Audio System Engineering

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Lecture - 22
Microphone – I

In the last three classes, we have discussed about the mathematics of transduction, transduction we have discussed. Now what is required let us start with the microphone. Now, suppose as if you say that if you have done that audio system engineering course and somebody told you can you show me or can you say something about that what kind of microphone I should select for this purpose of application. That means, or how can I design a microphone of this kind it is two questions can be asked by the society. One is that yes, I want to record this kind of things what type of microphone I should use or I can say I required this kind of application, so which microphone will be suitable or how to design that microphone.

Now, suppose you go for market, go to the market and find out which kind of microphone is suitable for your application, how to decide it. So, as you know that while you go for the shopping, suppose you want to buy a TV or buy a washing machine, as an engineer when you go for the shop what kind of questions you asks or what document want you see from for before buying that washing machine that is called technical specification. Means there is shorten parameter written on the sheet. If you see any data sheet or any technical specification of systems, there are certain parameters are written on that data sheets. You have to know which parameter is meaning what, then you can suggest which machine is suitable for your purpose.

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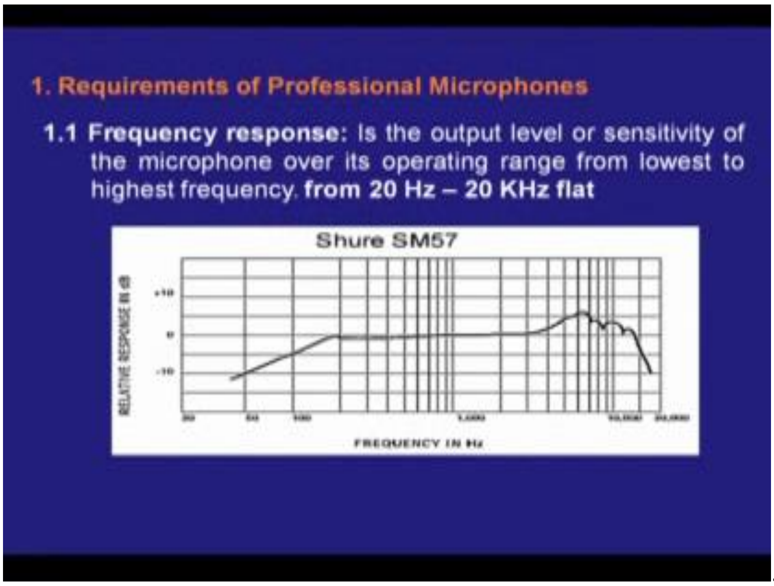

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Similarly, when you buy a microphone, what kind of specification I should see, let us first discuss that that part. One is first one is called frequency response, so which is the that means, that is the requirement specification means that somebody said me that I want to record this kind of performance which kind of microphone I should buy. So, you are seeing the specification of the microphone, and the vice versa it is the requirement of the user. So, I required this kind of microphone. So, you turn can convert that requirement to the microphone specification so that is nothing but a requirement of the professional microphone, what things you should look at. One is that frequency response one of the point is called frequency response.

So, what is frequency response, if you see in any anything, if you see that any, when you buying a audio systems or why do you buying a microphone or why do you buying a loudspeakers always you would asks what should. Or if you see that you want to buy a IC also that if you are an electronics engineer, you would say every IC there is a frequency response curve in the data sheet.

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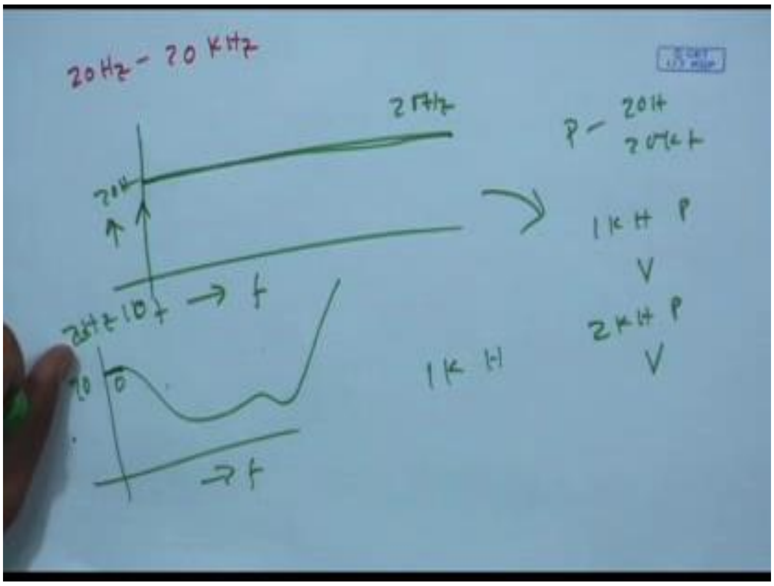

So, what do understand by the frequency response of the microphone? Suppose, what should be the ideal frequency response nothing is given, what is the ideal that human audio range is 20 hertz to 20 kilo hertz. So, if I say what should be the good microphone I will always say if all the frequency up to 20 hertz to 20 kilo hertz has the same response frequency response curve should be like this. What is the frequency response curve means this is called the sensitivity this axis and this axis called the frequency. So, sensitivity of the microphone should be equal in all frequency that means, I cannot say that sensitivity I come on later. I cannot say suppose I producing the same pressure of P for all frequency of 20 hertz to 20 kilo hertz the output - electrical output of the microphone should be remain constant.

That means, if I apply a 1 kilo hertz P pressure and if I get the voltage V, then if I apply a 2 kilo hertz P pressure, I should get voltage V again then I said the frequency response of that microphone is flat. But in practical, frequency response is I cannot get the frequency response all in flat. If you say what is the human frequency response of the human ear, human ear are not all frequency are all sensitivity, all frequency are not equal sensitive. If you remember, we have said that loudness curve that during the frequency versus the loudness curve that if this is the frequency; this is the audio range this means if it is say zero d B. So, same loudness of different frequency are not perceive the equal loud or you can say if I say the 10 d B of 20 hertz, 20 hertz 10 dB and 1 kilo hertz 10 dB both will be not perceive equally loud because of the frequency response will the outer ear and inner ear like this.

Then human being also to perceive the low frequency I required larger amplitude pressure amplitude than the high frequency. And also very high frequency again the frequency response - the sensitivity of the ear is goes up. So, depending on the required since the ultimately the microphone actually what I required that I will catch the signal by microphone then again convert to the loudspeaker that will be listen by a human being only. So, I can say since the human frequency response is not flat, I may not require a very flat frequency response of microphone. So, I may require a frequency response of microphone like this.

If you see this is the Shure SM 57 micron from the data sheet frequency response at 20 hertz that is not required is it human voice 20 hertz is audible, but it is purpose of voice recording or music recording I said below 20 hertz I cannot required. So, if you say, at here, response is same and it is down. So, after roughly 200 hertz I get flat response up to maybe it is up to maybe 1.5 kilo hertz no not 1.5 kilo hertz this is 1 kilo hertz then this is 10 kilo hertz, so up to 10 kilo hertz roughly this flat and then it is going down and here slightly upper sensitivity is there. So, I have do not know problem. So, I can say this microphone may have a frequency response of the gets 300 hertz to 200 hertz or less 100 hertz to 10 kilo hertz.

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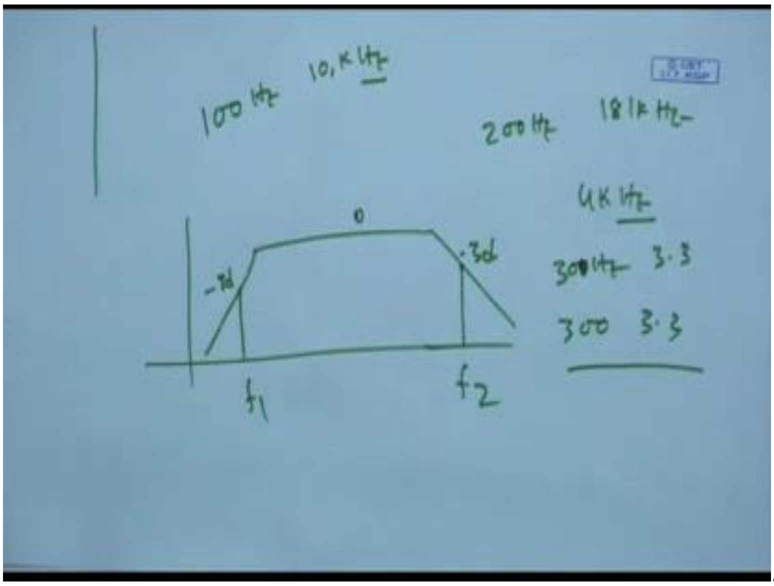

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So, I said microphone have a frequency response 100 hertz to 10 kilo hertz. Actually this is measure in a 3 dB down, if I have a frequency response like this then I can say a frequency response here 3 dB down from if it is 0 dB minus 3 dB that side minus 3 dB, so this f 1 to f 2 in the frequency response of that microphone. So, if I say that I want to record music, it may not be say that music is required lets 200 hertz to at least 18 kilo hertz, but if I say I want a microphone to capture the audio signal and transmit in a telephone channel. So, the telephone channel bandwidth lets 8 kilo hertz frequency, so 4 kilo hertz. So, above 4 kilo hertz I do not required that signal. So, I can say I can buy a microphone a telephone channel is 300 hertz to 3.3 kilo hertz, so I can say 30 hertz to 3.3 kilo hertz is then I can say I want the microphone its response is sorry 300 hertz to 3 kilo hertz is flat, rest of that I do not bother. So, this is the frequency response meaning of the frequency response.

So, now there is a problem, what is the problem? If I want to increase the frequency response, the cost of the microphone will be very high. That means, if I a wide range of frequency response means suppose I want to microphone who is as they 100 hertz to 20 kilo hertz flat frequency response cost may be very high, because the construction of the microphone if you see in the design time the construction of the microphone is very costly. So, this is the meaning of the frequency response.

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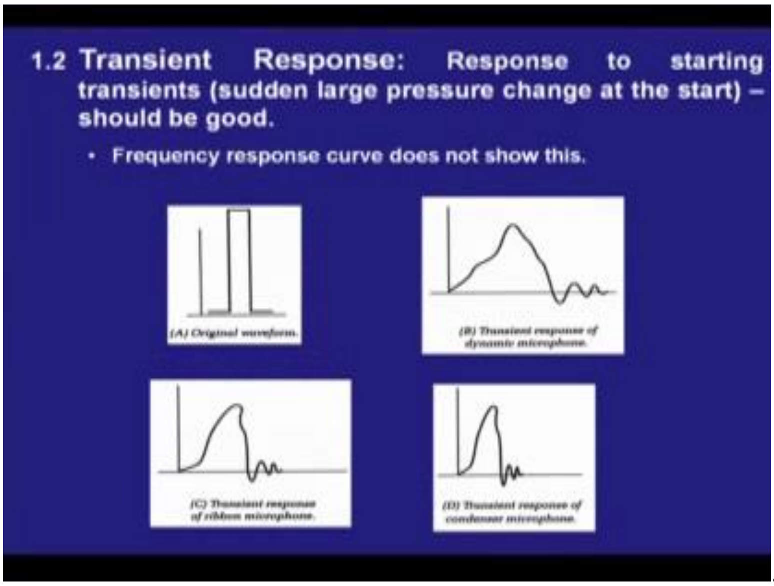

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The next parameter will cover called transient response. So, suppose I design a microphone, sudden changing pressure sudden large pressure change should not be change in output voltage of the microphone also suddenly. So, I want the microphone is working, but if I apply a pressure involve like this graph, my transient response should be the as much as flat is possible. So, transient response should see a transient response for a dynamic microphone, transient response is a ribbon microphone, transient response for a condenser microphone. So, what is another microphone, electro dynamic microphone, ribbon microphone and condenser microphone we will study that all kinds of microphone, what is the kinds of microphone. So, I required a transient response should be very low, very not be Shure high if it Shure high that it creates when disturbance and or noise in the recorded signal.

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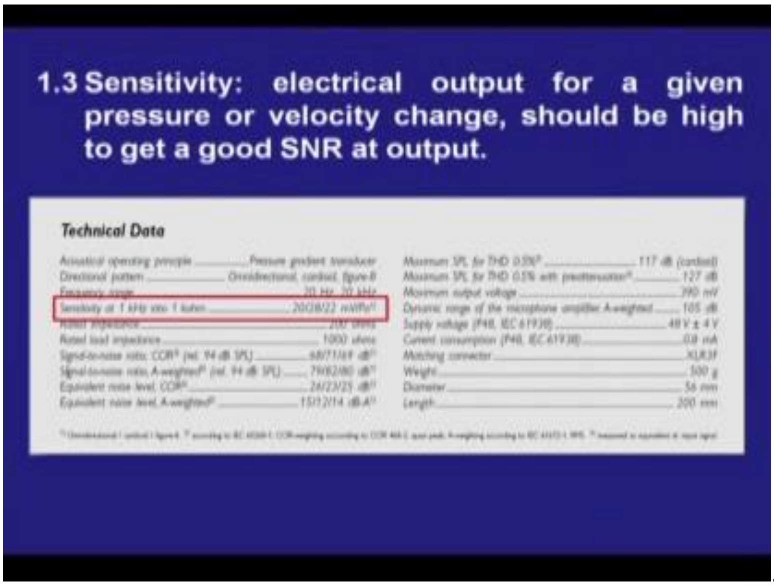

Next one is sensitivity. So, I said sensitivity I have already said in during that frequency response. So, what is sensitivity, what sensitivity is that if you say that this person is very sensitive to this things, what is the meaning is that the amount of stimuli you apply and the reaction. So, there is a measurement between the amount of stimuli I applied and the reaction. So, in case of microphone the sensitivity is that sensitivity defines as that if I apply a pressure what should be the electrical output.

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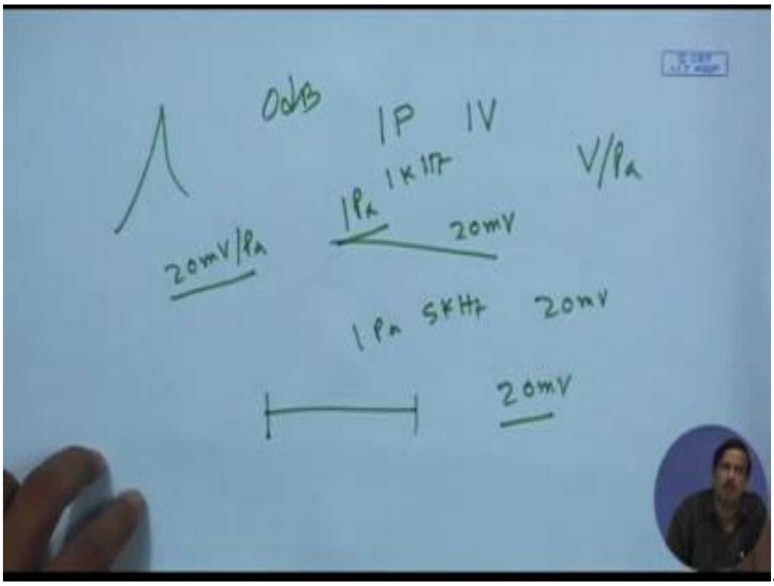

So, sensitivity of a microphone is 0 dB, if I apply a 1 Pascal pressure on the microphone if it is produce 1 volt at electrical circuit. So, if I say the sensitivity is define voltage per Pascal, voltage per Pascal. Now, if written like this 20 milli volt per Pascal, what is the meaning that if I apply a 1 Pascal pressure on the microphone, it will give me 20 milli volts is the sensitivity. Now, it is the sensitivity, frequency independent. If I apply a 1 Pascal pressure of 1 kilo hertz and 1 Pascal pressure of 5 kilo hertz are they produce both 20 milli volt, and they produces different that depends on the frequency response of the microphone. If that frequency response of the microphone between 1 kilo hertz to 5 kilo hertz, then it should produce 20 milli volt. So, on the vice versa the sensitivity of the microphone depends on frequency.

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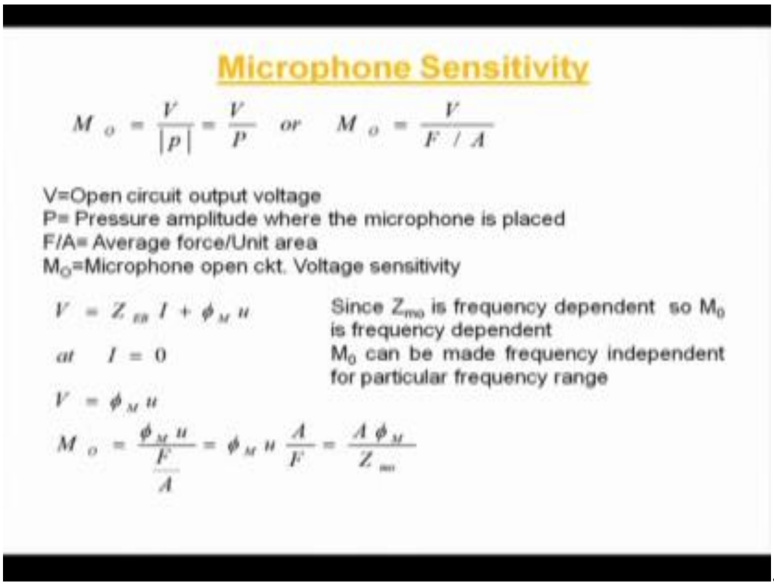

How, it is depends on frequency let us see. So, I said lets sensitivity of the microphone is define is M 0.

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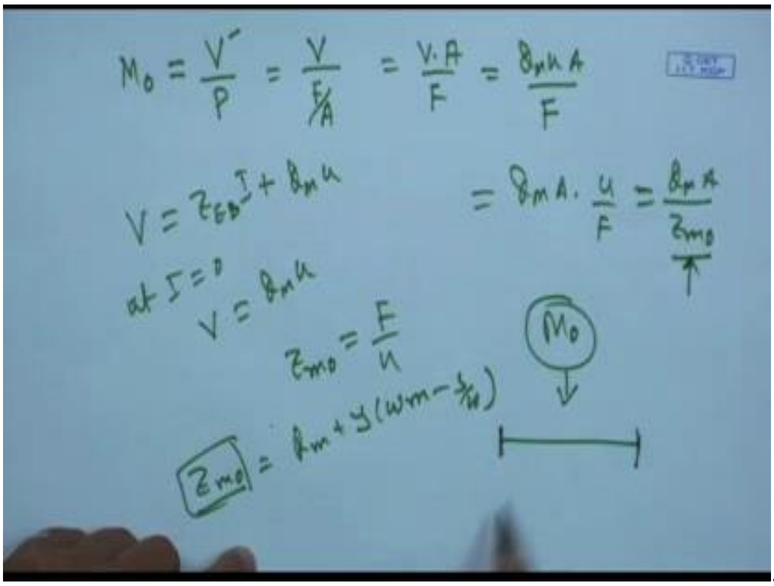

So, M 0 is nothing but a voltage per pressure. So, what is pressure voltage per force per unit area pressure is nothing but a force per unit area. So, force by A. So, it is nothing but a V into A by force, where V is the open circuit output voltage the condition yes sensitivity is measure at the condition when the microphone is in open circuit; that means, microphone is not connected to other device. The load is not applied to the microphone. So, open circuit voltage sensitivity of the microphone if M 0 then the open circuit voltage divided by the pressure amplitude P and pressure is nothing but force per area, V into A by F.

Now, what is V, V is as you the studied that Z E B - block electrical impedance into I plus phi m u. Now, if at I equal to 0, V is nothing but a phi m phi m into u, v is nothing but phi m into u. So, I can write phi m into u into A open circuit voltage that means, there is no current flow. So, I equal to 0. So, I equal to zero means V equal to phi m into u, so phi m into u a divided by F. So, it is nothing but phi m into A u by F. What is u by f, Z m o - open circuit mechanical impedance is nothing but a force by velocity. So, I can write this is nothing but a phi m A divided by Z m o. So, what is Z m o, Z m o is depends on the construction of the… So, Z m o may be either if it is a electro dynamic transducer Z m o is nothing but R m plus J omega m minus s by omega. So, or Z m o depends on frequency. So, I can say sensitivity M 0 is also depends on frequency.

Now, how do you make a flat frequency response? So, what is my motivation, I want that M 0 should be frequency independent for a particular range of frequency, so I have to met Z m o frequency independent for a particular range of frequency. Then I can say the microphone is microphone sensitivity that particular range of frequency sensitivity frequency independent; that means, for within that range for every frequency the sensitivity will be same. So, that is the frequency response of the microphone. So, how to make this M is frequency independent is depends on how we design; if I design the microphone such a way that Z m o is frequency independent then I can say yes microphone is for these particular frequency range microphone sensitivity is frequency independent. So, characteristics frequency curve of frequency characteristics of microphone is flat during that range.

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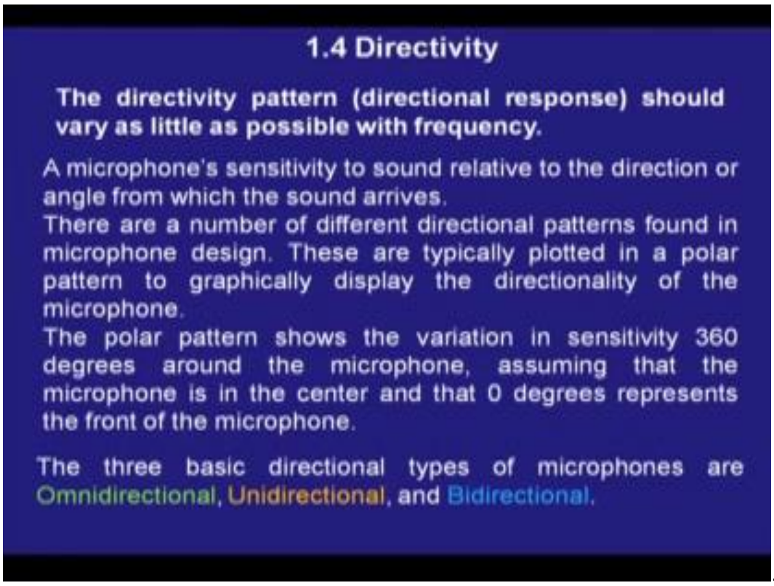

Another one is that directivity, you know that directivity pattern you say that directivity pattern. What is directivity of a microphone? Now, if I you see in the collar mic, if I speak from this direction it is catch; if I put the mic reverse direction, the mic not be catch, so that means microphone has a specific direction to catch the sound pressure. So, directivity pattern should vary a little as possible with frequency this is one requirement. I have said that directivity pattern directional response should vary as little that is the requirement of the microphone and directivity pattern also not frequency dependents that much. So, if it is frequency independent, then how do you make the directivity. So, microphone sensitivity sounds relative to the direction or angle from which the sound arrives. So, you can read the slides, I will give you the slides, I am not reading the slides.

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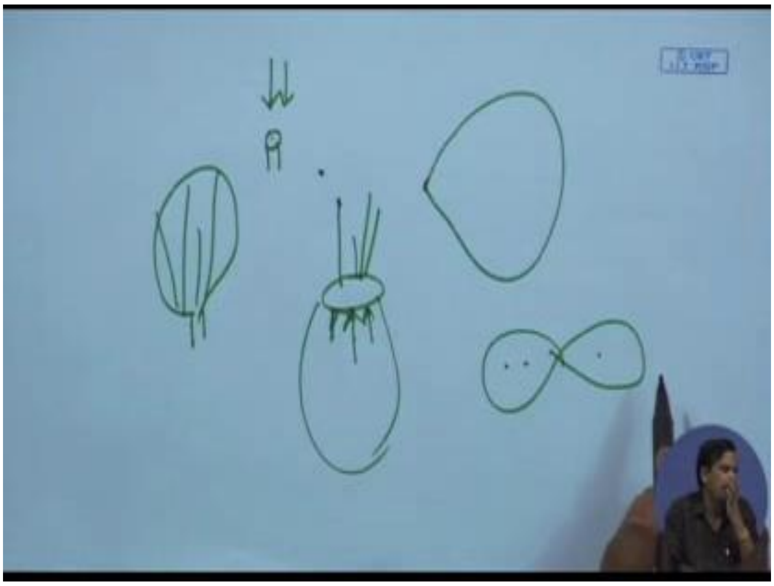

So, what is they are. Suppose I have a microphone like this. And if microphone only catch from this direction of sound then has directivity. The directivity pattern of the microphone always draw in polar coordinate; that means, suppose I have a microphone here with the microphone direction this side then I will write a this kind of pattern this is called the directivity of the microphone. So, a microphone based on the directivity can be three types one is called Omni directional microphone, unidirectional microphone and bidirectional microphone.

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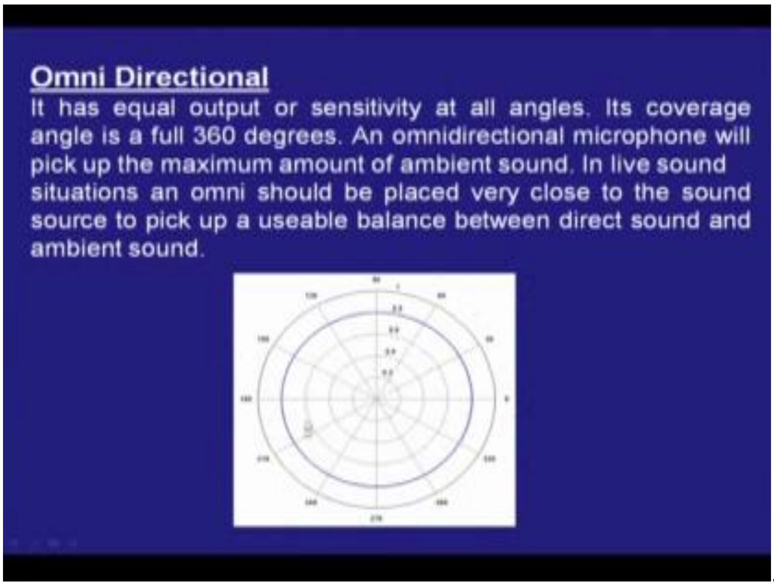

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What is Omni directional microphone? If you see this directivity pattern or Omni directional microphone, sound coming from any direction microphone will sense or microphone response will be the same. If the sound coming from the top, bottom, side any angle of that microphone the directivity if the Omni directional mic sensitive will be remain same then it is called Omni directional microphone.

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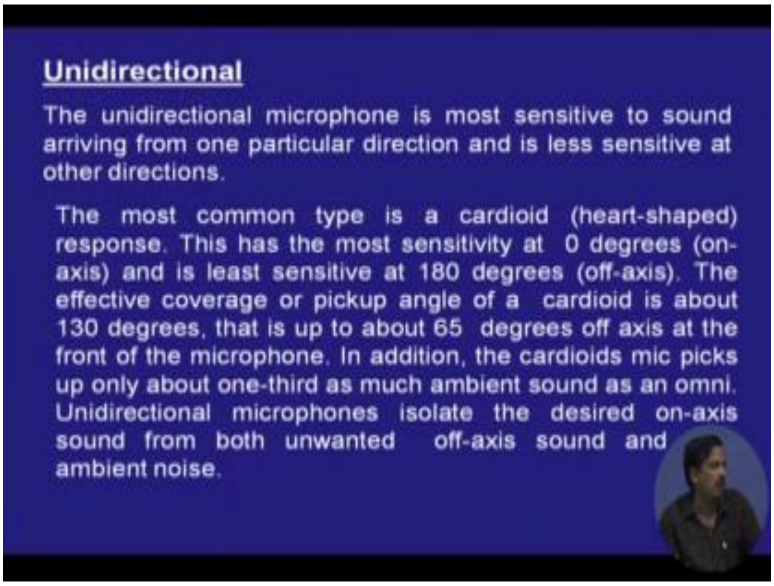

What is unidirectional microphone uni means only single sides that suppose I have a microphone that only catch this side then I call say it is a unidirectional microphone. This area if the sound is coming from this area only the microphone will be sensitive; on the other side microphone is not sensitive.

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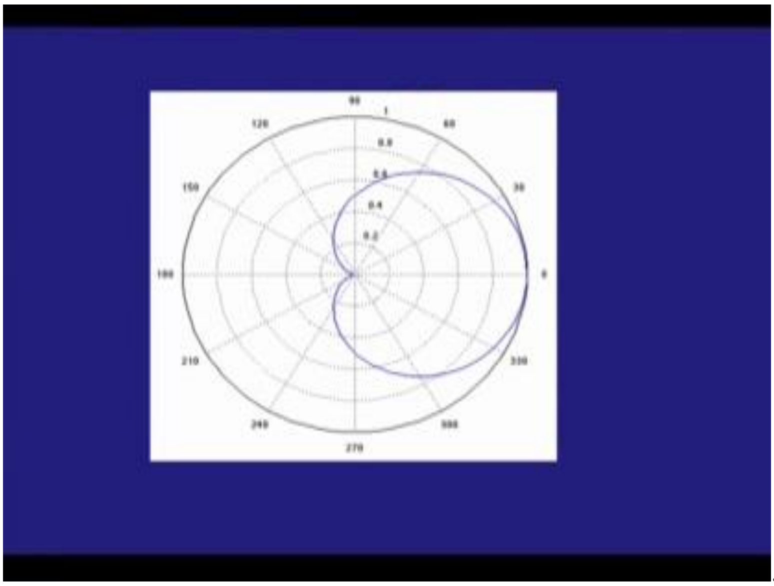

So, if you see that unidirectional microphone plot is like that; blue line indicates the directivity of the microphone, this is the microphone position. So, if it is this, you see only this direction microphone is catch; if you speak from this direction only microphone will catch; if you speak from this side, microphone will not catch. So, I can put a microphone likes collar mic why I put this one is top side because I said this is a not a Omni directional microphone it is a unidirectional microphone directivity pattern is in upside. So, if I put it up, if the sound pressure is coming from upside it catch very good or it sensitivity is good, so that is why I put the microphone this side.

If you stage you see that microphone the loudspeaker the microphone the speaker is fitting from the front side of the microphone; that means, the directivity pattern of the microphone is front. If you say in the stage earlier that there will be catcher, catcher directivity pattern is this side only not back side top of the phase nobody is there. So, I do not require the sound be should catch from this side I only required the sound should catch from this side sound should catch. So, this is the directivity pattern.

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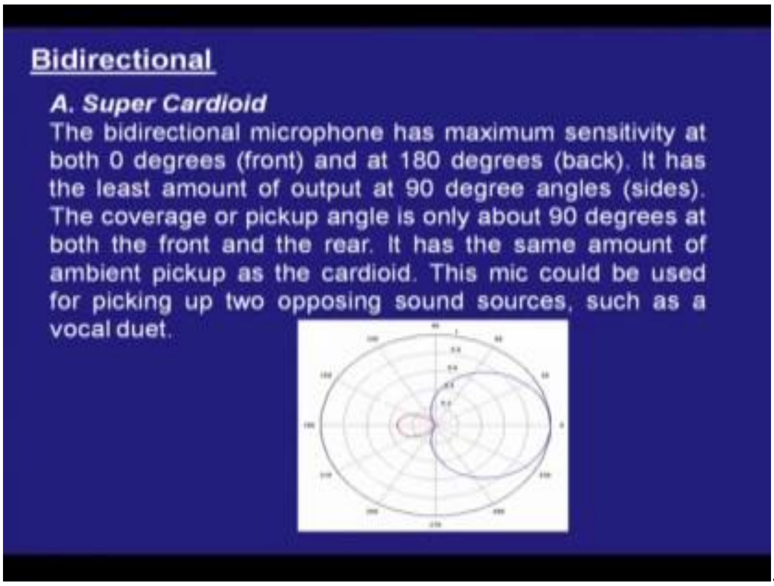

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So, there is a bidirectional microphone which can take the sound from the both the direction. So, it is a non nothing but a figure of eight. So, if it is both are same then it is a figure of eight, if it is depending on the directivity pattern on both sides the microphone are two type super cardioid and hyper cardioid.

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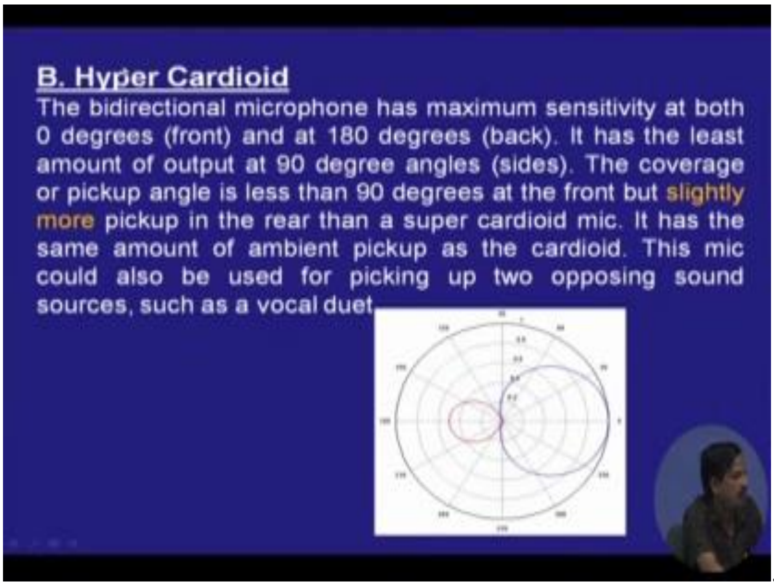

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I have not saying that, you can read the slides on that.

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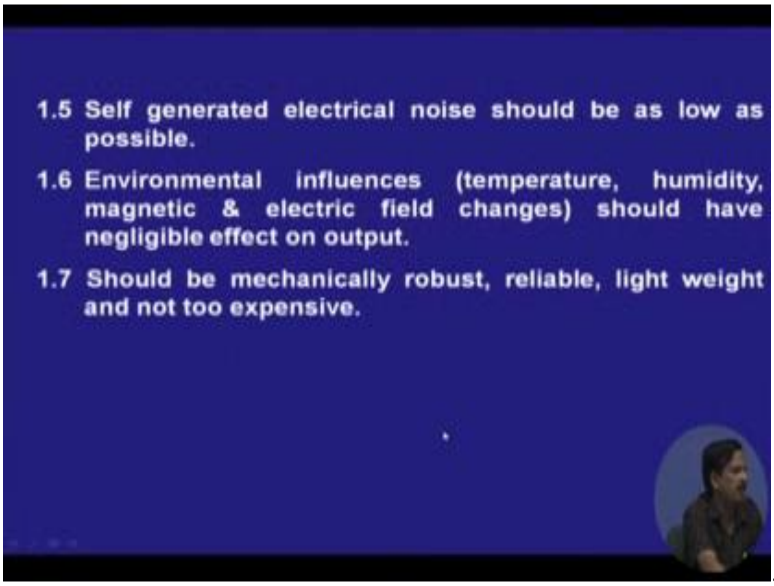

Then what is else we required self-generated electrical noise you should check. So, you check the frequency response you check the sensitivity you check the transient response you check the directivity pattern of the microphone. So, suppose I want to use the microphone for lecturing then I may be unidirectional mike is very enough look this unidirectional mike is enough, but suppose I want the microphone I should put the microphone here on the both side of that speaker will be seated then I may required a bidirectional microphone. Or suppose I put a microphone here in any side any point of any direction speaker can say I want that catching, so I put a unidirectional microphone. So, depending on the type use of the microphone, you should choose the directivity pattern.

Next one is self-generated noise electrical noise. If the self-generated electrical noise is high of the microphone, then it will be amplified the noise also will be amplify and the output of the loudspeaker will be very bad. Then in environmental influence; if I construct a microphone if it is it is very, very fine in during there is AC environment if it is go to outside it is not working; that means, you should not be temperature humidity magnetic or electric field change. So, it should not be suppose this is the dynamic mic and I have a magnetic field is here the magnetic field strength is B in here if I change its strength if it is change in outside if you change the position of the microphone magnetic strength is change that will not work.

So, I want the microphone should work with the humid or different temperature electric field and magnetic suppose I put the microphone in here and the high voltage line is going on. So, microphone should not be interfering by the high voltage line, so that kind of microphone I want. Should be mechanically robust, reliable lightweight, not too expensive this is the custom of this is the point to discuss. If I want a very good sensitive microphone a very good frequency response microphone with the very high sensitivity I cannot get a low cost, the cost will be high.

Similarly, I want the microphone very robust; you should not be handling with care. And if I connect little bit of tied then it will tear up that kind of microphone you should not want. We want the robust microphone then we want lightweight it should be a heavy weight if it is heavy weight if the collar mic is heavy weight I cannot put it in here. So, I required a light weight microphone. So, depending of the application and cost and the requirement, you should choose your microphone based on those parameters.

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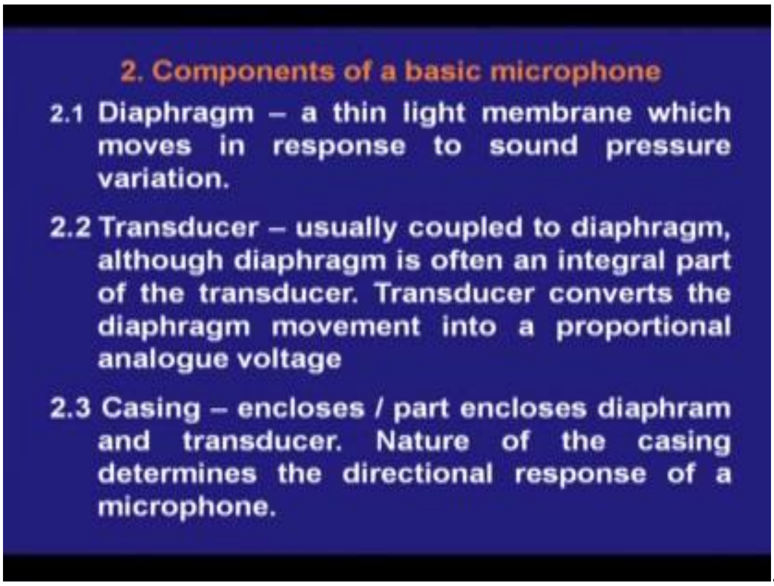

Now, I go for the component of the microphone. If I want to design a microphone what are the basic component first one is the diaphragm I can show you the next, next lecture diaphragm of the microphone. I can show the next lecture the diagram. A thin light membrane which moves in response to sound pressure variation, there from as you discuss in transduction during the anti reciprocal and reciprocal transducer, diaphragm is a thin membrane which can move due to the sound pressure. So, if the micro microphone diaphragm if it is exposing to the sound pressure and it should move and this mechanical movement will create the electrical variation transducer usually coupled to the diaphragm.

What is the work you have already study the transducer principle; based on the principle of the transducer it should convert that mechanical energy to electrical energy. Or you can say if I laud apply sound pressure you should create a voltage or current depending on the requirement. Then casing, diaphragm transducer and should be casing a very large rigid casing show that it should be environment ragged and it should be environment friendly. So, enclosure part enclosure diaphragm and transducer nature of the casing determines the directional response of the microphone. Casing has other important parameters that depending on the casing the direction of the microphone will be determine.

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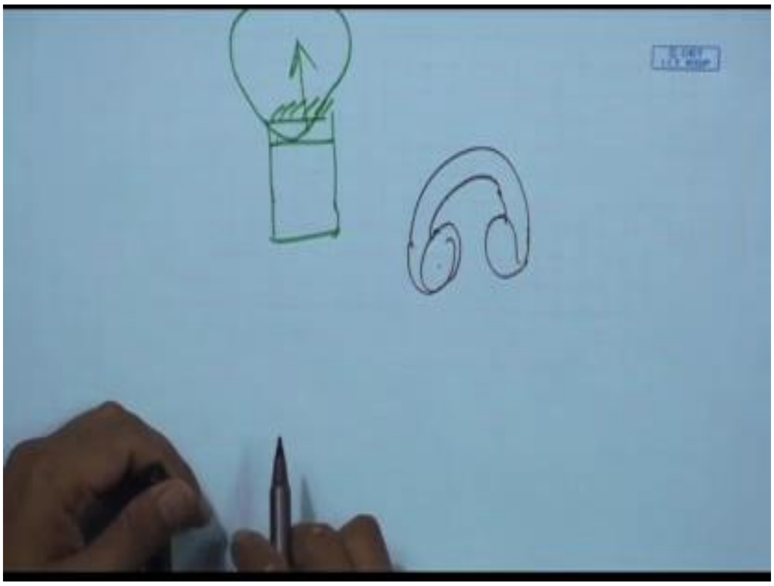

Suppose if my diaphragm is here and put that microphone is this kind of metal casing. So, here is opening then the sensitivity of the microphone will be this side, sensitivity microphone will be this side. So, I can say the directivity pattern of the microphone will like this if I say this microphone if you see it that top side all are enclosed, only top side is perpetrated that means, voice pressure is coming in the top side and the directivity pattern is in the up.

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Then basic microphone types, what are the basic components depending on the construction of the microphone. There are different types of microphone - carbon microphone, piezoelectric microphone, dynamic microphone, condenser microphone electret microphone, ribbon microphone. Carbon microphone piezoelectric microphone depending on the constant, do how do you make the microphone. Those are the different types of microphone; there is a boundary layer microphone. They were the application type boundary layer microphone tabletop microphone, boom microphone, but construction vice carbon microphone, piezoelectric microphone, dynamic microphone, condenser microphone, electret and ribbon these are the basic type of the microphone depending on the construction of the microphone.

Carbon microphone as you already has you see any if you see today the nothing no carbon microphone is used. If you see the earlier telephone that cartel telephone black on there is a carbon microphone. If you see that there is a cartel type microphone and has a huge cartel in this side and then this side also cartel, so that microphone was carbon microphone. So, the basic principle of carbon microphone you know that.

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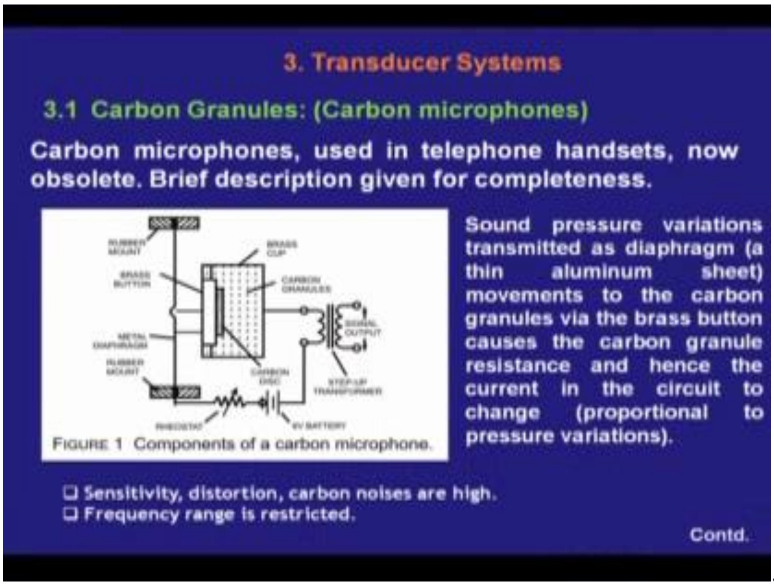

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So, this is the construct this is written you can see that you can read that slide. So, there is a diaphragm connected with a metal and there is capsule box capsule within the capsule there is carbon granules. So, if the diaphragm is connected to the this metal with a pin and then if the diaphragm is vibrate in this side placed in this side that this also this also placed in this side and carbon granules will be this place. And registration resistance of this between this two electrode will be changed here is a electric connect there is a connector here and here is a connector, if the resistance is change, so change of current will be happened and I put a transformer here, the change of current inducer voltage in here, so I can say that this is the signal output.

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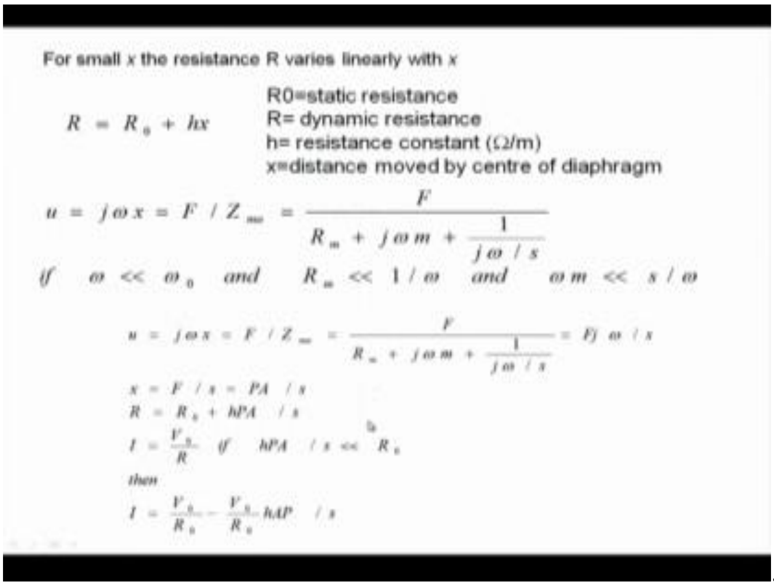

So, depending on the motion of the diaphragm, the resistance will be changed, change of resistance create the output.

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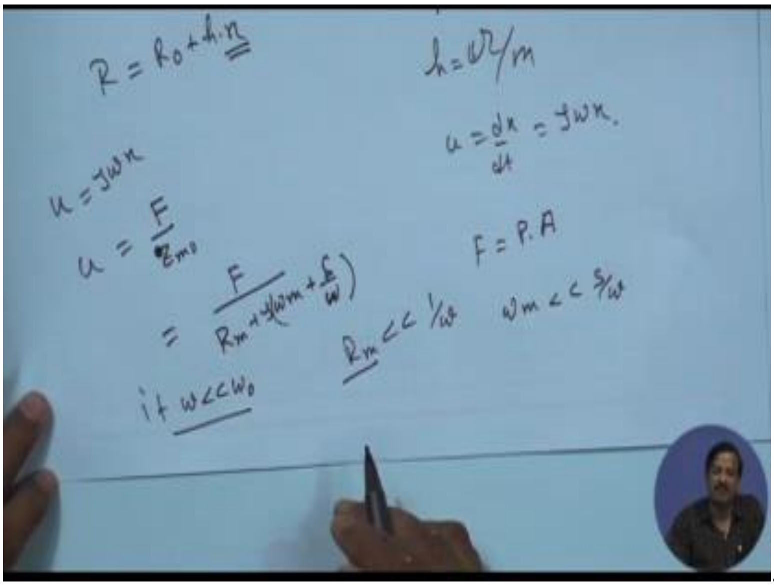

If you want to see the simple mathematics on here lets I say that, so actually what is happening here lets R 0 is the static resistance of the granules then R is the dynamic resistance if it is change then it will be R. So, let us diaphragm is move in x distance. So, the R will be R 0 plus h into x, what is h resistivity of the carbon granules. So, if the x distances change h multiply by x or resistance constant resistivity q per ohms per meter. So, h is nothing but a ohm power resistance constant or ohm per meter.

Now, if I say what is how do you derive x next diaphragm has a motion u, there from is expose to the pressure and has a motion velocity is u. Then u is nothing but a J omega x d d x u is nothing but a d x of d t. So, d d t can be written as j omega x. So, u is nothing but J omega x. So, what is j omega, what is u, u is nothing but a force divided by mechanical resistance force by Z m o. So, if the diaphragm is expose to the force f then force by Z m o is the u. What is force, force is nothing but the pressure multiply by the area of diaphragm; pressure is nothing but force for unit area. So, it is pressure multiply by the area of the diaphragm. So, I can write that u is nothing but let F divided by what is Z m o R m plus J omega m plus 1 by or you can say s by omega Z m o.

Now, if it is u, then if let omega is less than omega 0. What is the meaning thus the operating frequency of the microphone is very low compare to its resonant frequency omega 0 then and R m mechanical resistance is very low compared to 1 by omega then and another omega m is much, much less than s by omega, this is free condition. Microphone is operated below the resonant wired resonant frequency resistivity what mechanical resistance of the microphone while below the 1 by omega and omega m much, much less than s by omega.

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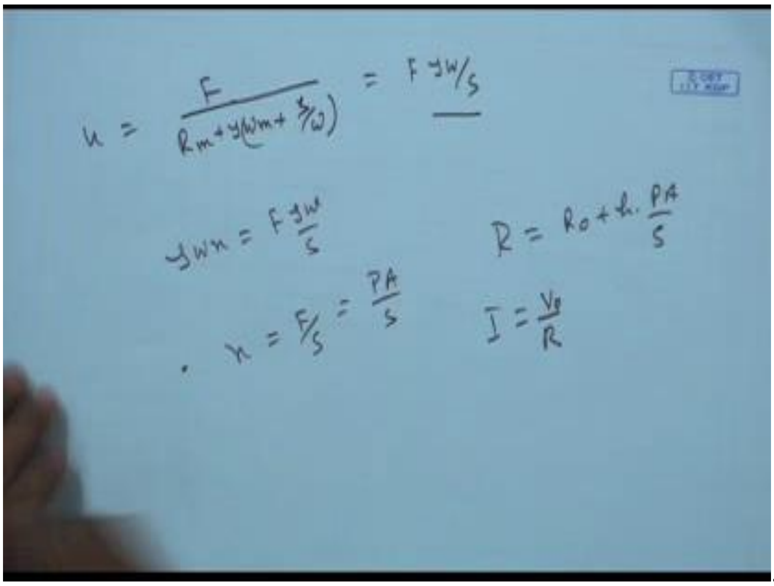

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Then I can say u is nothing but F by R m plus J omega m plus omega m sorry J omega m by s by omega s by omega. So, I can say in that case if it is that then I can say the plus or minus it is nothing but F J omega by s if all this three limitation are applied. So, now J omega x is equal to nothing but F J omega by s. So, x is nothing but F by s. So, it is nothing but a pressure P A by s. So, R now come R 0 plus h into P A by s. So, I is nothing but a current. So, current is nothing but voltage by resistance V 0 by R. So, if say initially I have applied V 0 will here 6 volt battery. So, we required a battery I applied a V 0 in here. Now, the resistance is change total resistance is change. So, I can say I will change from V 0 by R 0 plus h into P A by s then I can write then it will become then I can say I will change. So, now current is change. So, I can this current will be taken by the transformer and we can get the equivalent current of the pressure. So, this is the resistance microphone, which is total almost obsolete from the markets, you cannot get the resistance microphone today.

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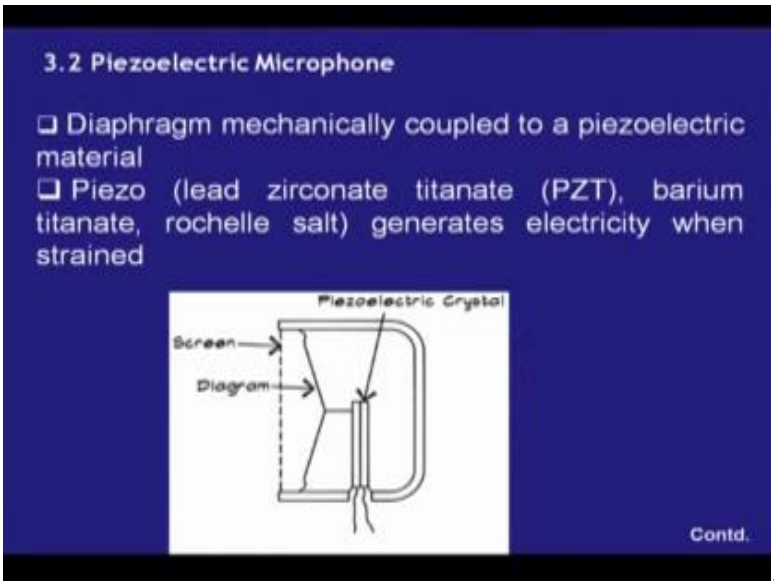

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Next one is piezoelectric microphone where diaphragm is mechanically coupled to piezoelectric crystals. You know that if I deform a piezocrystal there its changing polarizer and it produce charge differences and which can induce a current or which can flow a current or voltage or you can get equivalent voltage, so that is the basic principle. So, if you see the construction, there is diaphragm connected to a piezocrystal by a pin, pin head diaphragm mechanically coupled to a piezoelectric material piezo you know the piezo material, what are the piezoelectric material.

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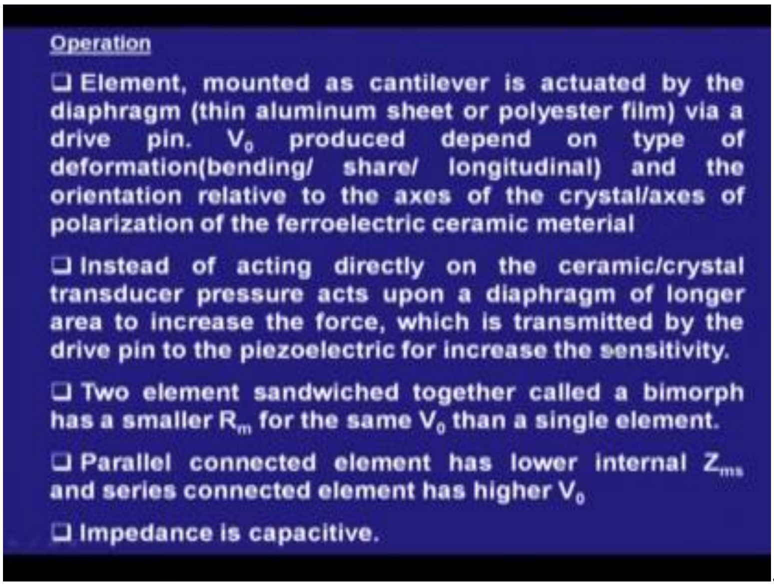

Then what is happen, so if you see this here forget about the read the slides. If I generate a pressure in here if I apply a pressure on the diaphragm the pin will put on the pressure on the piezo, and its changing direction and then will be a equivalent charge differences create a current. If it is diaphragm move this side then also you change its direction and it produce a current. So, change of direction of piezoelectric crystal produces a current, so that is a mechanism for piezoelectric microphone.

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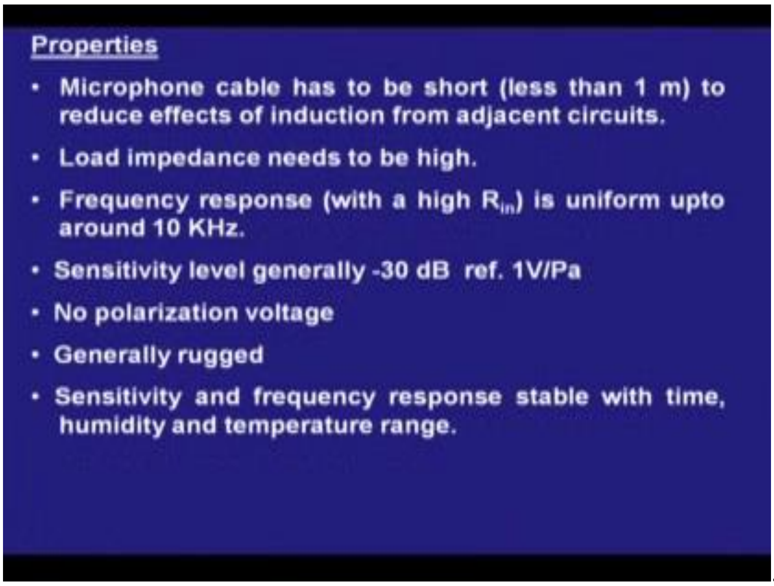

What is the property? So, microphone cable should be very short less than one meter to reduce the effects of induction from the adjacent electrical circuit. So, main drawback of the piezoelectric mic is a very cost effective solution, very cheap mic because construction of the piezoelectric mic nothing but a diaphragm connected to the piezoelectric crystal by a short pin. Now, it is very, very cheap, but the problem is that I can amount of the charge which is given by the two wire is very much sensitive to the induction from the adjacent circuits. So, if I take a long cable and there are lights and fan and everything. So, induction charge also differ the current will be interfere by that induction. So, the sensitivity is very less or the sensitivity is minus 30 dB per Pascal 30 dB. So, minus 30 dB is the sensitivity.

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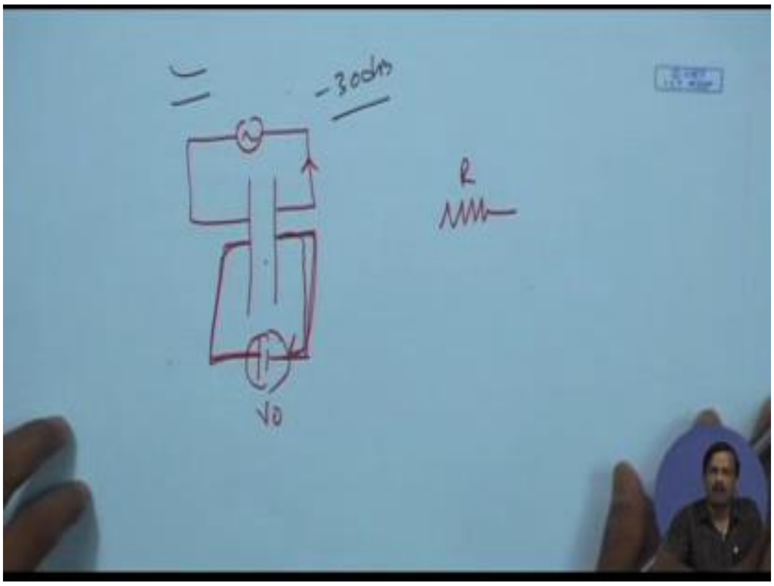

So, I can say the length of the cable is less that is why if you see your headphone may be a piezoelectric mic, but I cannot connect a piezoelectric mike in a dais because the long cable is required. So, piezoelectric mic are cheaper solution of microphone and it can be used for a short distance microphone, because very rugged, it only have a diaphragm pin and piezoelectric crystal. Load impedance need to be high. If piezoelectric mic is connected then it required very high low impedance and sensitivity level is minus thirty dB no polarization voltage required generally rugged sensitivity and frequency response stable with the time humidity and temperature range. So, no problem sensitivity is if put the microphone one ear sensitivity does not change that much. So, sensitivity microphone is very lagging, but only drawback is the cables are be very short on the frequency response is reasonably good, but not very good.

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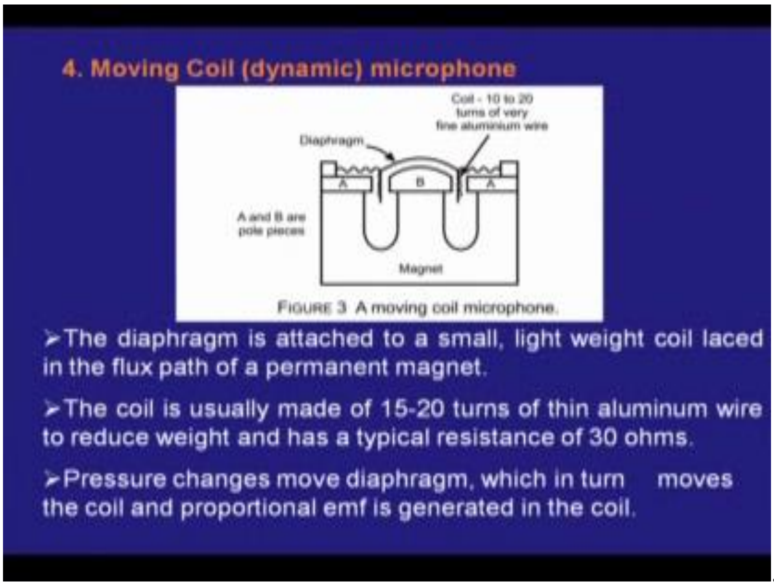

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Then will go for another microphone is called moving coil microphone. Construction of the moving coil microphone is already I have discussed. The magnet, coil, doom diaphragm then are diaphragm and then it connected housing in a casing or you can say this is the suspension or mechanical resistance come from this suspension and then this coil may be either aluminum or copper.

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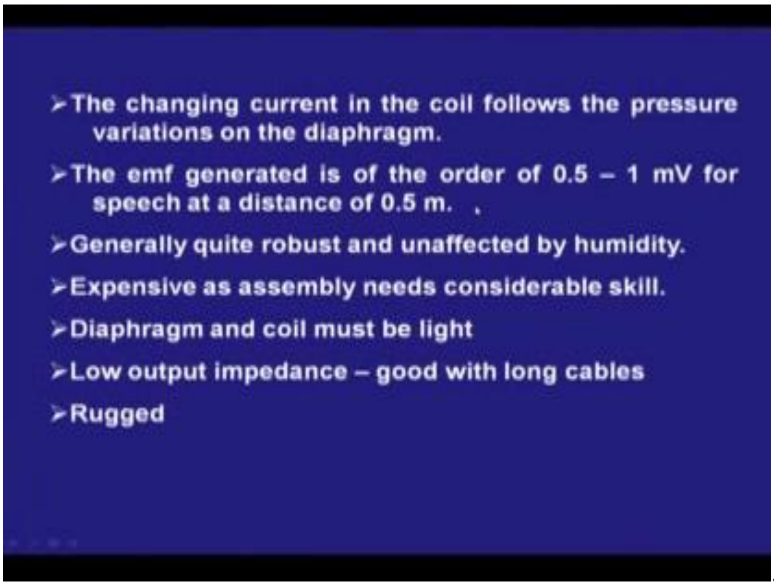

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Now, I am not going to those things. So, changing current in the coil follows the pressure variation on the diaphragm the EMF generated is in order of 0.5 to 1 milli volt for speech at a distance from 0.5 meters. Generally, quite robust and unaffected by humidity, because nothing to change with the humidity here, very slight change in diaphragm, weight may be increases, but not that much of robust unaffected by the humidity. Expensive as assembling it this is considerable skill. Diaphragm and coil must be lightweight and low output impedance good with long cable. So, all the stage microphone if you see I have required a long cable I required a dynamic mic and it also very longest.

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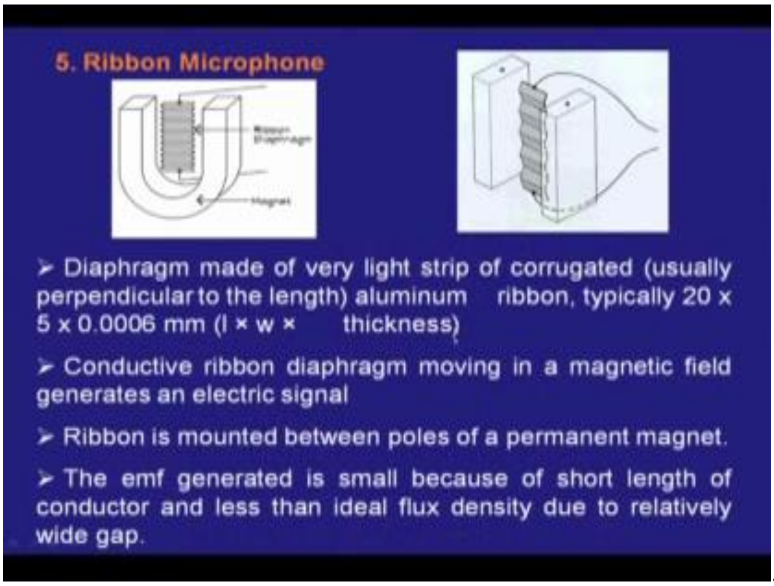

Then there is another kind of microphone ribbon microphone. So, there is a ribbon in a magnetic field if I apply a pressure ribbon will move and that induces voltage is create the signal.

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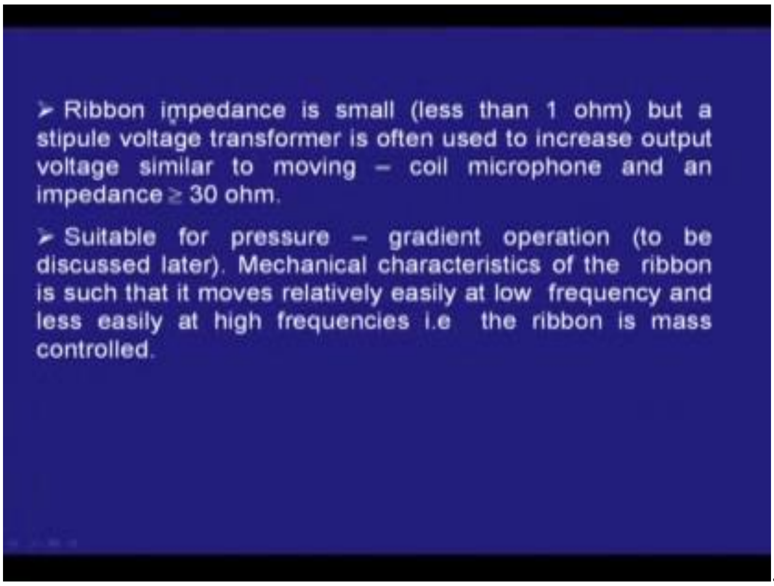

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So, ribbon impedance is small, but this stipulated voltage transformer is often used to increase the output voltage similar to moving coil microphone; and impedance is below 30 ohm. Suitable for pressure gradient microphone, I will come what is pressure gradient microphone. So, ribbon mike is use for pressure gradient microphone.

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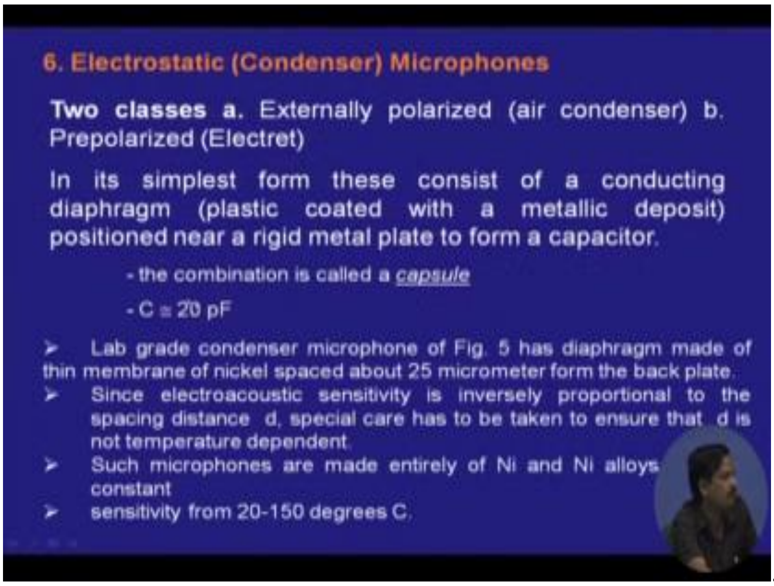

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Then electrostatic microphone as we discuss capacity microphone. So, moving coil microphone and ribbon microphone. Ribbon is also electro dynamic microphone by insulated of coil I put a ribbon there. So, ribbon is nothing but some wire wasted on a very thin I should insulated material. So, it is nothing but a moving coil microphone, but it is construction it is called ribbon microphone. Electrostatic microphone you can read - I will share the slides, so there is a time constant. So, I have not reading the slides and I am not I just discuss what is electrostatic microphone is earlier.

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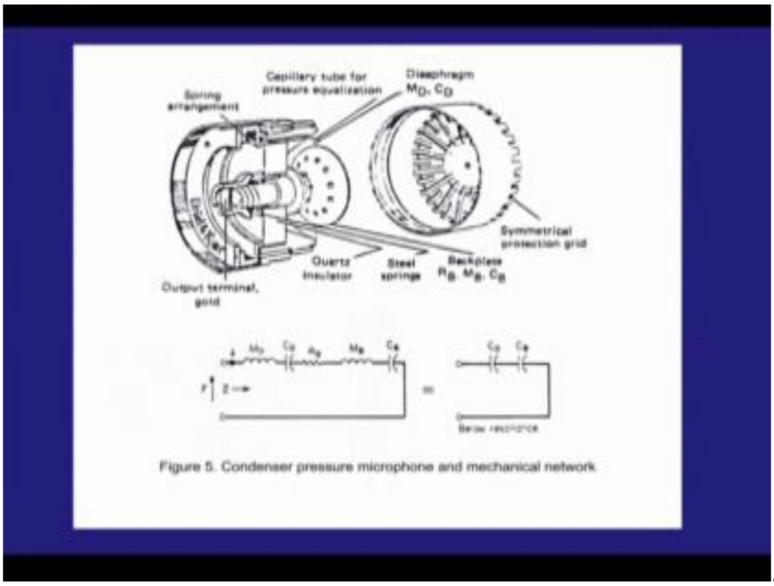

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So, it is same in the here also given and that the construction is given. So, you know that there is a M b C d C b which is comes from the microphone side and M b C b, I have already discussed what is there. So, electrostatic microphone it works on a plate. So, in between two plates, I apply a dc voltage initially and then if I apply a alternative current or if I apply a pressure, if I plate distance is change, it produce the change of capacitance and produce the change of current and that act as a signal, I get the signal. So, that this how this voltage will be connected is very important. So, capacitance microphone required a power supply; without this V 0 capacitance microphone will not work. And V 0 is connected to the capacitor with a large input resistance, so that this when I apply the signal or when the diaphragm is vibrating that ac signal should not flow in the battery side. So, this is the main drawback in capacitance microphone.

So, if you see the piezo mic, It does not require any power supply, for operation of the microphone. Dynamic mike moving coil microphone, It do not require any power supply dc power supply for the microphone, but for the capacitance microphone and carbon microphone I require a dc supply this is the main problem. So, suppose I want to I have a computer and that is a lining if you see the lining means there is only RCA jack is available, but which I can connect a microphone.

Now, if I connect a capacitance microphone is it work, if the capacitor microphone does not have the battery within that microphone, they do not work. So, if you see there is a some amplifier earlier there, there is a some amplifier while I have use the capacitance mike that means, a dc supply will be supplied from the amplifier to the microphone by a circuit a very high resistance and then that then the signal will be transferred to the amplifier.

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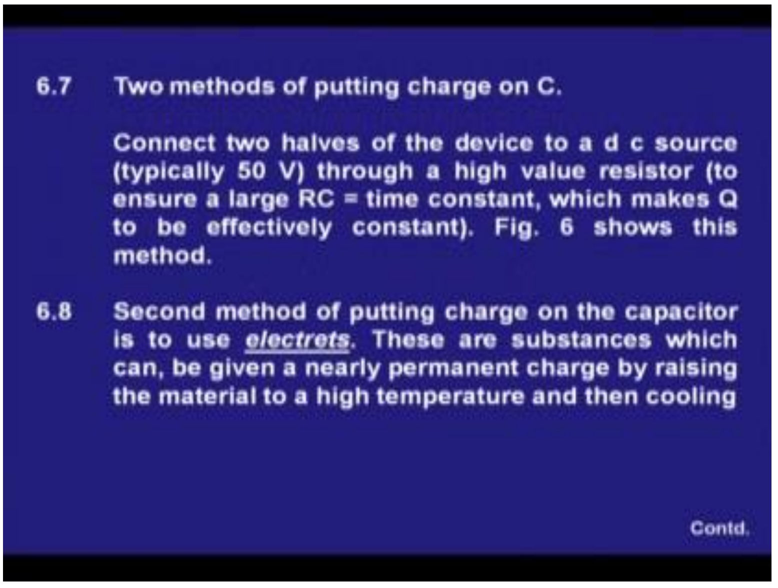

So, if you see the properties of that microphone I have not discussed about this part.

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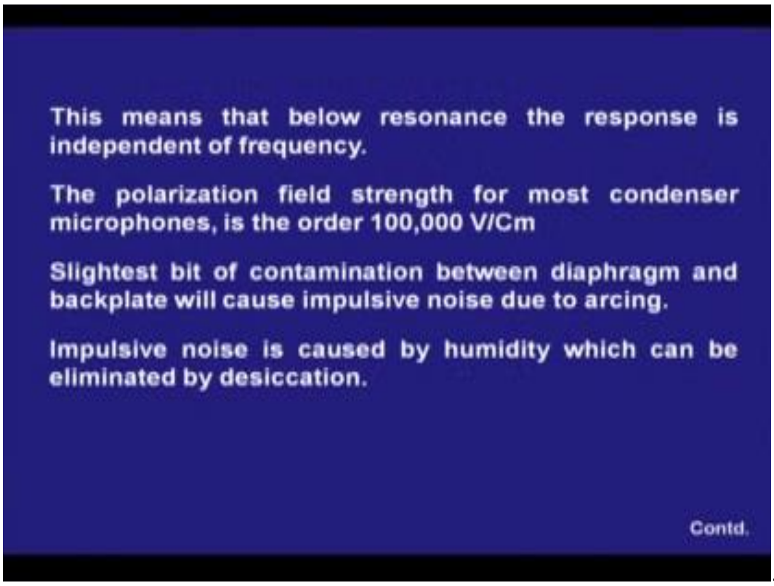

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Two methods; there is a two methods for putting I said that in capacitive microphone I required an initial charge. So, in the order of 100,000 - 10 to the power 5 volt per c m – cubic meter, c m per c m, in that order how can I put the charge on the capacitive microphone there are two procedure one is I supply a battery or a put a battery on the microphone or supply the dc supply from amplifier to the microphone that is the one procedure one. And it should be supply to a high value resistance, so that RC constant time constant which make Q to be effective constant and figure and you will see the figure.

And second method is putting the charge on capacitor to use electrets. So, I can use a electrets and charge the electrets and that microphone well hold that hold the charge, but it is there is humidity then by electrode may be discharge. So, if it is discharge then sensitive of the microphone will be goes down. So, by electrets, it is not that good, but that putting the dc supply on the microphone is very good arrangement.

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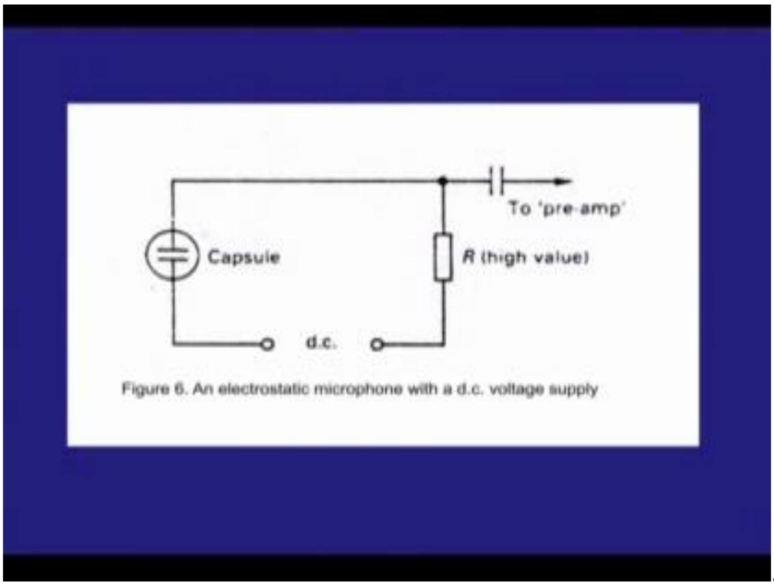

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So, how do you do that if you see this is the microphone and this is a dc. So, this is the high value resistance dc supply connected to the microphone with high value resistance then I put capacitance and to go to the preamplifier, or I can put a electrets material which charge it. So, like that way it will charge you know the electrode material it would charge.

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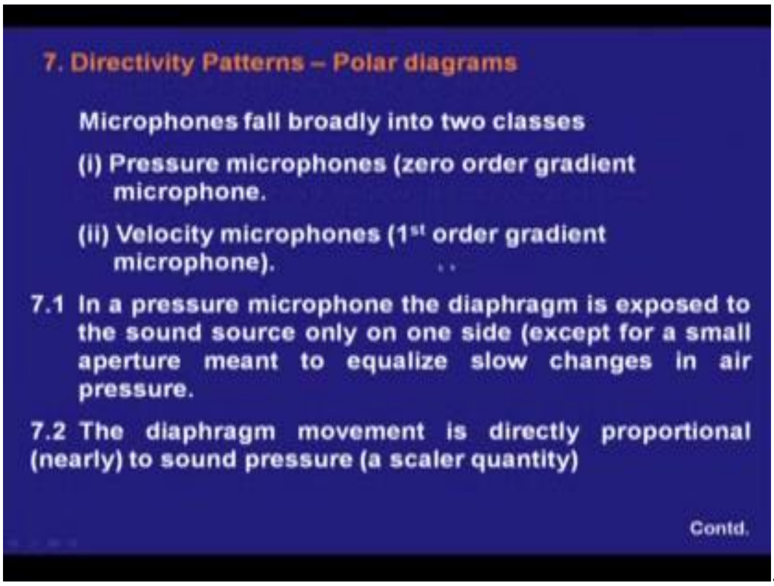

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So, directivity pattern now I go for the all kind of microphone I discussed then I go for the directivity pattern or polar diagrams directivity pattern is in polar diagrams. Now, how the microphones work. Suppose, this is the diaphragm either the pressure which coming from the source or acoustic source should fall on the diaphragm and diaphragm vibrate and produce the electrical voltage. So, it is a pressure sensitive microphone so that means, the change of pressure creation vibration of the diaphragm and microphone work microphone produces the voltage so that is called pressure microphone or pressure sensitive microphone or zero order microphone zero order gradient microphone.

Then there is another kind of microphone which called velocity microphone or pressure gradient microphone it works on different of pressure both side of the diaphragm that is the velocity microphone velocity microphone. So, pressure microphone and the diaphragm is exposing to the sound source only in one side. If I want to make the pressure microphone that this is the diaphragm, lets this is the diaphragm, then it should be exposing this side only not this side. If I expose this side then the vibration will be not come, so I enclose that I make that enclosure in back side and put the only open in the top side then this microphone will be the pressure microphone, directly propositional to the sound pressure.

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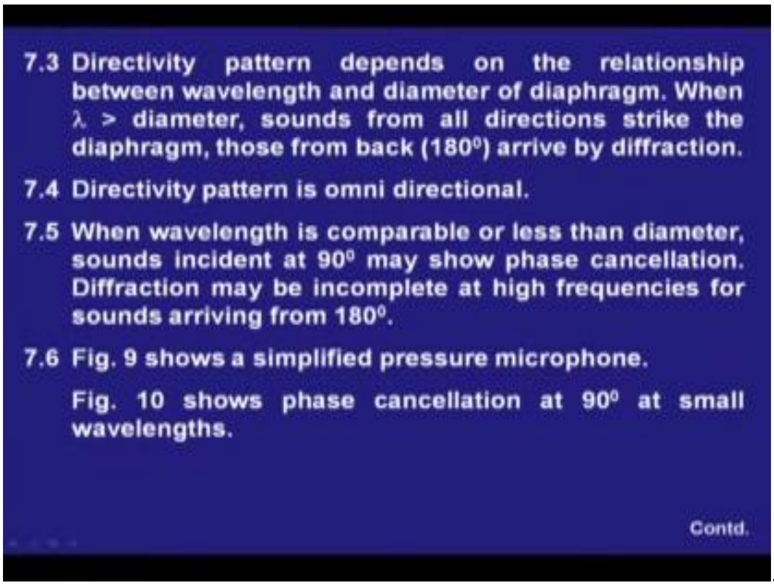

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Directivity pattern depends on the relationship between the wavelength and diameter of diaphragm. When the diameter lambda is very greater than the diameters, sounds from all directions strike the diaphragm those from back arrived by diffraction. So, you know that with the diffraction. If I put this is the diaphragm that the acoustics wave for coming out which are lambda is much, much greater than the diameter of the microphone that can refract and come easily comes to the come. And if it is not that then if it is from the all directions strike that diaphragm those from both side back also arrived in diffraction. Directivity pattern is Omni directional because microphone diaphragm is open from only one direction that is why the directivity of the microphone is Omni directional.

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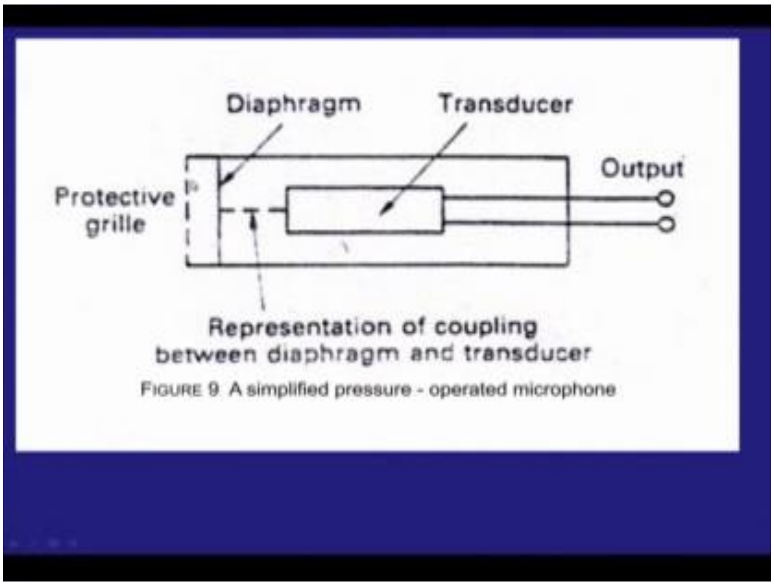

When the wavelength is comparable this is not that much important shows an - if you see this is a microphone diaphragm exposed to that side only. There may be made a little hole in here because if the sound pressure increases that to make it if it is completely enclosure the sound pressure inside this enclosure if there is a some pressure is develop then the diaphragm movement will be affected. So, I put a small aperture in here and this aperture is also canceling this. Wavelength is comparable or less than diameter sounds incident 90 degree may show phase cancellation difference may be incomplete at the high frequencies for sound arriving from 180 degree. So, if the sound arriving in 180 degree phase shift then there may be a cancellation of the sound because it can say that interaction that you can say - what is said that if it is same phase, it will be amplify it added up arithmetic sum; if it is opposite phase destructive it will be destructive.

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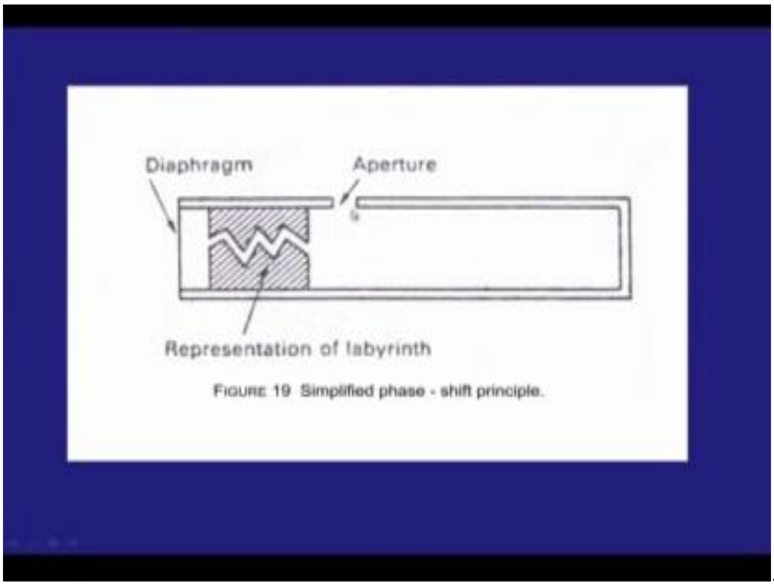

FIGURE 19 Simplified phase - shift principle.

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So, do to avoid that part to make a small kind of aperture here and there is a small passage of the air pressure, so that 180 degree also come in here.

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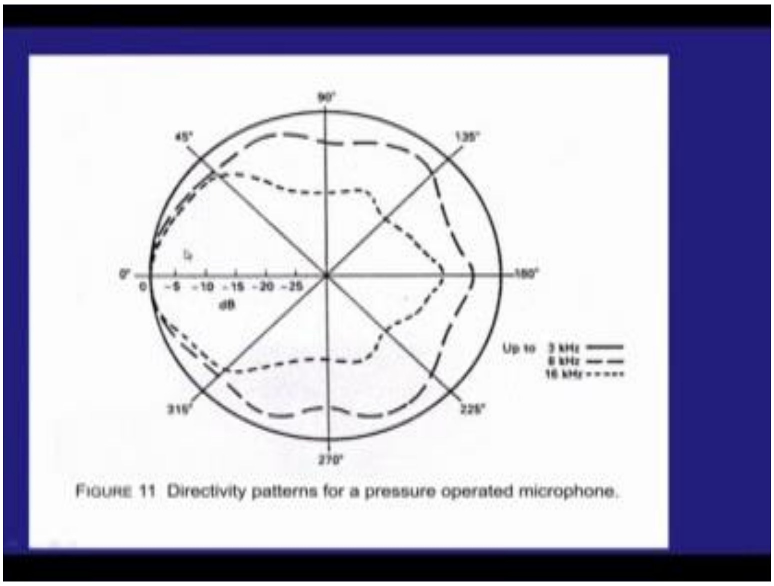

FIGURE 11 Directivity patterns for a pressure operated microphone.

Then the directivity pattern of this kind of microphone will be like this pressure microphone.

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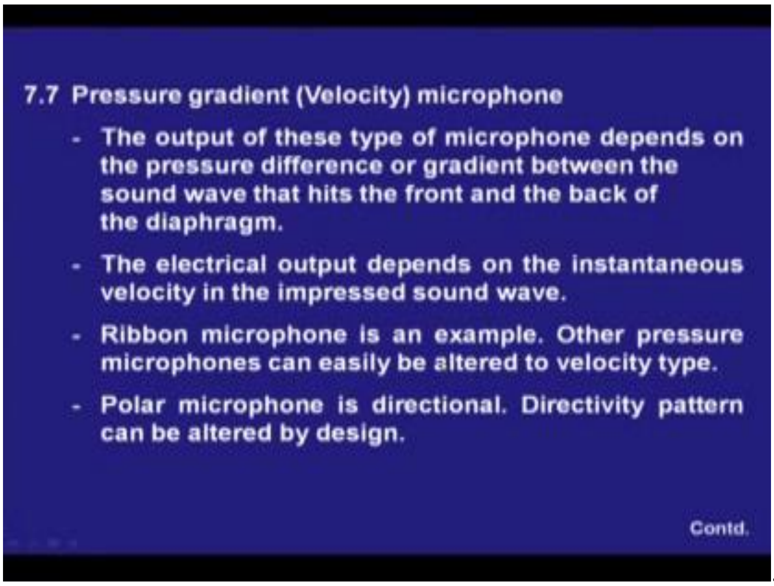

Then I go to the pressure gradient microphone or velocity microphone. The output of that type of microphone depends on the pressure different or gradient between the sound waves that hits the front and back of the diaphragm.

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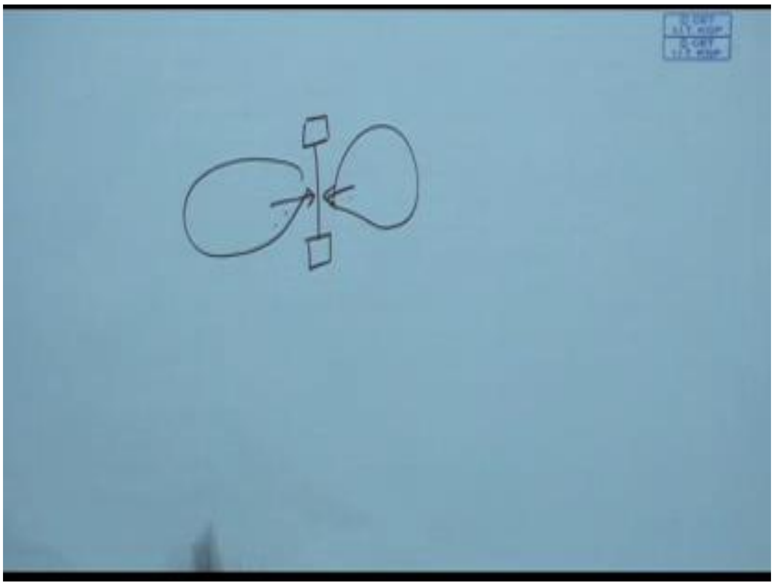

So, diaphragm has to be exposed in both sides so that this microphone will work the pressure different between this side and this side; pressure different between this side and this side then I call it is a pressure gradient microphone.

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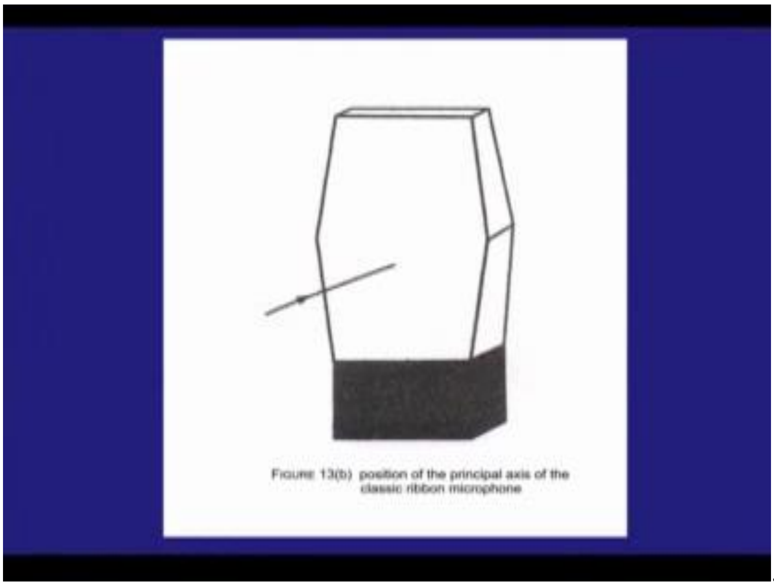

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If I see a gives you a picture pressure gradient microphone. Diaphragm is exposed on both sides. Example, if you see the commentary microphone that is pressure gradient microphone both side is there.

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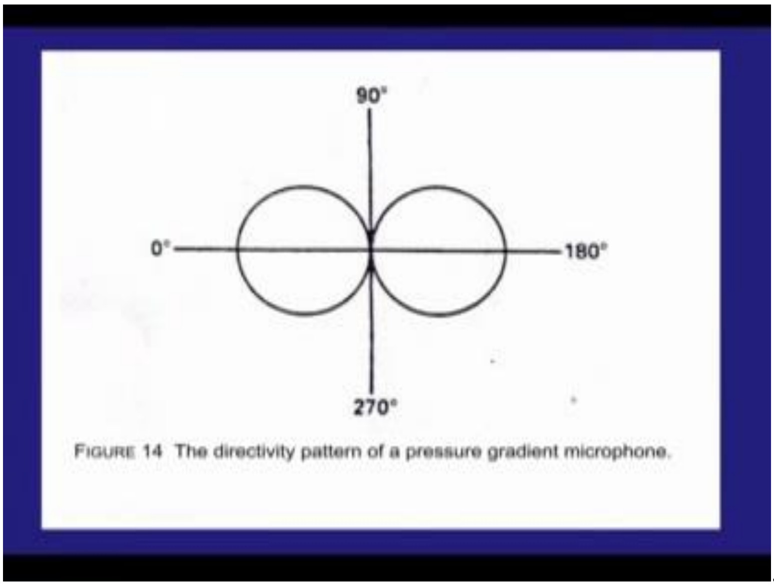

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Now, the directivity pattern will come figure of eight will both side of the diaphragm is open. So, I can take the sound from this side and this side both sides. So, it is a figure of eight.

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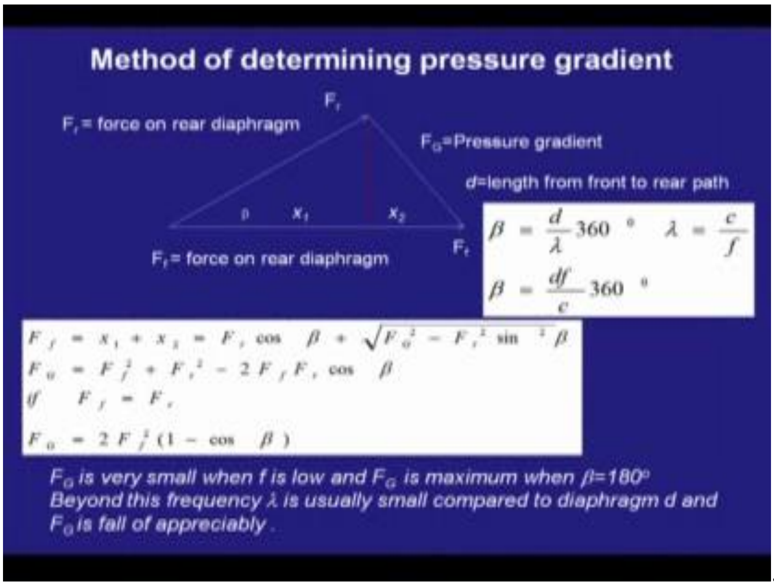

Now, can I calculate method of determining pressure gradient, how we determine the pressure gradient of pressure gradient microphone. So, it is very simple.

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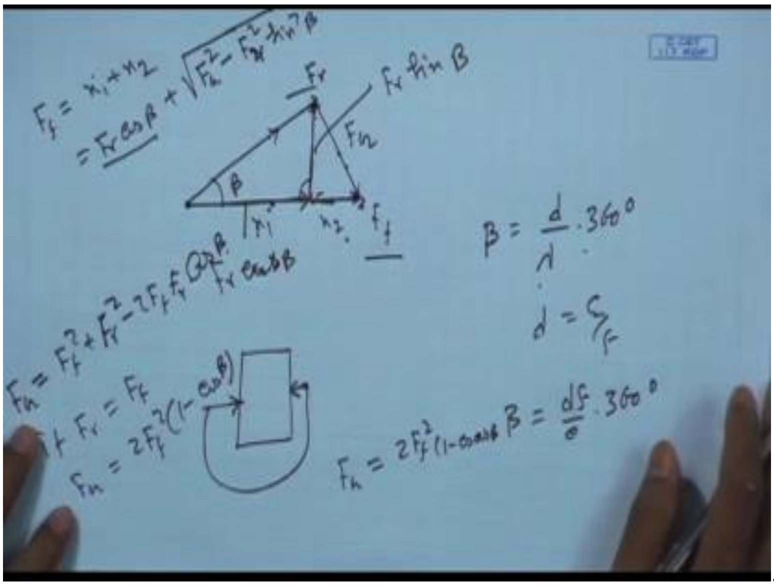

Let us this is F r, what is F r force on rear diaphragm. So, there is a two diaphragm is expose both sides rear side and backside and this is. So, the rear side and sorry if you see this slide, there is a mistake in the slide. So, it is the front side, it is front side and it is backside; this is front side and this is back side. Let us F f and F r, front side pressure and backside pressure. Now, so this is the pressure gradient because your pressure is coming from the same source. So, this is the pressure gradient F G, so this is F r, F f, F G.

Now, if I say I draw a 90 degree, and this is x 1 and this is x 2 and this angle is beta. What is beta? Beta is nothing but a d by lambda into 360 degree. Why it is d, d is the length from the front to rear part. So, suppose I make a diaphragm expose like this way. So, the front is this back is this. So, front to rear path that is the d. So, d by lambda into three sixty degree is the angle beta how the sound is coming. So, if it is beta is that then lambda is equal to c by f. So, beta can be d f by c into 360 degree.

Now, if do some arithmetic in here what is F f is nothing but a this distance plus this distance x 1 plus x 2. What is x 1, x 1 is nothing but the F r cos beta projection of f r on this side, so f r cos beta. If this is the right angle triangle, so this is x 1 is nothing but a f r cos beta plus what is this length hypotenuse minus base root over of hypotenuse. So, root over of F G square minus F r square sin square beta. Now, you understand this is nothing but a F r sin beta and this is nothing but F r cos beta. So, this is nothing but f r sin beta. So, it is e f is nothing but x 1 plus x 2. So, x 1 is f r cos beta x 2 is the base. So, it is hypotenuse root over of this square minus this square. So, F g, if I simplify this, F g will come F f square plus F r square minus 2 F f F r into cos beta. So, if both are same if f r is equal to F f then F g is nothing but 2 F f square 1 minus cos beta. So, F G pressure gradient is nothing but a 2 F f square into 1 minus cos beta. So, F g is very small when F is low and F g is maximum when beta is 180 degree, this is ok.

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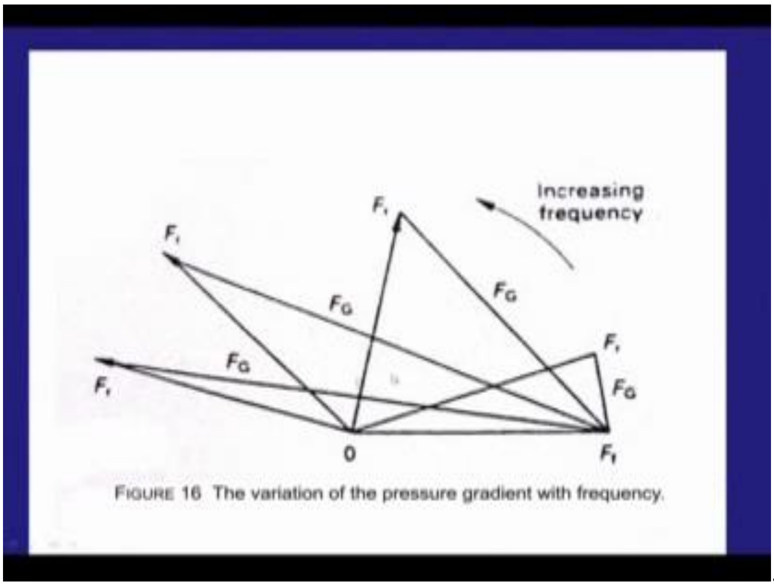

FIGURE 16 The variation of the pressure gradient with frequency.

So, now I can draw the F G versus frequency versus the f G curve and if you see this is will be look like this. So, in the next class, I will discuss about the sensitivity mathematics. So, here I have discussed about the different kind of microphone and their construction. And I discuss about the pressure gradient microphone, pressure microphone, directivity pattern and their directive directivity pattern of the microphone sensitivity and their constructional things. And already I have discussed about that transduction that mathematics detail of mathematics. So, while you design the mathematics, the sensitivity is nothing but M 0 which will come from that transduction mathematics. So, next will see what is the sensitivity, how it measures then relationship the sensitivity GIA, NPA all kind of things will be discuss.

Thank you.