Basics of Noise and Its Measurements
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Lecture – 20
Classification of Microphones

Hello again, welcome to Basics of Noise and its Measurements. This week, we are giving detailed exposition on this whole topic of microphones, and we just began in the last class by discussing different types of microphones and essentially we covered two broad categories of microphones, one was resistance based microphones and then the second category was capacitor based microphones. In capacitor based microphones, we had discussed several categories DC biased microphones, RF microphones, Electret microphones.

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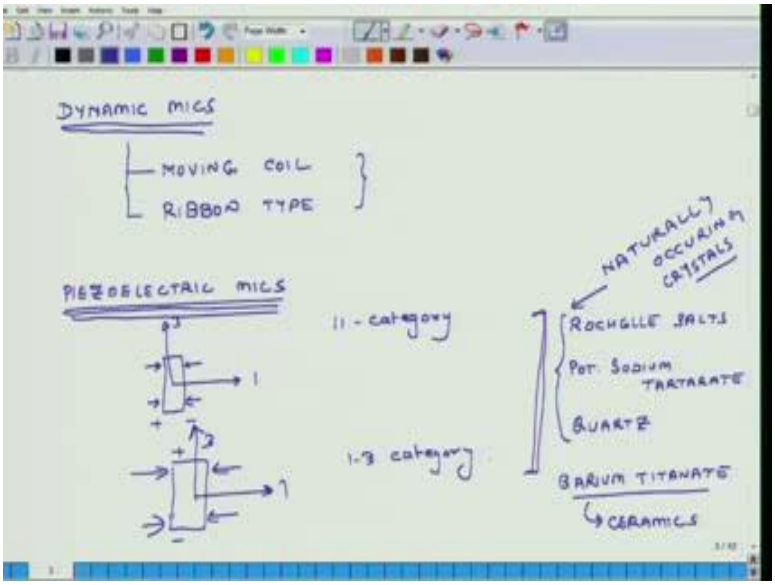

Now, what we will do is we will continue this discussion further. So, we will continue with our discussion on classification of microphones. The next category which we are going to talk about is known as dynamic microphones, so dynamic mics. So, how do these work? Essentially, what happens is that they work on the basis of principle of this electromagnetic induction. So, we all know from our 12th standard and 11th standard

physics classes, that if you have a conductor which moves in a magnetic field in such a way that the conductor cuts the magnetic field lines, then a current is generated in the conductor and that is how generators also work, because you have a conductor which cuts the magnetic flux in it and current is generated and that current is used for electricity purposes.

So, essentially same principle you have for the dynamic category of microphones. So, you have magnetic field and the structure is morphologically or fundamentally very similar to that of a speaker, but the behavior is just the opposite. In a speaker, you have current which goes into a coil and this current cut the magnetic field lines and because of this we generate this force and known as Lorentz force and because of the force the diaphragm of the speaker moves up and down. You can use existing speaker and if it is fairly sensitive you can use the same speaker to behave as a microphone also, but the mechanics is just inverted. So, in that case you have a diaphragm and a sound wave comes and hits the diaphragm because of which the diaphragm moves back and forth.

The diaphragm is connected to a coil which is basically what we talked about as the conductor, and this conductor as it moves in and out on the magnetic field, now which is being offered by the magnetic structure of the loudspeaker. Or in this case, the microphone current is generated and if you measured this current or the voltage difference across the coil you should be able to translate the sound pressure level which is impinging on the diaphragm into voltage signal. So, that is the fundamental principle.

And these microphones are of two categories, moving coil and ribbon type. I will not go into detail into each of these two different categories of these microphones, but the fundamental working principle is the same that you have through a magnetic field, moving conductor. And the motion is coming because of the sound pressure level attributable to noise or sound, and that generates a back EMF; and this EMF is once you sense it you can convert it that EMF, from that EMF you can infer what is the amount of sound pressure level which was been generated. So, these are dynamic microphones.

Now, a lot of microphones which we use in entertainment industry and in auditoriums, they belong to this category of microphones. These are easy to produce, they are less

expensive and because of these two important reasons they are extremely widely used. However, if from the stand point of measurement if I am interested in making very precise measurements of sound pressure levels, the resolution and the accuracy of theses microphones and the linearity of these microphones is not exactly great. So, we do not in general use this dynamic category of microphones for measurement purposes, and that is one reason I am not going to discuss more about this category of microphones.

Then there is another category and these are known as piezoelectric mics. So, again you must I am fairly certain you are familiar that this piezoelectric materials they have a property that and it depends on which type of material we are talking about, but suppose you have let us say this is a piezoelectric material, this is my, I call it direction 1 and I call it direction 3, suppose. And there are some materials, some piezoelectric materials that if I press them like this, then there is a potential difference which is generated across these two phases, these types of materials are known as 1 1 category. That the potential difference which is being generated is in the same direction along which the pressure is been applied.

Then you have another category of materials and here this is 1, this is 3, if I apply pressure like this then my potential difference. So, this is direction 3, this is direction 1, so, here the potential direction difference is in the normal direction, so this is 1 3 category. And using this particular property because of application of pressure voltage difference is produced by the material itself, and if I can measure that voltage and if I can make sure that the response is linear, then I should be able to figure out what is the value of sound pressure level. So, this class of microphones which exploit this property of these materials they are known as piezoelectric mics.

Some materials which are used to get this; so I just wanted to give some names - Rochelle salts, this is a naturally occurring material - Rochelle salts. Then potassium sodium tartarate, then another material is quartz. These three and there are bunch of others also, these are naturally occurring materials. But then there are certain materials which you can synthesize and they are a ceramic in nature, one example is barium titanate; these are ceramics and they are several ceramics which exhibit this behavior, you can actually synthesize these materials in the lab.

So, you have naturally occurring materials. So, these are actually naturally occurring crystals or you can have synthesized materials. Lot of them belonging to the ceramic category, and you can use these to design microphones which meet your needs. Couple of comments about these piezoes, first thing is that unlike our condenser microphones which are sensitive to extremely small amplitude of vibrations, but they cannot take a lot of external static pressure; external static pressure, for instance if I take a microphone condenser microphone and somehow seal it so that no water goes into it, but I bring it may be one kilometer down in the ocean, the overall hydro static pressure of the water will be so high that this microphone will not be able to resist; the diaphragm will not be able to resist that kind of a pressure.

So, most of these condenser mics, they fail to work when you have high hydro static pressures, but these piezoelectric because they are made from crystals and they are very robust in terms of their strength, comprehensive strength and ability to withstand compression and comprehensive forces they are very popular. And actually in water based applications they are more or less exclusively used for sensing sound. So, because of this property they are used lot in water and then they are also used as something we call it as contact mic, for instance if you have a tabla and you want to see what is the contact pressure and the sound being generated, physical contact. If I tap diaphragm based microphone, the diaphragm is extremely sensitive even it may get destroyed, but the same may not be true of these piezoelectric mics.

So, they are used as contact mics where you want to sense the contact based sound you know sound due to contact of the finger and the drum in that kind or in acoustic guitars and some of these applications. So, they are used in water and also as contact microphones. So, this is another thing. Another important feature of these microphones is that, you do not have this problem of leakage of charge because the operating principle is totally different. They are not sensitive or susceptible to EMI or external electromagnetic waves and electromagnetic interference EMI and EMC issues. So, in that sense they are more robust, but their sensitivity is somewhat less compare to a diaphragm based mics, for instance compare to condenser mics for the same reason. So, this is another category of mics.

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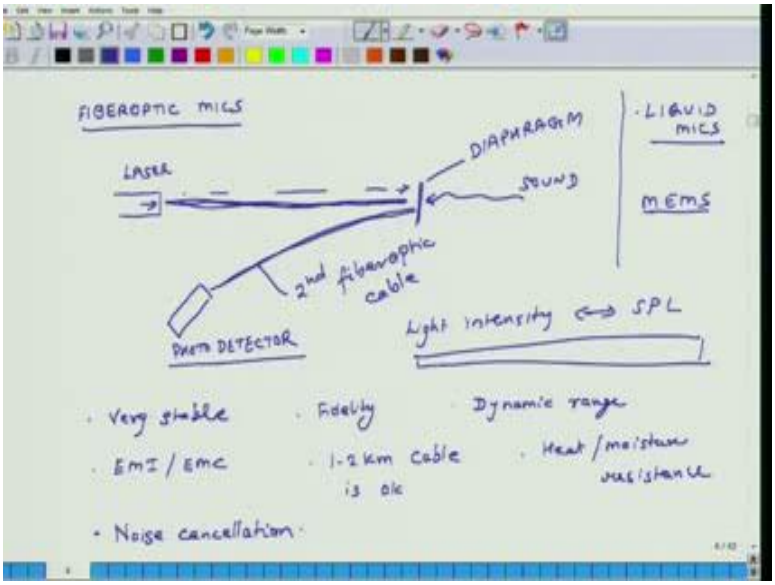

Then we have another class of mics known as fiber optic mics. Now, these are not very well known or very popular, but at least for the sake of completeness I wanted to cover this category of mics also. So, what happen here is that you have that a fiber optic cable and a laser source. So, you have this laser and its sense some light along the fiber optic cable and then, here you have this diaphragm which sense as the sound pressure level. This is your diaphragm, and here you have sound and then here you have a second cable and at the end of this I have a device called photo detector. So, when there is no sound the diaphragm is a straight and I measure a certain amount of light which comes back and I calibrate with respect to that situation.

When there is motion based on the pressure the deflection of this diaphragm, the motion of the diaphragm is more or less and based on that the intensity of light which comes back and which is detected by the photo detector it changes. So, here what I am doing is that I am correlating light intensity to SPL, to sound pressure level. These are somewhat exotic mics, not very popular because they are little more expensive, but they have some very unique attributes. First thing is that they are very stable, stable in the sense they are not that much sensitive to temperature that much sensitive to all sorts of operating conditions, that much sensitive to the sound pressure level and so on so forth.

Very fidelity, fidelity means whatever results they are giving us they are more believable. Whatever is going in and the output it is highly linear, that relationship. Then they have a large dynamic range, large dynamic range. So, they can capture almost sudden changes and sound level, much more accurately; a lot of other microphones do not have this capability, their dynamic range is not that high compared to these ones.

Fourth is, they are resistant to EMI that is electromagnetic interference, and EMC. Fifth is, I can send the information about sound pressure level through very long distances in a lot of other type of microphones, condenser based or carbon based or dynamic microphones. If I make the cable length long, then I start getting some corruption of the signal, but here the light is passing through a very long. So, I can send the signal as much as 1 to 2 kilometers. So, even very long cables are ok. Then, these are fairly insensitive to changes in heat moisture, so this resistance to heat and moisture because, they have a lot of high fidelity. They are used also nowadays increasingly in noise cancellation algorithms. So, this is what fiber optic and mics are all about.

And the last category, then we have two other categories and I am not going to describe too much about their, but I will just mention one category is known as liquid mics. These are absolute not used a whole lot and then the other category is MEMS. Now, they can be diaphragm base, they can be fiber optic base, MEMS they can be dynamic based, but because MEMS technology is used to fabricate these so they are known as MEMS mic, but they could belong to either of these categories.

They are becoming more popular nowadays, because these types of microphones can be produced in large amounts. They can produce in large amounts and at less cross points, but from the stand point of accuracy and reliability of the data which we get from these mics, it is a still questionable. So, this covers my overview of classification of the mics from the stand point of operating principles in the next class what we will do is, we will continue this discussion from the stand point of applications.

So, here I have discussed and classified microphones based on how they work; what are their operating principles. And, in the next class I will discuss the same classification, but

not on the basis of their operating principles, but rather on the basis of their usage and application stand point.

Thank you very much, and we will meet once again tomorrow.