Basics of Noise and Its Measurements
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Lecture – 19
Classification of Microphones

Hello, welcome to the Basics of Noise and its Measurements. This is the 4th week of this course, and what we are going to cover in this particular week is a lot of stuff about microphones.

So, in any sound related measurement the most important instrument in most of the cases is the microphone. In last week, we had seen that how we can use an impedance tube which is mounted to the traveling microphone and information which we get from this traveling microphone can be used to figure out the value of impedance. But then, we do not measure impedance directly, we measure pressures and from the information which we extract for pressures we ultimate are able figure out what is the impedance of the material which is positioned at the end of the impedance tube. So, this is one example.

So, essentially what I am trying to say is that microphone is perhaps the most important instrument which is used in an extremely large number of sound related experiments. So, this week will purely focus on, what is a microphone? How does it function? What types of microphones are there in the market place? How do we select a microphone? What is the sensitive of the microphone? What are the different considerations which we have to factor in as we go ahead and a select a microphone which meets our applications? And then, some information also about instruments which are attached to the microphone for instance of preamplifier, what is it? What does it do? What is its importance and so on and so forth? So, that is what we are going to discuss today.

And as we walk through this course during this week, we will also see actually some of the physical instruments how they look like. So that you get a better feel what kind of microphones are there in the market place, and some more information about that.

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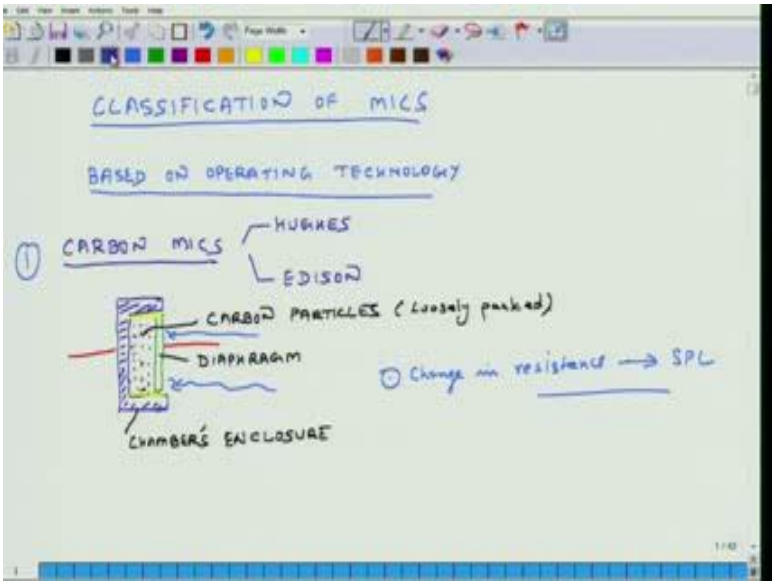

So, that is what we are going to do this week and specifically, in this particular lecture what I will be discussing with you is how we classify microphones. So, this week and probably also this lecture and may be also in next lecture we will discuss about classifications of microphones. I think that is important to know, because lot of terminology which goes with usage of microphones is associated with this classification. So, once you have a feeling of how things are classifieds and what is the fundamental behind its terminology, it will be helpful for you when you go out in the field and do some sound related measurements.

So, what we will discuss is classification of mics. Before I dig deeper into it, in lot of places you will see there is a symbol for a microphone for instance there is a symbol for resistor and the symbol for resistor is like this. There is symbol for inductor, which is like this. There is symbol for capacitor, which looks like this. Similarly, there is a symbol for microphone and the symbol for microphone, it looks like this. So, that is how at least from the electrical world, this is the symbol standard symbol for microphone.

Now, what we will do is we will start the classification and we will classify these microphones in couple of ways. The first bases, which we will classify these will be based on technology, so based on operating technology. So, what we are going to do is

we will classify based on how they actually work.

So, the first type of microphones which came into existence, that was way back in time at in late 1800s and they were known as carbon microphones. So, actually they were two people who invented them independently, one was Hughes and the other inventor. So, both of them invented this microphone independently. They did not talk to each other and actually there was a lot of confusion and also to some extent, some bitter and acrimonious fight between these two inventors in terms of who was the first person to get to this microphones, but regardless how do this work.

So, what happens is that what you have let say a diaphragm. So, this is a very course systematic diagram. So, this some sort of a chamber and here you have a very light metallic or some sort of a diaphragm. So, this is your chamber which is covered by some metallic thing and there is some sort of insulation here. So that this green diaphragm, it actually does not touch the chamber and in the chamber, what we have are a lot of loosely packed carbon particle. So, that is your diaphragm, that is some sort of a chamber, chambers and closure; and in the chamber we have carbon particles and this is loosely packed.

So, what we are interested at least in context of this particular thing is, we measure the resistance between this chambers enclosure and the diaphragm; and because the diaphragm is not directly connected to the chambers, so all the current actually flows through these carbon particles. And the resistance of this, so now, if you have the sound let say your sound is coming like this and sound comes and it hits the diaphragm. So, it pushes the diaphragm inwards or if it is. So, the diaphragm moves in and out based on the pressure with it above atmospheric or below atmospheric.

As a consequence of this pressure the resistance of these graphite particles because they are loosely packed, so when they come closer resistance goes down and so on and so forth. So, the resistance modulates, so the current also which flows through this whole set up it changes. So, you silence the changes in resistance or through (Refer Time: 08:53) current or the voltage differences across it and that you convert it into SPL. So, change in resistance that is mapped into SPL.

So, that is why these were known as carbon microphones and they were based on the resistive principle. So, there were like resistance mics. The fundamental thing property which was varying here was the resistance of the systems. So, that is why some of these microphones sometimes people also call them as resistance microphones. And they were very widely used in past, so especially in the old style of telephones were you would have this rotating dial so those types of telephones or some earlier microphones or microphones which were earlier used in broad casting stations a lot of these a microphones they were actually using these carbon microphones. But they were not so much used for measuring sound. So, there were used to capture sound for communication purpose, but not for scientific and instrumentation related or related purposes.

So, this was perhaps the first category of microphones which came in to existence. Then, later people developed another class of microphones, and these were known as capacitor mics or some people call them as electrostatics mics.

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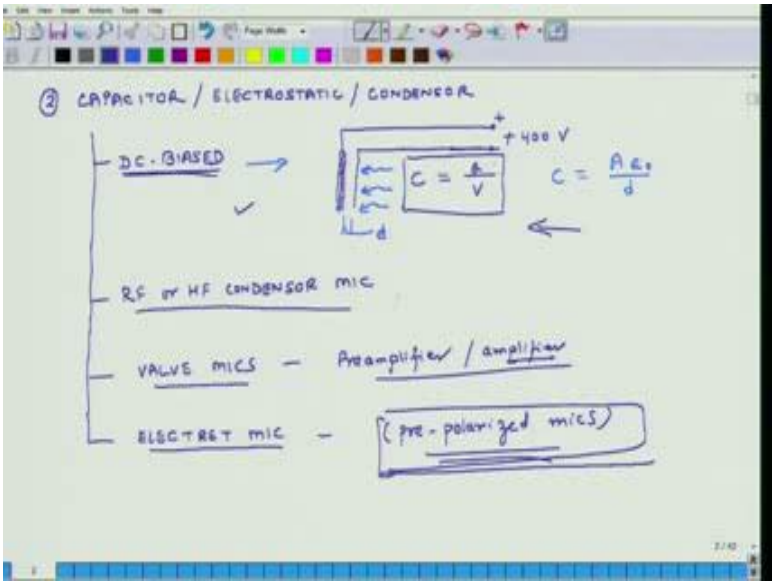

And then, there was a third term for these, these were known as condenser mics and most of the microphones which we use in modern days a large a very large number of modern microphones they belong to this particular category, capacitor mics, electrostatics mics,

condenser mics all of these things being more or less the same thing. The fundamental principle is that you have two plates; one plate does not move, the other plate is extremely close, and both of these are very close to it, so they are like two metallic plates and there is some air between these two and one does not move and other one is susceptible motion. So, that is like your diaphragm and when sound hits it, the second plate comes closer to the first plate, so the capacitor changes.

So, in the first category of microphones we were sensing the changes in resistance, in this category we are sensing the changes in capacitance. Now, we do it in several ways and that is why there are several categories of these capacitor microphones, but that is the fundamental principle that its change in capacitance that cause a change in the current or voltage or whatever, and we sense this change in capacitance and that is some which we convert into voltage or more appropriately sound pressure level. So, this is the second category.

Now, this class of microphones has several classes of this; one is DC biased, direct current biased microphones. So, what is there? So, in this what you have is let say you have one plate, let us say this is my reference plate and then the other plate is a your diaphragm and what happens is that these two plates are essentially having a constant or more or less constant voltage across them. So, let us say I (Refer Time: 13:10) something like plus 400 volts across these. So, this and it is a DC voltage. So, once this is there then the charge the capacitance across these two plates can be calculated in terms of charge which is accumulated on the plates divided by the voltage across the plates. So, this charge is there and this charge does not change a whole lot.

So, suppose you have again some sound pressure wave which comes and hits the diaphragm, then the distance between these two plates it changes and we know that this capacitors is also nothing but area of the plates, times permittivity constants divided by distance between the two plates. So, as distance changes capacitance changes because of this charge changes, the bias voltage is more or less constant does not change the whole lot. So, essentially what I do is I am trying to sense the change in charge and from that change in charge I am able to calculate the change in capacitance or I can also map it to the change in sound pressure level. So, that is why this thing is known as DC biased type

of capacitor, microphone or condenser microphone.

Now, this category of microphones it works fairly well for low frequencies to somewhat moderate frequencies when we are trying to capture and for a little higher frequency what people have developed is another category of microphones known as RF that is radio frequency or high frequency condenser microphones. So, this is the second category.

What happens in this case; so in this category, in the first case we were applying a pretty constant DC volt by its voltage across the two plates, here we are excite having a RF or a radio frequency oscillator as a source and essentially, the aim here is not so much to charge the plates, but again because of change in capacitance current which flows through the system, now we have radio frequency or some alternative excitation across the plates. So, current also it changes and that is sensed and the changes in that are sensed and through that we are able to figure out what is the SPL. So, this is the second category of microphone.

Then we have Valve mics, what are these? They are essentially same as these earlier types of microphones which we have discussed, but the only difference here is that the preamplifier or some amplifier or amplifier that mostly it is at the pre amp stage, they use instead of transistors and modern electronics they use valves tubes. So, again this is a little obsolete technology we do not have to worry too much about it, but for just for the purpose of completeness this is a third type of capacitor microphone, which we may here about as you explore these microphones.

And then, there is something called an Electret microphone. Now this extremely popular, and it has some very powerful advantages. Now, what is Electret? So, electret is essentially type of material which stores some sort of permanently some charge on it. So, some of these types, it could be something similar to the faro magnetic material something like that. How this is done? So, what people do in this DC biased microphones you are applying some external DC voltage to have a charge on the system, but in electric you do not any external DC bias, but rather there is physical charge actually which is deposited on the diaphragm, and how is it done? So, some special

materials, some special types of plastics or especially formulated materials what they do is they have a very thin sheet of it and just as in faro magnetic materials there are dipoles which get oriented with respect to the direction of magnetic field. So, these materials have similar characteristic.

So, what you do in this materials you heat them, and at a elevated temperature these electric charges get oriented and then at a heated stage you have a very thin sheet of this material at a heated state you subject them to some intense fields and what happens is as a consequence this charge accumulate in a particular direction and then it get concentrated and the accumulate orient in a particular direction. And they are, let us say a line and they get deposited in a particular direction and then you cool it to a lower temperature. So, these charges they get something like frozen in the overall material and they cannot run away easily, and then you cover this thin sheet of electric material with some other layers for protecting the thing and stuff like that. So, now what you have is there is a charge on deposited, on this thin sheet and because you are using this electric material it is known as an electret microphone.

So, this is an important to note and then when you have two of these sheets very close to each other charge is already there. So, there is also a voltage difference across the two plates, across two plates; and then when you move the microphone closer or it moves out then there is change in voltage, the charge is more or less constant and that change in voltage can be sensed using electronics. So, this is what electret microphone is all about. Where do we these electret microphones? Most of the microphones which you will see nowadays in day-to-day applications your cell phones, laptops, a lot of desktop applications, maybe even this particular type of microphones which I am having on my shirt, it maybe of electret type.

Very significant advantage of these microphones is that in this DC biased for instance you have this charge, but if you have a lot of humidity there could be leakage of voltage and charge to the outside world. But here because the charge is kind of logged in, you know it has nowhere to go. So, these are fairly stable systems over a period of time and they do not leak very easily, they are most stable, more resistance to humidity and environmental changes, so they are more stable systems.

However, earlier when these were invented, at that time the quality of these microphones in terms of their linearity and frequency response it was not that great, what do you mean by linearity in frequency response? We will discuss that, may be a couple of days later. But in a broad sense for instrumentation and for purpose of measuring noise or sound they were not very viable candidates, because they were not very predictable in their response or not very well behaved in their response, but over a period of years now they have become extremely good and a lot of time we actually use these type of microphones to measure sound and a lot of times these microphones are also known as pre-polarized microphones.

See, here we need a polarizing voltage in case of DC biased. Here we do not need any external polarizing voltage. So, that is why they are known as pre-polarized microphones. So, this very popular category and increasingly it is also being used for measuring noise, recording noise and doing analysis not just for entertainment purposes these mics are used, but they are also being increasingly used for scientific computation and scientific measurement of noise.

So, this is the second category of microphones and we will continue this discussion in the next lecture. But, what we have captured today; two categories, capacitor based systems and resistance based systems. We will continue this discussion in the next class. Thank you very much, and look forward to seeing you tomorrow.

Thanks.