Op-Amp Practical Applications: Design, Simulation and Implementation
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Lecture – 15
Op-amp As Wien Bridge Oscillator

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So, welcome to this module and last module, what we have seen? We have seen the RC phase shift oscillator. In this module let us see another oscillator which is the Wien Bridge Oscillator which is the Wien Bridge Oscillator. Now in Wien Bridge Oscillator we do not require the feedback or the feedback of 180 degree because the phase shift phase at the output of the Wien bridge is 0. So, we do not really require an external RNC to get back another 180 degree and feed it to the input.

So, now when you talk about Wien Bridge Oscillators, how when Wien Bridge operates we have seen in the theory class, but we will again quickly see in just one or two slide how the Wien bridge oscillator operates so, that you can understand when we do the experiments. In a same time we will see some problems that if for a given problem, how it is solution and then how you can design this Wien Bridge Oscillators alright.

So, when you talk about Wien Bridge Oscillator, one thing that you would to understand is that the in this kind of oscillator. So, let us go to the screen. So, that it is easy.

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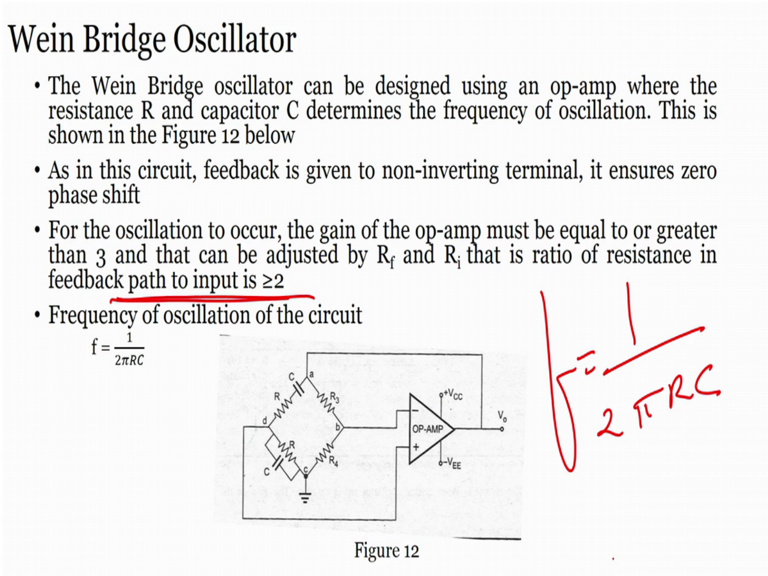

And we do not waste our time. The Wien Bridge Oscillator can be designed by using op-amp the resistance R and capacitor C determine the frequency of oscillation this is shown in figure. So, if you see this one right, what you see? Here you see that there is a resistor capacitor r capacitor C and register R. So, this two these two arms are the arms, that determines the frequency, the frequency determining arms alright so, resistor R and capacitor C determines the frequency of oscillation.

So, in this circuit feedback is given to the non inverting terminal as you can see the feedback is given from this circuit. If you see this feedback is given to the non inverting terminal to ensure zero degree phase shift. Here we do not require 180 degree phase shift, here we do not require 180 degree phase shift right that is why we are giving the feedback to the non inverting input. And for the oscillations to occur here we have seen in theory, the gain of op-amp must be equal to or greater than 3 gain should be equal to or greater than 3 we have seen it right. And this can be adjusted by R f and R i this can be adjusted by feedback resistor R f and input resistor R i.

So, various feedback resistor R f; this is your R f, this is your R i because this is input to the op-amp right. So, here we have feedback resistor R f we have feedback resistor R i and the ratio of the resistance part feedback path to input should be greater than equal to 2. Why greater than equal to 2? Because if I have a gain if I have a gain which is equals to 3 or gain is greater than equal to 3 right, my bar cosign criteria says A into beta should be should be 1 should be 1 and phase shift phase shift should be 0 phase shift should be 0. So, if my A is greater than equal to 3, my beta should be greater than or equal to 1 by 3 right but if I have this one, then only I can have the this particular gain greater than 3 right, why? Because the non inverting amplifier. So, formula is 1 plus R f by R i. If it is greater than equal to 2, if it is equal to 2, this will be 3. So, my gain is equal to 3 this is satisfied this is satisfied all right.

So, that is why we say that the ratio of the feedback resistor the ratio of the feedback resistor should be greater than or equal to greater than or equal to 2 understood. Now frequency oscillator for this particular circuit frequency formula is f equals to 1 upon 2 pi RC. So, easy right; easy to remember frequency is nothing, but 1 upon 2 pi RC ok. This is the case when we are talking about Wien Bridge Oscillator the case where we are talking about Wien Bridge Oscillator.

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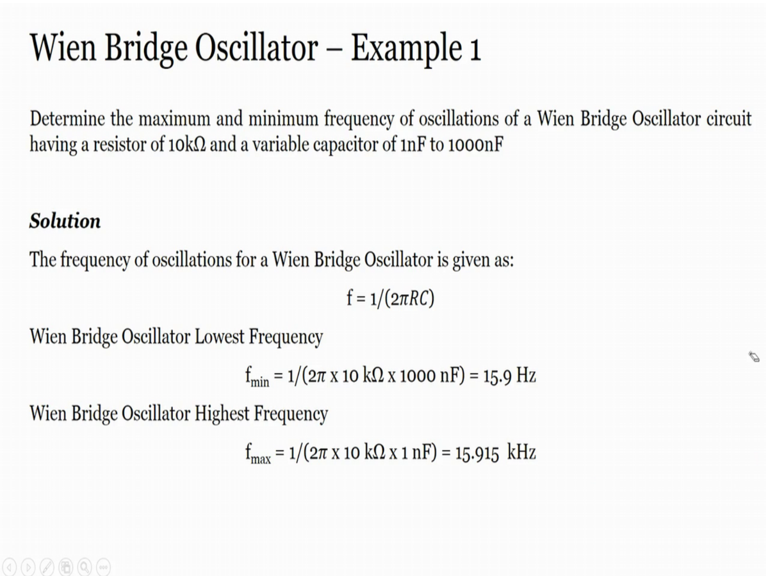

So, let us see an example let us see an example of a Wien Bridge Oscillator and determine the maximum and minimum frequency. So, what is the equation? Our equation or our problem is that we have to determine the maximum and the minimum frequency of oscillations of a Wien Bridge Oscillator circuit right. What we determined? Maximum and minimum frequency f minimum f maximum having a resistor of 10 kilo ohm R is given, 10 kilo ohm variable capacitor of 1 nano farad to 1000 nano farad; C equals to 1 nano farad to 1000 nano farad. If this is the condition that is given right, let us calculate the f minimum and f maximum.

Now, we know that in case of Wien Bridge Oscillator in case of Wien Bridge Oscillator, the formula is f equals to one by 2 pi RC we know this right. So, if I want to measure the minimum f minimum, then what will I do? I will have f minimum 1 upon 2 pi R we know 10 kilo ohm, C for minimum frequency C should be maximum. So, I consider the maximum value 1000 nano farad right for because it is inversely proportional inverse your portion that is why C should be maximum to find the minimum f minimum.

So, my value is 15.9 hertz my minimum value is 15.9 hertz. But for the higher frequency, Wien Bridge Oscillator for highest frequency that is your f max my formula would be same f equals to 1 upon 2 pi RC, but here my capacitor value would be the capacitor value would be 1 nano farad. And if I use this particular values, what I am having? I am having a frequency f max equals to 15.91 kilo hertz.

So, if you are given an example like this or a problem like this, you should be able to solve within 1 minute or within 2 minutes within 2 minutes, why? Because I am taking long time; so, that you understand clearly, but when you want to solve. So, easy if you are given this maximum minimum Wien Bridge Oscillator the R is given R is given 10 kilo ohm C is given from 1 nano farad to 1000 nano farad alright. My formula for frequency is nothing, but f equals to 1 by 2 pi RC.

So, what is said 1 upon 2 pi into 10 kilo ohm into C which is 1000 nano farad this will be my f minimum. This when I calculate by calculator, I will have the value equal to nothing, but 15.9 hertz right. Same way for f maximum I will say f maximum equals to 1 by 2 pi into 10 kilo ohm into 10 nano farad right 10 or 1 nano farad for a maximum minimum. So, 1 nano farad right, if I use this formula my f maximum would be nothing, but 15.915 kilo hertz done right.

So, I am I can again find this formula because it is already written here that is why I can do it within one minute. But if you want to use calculator it that is why I said around 2 minutes will require or less than that you require to find the for solution for such a problem right. So, so when you are given a problem do not do not do not do not get nervous right it is very easy f x minimum f x maximum or f minimum f maximum, we can find it for the given set of values that is our R that is our C alright.

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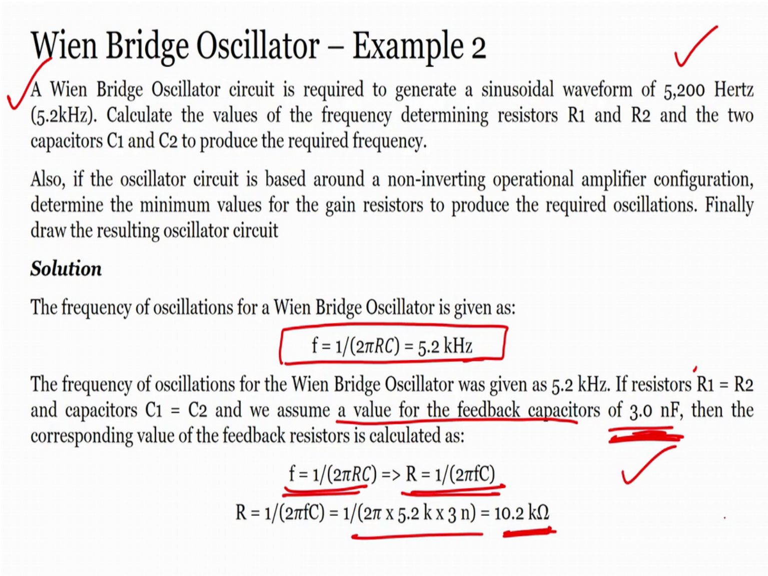

So, let us go to the next slide and next slide is our second problem. Example 2 : so, we are making example little bit tougher little bit tougher, let us see. What is the what is the question ? The question given is that for a Wien Bridge Oscillator is required to generate a sinusoidal waveform or 520 5200 hertz 5200 hertz or we can say this one is nothing, but this one is nothing, but 5.2 kilo hertz right calculate the values of frequency the remaining resistors R 1 and R 2 R 1 is not known, R 2 is not known and the capacitor C 1 and C 2 to produce required frequency; C 1 not known, C 2 not known. Also if the oscillator circuit is based around a non inverting operation amplifier, very important thing is given. Determine the minimum values of gain resistors we had to find R f we have to find R in to produce require oscillations. Finally, draw the resulting oscillator circuit oh my god.

So, big problem right, Is it difficult? Is it difficult? What you are telling I cannot hear and that is the beauty of the course that I cannot hear what you say, but I can understand what you say when you let me know through the forum right. If you have any difficulty if you do not understand, if you find the solution and you are not matching the solution is not matching ask, but first try first try alright. So, problem is easy I am just kidding problem is really easy right. Let us see how we can solve for the given set of values how we can solve this problem all right starting with we know frequency formula right f equals to 1 upon 2 pi RC 5.2 kilos hertz is given this much is given ok.

Now, the frequency of oscillators for when be a filter was given this one if resistor R 1 equals to R 2 and C 1 equals to C 2, we assume a value of feedback capacitors to be 10 3 in a farad. Let us assume it to be 300 farad, then the corresponding value of feedback resistance calculator is; so, if I have the value which is about 3 nano farad right my R value R value would be if I have f equal to 1 by 2 pi RC, R equal to 1 by 2 pi fC; I have considered C equals to 3 nano farad, then my f R value would be 10.2 kilo ohm. This easy this easy one assumption we have made 3 equals to 3 nano farad.

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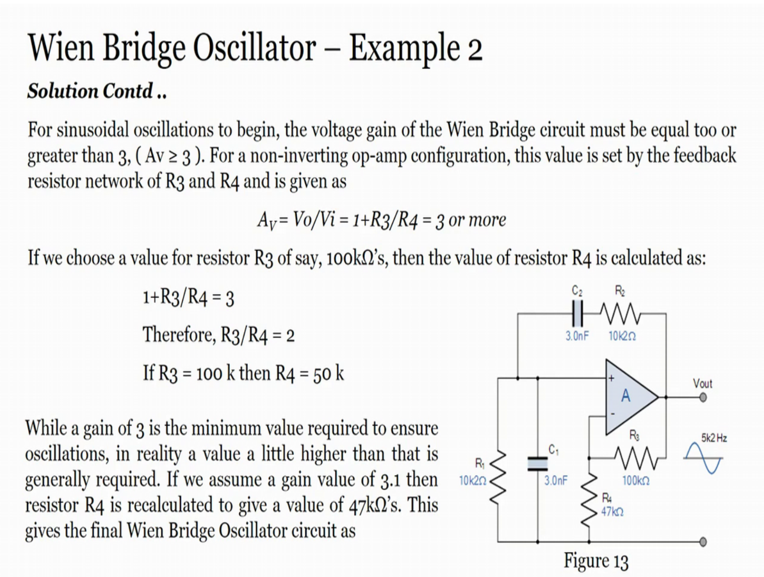

Now, now for sinusoidal oscillations to begin right, the voltage gain must be equal to or greater than 3; we know that right. In Wien Bridge Oscillator, the voltage gain should be greater than or equal to 3. For non inverting amplifier, the value set by the feedback resistor network is given as 1 by R 3 by R 4; we already know this right. We have just we have just designed this which is similar to your which is similar to your this one this circuit with this. It is similar circuit or light it is similar circuit just we have just placed the component. So, that it looks it is looking different otherwise its same circuit.

Now we know that is the input here we consider the we have to consider the non inverting amplifier right where you consider non inverting amplifier. Now we know that we the gain will should be the gain for Wien Bridge Oscillator should be greater than or equal to 3, then we should have a feedback resistor which is R 3 by R 4 1 plus R 3 by R

4, why? Because in non inverting amplifier, this should be equal to 3 minimum this should be equal to 3.

So, now we have 1 by 1 plus R 3 by R 4 equal to 3 or R 3 by R 4 equals to 2 right because 1 plus R 3 by R 4 equal to 3 implies R 3 by R 4 equals to 3 minus 1 equals to 2. So, now, I have to have a ratio of R 3 by R 4 equal to 2. So, I can assume any value I can assume any value R 300 kilo ohm R 4, 50 kilo ohm my answer is R 3 by R 4 equals to 2 right. So, using this using this we can find the value of R 3 R 4 ok. Feedback values fine found are found eh capacitor. We have considered 13 3 nano farad right.

So, will have a gain of 3 is minimum value or required Wien's oscillations in reality a value little bit higher than it is required. Generally if we assume again of 3.1, the resister R 4 recalculated to be given as 47 kilo ohms alright which is this one. This gives us final Wien Bridge Oscillator circuit as shown here as shown here right.

Let us see what we are done for this particular problem for this particular problem right quickly, we have found f formula this frequency formula right from that we know 1 upon 2 pi RC. We have assumed C equals to 30 nano farad for that we got a value of R to be 10.2 kilo ohm, then we know that it is a non inverting amplifier. So, non inverting op-amp configuration for non inverting op-amp, we know that the gain. In the case of Wien Bridge Oscillator should be a is greater than equal to 3 right.

So, for that we have greater than equal to 3. Now non inverting amplifier, we have formula 1 by 1 plus R f by R in 1 plus R f by R in equals to 3 right from that we have found R f and R f R r in R f and R in is nothing, but R 3 and R four R 3 and R 4. From that we found what is value of R 3? What is value of R 4? This is the ideal situation. So, that is why to have the oscillations to start we need to have a gain or the value of R 3 by R 4 a value of gain actually should be little bit more than 3 which is about 3.1. In that case if I have 3.1, my R 4 value will be about 47 kilo ohm and the circuit is shown here. So, this is how you can solve an example for given Wien Bridge Oscillator nice good. So, what? Now the real thing is can we implement this circuit on the breadboard?

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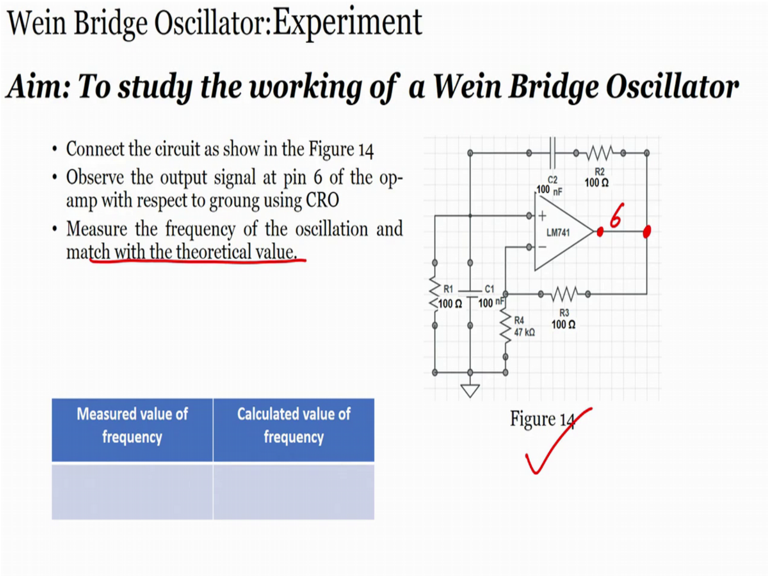

Can we implement this circuit on the breadboard right? That is the that is the idea.

So, we have this again the table. You can calculate the frequency you calculate frequency by yourself. Right now what we will we what I want to show you is if I connect the Wien Bridge Oscillator in this particular configuration, whether we are able to see the output voltage output waveforms in the digital in the DSO in the DSO? So, we have to connect the circuit as shown here. Observe the output at pin number 6 and with respect to ground measure the frequency oscillation and match this with theoretical value theoretical value will match later right.

Now let us just see quickly that if I connect a DSO at output here or here with respect to ground, what kind of signals I obtained at the output? Again you can see here we are not giving any input in particular to say right. So, let us see how it looks like on the breadboard. Let us see on the breadboard how it looks like.

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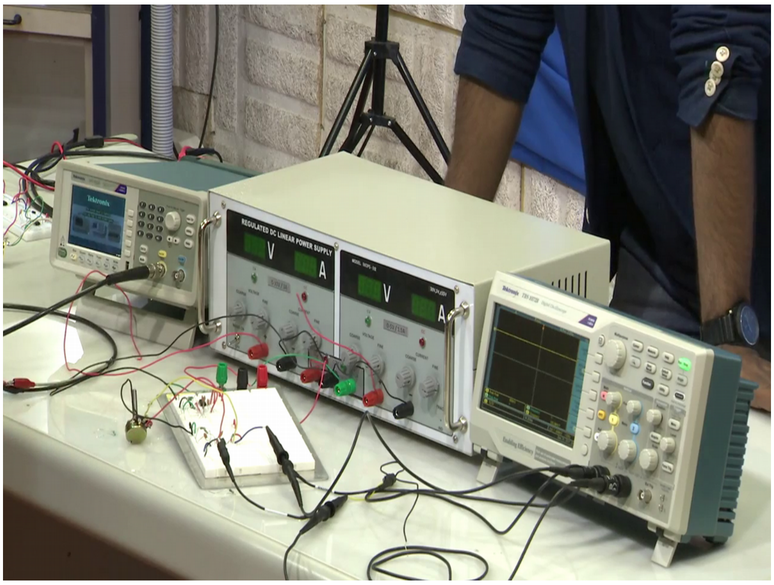

So, if we see, we will call Anil to help us. So, Anil is expert in oscillators. So, that is why we are calling him. I am just kidding all the all the teaching assistants that will help you in this particular course, they have a good amount of expertise in analog electronics and I will be there to help you out. So, feel free if you have any questions. The only thing that I will request is first try and then ask ok.

So, if you see this circuit which is the Wien Bridge Oscillator, you can see as you can see here the RNC the RNC. These are the arms that are used for adjusting the frequency for adjusting the frequency. And now we have connected the oscilloscope which is here right which is connected to the output of the Wien Bridge Oscillator output of the Wien Bridge Oscillator and let us see what is a output in terms of into the in the oscilloscope.

First we had to apply the first way to apply the bias voltage. And now we here right now the DC bar the supply was off, he just turned it on and the applied voltage or bias voltage is plus minus 15. And you can see on the oscilloscope, you can see on the oscilloscope that you can see immediately generation of the oscillations oscillations. Now if you here also if I change the fourth register, if you come back to the circuit you will see that the force resistor is the variable resistor. We have used a potentiometer you can show the potentiometer.

So, you see here we have used we are using the potentiometer as a fourth register in this Wien Bridge Oscillator. So, if I change the value of this resistance, what will happen?

That is I am changing the gain. If I changing this resistor, then what it what will happen? You see on the oscilloscope, if you can magnify yes.

So, now I am changing the value of resistor and you can see immediately a change in the change in the oscillation change in the oscillation. You are able to see right you guys are able to see now. So, this is how the Wien Bridge Oscillator would work; this is how the Wien Bridge Oscillator works. If I keep on if I have a variable register, I can keep on changing the oscillation all right. So, what I understand is now you at least know right how Wien Bridge Oscillator would work how a Wien Bridge Oscillator would work and what will happen what will happen if I if I keep changing the values of resistors. Can I design a Wien Bridge Oscillator? Yes, we have taken 2 examples by changing the by getting some of the values, we can determine f minimum.

By understanding, the values we can determine f maximum right why by changing the value of resistors we can get the output of our desired frequency. And we can also we can also use this Wien Bridge Oscillator with a phase shift of 0 degree. Because there is no phase shift at the output of the Wien Bridge and that is why we are using an operational amplifier and we are applying the output from the bridge to the operational amplifier non inverting terminal because we do not need another phase shift because here the phase is 0 degree.

So, total we have to understand is one thing is your gain and your feedback network should be equal to 1; the mode of your gain in feedback network should be 1 and the phase shift should be 0. We understood this we kept the same criteria we try to see and implement it on the board and we were able to see that the oscillations generation of oscillations by changing the resistor. So, here the main thing here compared to the earlier oscillator is here, we have we do not have to give a separate phase shift of 180 degree another phase shift of 180 degree alright.

So, I hope that you understood what is the, how we can use the Wien Bridge Oscillator and how we can implement the Wien Bridge Oscillator using the operational amplifier and using capacitors and resistors. And here also one thing is very important, we are not applying any input signal we are not applying external input signal the input is generated by the in the op-amp by itself alright. So, you just look at the video once again; read it, understand it right. If you have difficulties if you do not understand, you are free to ask me any question all right. So, till then you take care I will see you in the next module, bye.