Biomedical Signal Processing
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Lecture - 57
Tutorial – IV

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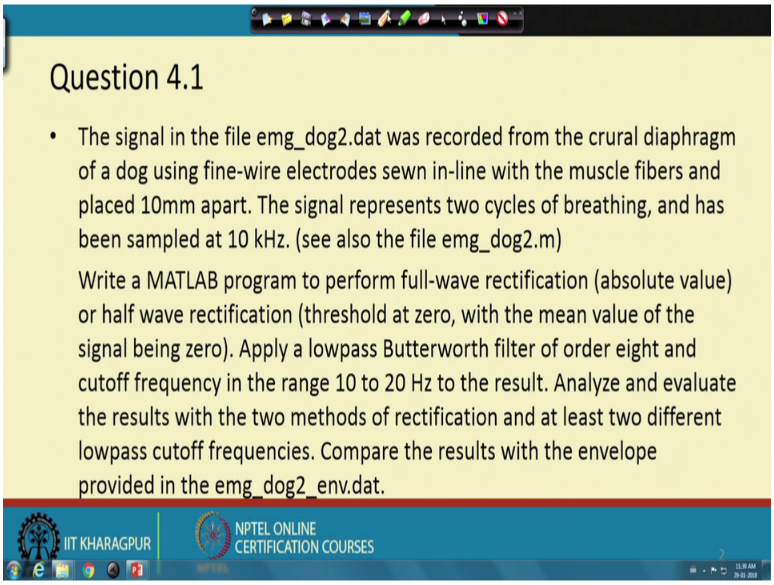

So, now we are starting the tutorial 4 with the assignment one. Here we have provided with the signal emg underscore dog 2 dot dat. It is taken from a diaphragm of a dog crural diaphragm means it is near the lake. So, some find wires electrodes they are actually sewn in line with the muscle fiber 10 millimeter apart. And we get these signal the 2 cycles of breathing is captured and with very high frequency it is sampled 10 kilohertz ok.

And we also two actually get that to read that signal we should look at that emg underscore dog 2 dot m. Now job is to write a MATLAB program for full wave rectification and or half wave rectification. In fact, we will be both and after that we should apply that low pass Butterworth filter of order 8 and cutoff frequency should vary from 10 to 20 hertz. And we should actually see analyze and evaluate the result of these two techniques of rectification and at least two different low pass frequencies; that means, the impact of choice of the rectification algorithm and the choice of the cutoff.

And to compare the result that the envelope is also given the envelope is given here that is also a signal and drawn that is given that what is the envelope signal here.

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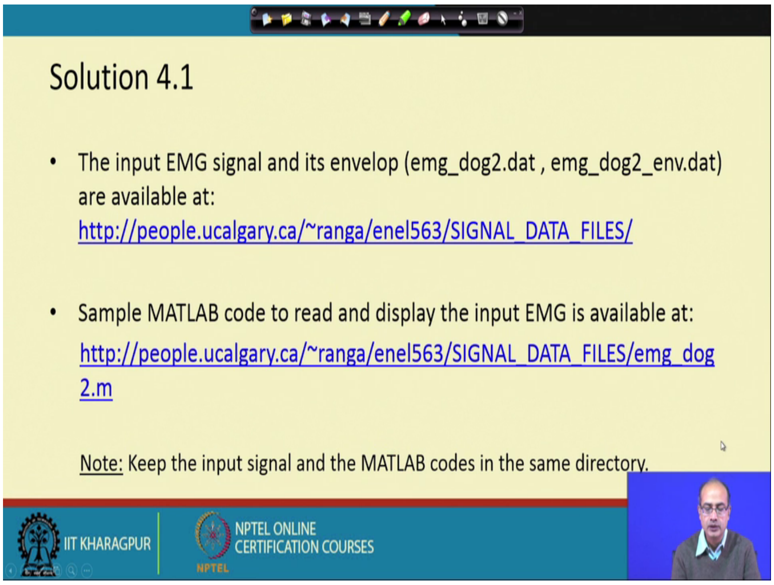

So, first we take the EMG signal and that corresponding MATLAB files that to read them and we put the input signal and the MATLAB code in the same directory ok, the working directory of MATLAB and our work starts from here first we have to read the file.

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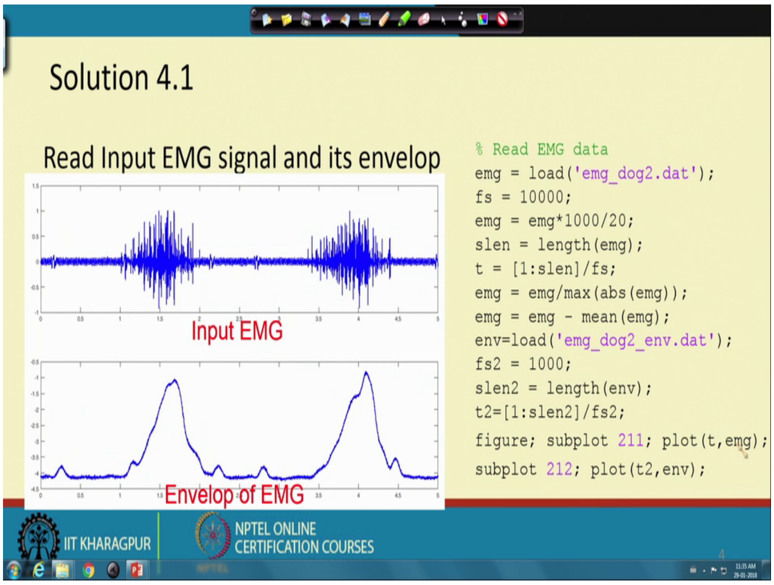

So, we load the signal that then the variable EMG, we know the sampling frequency is 10 kilohertz.

So, we are actually scaling that signal here and we are finding out the length of the signal EMG and with that we are finding out the time axis that one 2 s length gives the ram and multiplication with one by f s that is the that inter sample into a that interval that we multiply to get the exact time point and then we normalize the signal, we eliminate the mean. In fact, this two order could be changed we can remove the mean and then do this.

Then we have loaded the e n v that envelope also what is given which we need to compare and again we have taken the corresponding that length and using the figure and the subplot command at the top we are showing the EMG signal and below the envelope; that means, what we are supposed to get and here we are showing the EMG signal and here is the envelope we are supposed to get the envelope of the EMG signal like that which should actually look like the envelope the target envelope which is provided with us ok. So, this is the target.

This one is the target this is not derived from the EMG. So, this part this is for the reference it is given.

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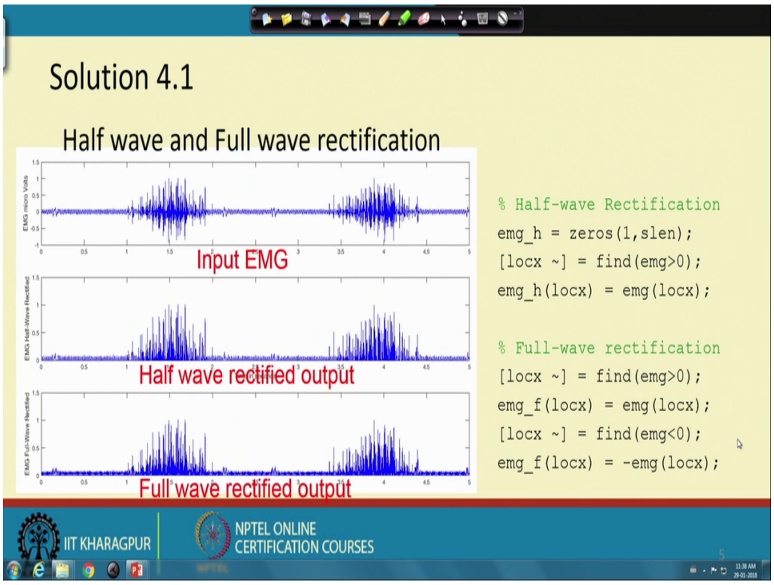

So, first we do the high pass at the low pass filter for the half wave rectification. So, the first we do the rectification rather than filtering that half wave and the full wave rectification what we are doing where are signing the variable that emg underscore h for that half wave rectification and emg underscore f for that full wave rectification that with the that we are assigning the length and after that the same as that the emg signal we are finding out the locations that where it is above the that 0.

So, that gives us that half wave rectification and here what will be the value that we do not need. So, we are given here till day that we do not stored that for those locations. Now what we are doing, we are signing the value of the emg signal. So, the positive half is restored or we are actually preserving the positive verb the negative half where the value is negative it is because you have assigned it with 0, it has gone to 0. Now, in this case, the next for the full wave, we are finding out first where it is the value is greater than 0 again we take that location and assign that in emg underscore f ok.

Here and then we are finding out that the location again where it is negative and please keep in mind that these location and these location would be different. So, first is it is assigning here the value of the emg signal for the positive cycle and for the negative cycle what it is doing it is taking the negative of the value; that means, it is making it positive and storing it at the same location. So, that the full wave rectification is happening because it is taking the positive half as positive the negative have also it is making it positive and preserving it ok.

So, with that we get the full wave rectification and here we see that output for the emg signal given here this is the half wave rectification and the full wave rectification we cannot actually see much difference from this plot ok, though there will be some difference as we can get that operation is a different, but it is not apparently visible from there the plot.

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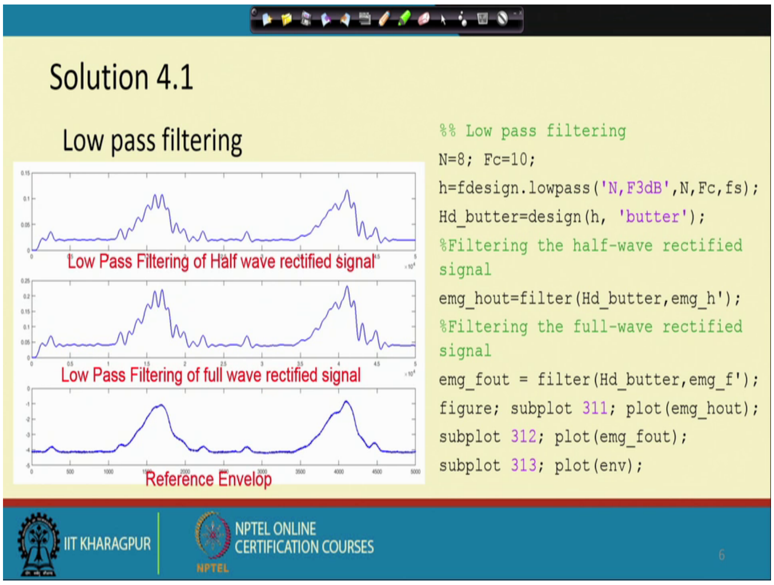

So, we go for the next state that is the low pass filtering, what is this purpose of this low pass filtering because that after the that rectification what will get that viewed get a that jagged signal or we can say a lot of ripple is there along with that d c signal.

So, we would like to remove that the ripple or reduce the amount of ripple or a c frequencies in that and for that purpose a low pass filter is suggested with order eight and first starting with cutoff frequency at 10. So, using the that the design criteria that the order and the that 3 dB band width that we assign them n and Fc the 10 and f s is we know that in this case that we have 10 kilohertz that with that that we have created the design and then we have created the low power butter worth filter here using that that criteria.

And then first we the actually use the that half wave rectified emg signal to pass it through that butter worth filter and next we also get the filtered output of the full wave rectification using the same filter, we get here and now we are having three plots one below other at the top that we have that the half wave rectifier output that which is that after filtering we are getting. So, second we are getting that low pass filtered full wave rectifier output and at the below of this two we get that envelop that is given as a reference ok.

So, these through three we expect here and this is the 3 inputs that is given here that at the top half wave rectifier output after filtering that what we get that because of the filtering lot of high frequency component has reduce. So, ripple has gone down it does not look. So, jagged it both of them they look close to the reference in below.

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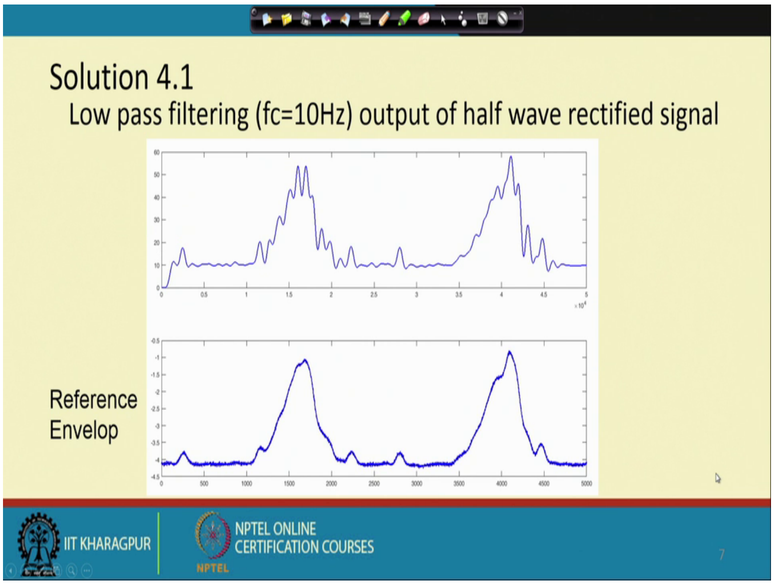

So, here we can see it more clearly for the low pass filtering at 10 hertz cut off frequency the output of the half wave rectifier it is shown with respect to the reference ok.

Next which is the that cutoff frequency cutoff frequency is increased that it has taken to 12.5 now as we are increasing the cutoff frequency that the increase in the that envelope this part it is following more with like the that the reference envelope the movement is faster, but the ripple is increasing ok. So, that is the thing what we notice next we increase it further it has made to fifteen hertz the cut off frequency. So, more high frequencies are allowed.

So, we get that this is the rise are becoming more actually smooth and it is actually do not have much lag it is following the same as the that increase here, but ripples are increasing ok. So, with that let us moved ahead increase the cutoff frequency further. So, we are preserving up to 17.5 hertz and we see that ripple has again increased a little more and then we go for the 20 hertz, we get further increase. So, which actually makes it sure that the more we are increasing that cutoff frequency the envelope is getting deteriorated ok.

We cannot say that envelope is looking better though it is actually changing faster and following that the faster change as with their with respect to the reference envelop.

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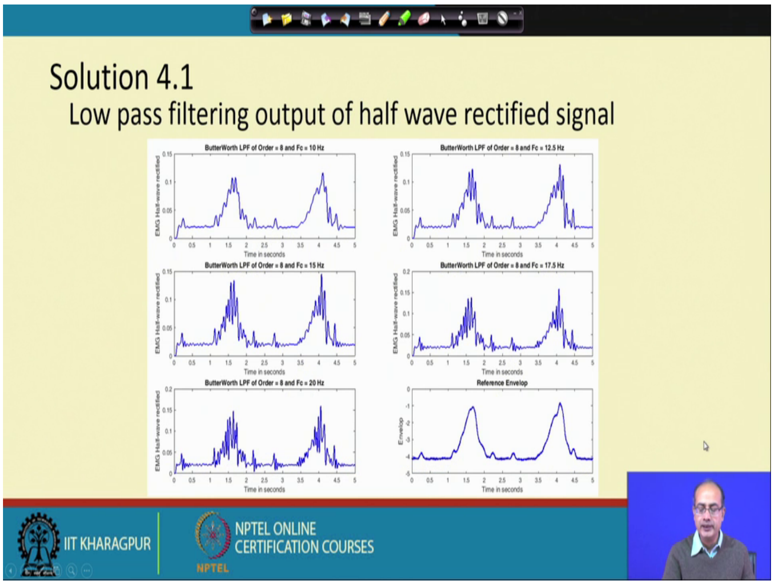

Now, let us put them together to study their effect side by side here we start with that that we are start starting with that the 10 hertz and in each case the low pass filter order is same. So, only change is in the cutoff frequency, then going to 12.5 then fifteen 17.5 and 20 what we see that as we are increasing the cutoff frequency more and more ripples are coming in the output and that when we compared with the reference signal we find that that is not a desirable one.

So, out of them though maybe the change maybe a little slower; that means, the way it is increasing or decreasing that may be better when we have more high frequency terms, but because of the that the presence of ripple in the output we find that at 10 hertz the output was the best for the that half wave rectifier. Now we have to go for the full wave rectifier output. So, first we take that case that when 10 hertz is the cutoff frequency. So, we get some small amount of ripple at 10 hertz, then we move for that other cutoff frequency next point is 12.5 hertz we are going for that we see there is some increasing ripple.

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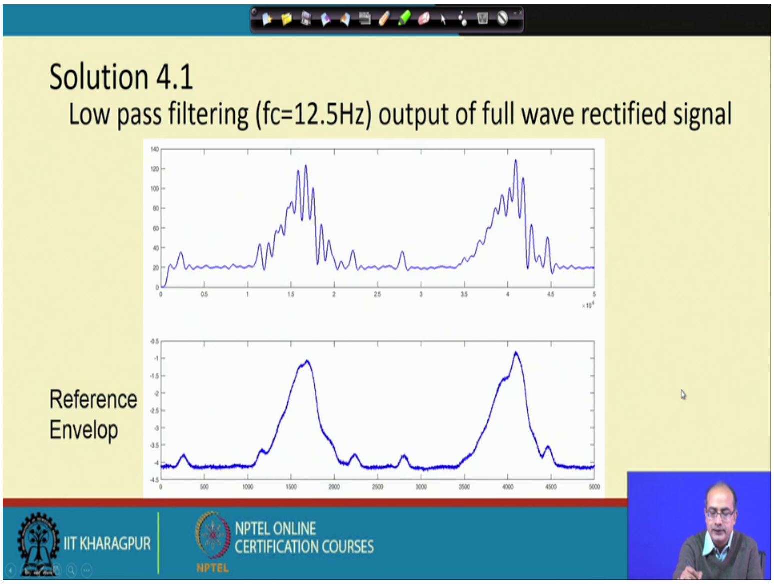

Next we would increase it further to see that what is the change.

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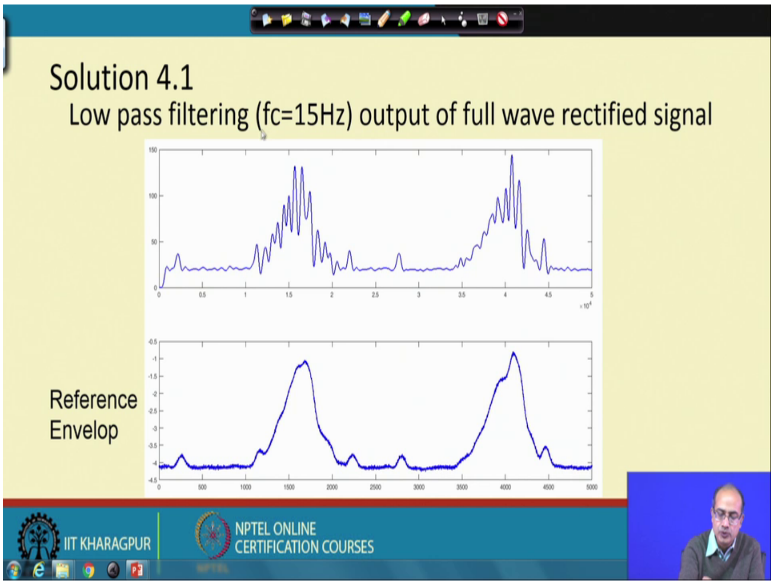

So, it is increased to 15 hertz ok. So, as it is increasing that it is the changes are coming in the same way. In fact, the shaft reduction it is followed here, but what we find that ripples are also increased.

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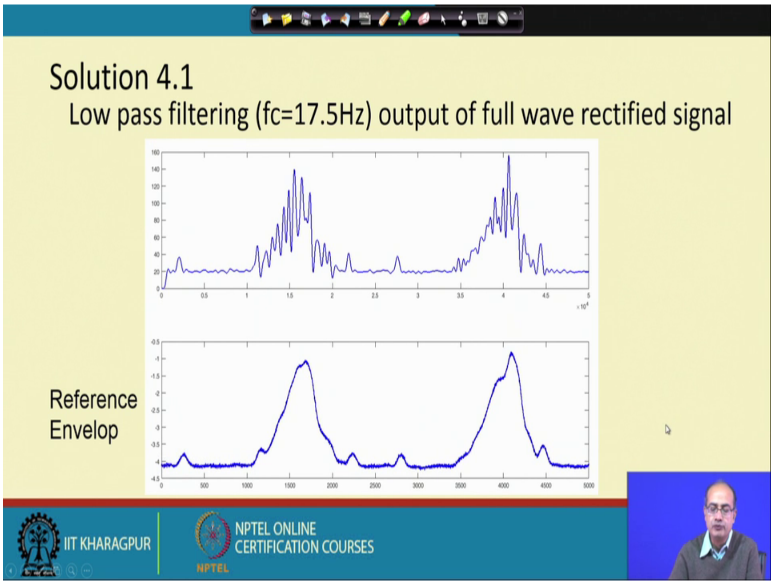

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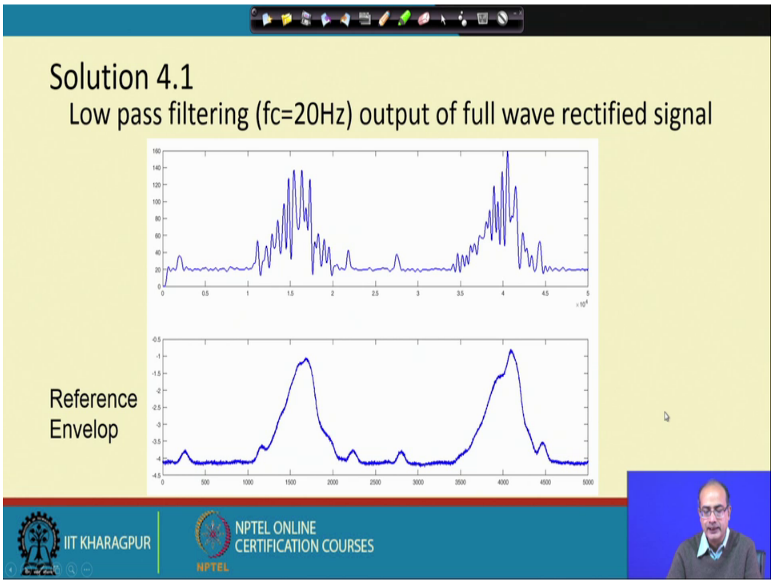

So, again it is interested further 17.5 hertz and we see more and more ripples are coming at 20 hertz. We say that the ripples are almost as big as the envelope and to compare them we put them together what we see here that starting from 10 hertz as we increase the cutoff frequency to 12.5, 15, 17.5, 20, each of these case that we have increased in that ripple in the output though at higher frequency the changes what is occurring in the reference envelope those changes are reflected in a better way, but the amount of ripple that is getting in the output that does not make it a good representation of the envelope.

So, if you look at these cases, we can easily say that 10 hertz is better as a choice of cutoff frequency for that and another thing, we get that when we are going for the full wave rectifier the output is more closer to the reference wave form what is provided with us ok.

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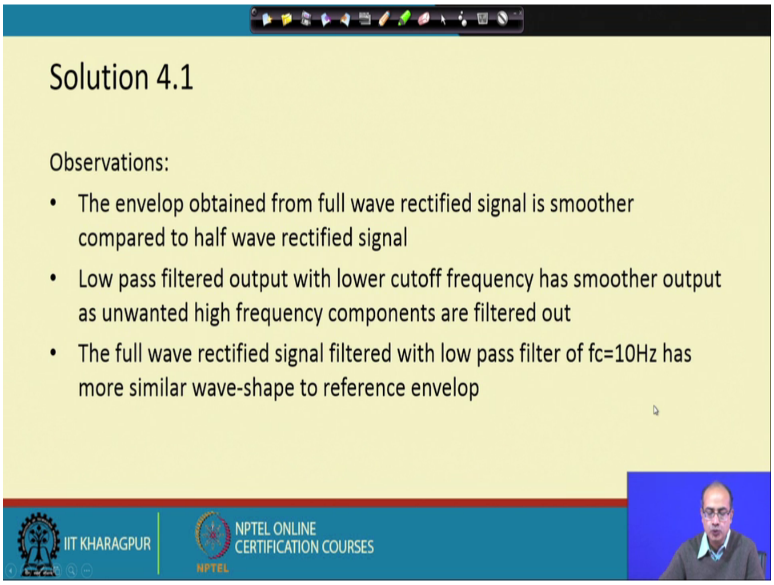

So, these are the things we get now let us conclude with the observations here the envelope obtained from full wave rectified signal is whether compared to the half wave rectified signal ok; that when you go for the full wave rectified signal that it is have been will be smoother than the half wave rectified signal.

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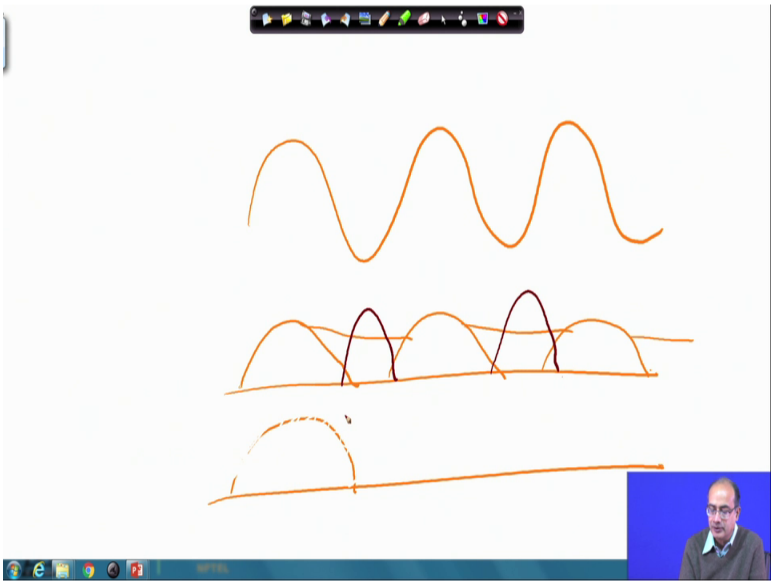

The think could be we can look at the picture one picture to make it easy that let us take a sinusoid ok, a sinusoidal signal. Now, if we have half wave rectification what will have will have the output would be like this and after the filtering, we will get this kind of signal compare to that that what will get in that or let me clean this part that or I think better, it would be let me change the color ok, if we take Fourier rectifier we are getting one more actually the negative parts are also having that.

Now, if we look at the ripple frequency ripple frequency has increased now because of that the rejection would be better that actually giving rise to the fact that we are having a better actually signal as an output ok.

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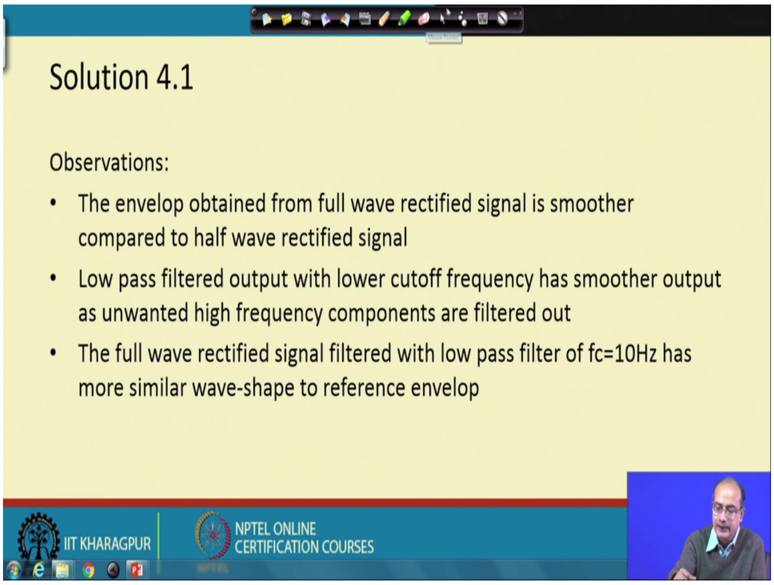

So, we get a better signal as output. So, smother signal as a output second part is low pass filtered output with low cutoff frequency has smoother output has unwanted high frequency components are filtered out when we are increasing the cut off frequency. It is allowing more and more high frequency components and actually destroying the quality of the envelope. And in both the full wave rectifiers signal and that what we get and for that half wave rectifier that we found that low pass filter with cut off frequency 10 hertz. It gives us the best output ok. So, that is our observation from this assignment.

Thank you.