Noise Management & Its Control
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Lecture – 08
Decibel Scale – Part 2

Hello. Welcome to noise measurement and it is control course again. Today is the second day of the second week of this course. And what we will do today is continue our discussion on decimals, and we will learn how to add up decibels if there are more than one signals present.

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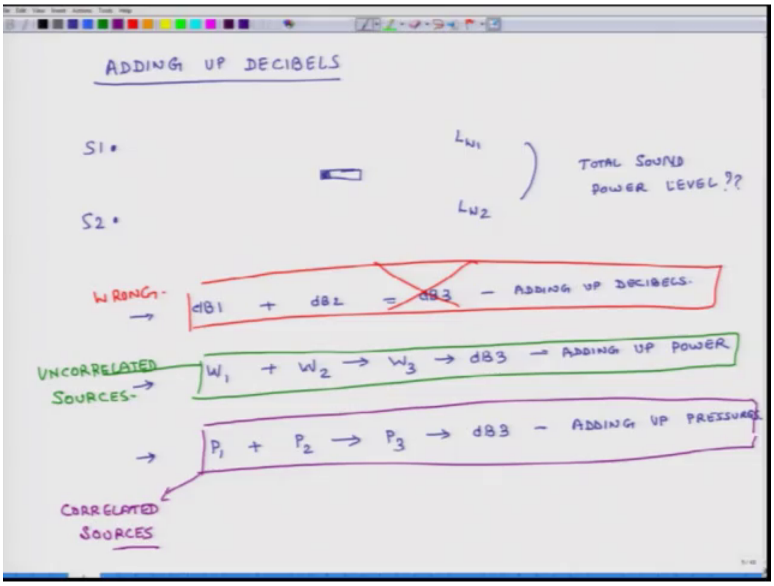

So, the theme of today's discussion is going to be adding up decibels. So, what do we mean by adding up decibels. So, essentially what I imply is that suppose there is one source S1, there is another source S2 and we have a microphone here. And let us say source 2 initially is not active. So, only source 1 is working and let say my decibel level is LW1 only in presence of the first source.

And only in the presence of second source my decibel level, when the only second sources present and first source is not present it is LW 2. Then the question would be that when both of these sources are present, what is the total sound level. So, in this case it is W. So, I will say sound total sound power level, what is it now there may be several ways to do this and some of the ways may be correct some ways maybe approaches may be wrong. One would think that maybe if because of S1 it is dB 1. And because of S2 if it is dB 2, then I just add them up and that gives me dB 3. So, in this case what we are doing is adding up decibels. This is one way to add it. So, first we will write what are several possibilities and see whether it makes sense or not.

So, suppose in first case it is 100 decibels and dB 2 is 20 decibels I just add them up and I say what is going to be 120 decibels. Is that correct or is that wrong we will see it. The other one could be that I actually instead of adding up dB is I add up watts. So, first I calculate the watts emitted by source 1, and I calculate watts emitted by source 2. I compute total amount of watts which will be received by our microphone or by the year and then from that I calculate dB 3. So, in this case I am adding up power or energy per unit time.

So, this is another one. The third could be I back calculate pressure P 1 because it is source 1 is going to generate some pressure at the microphone level. And I calculate pressure from source 2, add them up I add them and I get third pressure P 3 and from that I get dB 3. So, here in this approach I am adding up pressures. Now which one is right? Well one thing I can say for certain is that this approach is certainly wrong this is wrong. So, we never add up decibels. This approach it is it works for uncorrelated sources and we will explain that.

So, if there are 2 sources which are uncorrelated. And we will explain what is meant by correlation. If 2 sources are uncorrelated then we compute the wattage is associated with it source and add up the total watts and then we get the final decibels. For uncorrelated source. And the third one where we add up pressures. This is also, but this is only for correlated sources. This for correlated sources. So, if we have uncorrelated source we use the power method, if we have correlated sources then we use the pressure method to compute the overall decibels when several sources of noise or sound are active.

So, now we will discuss some more details about these methods. But before we do that we should know what is a correlated. So, what are correlated and uncorrelated sources.

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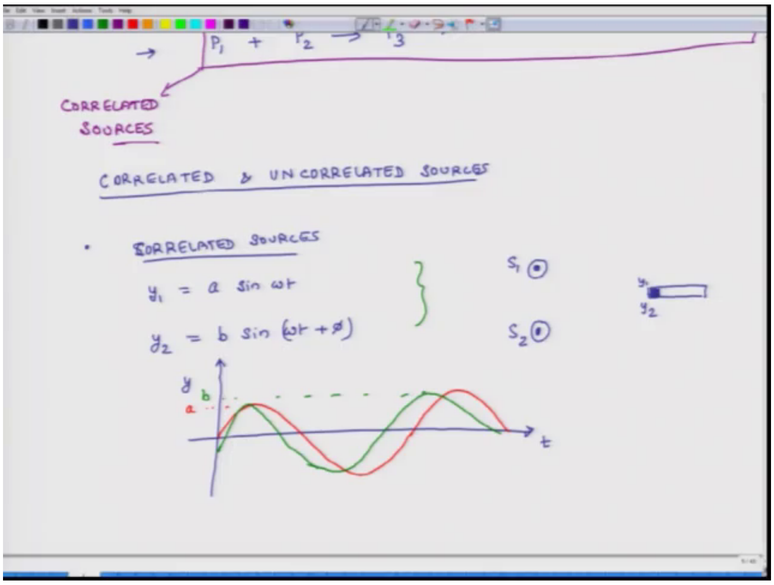

So, what do we mean uncorrelated sources or correlated sources. So, consider 2 loud speakers and both these 2 loud speakers are getting the same signal. We are getting the same signal. So when the sound from coming from first speaker goes up sound from the second speaker also goes up. Because it is getting the same signal. So, when sound is going up in the first case sound is going up in the second case when sound is going up down in the second first case same thing is happening in the other case also. So, in this case the change the behavior of the signals, which are being generated from both these speakers are they may not be exactly same, but they are similar.

So, they may not be exactly same because maybe less current is going in the second speakers. So, it is producing less sound, but when first one goes up second goes up when first goes down second goes down and so on and so forth. So, in that case. So, in correlated sources, if the signal from first source is y1 is a sin omega t. Then the signal from the second source is also similar, but it is amplitude may be different b, but the frequency will be same otherwise it will not go up and down at the same time if the frequency is not same right. So, sin omega t, but there could be a phase difference.

So, if I have to plot this this on a graph, maybe the first source is looks like this. And this is a and the second source it has a phase difference. So, it goes like this. And this amplitude maybe slightly different or it could be totally different and let us call it b. So, the amplitude could be different frequency will be the same and there could be some phase difference phase shift. So, in this case these 2 signals are correlated. Because I know the mathematical relationship between the behavior of first signal and the behavior of second signal, I know the relationship how I can predict that is y 2 is going to be something then what will be y1 because I know the exact behavior.

Now, in uncorrelated sources this is not true.

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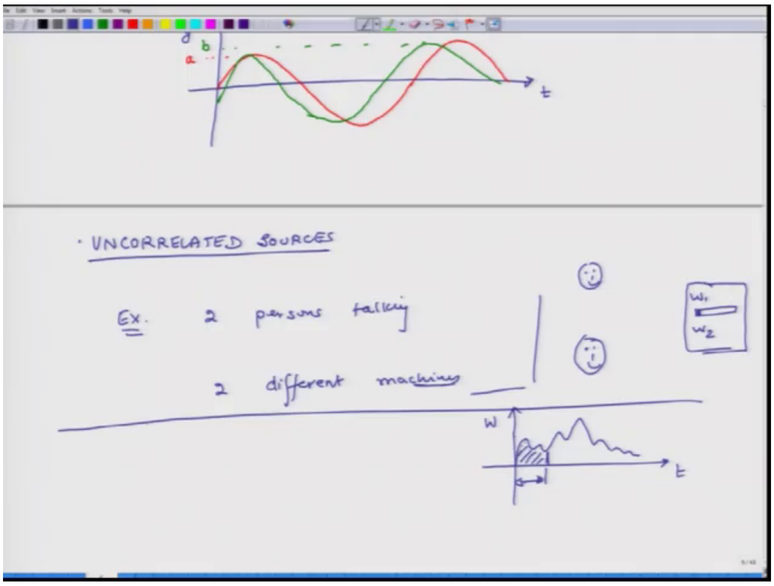

Uncorrelated sources this is not true. For example, the 2 individuals talking right. So, one person is source 1 another person is source 2, but you cannot correlate you cannot have a mathematical relationship between what the person is talking and what the person is going to talk right. So, the behavior of person once sound has no mathematical relation or bearing or influence on what the second person is going to say right. So, here there is no correlation between sources sound coming from 2 different sources. So, those are uncorrelated sources. So, example as I said or 2 persons talking.

Another example could be 2 different machines they are generating sound, but they do not know each other. So, machine one noise from machine one is independent of the noise coming from machine 2. There is no mathematical relationship between different 2 different type noise. So, this is there. So, if the signal is like this then. So, again I will. So, this is source 1, this is source 2. This is the microphone where we are measuring and if the nature of signal at the location of measurement, which is here not at the not at S1 or not at S2 at the location of measurement is y1. And at the location of measurement is y

2 because of S2. Then if both the sources are active then what will be the total signal it will be y1 plus y 2. It will be y 2, and I know the relationship between y and y1 and y 2. So, I can add them up and now if y1 is pressure, if y1 is pressure then if the pressure due to signal one is P 1. And pressure due to signal 2 at the location of measurement is P 2. Then at the location of measurement total pressure will be P 1 plus P 2.

In that case we use this approach. We add up the pressures, we add up the pressures and we compute the overall decibel level; however, if the sources are uncorrelated. So, what does that mean? Suppose there is a person and there are there is another person. And both of them are talking something. And we have a measurement here, measurement device. And the signal is coming at this location I do not know what is the mathematical correlation between the signals coming from these 2 individuals. So, I cannot add of these 2 things right. So, I cannot add up these 2 things, but what I can do is that I can complete the energy which is coming at this point from source 1 per unit time which will be W 1. And I can also measure energy coming to the location of the microphone from source 2 per unit time which is W 2. And I know that way I can add up energy is because the energy does not get destroyed. So, at that location the total energy will be the W 1 plus W 2 per unit time it will be per unit time.

So, if there are uncorrelated sources. Then this is the method we use to compute the overall decibel level. There are uncorrelated and we will explain this further by example. This is how we add up now it should be understood that when I am talking about energy. So, this is time. Let us say this is watts and let say the watts is like this. When I am adding up energy I have to add of energy over a period of time right. Not at 0 time because in 0 seconds how much energy will be coming 0 only in a finite amount of time I can add up energy. So, this is a plot of power with respect to time. So, I have to add up the energy over a period of time. Which means when I am adding up energy I am add doing this edition over a period of time which indirectly implies that this method of adding the energies works in a statistical sense. Because it is not at every instant I am doing this I am adding up over a finite period of time. And then based on that I am calculating the overall sound power level. So, this is important to understand.

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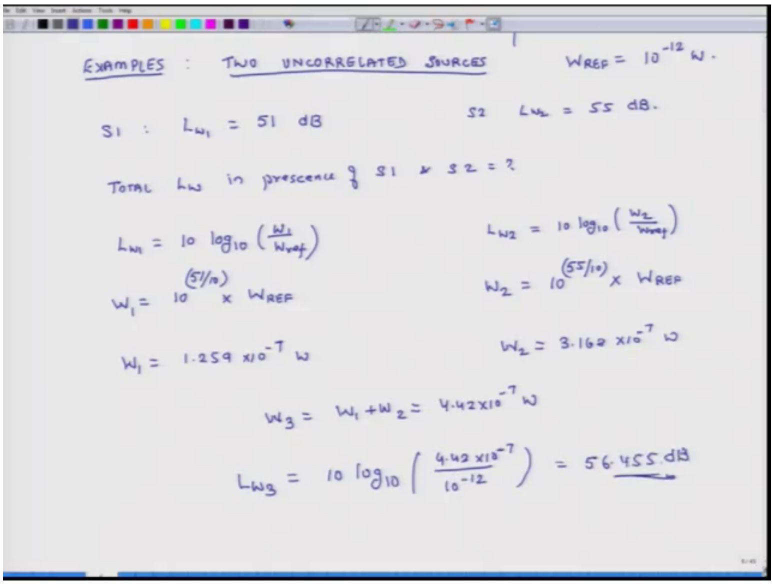

So, let us do a couple of examples. So, let us say. So, we first we will do for 2 uncorrelated sources to uncorrelated sources. So, let say I have a source S1, and it is generating LW1. And that is equal to 51 decibels. And then I have a sources S2 it generates LW2 and that is equal to 55 db. So, these are sound power levels these are sound power levels. So, then the question is total LW in presence of S1 and S2 is how much? Then both the sources are active what is the overall sound power level. So, because these are uncorrelated sources, I have to come add up the wattages. So, what; that means, is first I have to calculate the total amount of watts. So LW1 equals 10 log 10 W by W ref, which means W equals an LW1 is 51. So, 51 divided by 10 into W ref this is my. So, wattage of the first source and LW2 is equal to 10 log 10 W 2. So, this one W 1.

So, W 2 10 to the power of 55 divided by 10 into W ref and what is W ref ah.

Student: 10 to the power minus 12

10 to the power of minus 12 watts. This is something we had yesterday or last week. So, W 1 equals 1.259 into 10 to the power of minus 7 watts. And W 2 equals 3.162 into 10 to the power of minus 7 watts. So, W 3 which is the total is W 1 plus W 2 and that comes to 4.42 into 10 to the power of minus 7 watts. So, LW3 which is the total sound power level is equal to 10 log 10. And if we do the math we get 56.455 decibels. So, this is for 2 uncorrelated sources. And this is for the case when we have powers in watt.

We will do another example and what I will do is I will have the same numbers.

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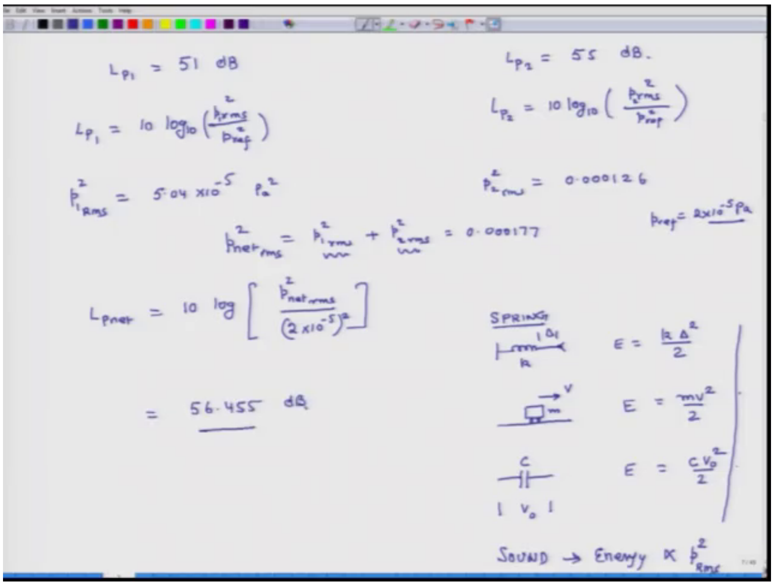

So, still the we will consider 2 uncorrelated sources, but I will say that the pressure level L P 1 is equal to 51 decibels and L P 2 is equal to 55 decibels. So, in this case I am not measuring the sound power level, but I am measuring the sound pressure level. And the pressure level is 51 decibels and 55 decibels. And now I have to calculate the overall sound pressure level and the question. And how do we do that this is again uncorrelated source this is uncorrelated source. So, he also thinking is the same for uncorrelated sources we have to add up.

Students: Watt wattage.

Wattage or the energy that is what we have to now L P 1 will give us will it give us wattage or it will give us something else it will help us calculate pressure.

Student: Pressure.

Ok, but it will not help us calculate the energy level or the wattage level, but there is an important thing to understand and that will help us actually indirectly compute the wattage level also. So, I will explain that. So, consider and to understand that will go a little bit in a on a different track. Consider a spring. And the spring is having a stiffness k and it is deflecting by a distance delta. Then the energy stored in the spring is how much k times delta square by 2 k times delta square by 2. Consider a mass and it is moving with a velocity v. What is the energy of this mass? And it is mass is m, it is m v square over 2.

Consider a capacitor and I apply a voltage of v naught. What is the energy stored in this capacitor? It is c v naught square over 2 c times v naught square over 2. In all these cases what you are seeing is that whatever is the excitation. Here the excitation was deflection and the energy is proportional to square of that. Here an excitation is velocity and it is proportional to square of velocity energy. And in this case energy is proportional to square of voltage. Energy is proportional in a spring to deflection square in a move freely moving mass to velocity square in a capacitor to voltage across the capacitor.

Similarly, by analogy I mean we will not go into detail rigorous proof, but by analogy we can say that in sound waves the energy which is there is for sound. Energy is proportional to pressure square. And is proportional to pressure square. And in this case it is pressure PRMS square. So, with this understanding. So, what we will do is we will compute PRMS square for both the situations and then because these sources are uncorrelated what will be do? We will add up the PRMS square from both the sources. So, L P 1 equals 10 log 10 PRMS square divided by P ref square. And L P 2 is equal to 10 log 10 where PRMS square. So, this is second this is one divided by P reference square P 1 RMS square equals. So, if we do the math from this L P 1 is 51 decibels, if we do the math you find that it is equal to 5.04 times 10 to the power of minus 5 Pascal square and P 2 RMS square is equal to 0.000126.

So, P net square is equal to P 1 RMS square plus p. So, what I am doing? I am when I am adding up the squares what am I doing effectively I am adding up the energies. Of course, it will be multiplied by some constant because this is proportional not same. So, this comes to be 0.000177. So, L P net is equal to 10 log. Now this is RMS and by the way what was P reference 2 times 10 to the power of minus 5 Pascal’s.

So, this is 2 into 10 to the power of minus 5 square. And if you do the math you get the same number 56.455 dB. So, the point is that whether you add up decibels for uncorrelated sources, using the pressure formula or the wattage formula you will end up with the same number. So, this is important to understand. So this concludes our discussion for today. We will continue this discussion on how to add up decibels tomorrow. As well and tomorrow what we will do specifically is to figure out how do decibels add up when the signals are correlated. So, that is all and thanks for the day bye.