Noise Management & Its Control

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Lecture – 07
Decibel Scale – Part 1

Hello, welcome to Noise Management and its Control. This is the start of the second week of this course and what we will be talking about this particular week are several important concepts. The first thing we will start our discussions on is a continuation of our concept of decibels. So, what we will learn is that if there are multiple noise sources; how do they add up and in that context we will also learn about different types of sources; correlated sources, uncorrelated sources and so on and so forth.

Then we will proceed to learn couple of other concepts; specifically we will learn; what is a linear system. The second thing is we will also get back to some basics about complex numbers and finally, we learn about transfers function; the concept of transfer functions. So, this is what we planned to cover over this week and with this; we will conclude our discussions on overview of some of the important concepts which will be used in this course.

So, starting today, we will continue our discussion on decibels.

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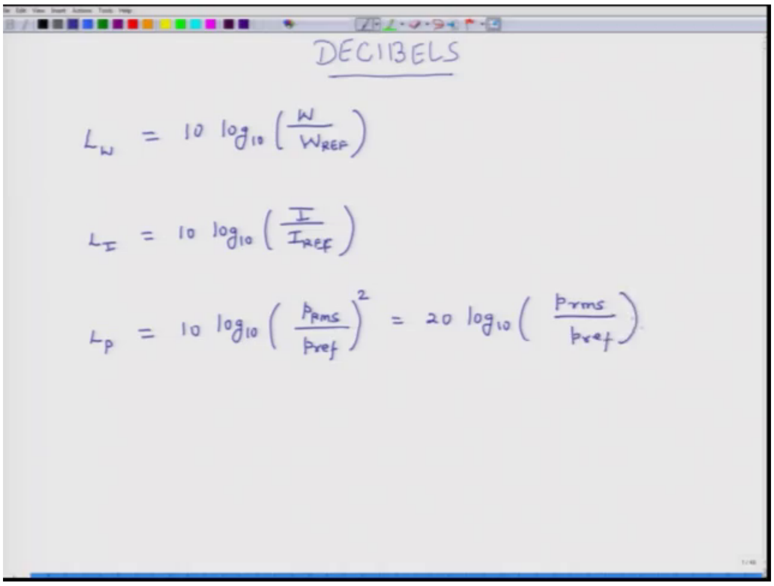

We will learn a little bit more about decibels, we had defined three decibels levels; first one was sound power level L W and that was defined as 10 log 10. And then whatever is the number of watts; which are being emitted by the sound source divided by reference watts. Then we had defined sound intensity level and that equals 10 log on base 10; I divided by reference intensity.

And finally, sound pressure level L P and that is 10 log 10; PRMS by P ref and then this entire thing was squared. So, this could also be written as 20 log; 10 PRMS divided by P ref.

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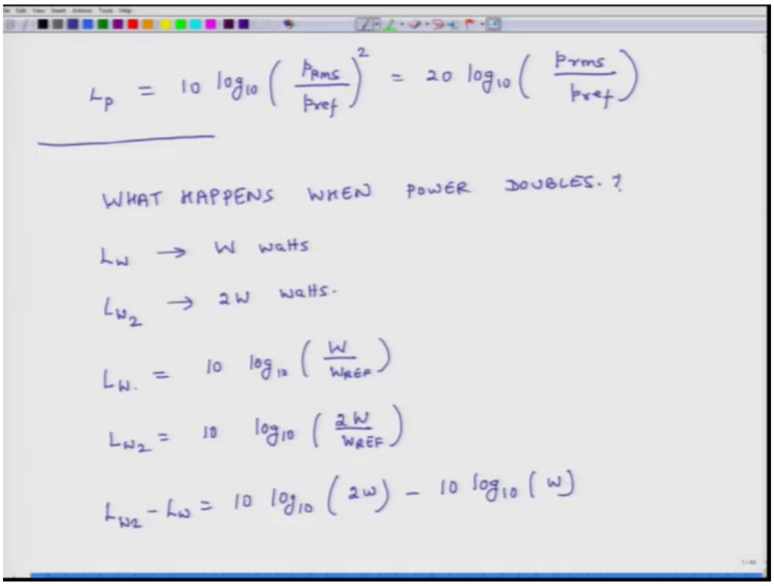

So, the first thing we will see is what happens if power doubles or pressure double or intensity double. So, what happens when power doubles? So, let us say the original; initially the sound power level is L W and that corresponds to W watts. And then we want to know what is L W 2; when twice as many watts are produced. So, L W is equal to 10 log 10; W by W REF and L W 2 is equal to 10 log 10; 2 W by W REF.

So, if I take the difference between these two; L W 2 minus L W; that equals 10 log 10; 2 W minus 10 log 10 W because the log of the W REF gets cancelled from both the sides.

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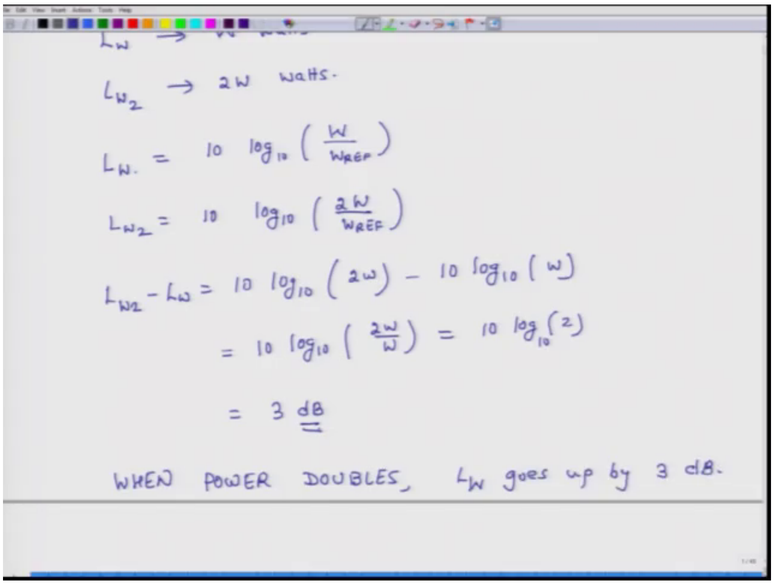

And this is equal to 10 log 10; 2 W over W and that equals 10 log 10 of 2 and log of 2 is 0.3 roughly, so this is equal to 3 dB; 3 decibels. So, if this is an important lesson that when power doubles then L W goes up by 3 decibels.

Similarly, when intensity doubles the relation is similar, so L I goes up by 3 decibels or let us see what happens to pressure.

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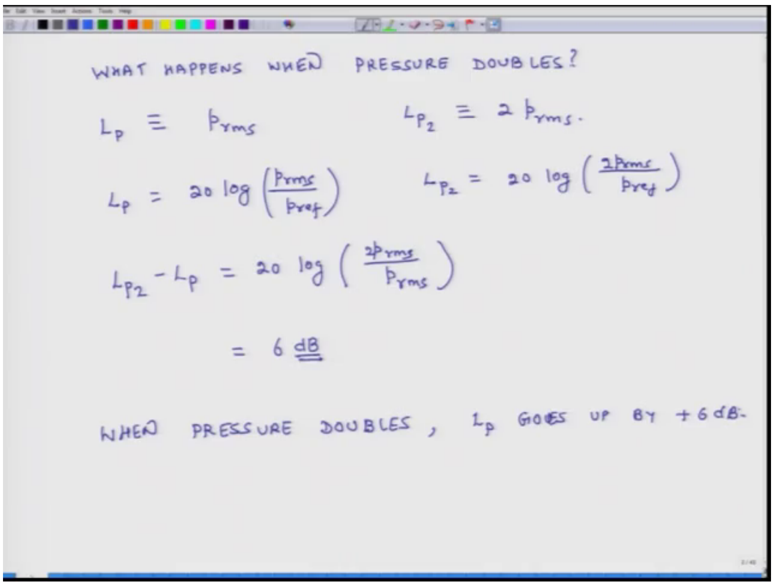

So, what happens when pressure doubles? So, let us say our initial pressure is L P and so, that corresponds to a pressure value of PRMS. And suppose I double this pressure, then the new pressure level is L P 2 and that corresponds to pressure level of 2 PRMS. So, we will figure out what is the difference between L P 2 and L P? So, that is L P equals 20 log PRMS by P ref and L P 2 is 20 log PRMS but the value of PRMS is twice the original pressure and then divided by P ref.

So, L P 2 minus L P equals 20 log PRMS; divide twice of PRMS divided by PRMS. So, PRMS cancels out again log of 2 is 0.3, so this is equal to 6 decibels. So, the important thing to note is that when pressure doubles, L P goes up by 6 decibels. So, we cannot impulsively just say that of pressure has gone up, so it will be 3 decibels. So, that would be true for power and intensity, but for pressure it is 6 decibels; so, we will make some important observations.

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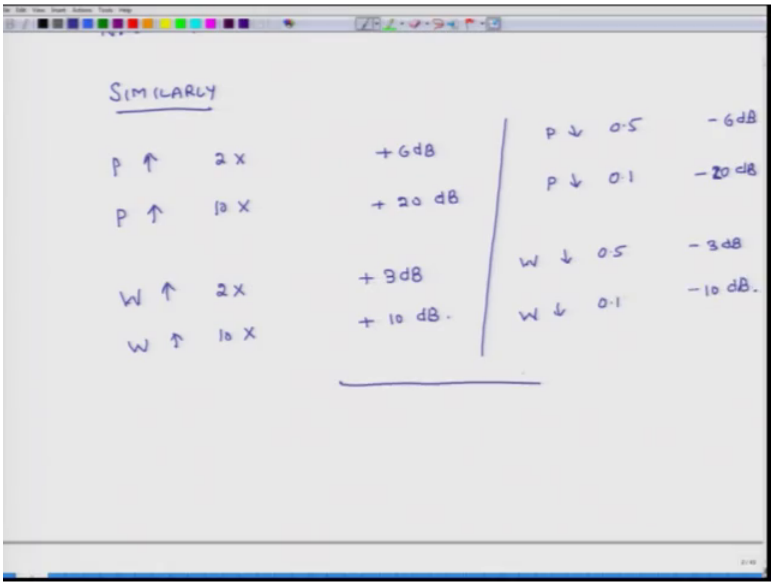

Similarly, when pressure goes up by 2 X; we gain 6 decibels, when pressure goes up by 10 X; 10 times, then we get 20 decibels increase in L P.

When watts or power goes up by 2 X, we gain 3 decibels in power and when watts or power level goes up by 10 X; then we gain 10 decibels in power. I can also extend this logic when pressure goes down by a factor of half, then I lose 6 decibels in sound pressure level. And when pressure goes down to a tenth of it is original value; so, it is 0.1, then I lose 10 decibels in sound pressure level. Similarly;

Student: Minus 20.

Minus 20; I am sorry, similarly when power goes down by a factor of 2; that is half, I lose 3 decibels in sound power level. And when power goes down by a factor of 10, then I lose 10 decibels in sound power level. So, these are some important observations and it will be worthwhile to remember them as we move on. So, the next thing I am going to discuss is RMS.

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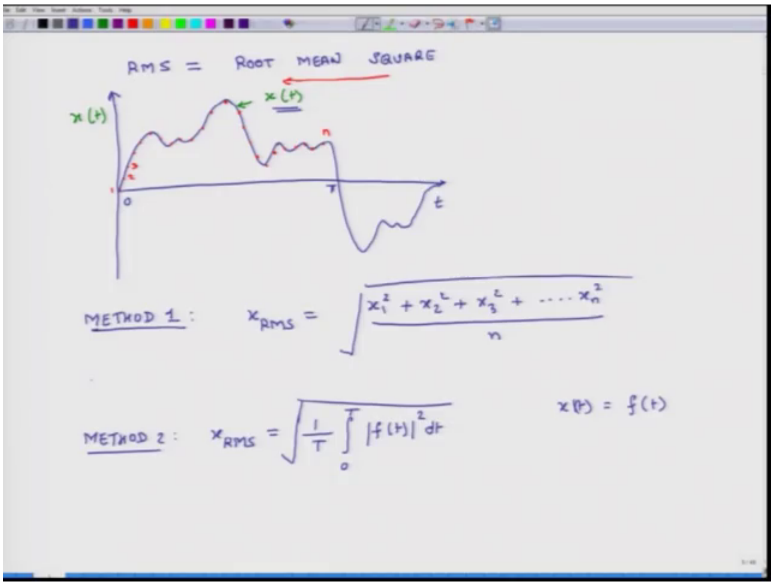

So, why is RMS important? We need to know what is the RMS value of a signal because when we are computing sound pressure level then this is defined as 20 log p rms divided by p ref. So, we have to know what is the RMS value of a signal? So, we will have some a little bit extended discussion on this RMS pressure or RMS value of any signal.

So, RMS it stands for root mean square of a signal. So, how do we compute it? So, let us say I have a signal and there are two ways to calculate it. One is using calculus and the other one is using numerical integration, it depends on what type of signal we have. So, let us say we have a signal like this and I depict this signal as; I call it X as a function of time. So, this is my time axis and this is X; which is a function of time.

And what I will do and this I had explain earlier also, but I will recap this because this some additional information we will learn today. So, what we do is we break this; so, one way to compute the RMS of the signal is to break the signal into small, small points; discretize it.

So, let us say this is point 1, 2, 3 and let us say this is point n; nth point. Then the first way to compute RMS method one; so method one is useful when I do not have an explicit form of X t; rather I have some data points, discrete data points with most of the experimental data which we collect we do not get continuous functions, rather we get discrete data points. So, if we have discrete data points then we use this; then value of X RMS.

So, value of the RMS of the signal is what? First I take the squares. So, x 1 square plus x 2 square plus x 3 square put a dot; x n square. So, I have taken the squares of it, next I take its mean. So, there are n points; so, I divide it by n and then I take the square root, so, this is method one.

So, that is root mean square; now there could be a situation where I do not have these discrete data points, but rather I know the continuous function in some algebraic form. So, in that case I may want to use a second method; method 2, here x RMS is; so, I will explain what is T? Is this relation. So, let us say this is time is 0 here and this is time is equal to T and suppose I want to compute the RMS of this signal which is t seconds long.

Then x t is defined as is same as f t; then the RMS value of this is. So, what I do is; I have this expression f t, its absolute value the whole thing squared into 1 over t then I integrate this thing and take the square root and that is how I get the RMS value. This is a definite integral; so, I integrate it between time T is equal to 0 to time T is equal to T.

If I am interested in finding the RMS from time T 1 to T 2, then these just limits change from T 1 to T 2; I integrate it and I divide the entire thing by T 2 minus T 1.

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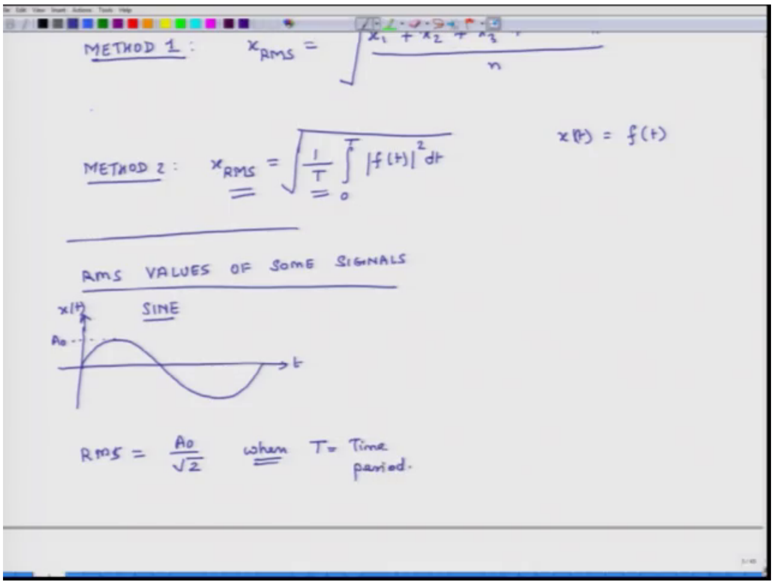

So, with this understanding we will look at some signals. So, RMS values of some signals, so if I have a sinusoidal signal or it could be a cosine signal as well; does not matter. So, this is a sin and let us say this; amplitude is A naught, so my X axis is time, y is X t; then RMS is A naught divided by square root of 2.

So, for a sinusoidal or a cosine signal; perfect sin cosine wave, the RMS is A naught divided by square root of 2; when because remember the RMS is computed over a time length. So, here when T equals time period; if I compute over some other time then it will not be A naught divided by the square root of 2. So, it is important to understand; if I am trying to compute the RMS over the time period of a sin signal only then it will be A naught divided by square root of 2.

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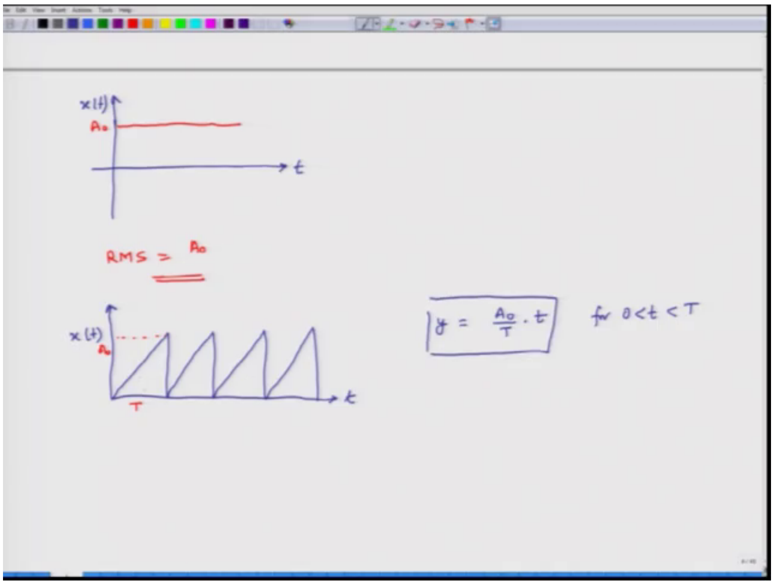

Another signal; so, this is t; this is X t and my function is just a straight constant line. So, in this case RMS equals; so, if this is A naught then it is equal to A naught; here time period does not matter.

Third case; so, the third case is a saw tooth pattern and let us say that. So, this is repeating; this thing is repeating itself and the amplitude is A naught, time period is T then I can say that y is what? A naught divided by T times t; for t between limits 0 and T; this is the function. Over a time period, the signal looks like this and then it repeats itself. So, over a time period if I have to compute it is RMS; I know the answer, but in this case we will actually do it. So, y RMS equals; so, we will go back to the relation.

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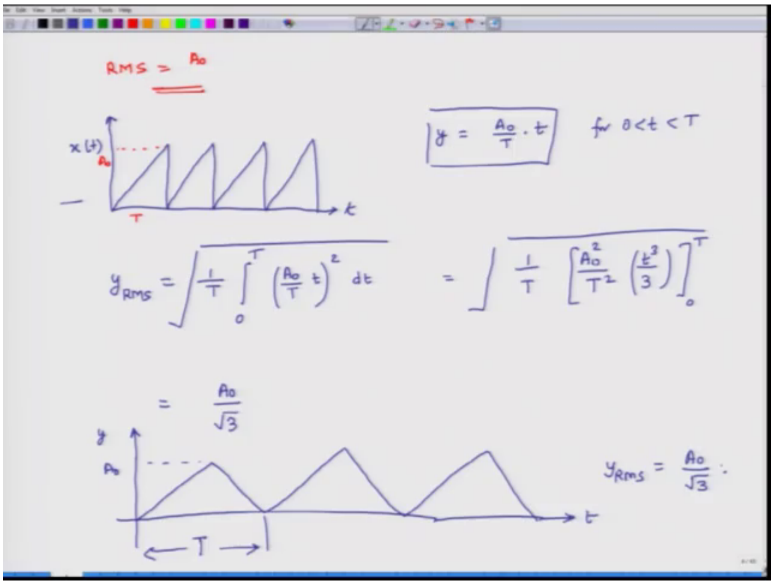

F t; the modulus of this thing whole square integrated overtime, divided by time period and then we take the square root.

So, this is 1 by T; 0 to T and the function is A naught divided by capital T times t; the whole thing square. So, A naught divided by T times t and this I do not have to worry about modulus because A naught is positive, capital T is positive; t is positive. So, everything is going to be positive; d t. So, this is 1 over capital T; A naught by T square; t cube by 3. And this is evaluated from 0 to T and this equals; A naught divided by square root of 3, because when I evaluate t cube over 3 at capital T n 0 this is what I end up with. So, the RMS of this signal; the saw tooth pattern is A naught divided by the square root of 3.

Similarly, the RMS of a triangular wave; so, this is my time period and this is A naught. So, that is my X axis time; Y axis is X t; here also in this case also y RMS is A naught divided by the square root of 3. You can prove it do it and convince yourself. So, I think this concludes the discussion on RMS as well as a little bit of discussion on decibels and we will continue this discussion tomorrow also. So, till then have a great day and we will meet tomorrow.

Thank you.