Fundamentals of Acoustics
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Lecture – 63
Microphones

Hello. Welcome to Fundamentals of Acoustics. Today is the third day of the eleventh week of this course, and today we will continue our discussion on sensitivity of microphones. Yesterday we had stated that while defining microphone sensitivity there are two reference standards; one standard is for a mic which generates 1 volts for each pascals sensed by it, and the other standard corresponds to 1 volt for each micro bar.

So, what we plan to do today is do a small numerical example for the second standard. And using our method we will compute the voltage generated by a microphone for such a device.

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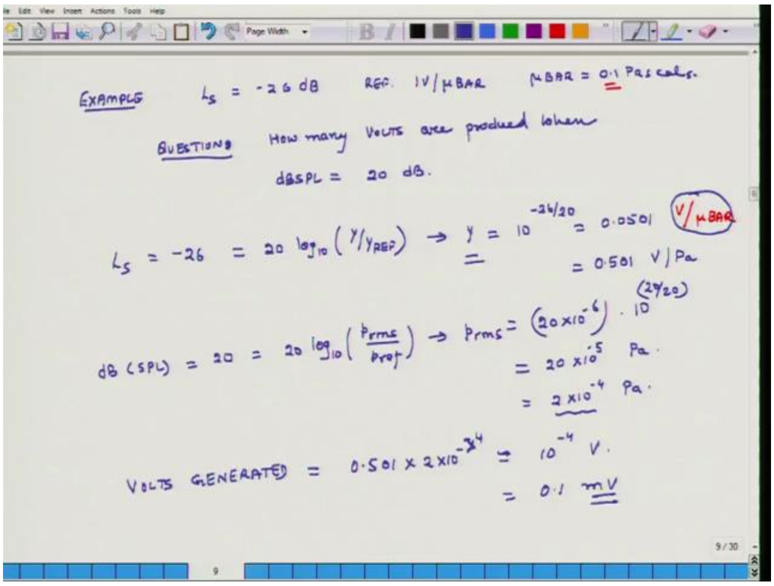

So we will do an example. And let say that sensitivity of the microphone is still minus 26 decibels, but instead of 1 volt per pascal are references 1 volt per micro bar. And one micro bar is equal to 0.1 pascals. So question, this is the question we have to answer. How many volts are produced when dB SPL equals 20 decibels? So, when there a sound pressure level of 20 what is the value of volts generated by this mic? So, what we will do is we will compute how may volts are produced for each pascal and then we will accordingly do the math.

So, L S equals minus 26 decibels and that equals 20 log of 10 y by y ref. So, that gives me y equals 10 to the power of minus 26 by 20 is equal to 0.0501. Now what is the unit here? Volts per micro bar, which means that if the microphone is subjected to 0.1 pascals it will generate 0.05 volts. So, alternatively I can write it is as 0.501 volts per pascal. So now, for SPL this equals we are saying that it is 20 decibels that equals 20 log 10 p rms divided by p ref. So, p rms equals 20 into 10 to the power of minus 5 times 10 to the power of 20 divided by 20.

So, that works out to be 20 into 10 to the power of minus 4 pascals or it is 2 into 10 to the power of minus 3 pascals. Then volts generated, this is volt generated is what is equal to 0.501 times 2 in to 10 to the power of minus 3, so that comes to 10 to the power of minus 3 volts.

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So, our reference pressure is 20 micro pascals or 2 into 10 to the power of minus 6, so that becomes 20 into 10 to the power of minus 5 or 2 into 10 to the power of minus 4. So, if I multiply this number so this should be 4. So, if I multiply this number it is 10 to the power of minus 4 volts, roughly because 2 times 0.501 is about 1. So, that is 0.1 mille volt. So, it is important to understand the significance of this reference press number, because based on this reference number this value y changes.

The next thing I plan to do today is discuss microphones. What we will do is, earlier we had classified our microphones from the stand point of working, but perhaps an important way to classify microphones is based on application.

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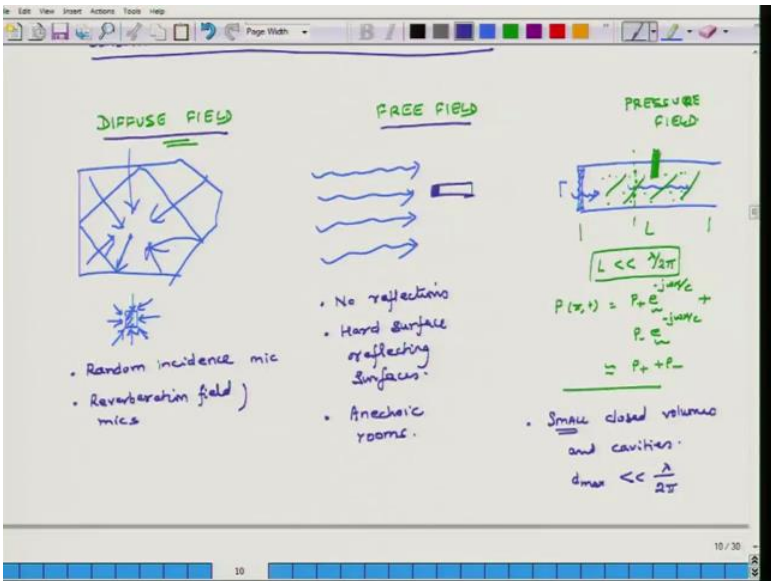

Classification of mics by application. Now in general there are three broad categories of mics if we classify by them by application. The first type of microphone is known as defuse field microphone. The second type of microphone is called free field microphone. And the third type of microphone is called pressure field microphone. So, these are three classifications of microphones based on application and we should understand what these terms mean. So what is a defuse field? Defuse field would be suppose you have a room, suppose there is a room and typically rooms are not just rectangular volumes they may have some slanted surfaces.

So, if I have sound source here it comes to this edge it gets reflected, it gets reflected again, it gets reflected, so you may have reflections coming from all the directions. So, if in such a room where reflections are coming from all the directions we want to measure sound pressure level, we need a microphone which can sense sound waves coming from all the directions. So, we need a microphone. So let say this is our microphone, and it is sensitive to sound coming from all the directions. So here the sound pressure filed is defuse it is not in one particular direction it is all over the place at every point sound is coming from all the directions. These types of microphones are also called random incidents microphones, because the noise is coming the incident angle of the noise which is a striking the microphone is at all sorts of angles. So, it is randomly oriented, so this is one.

Second thing their also known as reverberation field microphones. So, this defuse field microphones are also known as random field mic incident, random incidents microphones or reverberation field microphones. Why is it known as reverberation field microphones, because when sound comes hit hits are reflecting surfaces comes back. So, it has a lot of reverberations. So, the sound in the room or closed space has a lot of reverberations, so microphone which is sensitive to sound coming from all directions will measure also reverberations accurately. So, this is one category of microphones which is defused field microphone.

The second category of microphone is known as free field microphone. Now what is free filed? So imagine that you have in air there is a bird which is chirping and may be 50 meters away from their in the air you want to see how much sound is being is coming from that bird. So, in such a case your sound filed is typically like this, sound waves are travelling in a particular direction. So, this is a bird or this is a speaker and the sound is going like that. And your microphone should be of a nature that it is sensitive to a particular direction which is the direction of the sound you know the direction from where the sound is coming. So, these are free field microphones.

In free field microphones what is there, when do we have a free field? We have a defuse field when we have lot of reflections. So free filed microphone occurs when no reflections occur and this typically happens when there are no hertz surfaces or reflecting surfaces. So, typically it can happen when you are way up in the air, so that is one area or if you are on the ground and your sufficiently above the ground so that sound does not get chance to come hit the ground and again approach you; so whatever sounds your receiving your microphone it is coming directly from the source. So, that is also a free field micro situation.

And we can create free filed conditions in rules by using anechoic chambers; so in anechoic rooms. So anechoic means, room where there are no echoes. So now, if I have a sound source here and I have a microphone here all the sound which it will sense it will sense only the free field sound, because the room is lined with materials and geometries so that there are no reflections coming back to the microphone. So, this is the second category of microphones- free field microphones. So, we have to be aware whether we are making free field measurements or defuse field measurements.

The third category is pressure field microphones. Now what is the pressure field? So, imagine a box or let say a tube and this tube is being excited by some piston. So, sound is travelling here right and sound is also getting reflected here, but across this cross section the sound pressure level does not change. And if the length of this tube, so let say this length; if length of this tube is very small compare to one sixth of the wave length then sound is not only having same value across the cross section but it will also have same value at different points in the tube. We can show that mathematically, because the pressure will have a component. So, what is pressure? P x t is equal to what, P plus e j omega x over c negative plus P minus e minus j omega x over c.

If x is very small, which means the length of the tube is very small then this term goes away. Then the overall pressure in that tube it will be approximately equal to P plus plus P minus, right. If x the maximum value of x is very small and that will happen only when length of the tube is small. So, in such a case the pressure is uniform in the whole tube. So now, I want microphone. So how do I measure pressure in such a tube, I insert it from one end the microphone should be sensitive to pressure in a uniform field. These type of microphones are called pressure filed microphones.

Normally, we can use these defuse field microphones also in pressure filed microphones because these microphones are they can sense sound coming from all sorts of directions. So, if I use this in a pressure field situation then it will work here. Now these pressure fields microphones where do we use, we typically use them in small closed volumes. Now this volume could be a tube or a spear or whatever, so volumes and cavities. And what is the meaning of small? That the maximum dimension dmax of the volume should be very small compare to one sixth of the wave length.

So three times of microphones; defuse microphones, free field microphones, and pressure field microphones. And based on the measurement we want to do, we have to select our microphone carefully other we may get totally a wrong results. So, wherever in your field you want to do some measurement first understand whether your sound field is defuse which means does it have a lot of reflections or is it free field or is it a pressure field, and accordingly you choose in the nature of microphones.

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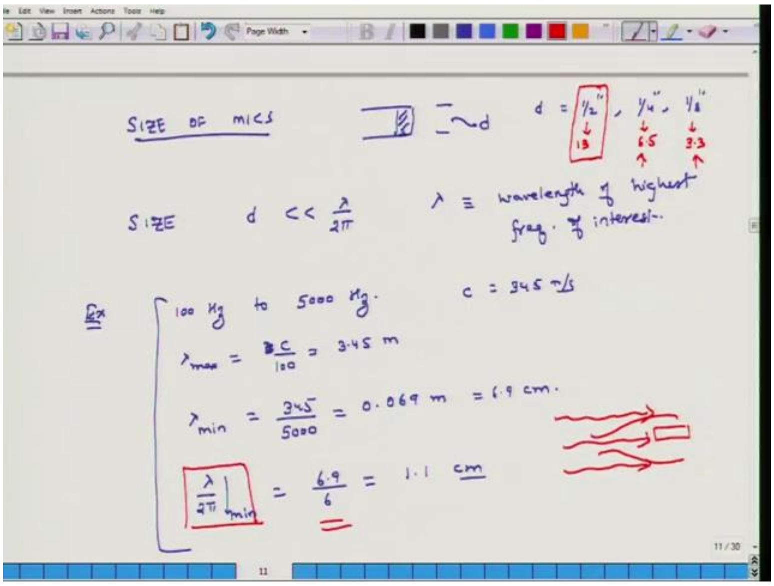

Last thing about microphones is about their size; size of microphones. Now a microphone comes in all sizes. So let say this is our microphone, and this is the diameter. Lot of times this diameter is either half inch or one forth inch or in very few cases we may get very thin microphones one eighth inch. So, half inch is about 12-13 millimetres, one forth inch is about 6 to 7 meter millimetres and one eighth inch is about 3 millimetres wide.

Now, the size of microphone should be carefully chosen such that d should be significantly smaller then lambda over 2 pi. What is lambda? Here lambda is the wave length of highest frequency of interest. This is important to understand. What does that mean? Example: suppose I am interested in measuring sound and I think that the frequencies of this sound may be from 100 hertz to 5000 hertz. Then for these range of frequency is lambda max will be what C over 100; so C is 345 meters per second. So, that comes to 3.45 meters. And the minimum wave length corresponds to 5000 hertz, so seamen equals 345 divided by 5000 and that comes to 0.069 meters or 6.9 centimetres.

So, lambda over 2 pi minimum value is equal to 6.9 divided by 6, so this is equal to 1.1 centimetres. For this application if I use a microphone let say half inch, so half inch means what 13 millimetres, one fourth inch means 6.5 millimetres, and one eighth inch means 3.3 millimetres roughly. So, if I use this microphone what will happen? Say suppose we are talking about free field then waves will be travelling like this and when I introduce a microphone which is fat then the nature of waves will change.

So, the sound field will get disturbed if I use a thicker microphone. If I use this microphone may be it will work, if I use this microphone the sound field will get disturbed the least amount. So, we have to make sure that the size of the microphone does not disturb the overall sound field, and that will happen when these parameter lambdas over 2 pi its minimum value is less then or it exceeds the size of the microphone. So, that is important to understand.

So, that concludes the discussion for today. And tomorrow we will start discussing a new concept known as Weighting. So, we will discuss the concept of weighting, and with that we close our discussion and we will meet once again tomorrow.

Thank you. Bye.