Op-Amp Practical Applications: Design, Simulation and Implementation
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Lecture – 17
Op-amp As Colpitts Oscillator

Welcome to this particular module and in this module as I promised we will look at the Colpitts oscillator right. In last module, what we have seen? We have seen the Hartley oscillator. So, when we talk about Colpitts oscillator and when we have to compare a Colpitts with Hartley oscillator, what are the changes what are the changes right in this circuit? So, if you really think about what are the changes, then you will see that it is exactly opposite of Hartley oscillator; that means, wherever the inductors were there, now we are replacing that those inductors by capacitor; wherever the capacitor was there, the Hartley oscillator we are replacing by an inductor. That is why we say it is exactly opposite to the Hartley oscillator right.

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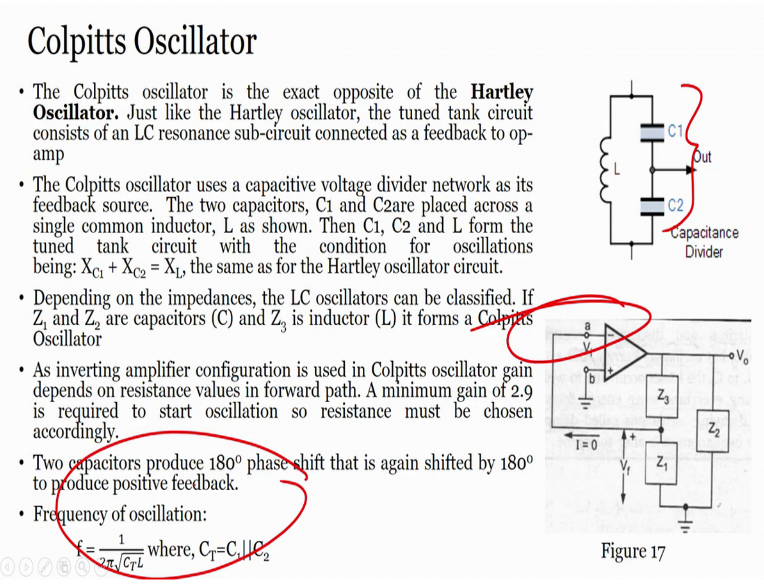

So, now let us see the Colpitts oscillator. If we see the screen and what we see like the first sentence itself says that the Colpitts oscillator is the exact opposite of the Hartley oscillator right. So, just like Hartley oscillator, the tuned tank circuit consists of LCresonance consists of LCresonance sub circuit connected to a feedback of the operational amplifier. So, here you see you have 2 C you have 1 L. You have 2 C you have 1 L. If you see just a what capacitance then this is nothing, but your capacitance divider capacitance divider. You have seen a resistance divider right, you have seen a resistance divider instead of resistance I am using the capacitance. So, it is a kind of capacitance divider right same circuit here equivalence circuit or re representative circuit.

So, here the our Colpitts oscillator uses capacitive voltage divider network right as the feedback source as the feedback source. The Colpitts oscillator uses a capacitive voltage divider network at it is as its feedback source. Now the two capacitors C 1 and C 2 are placed across a single common inductor; are placed across single common inductor as shown in your figure. As shown in this figure, C 1 C 2 and L form the tuned tank circuit with the condition for oscillations being X 1 plus X 2 or X C 1 plus X C 2 equals to X L which is same for the Hartley oscillator as well right that was X L 1 plus X L 2 equals to X C. Here X C 1 plus X C 2 equals to X L.

Now, depending on the impedance the LC oscillators can be classified as Z 1 and Z 2 are capacitors Z 3 is inductor it forms Colpitts oscillator. I have told you earlier also that if I have Z 1 and Z 2 inductors and Z 3 capacitor, then it becomes my Hartley oscillator. If I have Z 1 and Z 2 as capacitors and 3 as inductors, then it forms my Colpitts oscillator forms my Colpitts oscillator right. As an inverting amplifier configuration is used in the Colpitts oscillator gain depends on resistance values in forward path right. Here we know the amplifier is used gain depends on the forward path and minimum gain of 2.9 is required to start oscillation.

So, resistance must be chosen accordingly here the minimum gain is required is 2.9 alright. Now 2 capacitors produce the now if I have 2 capacitors, we will produce a phase shift of 180 degree right. 90 90 180 degree alright that. So, from here what we get is that if I use 1 capacitor, I have phase shift of 90 degree. If I use another capacitor, I have phase shift of 90 degree.

So, I have 2 capacitors, I have phase shift of 180 degree right. This is what we understand alright. So, 2 capacitors produce 180 degree phase shift that is gain shifted by 180 degree to re produce the positive feedback to produce the positive, why? Because we are applying the signal to the inverting amplifier inverting terminal of the op amp; so, inverting terminal of the op amp when we apply the signal, where their output would be

180 degree phase of the output phase would be 180 degree out of phase with respect to the input voltage or input signal.

So, to have we should have 1 more 90 degree gain phase shift and plus 180 degree phase shift is give with the help of 2 capacitors. The frequency formula is kind of similar 1 by 2 pi root of LC where here is C T, then in that one it was L T. So, here C T you can see here. So, we can write C T is C 1 in parallel to C 2 correct; C 1 in parallel to C 2. Thus we now know that here in Colpitts oscillator, the phase shift is given by capacitors and the formula for frequency is nothing, but f equals to 2 pi under root of LC.

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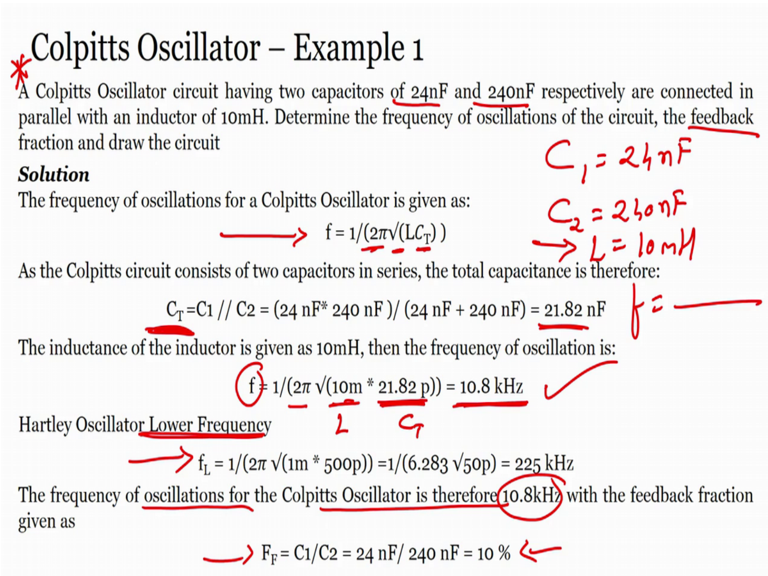

So, if I want to now solve problem if I want to solve a problem right, how can I solve problem for the Colpitts oscillator? So, for a given problem which is right now in front of you in this particular problem. What is the problem? The Colpitts oscillators are circuit having 2 capacitors24 nano farad and 240 nano farad. So, we have capacitors C 1 equals to 24 nano farad, we have capacitance C 2 equals to 240 nano farad right C 1 equals to C 1; we have C 2 respectively.

And are connected in parallel with an inductor; inductor is L equals to 10 mille Henry right, then what we are asked to find? We are asked to find that determine the frequency of oscillation of the circuit feedback fraction and draw the circuit ok. So, we are asked to determine a frequency, we are asked to determine the feedbacks fraction feedback fraction and we are asked to draw the circuit.

So, let us do one by one. Now we already know that when you talk about the Colpitts oscillator the frequency formula is f equals to 1 by 2 pi under root of LC and by C is nothing, but C T. So, here C is C 1 parallel to C 2. So in that case, I can write 24 nano farad into 240 nano farad divided by 24 nano farad plus 240 nano farad, which is equals to 21.82 nano farad right.

So, I can give the value of CT. Now I can place this value of CT here I have the inductor value L given here I know 2 pi from that I can find f. So, f I put the value of inductor, I put the value of CT. The CT this is L, then I get value of frequency 10.8 kilo hertz. Now if I want to measure the Hartley oscillator frequency which is lower frequency lower frequency, we have to consider we have to consider 1 by 2 pi under root of 1 m in to 500 pico farad equals to 1 by 6.283 under root of 50 picofarad which is 225 kilo hertz. So, the again we are just talking about the we comparison with Hartley oscillator. So, if I compare with Hartley oscillator, then I can see this alright then I can see this change that is why you are comparing because what I thought is now we are comparing that is why we have this values alright.

So, the frequency of oscillation, for Colpitts oscillator is 10.8 kilo hertz, which is here within the feedback fraction is given by f feedback fraction is C 1 by C 2 which is about 10 percentage which is about 10 percentage alright.

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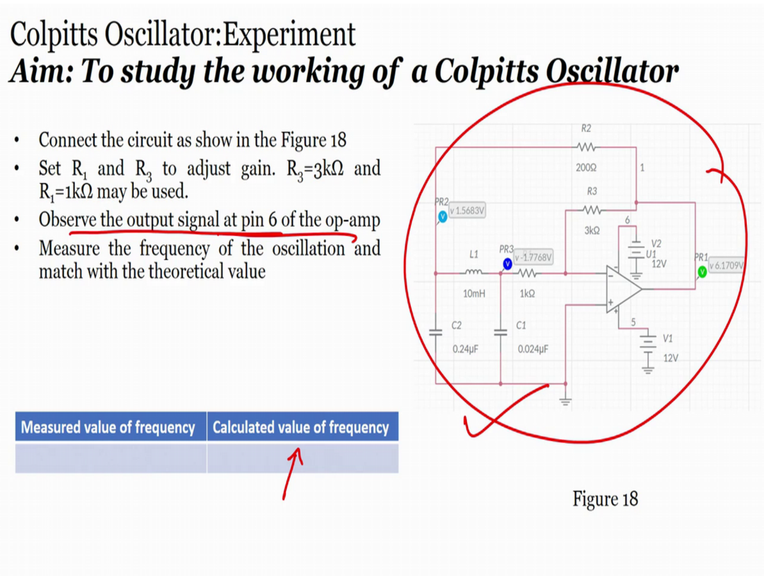

So, if I want to actually design the Colpitts oscillator, if I want to actually design the Colpitts oscillator how can I design the Colpitts oscillator? So, you remember last time we have seen the Hartley oscillator using multisim right and we saw that how we can change the output right by changing the or how whether you can change the output or whether you can see the change in the oscillation or how can we change the oscillation. This everything you can do by changing the value of inductors, in case of Hartley oscillator where here if I keep changing the value of capacitors; I will again see the change in the output.

So, here to get the similarly at the output instead of using breadboard and the components, we are again trying to show you using the multisim software. So, here what we have to see? Here we can see that we once we connect the free once we connect the circuit as shown in figure in multisim which is figure number 18 right, we set value of R 1 and R 3 R 1 and R 3 to adjust the gain. And if you have R 3 equals to 3 ohm and R 1 equals to 1 kilo ohm can be used. Then what we have to see? We have to see the output at pin number 6 of the op amp and then we can measure the frequency of oscillation with the theoretical value. So, theoretical value calculating right now right, we have seen the example previous example, how we can measure the frequency of oscillation using the formula.

What I want to show today here is, how can you measure how can you measure the output signal using the multisim. So, how you will design this circuit in multisim and how you will see the change in the output signal. So, for that let us again ask Seetharam to show it to us how can we design the circuit in multisim. When he is designing I will show it to you, what exactly we have designed.

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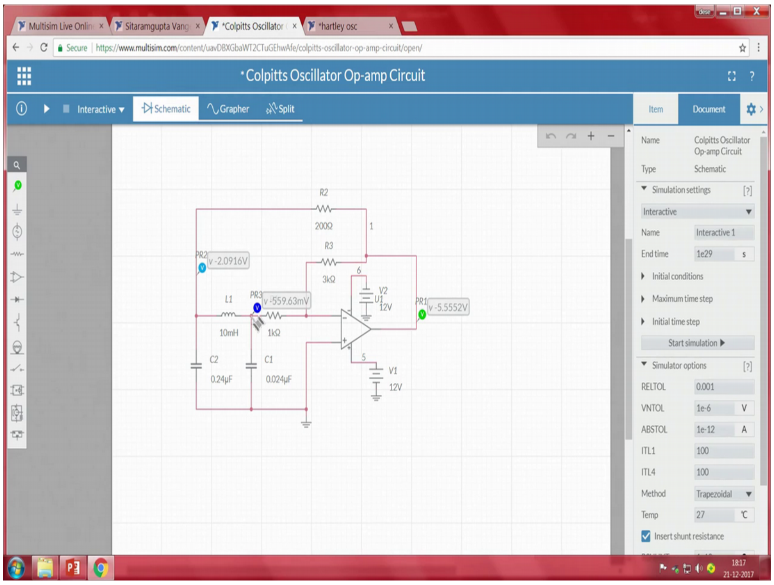

So, now if you see the Colpitts oscillator you see the Colpitts oscillator, it is similar circuit which is given to you as an example right. It is similar circuit which is given to you as an example.

So, now if you see that you have here 2 capacitors, you have 2 capacitors [vocalized-noise:] you have here capacitor 1, you have capacitor 2 right here and here; you have 1 inductor you have 1 inductor. So, whenever you see certainly this kind of circuit, you should immediately strike you that oh this is the Colpitts oscillator. If you see C 2 inductors and 1 capacitor, you will see here is the Hartley oscillator.

Now you what he has done is he is measuring voltage here which is right over here he is trying to measure in voltage over here and the he is looking at voltage output right; 3 things he is doing simultaneously. What I will ask him is show 1 by 1 just show. First output voltage, which can be generated in terms of the waveform and then we show second one, then we show third one and then we show all 3 voltages simultaneously; all 3 signals simultaneously.

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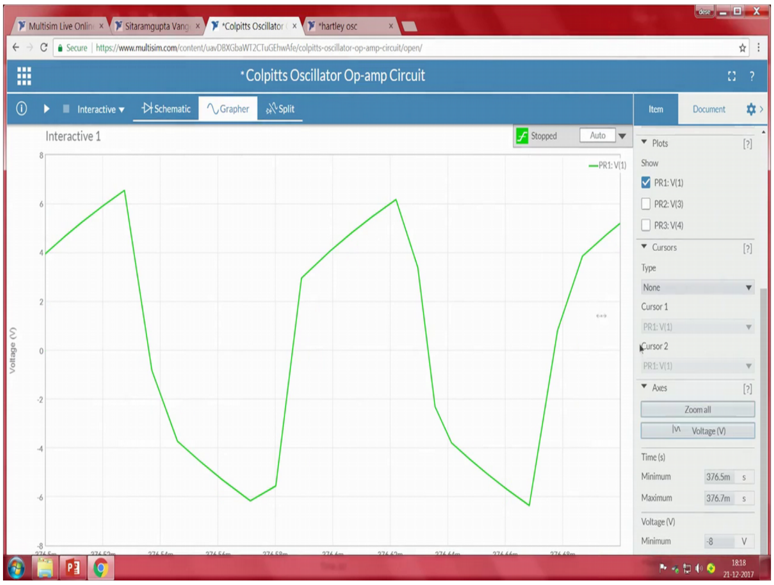

So, now, you see that is using this split screen and then here we can just remove or show you have the on the right side you have the button where this just show you have removed right. So, if I add this we can see signals, if I remove this we cannot see the signals at the particular point.

Now, if I looking at the voltage and if I am running the oscillator running the oscillator, then I can again see I can again change the ps. So, you can see here you can see here the oscillations are there oscillations are is there. Again you can see the times per you can change the per division to have the better idea, you can play with the tool and you can see that by changing this divisions you can see number frequency increasing or the number of divisions are higher time per division is higher. And now you can see both the things simultaneously, you can also see the corresponding voltage at the output and how the oscillations are occurring with respect to that particular corresponding voltage.

Now, if I see the voltage at a pin number at the input somewhere where the 2 capacitors are inductors right at the feedback, at the end you can see the voltage as well I can also see the voltage across the inductor is right over here. And then if I want to see the all the signals together, then I can see the all the signals together as well. You see all the signals I can see simultaneously which you can see right over here right.

So, this is the again a beautiful way of understanding whether my circuit will work or not whether my circuit will work or not. And if it works what is the voltage, at what particular point I can change the point. I can change the point from here to another point if I want to do that you see. Now we want to see the change at the inverting terminal of the op-amp. We want to see the change in the voltage inverting terminal of the op amp and then, just let us see only that particular voltage yes. So, this is the voltage at the inverting terminal of the op amp right.

So, if I want to see the change, if I have see want to see that voltage over here yeah; here is fine is a same voltage you see the voltage at output you can see it is same voltage which is right over here. This point right this point and this points are same alright.

So, you can see voltage at here which is here, here, here. You can just put number of points and you can measure the voltage at particular point. So, easy way of understanding the things, but the difficulty will be when you actually implement the circuit. So, try to both the things; first try to do this simulation and then try to do the experimental work. When you go to the lab and try to try to design your Colpitts oscillator alright guys.

So, this is how we can design a Colpitts oscillator and the, this is the this is the end of the oscillator sections. When we talk about the oscillators using the operation amplifiers, these are the Colpitts oscillator. Earlier we have seen Hartley oscillator is Hartley oscillator and Colpitts oscillator, both are the oscillators which are the tank oscillators or LC oscillators. Before that we have seen Wien bridge oscillators, before that we have seen RC phase shift oscillators.

Now, you know how we can design phase shift oscillators, you know how we can design Wien bridge oscillators, you know how we can design the LC oscillators whether it is Hartley or if it is a Colpitts oscillator. And you also know, if I give you a breadboard to work with if I give you a breadboard to work with, then you can also design the circuit.

If I give you the simulation tool, then also you can design the circuit right. So, now, you are able to have a better experience. I hope you have a we have a better understanding of the oscillators you have better understanding of using operation amplifiers using this particular videos and you learn different things you understand different things and you also saw a different problems. We have seen several problems sometimes in this particular module right that how we can design the oscillators or if I ask you to design calculate the bandwidth or if I ask you to calculate the f frequency high frequency and low frequency, how you can calculate it right.

So, this is the end of this particular module and I will see you with a new applications or other applications of operation amplifier in the next modules. So, till then just look at the video right; see the video, understand the circuits that I have discussed and if you have the questions feel free to ask the questions once you try it right. So, this is the last slide for this particular module. So, I will see you in the next module, till then you take care, bye.