Basics of Noise and its Measurements
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Lecture – 41
Octave Band Analysis

Hello, welcome to Basics of Noise and its Measurement. In the last lecture, we had discussed this concept of octave bands and explained that, having and using these industry standard internationally accepted definitions of octave band is useful, and it helps compare our results with other results, which have been generated elsewhere, so that we have a common language for communication at least in context of noise. So, that is what we had discussed in the last class.

Now, what we will do today is continue that discussion forward. And, specifically what we will do today is to learn how to calculate results for octave bands. So, what do I mean by that? So, we will discuss octave band analysis.

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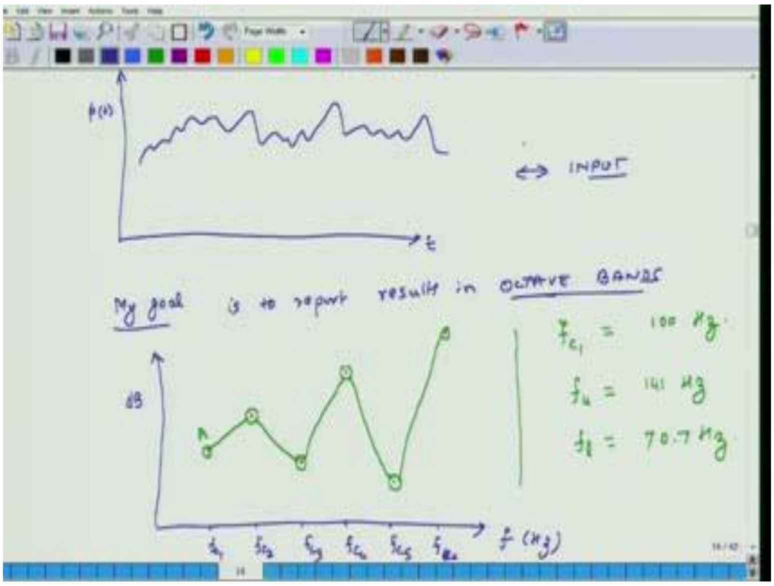

And, what I mean by that is that, suppose this is my time axis and this is my let us say pressure as a function of time. And then, I take my data using data acquisition system and the microphone and all that stuff. I may get some curve. And, what is my goal? So, this is my input. And, my goal is to report results in let us say Octave Bands. My goal is to report results in octave bands. What does that mean? What it means is that, on my frequency axis, which will be in Hertz, I will have a specific centre frequency. And, let us say this is 100, 200, 400, 800 or something; but, these are my standard octave frequencies.

And, on y axis, I had to plot decibels. So, actually instead of, I will just call it f c 1. This is second second – f c 3, f c 4, f c 5, f c 6 and so on and so forth. And, for f c 1 let us say the value is this; f c 2, the value is somewhere different. This is my value for f c 3. That is my value for f c 4. This is f c 5. This is f c 6. And I am going to connect these with some line. So, what does this point mean? Let us say look at this point A. So, let us say the value of f c 1 is equal to 100 Hertz for we can assume that. So, f u is equal to 141 Hertz – 100 times 1.414. And, f l is equal to 100 divided by 1.414. So, it will be 70.7 Hertz. Now, if I look at my f f t plot; so, this is my time series plot. If I do its f f t, I will get some frequency spectrum.

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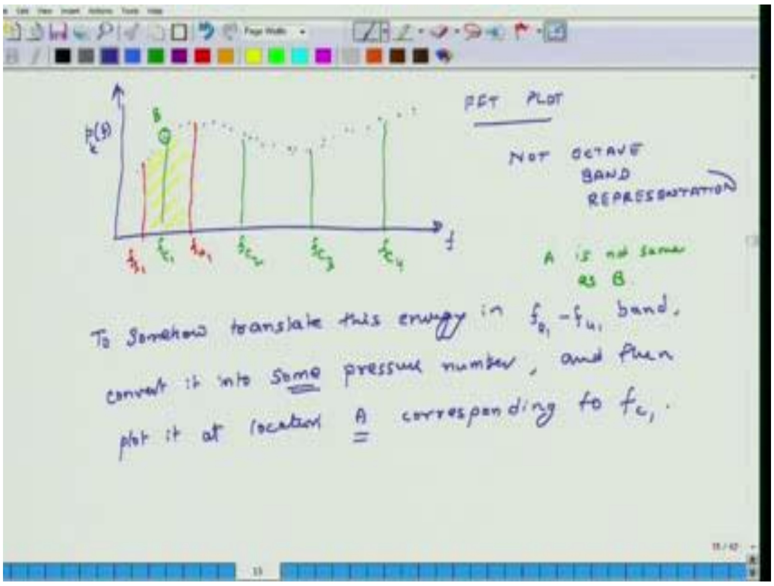

So, this is my f f t plot. This is not octave band analysis. This is not that. So, on my f f t plot, what will I have? It will have some pressures, but they will be a function of frequency. And, how do we get that? We use this d f t; we calculate s k. We convert that s k into the amplitude by dividing it by n, and then taking the magnitude of that. So, that is the actual magnitude, because it will have a phase component in a magnitude. So, what I am plotting is p k for different frequencies. So, I will have all sorts of values. And, there will be 1000s of values. In an octave band analysis, we are reporting results only at a very limited number of points.

Here, if we have a total number of let us say 40,000 points, we may have tens of thousands of these values. We may have 1000s of these values. And, let us say that, this frequency corresponds to f c 1; this frequency corresponds to f c 2; this frequency corresponds to f c 3; this frequency corresponds to f c 4.

So, when I do an octave band representation, I do not use this point to plot on this graph. This point A is not same as point B, A is not same as B. That is not what I am interested in. What I am interested in is that, so this is f c 1 and this may be f u 1; and, this may be f l 1. There may be f u 1 and there will be f l 1. And, there is this energy contained in this whole band. So, what is our aim? Our aim is to somehow translate this energy in f l 1 to f u 1 band; convert it into some pressure number and then plot it at location A corresponding to f c 1, understood?

So, if I just took this value, which is at B and I plotted it in this graph, it would be totally wrong. What I have to do is I have to see this band, see what all points are there - maybe there are 600 points or 1000 points in that band. I have to take care of all those points; somehow each point is associated with some amplitude for of particular frequency. So, I have to somehow add up all that energy and convert that energy. So, then I will get one single number – one; that number I have to be back calculate into pressure. And, that is the pressure which I report here, understood?

So, that is very important to understand. So, it is important to advise the method is very simple, but we have to understand what is happening; what is it that we are doing. So, now, I will explain you how we do this. And, the method is very simple.

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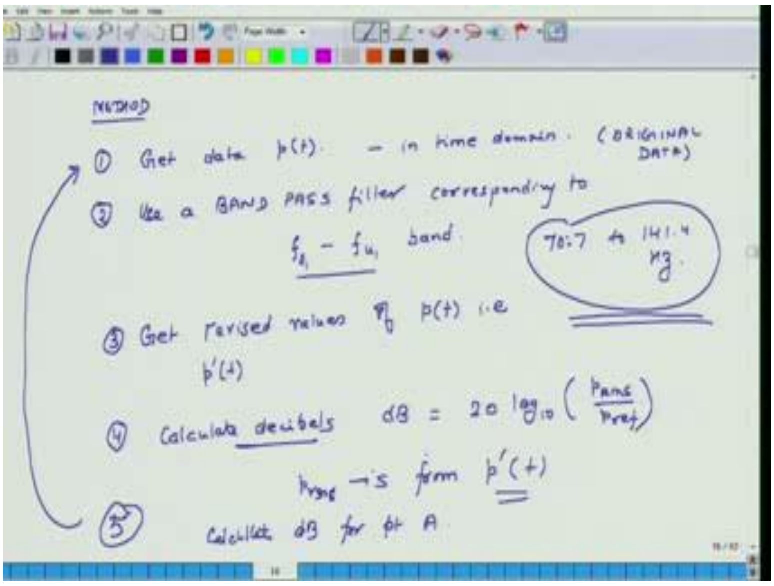

So, first method - first is get data p t. So, this is pressure of the functions of time. This is in time domain. This is my original data. And, I do not use these data ever, because I will be processing this data. So, I have to keep same copy of this for second use and third use and twentieth use. So, I have to save this data.

Second – now, what am I interested in? I am interested in understanding how much energy is in this band. So, what do I do? I use a band pass filter. This again a standard method, I use a band pass filter corresponding to f l 1 to f u 1 band. What does a band pass filter do? So, you can have an actually an electronic filter – hardware. If you put it, then the only signal for you will get from microphone will be for this band. But, you do not want to do that otherwise; you will have to do this experiment lot of times.

So, you get your original data p t and then there are digital filters. So, you were to matlab or some software tool and you say that - this is my original data; either I am giving you this band f l 1 to f u 1. What is the value of this band? 70.7 to 141.4 Hertz; so I give this to matlab and I say please use these bands of pass filter corresponding to this band and give me the revised values of p t, that is p prime t.

So, what have we done through this filter method? We have eliminated all the energy which is below 70.7 Hertz and all the energy which is above 141.4 Hertz. How many points we will have? We will still have not 20-30 points, 1000s of points. But, it will eliminate all that using these software methods, we do not have to discuss them; it will eliminate all the energy from corresponding to all frequencies. It will retain only that energy and those components which are for this band, understood?

Then, what do you do? Now, it is very simple. Fourth – now, what is decibels? Now, you calculate decibels – dB equals 20 log of 10 p rms by p ref. So, let us say 15,000 points. You take the RMS values of all these 15,000 points, understood? And then, you put that in this formula. So, this p rms is from p, is revised data. This is from revised data. So, you get this dB. So, then this gives you? This gives you this value – A.

So, here you are putting in decibels. So, you will get this A. So, what have we done? We have right now done only for that band; now, we have to calculate for the next point. So, how do you do? You go back; so, this thing – p rms. So, you calculate dB for point A. This is fifth. Then you have to go to the next point for – to the next point, you again have to refer to the original data; you do not destroy that original data. And then, what do you do? For the next point, your band is going to be shifted. So, it will be 141.4 times 2 – 282.4. And then, again you apply the band pass filter. You have energy only for that; take the rms; plot it there.

So, when we did this octave analysis, we do not have a phase plot in a magnitude; you only get the energy which is magnitude, because that is what you can; you cannot calculate phase because all frequencies are clubbed into one signal number. So, there is no such thing as phase, it is irrelevant. So, this is what you do. So, here we do not use f f t in this context. If we use f f t and you pick up point B; this will be totally different, because this value will be extremely less, because see the energy is distributed among thousands of points. So, this value will be extremely small if you calculate it at decibels. What we are interested in is adding up all the energy in this thing. So this is how you do it.

So, it will be important to learn to go to matlab and explore what is the matlab; you know this function for band pass filter. Just create an artificial signal, what you can do is, it becomes y is equal to A 1 sin 2 pi f t sin and you put in all the frequencies. So, you know how much energy you are putting for all the frequencies. And then, you can put the filter; calculate what is the decibel value of that thing using this method, which I am explaining you. So, you will get one value.

And then, in another case, what you do is you physically do not include all other frequencies, but only those frequencies in that band. And then, you calculate another value. And, if you have done a math, they should match. So, that way, you can compare whether you are octave band analysis numbers using this method are coming correct or not; whether you understand this concept correctly or not.

So, this is what I wanted to cover in this lecture. And, in the last and in the class which will be tomorrow, we will discuss this concept of weighting.

Thank you very much and have a great day. Bye.