Op-Amp Practical Applications: Design, Simulation and Implementation
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Lecture – 16
Op-amp as Hartley Oscillator

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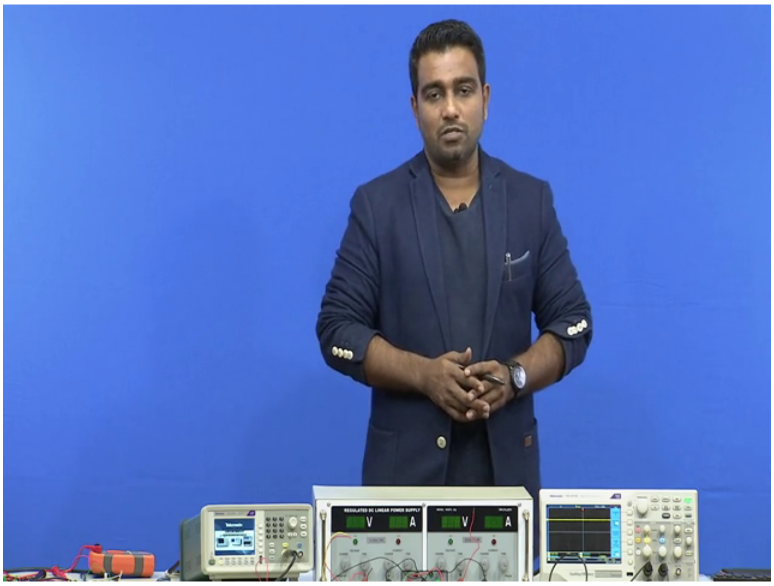

Welcome to this particular module and here we will look at one more type of oscillator which is your LC oscillators alright. So, this is also called tank oscillators and we have seen until now RC oscillator or phase shift oscillator. We have also seen the Wein Bridge Oscillator. Now, it is time for us to understand what are L and C oscillators; L when I say, it is inductor; C when I say, it is capacitor. So, there are 2 reactance reactive components in the RC oscillator and of course, to sustain the oscillation to sustain the oscillation, we have to use amplifier we have to use an amplifier.

So, when we talk about an amplifier, then what we see? We can change the gain; we can change the gain of the amplifier. So, here to make it little bit different, then our previous experimental modules right that we have seen. This time we will see how we can use a multisim to implement this RC or to implement this LC oscillators.

And we will see that how we can design the LC oscillators in multisim and how we can see the change in oscillation without actually using the DC power supply or without using the oscilloscope alright. It is kind of simulation that is right is a simulation. So, but the point is that if you do not have you do not have, this equipment with you can also do the you can you can use multisim at home at home and try to design this circuit and see the output right.

So, it will be a good exercise and we will when the time will come I will ask Seetharam to come here and show us how the multisim can be used. And when he is op when he is using the multisim, I will also help and tell you how the frequency is generated and how the oscillations are generated in that particular tool alright. So, coming back to the LC oscillators, the one thing that you need to understand is the Lenz's law is Lenz's z is nothing but Z you can say Z we can say Z e.

So, Lenz's law you have to understand and then you need to understand how capacitor charges and capacitor discharges alright. So, that is extremely basic and I expect that as an a as an undergrad or as an master students or as an PHD student, you already know how the capacitor is working or how the inductor is working alright. If you do not know, please study and now how the capacitor and inductor works; then you will understand what is Lenz's law right.

So, to understand the LC oscillators, we will see 2 kind of LC oscillators. In this particular module, we will see the Hartley oscillator and in the next module we will see the Colpitts oscillator. So, what is Hartley oscillator? For understanding Hartley oscillator, first we should understand that the Hartley and Colpitts oscillator, they both work on the principle of using L and C. There is charging and discharging of capacitor inductor happens and because of which the oscillations will start generating. And when it charging discharging of capacitor and the inductor happens when capacitor charges, there inductor charge discharges; inductor charges, there capacitor discharges, then the loss of energy loss of energy. And that is why at the output of the Hartley oscillator or Colpitts oscillator or LC oscillator in general, the waveforms will start damping it will go down it will go down. And that is why to sustain the oscillation to sustain the oscillation, we have to use an amplifier alright. These we already have discussed in the theory.

Now, let us see quickly what we have discussed and then we will implement this on multisim.

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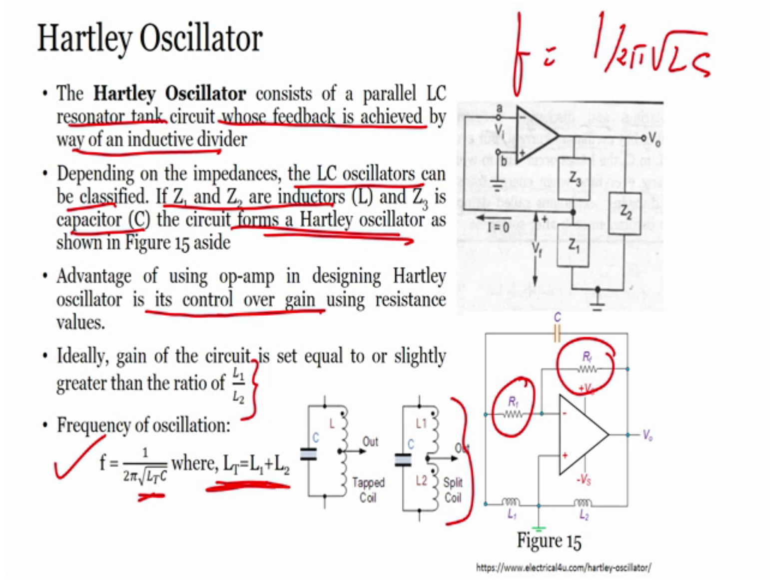

So, if you see the screen, what we are looking at? We are looking at Hartley oscillator we are looking at a Hartley oscillator and its nothing, but consists of a parallel LC resonator tank circuit whose feedback is achieved by way of inductive divider we way of inductive divider. So, this is a representative circuit where you can see that the feedback circuit is given by Z 1, Z 2, Z 3. In case of Hartley oscillator, we will find that Z 1 and Z 2 will be L and Z 3 will be C or you can say Z 1 Z 3 are L and Z 2 is C. So that means that we have 2 inductors and 1 capacitor. If I actually draw a circuit you can see here as inductor 1, inductor 2 capacitor and then this feedback register can be used to change the gain; I mean used to change the gain.

Now depending on the impedances LC oscillators can be classified. If Z 1 and Z 2 are inductors and Z 3 is capacitor, the circuit forms an Hartley oscillator which is shown here in figure number 15 in figure number 15 alright. Advantage of using op-amp in designing RC oscillator is to control over gain using resistance values. We already know there is op-amp if we use, then we can have the change in the gain with the help of the resistor values. So, ideally the gain of the circuit is said equal to or slightly greater than L 1 by L 2 ok. You said you remember that the ideally the gain of this particular oscillator is said equal to or slightly greater than L 1 by L 2. And we have seen the frequency formula is nothing, but f equals to 1 by 2 pi f equals to 1 by 2 pi right under root of LC under root of LC. Here we have L T we are giving which is equal to L 1 plus L 2, if it is going here L 1 plus L 2 alright.

So, if I want to actually design this oscillator, how can I design this oscillator right?.

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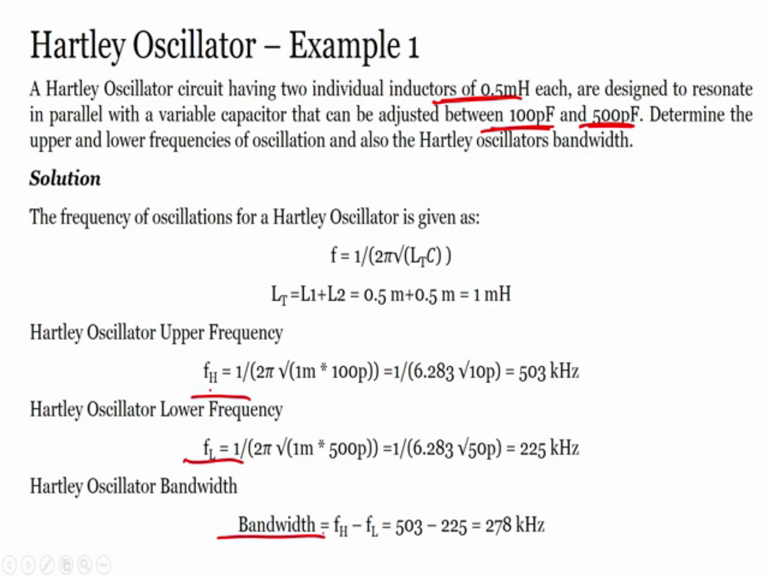

And let us see let us see a question, let us see an example that if I want to design oscillator, what can how can I design?

So, that problem statement is that a Hartley oscillator circuit has 2 individual inductors; 0.1 0.5 mille Henry and are designed to resonate in parallel with a variable capacitor that can be adjusted between 100 picofarad and 500 picofarad means we can have C equals to 100 picofarad minimum and we have maximum 500 picofarad. We have inductors 0.5 mille Henry right, determine the upper and lower frequencies of oscillations and also the Hartley oscillator bandwidth. We have to find f H; we have to find f minimum or f L f minimum or lower. So, f L and we have to find the bandwidth, this three things we have to find alright.

Now we already know what is formula for frequency? For the Hartley oscillator if the formula of the frequency is f equals to 1 upon 2 pi under root of LC. What is L? L T equals to L 1 plus L 2 we have already seen in the previous slide. So, we have to add 0.5 plus 0.5 this will be a 1 milli Henry. Now we have value of L T. Now we have to consider the capacitor C right. So, for 100 picofarad I have f H equals to 503 kilo hertz right. For 100 picofarad, if I use upper frequency, there I have f H equals to as you can see this value. We have seen this example previously also right why we are using capacitor of lower value when we have to measure upper frequency. When you want as a lower frequency, I will use a capacitor of higher value to maximum value which is my 500 picofarad.

So, for the f H, I will have 500 and 3 kilo hertz, for f L I will find it above 225 kilo hertz. Now if I know what is f H if I know what is f L my bandwidth is nothing, but f H minus f L my bandwidth is nothing, but f H minus f L. So, 503 kilo hertz minus 225 kilo hertz will give me 275kilo hertz.

So, an easy problem in front of you, easy example that is given the solution is super simple. So, you should be able to do it at home right without any without any problem without any problem ok. So, this is the case, when we have using an Hartley oscillator with inductors value given capacitors value given right and we have to find the f H we have to find f H we have to find f L when we draw bandwidth. But what if we have a different kind of problem?

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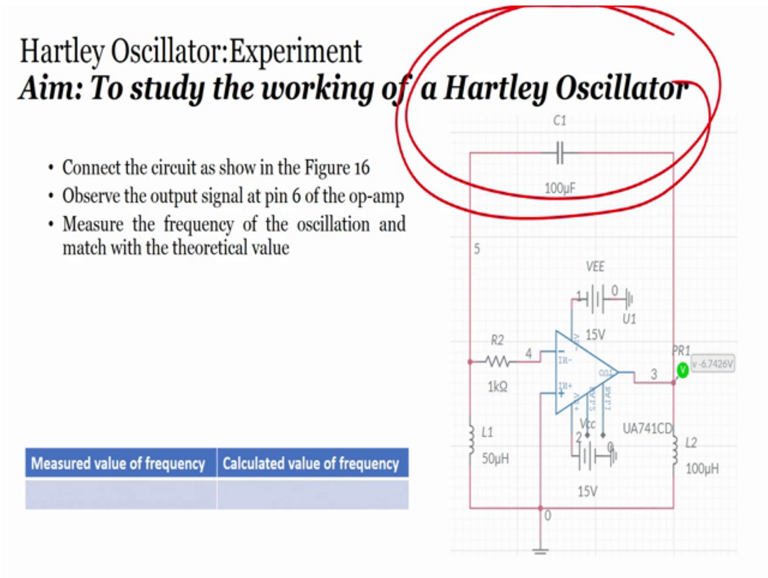

Then in this particular case which is your experiment right, how we can how we can design this particular oscillator? How can design with this particular oscillator? Again you can see the same circuit is there same circuit is there and here we can connect the circuit as shown in figure. The same circuit we can design in multi sim like I said right. We had to observe the output signal at pin number 6, this is a pin number 6 and then measure the frequency of oscillation and match the theoretical value alright; match the frequency and measure with the theoretical value.

So, let us see how we can use the multisim to find out the Hartley oscillator to find the Hartley oscillator alright. So, I will I will ask Seetharam to show us on multisim, how we can design the RC oscillator.

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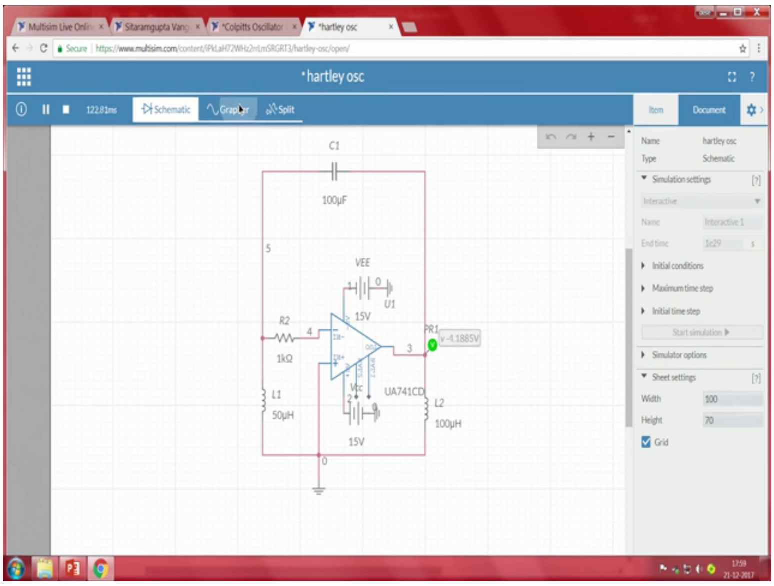

So, if you see here, if you see here we have this schematic diagram right which is similar to what you have seen in the slide. And here we can see again we have 2 inductors, we have 2 inductors R 1 L 1 and L 2. We can we can see on the screen, there are 2 inductors L 1 and L 2 right and we have a one capacitor which is C 1. So, the values are 50 Henry, 50 micro Henry, 100 micro Henry and the capacitor is 100 micro farad. So, if we have this values and if I have R 2 equals to 1 kilo ohm, in this particular condition right what kind of wave forms I can generate? What kind of waveforms I can generate?

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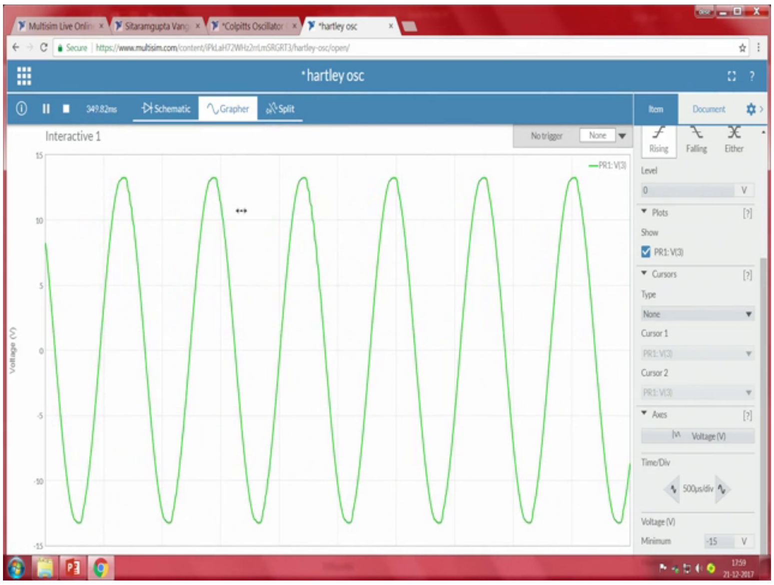

So, you will see here the output voltage. You will see here the oscillations in the at the output of the Hartley oscillator right and if you if you change the it is it is really sim similar to oscilloscope. You can change the frequency you can change the time per division right by using the knob. And you what right now we are doing, we are increasing the time per division right. So, you can see this; we can decrease the time per division. So, we can see this right. Also we can see simultaneously both the screens when we can see the change the output voltage, you can see the change in the output voltage at the green terminal the green point right. And correspondingly we can also see the change in output voltage in the plot in the plot right.

So, this is the super easy way of using the multisim at your home. It is of free version it is a free version. So, just try it and try to design the circuit try to design all the circuit. In fact, and see whether you can find similar kind of waveforms and the same time you can always go to the laboratory and use the facility in the laboratory to see whether you can have this similar kind of waveforms or not alright.

So, we will we will stop here for this particular module and this how we can quickly design the Hartley oscillator using the multisim alright using the multisim. But, what if I have capacitors what if I have 2 capacitors and I have one inductor? If I have 2 capacitors and if I have one inductor, then it becomes my Colpitts oscillator; it becomes my Colpitts oscillator. So, when I have Colpitts oscillator, then what kind of changes I will get in my in my output or how can I design my Colpitts oscillator? So, that Colpitts oscillator, we will see in the next module. It is again the part of LC oscillator, it is again the LC oscillator, but here the reactance is we are using 2 capacitors and we are using one inductor alright. In the Hartley that we have seen recently right now is we have used 2 inductors and we have seen one capacitor.

So, we will see in the next module how we can design the Colpitts oscillator till then you try to load the multisim is free versions. So, you can just design the circuit design the circuit that we you look in the Youtube or the or the uploaded version of this NPTEL videos and try to see whether you can find this similar kind of waveform which we have seen which we have shown you on this particular screen alright. Till then you read once again right ask me any question if you have a difficulty right try by yourself first and then only you ask. So, I will see you in the next class and we will see how you can design a Colpitts oscillator with the help of again a multisim.

So, now you have you are able to understand that we are we are not only able to design this circuit by using breadboard and the equipment, we can also do a simulation at home using this particular tool right. So, one step up like I said that as we move towards the experiment part and we go towards the end of the experiment parts, you are yours complexity of designing the circuit will slightly increase right. We started from very basic thing which is offset right and we reached to the thing that we are now able to design an oscillator alright. So, I will see you in the next class with an Colpitts oscillator, till then you take care and I will see you in the next class, bye.