Sensors and Actuators
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Lecture - 21

This will be lab class number 7 and in this lab class, we will be demonstrating the DC motors as an Actuator. Actually, we will be showing it to you how DC motors can be used as an actuator. It is a small demonstration. Focus on that particular laboratory experiment and if you have any question feel free to ask. Lab 7 will be demonstrated by Arjun and he will be teaching you the use of this DC motor as an actuator and this is just one example.

Instead of DC motor you can use some other actuators as well but just to help you out how can you use DC motor as an actuator, we will be taking this particular experiment in this particular course and let me discuss it more in lab class 8 in an upcoming module. Lab class 8 will be more on the peristaltic pump using Arduino. I will talk about that in lab class just before we demonstrate to you how you can connect the peristaltic pump with Arduino board. Till then you take care, have fun. Enjoy lab classes and I will see you in the next lab class, bye.

Hello and welcome to the Sensors and Actuators course. In today's session, we will be discussing some of the actuators that we have discussed in the previous lectures. You must have heard what sensors are, what actuators are and even the working principles of sensors as well as actuators. Today, we will see some demonstration of different actuators and first I will be showing you the demonstration of a DC motor. You have seen how a DC motor works and how its internal wiring is, and the principle of operation of a DC motor.

I am going to show you how to use DC motor as an actuator. The DC motor as you know will have two terminals across which you can apply a potential and the motor will start rotating. If you reverse the direction of the potential, the motor will rotate in the opposite direction. This is what you must have discussed or learned in the previous lectures. This is a simple process that we have discussed now, but when it comes to a mechatronic system or a robotic system, you need to control it by some intelligent means. You cannot just switch the motor by just switching the polarity of the battery. But, for this process instead of manually changing the polarity, you will have to use some other methods.

In the previous lecture, we have discussed how to use an Arduino board and how to interface an Arduino board with a potentiometer, LED and other things. And different functions of the Arduino. Here we will be using that Arduino board to control the direction of and speed of the DC motor. This will be an experience to you because you will see how it logically works using an external circuit and in programming to control the direction as well as the speed of the DC motor.

After this session, we will be discussing different pumps and so on in the coming lectures

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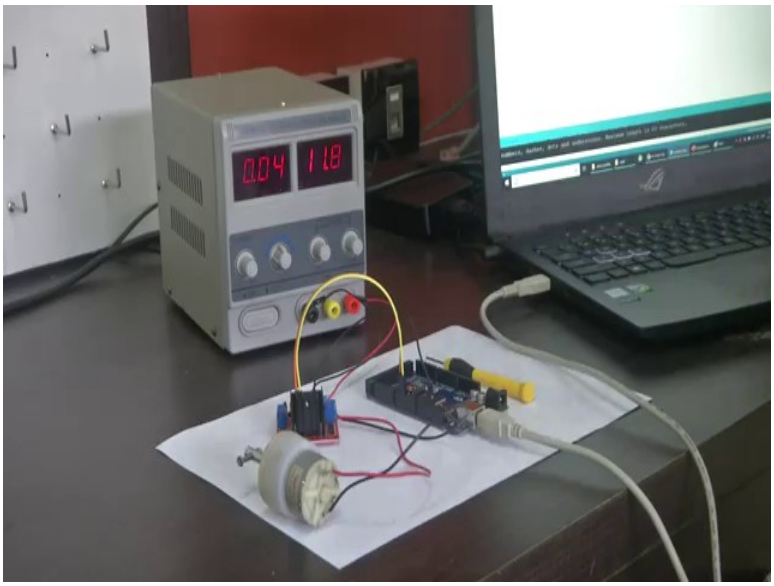

Here you can see a circuit. This is one of the examples of a DC motor. We usually call it DC geared motor; other than that there are Johnson's motor, BO motor and other different types of motors. Industrial grade motors are different and you can see some other things. This board you are familiar, this is an Arduino Mega board. I have previously shown you this and here we have something different. What is this? This is a motor driver board.

This is a motor driver or its name is L298N. I will be showing you how it works and here we have a DC power supply. I have used this instead of a battery. You can see the current drawn and the voltage over here. It is 11.8 volt, but the motor is not rotating. I will show you exactly how.

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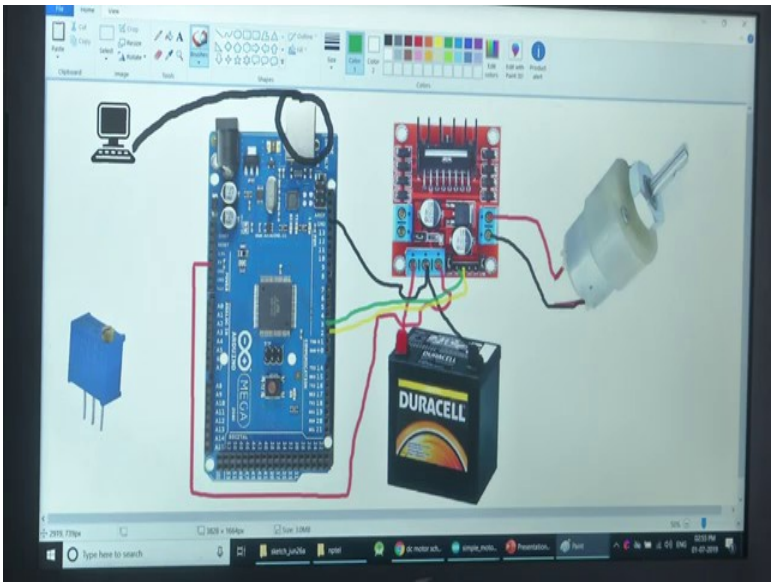

Here you can see some components on my screen. This is an icon of a PC, this is a trimmer or a potentiometer, and you have seen this in the last session. This is the Arduino Mega board which we discussed previously. This one might be new to you but, you must have seen this also in the session a motor driver circuit. This is an L298N and I have kept a battery here instead of a DC power supply to make it easy for you to understand and then we have a DC motor. I am just going to tell you how we wire this and how it works and what's is the logic behind it.

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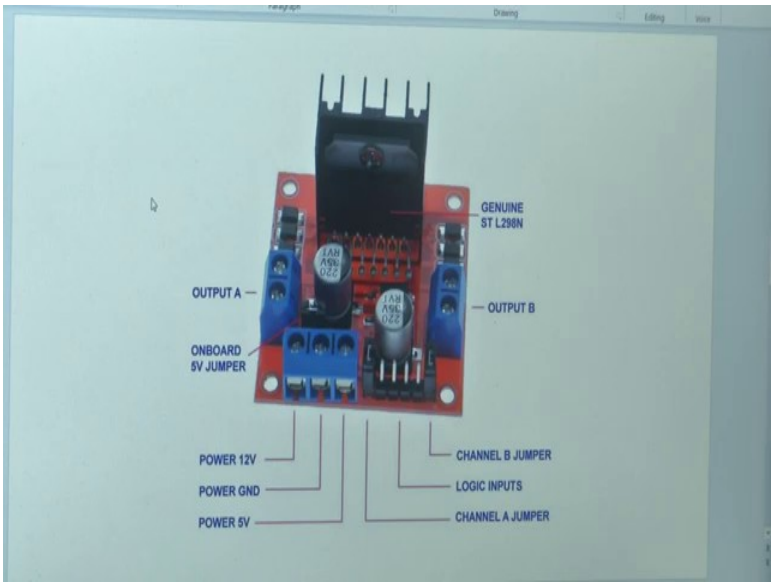

This is the main thing that is unknown to you. This is an L298N motor driver. You can see some markings here. Why do we need to use a motor driver? In the previous session I must have told you that in Arduino Mega, we can give 5-volt output.

If you write digital, write high or something, we have seen in the previous sessions that Arduino Mega can give logical outputs. Logical output means it can give either 0 volt or high 5 volts as the output or even not exactly analogue values, but by means of a varying voltage by means of PWM. How does that one actually be used in case of a motor, how those signals can be used in case of a motor.

The motors actually work with high voltage as well as high current, but you can see that the Arduino can only provide 5 volt as well as current maximum up to around 200 milliamps; that is 200 milliamps is the rating of the Arduino. The current output of the Arduino will be as low as even 40 milliamperes.

This current will not be sufficient enough to make the motor rotate; some motors take even more than 1 or 2 amperes. With this 20 milliampere or 40 milliamperes of small current in from Arduino Mega, we cannot make the motor rotate at the required speed and required torque. That

is why we use a motor driver; you can see here it is a motor driver. This is something like a logical circuit only.

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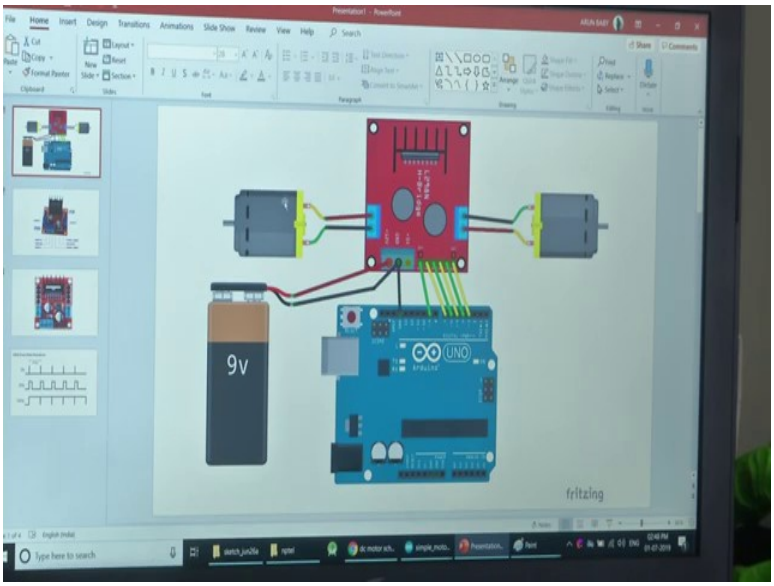

What happens is when you give the signal from Arduino, it will go to the motor driver. The motor driver will make some decisions based on that and from an external power source it will divert power to the motor. This Arduino UNO over here maybe providing only 5 volts, and some logical signals to the motor driver and based on these logical signals, it will divert power from this 9-volt battery which can also deliver some high current to these motors. This is how it works.

You can see here, there is an input of 12 volt that is where you connect the 12 volts or the positive terminal of the battery to this board and also this is the ground pin where you connect the ground of the Arduino as well as the battery. Why we have to connect both ground of Arduino as well as battery is because we can ground or common ground the Arduino as well as power supply. We need to do that so that the reference will remain the same.

You have two common ground both Arduino as well as power supply over here then you have a power of 5-volt input which is for powering or making the IC over here work. The IC here works at 5-volt logic and you need to give some 5 volt supply for it to work. Usually what happens is,

there is a regulator within the circuit so that even if you give 12-volt power supply, using a voltage regulator it will create 5 volts and make this IC run, but you can also give this one.

You can see an on-board 5-volt jumper. If you remove it you can give an external power supply otherwise it will directly give 5 volts to this one, but you have provisions for both. Then you can see four pins over here, four jumper pins or main pins over here. This is where you can give input signal to this board. These are the four pins where you give input signals to this board. You can see an output A here and an output B and two terminals from each.

An L298N board can control two motors. A motor requires two terminals and to control it one positive terminal and one negative terminal; if you switch the potential it will rotate in the opposite directions. You need two terminals for the motor.one of the two terminals for if I have a motor here these two terminals can drive one motor and another motor over here. There are four terminals, four outputs and similarly we have four input terminals.

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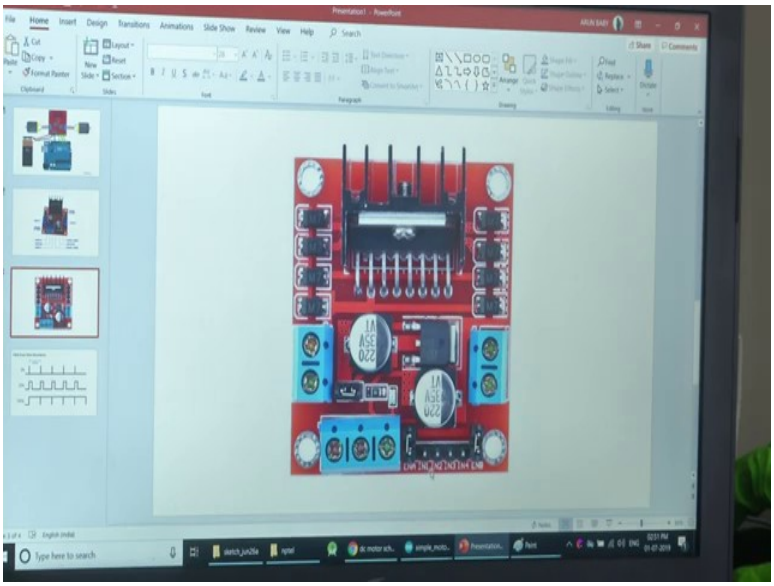

these two, one over here and one over there you can see the IN1 and IN2 are for a motor over here and in 3 and in 4 are for motor over there. This is how we give the logical input that is if Arduino makes this 5 volt to IN1 and a ground signal or a low signal to IN2 then this pin will become 12 volts because if we are connecting a 12-volt power supply here this pin will become

12 volts and this pin will give ground. The motor will start rotating in one direction and similarly, if you make this IN1 low and IN2 high, one will go high and the other one will go low and the motor will rotate in the opposite direction.

Similarly, we can use IN3, IN4 and take the output from output 3 and output 4. This is how an L298N works. You know how important this circuit is when it comes to rotating a motor. Similarly, most of the motors, as well as actuators, will have a driver circuit like this to control it because the microcontroller or the microprocessor can only give some digital or logical signal. This logical signal will have low voltage as well as low current which are insufficient to make the actuator work.

I will show you how I am going to wire this one. You can see a PC to which my Arduino Mega will be connected; I have a trimmer here, I will use it later on. Here we have the L298N, battery and the motor. I will be using this output here and I will show you how I am going to connect it simply. First, I am going to just connect my PC to the comport of the mega Arduino Mega. We can use the Arduino IDE on my PC and send data as well as write data or change the program or whatever we need to do with it.

Now, as I said earlier we have to connect the 12 volts of the battery to the 12 volt terminal of the L298N. I have connected it now I can connect the ground also to the battery so the L298N will get 12 volts as well as ground and I also said that we need to make the common ground from the Arduino.

This is the ground over here in Arduino. I am just connecting it. I have made the ground common. I can also give the 5 volts if I wish since the jumper is here, this jumper is over here we need not actually give power supply to this one, but still for your better understanding I am giving this 5 volt over here. this IC will be powered up now. this is how you connect the power supply to the system.

Now, I am just wiring the output terminal to one motor as well as the other output terminal to another motor from the motor driver. We have to give the input. I am going to take the pin numbers 2 and 3 from the Arduino to these ones. I am using a different colour you cannot see maybe. I will connect both.

Now, if I upload the code to the motor it will start the motor and it will start rotating based on the signal that you send from the Mega. This is how the connection goes. This is a better connection but we have a Mega here and the pins are different.

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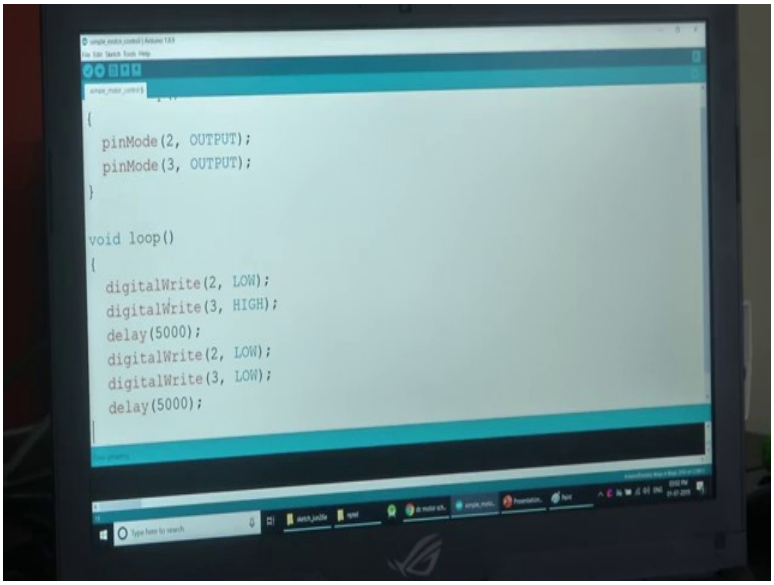

You may remember this Arduino IDE I showed you before. I am showing a simple code over here. You remember void setup, now pinMode (2, OUTPUT), that means, the pin number 2 of the Arduino Mega is output, and then pinMode (3, OUTPUT) that is the output pin 3 is also output. The digital pin 3 is also output then inside the void loop, I have written only two statements one is digitalWrite (2, HIGH) and digitalWrite (3, LOW).

as I already explained in the picture before that pin number 2 and 3 are connected to the input pins of the motor driver. What happens is if I say that 2 is high and 3 is low; that means, the motor will get 12 volts on one of the pins and ground. That is what this simple code means. We will see how this code works. I am just going to upload this code into the Arduino board now by pressing a button.

when I press the upload button, the code is being uploaded and you can see the motor rotating. This is a thousand rpm DC motor and you can see that it is rotating. I can change the code now. I

am going to just change the code now. If I make this one LOW and upload the code, the motor stops.

This is because both pins are low or both are similar to ground or 0 volts. the motor driver will not give any more of a 12 volt supply to the motor and motor is not rotating. If I change the third pin to HIGH and upload the code then the motor will start rotating in the opposite direction. This is how this logic from an Arduino is translated to have rotation of motion by means of a motor driver.

We can do different functions here. You may remember the delay functions. If I am doing a delay function here, say for 5000; means 5 seconds, the motor will be rotating in one direction for 5 seconds after that it will be off for 5 seconds.

This is how you program an actuator by means of Arduino or any other programming board.it can be Arduino, it can be Raspberry Pi, it can be MyRIO. It can be any other programming board, any other microcontroller or processor, this is the logic of how everything works.

You remember this circuit that we did before and now we are going to use this trimmer. Previously when we used the Arduino and the motor together, you can see that the motor was running at full speed in one direction. We switched it off, we reversed the direction and ran it intermittently. Now, I am going to show you how to control the speed of motor using a potentiometer.

If we connect a potentiometer in series with a motor, it becomes a simple circuit that we can use. We are going to use some logical operations here now.

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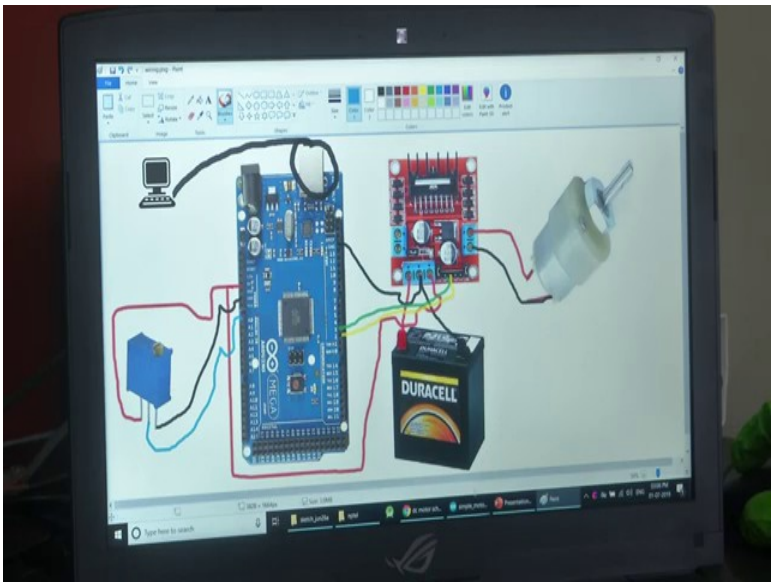

I am just connecting the potentiometer to the 5 volts now and similarly the ground also. Then, we have the signal pin. I am just taking the colour blue and I am connecting this one to analogue pin A0 of the Mega. This is the circuit I have just connected.

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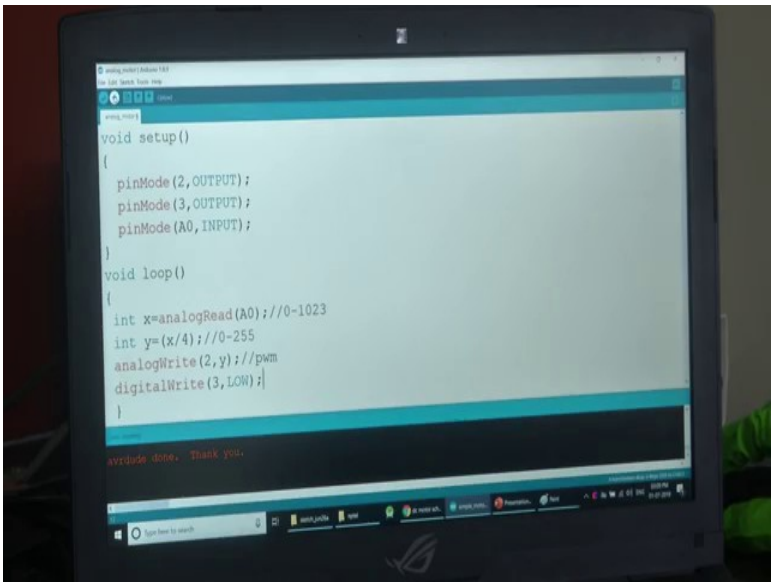

I will take you to the code you remember this code like before also. pinMode(2,OUTPUT), pinMode(3,OUTPUT). There pin numbers 2 and 3 are output and I have defined analogue pin

A0 to be input. I have told you before even if we do not do this it is input by default in Arduino. And, in the void loop, we use the same thing for the dimming of LED or changing the brightness of LED with the help of a potentiometer.

Here I have to do the same operation. I have put int x=analogueRead (A0). The value from A0 is read and stored in the variable integer variable x. And, in another operation, I have created the variable integer y and stored it with the value x /4 because you remember that the analogue value when we read it is in the range of 0 to 1023 and the PWM output that we usually give was in the range 0 to 255; this is by 4 operation approximately.

then I have given analogueWrite (2, y). This function also you must be remembering. This is a PWM output signal. If we use digitalWrite this is invalid, it can only be HIGH or LOW. If I am using analogueWrite the value should be given in the range of 0 to 255. That is what's going to happen here and I have only used digitalWrite (3, LOW) here because the motor the third pin will be connected to the motor driver and it goes to the motor also and this is grounded. We need not give any special PWM signal there to control the speed. This is how it is connected.

The circuit remains the same just that I am taking the value from the potentiometer dividing it by 4 an that value is being written as PWM to the second pin of the Arduino board. This PWM signal will go to the motor driver and the motor driver will change the speed accordingly. I am uploading this code now. I am switching on the power supply, but we can see that the motor is not rotating. I am going to turn the potentiometer, slowly increase. You can see that the motor starts done and its speed is increasing. You can adjust the speed of the motor.

This is how you control the speed of the motor. I can even show you the variation in both motor speed with respect to potentiometer as well as on the serial plotter. I have updated the code now. I have added the serialbegin function to transfer the data from or serially transmit data from Mega to the Arduino IDE into the PC. In the word loop I have done the same thing and added this one to adjust for the scaling defect in Arduino IDE plotter.

It is not necessary, but I am doing this because you will get an idea by seeing a constant scale and it is the same thing everywhere. I am uploading the code now. I am just taking the serial

plotter. You can see that the potentiometer value is somewhere down here the green line; the green line is the potentiometer value here I am just increasing the port value now.

You can see that the motor starts rotating at the same time as in the serial plotter. The analogue value from the potentiometer is being very straight and when we reach the maximum value, the motor will be rotating at its rated rpm that is around 1000 rpm. Now, the motor is running at 1000 rpm, if I am decreasing it again motor speed will start reducing.

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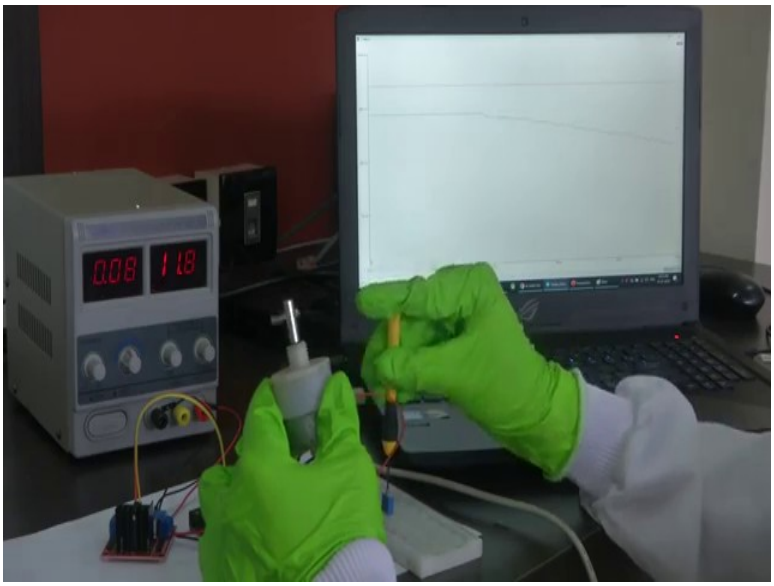

You can hear that sound variation also apart from seeing the motor shaft rotate. We have seen how we make one motor rotate another DC motor with the help of Arduino. Any mechatronics system or any robotic system will be having a microcontroller or a microprocessor to control the actuator and there will be some driver circuit. There will be a power supply and everything in between. This is how we use an actuator.

In the coming sessions, we will be discussing different other types of motors and other things.

Thank you.