Basics of Noise and Its Measurements
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Lecture - 36
Considerations while Deciding Instrumentation

Hello, welcome to Basics of Noise and its Measurements. Today, we are going to change gears and we will discuss some details about instrumentation because whenever we take measurements, we use a lot of instruments and equipment to take these measurements, and it is important to know some basics which will help us pick the right type of instruments, when we are in this business of making noise related measurements. So, that is what we are going to discuss today, considerations while deciding instrumentation.

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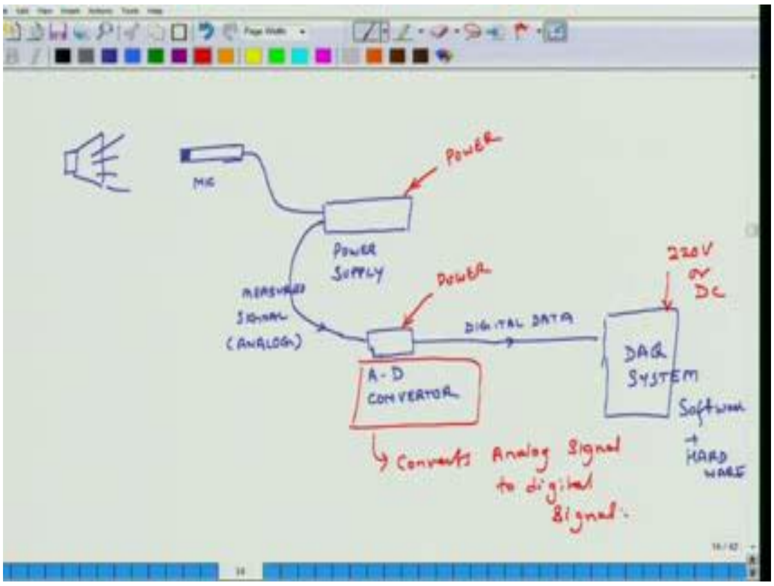

So, what I will do is I will first draw a schematic layout of one noise related set up. Suppose, I have some noise source, and I want to measure it using a microphone. So, that is my microphone, there is may be a preamplifier attached to it. So, we have learnt significant details about microphones. So, this microphone maybe connected to a power supply and this power supply is such. So, this cable it is not one signal conductor, but there may be several conductors, some conductors may be drawing power to this microphone and some conductors may be sending signal back to this power supply unit. Maybe from here, I have another port in this power supply box and from here I get my noise signal out. So, I will not call it noise signal I will call it measured signal, because noise is always sometimes all for used as something which is unwanted.

So, I get measured signal, which is which comes out of this power supply, and then, this is analog. It is analog data and then, I converted into digital data. So, using this something called A to D convertor, analog to digital convertor, or some people call it A-DC, analog to digital convertor. So, here inside whatever signal is going in, it some current or some voltage, what I am getting out is a string of zeroes and ones. It is not a current or a voltage it is string of zeroes and ones. So, this is digital data and this I feed it to a computer, which is having some hardware to actually store data, convert that data, interpret that data. So, this is data acquisition system.

So, this will be having some software and also hardware. So, this is the overall schematic. One schematic and this data runs on power, electric supply this could be 220 volt AC or it may also run on DC source, for instance, a laptop in which. So, it may run on a DC power supply also. This will also requires some powers, you know a typically these guys run on some DC sources, and this will also require some power supply.

Now, you can have adapters, typically these require DC power supply, but lot times we have some adapters which convert this 220 volt into DC and then feed it to the system. So, this is the overall thing and what we are going to discuss today is about this A to D to convertor and it is importance. We will discuss about other things may be at a later point of time, but I think it is important to understand about A to D convertor. So, A to D convertor, it converts analog signal to digital signal.

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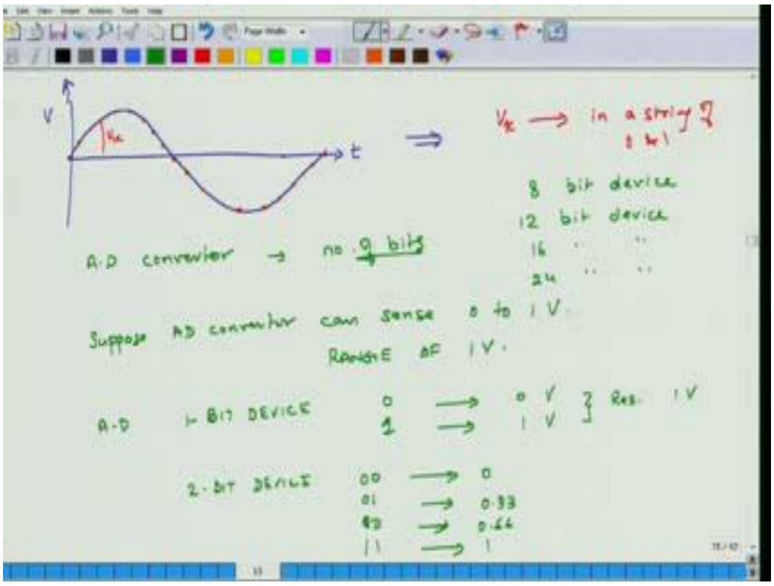

So, what is an analog signal? Suppose, you have sine wave; this is time, let say this is voltage this is an analog signal, because you have infinite number of point between two, between in a time interval. What this A to D convertor does is, it first thing is it breaks it up into discrete points that is the first thing it does. So, it does not it looks at this, it actually does sampling of it. So, each of these let say this is v k. So, it actually converts this analog signal into v k, that is the first thing it does and then it represents this v k in a string of 0 and 1. So, first it will measure v k at different points and then corresponding to each value of v k, it will send out a string of 0 and ones. That is, what it does now?

These A to D convertors are, they have a several specification parameters, but one very important parameter is called number of bits. So, you may have an A to D convertor, which may be 12 bit device, you may have 8 bit device, you may have 16 bit device, you may have 24 bit device. It could be anything I mean typically it is some even number. So, what does an 8 bit device mean, what it means is, that suppose the A-D convertor can sense voltages over a range, suppose sense 0 to 1 volt. So, it has a range of 1 volt.

Now, let us say that, the A to D convertor 1 bit device we will start with 1 device which means, it will send out 2 possible signals it will send out a 0 and it will send out a 1 these are the only 2 possible numbers it can send out. So, what does that mean it will say if, I send out 0 then the data acquisition system you interpret it as 0 volts. If I send it out as 1 then, you interpret it as 1 volt these are the 2 possibilities. So, in this case I cannot sense half volt accurately. In this case, the resolution is what, 1 minus 0 is 1 volt, if it is a 2 bit device then what are the parameters it will send 0 0, 0 1, 1 0 and 1 1. So, then this will correspond to 0 volt, this will correspond to 1 volt and these will correspond to something intermediate. So, I can make this 0.33, 0.66 and so on and so forth. So, may be the protocol could be if, I send out a string of 2 zero's consider it as 0; 0 1, 0.33; 0 0, 0.66; 1 1, 1. So, I can extend.

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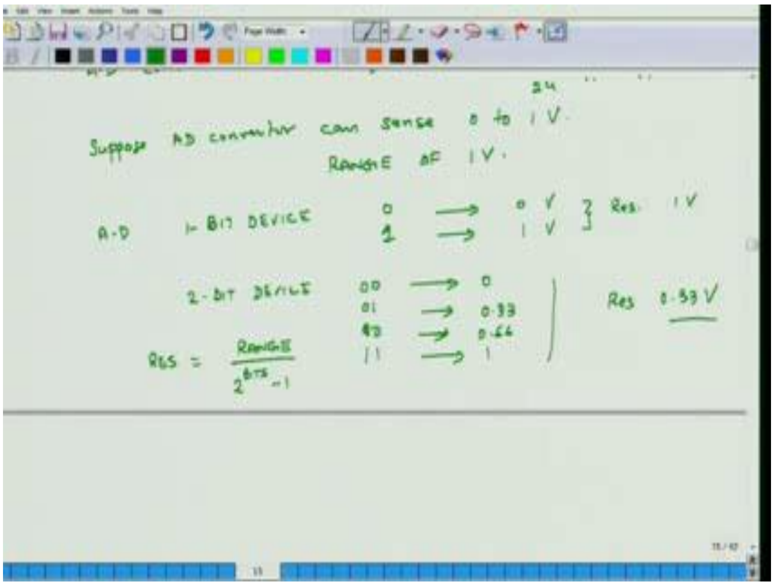

So, what we see is that here resolution is 0.33 volts and we can actually have a formula. So, resolution is equal to what, range over 2 to the power of bits minus 1.

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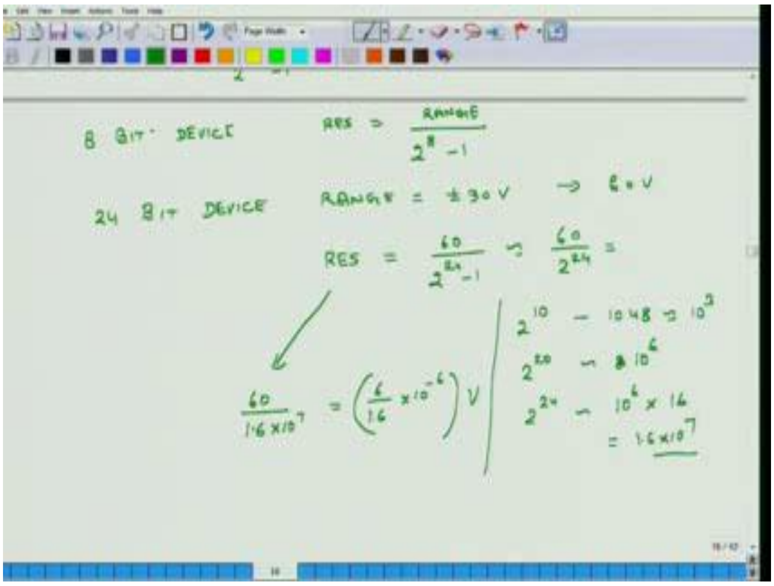

So, if it is 8 bit device resolution is range divided by 2 to the power of number of bits, which is 8 minus 1. Now, I have A to D convertor, here this is a 24 bit device. So, for a 24 bit device and its range, it is says, is plus minus 34 volt range it says is plus minus 30 volts so; that means, it is range is 60 volts. So, resolution is equal to 60 divided by 2 to the power of 24 minus 1 and because this 2 to the power of 24 especially is, extremely large. I can approximate it as 60 divided by 2 to the power of 24. If this number of bits was very small then 1 mattered, but now it does not matter and this is. So, what is this thing? This is 2 to the power 24.

So, we know that 2 to the power 10 is 1048. It is approximately equal to 10 to the power of 3. So, 2 to the power of 20 will be approximately equal to 2, 10 to the power of 6 and 2 to the power of 24 will be approximately equal to 10 to the power 6 into 2 to the power of four. So, 2, 4, 8, 16, so it is 1.6 into 10 to the power of 7. So, here the resolution will be 60 volts divided by 1.6 into 10 to the power of 7. That is 6 over 1.6 into 10 to the power of minus 6 volts. So, now, you would be wondering why is this important, but first we have to learn that, how to calculate the resolution of this A to D convertor, this is important. Because, if we are interested in making very small measurements, then the resolution of the A to D convertor has to support that kind of a measurement.

We have seen that a lot of time sound pressure levels are extremely small, and then a lot of these microphones their sensitivity is not 0 dB or 1 dB or 10 db. It is negative 20 dB negative; 30 dB. So, these small voltages small pressure fluctuations are converted into even smaller voltage levels. So, we have to have some idea before we start taking measurement that what kind of voltage measurements, we will expect from our measurement experiments and once we have that idea, then we have to make the right type of selection for this A to D convertor.

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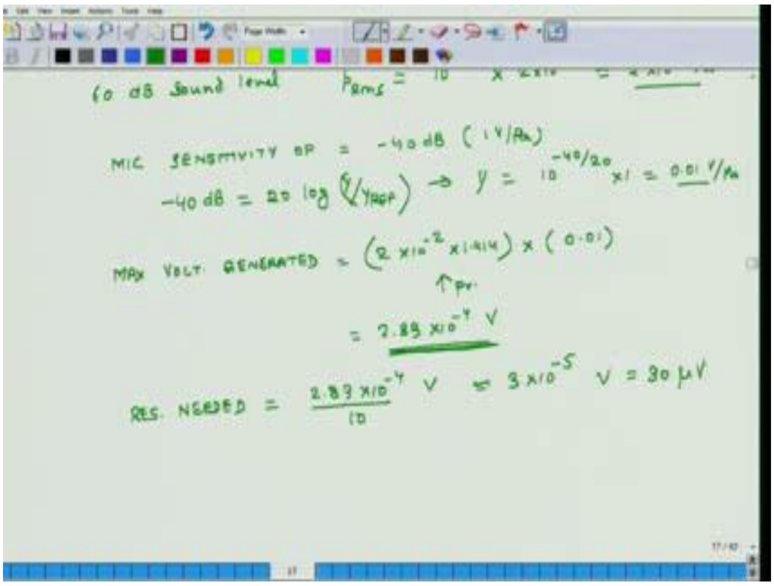

So, I will give you an example; suppose, I think I have a 60 decibel sound in that case p rms equals 10 to the power of 60 divided by 20 into 2 into 10 to the power of minus 5, and if you do the math, you get something like 2 into 10 to the power minus 3 pascals. Actually, excuse me, it is 2 to the power of 10 to the power of minus 2 and let say microphone sense is, and let us say I am measuring this sound using a microphone, which has a sensitivity of minus 40 decibels and reference is 1 volt per pascal you seen, what is that?

Then, what does it mean? It will give me. So, this means minus 40 dB equals 20 log y divided by y REF and from this I calculate y equals 10 to the power of minus 40 divided by 20 times 1 and that gives me 0.01 volts per pascal it will give me 0.01 volts per pascal. So, each pascal I generate it will just give me 0.01 volts. Now I have to sense how much maximum pressure I will sense is 0.02 pascals. So, maximum voltage generated will be 2 into 10 to the power of minus 2 into 1.414. Suppose, it is a sine wave, then I have to multiply that by rms. So, this is the pressure times this number 0.01. So, this comes to 2.83 into 10 to the power of minus 4 volts. So, I should be able to sense at least 2.83 into 10 to power of minus 4 or I should be able to generate this much, at least this much, but when I make a measurement I will not just measure the maximum pressure.

I will like to measure some intermediate values also maybe at least 10 values suppose it is a sine wave, I would like to get good shape. So, may be resolution expected is equal to 2.83 into 10 to the power of minus 4 volts divided by 10. So, I am going to round it off. So, it will be 3 into 10 to the power of minus 5 volts that is 30 micro volts.

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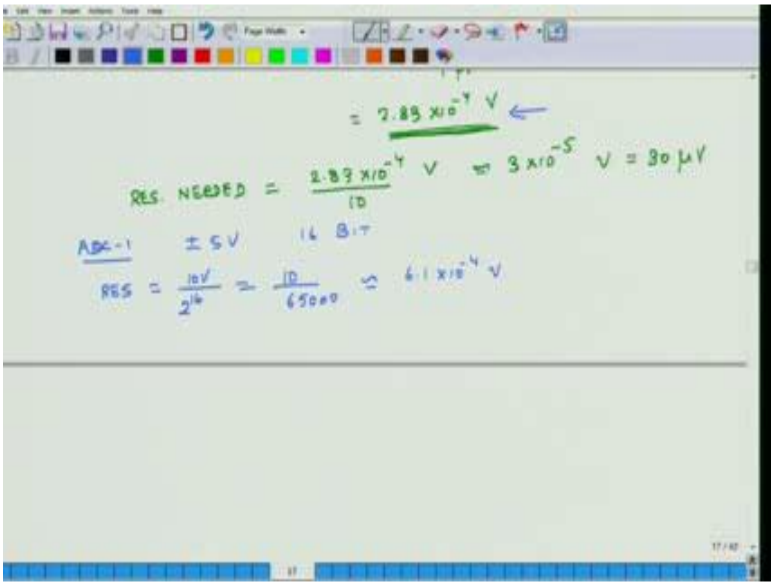

Now, let us say that we have 2, A to D convertors. First A DC, A to D convertor 1 it is range is, plus minus 5 volts and it is a 16 bit device then what will it is resolution be resolution equals range which is 10 volts divided by 2 to the power of 16. It is 2 to the power of 16 minus 1, but I am just ignoring minus 1. So, this is equal to 10 divided by 2 to the power of 16, is roughly 65000. I am just approximating it and if you do the math you get roughly something like 6.1 into 10 to the power of minus 4 volts. So, if you use this instrument you will not even be able to sense this number, the maximum voltage.

So, you use this instrument and you do all the recordings, you have great microphone everything is working fine, but on the computer you will see nothing. So, we will say what is happening maybe something is bad or something, no you selected a wrong A to D convertor. So, then you say what should I do?

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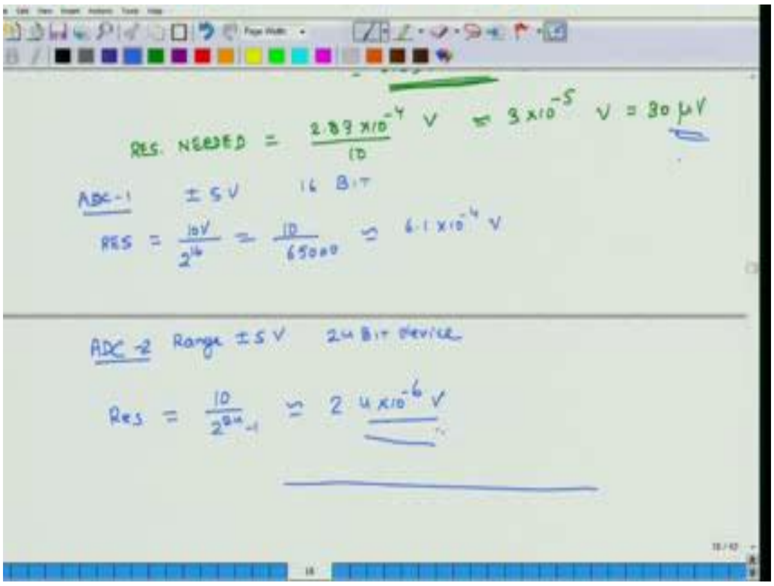

So, you go and spend more money, and you go and buy a more expensive A to D convertor and let us say, this one has a range of say a DC 2, it has a range of plus minus 5 volts, but it is let say 24 bit device. So, then what is it is resolution? Resolution is 10 to the power of 10 volts divided by 2 to the power of 24, and that minus 1 it is approximately equal to if you do the computation 2.4 into 10 to the power of minus 6 volts. So, you see this and you compare it how much do I want at least? I want at least 30 micro volts. So, this gives 10 times less than this, so this is going to meet my need. So, this is an very important consideration, A to D convertors and what I have explained you is how to go around making the right type of selection at least in context of A to D convertors, from their strength point of only one parameter, which is how many bits it has there are several other parameters associated with these convertors.

So, we look at some of these parameters also in the our next class, but today we just wanted to terminate our discussion at this point of time and then we will also look at other parameters which are important as and when we develop complex noise and sound measurement related set ups.

Thank you very much and we will see you next day. Bye.