Audio System Engineering
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Lecture - 23
Microphone Sensitivity

Now, in this you have heard about the different kinds of microphone, they are directivity pattern, they are frequency response and they are sensitivity. Now, in this lectures, we details investigate what you mean by sensitivity of a microphones, how the microphones sensitivity is desired or defined or how to measure you can say how determine and then we will discuss about what will happen if the microphone is connected to the pre amplifier and in which condition it will be deliver the maximum power.

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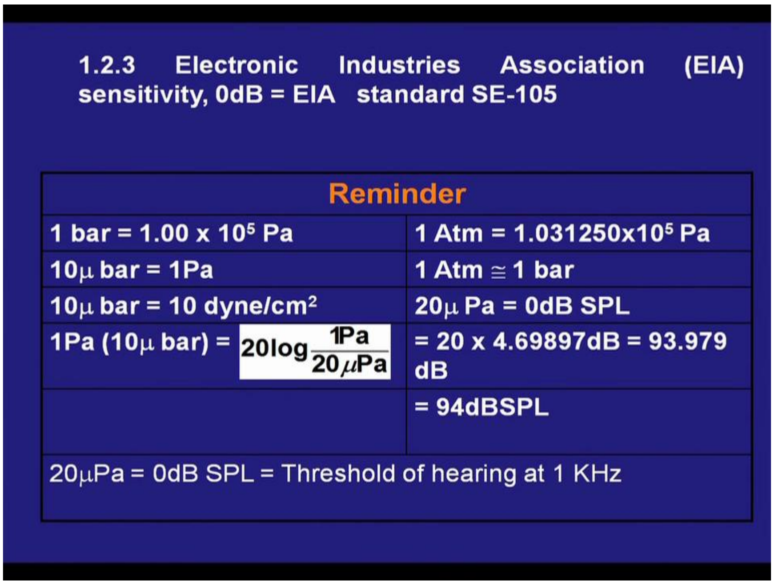

And what is the electronically standard sensitivity defined by electronic association in electronic industries association EIA.

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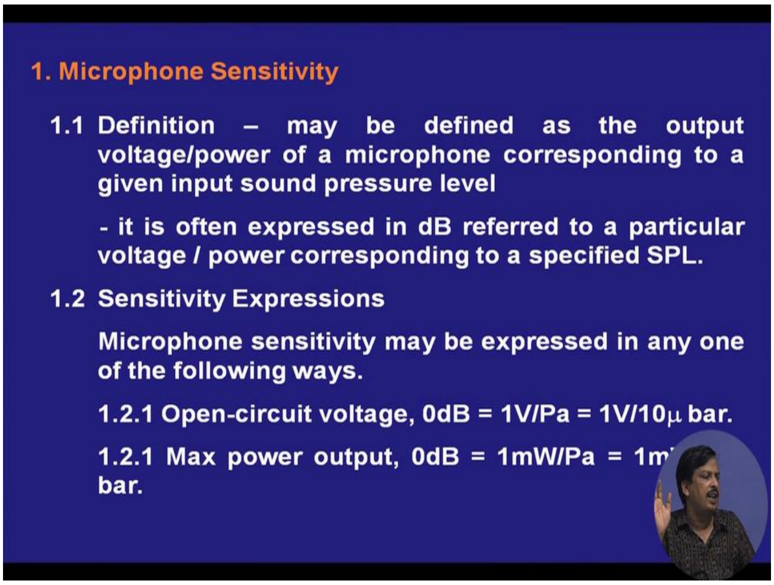

So, as per the EIA definition, the sensitivity of the microphone is defined as that how the voltage produced by the microphone for a given 1 Pascal sound pressure is called 0 dB voltage sensitivity of the microphone.

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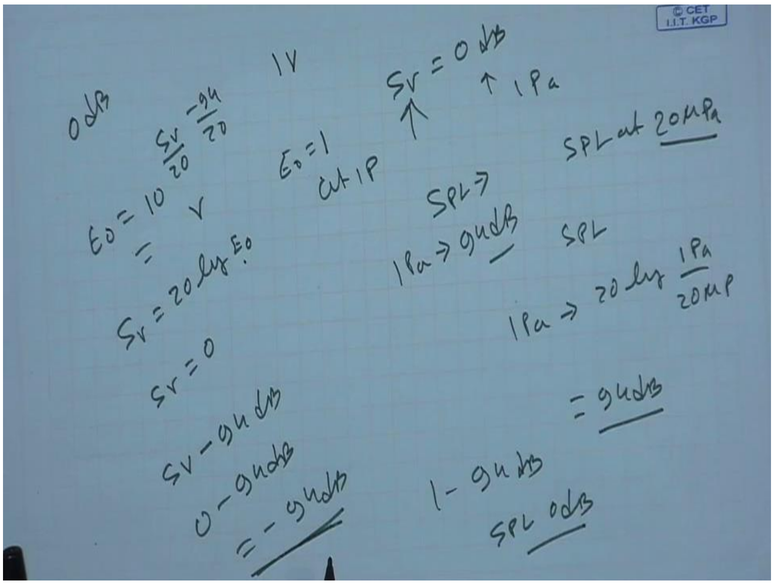

What are the meaning of that that suppose this is the my microphone, I will say the sensitivity of the microphone is 0 dB, if I expose this microphone to 1 Pascal sound pressure and if it is produces 1 volt output at open circuit condition. So, open circuit voltage 0 dB means, so sensitivity is 0 dB of the microphone means if I produce a 1

Pascal sound pressure at open circuit condition of the microphone, if it is produces 1 volt outputs then I call sensitivity of the microphone is 0 dB. Similarly, power, it may be voltage sensitivity, it may be power sensitivity. What is the power sensitivity maximum power output of a microphone we will said 0 dB or 0 dB power output of the microphone is defined as if the microphone is expose to a 1 Pascal sound pressure, if it is deliver 1 milli watt power, then we said the power sensitivity of the microphone is 0 dB.

So, in the specification of the microphones, both can be written or one can be written. The voltage sensitivity of the microphone 1 Pascal pressure 1 volt; power sensitivity of the microphones 1 milli watt power 1 Pascal pressure, now, if I say this is one Pascal pressure is 0 dB, if the sensitivity of the microphone is 0 dB, then if it is produces by 1 Pascal pressure. Now, if I say if I connect this microphone in or if I expose this microphone in a threshold of hearing SPL, SPL at threshold of hearing which is 20 micro Pascal in air threshold of hearing 20 micro Pascal in the refer as 1. Then how much voltage or what should be the sensitivity of that microphone at that pressure or I can say what should be the voltage output of the microphones in dB.

So, I say S v is equal to the nothing but 20 log E 0 the voltage produces at the output of the open circuit condition of the microphone. Now, if I say if E 0 is equal to 1 volt at 1 Pascal pressure then S v is equal to 0. Now, if I say some microphone places in a sound pressure level SPL, where it is just threshold of hearing then what is the sound pressure what the dB in 1 Pascal. So, 1 Pascal is equal to 20 log 1 Pascal divided by 20 micro Pascal. So, 1 Pascal SPL 1 Pascal SPL if I expressed in dB what the dB it is almost 94 dB, because it is 20 into 10 to the minus 3, if you calculate that mathematics it will come almost 94 dB. If it is 94 dB, so one Pascal sound pressure in dB, it is 94 db. Now, in one Pascal it is produces is 0 voltage, if I expose in minus 94 dB is the threshold of hearing (Refer Time: 05:19) Pascal. So, one Pascal is 94 dB that means, if I expose the microphone in SPL 0 dB that means, as threshold of hearing. So, pressure is drop by 94 d b.

So, S v minus 94 d B, so it is 0 minus 94 dB is equal to nothing but a minus 94 dB. So, same microphone is the same bit of the microphone is 0 dB then the microphone sensitivity at threshold of hearing assume is nothing, but a minus 94 dB. So, how much voltage it will be produces if it is one volt E 0 is one volt means 0 dB. So, I can say that E 0 is nothing but what is E 0 is 10 to the power S v by 20. Now, S v is minus 94 divided by 20 into the 10 to the power. So, I can get that voltage, I will get output of the microphone.

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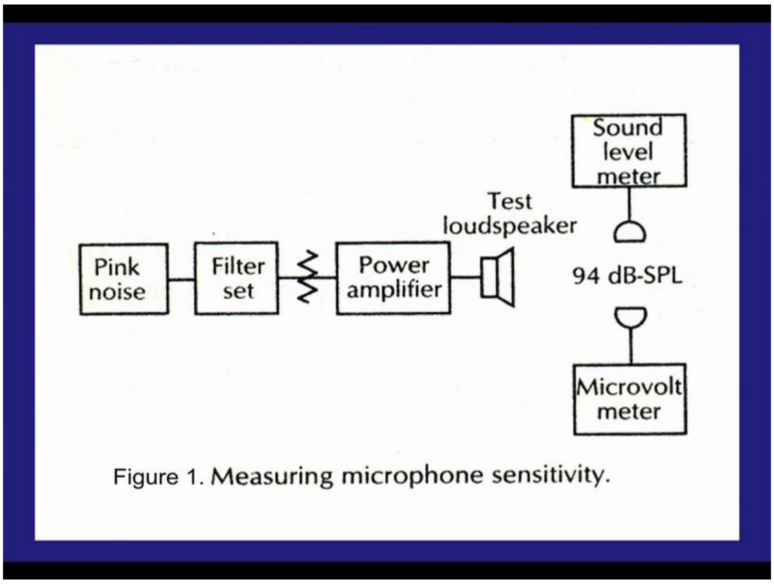

Now how do you measure that microphone sensitivity? So, microphone sensitivity is measured in a condition, what are the condition let us see the see the setup this is the setup. What is the setup I required a pink noise source, which is electrical signal, source and passed through a filter, go to a power amplifier, which amplifies that signal and connected to loudspeaker, a loudspeaker produces the sound. Let explain one by one why the pink noise source suppose I want to test these microphone what is required I to expose these microphone in a sound pressure level. Now, you know the sensitivity of the microphone is frequency dependent, but for a particular frequency range, I can make that microphone frequency independent that we discussed in past lecture.

So, now, if I expose this microphone in a particular sound filed, so I would produces that sound field by some loudspeaker, so that is why this is the loudspeaker. And to produces the sound I required a power amplifier and power amplifier required desired acoustic signal. What is the desired acoustic signal, I generate the desired acoustic signal of a particular frequency range by this filter, at input of the filter is a pink noise source that means, all I applied input to the filter all frequency with the same power same amplitude power amplitude then passed through a filter for a particular band.

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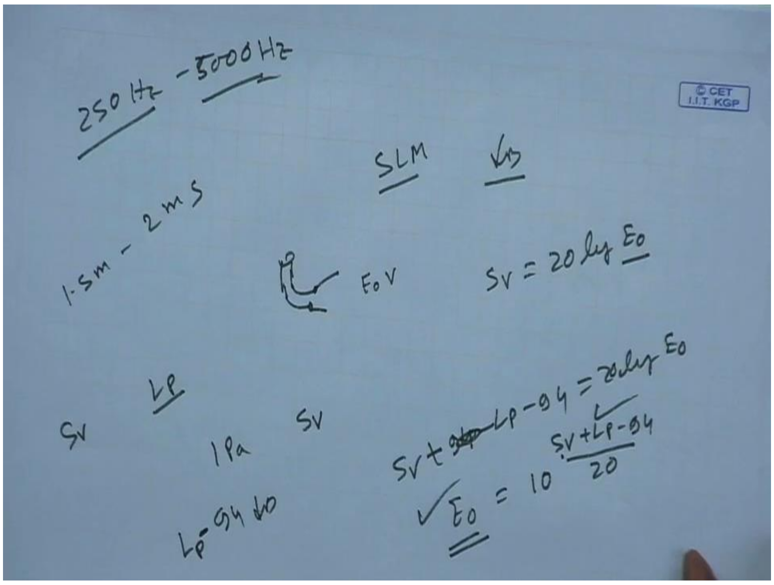

If I said my filter 250 hertz to 5 kilohertz which generally hertz in microphone 5 kilohertz then the acoustic signal produces for the loudspeaker is nothing but a acoustic signal of the frequency 250 hertz to 5 kilohertz. So, this filter hertz upper cut of frequency 5 kilohertz lower cut of frequency 250 hertz. Then this sound is propagated in the air, let there is no disturbance of the environment, there is nothing no disturbance of the environment and this pure pressure field this is no pre field it is no there is no reverberation version, it is not pre field, it is not I can say it is not reverent field. So, it is pure pressure field. If it is pure pressure field then what will happen once the sound is propagated the inverse power square law will be applied, the pressure will be dropped. Now, after certain distance let us 1.5 meters from the loudspeaker 1.5 meter to 2 meters from the loudspeaker, I could take sound level meter.

What is sound level meter? SLM- sound level meter measure the sound pressure level in d b; that means, respective threshold of hearing it dB it is measure. So, what is one Pascal should be reading 94 dB respective threshold of hearing. So, if it is I put the sound level meter and I increase the gain of the amplifier till the reading of the meters is not 94 dB; once the meter reading is 94 dB I fix the gain, and I have continuously sound is produces at 94 dB SPL at this point.

So, now I reach the 94 dB SPL, once I reach 94 dB SPL, I remove the sound level meter and put the test microphone there. So, I put the microphone there, let this is the microphone and two end two electrical end of the microphone connected to a micro volt meter which is micro volt meter. So, the reading of the microphone meter, if it is E 0 volt then what is the sensitivity of the microphone, so 1 Pascal pressure produces voltage is the 0 dB. So, I can say S v is equal to 20 log E 0 (Refer Time: 10:58), so that way sensitivity of the microphone is measure I can measure the sensitivity of the microphone.

Now, let one condition that I have taken a microphone in here and the data set the microphone sensitivity written is S v. Now, instead of 94 of SPL, lets I measure this pen the sound pressure level is L p. Now, if I expose this microphone in a L p sound pressure level how much electrical voltage should it produces in the two end, understand. So, I said that at 1 Pascal sound pressure if it is S v that means, 1 Pascal means 94 dB sound pressures. So, if it is L p in dB, so if it is respect to 1 Pascal sound pressure effective L p is l p minus 94 dB, because at least 94 dB, it is S v. So, at L p it should be L p minus 94 d b. So, output in dB sensitivity of the microphone at L p is S v minus 94 or in v plus L p minus 94. This will be 20 log E 0, the output produces by the microphone 20 log E 0, I can say E 0 is nothing but 10 to the power S v plus L p minus 94 divided by 20 ok or not see that I am not going to slide.

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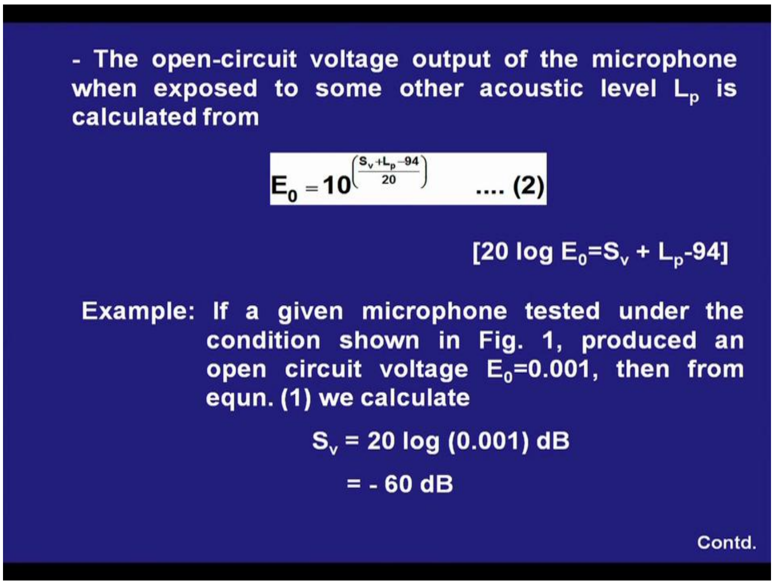

Or similarly, if I said if the microphone I do not know the sensitivity of the microphone I put the microphone in L p sound pressure level what should be the sensitivity of the microphone. Then sin that case I know E 0 I know L p, I have to calculate s v in dB or other way if I know the sensitivity I know sensitivity then I have to calculate E 0 I can calculate E 0 very easily.

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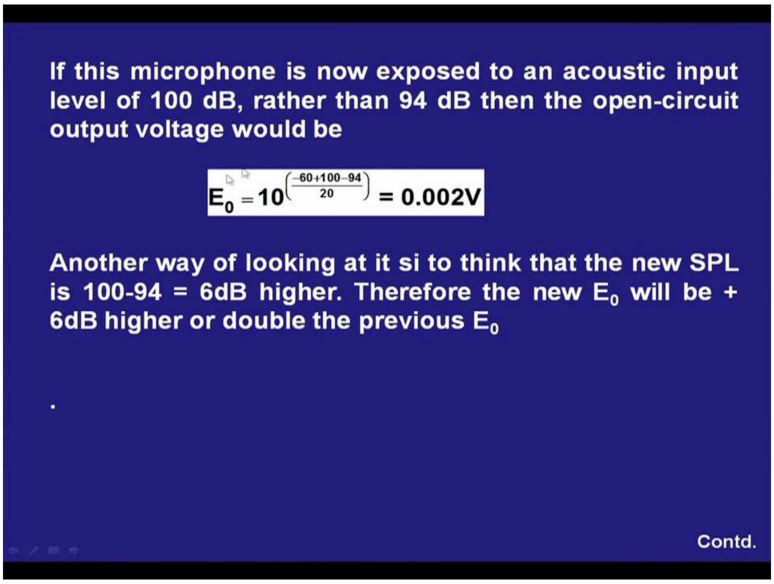

Now, let us look at this problem. A microphone if a microphone is now exposed to an acoustic level of 100 dB rather than 94 dB then the output circuit open circuit voltage should be E 0 should be L p is 100 dB.

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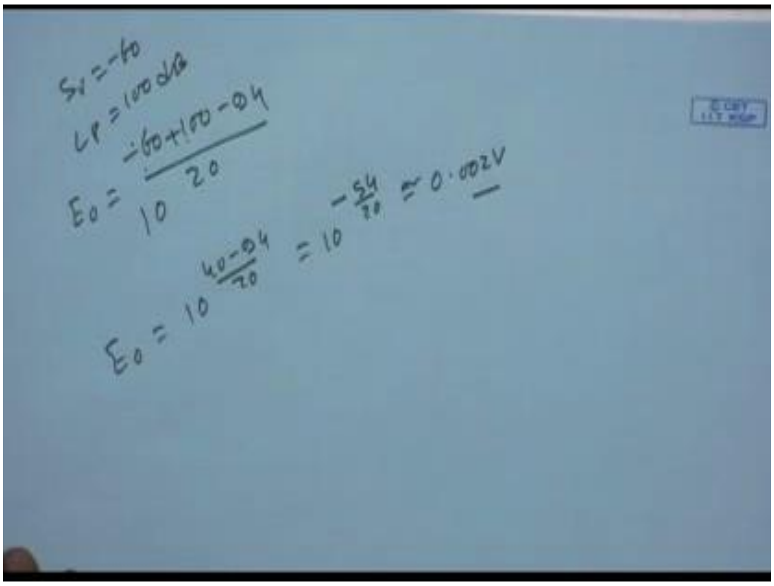

So, it is if it is microphone is minus 60 dB sensitivity S v is minus 60 dB exposes the microphone in a L p sound pressure level which is 100 dB. So, minus 60 plus 100 minus

94 divided by 20 10 to the power that is E 0 is nothing but 10 to the power how much will come minus 60, so 10 to the power 40 minus 94 divided by 20 that is 10 to the power minus 4 5 divided by 20 this is equivalent to 0.002 volt.

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Now, we have to justify why we have take the sensitivity in open circuit voltage. We said that sensitivity is measured in term of open circuit voltage. Why I would justify why I take the open circuit voltage why not it is closed circuit when there microphone is connected to the amplifier that I would take the measure of the voltage.

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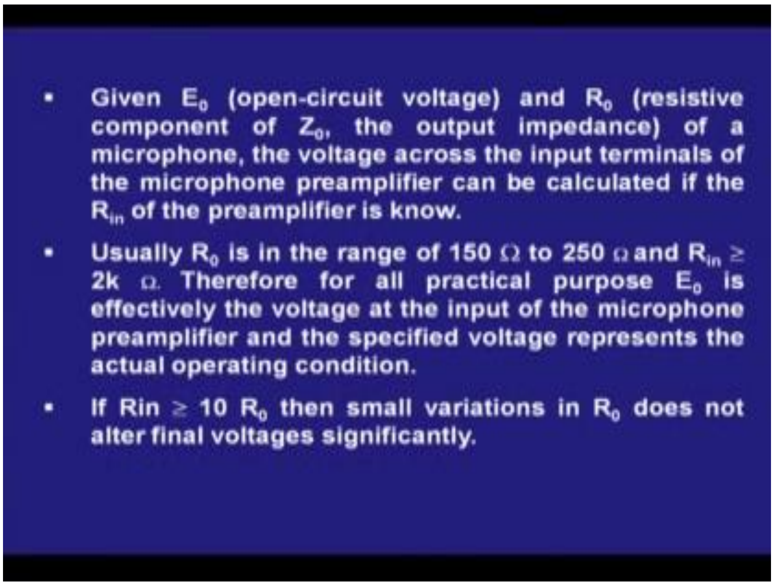

So, why it is, now if you see if microphone I take I am not getting the slide, let us understand that things.

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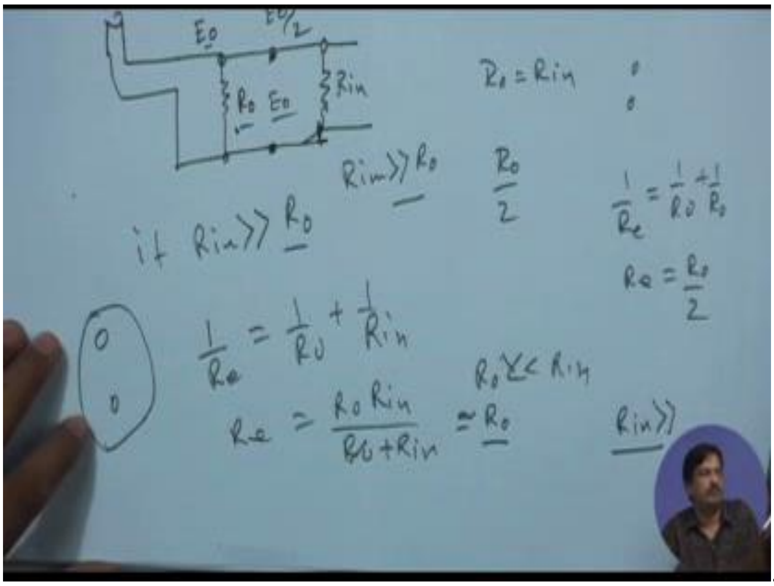

Suppose this is a microphone and these are the two vertical terminal two electrical terminals. So, if the microphone is connected to like this is the preamplifier two terminal, if the microphone is connected to the preamplifier then what will happen there will be a output resistance of the microphone will be could acoustic parallel of the input. It is the R in is the input resistance of the preamplifier R 0 is the resist compound of the microphone. If I say the R 0, if I connect this microphone with the amplifier in this condition then if it is microphone is produces the E 0 voltage then once R 0 is equal to R in, what will happen the effective resistance between two this terminal will come R 0 by 2. Same resistance in parallel it is reduces by half that is one equalize 1 by R e is equal to 1 by R 0 plus 1 plus R 0, it is nothing but R e is nothing but R 0 by 2.

Once the resistance is dropped then the E 0 will be E 0 by 2. But if R in is much, much greater than R 0 that means, that if R in very high then 1 by R e is nothing but 1 by R 0 plus 1 by R in. So, R e is nothing but a R 0 R in divided R 0 plus R in. Now, if R 0 is much, much less than R in than I can neglect this R 0 equivalently it will come to R 0 values. So, if it is R 0 then the acoustic this terminal the voltage will be E 0 in case of R in is much, much greater than R 0. So, I do not want when I measure the sensitivity once

I load it then the voltage is dropped. So, what I want I measure the voltage emission micro volt meter.

So, I want the input voltage input resistance of the micro volt meter should be sufficiently large, so that once I connect the micro volt meter that develop voltage should not be dropped. If R in is sufficiently high what is meaning of that R in sufficiently high that is nothing but open circuit voltage that means, as if there is no load acoustic two terminal of the microphone. So, load is only R 0 the output resistance of the R 0. So, there is no extra load is added on that R 0, so that is why we take them meter took them take the reading of the sensitivity at open coil or we can say data define the sensitivity in term of open circuit voltage.

Generally, if you see usually R 0 value for a microphone is 150 ohms to 250 ohms and we take R in which is 10 times greater than the R 0. So, if it is 250 ohms, it will be 2.5 kilo ohms greater than 2.5 kilo ohms. So, it take 10 times if it is 10 times large then almost the voltage R 0 does not change if I connect to the preamplifier or micro volt meter that is why we say the sensitivity of the microphone has to be measure in term of open circuit condition. It is not practically, not open circuit, so when you measure the open circuit voltage the input impedance of the measure instrument should be very high.

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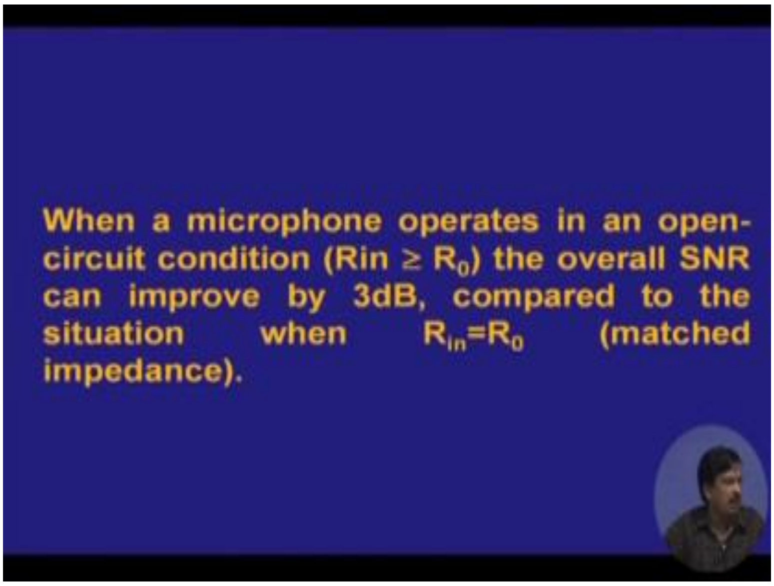

Then there is another condition is come. While a microphone is operates in open circuit condition, the overall SNR can be improve by 3 dB compared to the situation when it is connected in impedance matched condition that why I will ensure few slides ensure these issues.

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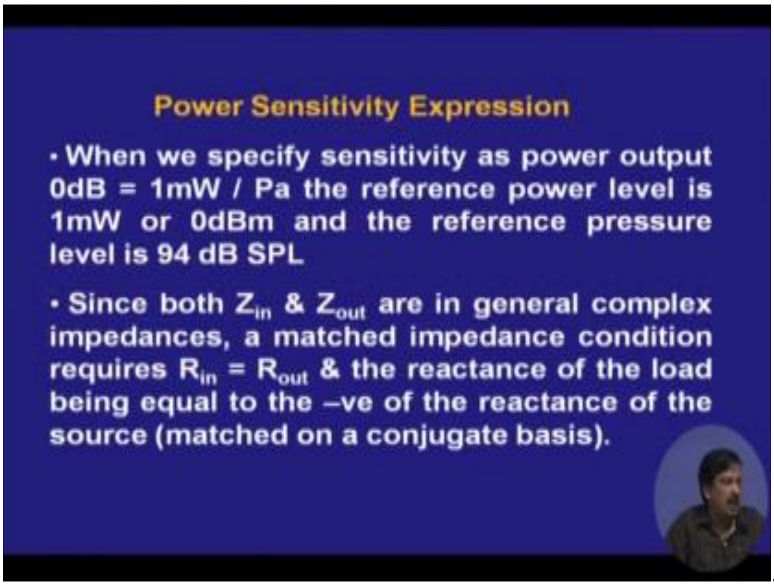

Another issues is there, bring the voltage sensitivity issue and there is a power sensitivity issue.

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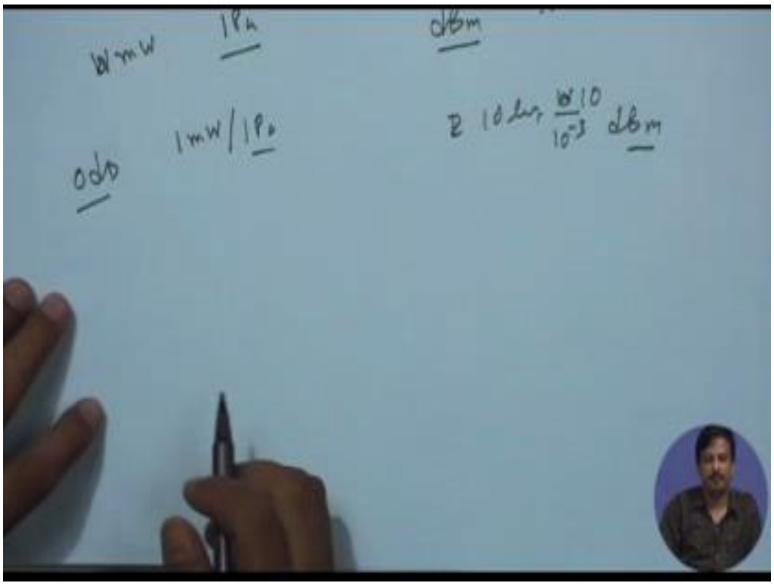

What is the power sensitivity of the microphone? We define in the power sensitivity the power sensitivity of the microphone is power deliver by the microphone in milli watt will compare in 1 Pascal pressure. So, what I say if I expose a microphone in 1 Pascal pressure, the amount of power deliver by the microphone in milli watt will be the power sensitivity of the microphone. So, it is 0 dB, it is not dB, if it is milli watt then it will go dBm power using dBm. So, we already discussed what is dBm, it is nothing but a 10 log power divided by 10 to the power minus 3 in power milli watt with respect to milli watt. If it is power expect to if it is microphone produces 10 watt then it is 10 watt divided by 10 to the power minus 3 that dBm. So, power using dBm ratio of the power using dB m, so 0 dB sensitivity of the power sensitivity 0 dB that means, 1 milli watt produced by 1 Pascal. Now, we will go for the watt part, how the microphone will deliver the power how the microphone will deliver the power.

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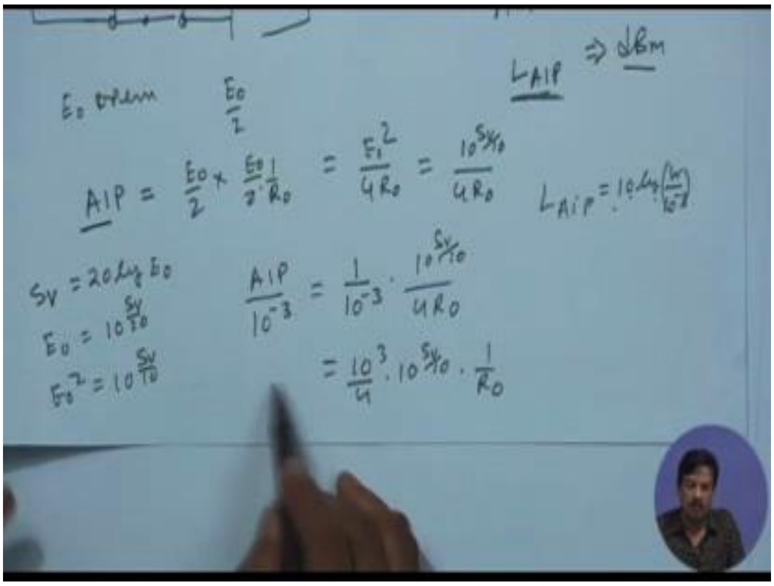

So, let us start with phase page, I have a microphone, and the two electrical terminals it is here and it is connected to a preamplifier, let using the preamplifier and would connected. So, output impedance of the microphone is R 0 and input impedance of the preamplifier is R in. So, if E 0 is voltage sensitivity of the microphone, E 0 voltages is produces by the microphone then this E 0 will be loaded here. Now, if you see when R 0 is equal to R in impedance match condition then E 0 will drop by half.

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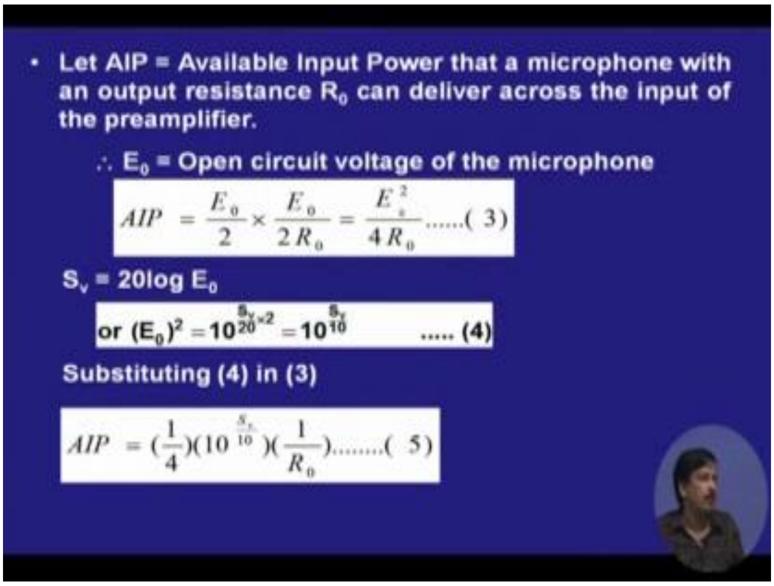

So, power sensitivity is defined by AIP - available input power AIP. When I expressed in dB we said L AIP available input power level, L means level; once it is level then AIP express in dBm - available input power level, AIP is defined as in dBm. So, if this is the condition when R 0 is equal to R in how much power will deliver by microphone to the amplifier to the pre amplifier. So, E 0 is open circuit voltage. So, once it is R 0 is equal to R in then E 0 will be drop by half, voltage acoustic this two terminal is E 0 by half. So, available input power if I say AIP not level, I said available input power, if it is level then it will be dBm. Available input power is E 0 by two voltage into power is nothing, but V into I what is I E 0 by 2 into 1 by half R 0 V into I d by R is the I. So, it is nothing but a E 0 square by 4 R 0.

Now, what is E 0 s v if the voltage is S v then 20 log E 0 is s v. So, if it 20 log E 0 s v then E 0 is nothing but a 10 to the power S v divided by 20. So, what is E 0 square is nothing but 10 to the power S v by 10 is 20 to 10. So, I can write it is nothing but a 10 to the power S v by 10 divided by 4 R 0. Now if I take available input power is 10 to the power S v by 10 divided by 4 R 0, if it is microphone is connected in impedance match condition.

Now, the L AIP when I said that L level of available input power or power sensitivity of to determine the power sensitivity of the microphone or L IP what I would take I would take milli watt because I said dBm is nothing but watt divided by 10 to the power minus

3. So, I have to divided AIP by 10 to the power minus 3 is equal to 1 by 10 to the power minus 3 into 10 to the power S v by 10 divided by 4 R 0. So, it is nothing but a 10 to the power 3 by 4 into 10 into S v by 10 into 1 by R 0. So, what is L AIP level is nothing but a 10 log power divided by 10 to the power minus 3. So, this I have known this part I have known 10 by this part I have known. I would then multiply log and 10. So, if I say take the logging of both side of this equation what will come.

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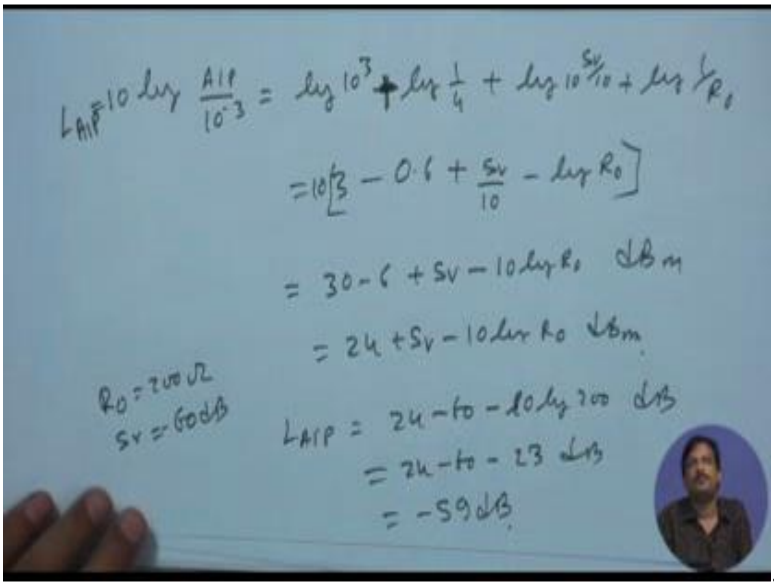

Take the logging both side of this equation. So, log of AIP divided by 10 to the power minus 3 is equal to log of 10 to the power 3 plus log of minus 1 by 4 minus 4 sorry plus log of 1 by 4 plus log of 10 to the power S v by 10 plus log of 1 by R 0. So, I can write log of 10 to the power 3 is 3 plus log of 1 by f4our is nothing but a minus 0.6 plus is nothing but a S v by 10 and it is nothing but a minus log of R 0. Now if I multiply by 10 both side then I get L AIP available input power L AIP. So, L AIP is equal to 10 log of AIP divided by 10 to the power minus 3 in dBm. So, it is nothing but a 30 minus 6 plus S v minus 10 log R 0 dBm. So, it is nothing but a 24 plus S v minus 10 log R 0 dBm.

Now, if I say the res output R 0 of the microphone is 200 ohms and S v of the microphone is minus 60 dB then what should be the L AIP. So, L AIP is nothing but a 24 minus 60 minus 10 log 200 dB m. So, it is nothing but if I said what is the value often log 200 this nothing but 23. So, it is 24 minus 60 minus 23 dBm. So, it is nothing, but a minus 59dB. So, L AIP you can calculate it.

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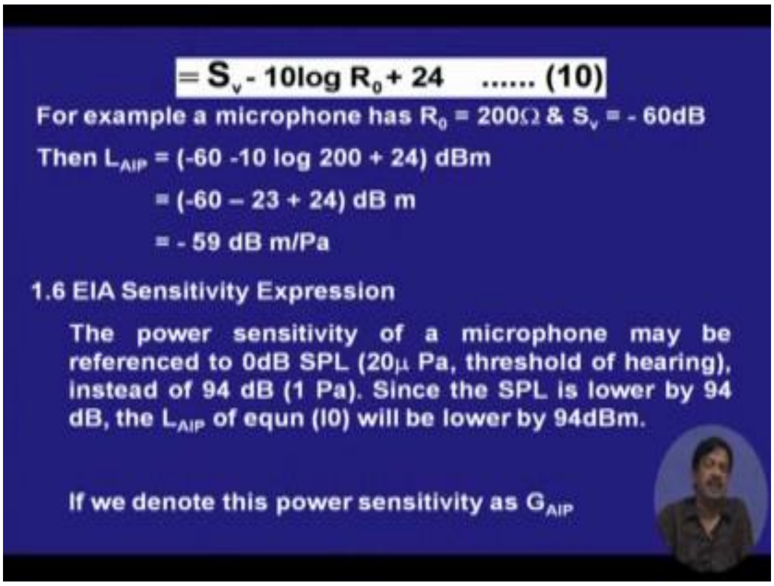

Similarly, if I say GAIP EIA is the specification of power sensitivity in G AIP is written as G AIP. What is the G AIP, G AIP is nothing but a power sensitivity with respect to SPL, sound pressure level references sound pressure level, which is nothing but a just respect 20 micro Pascal.

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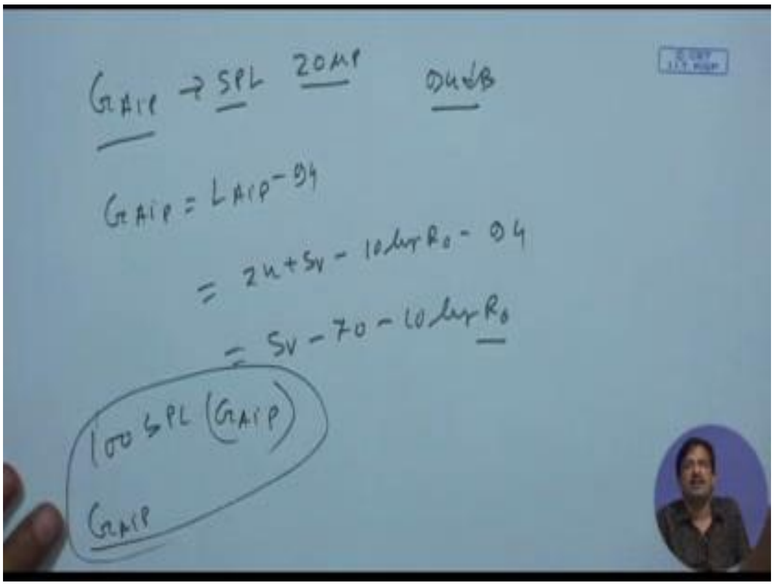

So, instead of 1 Pascal, if I said 20 micro Pascal then the 94 dB is the difference. So, I can write G AIP is nothing but L AIP minus 94 dB. So, if I know L AIP. So, what is L AIP is 24 plus S v minus 10 log R 0 minus 94. So, this is nothing but a S v minus 70 minus 10 log R 0. So, why I express in G AIP because if I express it since the SPL is lower by 94 dB the L AIP equation 10 will becomes lower by 94 dB. And we denote power sensitivity G AIP because when you measured microphone if you know the microphone g AIP in some SPL lets SPL the G AIP in L 1 SPL will be just suspect the difference of the power pressure level.

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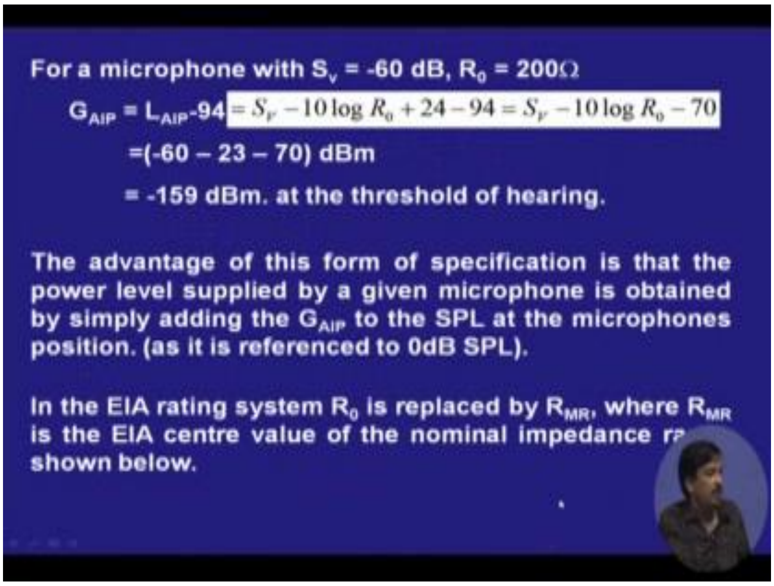

Suppose in 100 dB SPL if G AIP is given or G AIP given if the microphone G AIP know what should the G AIP 100 dB SPL I would just simply subtract that difference. So, it is 94 dB. So, it is 100 dB that is why all are expressed the power sensitivity in G AIP.

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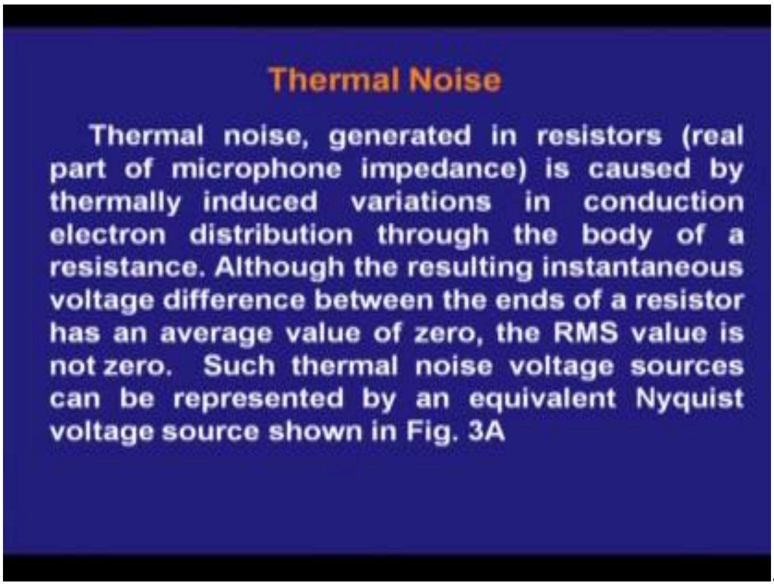

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Now, I come to the next condition while the microphone is connected then if the microphone why that is the questions that is the question which I have raised here. When a microphone operate in an open circuit condition the overall SNR can be improved by 3 dB compared to the situation when R in and R 0. Now, if a microphone connected to a preamplifier, there will be a thermal noise. Any microphone if it is connected to the preamplifier there will be a thermal noise. What is thermal noise?

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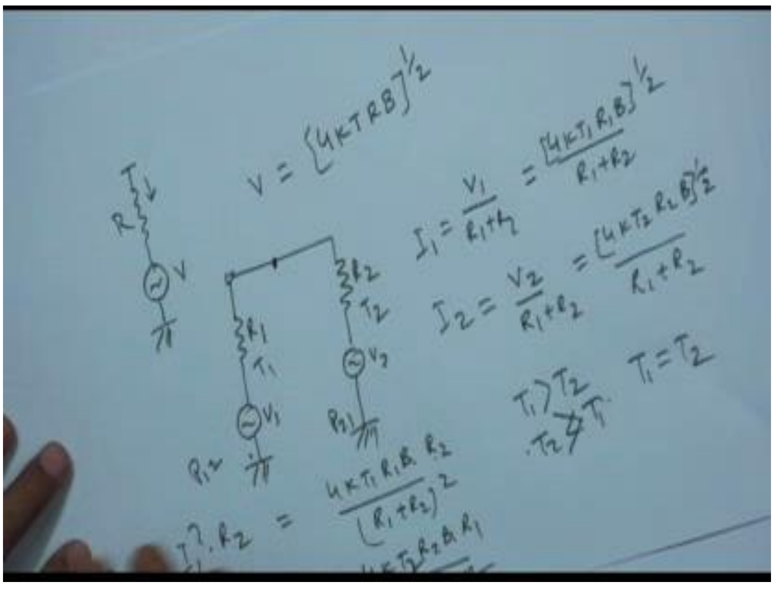

Since, the microphone if it is resistance suppose I have a resistance if I flow a current to the resistance then a thermal noise will be produces. Average value of the thermal noise cross the resistance may be 0, but the RMS value is not 0.

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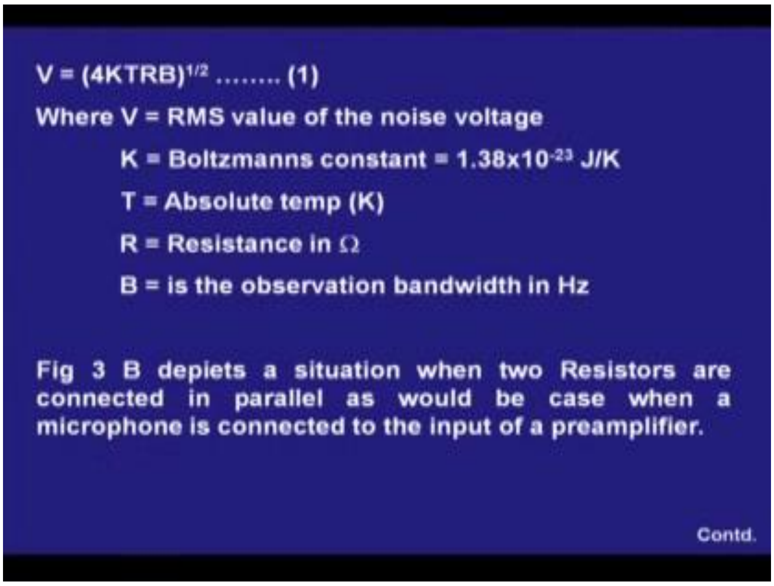

So, thermal noise of the resistance can be expressed resistance through and Nyquist voltage source let V, and resistance is R. Then the expression of the thermal noise V is nothing but 4 K T R B to the power half, this is the formula. What is K? K is the Boltzmann's constant. What is T? Temperature in Kelvin; what is R? R is the resistance, What is b is the bandwidth. If you see this slide, V is the RMS value of the noise voltage, Boltzmann's constant, absolute temperature resistance, b is the bandwidth. So, the signal bandwidth is also effect on the how much voltage will be produces.

Now consider the case of the microphone. So, a microphone let us microphone has R 1 output resistance and Nyquist voltage source V 1 of the thermal noise. Similarly, input resistance of the pre amplifier has R 2 and has a Nyquist voltage source V 2 for the thermal noise this is the condition. So, the thermal noise contributing to the amplifier if V 2 is not present lets v 2 is not present then the thermal noise the current flowing to the circuits it is nothing but a V 1 divided by R 1 plus R 2 when the V 2 is sorted.

Similarly, if I say this is I 1 current flowing. What is I 2 is nothing but a V 2 by R 1 plus R 2. What is V 1 if it if temperature of this resistance T 1 and temperature of this resistance T 2 then V 1 is nothing but a 4 T 1 R 1 b divided by R 1 plus R 2 root over?

What is V 2 4 K T 2 R 2 B same bandwidth root over of half by R 1 plus R 2. Now how many power suppose this source is not there. So, it is power P 1 and P 2, noise for deliver from the microphone to pre amplifier there is P 1 and P 2, noise power deliver by the preamplifier to the microphone is P 2 1.

So, what is P 1 2 I 1 square into R 2, the current I 1 current will flowing through R 2 and that noise will be that that power will be deliver. So, it is nothing but I 1 square into R two. So, what is the I 1 square is nothing but a four K T 1 R 1 B into R 2 divided by R 1 plus R 2 whole square. What is P 2 1 is nothing but a I 2 square by R 1, I 2 square into R 1. So, I 2, what is I 2 square 4 K T 1 R 2 B into R 1 divided by R 1 plus R 2 whole square.

Now, if you see what is the difference between the two expressions; only differ by T 1 and T 2. So, this is T 2, T 1 by T 2. If T 1 is greater than T 2 then the power will be transformed for T 1 to T 2. If it is T 2 is greater than T 1 then the power will be transformed for T 1, T 1 to sorry T 2 is greater than T 1 then the power will be transformed for T 2 to T 1. Now, at the equilibrium condition will be happen when T 1 is equal to T 2. Now I have to calculate what is the effective noise voltage acting in here. effective noise voltage is acting in here across this terminal effective noise voltage how do we calculate. The noise voltage across the power terminal can be calculated by super position of V 1 and V 2 super position.

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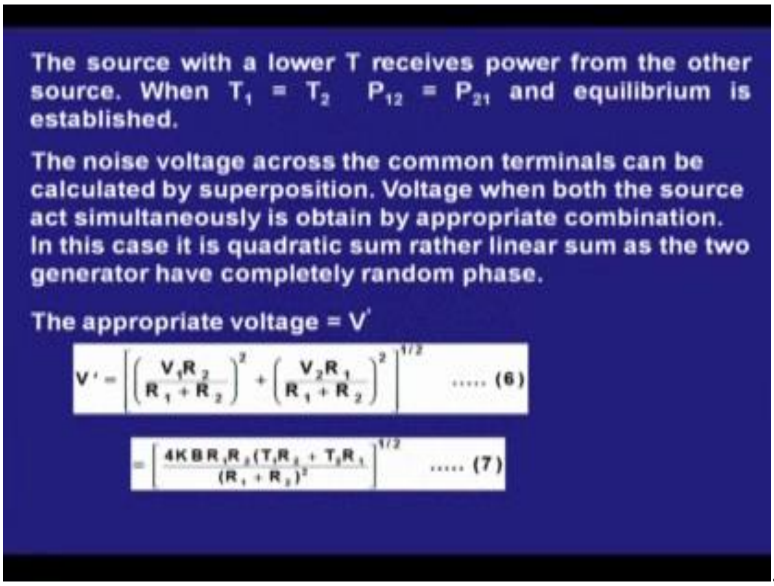

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So, voltage when both the source acts simultaneously. So, how do you get the super position first let V 2 is not there, I calculate the voltage, V 1 is not there I calculate the voltage then do the super position, but both the source simultaneously is on, then how do you obtain by appropriate combination. So, in this case, it should be quadratic sum rather than the linear sum, because I do not know the completely the generated source or completely in random space two source completely random space. So, I do not know whether it will be a linear super position. So, instead of take linear super position the effective voltage I can get by the quadratic super position. So, square of the voltage will be added up.

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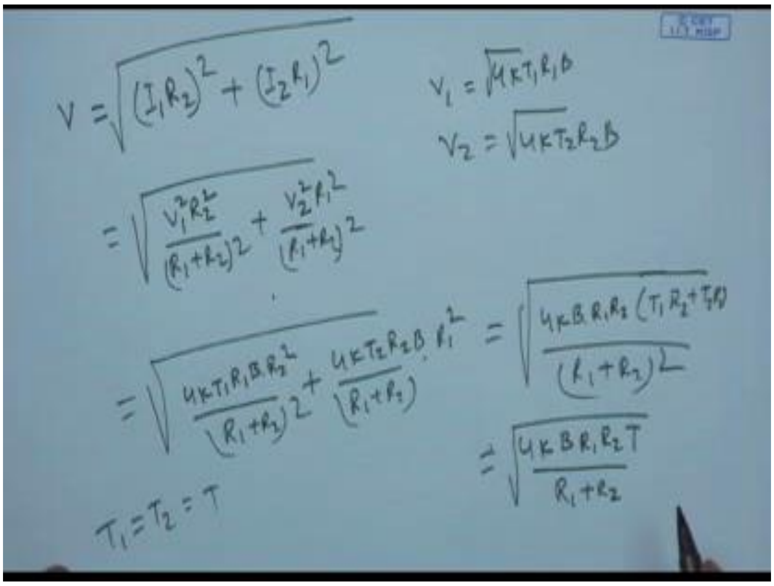

So, quadratic super position of v will be the square of the voltage added up. So, it is nothing but a I 1 current while across the R 2. So, I 1 R 2 is the voltage square plus I 2 current while across the R 1 whole square then take the root over quadratic voltage sum. So, what is I 1 is nothing but V 1 R 2 divided by R 1 plus R 2 V 1 square R 2 square divided by R 1 plus R 2 whole square. This is nothing but V 2 by R 1 R 2; this is V 2 square R 1 square R 1 plus R 2 whole square. So, what is V 1 v one is nothing but root over of 4 K T 1 R 1 B, and V 2 is nothing, but a root over of 4 K T 2 R 2 B.

So, I can put valid value then what will cut root over of V 1 is 4 k T 1 R 1 B into R 2 square divided by R 1 plus R 2 whole square plus 4 K T 2 R 2 B divided by R 1 by R 2 whole square into R 1 square. So, now, if I take it will be if I simplify it, it will be root over of 4 K B R 1 R 2 into T 1 R 2 plus T 2 R 1 divided by R 1 plus R 2 whole square. Now, if this is the case then if T 1 and T 2 is equal and equal to t then I can say this is reduces to 4 K B R 1 R 2 T divided by R 1 plus R 2 root to R 1 plus R 2 root, OK or not.

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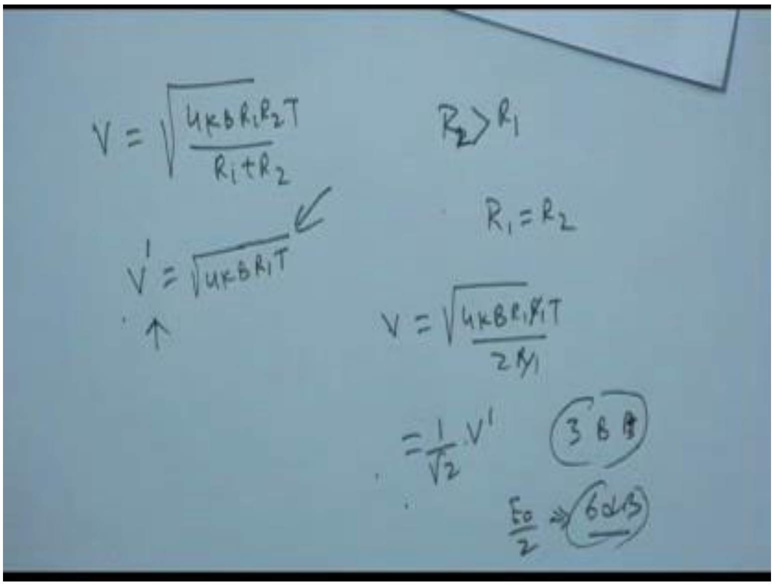

So, now I put the condition. Now, let the both the things or happen as the same temperature. Now, so voltage in that case the V is equal to root over of 4 K B R 1 R 2 T divided by R 1 plus R 2. If R 2 is much, much greater than R 1 what the meaning the input impedance of the preamplifier is much, much greater than output impedance of the microphone, then v will be R 2 much, much greater than R 1. So, I can this R 1 can be cancel. So, it is root over of 4 K B R 1 into T. Now, if R 1 is equal to R 2 R 1 is equal to R 2 then v will be root over of 4 K B R 1 R 1 into T divided by 2 R 1. So, R 1, R 1 is cancel. So, it is nothing, but a 1 by root 2 into if it is V dash, 1 by root 2 into V dash.

So, if the impedance matches condition if it is impedance match condition then thermal noise voltage is reduces by 3 dB. At the same time, if it is impedance match condition then available input power is E 0 is by half. so it will be reduces by how much 6 dB. So, overall SNR come if the impedance match condition then I get 3 dB less thermal noise, but I lose 6 dB due to the impedance match available input power. So, ultimately gain 3 dB is here if it is not impedance if R 1 is greater than R 2, I get 3 dB more noise power, but at least 6 dB down will be not there. So, I can say that in case of this case, so I can this statement I can said is true by the microphone operated in an open circuit condition, now overall SNR can be improved by 3 dB compare to impedance match condition it is proved.

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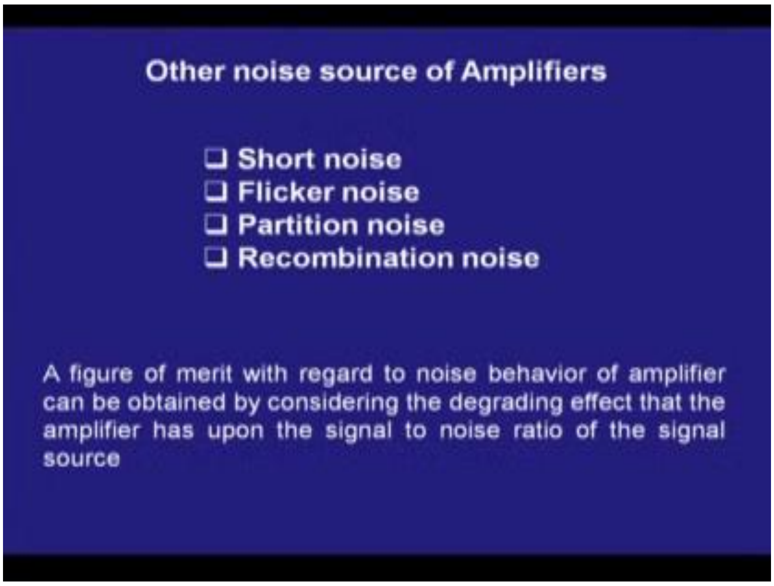

Now, suppose there is another situation you will heard over that when the microphone is connected to amplifier will consent about that all over the noise figure means microphone connected to the amplifier and output of the amplifier it produces noise that system call overall noise figure. So, I would calculate the overall noise figure. Instead of thermal noise there is another noise also short noise, flicker noise, partition noise all kinds of noise that may be a (Refer Time: 43:12) line this terminal noise all kind of noise will be there.

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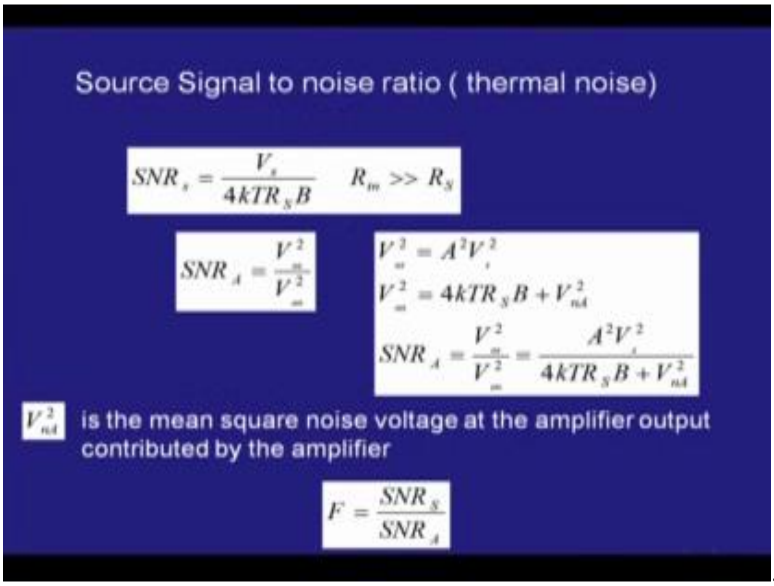

Now, let consider only thermal noise then, what is SNR S, what you mean by SNR S, SNR of the source.

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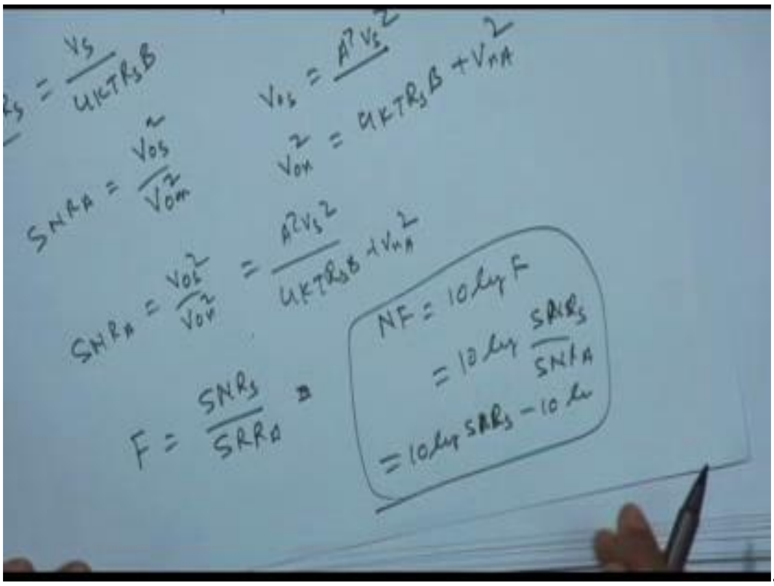

V s is the source sensitivity of the source V s and divided by the thermal noise 4 K T R s into B. T is the Kelvin temperature; R s is the resistance of the microphone; B is the bandwidth of the microphone, this is the SNR s. Now, in case of R in is greater than R s. Now what is SNR A is nothing but V o s input power to power to amplifier output of the amplifiers whatever the input for. So, V o s square divided by V o n square. What is v o s

V o s is nothing but A square by signal square. So, if the gain of the amplifier is s then the output of the amplifier will be divided by the gain.

So, the power is nothing, but the square SNR, if it is power then it will be voltage square. So, square voltage square O s square by V 1 square. What is V o 1 square the total output power is nothing but this is output power for the signal output for the signal noise 4 K T R s B, which is the thermal noise power plus V n A power, which is the noise for the amplifier noise produces by the amplifier. So, SNR A is nothing but V o s square by V o n square is nothing but A square v s square divided by 4 K T R s B plus V n A square. V n A is the mean square noise voltage at the amplifier output contributed by the amplifier. Now, what is the figure of merit f is called SNR S by SNR A.

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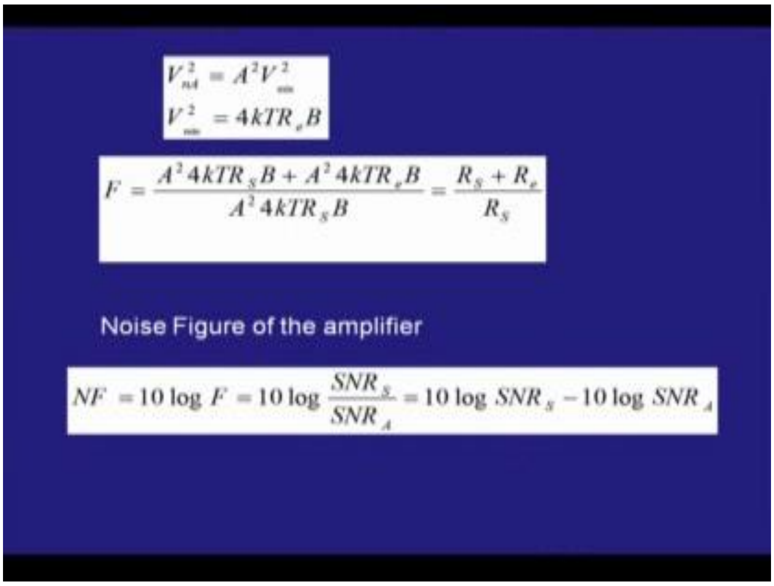

So, I can write F is nothing but I know then V n a is nothing, but this one the minimum and I know that B minimum this one. So, I can write this expression like this way. So, noise figure of the amplifier is in all over the said the noise figure said the noise figure of the NF is nothing, but a 10 log noise figure of the amplifier. So, what is the 10 log f 10 log SNR S divided by SNR A? So, it is nothing but a 10 log SNR S minus 10 log SNR A or 10 log SNR S is nothing but a 10 log SNR S plus noise figure or s n r a is nothing, but a 10 log SNR S minus NF. So, if I know the noise SNR S microphone SNR microphone SNR if I know and if I know the noise figure I can calculate the amplifier SNR. . So, you can solve this problem.

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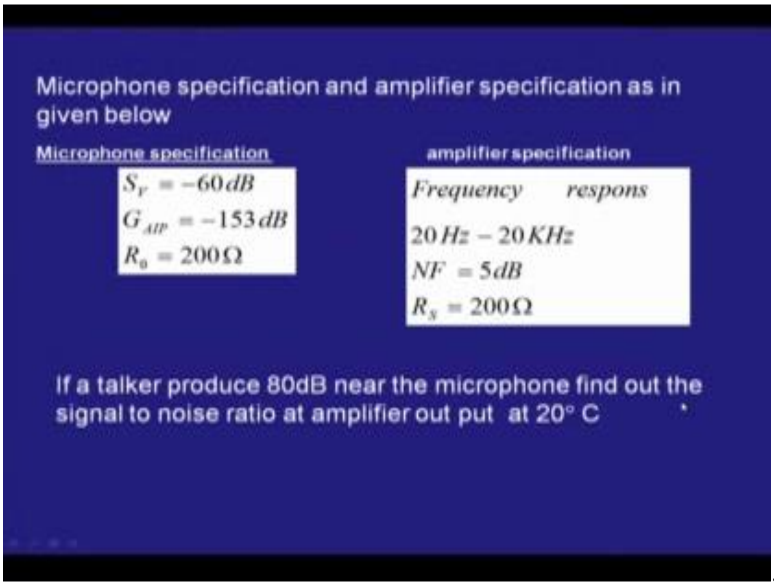

Let us I have problem, I have given a microphone and given an amplifier, amplifier specification. If talkers produce 80 dB near the microphone find out the signal to noise ratio at amplifier output 20 degree centigrade in dB, output at 20 degree centigrade in dB. So, use this equation and find out the amplifier output.

Thank you.