Embedded System Design with ARM
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Lecture – 28
Experiment with Speaker

Welcome to lecture 28. In this lecture, we will be showing you the Experiment with Speaker ok. So, we will be interfacing a speaker with the STM board and we will generate 4 different kinds of tones. So firstly, we will look into that how the connection diagram will be, PWM port, we have already discussed in detail in week 3. So, I will be using some of the functions that have been already discussed, which I will be using along with the speaker and then now I will be showing you how we can make different kinds of signals, the different kinds of sound through a speaker using changing the codes ok.

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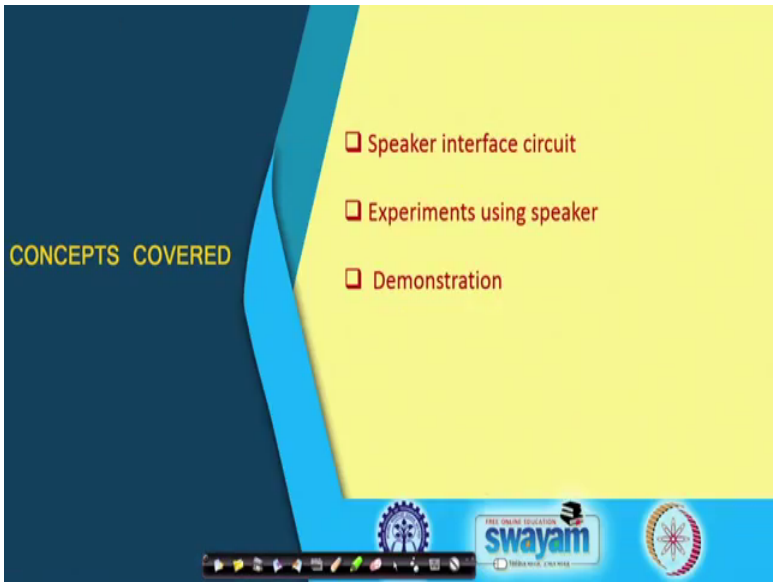

So, let us move on. So firstly, how speaker is interfaced we will show the circuit and then we will look into the various experiments with speaker and finally, I will demonstrate.

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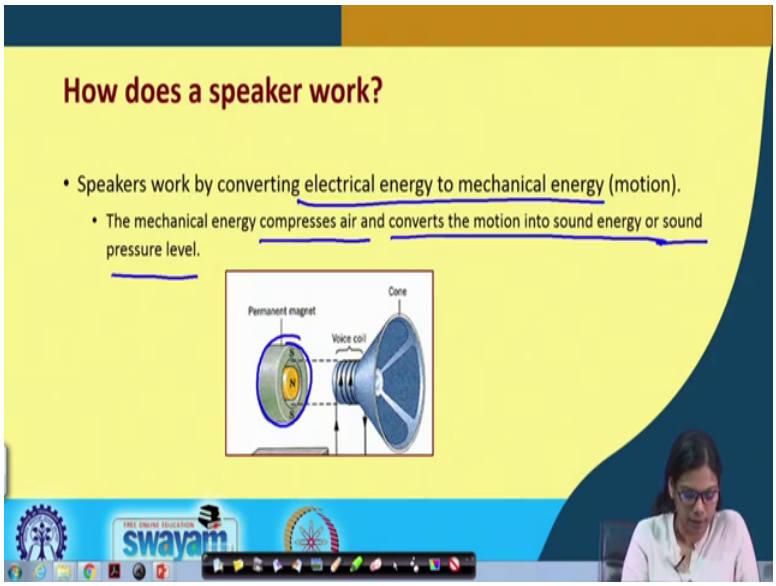

So, how does a speaker work? I have already it has been already discussed in previous week. So, I will very briefly see regarding this the speakers work by converting electric energy to mechanical energy ok. The mechanical energy it compresses the air and converts the motion into sound energy or sound pressure level ok.

So, inside it there is a permanent magnet, we sum voltages are applied and then there is a coil through which it generates some kind of sound here.

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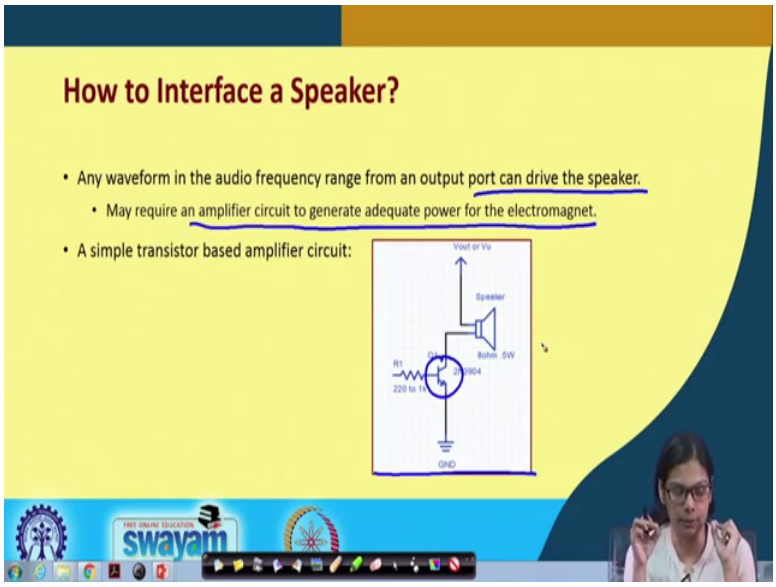

Now, how do we interface it how do we interface a speaker? If you think of any waveform in an audio frequency range from an output port can drive basically the speaker, but sometimes we see that we may require an amplifier circuit to generate the adequate power for the electromagnet that is required amplifier is required.

So, this is a typical circuit diagram ok. So, this is one end of the speaker, which is going to be out and another end through this transistor is connected, one through this resistance and another through route. This is a typical you know a simple transistor based amplifier circuit. Although in our case, we have not used any kind of circuit, but it might be required to use such kind of circuit, when you interface a speaker let us move on.

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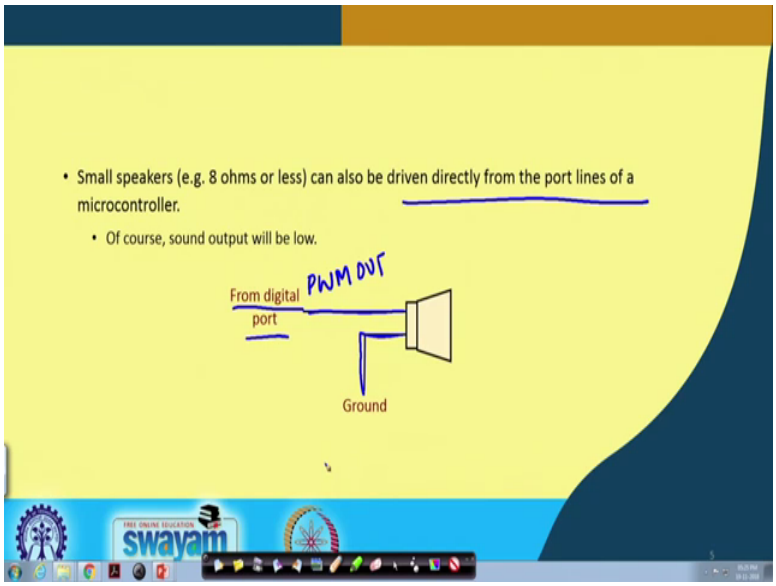

We have interfaced a small speaker.

So in that case, we have directly connected to the port lines. So, it can also be driven directly from the port lines of the microcontroller, but we have to connect to a PWM port line. So, this is the digital port these are the two ends of the speaker one is connected to ground, one will be connected to PWM out pay ok this we must remember. Of course, we will not be able to generate a very high end sound, but a reasonable amount of sound, which you can hear you can generate through this PWM port it directly connect it.

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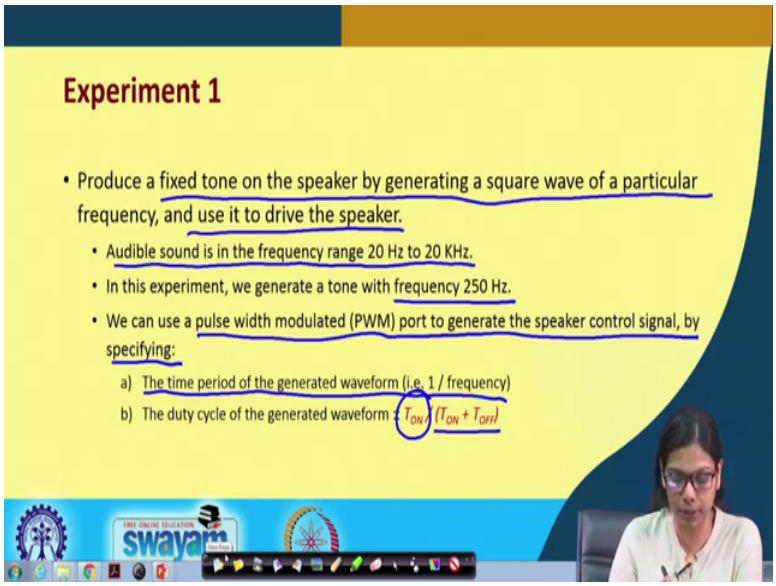

As I told you we will be doing couple of experiments.

So, the first experiment that we will be doing is, we will be generating a fixed tone on the speaker by generating a sound wave of a particular frequency, which we will use it to drive the speaker a fixed tone we will be generating, we all know that the audible sound or that the range the frequency range for an audible sound is 20 hertz to 20 kilohertz.

In this experiment we generate a frequency of 250 hertz, which will be audible to us we can use the pulse width modulated port to generate the speaker control signal by specifying the following, what we need to specify? We need to specify the time period of the generated waveform which is nothing, but 1 by frequency and the duty cycle of the generated waveform that is time period, which is on divided by the entire time page that is on plus off, these are the few things we need to remember.

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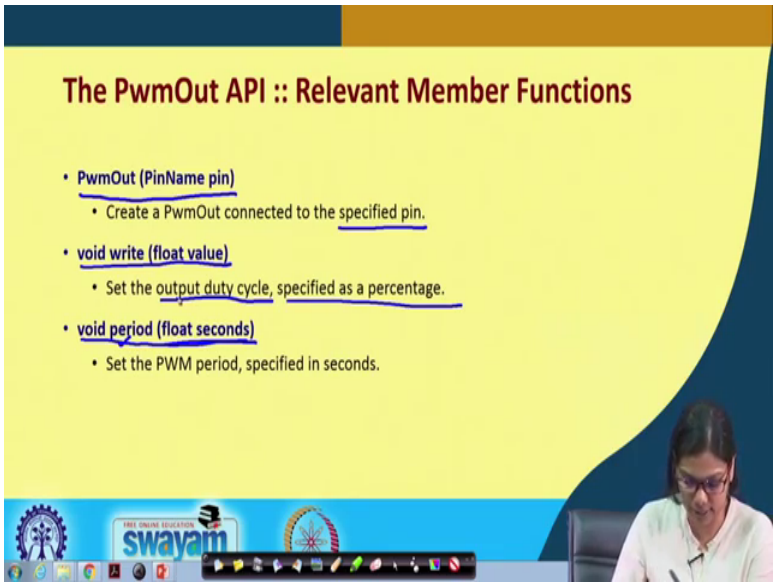

Now, these functions we have already discussed in previous weeks Pwm out, what it does it creates a Pwm out connected to the specified pin. So, whichever pin whichever PWM pin we will be connecting it to.

So once, we use Pwm out with that pin name, we can create this Pwm out signal to it void write some float value, what it will do it will set the output duty cycle specified as a percentage ok, the percentage time it is on ok. So, that can be written using this function void right. Similarly, void period we can also set the PWM period in seconds by specifying by using this particular function void period and specifying it the in this parameter the seconds ok. So, these are the few functions that I have discussed there are many more function, which has been discussed earlier in detail.

So, as I will be using in this particular lecture. So, I have just told you about this once again.

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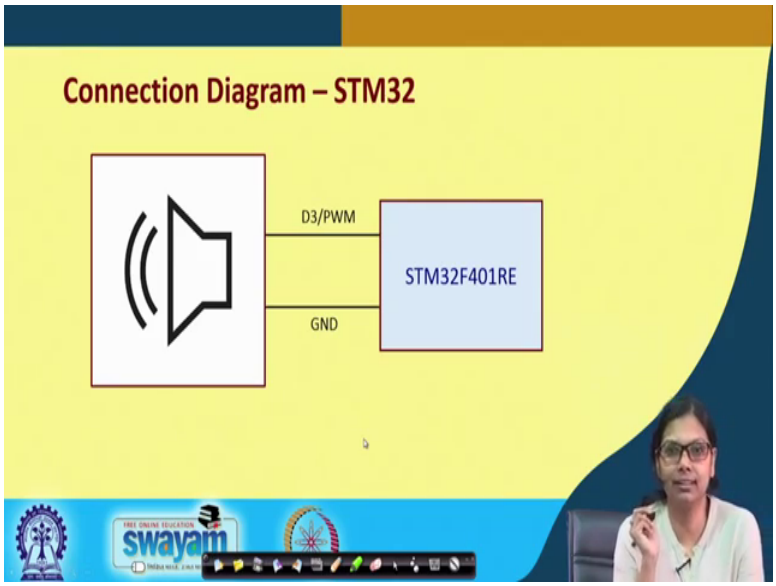

Now, this is the circuit diagram, circuit diagram is fairly straightforward, you will see that when I demonstrate I will simply connect one end of the speaker to ground and another end of the speaker with PWM port that is the D 3 port of this STM which is a PWM port, there are some fixed PWM ports you can is use any one of those PWM port for this purpose ok.

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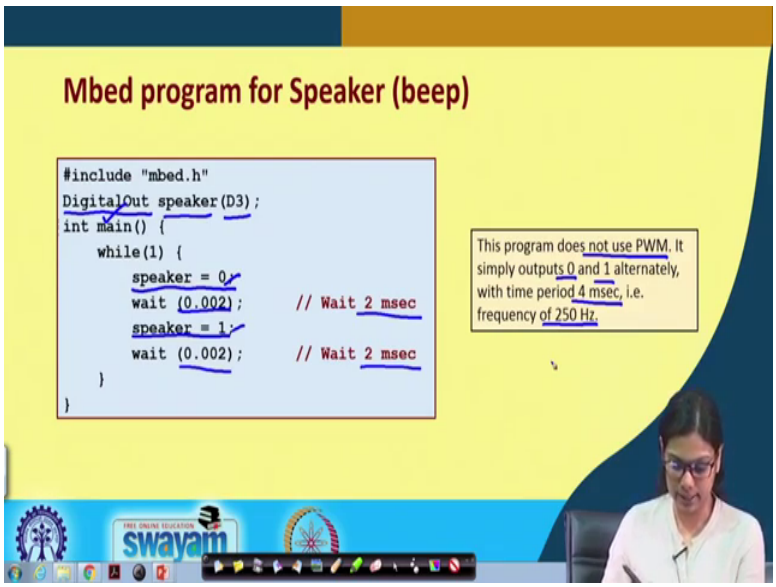

Now, I will be showing you a series of program, the first program this will actually generate a fixed tone ok. The fixed tone which is of frequency 250 hertz ok let us see

how digital out speaker, which is connected to D 3 int main and we are outputting speaker with 0 with a weight of 0.002 second, which is 2 milli second and speaker equals to 1 with weight of 0.002 milli second, which is 2 milli second ok.

So, we are generating a fixed tone, where we are sending A0 ones and over 1 ones and this is the period that is 2 millisecond and 2 millisecond. So, 2 millisecond it will be on 2 millisecond it will be off ok. So, this program does not use PWM as you can see we have just done digital out and not PWM out because, we want a fixed stone and we do not want it to change it is a fixed tone that it will be generating and it simply outputs either 0 or 1 alternatively with the time period of 4 millisecond as I said 2 millisecond on, 2 millisecond off. So, total period is 4 millisecond and which is equivalent to 250 hertz ok.

So, we will demonstrate this particular in at the end of this lecture.

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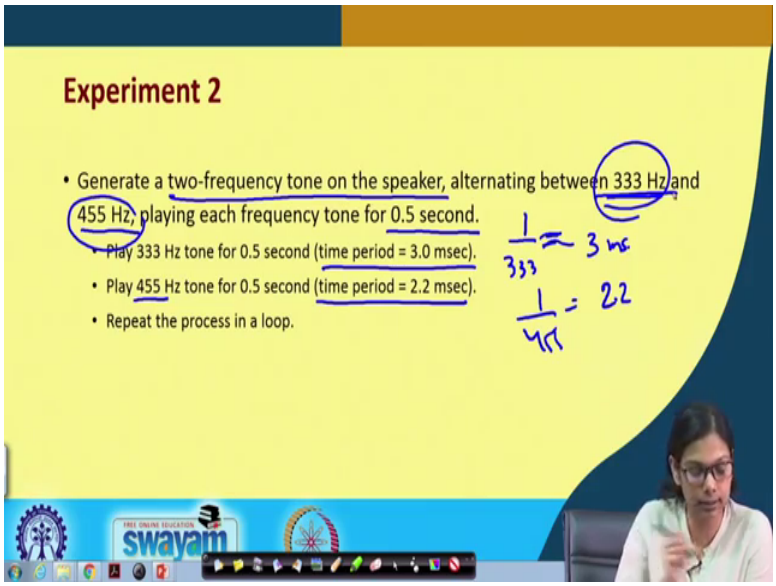

Experiment 2, in this experiment what we will be doing, we will generate 2 frequency tone of the speaker alternatively between 333 hertz and 455 hertz, how do I do it playing each frequency tone for 0.5 second? So, both will be played for 0.5 second. So, the first tone will be of 333 hertz, the next will be 455 hertz ok. If it is 333 hertz the time period will be 1 divided by 333; 1 divided by 333, which comes down to 3 milliseconds basically and it is 455 hertz.

So, 1 divided by 455 which will come down to 2.2 that is the time period that we have specified and we repeat this process ok. So, we have to first generate a tone of 330 333 hertz then 455 hertz and I will repeat this again.

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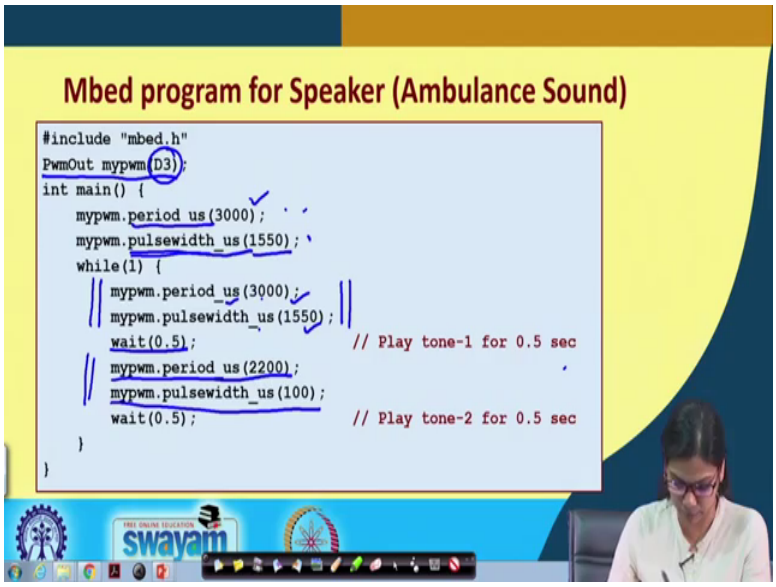

Let us see the code how it goes, this is the mbed code for it in this particular code, you see that first of all this is pw amount, which is D 3, which is Pwm out and we are using two functions period underscore microsecond and pulse width underscore microsecond, this is specified a in terms of this microsecond ok.

So, what we are doing we are doing mypwm period in microsecond 3000 and mypwm pulse width underscore us that is microsecond this 1550, we are specifying these two parameters here, these two parameters are used for the purpose of generating the tone then what we are doing? Then we are doing my pw m dot period in microsecond this one my pwm pulse width of this one then we wait for 5 millisecond because, I said that it will play for the first tone for how much period for a period of 0.5 second and again it will play a tone, which is of this period for another 0.5 second so that is what we are doing it here.

So, we are specifying these two things here, we wait for 0 0.5 second again, we specify these here and we wait for 0.5 second and this repeats. So, we will see that this will generate a side end like sound. So, it will be t t t t like that ok. So, we will look into that when we show the demonstration.

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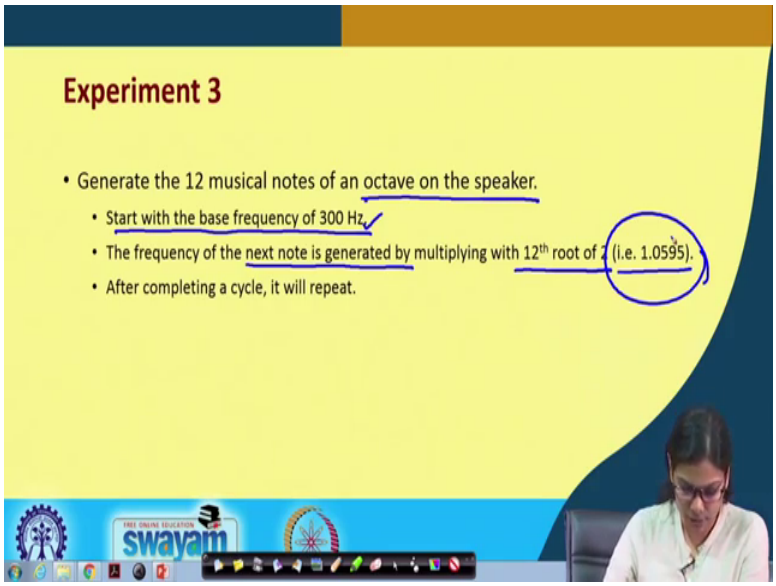

The next experiment that we will be showing is to generate 12 musical notes of an octave on the speaker basically; it is Sa Re Ga Ma Pa Da Ni Sa ok. So, we start with the base frequency let us say 300 hertz and then what we do the frequency of the next tone is generated by multiplying it with 12th root of 2, which is 1.0595.

So first, I will start with 300 hertz, the next tone will get generated by multiplying it with this particular value and then the whole things repeat for 12 tones and again it goes back to the first one ok.

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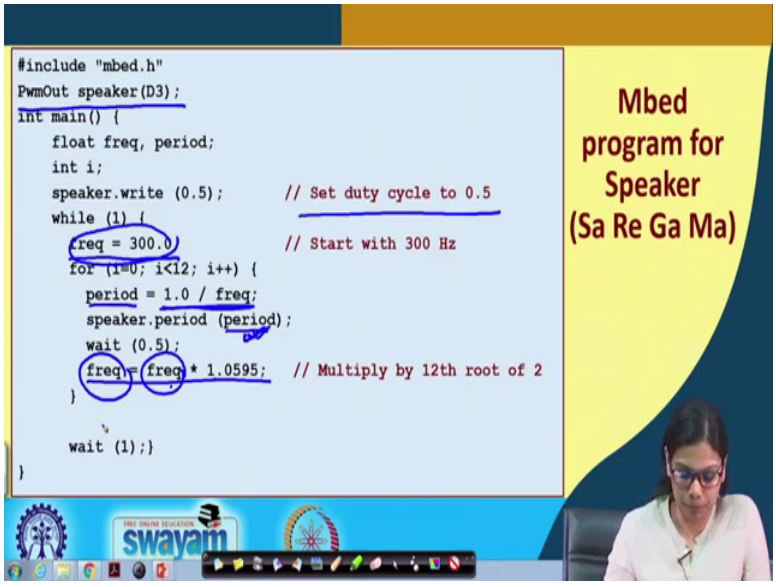

So, for this the code goes like this. So, this is the code again we use this Pwm out for the speaker which is connected to D 3 and here we set a duty cycle, which is 0.5 speaker dot write 0.5, we are specifying the duty cycle and then frequency is 3000 then how do we calculate the period, period will be 1 divided by frequency because, for each one now we have to calculate depending.

The next node will be calculated by multiplying certain value to this frequency ok. So, that is why period we are calculating which is 1 divided by frequency, then we are setting the speaker period as this period ok. Please see the period, we are calculating here and then we are setting the speaker period as this period, we wait for 0.5 second then the next frequency that is getting generated is again generated by multiplying the frequency which is 3 300 here multiplied by this that will become the new frequency and again that is divided by 1 divided by that particular frequency and that will get output and this will happen for 12 notes and again it will repeat forever. So, this is what is done to generate a tone for Sa Re Ga Ma Pa Da Ni Sa.

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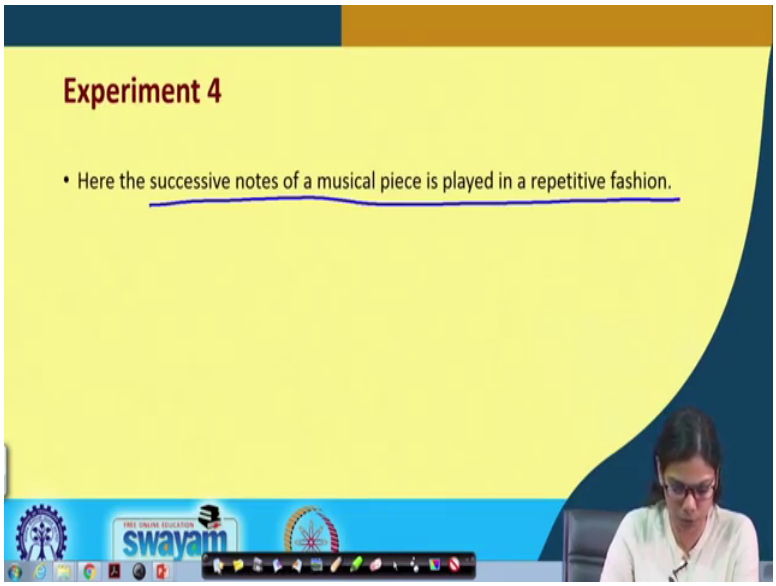

The next successive note here in this experiment, we will be actually playing some successive note of a musical piece is played and which will sound very similar to like happy birthday to you ok.

So, we have selected few notes few frequencies that we have played for certain period to generate that particular tone, let us see the code directly.

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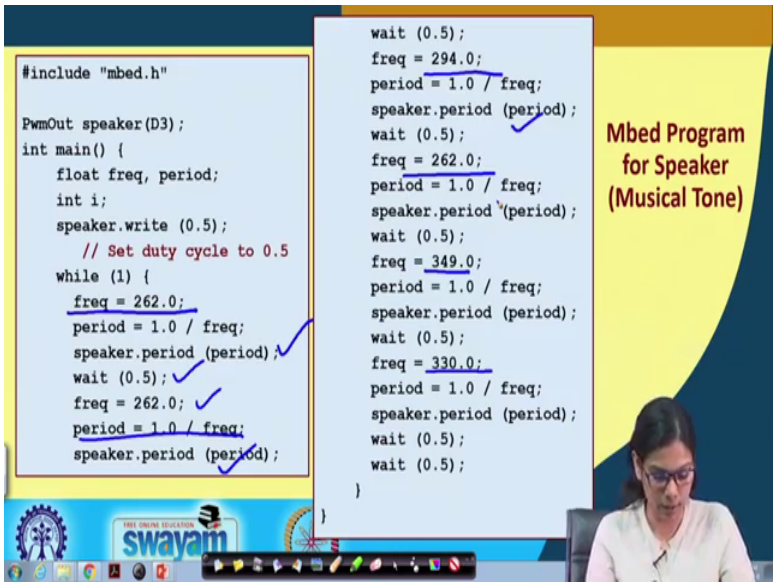

So, this is the code, here you can see that what we are doing, we are actually taking the first frequency that is 262 we are outputting it speaker dot period then we wait for 0.5 second then it is frequency is again 262 and again we calculate the period, which is displayed next frequency becomes 294 and then it is displayed then again it is 262 and then again it is displayed then it is 349, 330 and so on.

So, this whole thing if you see if you run this particular code, where we are doing nothing, but we are specifying certain frequency and we are generating that time period and we are writing it to the speaker and it is generating certain sound. So, it sounds like to some extent happy birthday to you will be looking into all the 4 codes that I have just now discussed after this, I will demonstrate each one of these codes using the speaker connection.

So, so this is basically all about that I have to tell you regarding speaker and then I will move on and I will show you how do I interface this, how do I interface this particular 4, all the 4 codes using a speaker and a microcontroller board. So now, I will be showing you the 4 codes on speaker that I have discussed just now ok.

So, those 4 codes what they were doing they were essentially doing like the first code, we will just make some sound make some random beep sound for a longer period, what the next code was doing? It was doing a sound like siren ok. It will be some something we all have heard of siren like sound. So, it will be making some sound like a siren then

the next code basically, there are 12 octaves that we have for that Sa Re Ga Ma Pa Da Ni Sa.

So here, I will be just playing the first 8 one that is Sa Re Ga Ma Pa Da Ni Sa and again it will repeat like Sa Re Ga Ma Pa Da Ni Sa. So, this with a wait period it will go on repeating this is the third quarter and the fourth code that I have shown you that is like a code where the tone of this happy birthday to you will be played ok. So, what I will be essentially doing now is that those 4 chords, which I have discussed I will show you first at how you will be connecting the speaker using a steamboat and then how you will be dumping the code one by one I will be dumping each one of this code and we will see that whether that sound is coming from the speaker or not ok.

So, let us look into the circuit ok.

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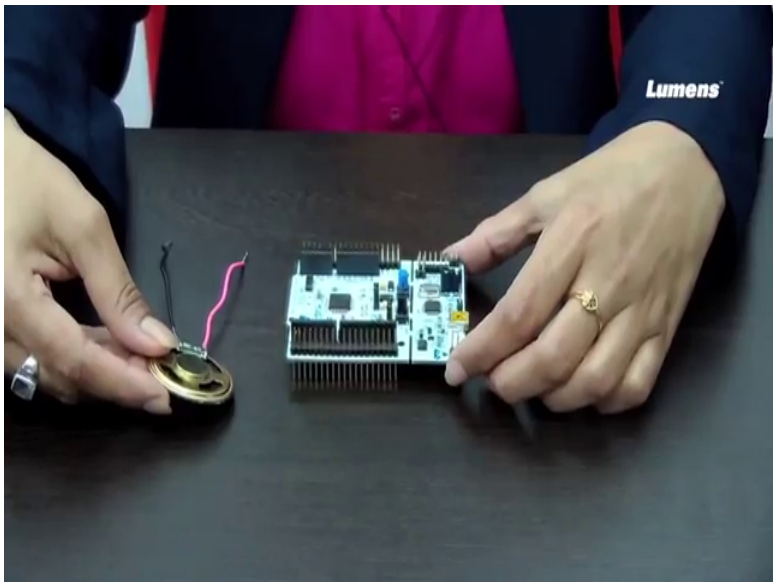

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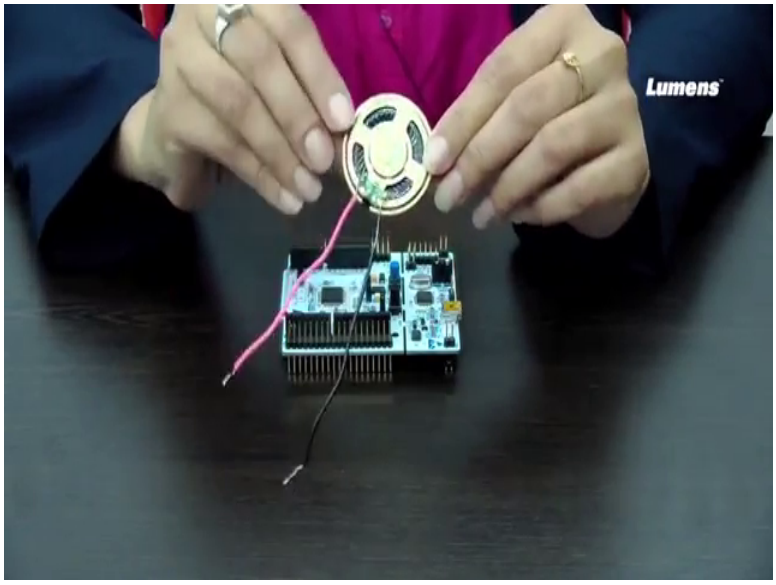

So, this is a speaker right. So, this is a speaker that we discussed. So, inside this the mechanism of the speaker I have already discussed, what it is actually doing the mechanical coil is a magnet and how it is repelling and going away.

So, that mechanism is performed in this speaker what I will do you can connect any of these end one end, I will put it into the ground and the other end I will be putting it into the PWM port.

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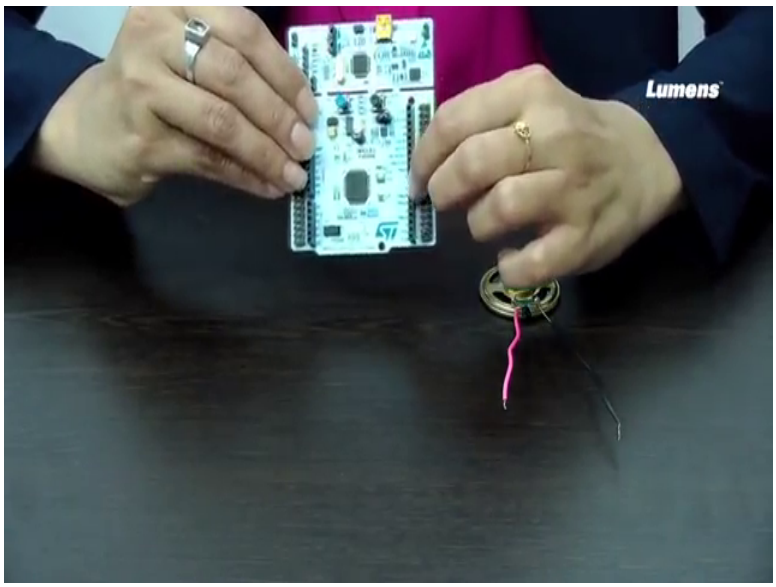

In this board, there are many PWM ports, which are there present here out of which I will be using a D 3 port. So, I will be connecting one end to this D 3 port, which is

output port as well as PWM and another one I will be connecting it to ground, this is the connection that I will make and then I will be dumping 4 code as I said. Ok, I have already discussed about the various functions or using the PWM port ok. So, there are many functions that, we can use some of the functions we have used in this particular code for the speaker. So, let me connect it.

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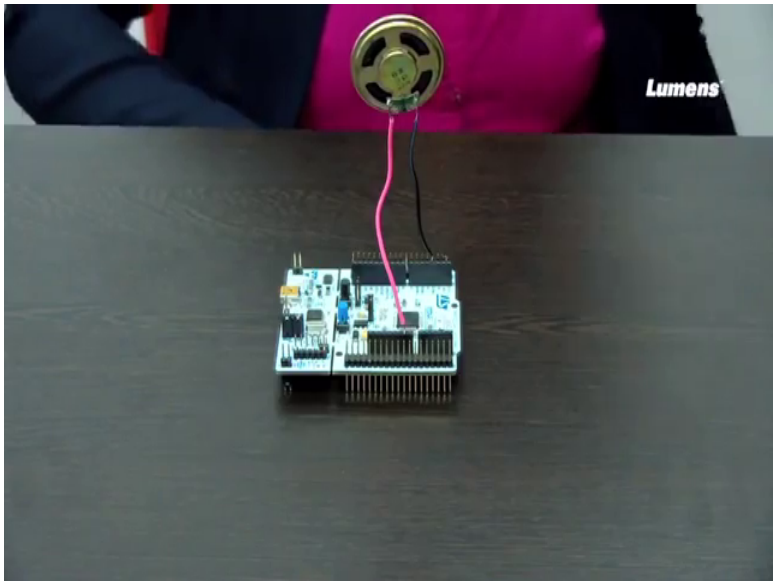

So, I will be connecting one end to the ground and another end I will be connecting to D 0, D 1, D 2 and D 3, which is PWM it is written if you if you are already working with this boards, you can see it as written PWM slash D 3 ok. So, this is all you have to make and now I will be putting up the codes one by one. So, the first code will be a constant sound that it will generate, you can hear this sound that is coming which is a constant sound that with a single frequency sound it is just plain ok. So now, we will go to the next sound. So, I'll just take this out.

So now, I will be dumping the next code. So, basically this is the code of a siren. So, you have must have heard of the sound, when some ambulance come. So, it blows the sound like some kind of siren sound. So, let us see how we can generate that ok. So, oh well just a second it is glowing the old sound, yes now it is glowing the siren sound. So, this is a kind of sound using the code which I already discussed it is playing ok. Ok now, we will move on with the next one, which is basically Sa Re Ga Ma ok. So next, I will dump the code that I have discussed with you using this Sa Re Ga Ma note instead of 12

octave, I am just playing the first 8th one, you can hear the sound. So, Sa Re Ga Ma Pa Da Ni Sa.

So, what is happening here it is it is playing Sa Re Ga Ma Pa Da Ni Sa and then again there is a some small delay and then again it is playing Sa Re Ga Ma Pa Da Ni Sa ok. So, the code which I have discussed it is doing the same thing. Here next, I will just play the happy birthday tone this is also some kind of you know tone that we can play. So, let us see with the code that I discussed just a second. So, it may not be the exact sound, but it is pretty similar sound ok.

So, the experiment using speaker was very straightforward, there was nothing much that we have to connect one port one point of the speaker I connected with D 3, another point I connected with ground and I have dumped the 4 codes that we I already discussed with you and one by one you can see that this is how a speaker works, but where you can use this? You think of a scenario, where you will be doing some kind of experiment, where you want that if something happens then you make the sound of a siren ok.

So, this is quite a small sound, you can even have a sound, which is much more louder that also you can make. So, you can have something like this that for security purpose, you have a lock ok. Let us say you are not in your house during a summer vacation, you went for a vacation and then what you can do is that, you can put some kind of sensor that if somebody touches your lock a particular part because, if somebody has to open the lock it they definitely will have to touch some part of the lock ok.

So, you can put the touch sensor there and if somebody touches then a sound like siren will come in and if you are staying in a place, where there are many other houses. So, they can really make out that something which something is happening, which should not happen. So, some kind of I am just giving you an example here it could be any application, where you can use this speaker ok.

Thank you.