Biomedical Signal Processing
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Lecture – 33
Waveform Analysis (Contd.)

So now we will summarize this topic of the waveform analysis. First, what we had looked.

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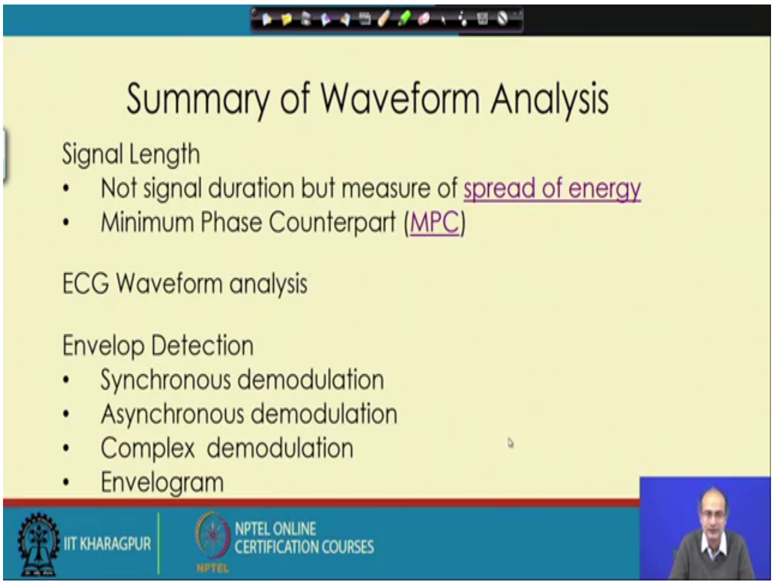

At that is a signal length that the; we need to keep in mind that signal length is not the duration of the signal, but what we are looking at that is the spread of the energy of the signal.

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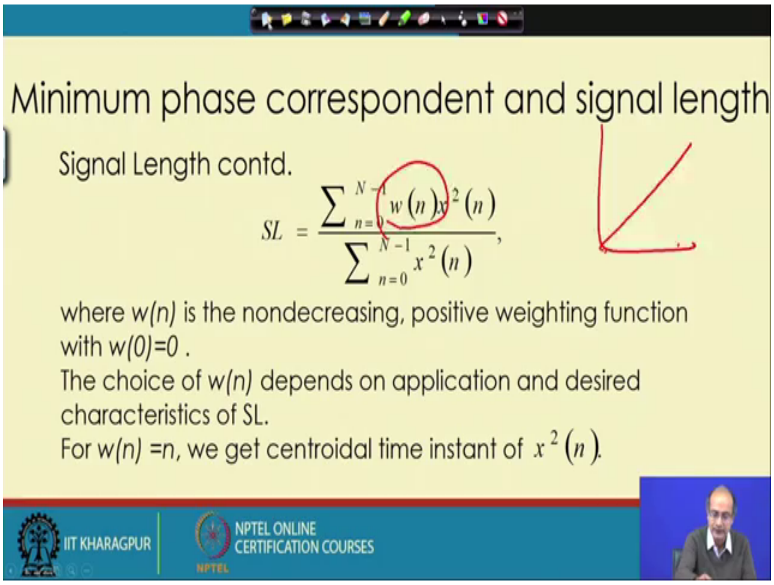

So, if we go back to the formula of that that signal length that will help us to remember that it is a ratio of the energies in the numerator we have a weighting function that wn that that is giving us actually the that the change and the wn is a non decreasing function the simplest form of of it could be that it is monotonically increasing ok.

So, in the case that what we are interested to get that the signal distribution is how far from the origin if the signal is located near the origin the signal length would be small if it is away from the origin then the that value would be more even for the same amount of energy and to make sure that we have actually used that estimate of the energy of the whole signal in the denominator ok. So, that was the; that notion and.

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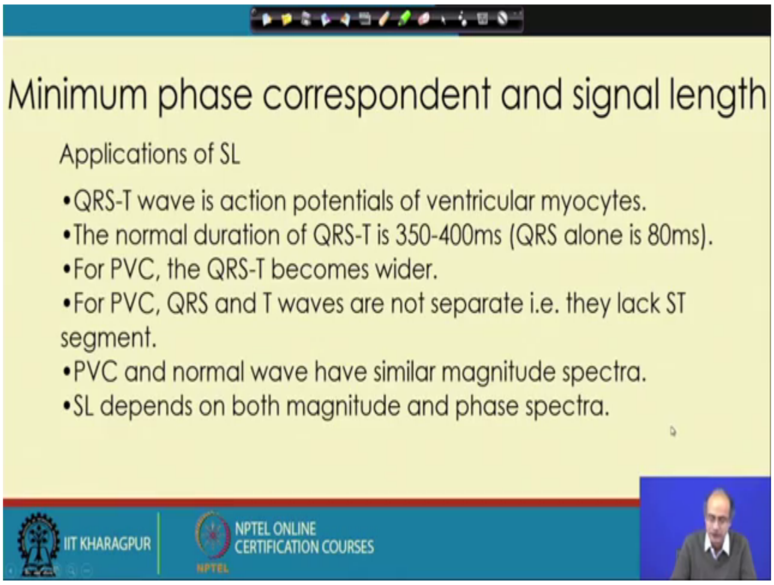

This has been used for many things like ecg signal in particular starting from the P wave that it has been done and most of the energy is concentrated in the QRS complex.

So, to get actually that how much energy is there in the QRS that in case of a topic beat and PVC we know the QRS becomes wider the ST segment that gets elevated. So, all these things can be actually captured in that though the; that there is not much change in the that spectrum of the PVC signal and compared to the normal that spectrum of the signal ok, but signal length is able to actually get that because it not only depends on the magnitude of the spectra, but the phase of the spectrum.

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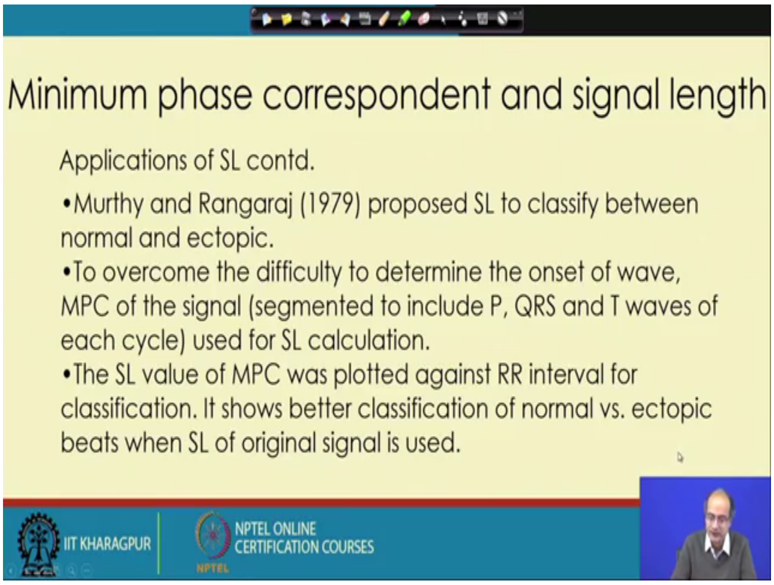

So, that Murthy and Rangaraj suggested a technique that they let us look at that part from P to T wave and what they have suggested to use actually MCP.

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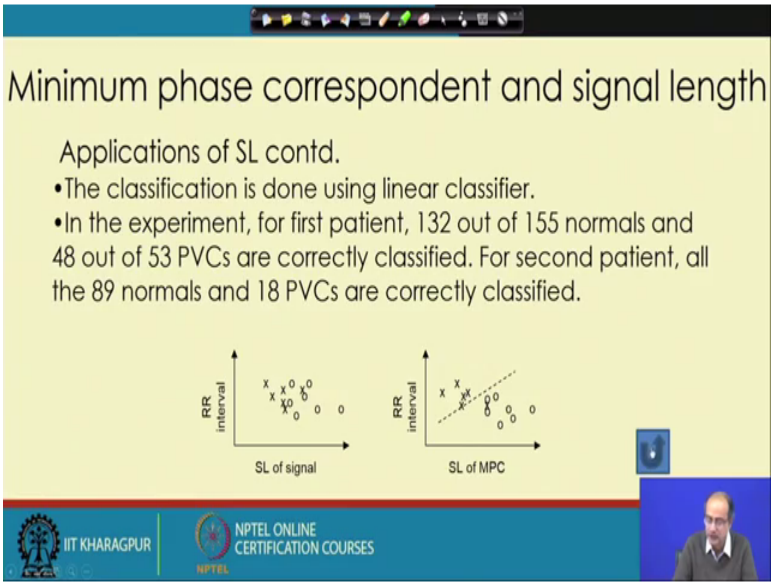

And using that they have conducted an experiment, where with the help of linear classifier they have shown ;that if we have taken the minimum phase correspondent that we can get better classification here compared to that the signal if we take the signal length which also somewhat gives the separation.

Now, here another part comes in that way that is minimum phase correspondent or minimum phase counterpart that that MPC.

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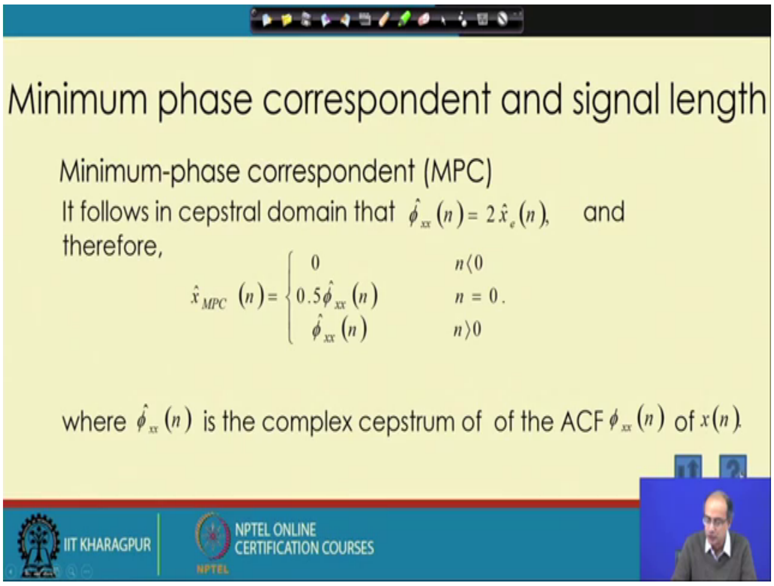

That if we look at that MPC formula, that here we have given that if we compute the that autocorrelation of the signal and if we go to the cepstral domain then we can using this formula we can get that minimum phase correspondent of that signal, but we need to keep in mind it is in the actually complex cepstrum of the signal.

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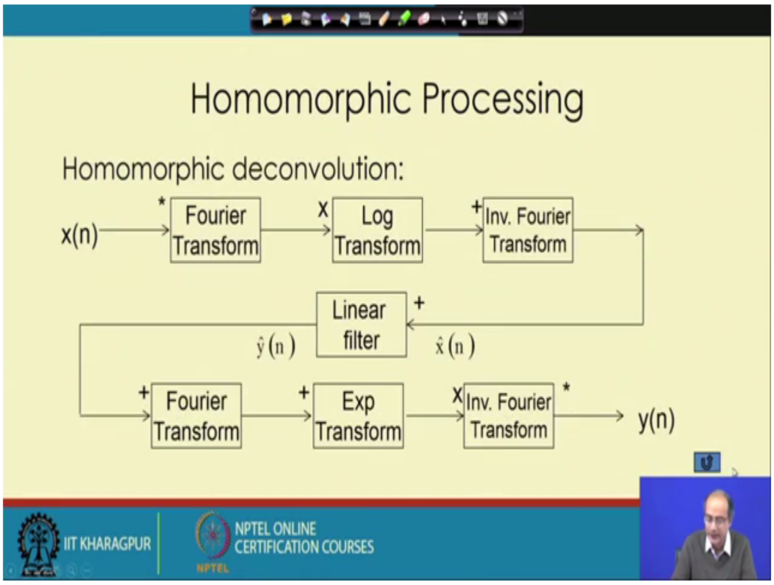

So, we should look back that what was the that how to get from the complex cepstrum to the that time domain signal for that we need to remember the that homomorphic deconvolution steps. Actually the cepstrum; when you look at it is here that we have computed. So, after that the steps which are necessary that we need to take and even for computing that that from the autocorrelation we need to come through this forward part.

So, with that we have computed that the minimum phase correspondent and at the end of it that we get the corresponding the time domain signal which is of importance and what is so important here? That when we take the minimum phase counterpart, we make sure that the starting point it becomes actually the same for all the signals. Otherwise; what will happen? That where we have taken the P wave by a small error of that we will change the phase of that signal and because signal length is very much dependent on the phase it will be disturbed by that actually noise and that is why we get when we take the minimum phase correspondent we get much better result compared to that the original signal ok.

And then we have gone for that ecg wavelet analysis, the simplest form of it if we take that.

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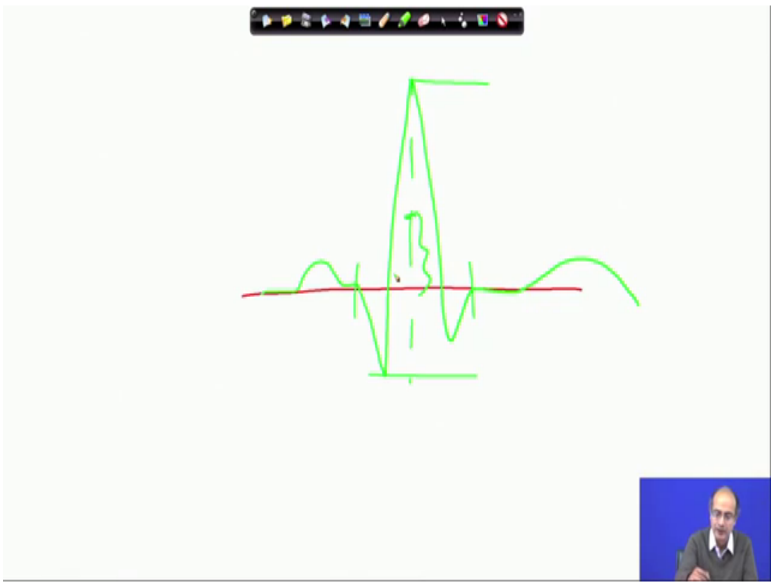

Here is the baseline say and we are taking that P wave followed by the QRS complex, then T wave we are actually interested in that this is the duration then this gives us the height then the midpoint of the height we get and what is the difference of it from the that baseline that gives us some actually way that how to describe the that QRS complex or the properties of it. So, that is a that was one of the suggestion for ecg waveform analysis. Then we have gone for envelope detection.

So, first we have gone for synchronous demodulation; where we have assumed that we know the; that carrier signal and not only the carrier signal frequency, but the phase of it. So, it is a bit synthetic kind of situation which will not get in practice what we will get actually that we get the signal there; so I think in practice asynchronous demodulation would be more useful and both the synchronous and asynchronous they are assuming that it is a monotone kind of signal. Only one strong actually that frequency is present and there is small variation around it, but in real life the signal could have actually multiple modes in the spectrum; that means, multiple tones could be there.

So, for that we should go for the complex demodulation where we target each of the band one at a time and take that the peak of that as a the carrier frequency or the central frequency of that and find out the corresponding modulating signal the amplitude as well as phase and we repeat that till all the prominent peaks are actually represented and thereby we get the full description of the signal. Now another technique is a envelogram and that that there are different motivation for that if we look at all the signal techniques, that synchronous averaging asynchronous averaging complex demodulation we are using a filter low pass filter is used and because of the low pass filter operation low pass filtering operation we need couple of samples to actually to do that filtering operation and that depends on how many points would be required that depends on that what kind of filter we are using; what is the length of that filter?

Now, that essentially means that we never get the instantaneous energy or the envelope of the signal now if we are very particular about the time we want the time resolution then we need to think in a different way and from that point of view, the envelogram was suggested where the hilbert transform of the signal was computed and that added up with the original signal that the complex combination of that that gives rise to analytic signal and the amplitude of the analytic signal provides the envelop of that real signal. So, using that fact we could get the envelogram, but there is still the problem remains that how to get the that hilbert transform. So, easily.

Now, to address that we looked into the fact that if we go for the analytic signal that only the come play that real part of the frequency we have the energy that negative part of the frequency that energy should be 0. So, using that observation we modified that; spectra of the signal in that way in the frequency domain. So, this energy actually that we took the dft and manipulated the spectra to get the spectra of the analytic signal and by the inverse dft we got actually the envelop. Now while we could get the envelop in that way which is accurate in that wave the penalty what we have paid that because of the fourier transform or dft. We have to wear to get some number of signals because the resolution of the fourier transform of dft that depends on the number of the points involved in it.

So, essentially it becomes a block processing algorithm; unlike the previous techniques. So, it becomes another offline technique ok. So, that is the tradeoff.

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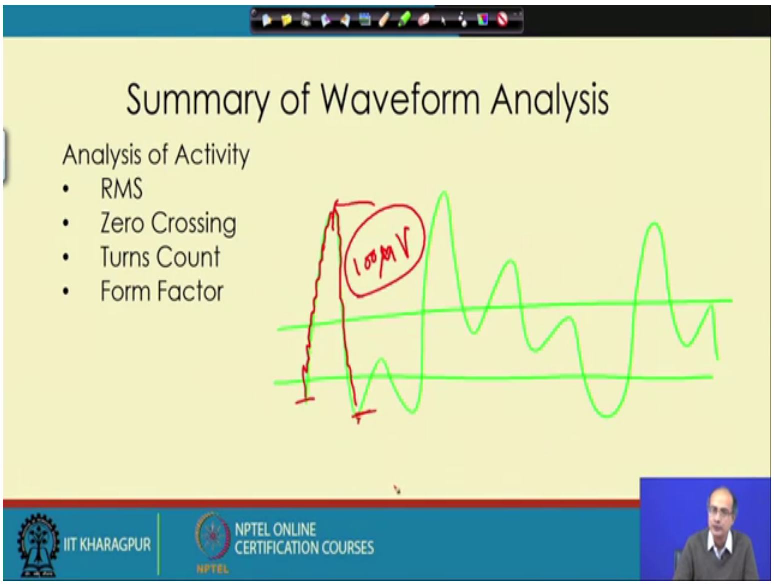

Now, let us look at the other set of actually that waveform analysis techniques; here we have the techniques the analysis of activity primarily they are concentrating on the frequency part of it most of them except for the RMS value. RMS is looking at the energy of that signal and how they are varying with time. So, we can say the amount of information and the quality of information is very similar to the envelope detection algorithm.

So, it can also give us some kind of envelop, but the definition of the envelop changes in this case and it has an interpretation in terms of energy that gives it the strength of existence. Next all the other actually that the techniques the zero crossing and the turns count both of them they are actually dependent on the change in the frequency. We know the signals like emg; the activity becomes more when we are trying to lift actually that more weight or trying to exert more force; that if there is magma in the pcg wave again there is change in frequency and that is actually captured by the simple algorithms like zero crossing which gives the basic notion of change in frequency or the frequency of the signal same thing we can get in the turns count that advantage of the turns count is that zero crossing was affected by that dc baseline.

If we think of a arbitrary signal at arbitrary variation of the signal that then that whatever the baseline will take that may determine that how many actually crossings are happening. If we take the baseline here the results would be different if we move that dc baseline the results will change. So, either we need to remove that dc bias that is one way to take care of that or we can go for that turns count which is not again affected by the dc bias, but again for the turns count; that is getting affected by the high frequency noise and to take care of that what the people have done that as a high frequency noise gives a small kink in that signal everywhere. So, they have told that peaks which are only prominent or having actually that samples in both the sides which are lower or higher than that point that; that means, if this is a peak that before other turn. So, many points would be there and these lengths should be that this magnitude of these changes in between they should be a minimum number only then I would take that as a card.

And for that example they have taken it is 100 micro volt; 100 micro volt, but this value is dependent on that signal and the amplification ok. So, you need to select this value carefully which would make it immune to that the noise corruption, but at the same time it should be sufficient to get the variation of the signal. So, it should not be too high in that. So, at the end of that that we have gone for the technique called form factor. And form factor is really looking at that; how the signal energy is changing? And what is the shape of it? And for that purpose we can say that as a form factor is 1 for our; that sinusoid signal. So, sinusoid is the simplest form of actually oscillation and that is taken as the reference that our signal is how different from the sinusoid that is what is measured by the form factor and that is also depicts the shape in a very concise way. So, with that we complete this chapter.

Thank you.