Integrated Circuits, MOSFETs, OP-Amps and their Applications
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Lecture - 57
Experiment: Introduction to experimental set-up for band reject filter

Welcome to this particular module. And in the last module what we have seen we have seen the Band Pass Filters right. This particular module we are looking at the Band Reject Filters right. So, what are band reject filters and how it can be implemented? You will again see a Passive Band Reject Filter and we will see an Active Band Reject Filter all right.

We will see both the filters and we will see how it can be used. We will see what we can we can show it to you, first let us understand from the theoretical point of view that what exactly are the band reject filters? And how it can be implemented?

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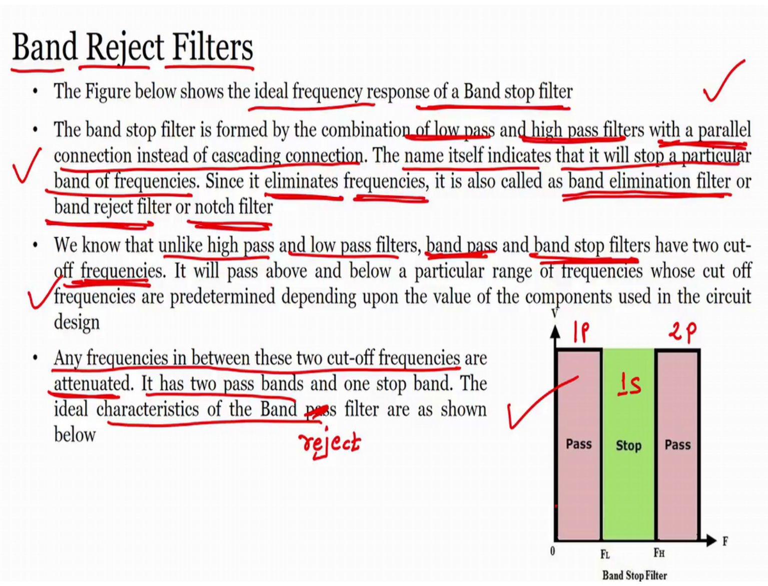

So, if we go back to the screen, if we go back to the screen what we see? right the figure here shows the figure here shows the band which is green colour right green colour that green band right or the frequency within this particular band will not be will not be allowed to pass and that is why this stop band is Band Stop. So, this filter is also called Band Stop Filter or it is called Reject this particular band we do not require Reject; that means, it is also called Band Reject Filters all right got it.

So, if you see this particular figure what we see is there is a certain band of frequencies that we want to allow, certain band of frequencies that we do not want to allow and this particular frequency we will not allow. So, how you can design this kind of filter right that is question. Again you has looking at FL, you are looking at FH right and you are looking at the frequency versus your voltage or amplitude right; y axis is your amplitude, x axis is your frequency right; y is your amplitude, x is your frequency ok.

So, the figure below shows the ideal frequency response of a Band Stop Filter this is ideal this is ideal right; you can see it is sharp. We do not require this particular the frequency between FL and FH sharp change, sharp drop like a brick wall like a brick wall, sharp change this is ideal. In reality in reality when you see you will see something like this right. So, it is not sharp it is you see is this decreasing. And that it is this particular. So, this is a band that we are trying to block actual ideally. So, the band stop filter is formed by combination of low pass and high pass filter. Now, in the band pass filter we had high pass band pass band pass filters. We had high pass filter connected to low pass filter correct; you remember.

In Band Reject Filter Band Reject Filter, first stage is low pass filter it is connected to high pass filter that is a difference. So, easy to remember extremely easy to remember what is that that if you take band pass filter high pass filter is cascaded with low pass filter, high pass filter is their input, low pass filter is their output and you connect both of them if you talk about band reject filter and low pass filter is at the input and high pass filter is at the output right. That is why when we say the band stop filter is formed by combination of combination of low pass and high pass filters with a parallel connection with a parallel connection instead of cascading.

So, do not worry about this just converting this thing just converting this thing. There is one more thing that you have to understand is the parallel connection parallel. That was series this is parallel right. So, we will see, we will see, just by converting high pass to low pass and low pass to high pass this is not enough for band reject; you also has to understand a parallel connection. We will see how the parallel connection can be done right, the name itself that it will stop a particular band of frequencies. The name itself indicates that it will be used to stop a particular band of frequencies right.

Now, since it eliminates frequencies, since it eliminates a frequencies unwanted frequencies, it is also called it is also called band elimination filter; it is also called band elimination filter or band reject filter band reject filter or notch filter; this filter is super famous right. It has so many names. It has so many names it is called band reject, it is called band elimination, it is called notch filter right. So, this filter in which we can reject the band right its called band elimination or notch or band reject.

Now, what we know here, what we know here, we third point. We know that unlike high pass and low pass filter, band pass and band stop filters have two cut off frequencies have two cut off frequency right, how if it is low pass, high pass, band pass, band reject.

Let us see, low pass, high pass, band pass, band reject all right. If I draw low pass. Low pass has one frequency. High pass, high pass also has FC correct. Band Pass this one band pass band pass has two frequencies FL FH. Band Reject band reject is two frequencies FL FH right. That is what we are saying that we know that unlike high pass and low pass, band pass and band stop filters have two frequencies; that is your FL and FH. It will pass above and pass above and below particular range of frequencies whose cut off frequencies are predetermined depending on the value of the components used in the circuit. It will pass above and pass below right pass above this one is pass above this is pass below a certain band of frequencies which we can decide which we can decide by using a correct components in the circuit.

We will see with a example. So, you got a better idea of what we are discussing all right. We will seen example. So, now, in this case any frequencies in between these values right any frequencies in between these two cut off frequencies are attenuated. Frequencies that we want to pass will easily pass. The frequencies between FL and FH between an FL and FH this range will be attenuated will be attenuated all right.

So, it has two pass bands correct. It has two pass band pass band one, pass band two and one stop band; stop band one 1 S 1 P 2 P right two pass band and one stop band. The ideal characteristics of the band pass filter are shown here are shown here right. So, this is your Band reject filter right. I think it is not Band pass filter. This is ideal characteristics of the Band reject filter all right. Band reject filter is shown here got it ok.

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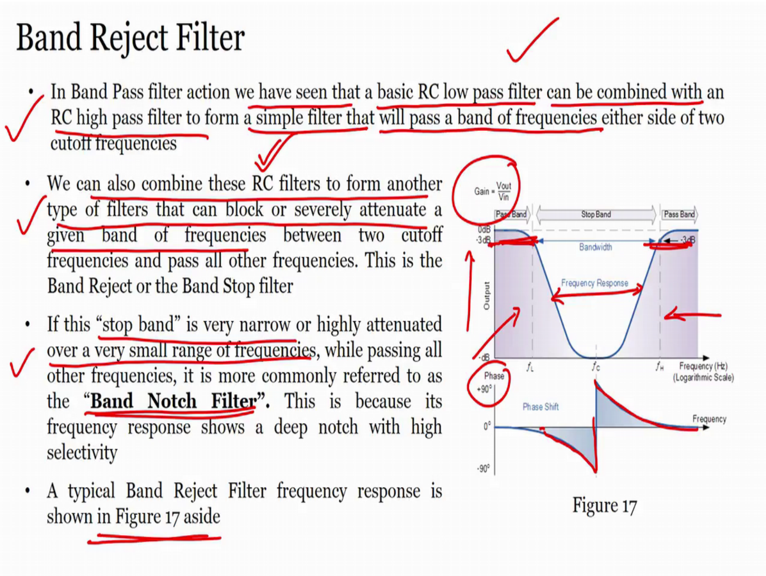

Now, let us see, further about band reject filter. In band reject filter again do not consider this pass this is my mistake the band reject filter right, or let us see this band pass filter first may be let us read it first before I tell. In Band Pass Filter action we have seen that is correct sentence. In Band Pass Filter action we have seen that a basic RC low pass filter can be combined with a RC high pass filter to form a simple filter that will pass a band of frequencies either side of two cut off frequencies we have seen that right, what we have seen that there is a low pass filter, there is a high pass filter both are connected in we are both are cascaded; and we could pass the frequencies either side of the cut off frequencies.

We can also combine what we have seen further; that we can also combine this RC filters to form another type of filters that can block or severely attenuate a given band of frequencies right, between two cut off frequencies. This is Band Reject or Band Stop filter. We can also combine these RC filters which RC filters, low pass and high pass. To form another type of filter that can block or attenuate band of frequencies. So, in this case we are passing certain band of frequencies in this case we are attenuating some band of frequencies right. So, same RC filters can be used in some different configuration to get us a band stop filter or attenuate the frequency that we do not desire all right.

Next if a "stop band" is very narrow or highly attenuated over a small range of frequencies, your stop band is extremely narrow or highly attenuated over a small range of frequencies, while passing all other frequencies, it is more commonly referred as "Band Notch Filter".

So, when you see a graph which is something like this. Then this is the frequency that it is attenuating only this frequency it is attenuating all right and that is why it looks like a notch, its looks like a notch. That is why what he is what is said here is that if a stop band is very narrow and highly attenuated, you see this stop band is extremely narrow. This stop band is narrow right and highly attenuated. In this particular case, this band reject filter is also called "Band Notch Filter" also called "Band Notch Filter" very easy to understand extremely easy right.

This is because a frequency response shows a deep notch with high selectivity. We have already seen the graph. A typical Band Reject Filter, A typical Band Reject Filter frequency response is shown in figure 17. So, let us see what is that? gain is Vout by Vin you always see here we have we are considering minus 3 dB right minus 3 dB this is your Pass Band, this is your Pass Band and this is your Stop Band this is your Stop Band correct.

So, now we have phase if I plot a phase plot. Then I will see here if you if you want to have a phase plot for frequency for this band notch filter or band reject filter or band stop filter, then we have phase plot which is shown here in here right. Phase Shift should be like this, start from f C then you will see a Phase Shift it was like this all right easy very easy ok.

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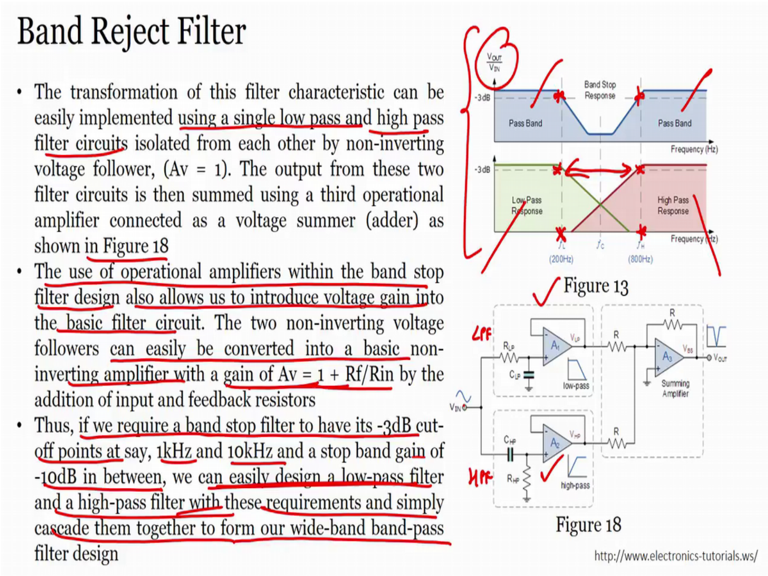

So, let us go to the next one right. So, now, here what we see, you keep focus all right keep your focus and see what we are looking at here. The transformation of this filter the transformation of these filter characteristics can be easily implemented using a single low pass and high pass filter circuits isolated from each other by non-inverting voltage amplifier or non inverted voltage follower the output from these two filter circuits is then summed using a third operational amplifier connected as a voltage summer. Now, you guys understand why I am teaching you one by one. Now, you already know when I talk about voltage follower. Now, you already know when I talk about the voltage summer right this is voltage summer. So, voltage summer summing amplifier right low pass filter high pass filter high pass filter low pass filter right.

So, what is a point you again let us look at this point the transformation of the filter characteristics can be easily implemented using a single low pass and high pass filter circuit; single low pass and high pass filters, followed by followed by right, this is you see low pass filter is here high pass filter is here, followed by what is this unity gain amplifier, unity gain amplifier. This is your buffer right buffer, voltage follower, unity gain amplifier.

So, your low pass filter cascaded with unity gain amplifier. High pass filter cascade with unity gain amplifier right. That is have you form your that is have start your band reject filter. And then the signal is provided the signal Vin is provided to low pass filter, it is provided to high pass filter, followed by voltage follower and the output is fed output here you have see this output is fed output is fed to the summing amplifier right. We already know the formula of summing amplifiers.

So, this will be Vin, this will be V 2 right. So, we have the R here right. So, we know that it is minus 1 by Rf into V one V two V three whatever voltages right or you can convert your shall we go back and look at the summing amplifier, you can see the output voltage formula correct.

So, when you see this when you see this is what you will get you will get is the difference between you get the band which are not allowed to be pass; you will see further here right in 18. The use of operational amplifiers within the band stop filter design also allows us to introduce voltage gain into basic filter circuit right.

Because now, you have voltage gain we can introduce the basic filter circuit the two in non-inverting voltage followers can be easily converted into basic non-inverting voltage with a gain of A v equal to 1 plus Rf by Rin right. Instead of here I can convert is to non-inverting amplifier very easy right. I can connect the second voltage follower also to a non-inverting amplifier. If I connect it to a if I convert this unity gain amplifier to a non-inverting amplifier. Then I can change the gain of the filter; that is what is written that are two non-inverting voltage followers can be easily be converted into basic non-inverting amplifier with a gain of 1 plus R f by Rin by the action of input and feedback registers.

Thus, if require thus if require band stop filter to have its minus 3dB cut off points say at 1 Kilo Hertz and 10 Kilo Hertz and stop band gain at minus 10dB we can easily design a low pass filter and a high pass filter with this requirements simply by cascade them together to from our wide band pass filter design right. So, it is very easy to understand.

So, here if you really see, the first one that is this particular plot what we see is here the band stop response a band stop response is between f L and your f H right it will not allow this particular band of frequency to pass. It will not allow this particular frequency to pass right.

So, this minus 3dB again minus 3dB right; so you see Band Response, this is your Vout by Vin or your gain; your gain or Vout by Vin. This is your pass band, this is your pass band, this is your high pass response, low pass response, this is reject; so band stop response. So, now we know how we can design a band reject filter right easy.

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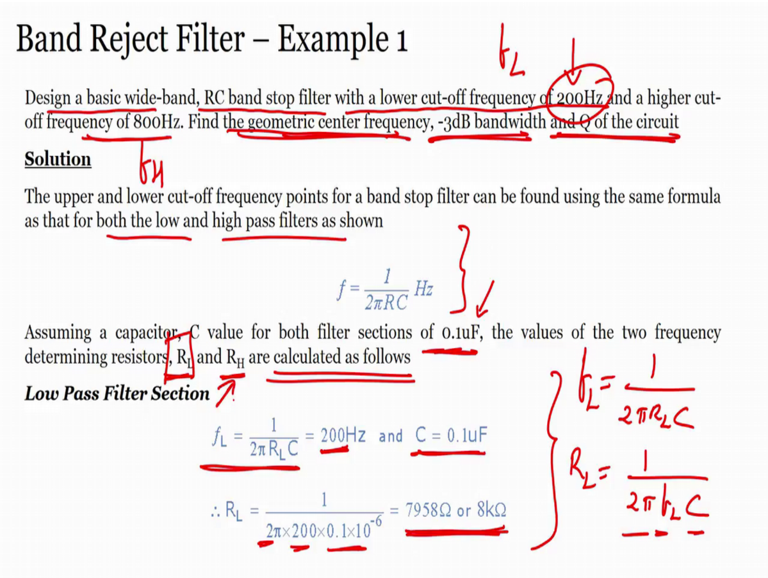

So, if I go on the next slide, then you have an example to solve you an example to solve. I give an example. So, that when we go to the experimental point of view you will not get confused and you will already know that what we are working on? What we are dealing with? That is why I also tell you the examples.

Now, Band Reject Filter we have an example. So, example is design a wide band design a basic wide band RC band stop filter with a lower cut off frequency of 200 Hertz and a higher cut of frequency off 800 Hertz. What is saying? You have to design RC band stop filter with a lower frequency.

So, RC band stop filter with a lower cut off frequency. So, this one would be fL right and this one would be f H ok. Now, find the geometric center frequency minus 3dB bandwidth and Q of the circuit. Three things we have to find. So, how can we find this how can we find this. So, if you find the solution the upper and cut lower cut off frequency points for a band stop filter can be found using the same formula as that for both low pass and high pass filter; that means, the frequency can be found using the formula f equals to 1 divided by 2 pi RC right.

Now, assuming a capacitor C value for both filter equals to C, here the capacitor values are given; where assuming 0.1 Micro Farad, the values of two frequency determines register R L and R H can be calculated as follows. First we look at the low pass filter section, low pass filter section f equals to 1 upon 2 pi RC right. Then we can put the formula of we have 200 Hertz right, we have 200 Hertz here, correct.

So, we and C equals to this one. So, if I substitute the value 2 pi R L is I do not know. So, I am putting R L equals to C; if I have this formula f L f L equals 1 by 2 pi R L C, then I will R L would be R L equals to right R L equals to one upon 2 pi f L C. I know what is f L, I know what is C, I know what is 2 pi. So, 2 pi into 200 into point 1 10 raised to minus 6 because it is Micro Farad correct 200 because 200 is Hertz given here. So, if I if I solve this thing well I have I have a load register of 8 kilo Ohms. I can find the value of R L. So, now I have value of R L I have found it.

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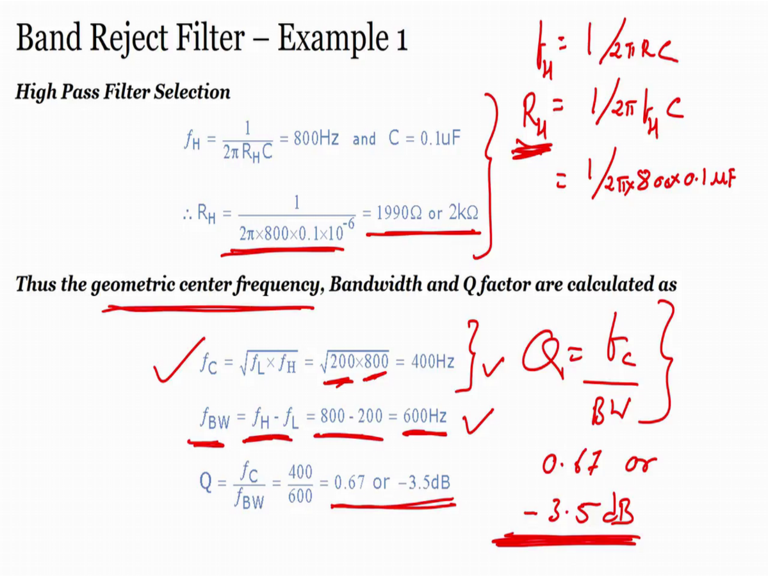

Now, what is the next step? I have to find R H. I have to find R H. So, for finding R H, we are again selecting the formula which is same formula where your f equals to 1 by 2 pi R C, 1 by 2 pi R C all right.

So, here if I want to measure R R equals to 1 upon 2 pi f C, what is f here f H; so f H right. I R is R H. So, here if I substitute 1 upon 2 pi f H what was f H. If I go back I will see f H is f H is 800 Hertz, f H is 800 Hertz. So, I substitute value of f H which is 800; I substitute value of C which is 0.1 Micro Farad and I am I multiplied by this things right. Then I have I have R H equals to 2 kilo Ohms R H equals to 2 kilo Ohms.

Now, what I found I have R H values I have R L values right. I had to find f C. So, geometric center frequency; we know the formula f C is nothing but square root of f L into f H right. What is f L? f L is 200 given, f H is 800 given, center frequency is 400 quad it done easy. What will be Bandwidth? Bandwidth, Bandwidth is very easy f H minus f L 800 minus 200 600 Hertz is my Bandwidth right. Quality factor, quality factor is given by f by Bandwidth.

So, what is my f C? f C by Bandwidth; f C is 400 Hertz, Bandwidth is 60 Hertz. I divided then I get volume of 0.67 or minus 3.5dB minus 3.5dB right. So, point is that if I want to design this band reject filter, I should know two things one is a formula for f, second is formula for Q. And f C f C is f C and Q. So, f C is super easy, f L into f H square root of f L into f H and Q is f C divided by Bandwidth. So, from that I can get values right I can add values.

So, if you quickly see back we can find value of f L and from that we have f L is given. So, we can find R L, then we have then we have f H from f H we can find this R H right. Now, we have Quality factor Quality factor we can find f C by W; Bandwidths we know. What is f C? f C is square root of f L into f H. What is Bandwidth? Bandwidth is f H into my f H minus f L. So, total is we have the value 600, 400; when you substitute, we get the value of Quality factor Q equals to minus 3.5dB right. So, the guys this is how you can solve a band reject filter right problem which is given for the band reject filter.

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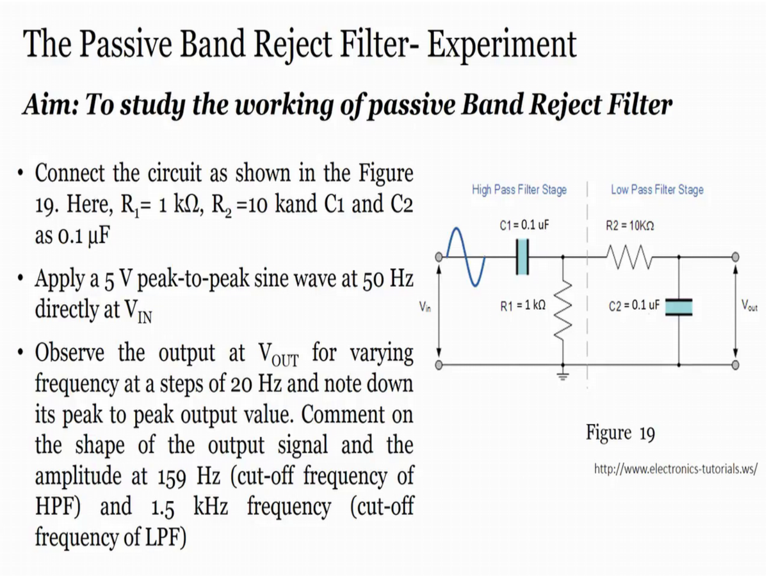

Now, let us continue ok. So, we will we will stop here right now and let us let us see in the in the following module right how we can design a Band Reject Filter. So, we will right now I have covered the theoretical portion once again small theoretical portion not ideally in depth, but what we understood is we can design this band reject filter right using and operational amplifier. That is your summing amplifier we can have the buffer or we can change the buffer in instead of buffer, we can use inverting amplifier or non-inverting amplifier. And you have low pass filter and by and the high pass filter corrected in the fashion that we have seen in the circuit; when we applied input, if the final output and the output of summing amplifier will be the notch amplification, notch voltage right. That were the frequency, the frequency that is rejected is the output of the output of the band reject filter.

So, now we can change this Bandwidth by calculating your f L and f H it is very easy f H minus f L you want to find Q again very easy right; f by f C by Bandwidth if I want to measure f C very easy under root of f L into f H right. And if you want to measure R L or R H we can find a formula of frequency. Frequency is nothing but 1 upon 2 pi R C. In case of R L 1 upon f L equals to 1 upon 2 pi R L into C. So, R L equals to 1 upon 2 pi f C f L into C; we can find R L. R H we can see by same formula and we can find R H. So, this if you know this things its very easy for you to calculate how you can design your band reject filter.

Now, in the next module let us see how we can implement this on the breadboard. And let us see the change in the output voltage when we apply different signal at the input voltage all right. Till then you take care read this things, learn, understand and look at the videos, learn this video, read this video, when I say read this video what does that mean, that if I ask you any question if you are confused you to go back and read somewhere all right; and you have to watch this video, you have to read, you have to watch and you have to understand. All three things you do simultaneously off course you have to listen right.

So, multiple things you can do a multiple things you can do by understanding this NPTEL videos right your curiosity, you can solve by testing it on the circuit that is why I am trying to put the circuit in picture. So, that it is helpful for you all right.

So, with that I will see you in the next class till then you take care. Bye.