Integrated Circuits, MOSFETs, OP-Amps and their Applications

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Lecture – 58
Experiment: Active band reject filter

Alright so, just now we have seen band reject filter right and let us see how we can use this band reject filter by in an experiment in experiment. So, to quickly recall what is band reject filter? Band reject filter is the filter that we can designed to reject the band of frequency. It is kind of opposite to band pass filter right. In band pass filter, we are passing the band of frequencies of desired frequencies, but when we talk about band reject filter then we are designing a filter that will reject the band of frequencies.

So, the point is how we can design this band reject filter? So, in the in the lecture right now, what I have taught you is how we can, what is band reject filter? What are the kind of band reject filter? How you can design the band reject filter? And now you know that, we are using the low pass filter and high pass filter, but not in terms of cascading. Like if you see band pass, it was high pass then you have low pass at the end and you have the OP Amp in the centre right. It can be buffer, it can be inverting, it can be non inverting amplifier.

In case of the band reject filter we are applying signal to low pass and high pass both right and then we are connecting it to the inverting amplifier or non inverting amplifier followed by a summer. Actually we are not using inverting amplifier and non inverting amplifier or we can use the point is low pass high pass goes to buffer, buffer to a summing amplifier right that is what we have already seen.

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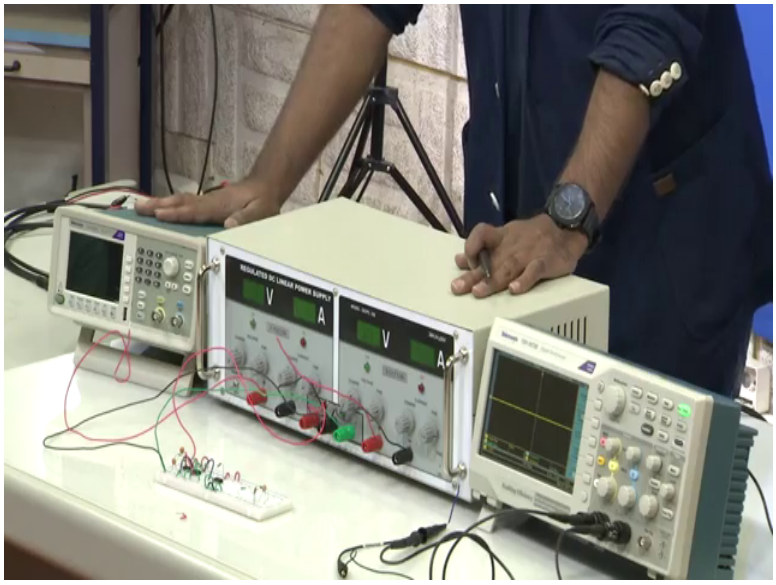

Now, let us see using our favourite equipment that is the DC power supply in a regulated power supply, function generator and the oscilloscope how we can design how we can design this band reject filter. And we will see active band reject filter, what is a what is active band reject filter? Where you are using the operational amplifier? So, now, this is a breadboard that you can see in front of you right. And today I will introduce you to my third teaching assistant Anil Vishnu and he will help us to understand how we can design this particular circuit.

So, Anil is here to help us and he will be he will be showing us how the circuit you can implement on the breadboard and while he is implementing I will keep talking, so that you understand what exactly he is showing ok.

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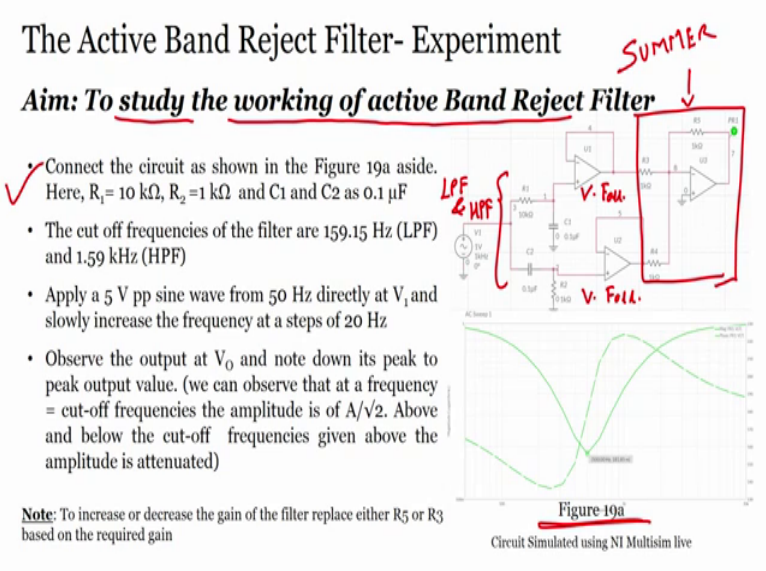

So, if you quickly go to the screen for a second you will see that the experiment is to study the working of active band reject filter active band reject filter. So, now, you what we see? You can see the circuit which is shown here circuit which is shown here right and the signal that we are applying is to the low pass and high pass filter you can see here correct. This output of the low pass and high pass filter is connected to the buffer to the voltage follower or to the buffer as you see here. And the output of this is fed to the summing amplifier. This is your summing amplifier easy? Easy?

So, let us see what is that ? What I have said ? Buffer or voltage follower voltage follower right this is a combination of low pass and high pass filter, low pass and high pass filter. This one is from here if I see this one is your summer or summing amplifier right.

So, if we want to implement this circuit what is the first step? You have to connect the circuit as shown in figure. This is figure 19 a right and the we have also perform a simulation that I will talk it talk in a second. Let us first see what the circuit is the circuit once we connect as shown in figure 19 a right.

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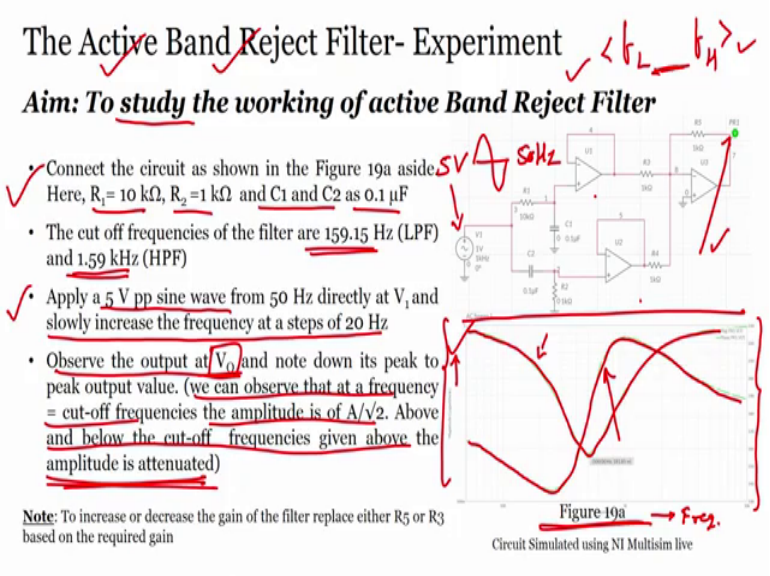

We have value of R 1, R 2, C 1 and C 2 right R 1 is 10 Kilo Ohm, R 2 is 1 Kilo Ohm, C 1 and C 2 are 0.1 Michael Farad. The cut off frequency here when we calculate it is 159.15 Hertz for low pass filter and 1.59 Kilo Hertz for high pass filter.

Now, what we will do? We will apply a 5 Volts peak to peak sine wave here. I will apply 5 Volts peak to peak sine wave right peak to peak sine wave of 50 Hertz 50 Hertz right at V 1 at V 1. And slowly increase the frequency at a step of 20 Hertz, slowly increase the frequency from 50 Hertz, we will go to 70 Hertz, we will go to 90 Hertz, we go 110 Hertz and so on so on and so forth.

Now, after this, what we have to see? We have to see the output we have to see the output at the summing amplifier, the output of summing amplifier. The combination of all this is your band reject band reject right you have OP Amps. So, it is active band reject filter active band reject filter right. Now apply a 5 Volts sine wave we have applied 5 Volt sine wave, we will applied say 5 Volt sine wave and then we will slowly increase the frequency then we observe the output at V o. This is output at V o which I have shown with arrow this one and what we will be observing? We will observe that, a frequency which is equals to cut off frequencies. The amplitude is A by root 2 and above and below the cut off frequencies the amplitude is attenuated. What does that mean? That whatever cut off frequencies is there right you have two cut off frequency; one is cut off frequency f L, second is f H; one is f L, one is f H right.

The frequencies less than less than f L and frequencies greater than f H would be allowed to pass would be allowed to pass. The frequencies between this will be attenuated will be attenuated right. So, if you see this particular graph this particular graph, this we have we have the results obtained using this N I multi sim, N I multi sim. And what we see here? There is a amplitude versus frequency. Here there is a phase also phase is also there right. So, one axis is amplitude one axis is amplitude another axis is phase, this is the amplitude plot. The one that I am drawing here right I am just following the amplitude plot and this is the phase plot this is the phase plot right. This is the amplitude plot, this is the phase plot.

So, let us see how our output voltage V o V o right changes when we apply input voltage 5 volts peak to peak from our function generator from the function generator.

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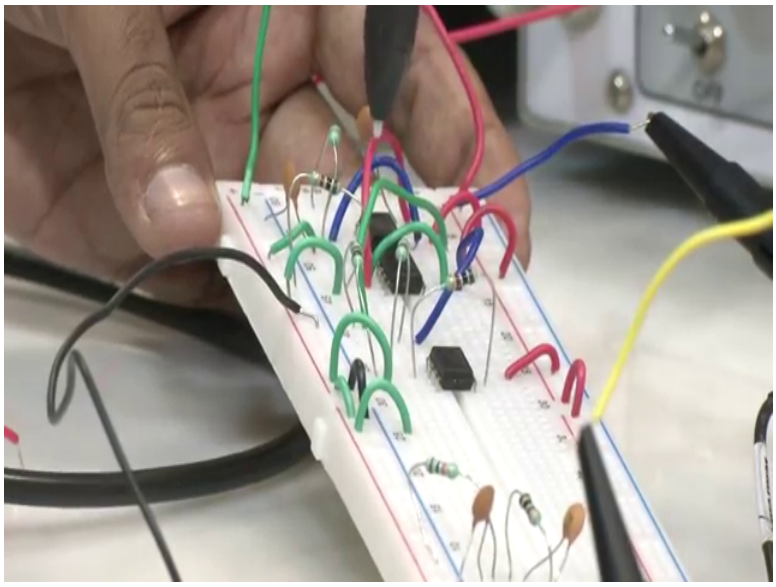

So, when we talk about function generator right in front of function generator the voltage that we are generating from the function generator will apply at this particular terminal V 1 alright. So, we have to see we have to see how the circuit looks like and then we will see how it works ok.

So, if we come back to the breadboard, if we come back to the breadboard we will see the function first the band reject filter which is right over here is right over here. And you can see that you know there are three OP Amps right there are three OP Amps just hold on you will see in a second yeah that is fine that is fine that is you do not worry about it.

So, now we have here three operational amplifier; 1, 2, and 3 right because in our circuit also we had three OP Amps right. 1 is summer which is this one and then there is a buffer and then input is low pass and high pass low pass and high pass and to the input we are we are applying 5 Volts peak to peak signal alright. So, from where will apply?

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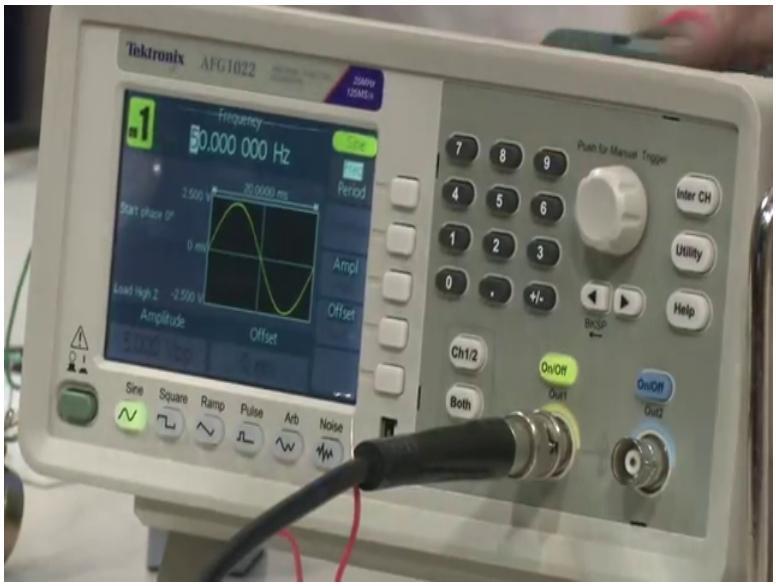

From the function generator, so if you can see the function generator, we will see that can you keep it back? Let him focus on function generator the is 5 Volt and now he is changing the frequency. Frequency is 50 Hertz 50 Hertz right 50 Hertz frequency, 5 Volts peak to peak. He is going to apply to the input of the breadboard.

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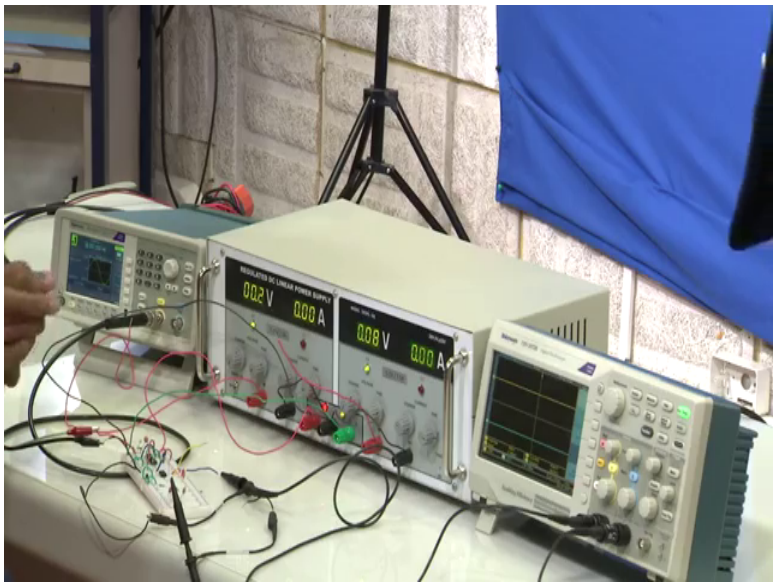

So, let us apply it let us apply it. The signal goes to the input and another terminal goes to the ground another terminal goes to the ground. And we have applied plus minus 15, we have to apply plus minus 15 that is the biasing voltage that is the biasing voltage to the operational amplifier all right.

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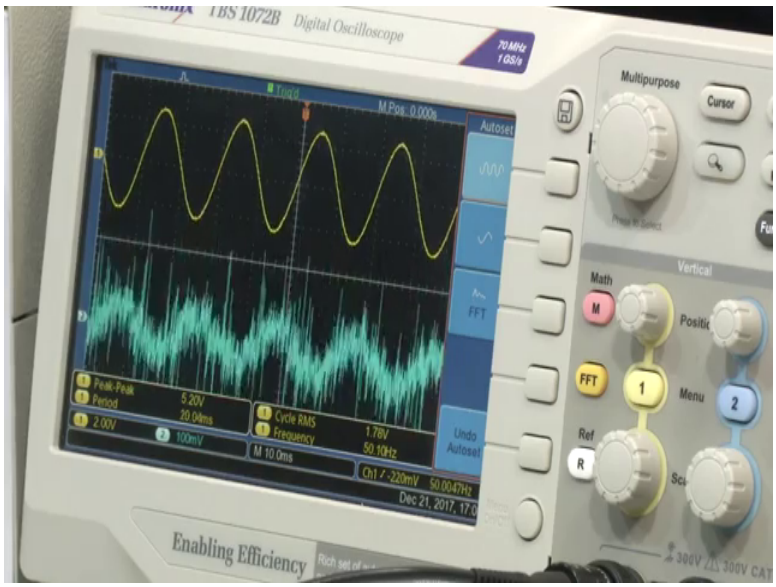

Now, we have to connect the oscilloscope that is the output voltage of the circuit to the oscilloscope. We will also connect the input and we will also connect the output. So, we can compare the input and output both. So, you are connecting the input and we will also

connect the output fell down. So, you can see clearly on oscilloscope the input signal, now we are connecting the output right. So, one terminal is ground one terminal is connected to the V o one connected terminal is connected to the v o.

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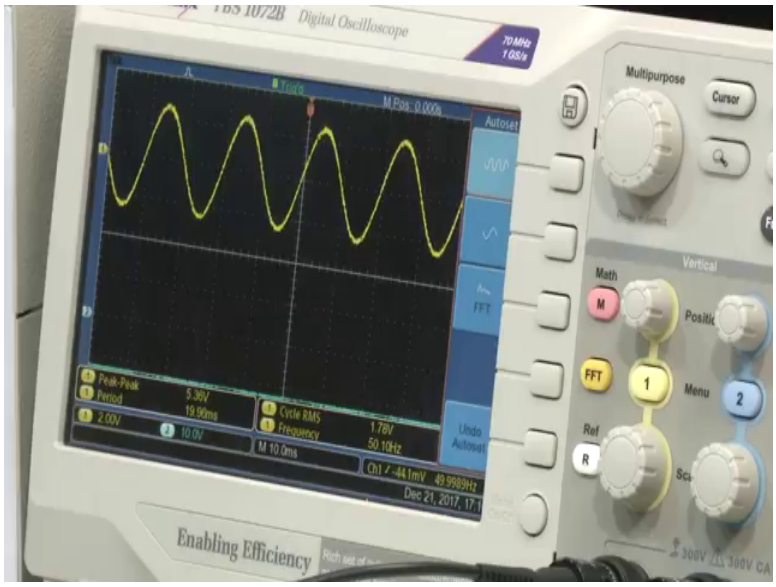

Now, at this point we should be able to see some voltage. So, let us see whether we can find some voltage at the output or not ok. So, what we find is, there is some problem with our circuit. So, let us troubleshoot the problem let us troubleshoot the problem and find out where is the problem lies and once we find out we will get back and continue this video.

Because I just do not want you guys to sit in front of the system and wait until we troubleshoot the problem. But the point is now in this case you can see that we have applied the input, since you have three operational amplifiers you have 3 OP Amps right why? Because you are using the buffer you are using the you are using the summing amplifier right. So, you have three operational amplifier.

So, three operation amplifier we have we have six resistors, we have two capacitors, we have we have bias voltages, we have input signals, we have output signals. So, circuit becomes little bit more complex. When this kind of circuit is there it will be difficult for us to get the result in one go and it may be the condition which we are finding right now which we are in right now right. So, the point is how can we find the solution to it? Or whether we can troubleshoot the circuit or not? That is the point that we need to

understand we will we will find it out and we will continue the video like where we stopped we will start up from the same point and the point was on the band reject filter.

So, when you talk about band reject filter right we were looking at the circuit and we were not able to see the signal in the oscilloscope right. So, point was why we were not able to see? Why we were not able to see? Ah so we have identified the mistake in the in the circuit design and what we found is one of the terminal was not properly grounded alright. One of the terminal of the summing amplifier was not properly grounded just because of this small error which is not really small you cannot find the output which you are looking for which you are looking for.

So, ah, but the point is you should be able to rectify your mistake, you should be able to find it find out where exactly the fault is right. So, that is what we have found and now if you see that when we apply a voltage apply a voltage at the input right apply the voltage at the input which is 5 Volts peak to peak at 50 Hertz then what is the output? So, if you see the function generator this is a function generator you can see 5 Volts that we have applied and the frequency is 50 Hertz. So, he is adjusting it to 50 Hertz 5 Volts with 50 Hertz, we have applied right and now we will look at the oscilloscope that is output of the band reject filter output of the band reject filter.

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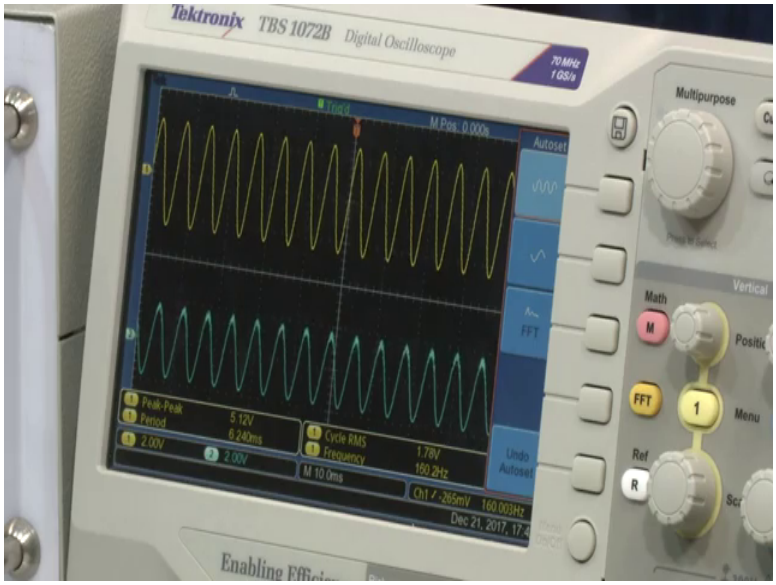

Now, you see the cutoff frequencies are f L is 159.15 Hertz and the higher frequency f H is 1.59 Kilo Hertz. So, anything below f L will pass anything above f H will pass the

frequencies between f L and f H will not pass. There is a roll of your band reject filter. So, we will keep on increasing the frequency you can see here yellow is your input signal, blue is your output signal, peak to peak voltage is 5.2 Volts and you see that slowly when we increase the frequency, I see 139 Hertz, stop it here 150 Hertz and for 150 Hertz, what is output voltage output voltage? So, the peak to peak voltage yeah 5.12 and you can suddenly see that now the amplitude will start decreasing right yeah.

So, frequency is 159.022 Hertz and if you increase the frequency increase the frequency suddenly you will see the drop in the amplitude suddenly you see the peak to peak amplitude is getting decreased. You see blue one on the left corner you can you point it out 3.12 6 9 6 yeah 2.96 Volts you see the amplitude is decreasing. Why now because it is within that band of 159.9 Hertz and 1.5 Kilo Hertz.

So, it will completely attenuate, it will start attenuating you increase the frequency keep on increasing frequency. Can you auto adjust it here oscilloscope please? Ok now keep on increasing the frequency please, yeah you can just see the oscilloscope and you can see that we are still increasing frequency. You can show the where you have reached the frequency place 1.75, 1.5 Kilo Hertz. Now if I keep on increasing the voltage frequency about this f H then I will again see the increase in the amplitude. That means, again my signal is allowed to pass through the filter, what you have seen again? You see the peak to peak voltage it is back to 4.56, 4.8 which is close to our input signal right.

So, what we see is when we have signals which are below f L we cannot we can pass, when the signals are above f H we can pass the signals between f L and f H we cannot pass. And that is what we have seen right now. Now we will do the reverse of this,. Now we will decrease this frequency, we will decrease the frequency and look at the signal. So, can you please show the oscilloscope once again; yeah. So, you see on the oscilloscope just hold on, show where the frequency they are to see. See the frequency is right over there and you have to see the peak to peak voltage at the output which is this one.

So, two things you have to remember frequency when I talk you to see frequency and the peak to peak voltage. The yellow one is your input signal blue one is your output ok. Now we are decreasing the frequency we are decreasing the frequency and you see that when we decrease the frequency you concentrate on your peak to peak voltage alright

decrease it further, decrease it further, decrease it further and you see now suddenly you can see that the voltage is also started decreasing.

Now, you go down all the way to 115 159 Hertz, 159 Hertz. Can you please auto adjust? See there is a function called auto adjust and it will automatically adjust your waveform right. If you do not need to adjust it manually, it can automatically adjust. Now you see here below 151 Hertz, below 159 Hertz it will again start increasing. You see the voltage; voltage again started increasing right voltage again started increasing. That means; that the peak to peak voltage will decrease or will attenuate only between 159 and 1.59 Kilo Hertz.

Now, if you come back to the screen. So, let us assume let us assume that this is 159.

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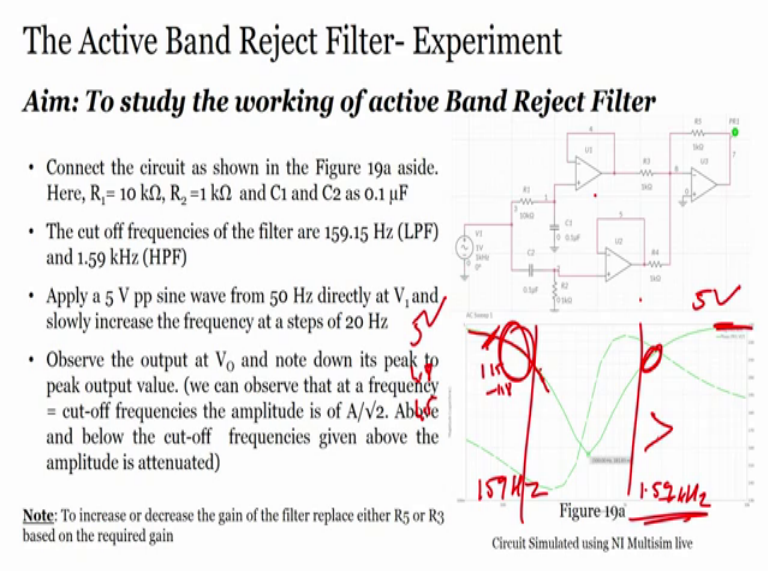

And this is one 1.59 Kilo Hhertz ok, this is 159 Hertz and this is 1.59 Kilo Hertz. Now you see this signal. So, voltage starts attenuating where from here actually right and then it comes down here. So, that is why you will see that even you come to 115 ah, 118 you can still see that voltage is decreasing. It is not 5 Volts anymore, it is 4.8, it is 4.5. So, this is the, this is a pic that you are looking at this amplitude you are looking at.

Same way when you increase it, it is still even it is outside this, even it is greater than 1.9, you can still see voltage which is less than your original voltage or input signal which is 5 Volt. That is why you cannot see suddenly there is a change in 5 Volts. Sudden

change will be there only when your filter is ideal your filter is ideal. That means what? That you have this instead of this kind of curve, what kind of curve you should have? Now suppose this is the frequency f L, this is the frequency f H your curve should be like this right. If you have only one frequency only one frequency then goes like this right, but we have, we do not have ideal filter we do not have ideal filter.

And that is why the change in the voltage that you seek or with increase or decrease in the frequency is not exactly like this, but it is similar to what we have shown in the in the slide all right.

So, do not get confused and do not say that oh it is not working. It is working, this is the area that you are looking at, this is the area you are looking at and after certain frequency you will be able to see 5 Volts again. You will be see able to see 5 Volts again alright. So, guys now you know, what are the band reject filters? Now you know, what are band pass filters?

And now you know, what are high pass filters? Now you know, what are low pass filters? Now you know, what are active filters? Now you know, what are passive filters? So, we have seen all the kind of filters possible filters that I can show it to you quickly in the part of as a part of this particular curriculum or part of this particular course. And we have seen the filters right from low pass to high pass to band pass to band reject right with experiments, with experiments all right.

So, I will see you in the next module and we will see other applications of the operational amplifier. Till then you take care, learn the filters, the understand the importance of filters, understand where you can use the filters, what are the real application of the filters? Right and try to see in which kind of electronic circuits the filters are used right.

So, the point was that in the starting of the this particular filters lecture, I told you that the filters are generally used or most widely used in the communication circuits in the communication systems alright ok. So, I will see you in the next module till then take care. Bye.