So, if you bring your finger that will also affect the value of the capacitance. The idea is something like that and the touch sensor that I built out of this capacitive sensing is similar to a switch. The way there built is that whenever you make a touch some switch is closed when you remove the touch the switch is open.

So, just instead of a normal push button switch, you can also use a touch kind of a switch ok. And broadly speaking this kind of touch sensors can be either capacitive or resistive; Of course, the capacitive touch sensors are much more flexible and better in terms of risk performance. So, as I told you there are many applications where we use touch sensors; like track pads many of the laptop mouses; mouses have there is no separate mouse there is a flat surface, where you have to move your finger to move the mouse cursor to move the cursor on this screen that is called a trackpad; touch screens, touch switches or other examples.

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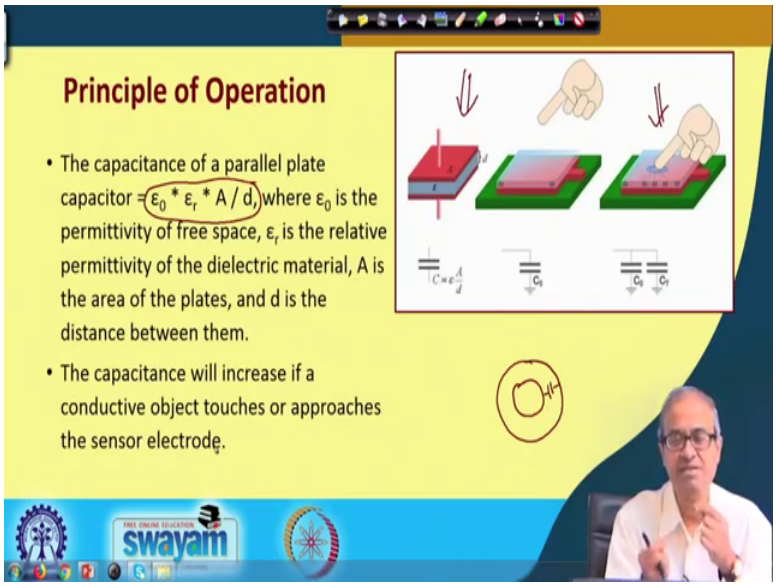

Now here as a very short explanation is given. This diagram here shows how a parallel plate capacitor looks like. There is a plate whose area is A, there are two plates parallel plates the separation is small d and there is a material in between that is called a dielectric, there is a dielectric constant. So, the value of the capacitance is given by this expression epsilon 0 multiplied by epsilon r multiplied by the area A divided by the separation.

Now, epsilon 0 is defined as the permittivity of free space and epsilon r is the permittivity of the material between the two plates. Now you see in this diagram when you are bringing a finger near to it, when you are touching the device with this finger. Then there are so many materials and via your finger your finger is also conducting. So, there will be a coupling through your finger. So, effectively the capacitance value like say instead of parallel plate you can keep the plates like this also; two circles, two materials. If you put your finger and top of that, these two materials will get a coupling via a capacitive effect there will be something like this. So, essentially a touch sensor works in this way.

So, when the object touches or even you are bringing your finger in very close proximity, then the value of the capacitance will increase. And if you have a appropriate circuitry to change to detect the change in capacitance, you can detect the touch.

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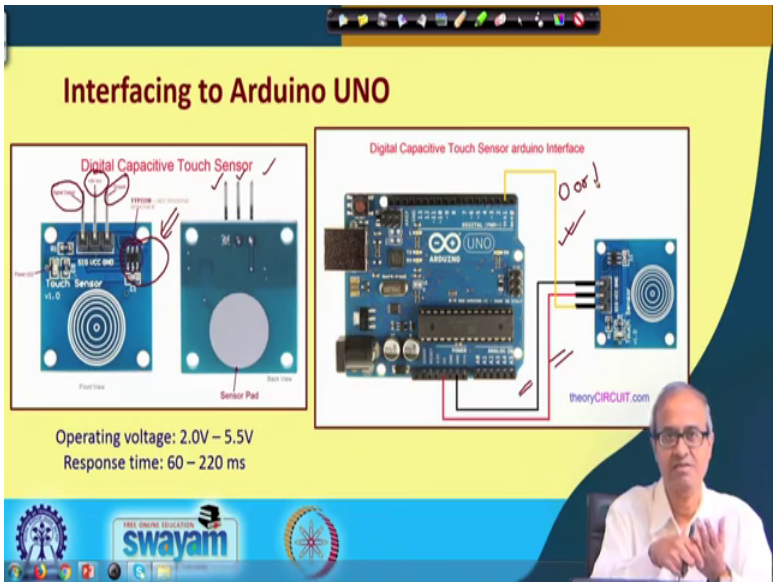

So, one kind of device this we shall be seeing as part of the experiment I am showing it on the left, it looks like this. You see here there are circular patterns as I showed you, this is your sensor pad; if you put your finger on top of this circular pattern area, the value of the capacitor changes. And in this board itself there is some electronic circuitry you see here there is a small ic which has all the sensing and conditioning circuitry inside it. So, in the interfacing becomes very simple there are three pins you can see there are three pins outside; one is your plus 5 volt power supply, other is your ground and the third one is your analog signal output; depending on your touch what is the output voltage that you can read.

So, when you are interfacing such a sensor to your to your microcontroller board, it becomes very easy 5 volts, grounds and this is your signal output. You connect it to one of your port pins. Now this port pin is not an analog output pin, it is like a digital output pin. It says whether you have touched it or not touched it 0 or 1. So, you can connect it not to one of the analog pins you can connect it to 1 of the digital input pins directly because this value will give either 0 or 1 0 means no touch 1 means touch fine; so very easy.

Next let us talk about smoke sensing, there are many applications where you need to just install a sensor. For example, in your home you want to install a sensor to check whether

there is a leakage of your LPG gas in the cylinder or not. So, the sensor should be able to respond to that LPG gas fumes, there has to be some kind of a sensor in that way.

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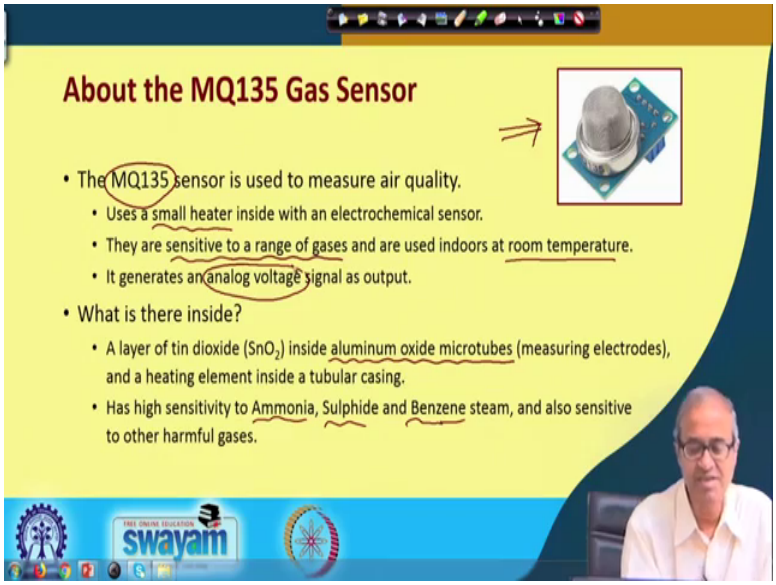

Here you see a sensor on the right side. Now in the experiment will also be showing you this kind of a sensor. You see there is a small mesh kind of a mask where you have to give that gas either you can put it in the environment for you are sensing the gas, but the gas you can put on top of it. It can also check your breath, you can also you can also excel on top of it. So, it can even check whether your bread that is coming out contains means alcohol vapor or not, that kind of checking can also be done by this kind of a sensor right. And the name of this sensor is MQ 135 that we shall be using.

Now, internally there are a lot of things in sizing although it is very small in size, there is a very small electric heater which heats up the material inside. And there are some so called aluminum oxide micro tubes, very thin tubes inside it and there is a heater coil in between in the middle. So, when it heats up this smoke that is that enters through this graded surface, will react with those tubes the material, which is they inside there is also a thin layer of tin dioxide, which is put inside this micro tubes and this tin dioxide acts as the main sensor.

So, the property of this tin dioxide material varies with the kind of gas that is being that it is being exposed to. So, this kind of a sensor can respond to gases like ammonia, sulphide, benzene and also alcohol as I told you and hence other harmful gases, but

depending on the type of gas how much change there will be in the output voltage that will vary, it depends it varies from gas to gas. So, these sensors are sensitive to a range of gases and you can use them in room temperature. It can directly generate an analog voltage signal as output it is very easy to interface.

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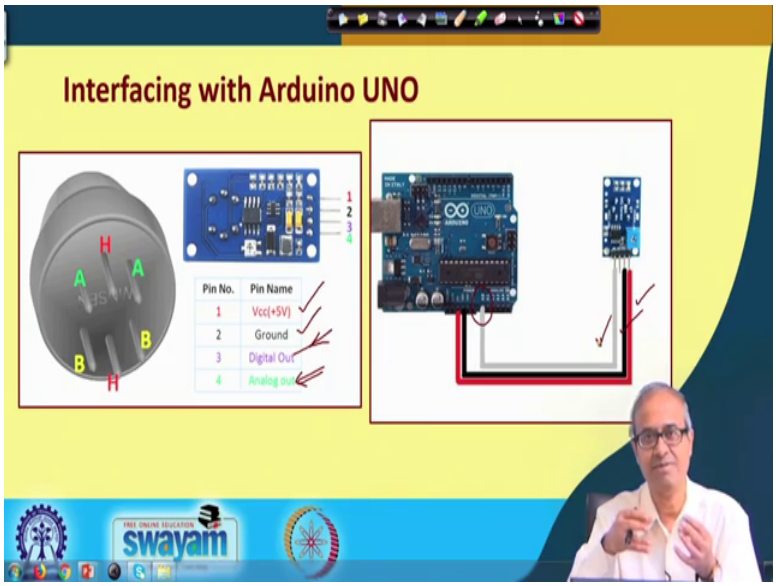

Like I am showing this device, this device you see has four pins; one is the power supply this is the power supply 5 volts ground, then this is analog out. Here you get a continuous voltage depending on the gas, but you can also have another digital out signal, that will tell you whether there is a gas or no gas there is a threshold level, which can be set by that and depending on that you can get either a 0 or 1.

So, if you do not require the digital out you want only the analog out, then you can only connect these three pins. The analog out you can connect to one of the analog input pins and 5 volts and ground. And just that device if you take it out you will see internally there are some pins, this H are the heater points. These two points have to be connected to the voltage to activate that heater coil inside and the output and the other things output via this A and B lines.

So, this circuit has all the required electronic circuit inside it. So, that when you interface it, it becomes very easy for the user that is the big advantage of these small sensor come driver products which are available today. Because earlier we had to design all this interface circuitry ourselves, and our circuitry would become so, large fine.

Now, let us come to actuators, we only talked about different kind of sensors from we can read the data, but now not only reading we want to also control some devices. We may want to turn on or turn off a heater, we want to turn on or turn off our ac machine or refrigerator anything you can think of. Most of these devices they are high power devices, you cannot directly control them from your micro controller in terms of voltages. So, you need some kind of a device which can switch high power electric or circuit lines, these are something called relays; you need relays for those kind of applications.

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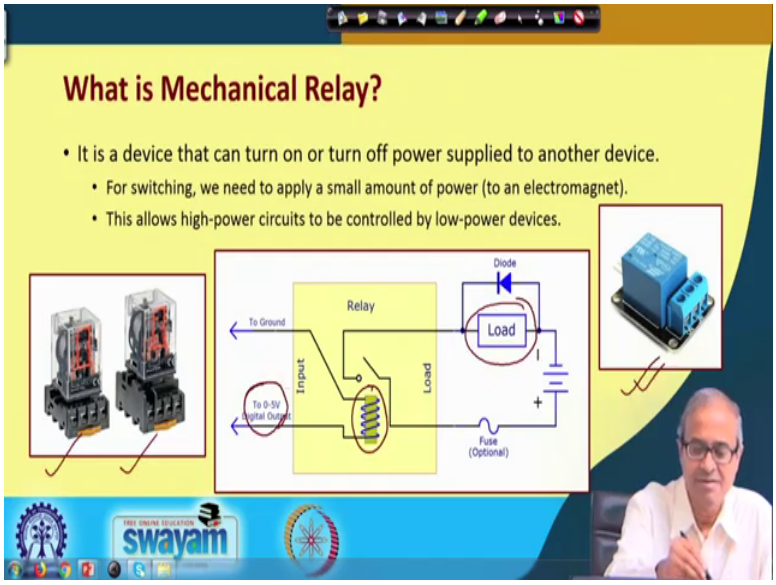

Relays can be of two types mechanical and solid state first let us talk about mechanical relay. Sometimes these are also called electromechanical relay because you are controlling a mechanical device, using electrical signals. So, on the left you see some pictures of this kind of electromechanical relays, where through a transponent material you can see what is inside. But some of these are also available in a sealed envelope you cannot see the one on the right. This is the relay that we shall be using in our experiment you shall be seeing that how this looks like.

Now, internally you see what it is there. There is a small electromagnet inside and there is a switch with one movable terminals spring loaded switch, when the electromagnet is activated it becomes a magnet, that switch is attracted and the circuit closes and if you withdraw the current the circuit again opens. Now this circuit which closes and opens

this is a high power circuit, this can be used to drive a high load, this can may ac machine it can be refrigerator it can be heater it can many thing.

But on the other side the current that you are passing through this electromagnet to pull that switch and release that switch, this can be a very low power circuit, this can be working at 5 volts power supply also this is essentially the working principle of a relay. You are using a very low power signal to control a higher power circuit. These two circuits are isolated, they are not directly connected there is no physical connection between these two circuits alright.

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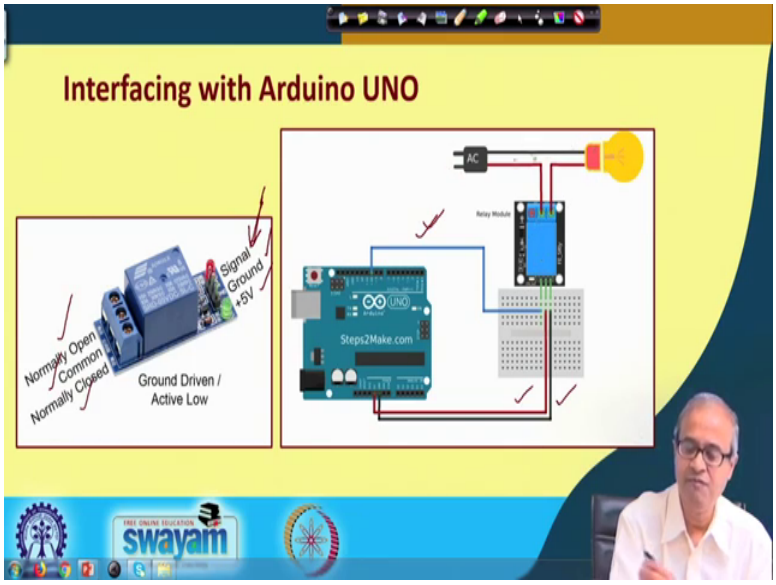

Now, here as I told you this is say the kind of device that we shall be using, well on one side you have the control mechanism. For controlling you connect it one point to ground 5 volt and here you are applying a signal to turn it on and off. There are two kinds of relays one is called ground driven means if you make it 0 it will be on. And there is another kind which is not ground driven it is voltage driven when you make it 1 it will be on ok. And on the output side you see there are three terminals which are provided, these are called normally open common normally closed common is the common terminal.

Normally open means normally open terminal and common are normally connected internally, when this switch is open when this switch is closed this gets disconnected, but this is sorry this is normally open. So, it is open when the switch is opened, it gets closed when the switch is closed, but normally closed is the reverse. If you connect a device

between normally closed and common then when the switch is open this circuit is normally closed, but when you activate the switch and you make it on then this circuit will open.

So, here you see here I have shown a very simple interface this kind of a module. So, on one side you are controlling this from your arduino board, your VCC ground and through a digital port pin you are controlling the relay on or off. And on the other side I am using the normally open connection. So, normally open connection is and the middle point is this is the common terminal. So, this I am connecting to a circuit let us say a bulb to the AC mains I have connected it.

So, when I am activating it and the relay becomes on, the bulb will glow and if it is off the bulb will be off this is how it works right. So, interface is very simple, we shall be seeing this kind of interfacing experiments later. Now there is another version of a relay which is not based on electromagnets pulling and releasing the switches mechanically, but these are called solid state relays.

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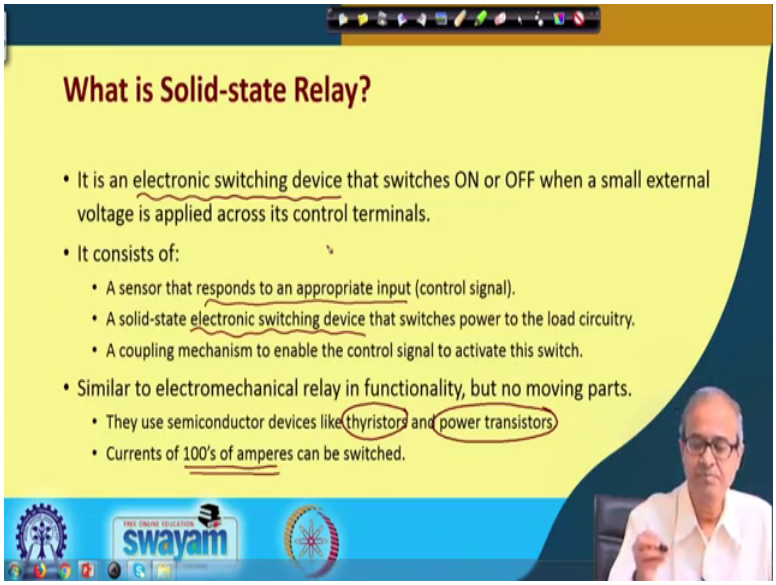

Solid state means everything is built inside a chip semiconductor device.

So, this you can say is electronic switching device, there is no mechanical moving parts like in an electromechanical relay. So, here the kind of devices you require for the switching are high power semiconductor devices like thyristors or power transistors, they

can switch very high currents at high voltages. For example, hundreds of amperes of currents can be switched.

So, inside there will be some electronic circuitry, which will be responding to some appropriate input that will be sending a control 0 or 1 and this thyristor or power transistor whatever is there. That will be this is our electronic switching device that will be switched on or off and that will be turning the power on or off to the device that is being controlled.

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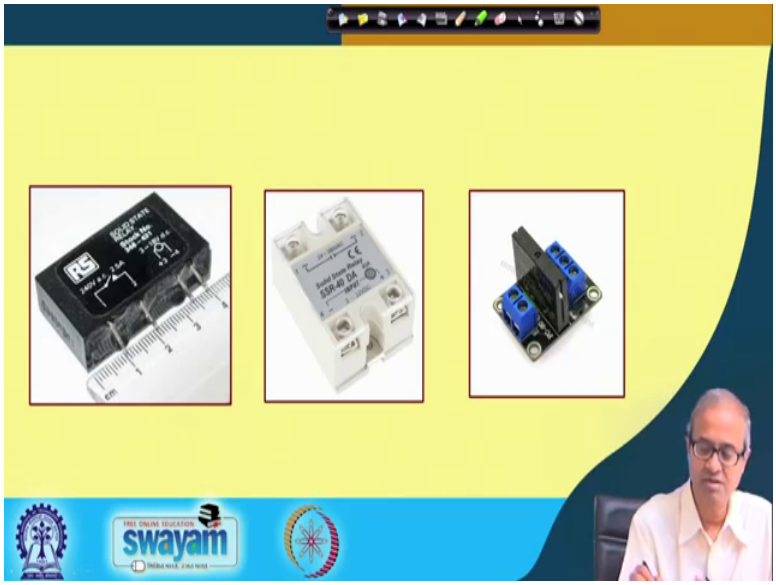

So, this is how solid state relay works. These are some of the pictures of some solid state relays. So, you see this is the middle one, it says that it works from 24 to 380 volts AC. So, there are these are much smaller in size because the semiconductor made of solid state devices, they are much smaller in sizes. So, you can see. So, one on the left you can see the dimension it is out 4 centimeters total in size, this middle one this middle one the same device is been shown here.

With this we come to our end of our discussion on the various kinds of output devices like LEDs and LDRs various kind of sensors we talked about and these actuators in particular the release. Now during the actual hands on sessions the demonstration sessions, we shall be showing you all these sensors and actuators actual means I mean in use. How to use them, how to interface them and how to write a program in the

microcontroller to control them in the way we want to ok. This we shall be discussing in our subsequent lectures.

Thank you.