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NPTEL ONLINE CERTIFICATION COURSE

Electronic Modules for Industrial Applications using Op-Amps

Module 7

Lecture-37

With

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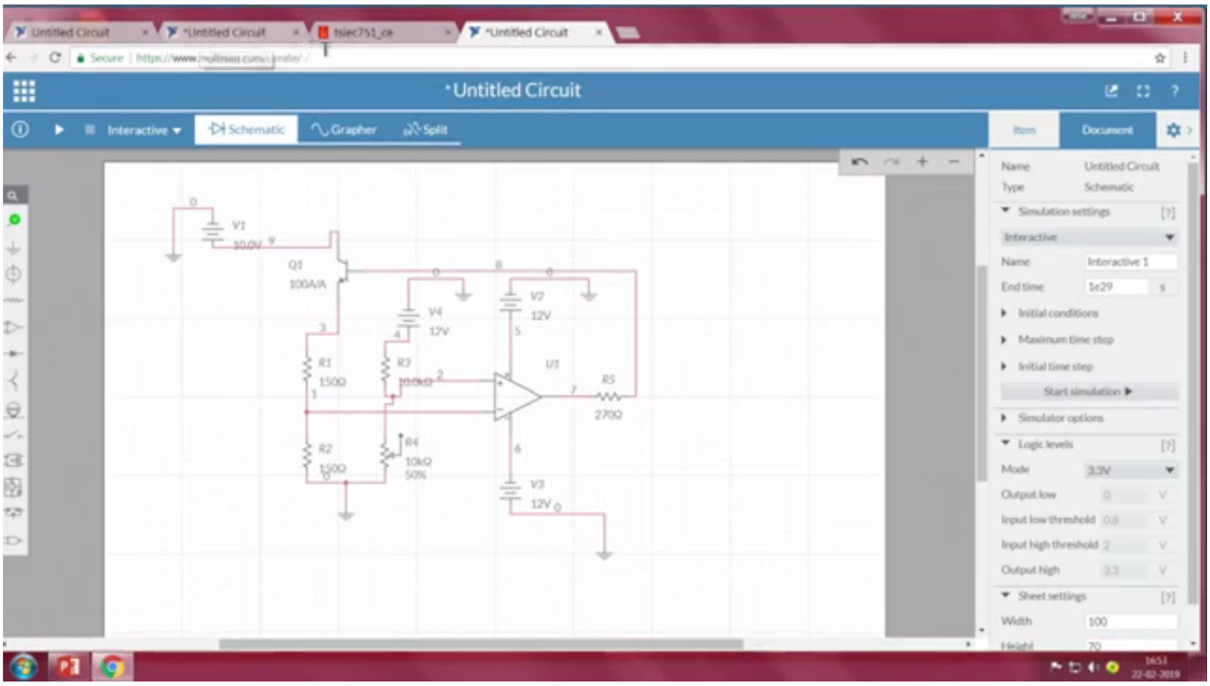
Hello everyone! Welcome to the next module. Today, let's see how do we simulate using multi-sim, the hotwire and the momentum.



Getting to the details about the simulation; so initially let's construct the bridge circuit. So I'll take the four arms of the bridge and then the change the resistance, let's take one 150 ohm here, and then the same thing here. Let's assume we have the platinum resistor here which is the other arm of the bridge and here, one this end, if I have mentioned in the previous module, we need a higher resistance on the other arm of the bridge.

So let's assume we take 1k on or we can even choose a 5k resistance. So it's okay to choose a higher resistance on the other arm of the bridge, assuming 10k would be sufficient. So this is the resistance that I've chosen on the other arm of the bridge.

Now that we have the four arms of the bridge, let's connect it to the source. So here we have the source. Let's give a source voltage of 10v and then connecting. So let's establish connections to all parts of the bridge. Now let's consider the amplifier circuit here and then establish connections from each of this branch to the bridge circuit, so the other terminal goes to the other arm of the bridge and we have to connect the supply to the amplifier.

So as we can choose from this source, let's choose a voltage source here and then since I need the positive terminal, what I do here is rotate and then establish a connection between the positive terminal to the source. On a similar basis, I choose the other source and then connect it to the amplifier.

And here, the negative terminal goes to your other end of the amplifier. So here, it is 12v that should be fine for us to drive the op-amp and then let's connect a base resistor here. Let's change the value of this base resistor and let's keep it to around 270 ohm. And then having a connection between the base resistor and the output of your amplifier.

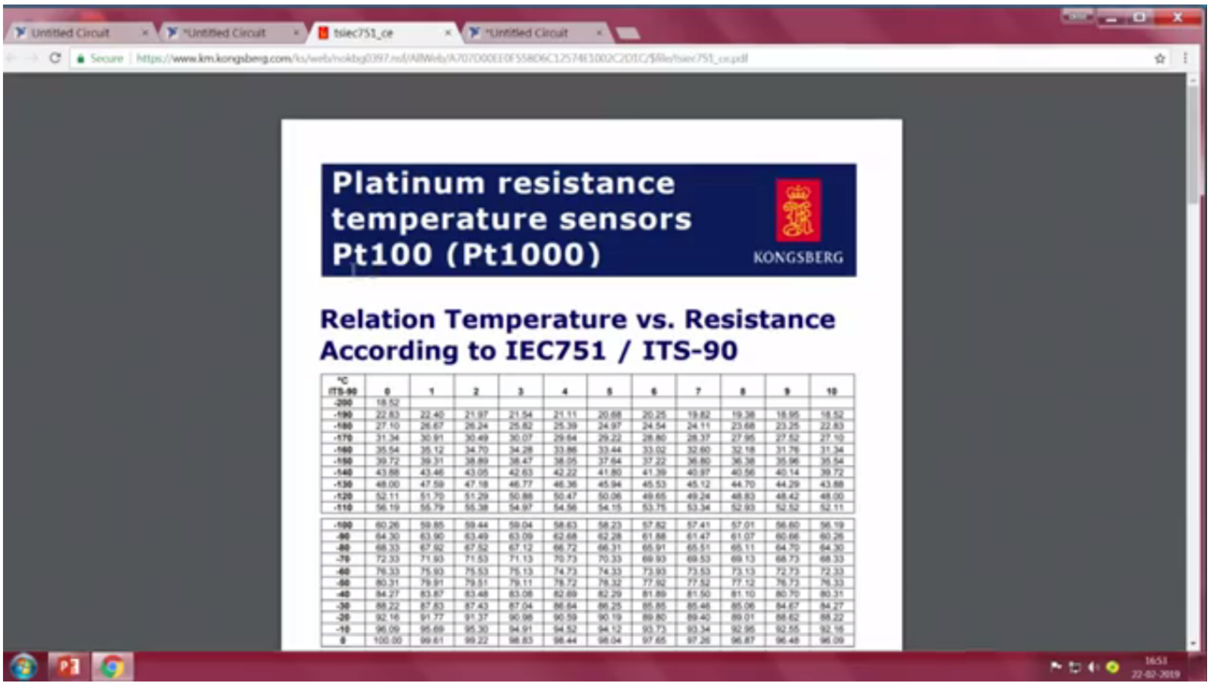
So the output of the op-amp goes to your transistor. So let's choose the N-P-N type transistor here that goes from the output of your amplifier and feeding the output of the amplifier to the transistor. So let's get the source here and then the transistor somewhere here. Let's establish this connection here and then let's connect the source voltage to your transistor, and the other end goes to the ground.

So we'll choose the ground icon here and then establish a connection between the other end of the source to the ground. So we have a 10v DC source here going as an output to that transistor and from the transistor to the bridge circuit and this has to be grounded here, the base circuit and the two terminals of the bridge to the amplifier, and then output of the amplifier driving the transistor.

Here, let me choose a variable resistor instead of a standard 10 kilo ohm resistor. Here, I choose the watt so that I can manipulate and explain to you how the parameters across the bridge can be changed and how it effects the entire setup and how feedback mechanism can be achieved using this circuit.

So here we have connected the two sources of the amplifier, but we haven't connected the ground. So make the ground connection to the two sources. So this basically sums up the entire process of building the anemometer circuitry. So we have the four arms, the Wheatstone's bridge circuit which has given as an input to the amplifier which drives the transistor here and then we have the source voltage. This forms a basic circuit for the anemometer.

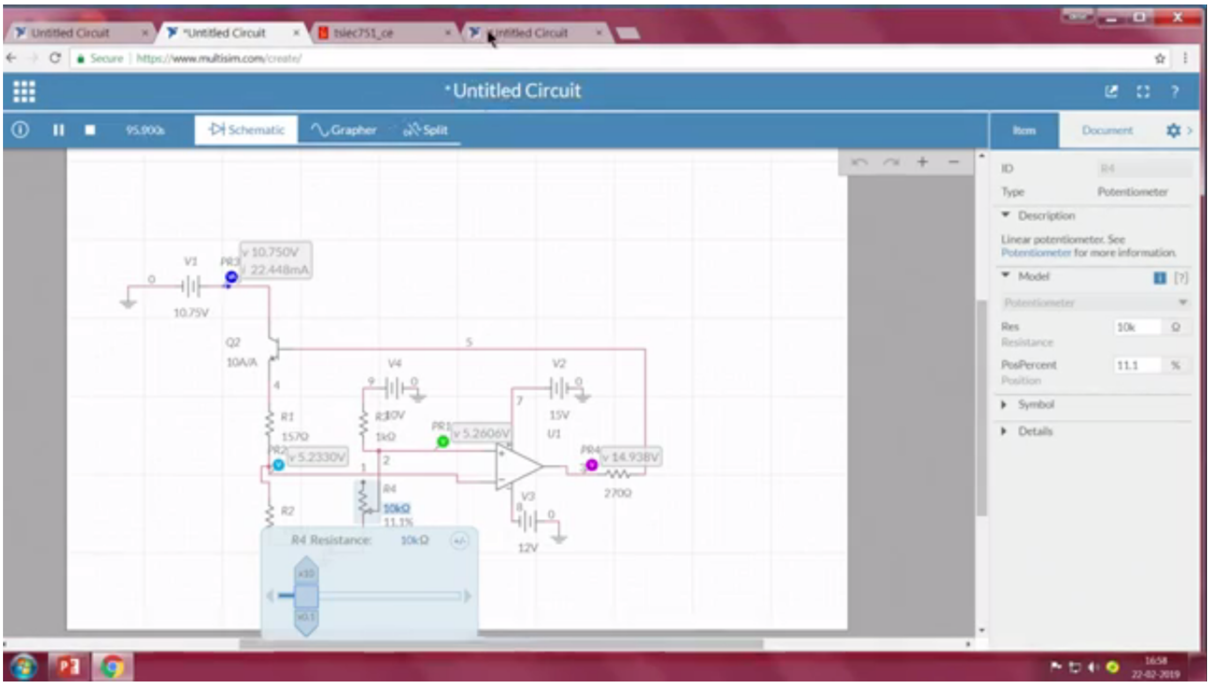
Now let's consider the case study.



Assume, I have already mentioned you to have a look at the temperature conversion table. So this, if you check, assume we are using a Pt100, the heater here and this is the table. I am sure you can google this and then find out the conversion table. So for each temperature here, for each temperature and resistance relationship is what basically the entire table would tell you and here, this is the different grid. Like you say, it is more like a quality parameter, the quality factor index where assume for -90℃, if you buy a grade 0 then this is the temperature what you get and if you buy a grade 1, then there is a difference, a minute change in degree based on your standard.

Now let’s assume we have room temperature which is 30℃. Assuming this is a room temperature at 30 degrees. So what is the resistance at 30℃? Pt100 can offer here is 111.67 but since I am using a Pt1000 in the arm, the compensation circuit correspondingly what is mentioned here I can just multiply it by 10.

Assuming at 30℃ if the resistance offered is 111.67.



So assuming I am building up this circuit and the current temperature of my room is 30℃. So what is it that I am supposed to set the compensatory circuit at 11.1. As you can see, this is set at -- since this is a variable resistor and then I’ve used a 10k I’ve set it at 11.1%.

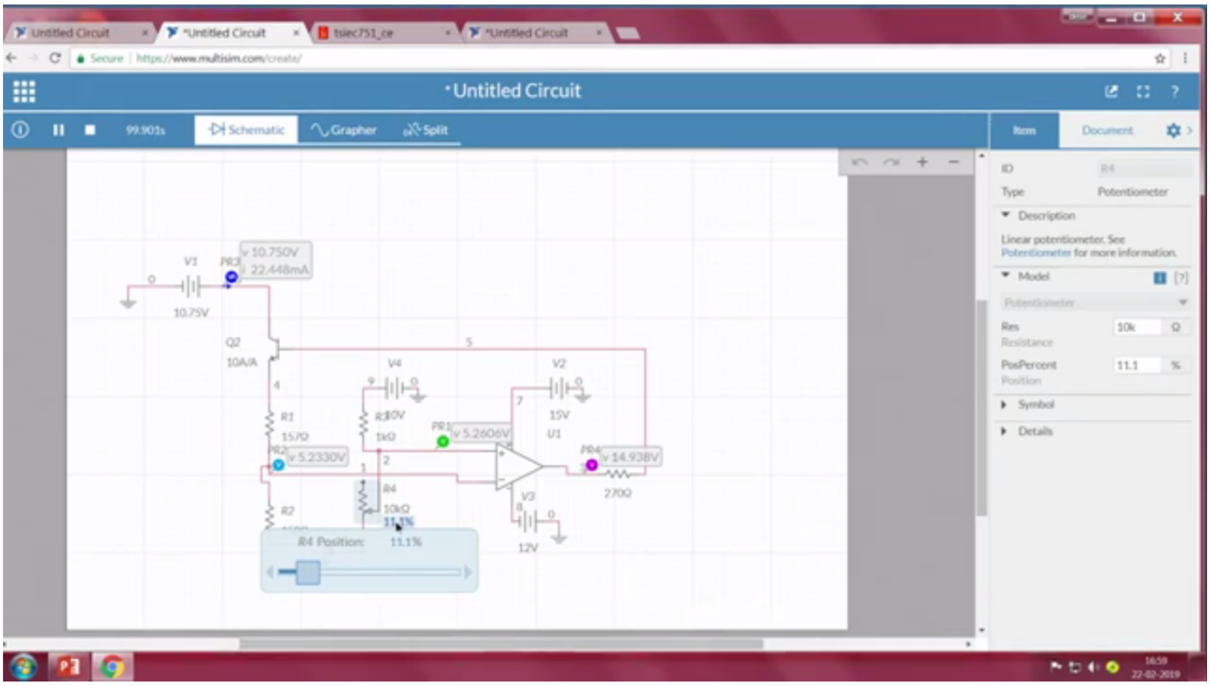
So essentially it is going to give me that resistance, 11% of 10k is what I am connecting my compensator circuit here at. Now I am driving the voltage. Now what is it at 30℃? You want this resistance. We are talking about a constant temperature circuit. So you want your device here to be maintained always at 150℃ that means the resistance should always be maintained at 150 ohm irrespective of the change in room temperature.

It could be an increase in temperature of room, the room temperature could go as high as 40℃, or it could go as low as 10℃. However, this part of your bridge should always maintain a constant temperature. How does that happen? You can maintain the constant temperature at 150 only when you are able to control the resistance of this bridge.

Now how are you able to control the resistance of this bridge because of the feedback mechanism what we have here. Now, the case study 1 here, I am talking about room temperature 30℃ and I have set the compensatory circuit accordingly. Now what happens? So these are a few voltage and current. You can always monitor at different points of your circuit what is the voltage and current that is being driven throughout your circuit.

Now this is, like you can see, this is 5v. Now it is ideally if you assume 5.2 and 5.2, the bridge is almost balanced. Assuming now my room temperature is increasing from 30℃, it rises to 50℃. So what happens? My compensatory circuit has to be – let's assume, now keep a note on the amount of voltage and current here.so here, the current that is currently being driven through the circuit is 22 milliamps and you can see here, 157 ohm because like I mentioned you in the conversion table, ideally at 0℃, it has to be 100.

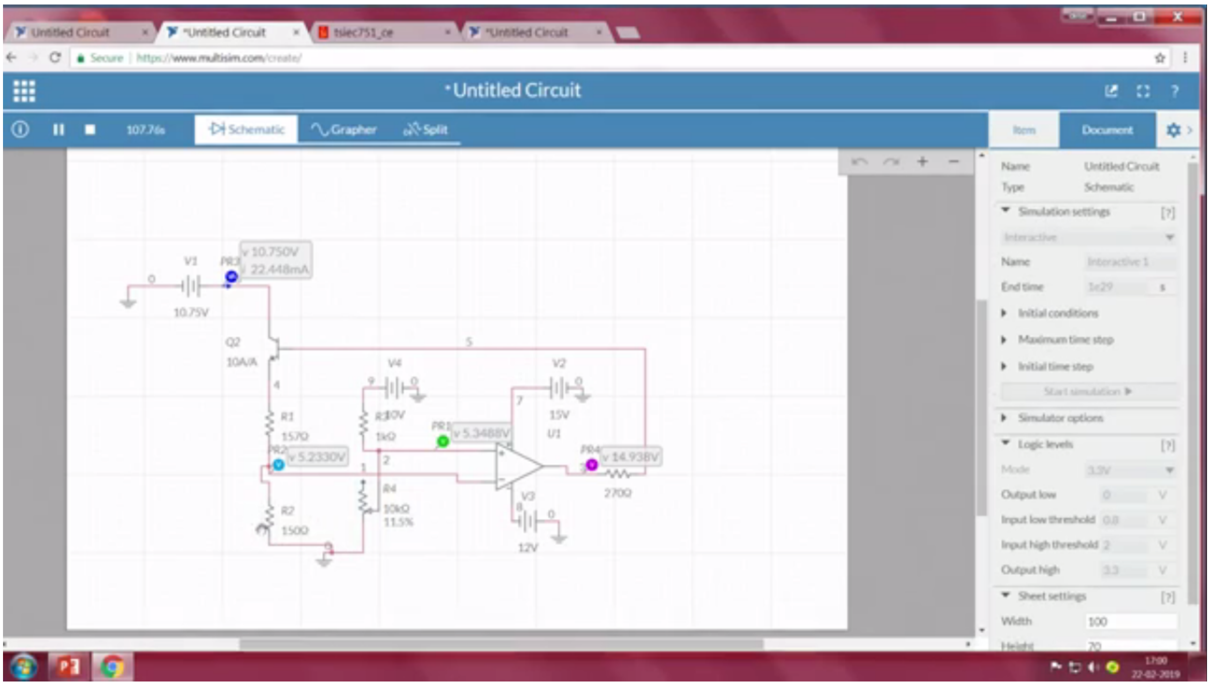
And what happens? When the temperature increases so there's different gradation and hence, we've considered this resistance here.



Now assume, I am going to change the compensatory circuit here assuming the room temperature is increased to 50℃. So what does my table here tell? At 150℃, it is around 157.33. Now how do I simulate that condition here?

I am going to change this resistance to 157. So that becomes 15%. Say, this is the room temperature which has risen from 30 to 50℃. So what happens can you see? There is a large variation in voltage. This was ideally 5.2, but what happens here, there is a drop in voltage and what happens when I simulate. There is a significant drop in voltage.

So this is at 6v and this is at 5v. Now this is your voltage and current. Setting back the room temperature to 30℃ assuming this is my room temperature. Now there is a less difference in voltage, and this is the current.



Now let's say, case 2, when air flow is happening through this device of mine. So this is the 150 ohm resistor R2 and then air flows across this. What happens when air flows through resistance? Ideally, the temperature should drop and what happens when the temperature drops, the resistance drop.

So I want to simulate that condition. What happens, let me reduce this resistance. Assuming I am flowing air at some meter per second velocity and what happens with air flow; my resistance significantly drops. Kindly look into the parameters.

Now the resistance is dropping and there is a 10 ohm difference, and what happens, there is a drop in voltage. Now what I want you to look at is what is happening to the current. What should happen? As the resistance keeps dropping, your feedback circuit should work in such a way that it will inflow current so that self-heating happens through the resistor and it regains its normal temperature that is it should come back to resistance so that the temperature is maintained at 157.

Now what happens, assuming there is a lot of airflow and your resistance is dropping. So now keep at 130 ohm load, what is the current, it is 24 milliampere. Assuming there is an increase in airflow, so there is a drop in resistance because there is a drop in temperature and the current has increased from 24 to 25 milliampere.

As you can see, there is a 1 milliampere increase for every change 10 ohm of resistance what I am changing. So from 150 ohm we have come down to 110. So there is 40 ohm difference and what happens. You see, the current, the feedback circuit is pushing more current through this part so that the self-heating happens and it regains with the increase in current which is pushed through this, it regains the temperature.

So this is the intention behind having rigging up this circuit and you always want your load to be working at constant temperatures and you see how the difference between the two voltage is always being adjusted by the amplifier here and fed back to your circuit.

So this was the brief introduction about how you can simulate an anemometer; the four arms of the bridge which are fed to the op-amp and then trigger transistor. As your flow assuming this is an ideal condition, we have a used a compensatory circuit at 30℃ and the relative resistance I've chosen accordingly assuming there is some amount of airflow. Because of airflow there is a change in the heat flux that is the amount of temperature across the resistor drops, there is a change in resistance and accordingly you have the drop and then the feedback mechanism works, drives additional current, self-heating happens, and the circuit regains its balance.

So there is some amount of time the feedback circuit takes to bring back the resistance back to the desired condition so that the temperature across this arm is maintained constant. So this was about the simulation and how to rig up. Let's see, how in real-time scenario we can have the anemometer circuit.

Let's blow in different temperature air across your load and see how the temperature varies and how your feedback mechanism maintains the temperature around your desired arm at a constant rate.

So this was the simulation part for today. Thank you.