Embedded System Design with ARM
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Lecture – 31
Experiments with Relay

Actually in this lecture, we shall be showing you some hands on demonstration experiments using relays ok. You have already seen earlier, what a relay is; relay is a device, which can switch a higher power circuit through the control of a microcontroller using a much lower voltage. So, the topic of our discussion is Experiments with Relay.

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So, we shall be talking about relay interfacing with microcontroller boards and we shall be showing you some experiments and demonstration ok.

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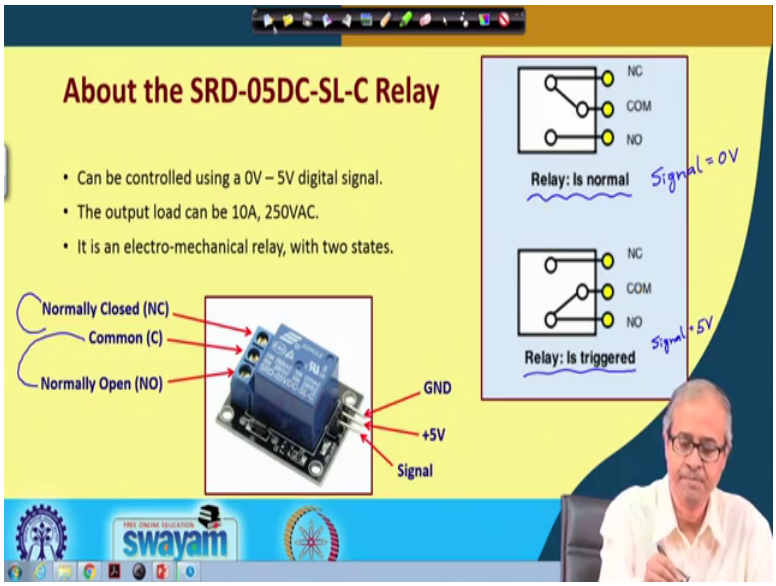

So, the type of relay that we shall be using in our demonstration is SRD-05DC-SL-C this is the name, as you can see this is a picture of that relay board that we shall be using. Just one thing you may note that although this particular relay, I shall be showing in this experiment has a single relay device, there are boards available where there are 2 such or 4 such relay devices integrated in a single board.

So, if you have any application where you want to control multiple electrical appliances from the same microcontroller, you can use one of those boards, but here we shall be controlling a single appliance that is why I am using a single relay module ok. Now talking about this relay, you see on one side this side, you connect this signal to the microcontroller. You see there is a ground there is a plus 5 volt, which provides the power to this device and there is a third pin, a digital signal using which you can switch on or OFF the relay ok.

Now, this signal can work in this 0 to 5 volt range, 0 means relay will be OFF, if you apply 5 volts the relay will be on. And on the output side, you are supposed to connect a higher power device, this can be 10 ampere up to 250 volt AC power supply, you can switch ON the output side ok. Now, the point to notice that this device is not a solid state relay rather it is an electromechanical relay. So, when you apply a current there is an electromagnet inside, which gets magnetized. There is a switch metal, which gets attracted and if there is no current it again using spring loaded it again turns off.

So, when we switch relay ON and OFF you can also hear a sound tuck tuck tuck tuck like this. So, that switch will be connecting and disconnecting connecting and disconnecting like that right. So, on the output side you see there are 3 connectors normally closed a common, which is connected to ground and normally open. So, when you connect any device you either connect them between the common and normally open or between common and normally closed.

The difference is that if we use normally open then when the relay is not on; that means, the signal is 0, this circuit will also be open there will be no current flowing, but when we apply a signal of 5 volts, this circuit will be turning on. But for the normally closed pin it is just the reverse. When you are applying a 0 volt on the signal; that means, relay is OFF, but on the output side the circuit will be on. But, when you turn on the relay the circuit will be off; that means, just the reverse convention pictorially it is shown in the diagram here.

So, this is the normal state of the relay, where this signal this input signal that you are applying where signal is at 0 volts. So here, you see for the normally closed connection it is internally connected in the normal state, but normally open is open. But, when the relay is triggered which means this signal input is at 5 volts signal is 5 volts then you see the reverse happens. The normally closed connection becomes floating and the normally open connection gets connected to COM ok. So, the way you connect the relays the external circuits; so, we will be connecting either between this NO N COM or between NC N COM right ok.

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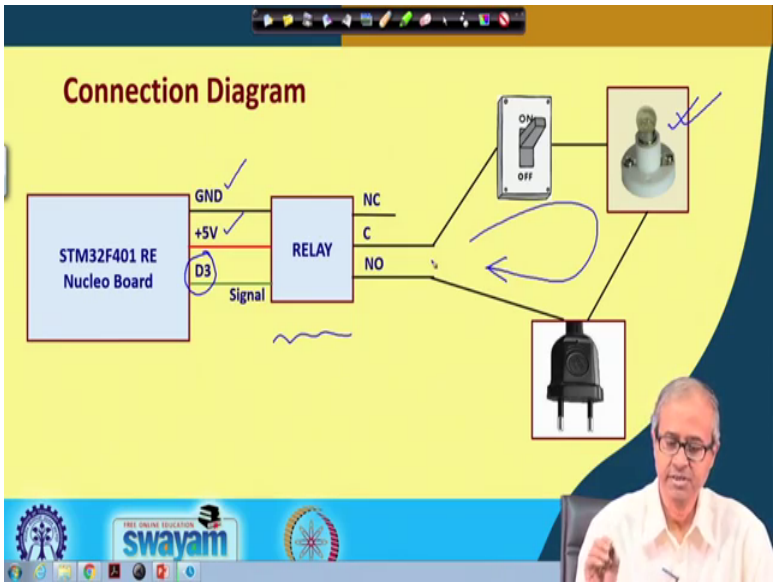

This is about the connection diagram how we will be connecting the relay to the microcontroller, we will be using STM 32 board for the demonstration. So, we shall be showing. So, you see this is the block diagram of the delay I am showing in the middle. So, when you connect it to the SDM board as I had said you require the ground connection, you require plus 5 and you require a signal.

Now in this experiment, I will be using the data line D 3 for feeding the signal and on the output side for the sake of demonstration, we will be using a small bulb an LED bulb, which will be turning ON and OFF under relay control. So, we will be using normally open means output of the relay so that when the relay is not switched ON the bulb will not glow.

So, in this circuit this is the circuit through, which the current will be flowing. So, you see there is an electric power cord, which will be connected to the mains, there is the bulb and there is an external switch of course, will not be requiring the switch in this experiment, this switch will be always on. So, whenever the relays turned ON there will be a current flowing and the bulb will glow and when the relays OFF there will be no current and the bulb will be turned off. So, this is the connection diagram that will be using.

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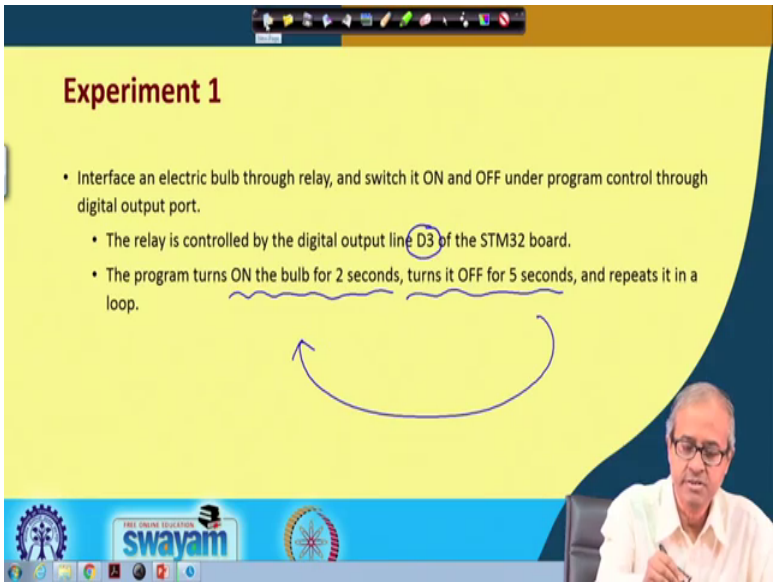

Now, let us come to the first experiment now the first experiment is very simple we shall be just turning ON and OFF the relay with some time delays. So, if you see the statement of this experiment will be interfacing the electric bulb, we have already seen how we shall be interfacing the circuit we have seen and will be switching it ON and off.

So, we have already seen in the circuit diagram that the relay is connected to the output line D 3 of the STM board and the program is written in such a way, that the relay will be turned ON for 2 seconds turned OFF for 5 seconds and this process will repeat indefinitely. So, ON OFF ON OFF in this way, it will go. Before showing you the demonstration, let me first show you the code what embed C code, we have written to do this to achieve this.

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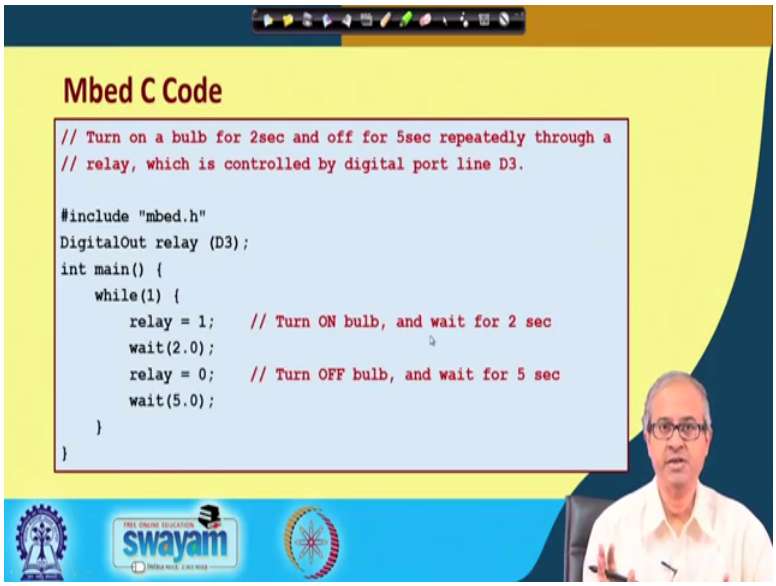

This is the code which is fairly simple and straightforward. So, if you look into the code well here as usual we have included this embed dot h header and D 3, we have declared as a digital out pin. Because, here we are using a simple digital output mode of that output pin and we are calling this spin as relay, this you can give any name here you know and this is our main function and this main function runs in a continuous while loop.

So, what it does it outputs 1 to the relay? That means, the circuit will be switched ON the bulb will glow wait 2 means the wait for 2 seconds relay equal to 0 means again, the circuit will be switched OFF bulb will be OFF wait 5, it will wait for 5 seconds. So, you turn ON the bulb wait for 2 seconds turn OFF the ball wait for 5 seconds in a repeated while loop this is our program. So, let us now see the demonstration.

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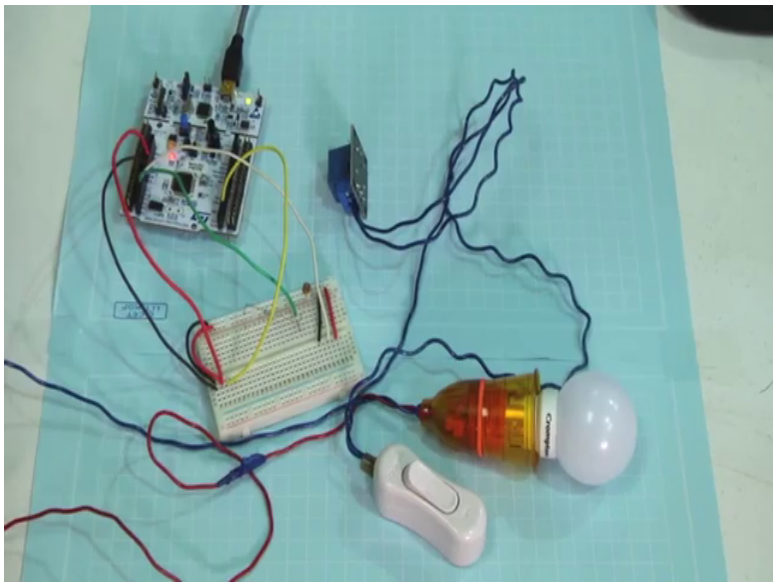

So, here you look at this circuit which, I am showing here. So, as you can see this is your STM microcontroller board and this circuit diagram for the bulb that I have shown there is an electric power inlet, which is connected to an electric power source AC 22 volts, there is a switch which I am permanently putting us on and this is a small LED bulb, I am using and this is the relay module that we are using.

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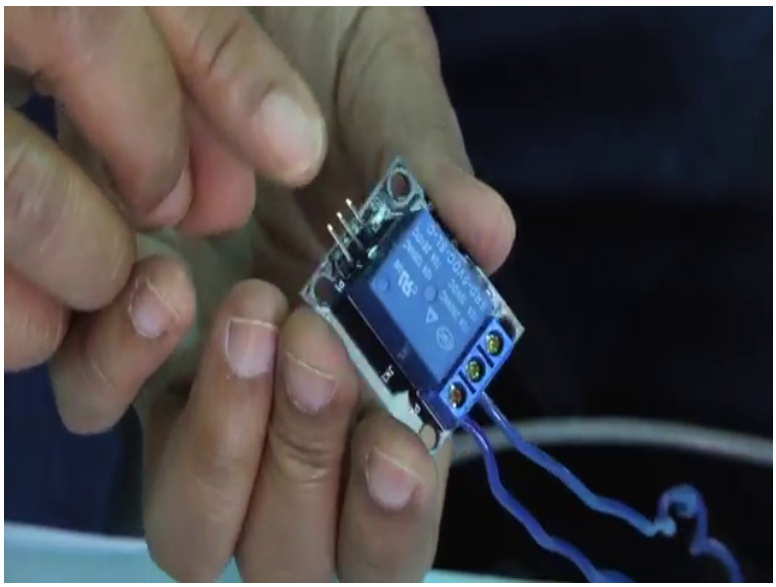

So, you see on one side you have connected this relay module to the normally open and the common connections, these 2 pins and on the other side there are 3 pins you have

seen. So, these pins are signal, VCC and ground these 3 pins have to be connected. Now on this breadboard, I have already made such connections on the right side I will simply plug in this relay into this board.

So here, I have plugged in this relay into this breadboard ok, let me make a solid connection yes yeah there is a loose connection let me just make it right. Now, let me compile this program, let me compile this program as you know you already know how to compile it, you save it by default it will get saved into the download folder and you copy and paste it to the F401 drive which has. So, the program has been downloaded.

So now, I switch ON the power. So now, you see what happens the bulb will switch ON for 2 seconds and will get switched OFF for 5 seconds, it is switching ON 2 seconds switch OFF for 5 seconds again, it switches ON for 2 seconds again switches OFF for 5 seconds right. So, interfacing of the relay is fairly simple in this case as you can see right. So, let us again come back to our presentation and the next experiment.

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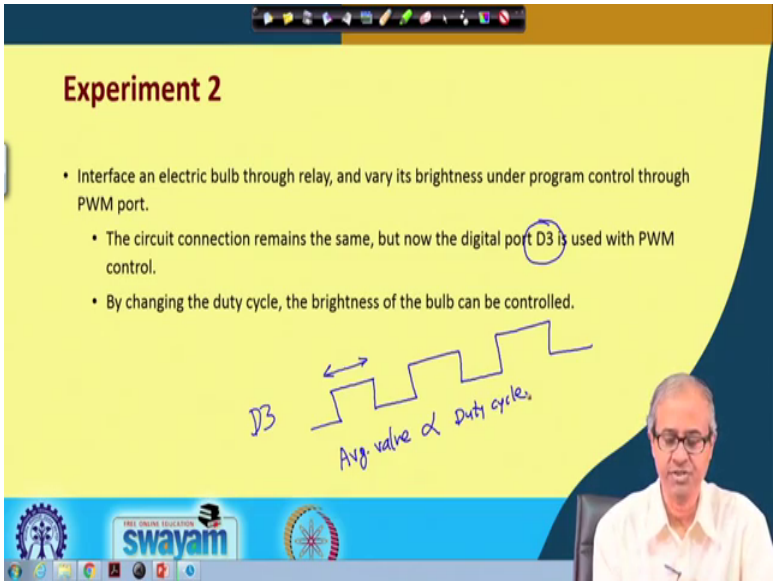

Just one thing you must have noticed that when the bulb is switching ON andOFF, there is a there is an audible sound you can hear that the relay switch is turning ON and off. In the next experiment, you can hear it much more clearly because, will be switching ON and OFF much faster ok.

Now, come to the second experiment here, the interface is very similar, we are again connecting the bulb through the relay using the same circuit, we are still connecting the relay to the port D 3, but in the previous experiments were using digital control either 0 or 1, but in this experiments were using pulse width modulation or PWM control to send a continuous pulse train on the D 3 output pin.

So, the relay will be turned ON for certain time and turned OFF for certain time and this will happen repeatedly and by controlling the duty cycle, you know what is duty cycle actually it is a measure of how much time, we are turning on the relay this proportion of this on period. So, as we change that duty cycle the brightness of the LED will change because, as you know for a PWM the average value this already, we have discussed earlier the average value of the voltage output will be proportional to the duty cycle.

So, as we change the duty cycle the average value of voltage, that gets applied to the relay and hence the area the bulb will vary in proportional to the duty cycle right.

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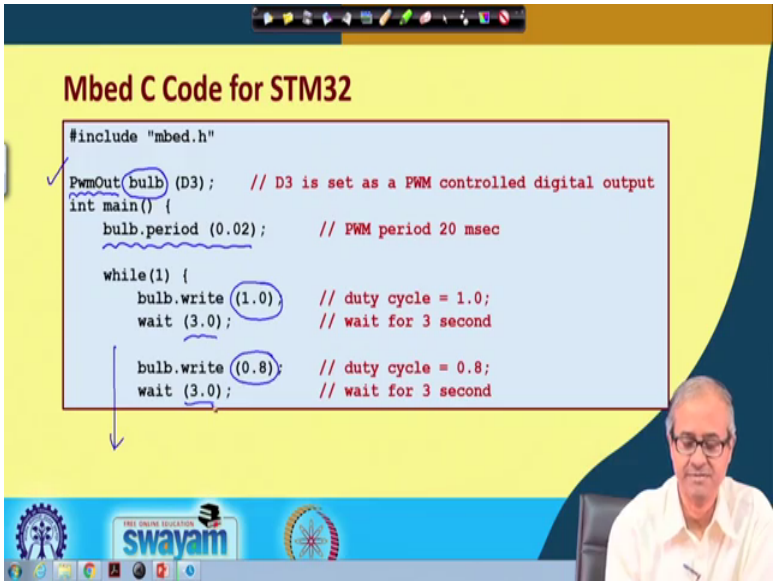

So in this program, just for the sake of demonstration, what we have done just see the scope. Here, again we have included mbed dot h, but now this D 3 we have declared as PwmOut. So, this is a pulse width modulated output pin and we have given the name bulb because, we have connected a bulb. So, let us call it bulb ok. Now, in the main function we have done a few things at the beginning, for this PwmOut, you already know that there are some functions we can use to set the period to set the duty cycle and so on.

So, first we set the time period in seconds as 0.2 0.2 second means 20 milliseconds, which means how much is 20 milliseconds? 1 divided by 20 milliseconds is 50 hertz. So, in every second the relay will be switching ON and OFF 50 times ok. This is what we have said you can change it of course, just for the sake of illustration I have kept it as 50 the point to notice that because, you using a mechanical relay we cannot have this frequency too much faster than the relay will not have time to switch ON and OFF fine.

Now, enough while loop. So, this program continues in the next slide in a while loop, we are doing certain things one by one in a repetitive fashion bulb right is a function, where you can set the duty cycle. First we are setting duty cycle to 1, which means it is continuously 1, it is never going 0, this is the maximum brightness and you wait for 3 seconds then we make the duty cycle as 80 percent. So, a little less then again wait for 3 seconds and this we repeat.

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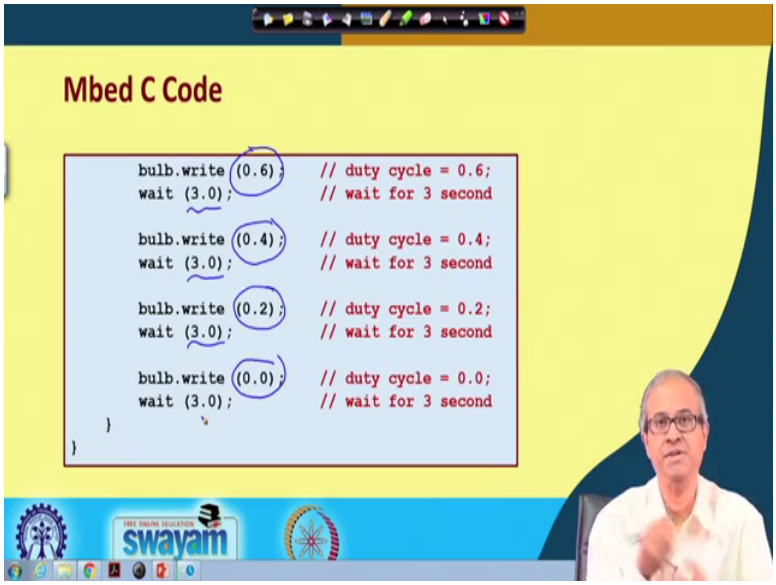

Then we make the duty cycle as 0.6 again wait for 3 seconds then 0.4 wait for 3 seconds 0.2 3 seconds and finally, we turn OFF completely duty cycle 0 means the signal is never going high it is always 0.

So, it is totally turn off. So, in a loop we will see that the brightness of the bulb will progressively change in a continuous fashion. So, let us see the demonstration ok.

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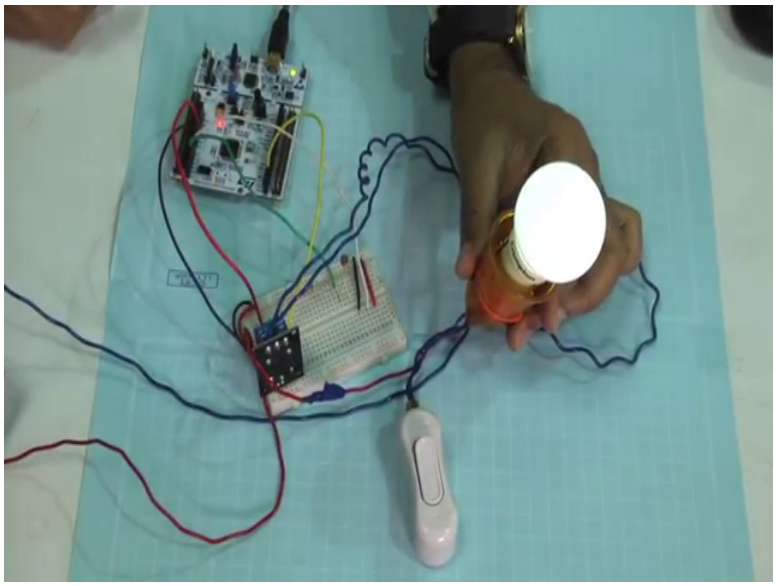

So, this is our second experiment. So, let us again compile this program, the program that I have shown that same program is here. So, we save it we copy this we paste it into this node F 40 and RE paste it.

So, the new program is getting downloaded. Now see now see what happens, now I can see that sound 50 times the relays switching ON and off. So, you can see that you can hear that sound very clearly and in the bulb you can see that with gaps of 3 seconds the brightness of the bulb is changed this is the maximum brightness then this is 0.8, this is 0.6, this is 0.4, this is 0.2 very light and then OFF totally OFF and this cycle repeats right.

So, this simple experiment actually shows you that how we can switch ON and OFF a bulb or any circuit for certain duty cycle, period on time, OFF time in a PWM controlled fashion. So, let us continue with our discussion.

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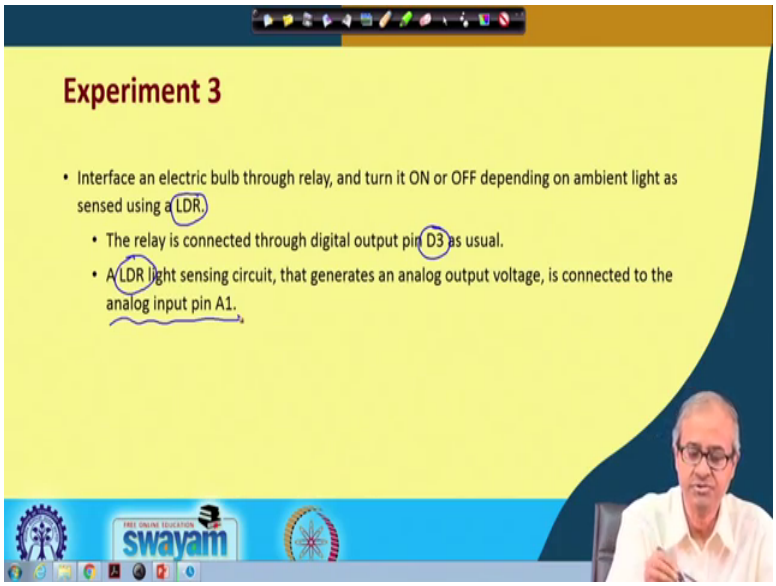

Now, the last code let the relay run the last code that we shall be showing you this is the same relay circuit, but we have made one more addition here, we have connected a light dependent register or LDR.

So, our circuit is like this electric bulb through relay that connection is already there and we have an earlier connected to it, the relay is still connected to the pin D 3, this is connected for switching ON and OFF and there is an LDR light sensing unit, which we are connecting to analog input pin A1 ok. Let us use this kind of a setup, this is our circuit diagram.

So, the relay circuit is the same, this is the circuit you are switching ON and OFF and this is the additional circuit, we are using. Here, with very is an LDR and another resistance connected as a potential divider. So, actually we discussed earlier that this resistance can be chosen suitably. So, that when this light intensity changes on LDR, there will be a significant change in this output voltage out here ok.

Now, this output voltage you have connected to the analog input pin A1 of the STM 32 board right. Now let us see the problem code, what we are doing the program is fairly simple here.

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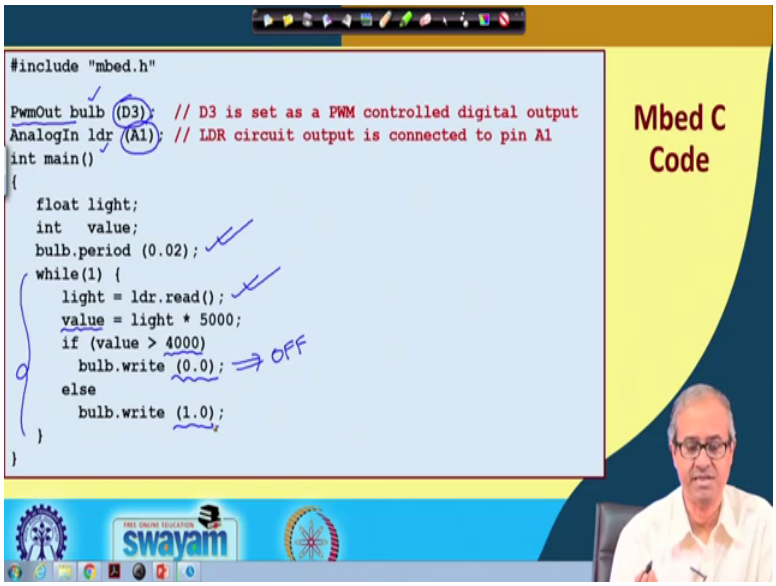

So here, they output the bulk again, we are controlling using a Pdm Pwm outline through D 3 and LDR as I said we are connecting through the analog pin A1 and the names you are giving board and LDR.

Now, the main program for to it doing for the bulb again, we are setting the period to 20 milliseconds, just like the previous experiment the sequence change if you want. Now in the while loop, what we are doing here, we are reading the light value from the LDR light LDR read and well the value that is read is a fraction between 0 and 1 you already know, it can be a very small fraction value. So, to scale it up to an integer value, which you can actually compare I multiply this by 5000, these things we have done through experimentation and the multiplied value, I am storing in a variable called value which is integer ok.

Now, I am this again through an experimentation, we found out 4000 is a suitable threshold value. So, greater than 4000 means we have sufficient light in the ambience. So, we have to switch OFF the light you think of a home, when there is sufficient light there is no point in switching ON the light. So, we set the duty cycle to 0.0, which means the light is switched OFF means the light isOFF, but when it falls less than 4000, it means that there is darkness.

Now, we have to switch ON the light of a room. So, we set the duty cycle to 1.0, which means maximum brightness and this process repeats. So, let us show you the

demonstration for this. So here, we show that same quote that we have shown on this slide. Let me compile this code first, save it then copy it, paste it on the nuclear board ok.

Now, let us see what is happening here. Now here in addition to the relay circuit, which is same now you can see we also have an LDR connected out here you can see this LDR this is the LDR and there is a resistance, this is the resistance, this is the resistance. So, LDR and resistances are connected together in one junction one end of the LDR is connected to 5 volts, this is 5 volts and the other end of the resistance is connected to ground and from the middle point of the LDR, this green wire, this green wire is getting connected to your analog input pin A1 right, this is the circuit we have give.

You see now there is sufficient light. So, let us turn ON the bulb. So, there is sufficient light. So, the bulb is not switched on. Now if I press the LDR, you see the bulb is getting switched on; that means, this is darkness I again remove my hand the bulb is switched OFF again, I press the LDR; that means, darkness the light is switched ON ok.

So, this is a very simple experiment as you can see which shows you how an LDR can be used under program control to switch ON and switch OFF any electrical appliance. So, this experiment you can very easily correlate with a some kind of home automation system, where you want to switch OFF some electrical gadget like bulb, bulb is a very practical example depending on the value of the ambience light ok. Here, I have given an example of a light there can be other things also temperature, if the temperature becomes too hot, you can switch ON the air conditioning machine. If the temperature is very cold, you can turn ON the heater in places, where it really becomes cold ok.

So, in this set of experiments where I actually show you, how we can use a relay controlled by a microcontroller to switch ON or OFF ON and OFF some electrical appliance ok. Now this concept, you can use for any kind of device not necessary for a bulb that I have given you can switch ON and OFF an AC machine or a heater as I told you can switch ON and OFF and refrigerator, you can switch ON a switch of any gadget not only one device as I have shown here you can have multiple such devices.

So, we should also be seen some more experiments later on, where you will see some kind of home automation system, where some more sophisticated kind of control and communication mechanism will be shown. So, with this we come to the end of this lecture.

Thank you.