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Course Title
Electronic Modules for Industrial
Applications using Op-Amps

By
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Department of Electronic Systems Engineering

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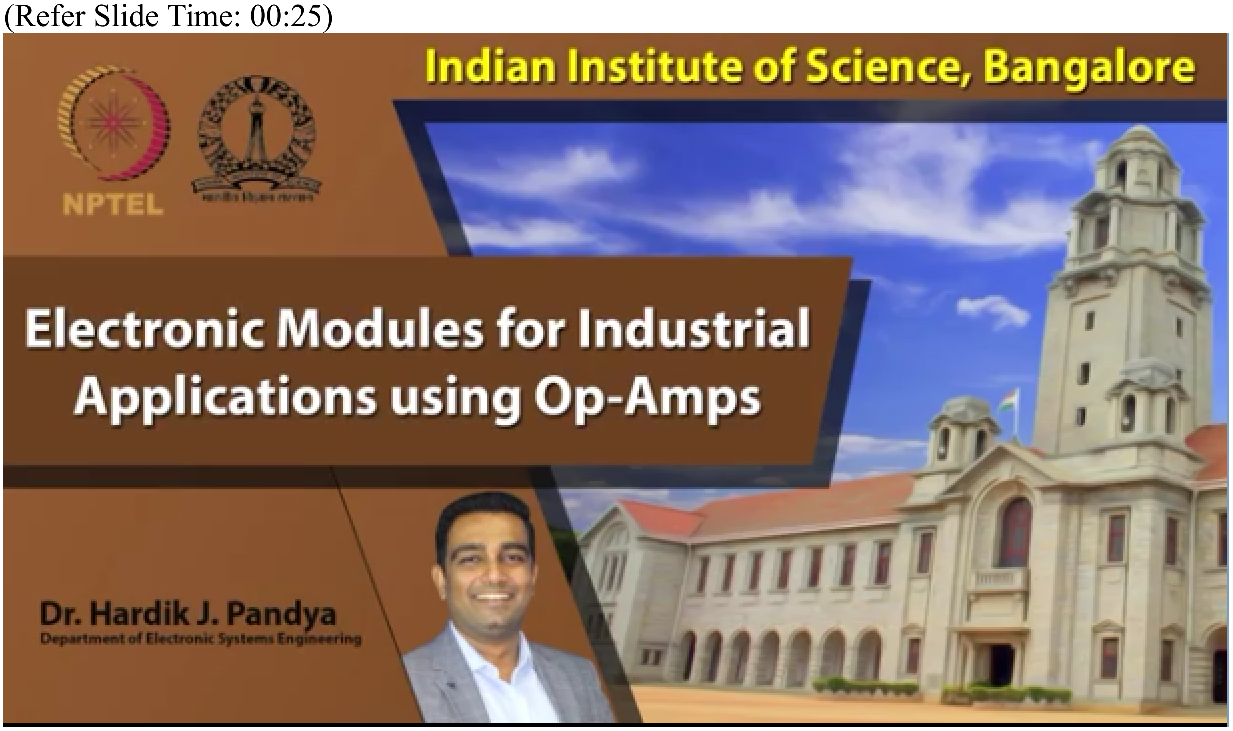

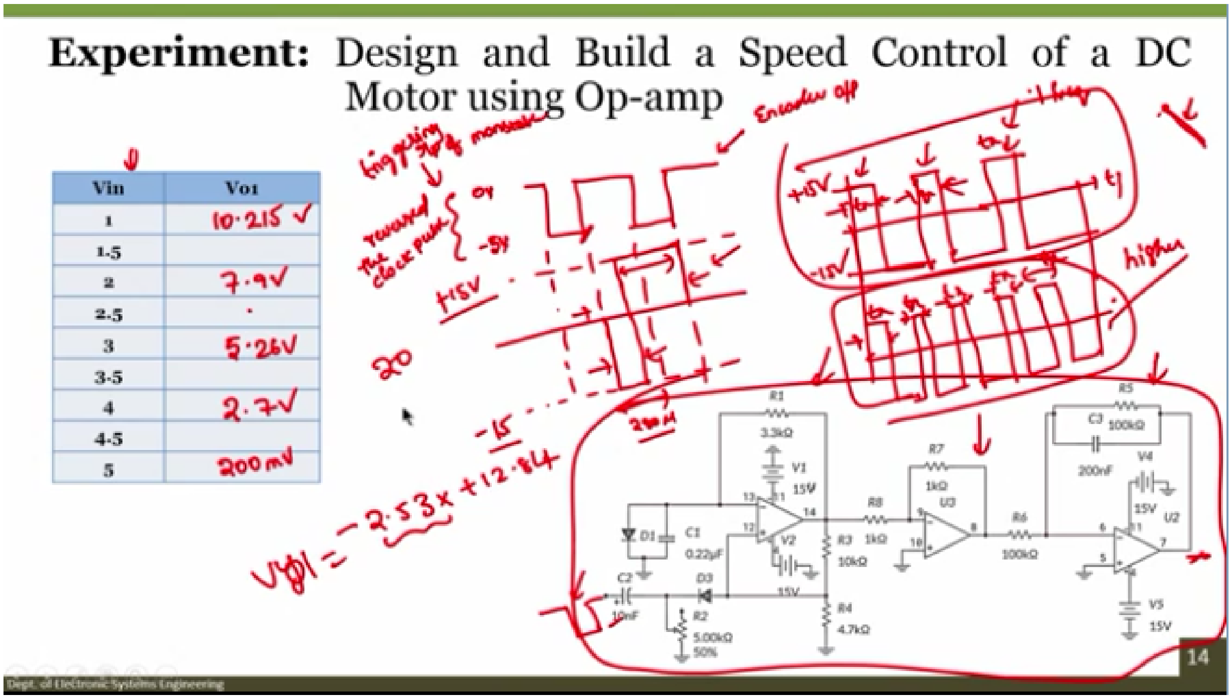

Welcome to the module, we have not completely finish our signal conditioning circuit, so for that we have to change our mapping factor, how do we do that? So right now we understood that for 1 volt I’m getting 10.215,
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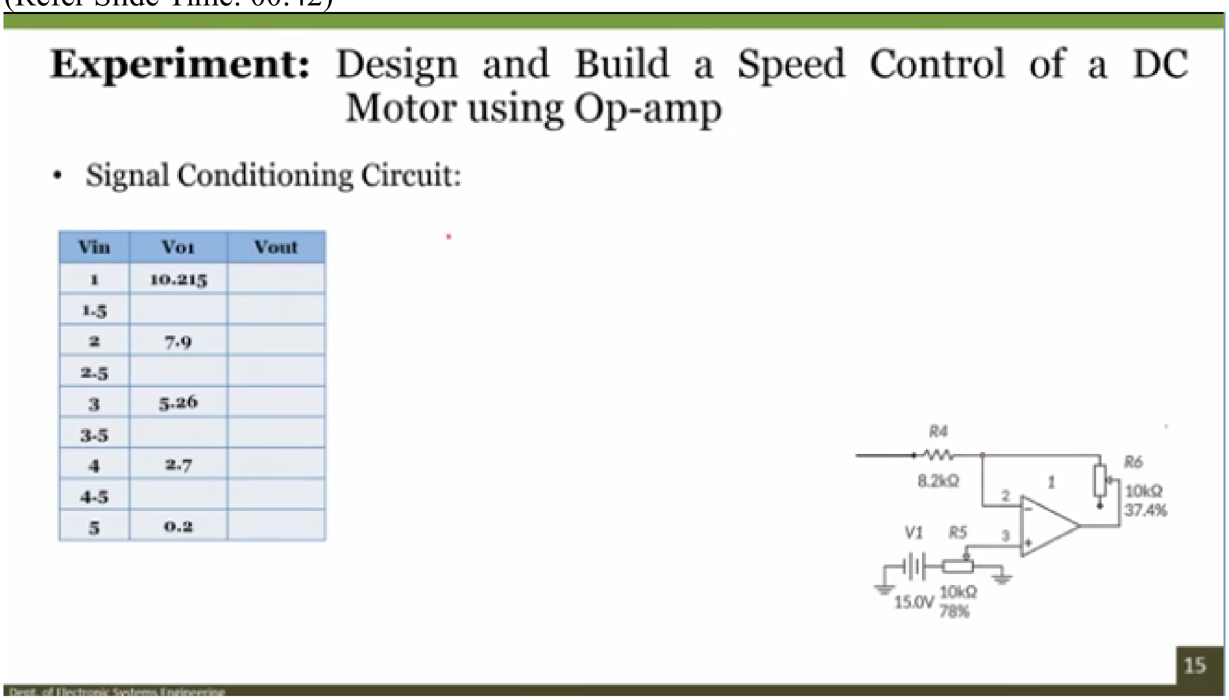

and for 5 volt I’m getting 0.2 volt, but I need for 1 volt the output from the integrator should also be 1 volt, whereas for 5 volts the output should also be 5 volt, that means 10.215 has to be converted to 1 volt and 0.2 volt has to be convert to 5 volt, how do we do that, and everything should be of linearly, which means that when this is linearly varying the output should also be linearly vary,

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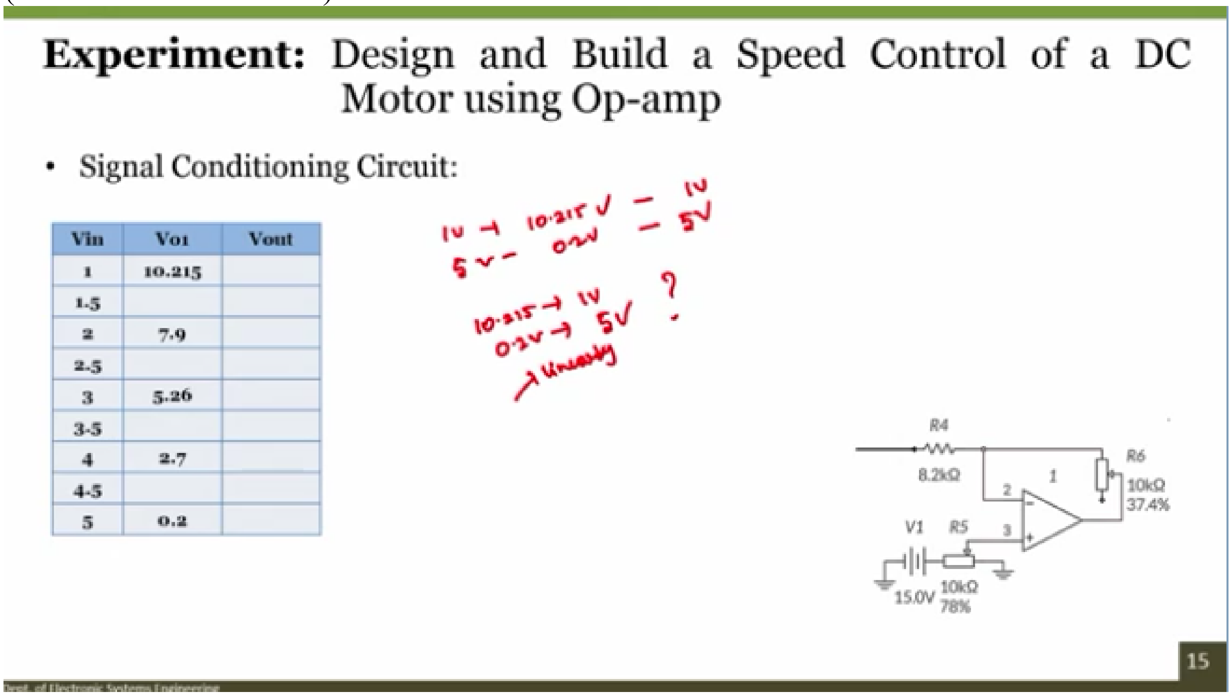

that means when the input is 7.9 I should get output as 2, when the input is 7.9 I should get an output of 2, then the input voltage that is giving at the set point is equal to the output voltage from the signal conditioning circuit, but are having the same mapping factor, but how do we do that?

So for that we have to further you know design a signal conditioning circuit, so what we do? So we know X1, what is an input that we are giving and we know what is an output that we need to get it, that means when I put a scale, right now the scale is like this, I want to change the scale from there to this, this is the input scale and I want to get it as an output scale, right.

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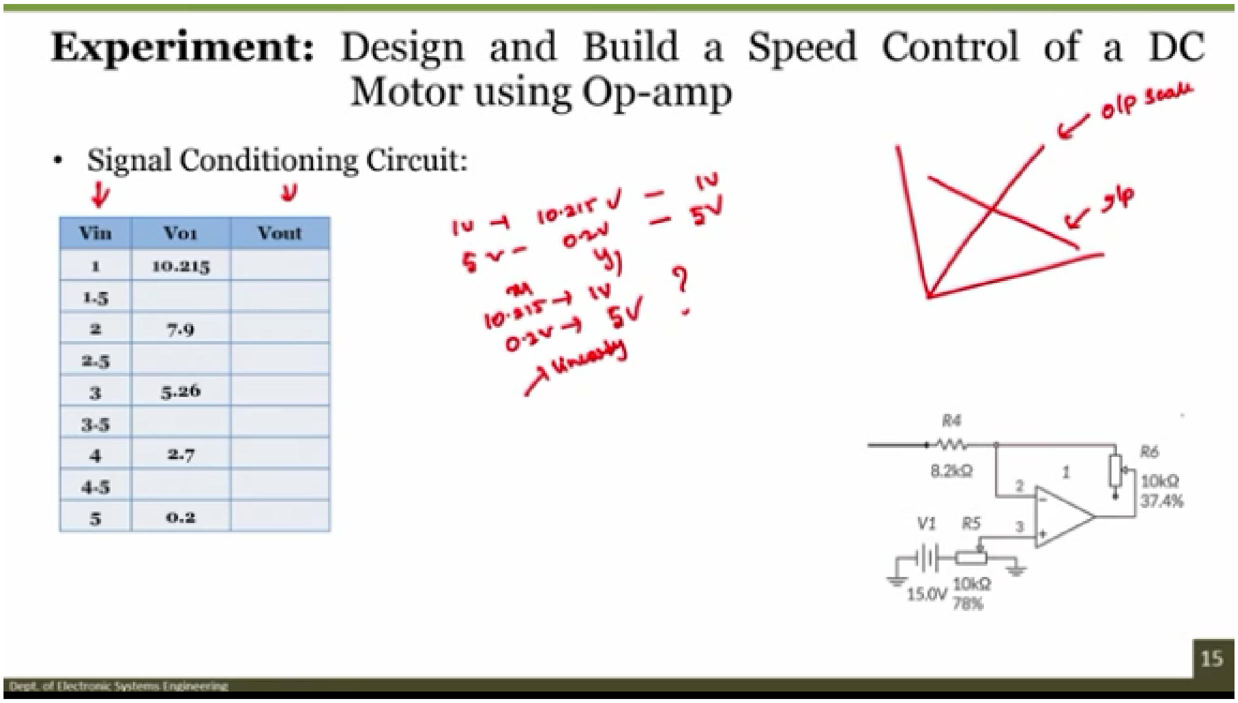

So one way if I want to graphically understand it what I can do? If I invert this particular input signal, so what do I get if I invert the signal? So if I invert the input signal, wherever the negative I have I will get a positive, so one good part is that I got in this case the input is negative slope, now it has been changed to a positive slope, right, slope is keep on increasing, then whatever the offset that I have if I remove it, remove offset or add some offset to the system so that it will go to this part, right, so but graphically it is easier for us to understand that I have to do the inversion,

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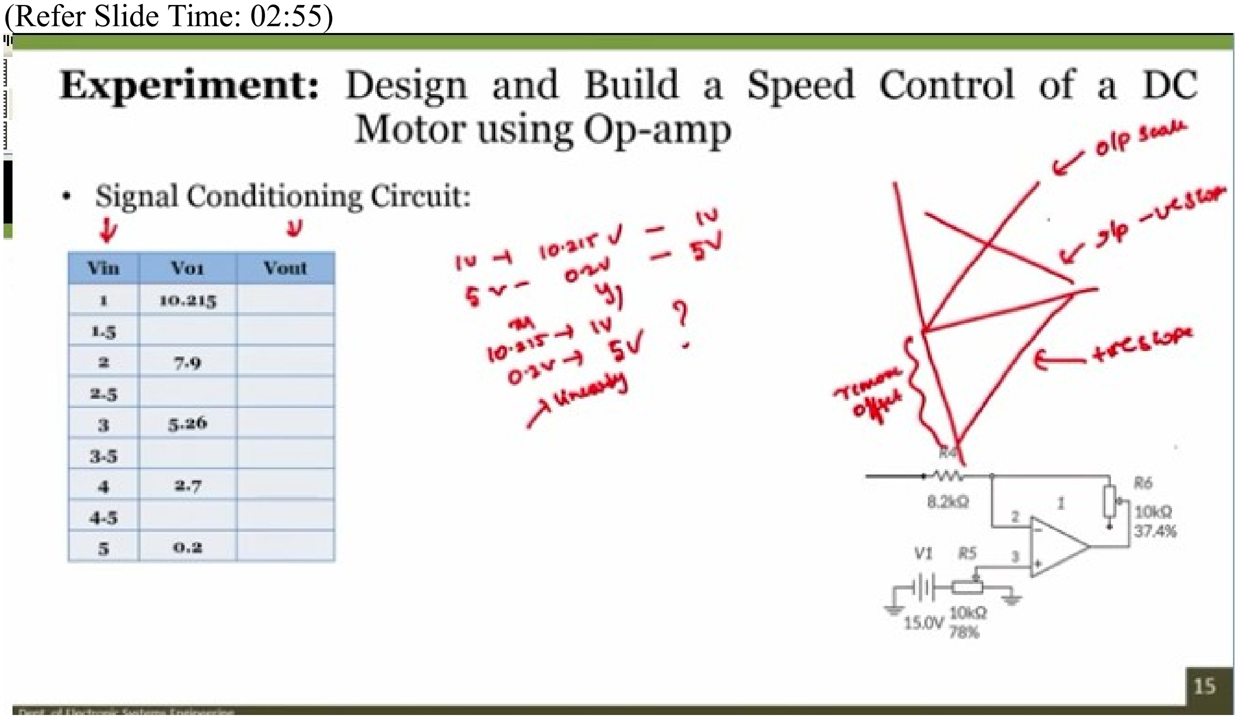

then I have to provide an offset so that this particular signal will shift from 0, but what values? What magnitude of offset that I have to provide, and what magnitude of slope that I have to do gives such that the input, input that we provide to the system will get an output of this one, so we require a theoretical understanding of conversion of the signal.

If I apply some mathematics into that we know that input in this case is 10.215, output we require is 1 volt, whereas when the input of 0.2 I require an output of 52, so I will apply equation of line formula which says that Y-Y1 = Y2-Y1/X2-X1 (X-X1), so what is Y-Y1? Y-1 volt is nothing but, sorry, Y1 I'm considering 1 volt, 5 – 1 divided by 0.2 – 10.215 (X-X1), X1 is 10.215, so when I do this calculation 4 divided by 10.215 – 0.2 which I got -10.015, right.
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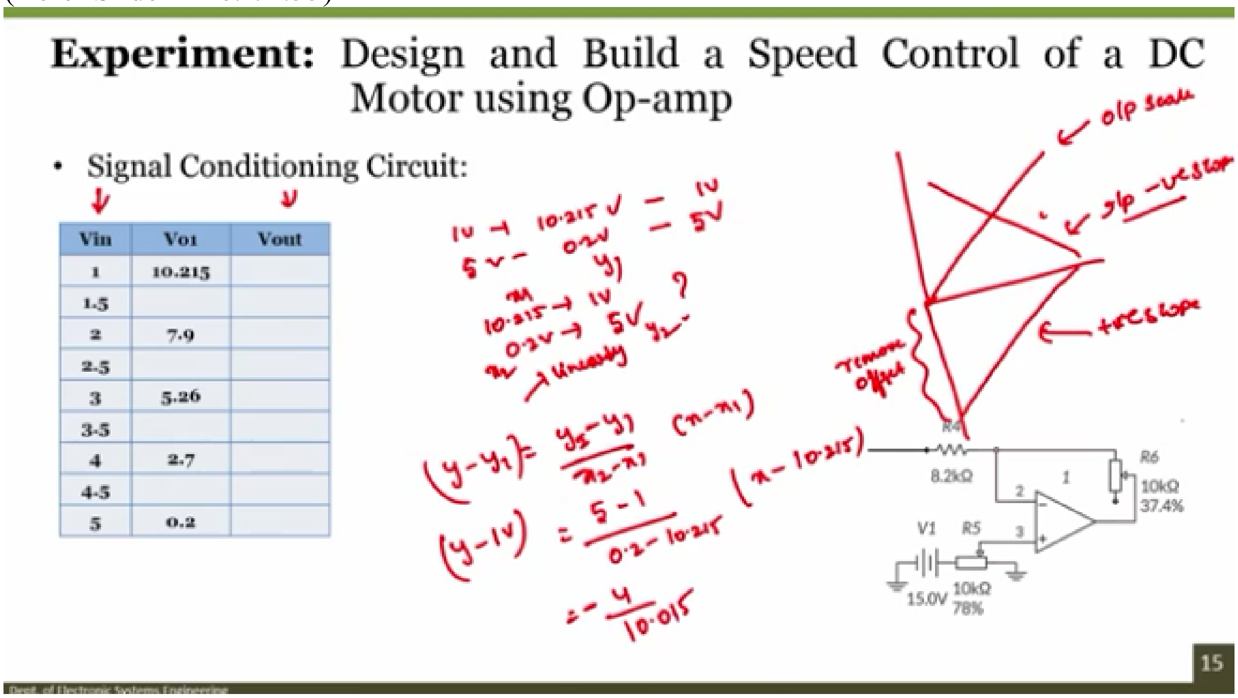

Then 4 divided by 10.015 when I do, I got 0.4,
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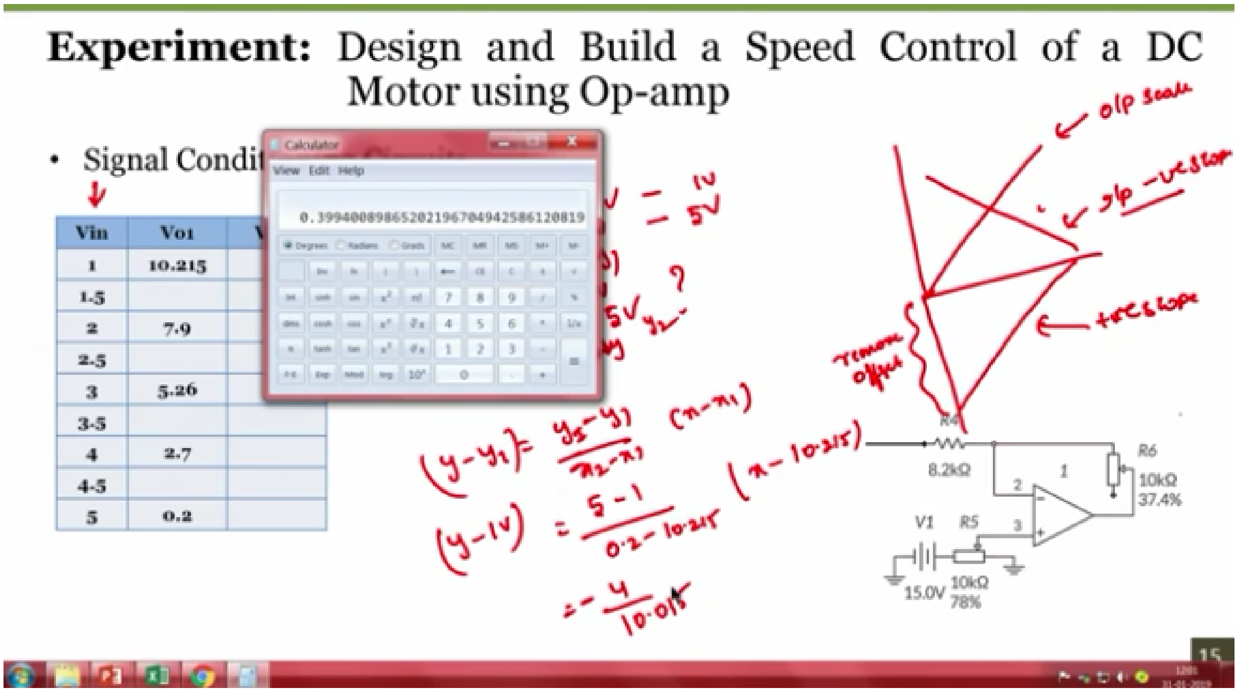

this value is approximately of 0.4 because 0.399, so I will change this to 0.4, 0.4 (X-10.215) which means that Y, so let me write down here, so Y = -4 + 0.4 into 10.215 which is 4, 4 + 1 that means if I provide a slope of 0.4 magnitude that too the negative slope with an offset of 5 volts, then my problem would be solved, so which means that, which means that so first case when I provide a negative with a slope which means that I will get this particular signal, this particular slope which is a positive slope, because initially we have an negative slope we have to change it to positive slope, then I have to shift it little bit, so for shifting we are using offset which is 5 volts, so when I provide a 5 volt signal to the input to this it will go to 0 to 1, so why don't we apply some formula? So -4 into 10,

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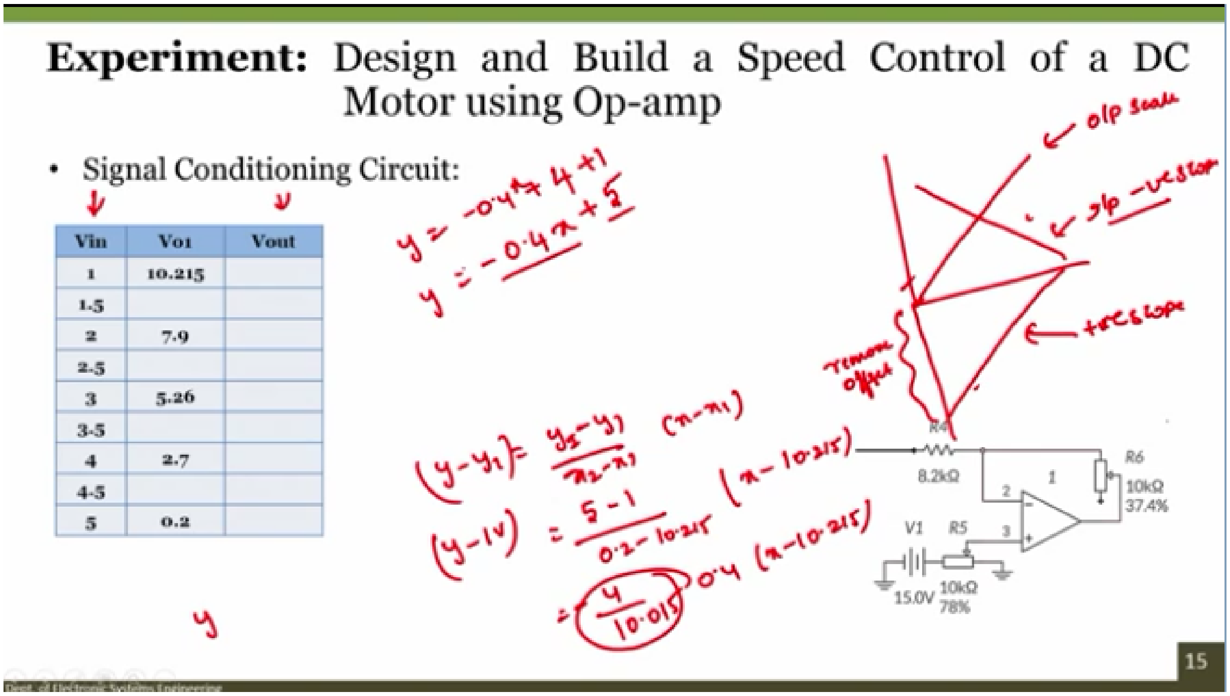

so when we do it will be somewhere around 4, -4 + 5 which is 1 volt, so 7.98, so 0.4 into 7.9 which his 3.16 + 5, approximately of -1.8 for which is 2 volts x 0.2 which is 4.92 approximately of 5 volts.

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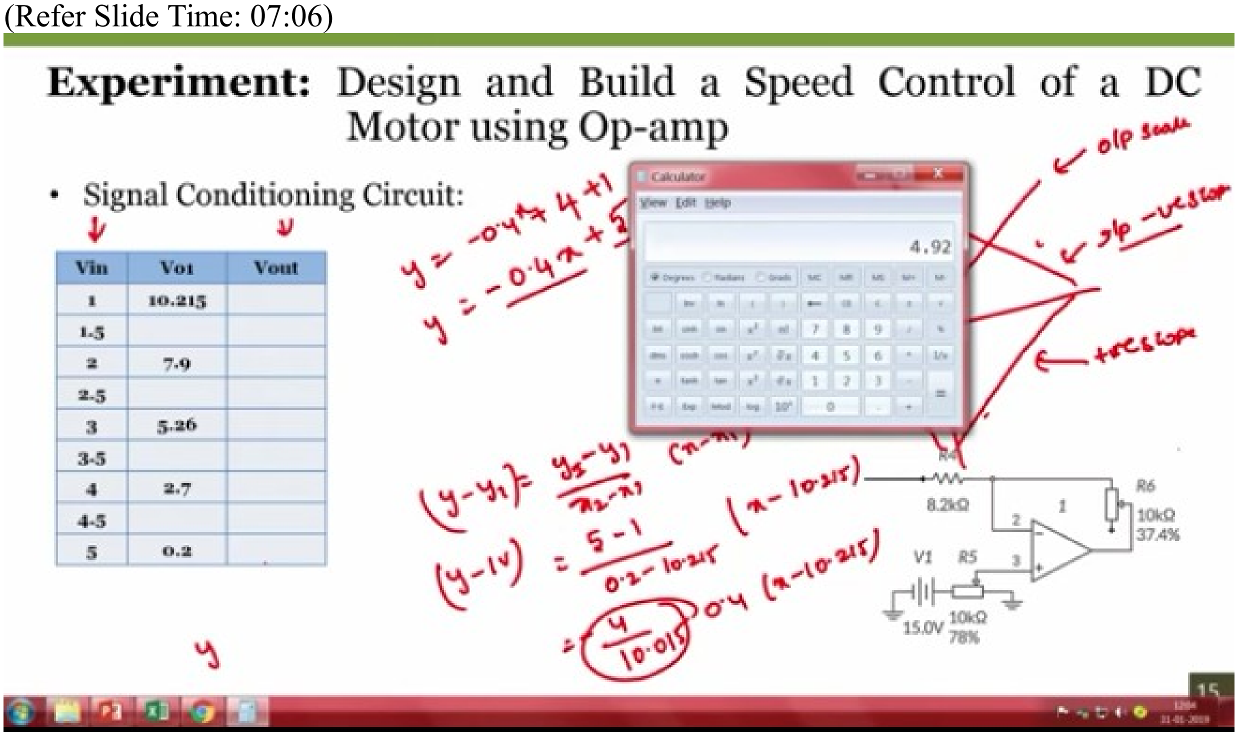

Let see for 4 volts too, 0.4 x 2.7 – 5 so we are getting 3.92 which is 4,

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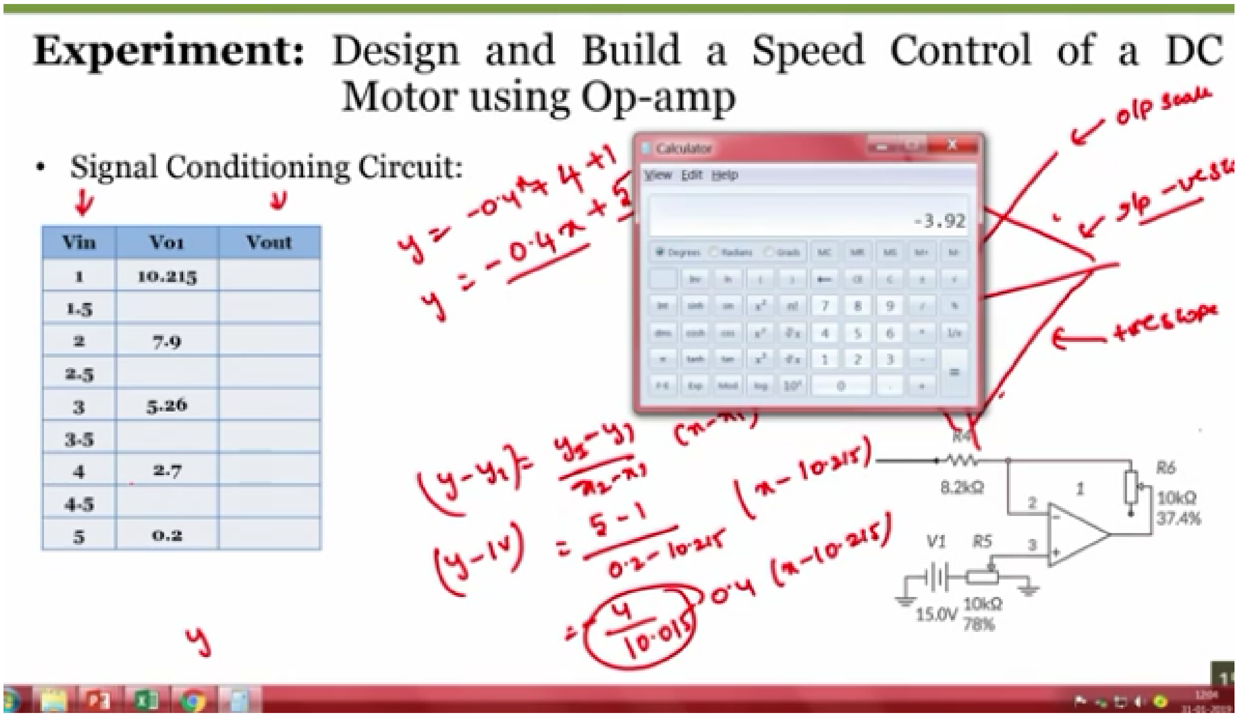

so for all set of values we noted that this is working fine, but how do I implement this? How can I get a signal conditioning circuit with a slope of 0.5 with an offset of 5 and that will make the slope, so if you recall at this particular point what we are doing?

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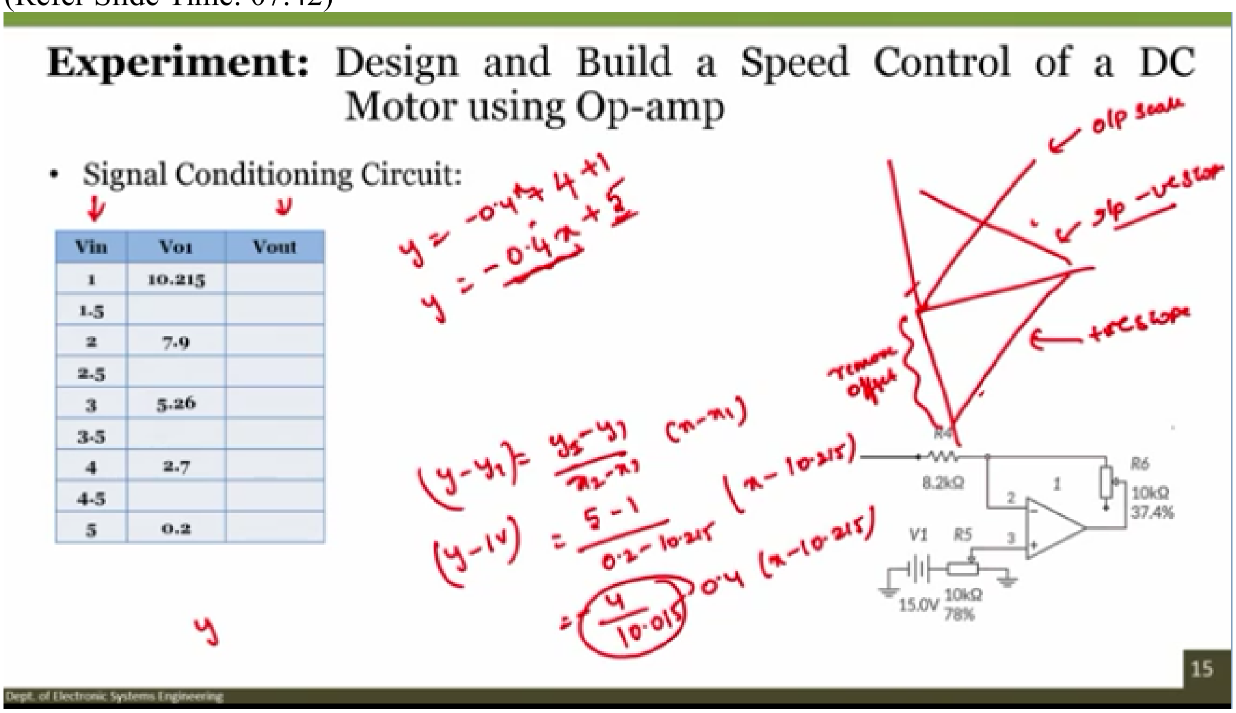

We are doing a multiplication, the input has to be multiplied with the factor of 0.4, then whatever the output that we get has to be subtracted with 5 volts, why don't we simply use? A inverting amplifier of this case which gets a negative output then add with 5, inverting amplifier + had a, yes of course we can use that too, because op-amps are generally meant for doing so

many operations like multiplication, addition, division everything, right, so we can also do that or if you remember that difference amplifier with a single operational amplifier we can do the difference between the two signals, so if I implement a difference amplifier with a gain of 0.4, and 0.4 and the input as 5, so but if you recall our difference amplifier, say this is V1, this is V2, R1, R2, R1, R2 the output voltage we know that output is nothing but R1/R2 into V2-V1, right,
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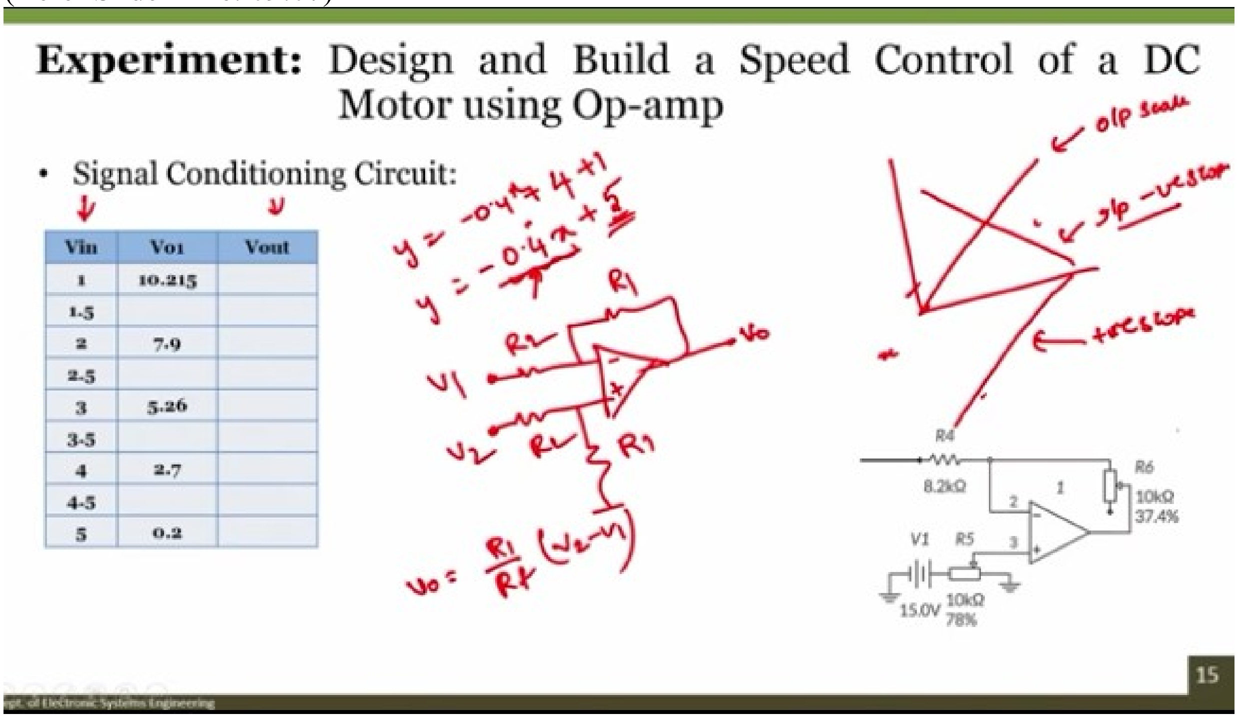

but in this case if I make R1, RF as a constant then the parameter we completely change, so because of that I don't make R1, this R1 and this R1 as same, so I will take a different R1, R2's, so which means that if I recall say if this is my this particular value V2, so we know that we naught applying super position principle I can write it down as V naught = -R1/R2 into V1 + 1 +R1/R2 into V2, this is the output, so when I correlate with respect to this and this, right, so this particular value I should get it as 5 volts, this particular should be -0.4.
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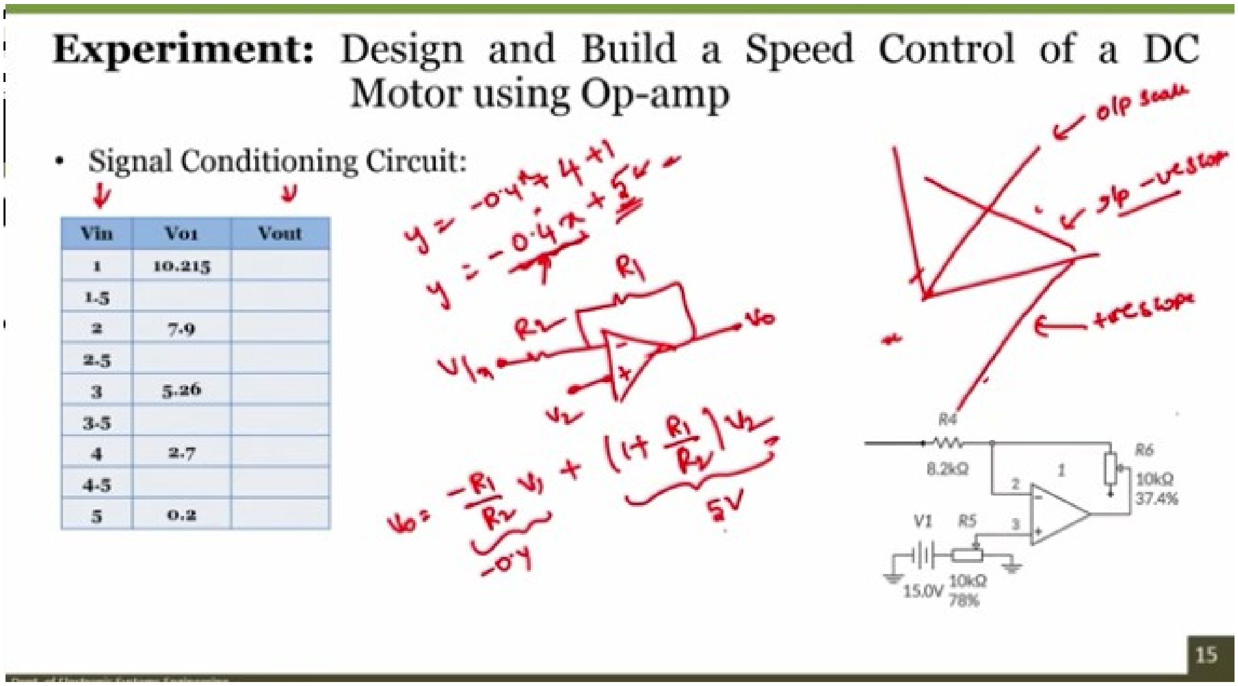

Vin	Vo1	Vout
1	10.215	
1.5		
2	7.9	
2.5		
3	5.26	
3.5		
4	2.7	
4.5		
5	0.2	

Whereas V1 is nothing but input, so if I connect input X, if I connect the complete with 5 volts which means that the set of 1+R1/R2 into V2 should be 5 volts, that means what input voltage if I connect at this point I will get 5 volts, so in order to get that value, so first we will design, we will come out with R1 and R2 values then we will see, R3 and R4 which to provide for this, right.

So we know that R1 and R2 we required to be 0.4, so if I take R2 as 10 kilo, in this case we have taken somewhere around 8.2K, so R1 = 0.4 x 8.2K, if I do the calculation 0.4 x 8.2, so we got somewhere around 3.28K, right,
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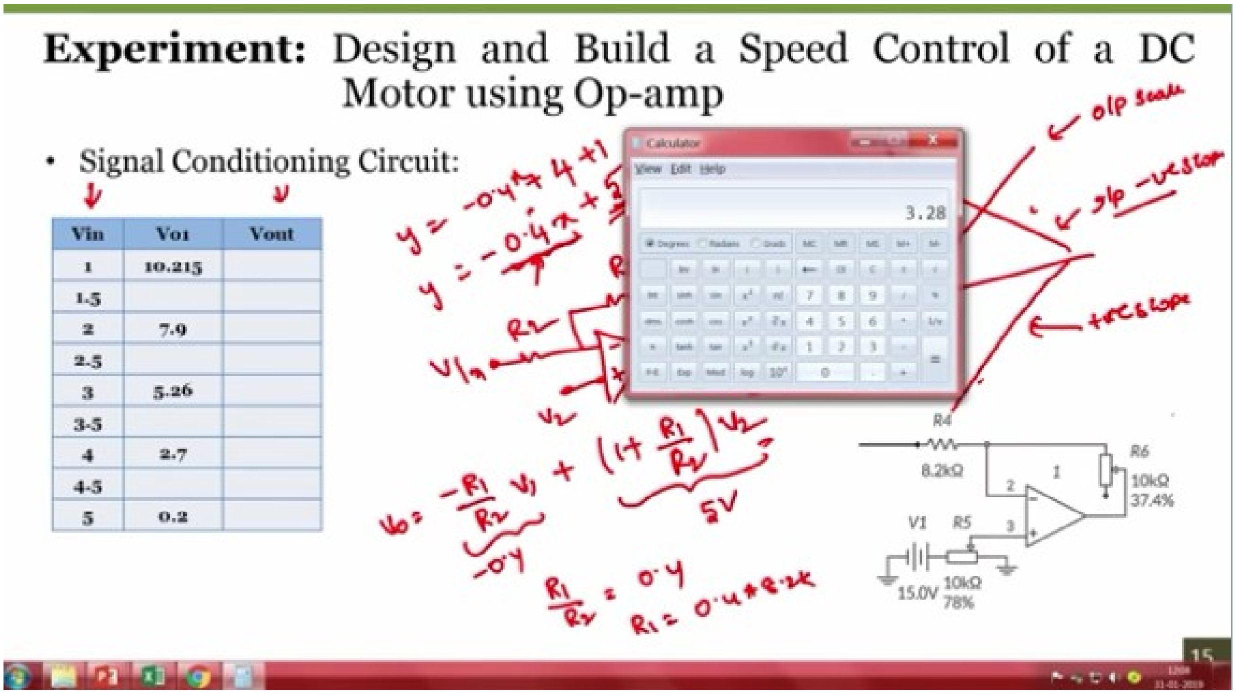

so since we don't get a 3.28K commercially or in market what we have used is that we used a port, port of 10 kilo ohms resistance, so by varying the port we can change the gain at this point, so this problem is solved, so we have considered R2 which is nothing but R4 in my case is 8.2 kilo ohms, then R6 is the port we are considering on behalf of our R1 to set the gain to get the required output, so that we can tune the gain as well as an offset in order to properly match 1 volt with 1 volt, right, so this part is done, but what about this part?

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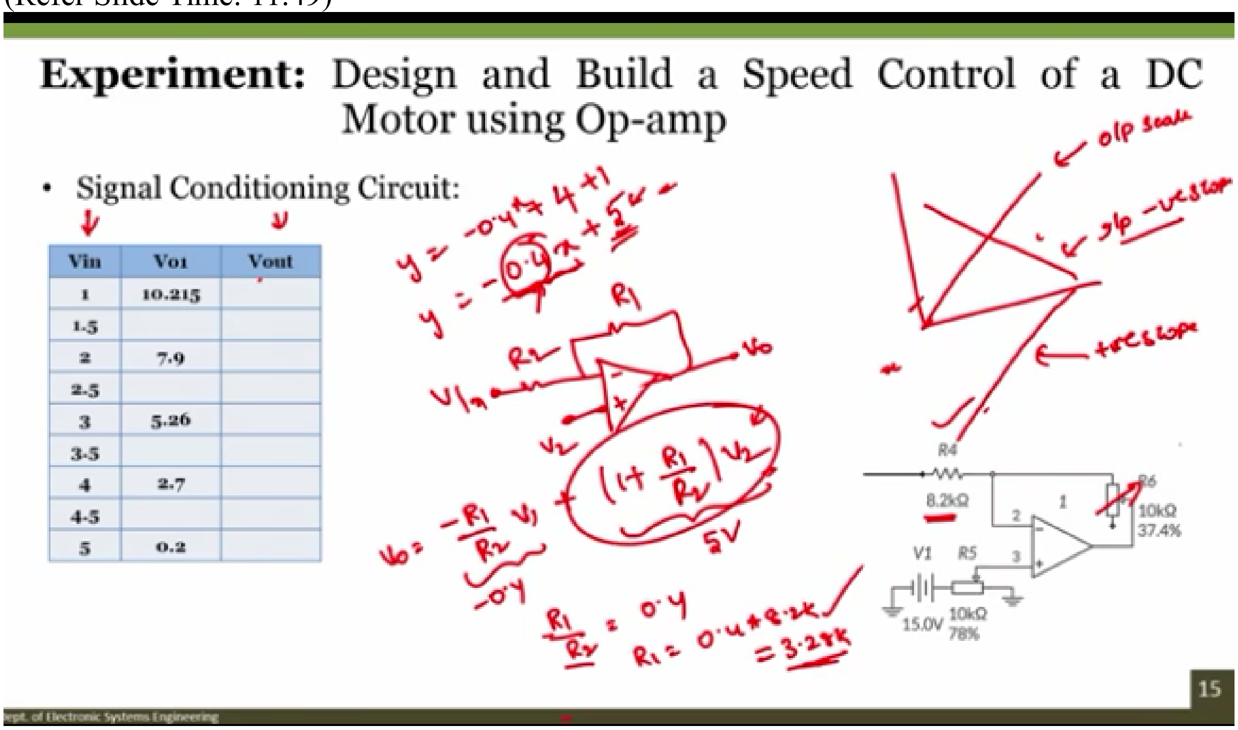

Right, so in this case R1 and R2 are fixed right now for us, so R1 and R2 should be 0.4, so that means 1 + 0.4 x V2 should be 5 volts, so that means that V2 should be 5 divided by 1.4, so 5 divided by 1.4 which means that 3.57, so if I can provide with 3.57 volt at V2 point, right, we can get output voltage of V naught, so that means when the input is 1 volt we also get output as 1 volt, provided the input should be connected to the motor, at the set point, at encoder to the motor, right, so but getting 3.57 exactly will be very difficult and these are the ideal values, practically there will be slight you know offset and gains has, there will be a slight variation in the offset as well as gain that we set here, right, so in order to you know make it realistic what we have considered is that, we have considered the input voltage of 15 because all the op-amps are powered to 15 it is very easy to take it, otherwise again we have to take another voltage source which should properly match with that.

And instead of providing directly 3.57, the 15 is connected to a potential divider circuit, so something like this, this is 15 volts we are doing, so this complete set, so in this case R5, R5A, R5B,

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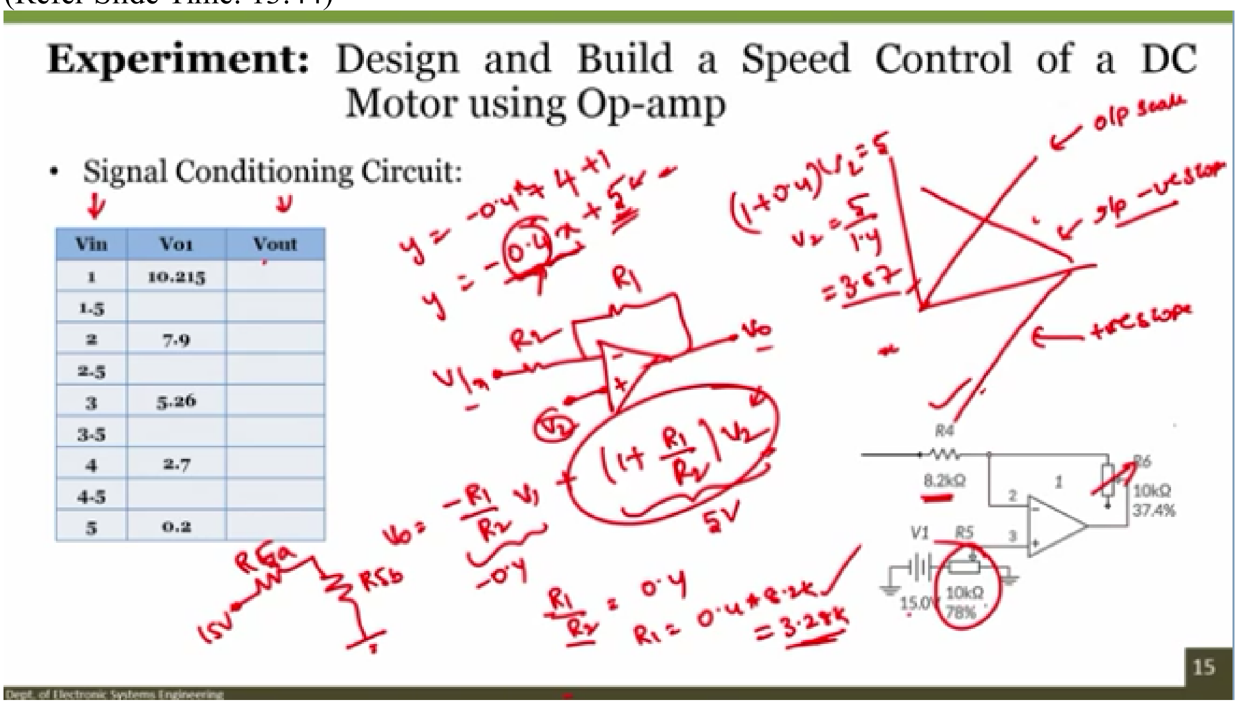

the addition of R5A and R5B is nothing but 10 kilo ohms, and since it is a port we are considering at this point, so by properly changing the position of our wiper we can get output voltage of 3.57, if I can achieve the 3.57 and connect it at this point, at the positive terminal of our operational amplifier then our problem is solved, so this is what we are doing it here, so why don't we try it?

So we'll open a multisim now, so what I will do is that, I'll create a circuit in a new file, so I will take op-amp, let me flip it, then I will take a potentiometer, so as we have already seen the offset is providing by using this potentiometer, I will connect the wiper of the potentiometer to this terminal, and the supply that we are using is 15 volts, so I will take a voltage source of 15, connected to this point, whereas other terminal should be always grounded, right.

Then the input voltage we have designed it for 8.2K, right, then this particular input voltage which right now we assume it as this input voltage we are getting it from the output of integrator, right, so which will be varied from 10 point something to the value, then the feedback resistance is also another potentiometer, the purpose of this, we are using the potentiometer because any variation we can easily wear, we can easily, if you want to change it gain we can easily change it if you have a potentiometer, right.
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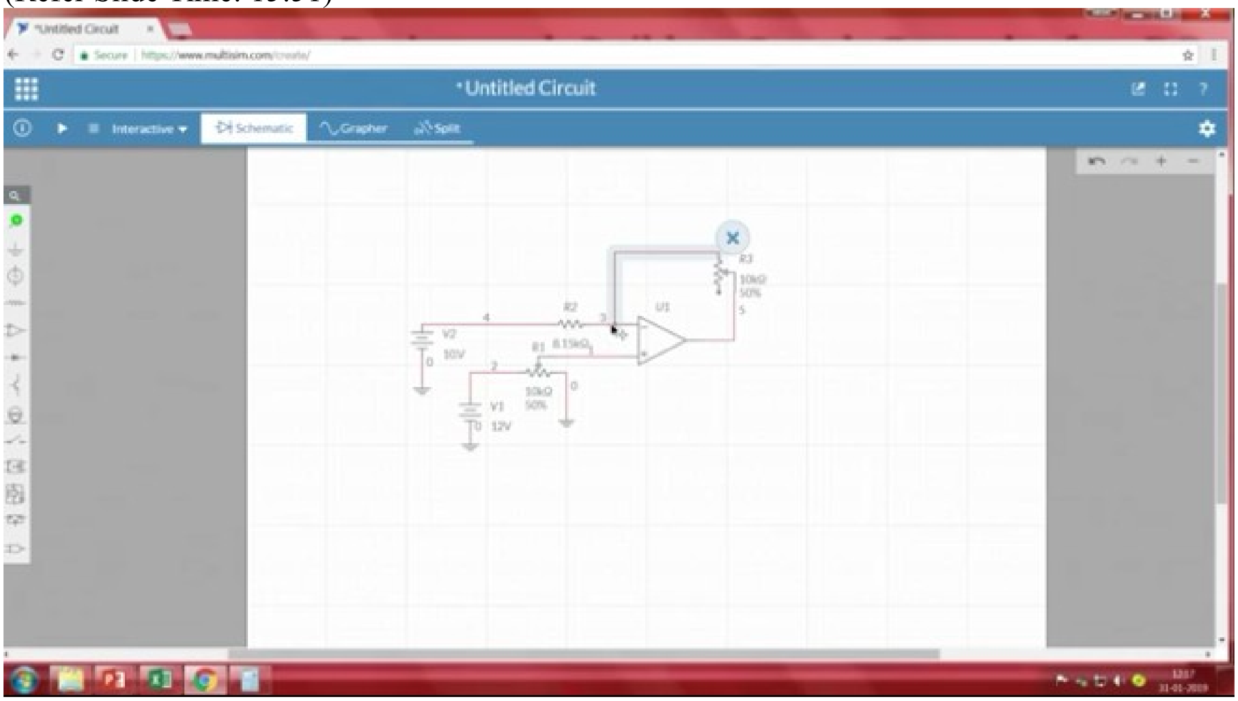

Now the circuit is ready, but only thing is that we have to take a values, 8.2, 10K, and another 10K, so 10K and 10K, now let me check what is the output voltage we are getting at this point? So what I will do is that, I'll connect one probe here, I'll connect one more probe here, so for time being now I'm applying input voltage,
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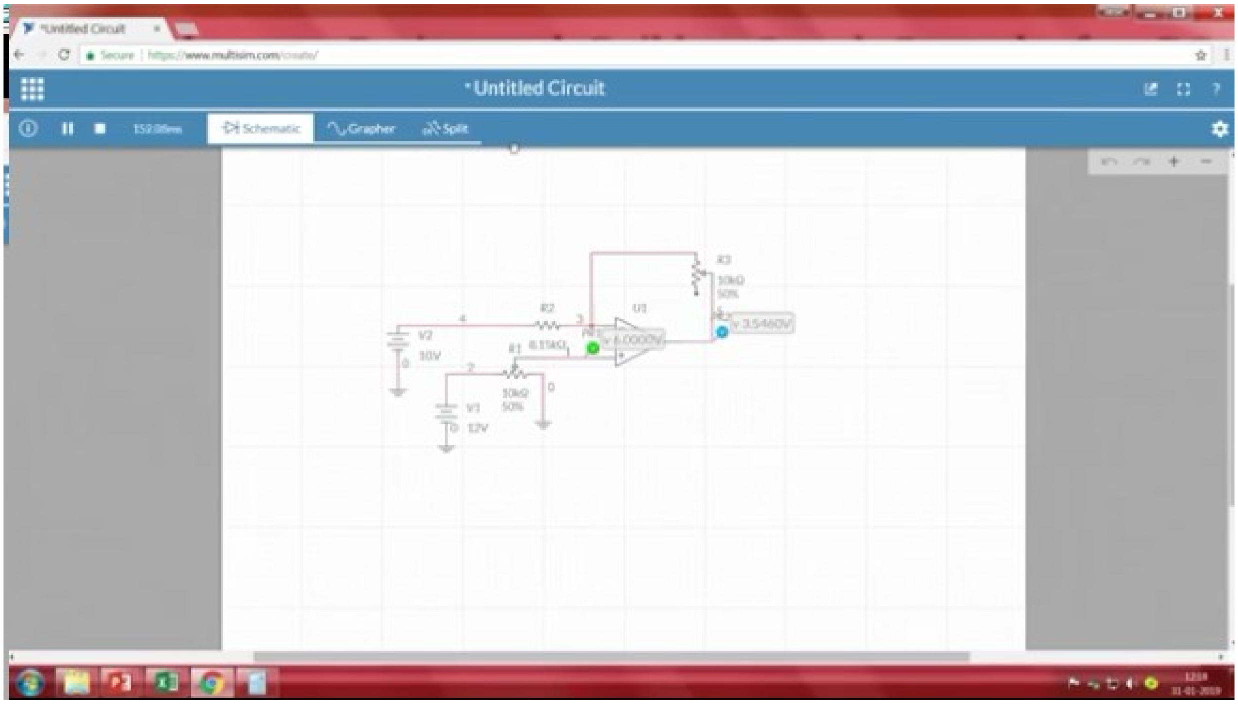

so we need this to be 3.7, this should be 15 that is another problem, of course we can also provide with 12 volts too, let me try for once again, we need 3.57, so I will change it to 3.6, okay, so for 10.215 I should get somewhere around 1 volt, approximately 93, so let me change this value, yeah, so we got 1 volt.

Then the second set should be somewhere around the value is 7.9, so I will change it to 7.9, we should get 2 volts, let me try, yeah, we are getting 1.911 almost close to 2. Then I will go with another set which is 2.7 volts, I should get somewhere around 4, we are getting 3.95 which is also close enough.

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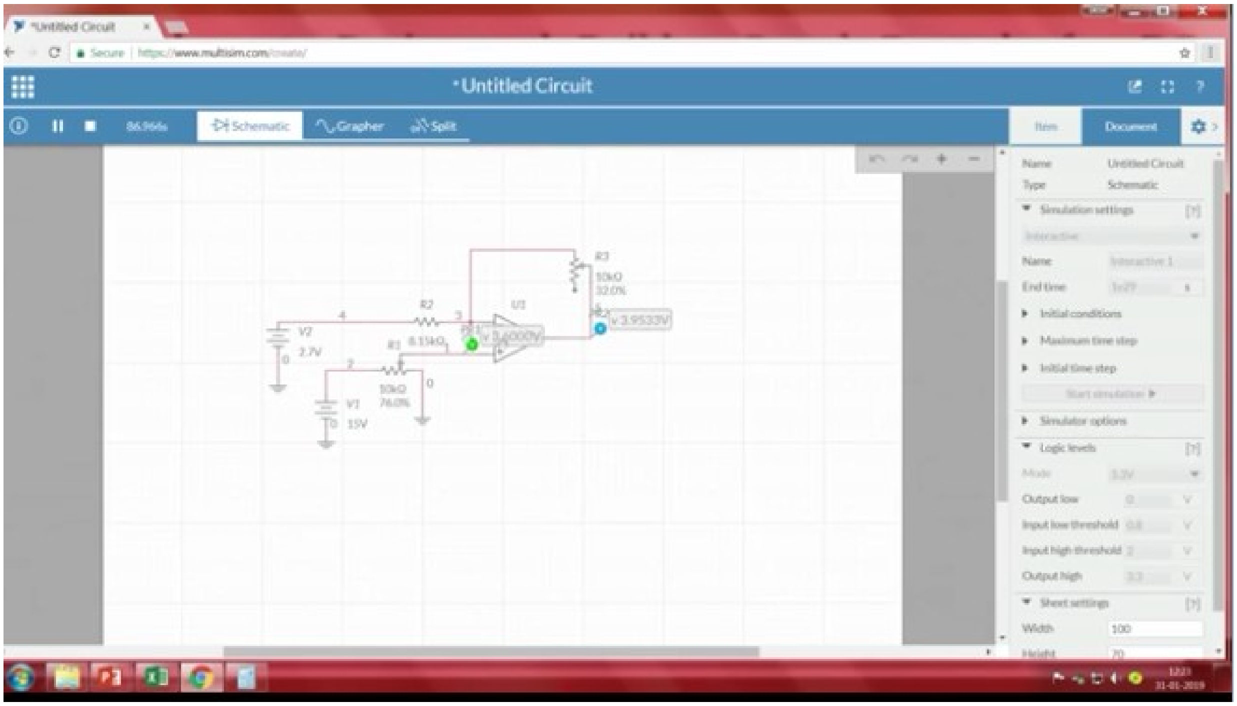

Then other values 200 milli we should get 5, so which are also coming very close to 5 volts, but there will be always a difference between your theoretical and ideal again, right, so because of that reason we have given the feedback resistance as well as this resistance, instead of direct resistance we have taken it as variable resistor so that in order to properly tune your output signal, but no matter what if you follow this particular the idea, we can easily convert our linear, the negative slope signal into a positive slope signal with a simple single operational amplifier, right.

Now we understood that with input voltage of 10.25 after passing through this signal conditioning circuit that we have designed we are getting 1 volt, whereas for 2 volts we are getting 1.9 volt somewhere around 2.7 we got 3.9 and whereas for 5 volts we got 4.93, right, so which is very close,

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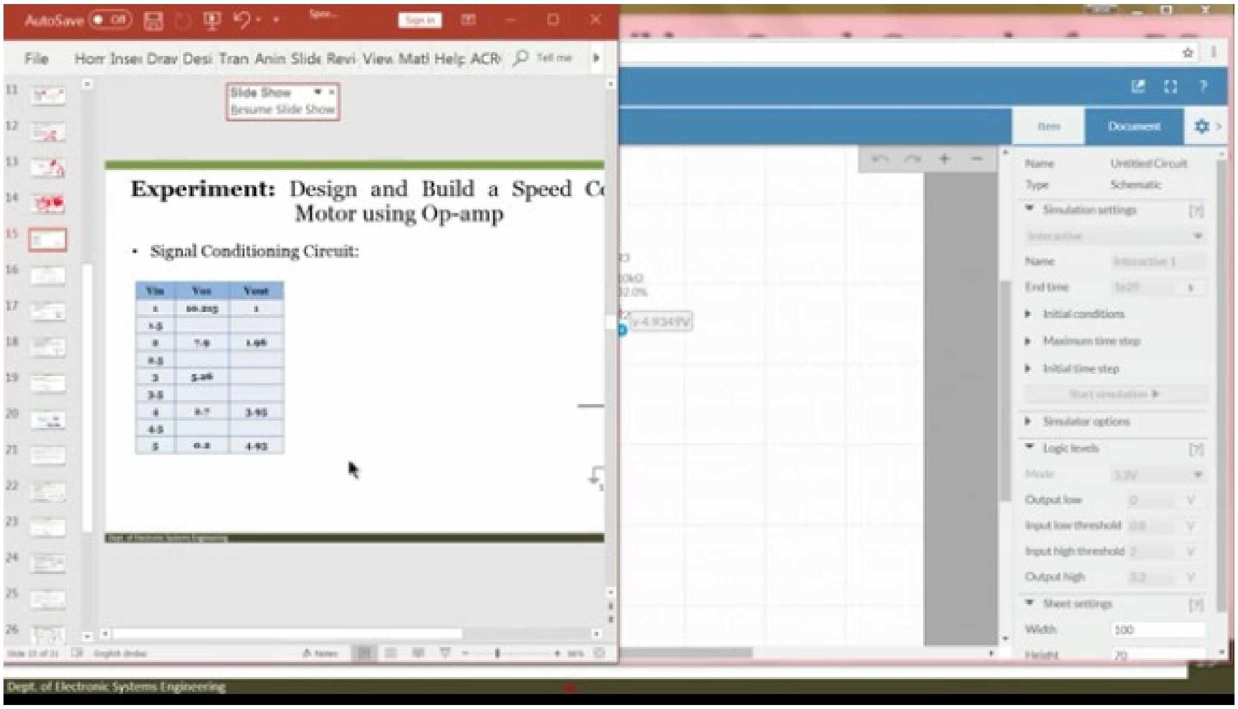

but we have not tried for that, but okay, so now from this it is clear that whatever we apply, whatever we required from the signal conditioning circuit are almost same, right, so that means that when we look into our closed loop control system,

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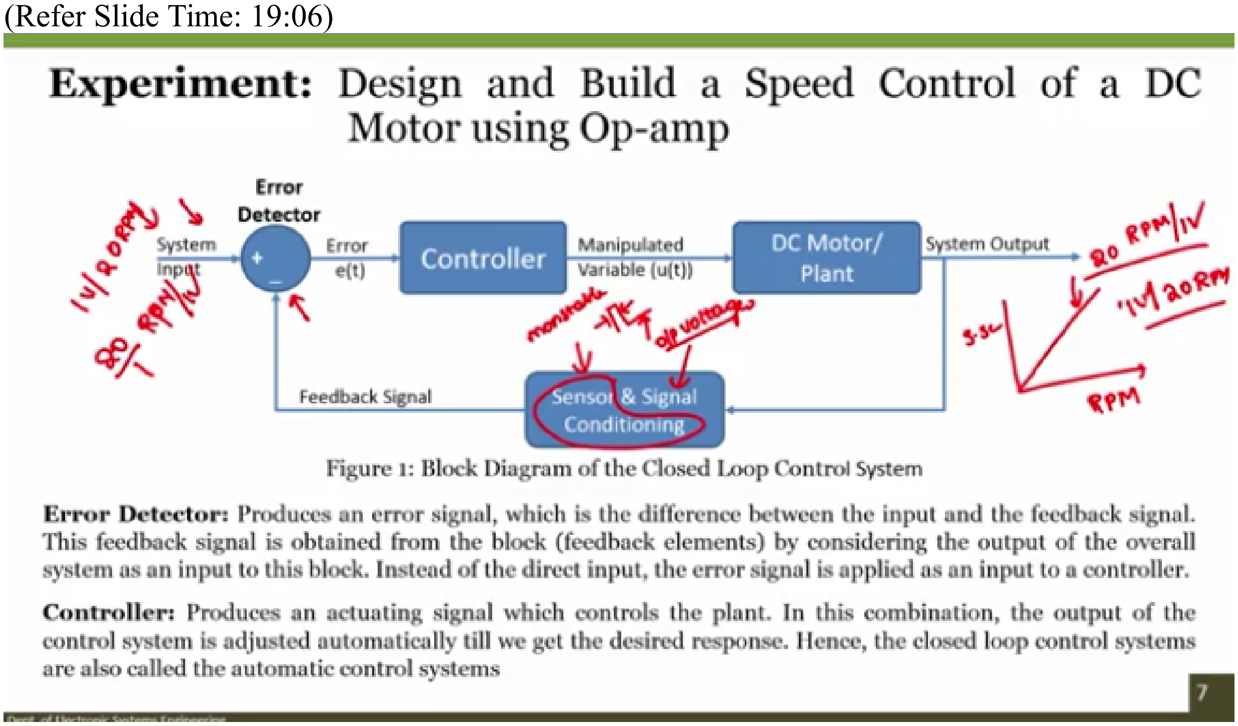

now we made the sensor signal conditioning output that means the sensor + signal conditioning output which is nothing but a feedback signal is having the same mapping factors as input, now our problem is solved, all the blocks are done, we have looked into the error detector, we have also looked into driver circuit for the DC motor which to make run even from the output from controller, by using you know operational amplifier as well as transistor, then we have also seen the characteristics of our motor, right, and we have also seen the characteristics of our DC encoder, since the encoder signal is providing me the digital pulses we require an linearly output varying signal based upon the change in the RPM of motor with respect to the change in the input voltage of to the motor, we also understood that in order to do that we have to design a signal conditioning circuit and we have done first part of a signal conditioning circuit to make it a linearly output by using integrator as well as monostable multivibrator, but the slopes are not matching with respect to the input slope, then we have also designed the second set of signal conditioning circuit to the sensor so that now the output of the complete circuit is mapping with respect to the input.

The next module we will see interfacing the output of a DC motor to sensor signal conditioning circuit and we will see whether we are getting the same linearly varying output signal or not, then after that we will design a controller, we will discuss about the controller, then we will, we will understand about the controller parameters, once we complete our explanation about that we'll interface each and everything, then we will discuss about it, till then take care.