Fundamentals of Acoustics
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Lecture - 69
Octave Band Analysis - Part III

Hello, welcome to Fundamentals of Acoustics. Today is the third day of the last week of this course, since last 2 days we have been discussing some of the important points and techniques which we have to know when we are trying to conduct an octave band analysis. So, in these 2 days we have got sufficient information and knowledge and today what we will learn is use this information to figure out how do we actually construct the plots which are required for performing octave band analysis.

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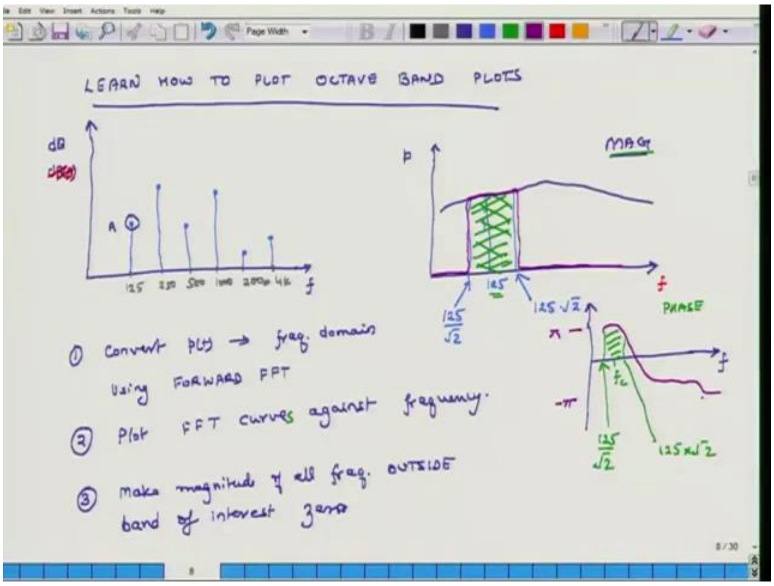

Our goal is to learn how to plot octave band plots. So, we will construct 1 hypothetical plot. So, on the x axis I plot frequency and on the y axis I plot either can, I have to plot decibels or I have to plot dB A and what I do is I plot first I select this specific frequencies. So, let us say we are plotting the octave band plot not one-third octave band plot. So, let us say I am starting from 125 hertz. So, this is my first central frequency then this is 250 500 1000 2000 and let s say 4k, I want to go up to 4k suppose. So, first thing is that I report these decibels only at these central frequencies. So, it will look like this. So, this is an octave band plot corresponding to octave bands which central frequency is 125 255 100 1000 2000 and 4000.

Considered this point A, what does this point A mean? What this point a means is that if. So, for the moment let us just consider that this is the plot on for decibels not dB A. So, what would A mean? What point A means is that is if I have on this plot pressure. So, I can our original data is what in time domain using FFT or DFT, I can convert that data into frequency domain data. So, my frequency domain plot will be something like that and on this plot let us say this is 125 hertz, let us say this frequency is what 125 by square root of 2 and this is 125 times square root of 2.

So, what this point A means is that all the energy associated with frequency is in this band we somehow add them up and convert it into decibel units and once I get decibels from all these frequencies I put it at this single point. So, this single point gives us information about all the energy contain in this band which has the central frequency 125 and which has a upper a upper frequency 125 times square root of 2 lower frequency of 125 divided by square root of 2. So, that is what it means? So, what this means is. So, how do we compute all the energy my FFT plot gives me this curve, it gives me this curve, but from this curve how do I compute all energy which is contained in this and somehow convert it into decibels that is what our aim is.

What we do? So, the way I compute this decibels is through this step by step process first I convert p t into frequency domain how do I do that using forward FFT or which I have also called several times as DFT, now second I plot the FFT curve against what frequency? How many plots will I get? Whenever I do an FFT, how many plots do I get? 2. I get one plot for magnitude. So, this is magnitude and similarly I will get another plot for phase and the phase will be from minus pi to pi. So, I am going to erase this line.

So, let us say this is my phase plot and so, my phase plot looks something like this. So, this is upper limit is pi lower limit is minus pi and this is let us say this is the band of frequency which I am interested in. So, what is this number 125 divided by square root of 2? This is 25 times square root of 2 and this is central frequency f c. So, this is my phase plot and this is my magnitude plot. So we plot the FFT curve, I actually it is not curve, it is curves why because there is some magnitude plot and there is a phase plot. So, we plot both of these then what is our goal what is our goal to add up all the energy in this band right. So, add up all the energy in this band converts it into decibels and plot point A that is our goal. So, our goal is that we have to plot point a from magnitude plot and from phase plot.

So, what do we know? So the third step is that make magnitude of all frequencies outside band of interest 0. So, we make all other frequencies. So, what I am going to do is this magnitude plot I am going to modify it. So, my modified magnitude plot will look like this no it will look like this now if I erase it. So, our original plot one second our original plot was something like this and our modified plot is purple. So, it is like this what does this mean once I have made the amplitude of all other frequency is 0 what have I done effectively I have eliminated the energy from all other frequencies except this band then what do I do?

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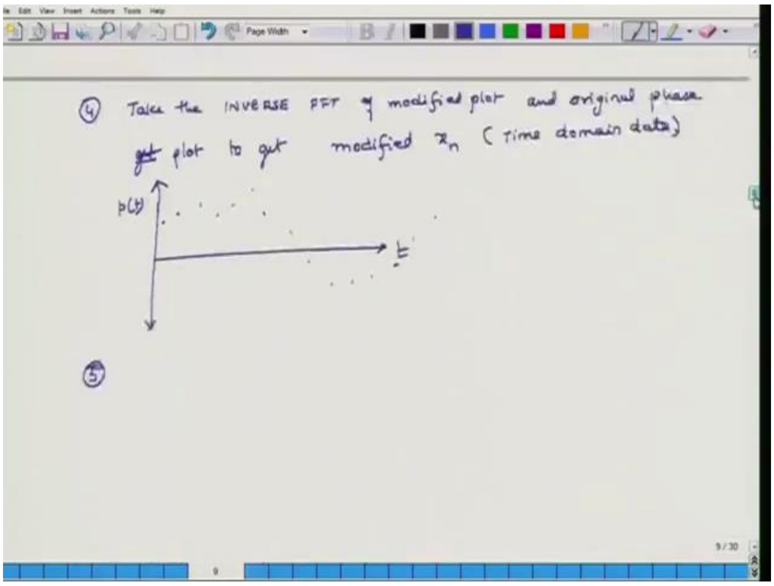

Then 4th by the way, what happens to phase plot, I do not have to worry because I made the energy 0. So, I do not have to worry too much about the phase plot. So, do not bother with the phase plot. So, the next thing is what do I do? I take the inverse transform inverse FFT of modified plot. So, remember when we are doing inverse FFT, we will have to use this information magnitude as well as phase information to do the inverse why you see it here.

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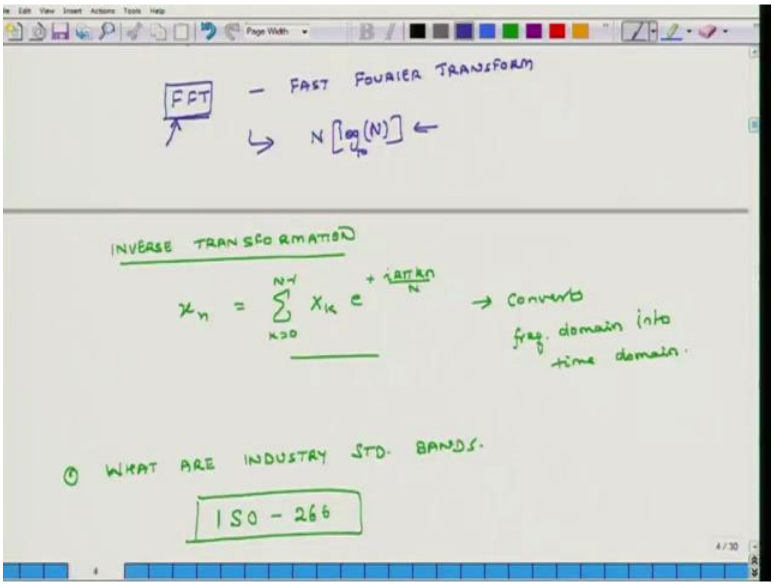

X K is not a necessarily a real number.

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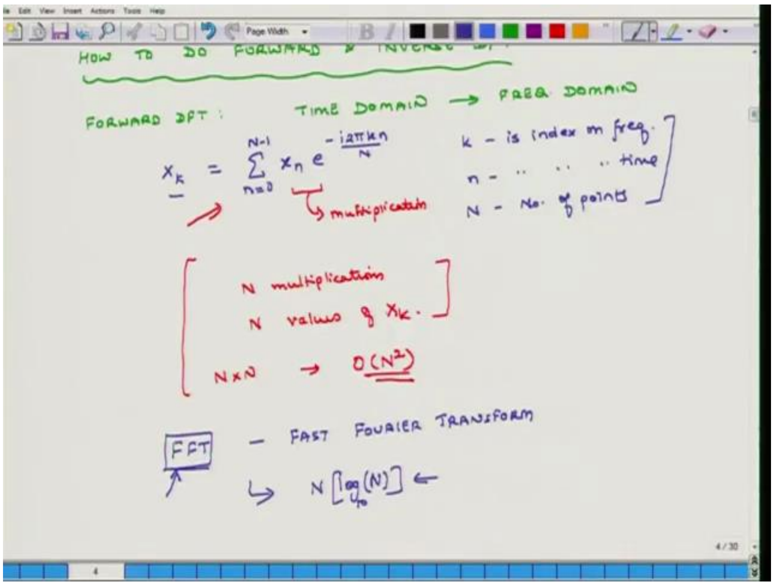

It has magnitude and phase right because it is a complex number. So, I have to use both these plots. So, take the inverse FFT of the magnitude plot and what do I get out of it and get what do I get if I take inverse of magnitude of modified plot and original phase plot. So, in inverse transform what do we get?

Student: Time domain.

Time domain data to get modified x n and this is in time domain data. So, how will my time domain data look like? So, this is my time and what will it look like. So, this is discrete plot. So, what will I get I will get lots of points right I will get lots of points and the y axis is p t and the x axis is time now what do I do this domain data does it have energy associated with other frequencies except for this band it does not because we have made it 0. So, now, what do I do?

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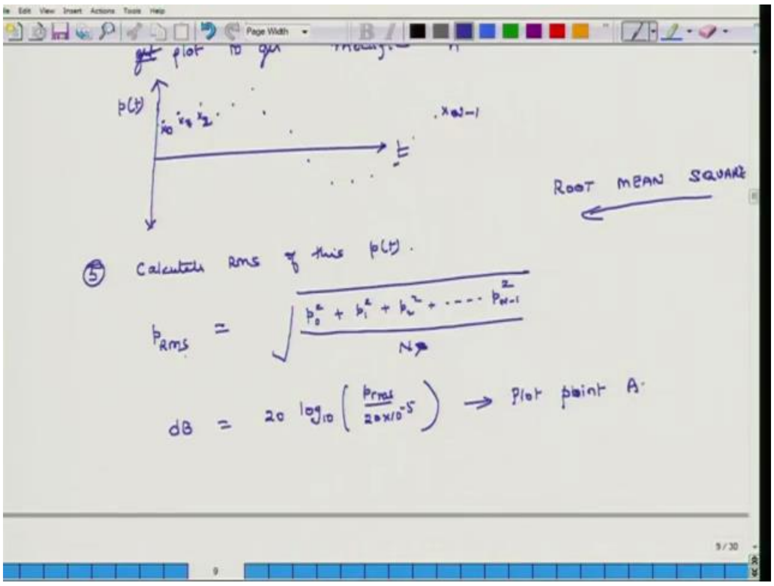

I calculate RMS of this p t root means square, how do I do? Let us say this is x 1 x 2 x 3 and it goes on till x n, x n actually it will start with x 0 x 1 x 2 and it goes on till x minus 1.

To find RMS what do I do? To find RMS first I take the square s, s is a square. So, I do this root means square root mean square. So, I always go in this direction. So, first I take squares. So, p 0 square plus p 1 square plus p 2 square p n minus 1 square then what do I do? I take the mean. So, I take divided by n and then I take the square root I get p RMS then what do I do then? Now I calculate decibels. So, dB equals 20 log 10 p RMS divided by 20 into 10 to the power of minus 5 and in this way I plot which point A or plot point A understood next thing, I have to do is I have to plot point, let us say this is point B, how could I plot point B? I do the same thing in the other case, I make this new band and I make the magnitude of all other frequencies outside this band 0 take the inverse transform get p RMS and I plot dB for point B.

So, likewise I get all these points across the a spectrum if I have to do one third octave band plot what do I do if here I am plotting plots for octave band there the band of interest at a given of point of time will be one-third octave band. So, I find out lower frequency, higher frequency and consider only those frequency is in one third octave band make everything l 0 and so on and so forth.

I hope this helps you understand how do we perform this octave band analysis and in this case we have learnt how do you construct a plot we are on the y axis you have dB and on the x axis you have frequency, but we have 2 types of plots, one is where on the y axis we plot dB and in the other case we plot dB A. Now, we will learn how do you we make a dB d plot.

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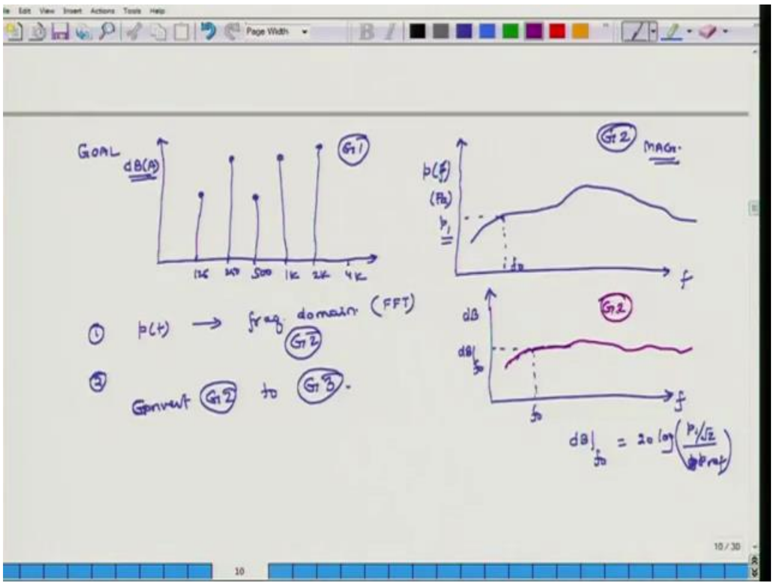

Goal is to make this plot. So, once again this is 125 250 500 1k 2k and so on and so forth 4k. So, here our goal is dB A, what is the difference between dB and dB A? dB is based on pressure data as measured by the microphone, dB A is the pressure data as perceived by year. So, what do we do is. So, first step we convert p t into.

Student: Frequency.

Frequency domain using forward FFT, so we will get lots of points and it will almost look like a continuous curve, but let us say this is my dB curve not dB curve. So, this is pressure as a function of frequency next. So, this is frequency. So, here this is units is pascals unit is pascal and let us say this is the magnitude plot and similarly we will get a phase plot. So, we do not worry about the phase plot that does not change.

The next thing is let us call this graph G 1, let us call this graph G 2. So, here we are getting G 2, now we change from convert G 2 to G 3, what is G 3? It is this plot. So, here I am plotting pressures in decibels, how do I convert this into decibels? Suppose this is some frequency f naught and here pressure is p 1 then how do I convert for f naught? How do I calculate decibels 20 log is it p 1 what is p 1?

Student: (Refer Time: 18:56).

But what is it? Is it the RMS value? No, it is the magnitude and these are specific frequency components. So, each frequency what type of wave is it is a sinusoidal wave. So, the ratio between sinusoid for a ration of RMS for a sinusoidal wave and its magnitude is a square root of 2. So, I take p 1. So, this is at dB at f naught and dB at f naught is what at frequency, f naught which is this is what 20 log p 1 by root 2 by p ref. So, this is important otherwise our answers. So, likewise we construct a dB plot for all the frequencies to construct dB plot for all the frequencies. So, this is our graph G 2 G 3.

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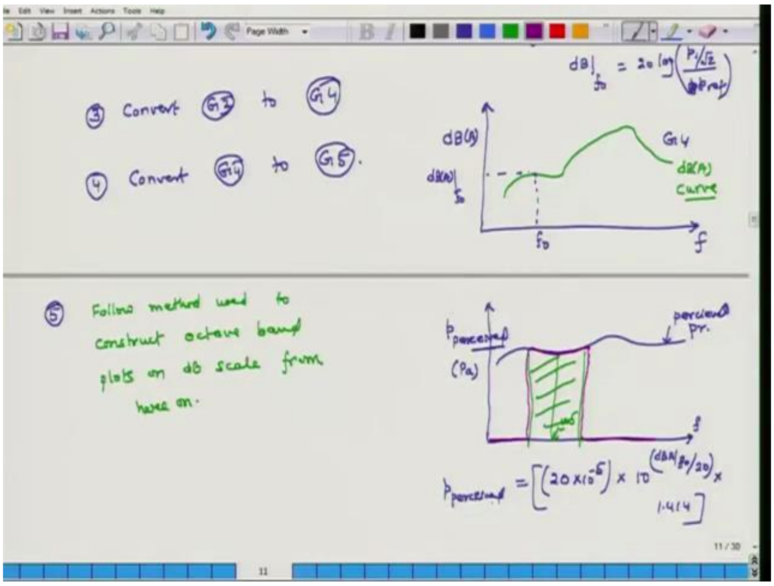

Next what we do? Convert G 2 to G 3, what is G 3? G 3 is a similar plot. So, this is G 3 and this is G 4. So, what is G 4 on the x axis? I am plotting frequency and on the y axis I am plotting dB A. So, this is the original, this is the dB curve, but now for each frequency I have to add or subtract the aviating. So, this is dB A curve, how do I convert a dB into dB A curve for each frequency? We have to calculate the weight, we have to calculate the weight, how much that point moves up or down by and how do we calculate that? In yesterday's class we have calculated, how do we calculate that weight? A f A is a function of frequency. So, I get this dB A curve, 4th convert G 4 to G 5.

This is the perceived curve. So, what does is tell us that for each frequency what is the perceived decibel level? What is the perceived decibel level and from that we can construct p perceived you can construct p perceived and here the units are pascals. So, how do we do that? So, let us consider this frequency f naught and let us say this is dB at f naught actually it is dB A at frequency f naught then p perceived is equal to what it is equal to 20 into 10 to the power of minus 5 times ten to the power of what this is dB A at f naught divided by 20 and this p perceived will be what this will be RMS pressure and what I want is into 1.414. So, I will get the p pressure sp this is perceived pressure at its peak value understood and then.

Now what we do? Now we start calculating energy or perceived energy in each band. So, suppose I have 125 hertz then it has an upper frequency limit, it has a lower frequency limit. So, identify those limits. So, from this I am going to write follow method used to construct octave band plots on dB scale from here on from here on. So, specifically what I do? If I have to get the energy in this band, I identify this band I modify this curve. So, that all other frequencies are 0 take the inverse transform of this modified magnitude curve the phase plot remains unchanged phase plot does not get changed.

So, use the phase plot and this modified p perceived curve compute the RMS construct get the value of dB, but it will not be dB, but it will be dB A because it is based on this p perceived level and develop the curve as shown here as shown here. So, this is the overall approach. So, using this method we can do octave band analysis or one-third octave band analysis or one-tenth octave band analysis whatever, but overall approaches this kind of a thing. So, I hope this makes things pretty clear because I think I have explained it in fair large amount of detail and all these information specially if you are in an industry setting or you are a noise engineer then this understanding of how to conduct octave band analysis will be very useful for your professional needs.

With that we conclude the discussion for today and we will meet once again tomorrow.

Thank you.