Principles of Mechanical Measurement
Dr. Dipankar N. Basu
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Module - 12
Special Topics
Lecture - 32
Introduction to acoustic measurement

Hello friends welcome to the last week of this particular course, where we truly speaking does not have any particular topic to cover, but there are several topics to be covered as well. It is been a quite facility journey over last 11 weeks and something like two and half months when I started the course or when I floated the course I was a bit apprehensive about how I can handle the course and exactly what kind of response I am going to get from all of you.

But I am quite happy about the responses that I have received from all the students who have participated in this one and also, from some other sources. So, and of course, students are participation in the portal could have been a bit more in the forum, but still whatever I am got I am happy with that.

We started with the fundamentals of mechanical measurement, here in the very first week if you just go back to the corresponding lectures corresponding slides, then you will find that we have discussed about the structure of a basic measurement system the different components of that; then different terminologies associated with the measurement system, static characteristics, several kind of static characteristics most importantly being the sensitivity and resolution of an instrument.

And also several kinds of effects that can hamper the final output that you can get like the drift, hysteresis, nonlinearity etcetera which we have discussed in the very first week. And we can also we have discussed about something which could have appeared anywhere in this course in the error analysis; different types of errors that can be present in a particular measurement both systematic errors and random errors. And particularly we have focused on the random errors using statistical means how we can eliminate different kind of random errors that we have discussed in the very first week.

Then in the next week we focused on the nature or mathematical characteristics of a measurement system, developed generalized mathematical equation in the form of ordinary differential equations, relating the output and input. And we have discussed the special cases of 0th first and second order systems there and the response of those systems when that is being subjected to when that is have been subjected to certain kind of standard input like a standard step input or ramp input or some kind of periodic inputs.

And then substitutes it is a different measurement systems that we have a discussed about, I hope you can easily relate each of them or at least most of them to one of those kinds like we know that the potential meter is an example of a 0 certain instrument. There are several examples of foster instruments that we have discussed like the basic liquid in glass thermometer or may be universal power transistor etcetera, which is a much more complicated construction compared to the liquid in glass thermometer.

Second order instrument we have discussed just in the previous week itself the vibration measuring instruments, vibrometers or velometers or accelero meters, they are prime examples of second order instruments. Then we have discussed about the digitalization how to convert an analog data o digital version and also, the opposite how to recover the analog information from a digital signals then we started discussing about different kinds of measurements.

Initially discussed about the read out devices in the form of electrical circuits, voltage and current measuring meters, different kind of impedance bridges and then sequentially we discussed about different measurement of different parameters. Displacement to start with then we discussed about stress and strain, then velocity and torque and pressure, flow, temperature and find finally, motion and acceleration or I should say velocity and acceleration of a vibrating member.

Of course, we had very big discussion about the validation part, because I was not willing to go into the deep of this topic which requires advance knowledge of vibration. Now in this week in this lecture and also the one that is to be followed, again like week number 11, we are going to keep the lecture a bit shorter compare to most of the earlier lectures, but I am trying to keep myself free in this week so that I can discuss about some special topic as the name suggest.

Special topic means we are naught going to focus on any one parameter or measurement of one particular parameter, rather we are going to see the measurement techniques of quite a few common parameters which are very much relevant in industrial applications. And actually when it started people in the slide I had a problem because apart from all those 6 or 7 kinds of a parameter that we have already discussed, there are several other parameters also which are relevant in industrial applications or scientific applications or even our day to day application.

Then which one I should put under the special topics and finally, from there I have converge up to just 3 or 4 I shall be talking about only one today and the rest will be coming in next lecture which is going to be the final lecture of this particular course.

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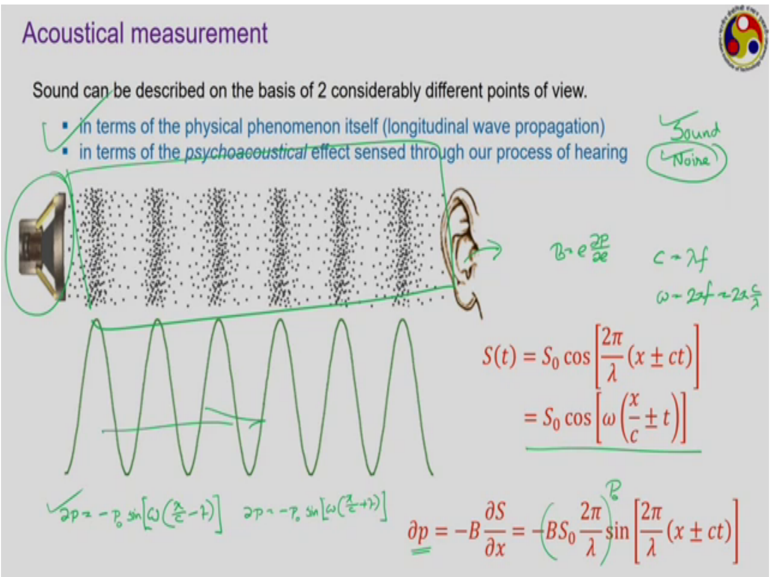

And the one that I have here is the topic of acoustic measurements or acoustical measurements. Now in week number 8 we discussed about the measurement of pressure, but what we are going to discuss about here is the measurement of identification of pressure waves. Because you know from your school level physics knowledge; that sound is nothing, but propagation of pressure waves through certain kind of medium liquid or solid and gaseous medium the propagation of pressure waves or certain wave leads to the sense of sound.

Now sound can broadly be described based on 2 considerably different kinds of approaches, like one approach can be in terms of what physical phenomenon that we are experiencing. Like the source of sound will always experience some kind of vibration, the vibration of let us say if this is a source of sound then, this definitely will be vibrating with certain kind of amplitude, because of the vibration of this particular source the surrounding ear mass all layers of ear that will get disturb.

And therefore, the vibration which subsequently affect the nearest layers of air, which will consecutively transfer that motion to the next set of layers and this way, a vibration wave keeps on propagating through the layers of air.

So, the phenomenon of sound propagation or sound production and transmission basically is nothing, but propagation of certain pressure wave inside a medium. And as it generally propagates only in the direction of motion or only one particular direction so often it call it longitude propagation. But this is just one point of view there can be another point of view from which we can sense the sound, which is related to the psychoacoustical effect says to the process of hearing by your ears or not only our, it can be relate to any living being who has the capacity of hearing sound something.

That is they have some kind of hearing organ which can sense the sound and definitely this second kind of option or second mode of view is much more complicated compare to the first one; because in the first case we are mostly looking for analysis of an wave or a wave. Quite similar to the way we analyze vibration those techniques can easily be used in the first case of measurement.

However, in the second case the our sense of hearing is there are a few absolute scale, based upon which we can classify the sense of hearing that I have or you have or someone else has, but truly speaking most of the concepts are very much relative. And this psychoacoustical effect this makes the task very very complicated, because it does naught involves acoustics only, but it also involves the psychological in fact, that the listener is having when he or she receives on sound wave.

So, we are going to keep ourselves limited only to the first case. And while the psycho acoustical effect related to hearing is very much important for our normal life normal operations, but the first one where we are focusing more on the physical phenomenon and not bothering too much about the hearing part. That is also differently very important in several kinds of applications. Like a for example, if we talk about the vibration of a structure or maybe we talk about one satellite or rocket when that starts to, when that is put into some kind of motion. The amount of sound that it can produce is that often is a result of or often is an indication of the vibration, that I the entire structure is being subjected to.

And therefore, any kind of structural failure can often be sensed from this sound and at this very point I would also like to classify between two terms, one is sound other is noise. A sound is the objective wave, but noise refers to all the other such waves that may be present in the surrounding like, a not applicable for this kind of video course, but when I take a lecture in a class, the sound that is being produced and the waves that is being produced because of my speech and also the queries that is coming from your side that is the sound the first one.

But if some guys keep on chattering on some part of the class, then that creates that is the noise or if someone keeps on banging the door of another class room just outside the outside my classroom then, that is another kind of noise which is a not a part of the main objective or main sound, but can often cause lots of destruction.

In an industrial frame work there can be lots of noise and therefore, this is the level of sensing the level of noise is also very important. Quite often, most of the mechanical engineering application actually is focus only upon the noise identification of the source of noise and identifying the options of reducing the noise are preferably completely eliminating the noise from the final signal. This is just what I am saying a representation of that. This is the source of sound and from there the wave that has been created that keeps on moving in the forward direction till it reaches the ear.

So, as long as we are restricting our self to this particular part then we are into the first framework; whereas when you want to study what is happening after this, that is the second case that we are talking about the psycho acoustical effect. Commonly sound wave or particularly earphone sound within a certain range of frequencies following periodic variation, it can be very simple periodic function it can be much more complicated periodic function as well and here we have considered a very simple periodic model of sound. Here S refers to the displacement of a particle in the transmitting medium because of this work propagation, S naught is amplitude of the displacement, lambda is the wavelength of this and c is the corresponding velocity of sound.

So, we can easily write c is equal to lambda into f if I write once more here c is a velocity of sound, lambda is a wave length so f definitely is the frequency. And therefore, if we take the c out of this bracket then we can write this one in the form like this also, where omega refers to the angular motion and we can write this omega to be equal to 2 phi f or 2 phi c upon lambda.

So, if you are talking about wave which is moving towards right towards my right, that I am talking about then we shall be using the minus sign; if you are talking about a lift moving wave we shall using the plus sign. So, this is the oscillation of one amplitude which we are represent in periodic function; and we are talking about the pressure or the corresponding pressure wave that is getting created then we just to differentiate this function and multiply that with B, now what this B can be? B is a bulk modulus of the medium that you are talking about. So do you remember what is the definition of this bulk modulus?

This B can be defined as rho into dou p dou rho. So, from that definition we get this dou p had this on refers to the change in pressure the left hand side refers the change in pressure because of the propagation of this wave. And it is minus B into dou S dou x and then differentiating this equation which is refer to x we get this particular form, where often this particular portion is separated out and given a symbol P naught to indicate that is a displacement part or I should say the main part of this pressure wave.

So, if you are talking about a right running pressure wave the corresponding change in pressure can also be represented as minus P naught into sin of omega into x upon c, minus t where as we are talking about a lift running wave; then it will be equal to equal to minus P naught into sin of omega into x upon c plus t let us strict to this particular form.

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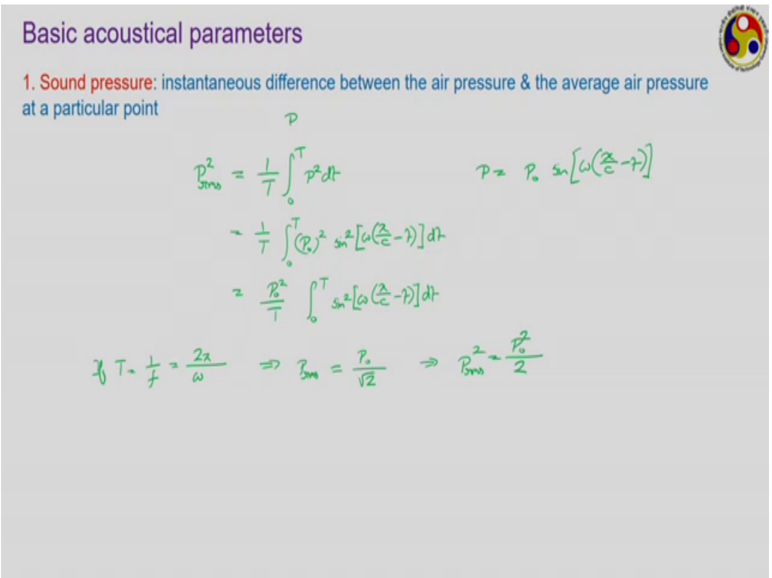

And with this let us define a few parameters which are commonly used for any kind of acoustic measurements which are the basic acoustic parameters. The first one is the sound pressure, it refers to the terms sound pressure refers to instantaneous difference between the air pressure and the average air pressure is a particular point, that is average air pressure is a before when it is not subjected to sound wave and the air pressure is the one when it is subjected to certain kind of sound wave.

And this difference is called the sound pressure. Let us see if the differences designated as p the small p designated this sound pressure then in that case it is also going to follow a periodic kind of nature and therefore, most commonly we define this one in terms of rms values.

So, the r m s values or squad of the rms values for the sound pressure can be defined as 1 by T integral 0 to T is square d t a remember P is refers to the sound pressure which is basically difference between the air pressure and the average air pressure. So, here T is the period over which we are doing this measurement or this capital T. Now let us take a right running wave so and very simple signal, something like P equal to minus P naught into sin of omega into x upon c minus t; just taking it from here for our simplicity. Let us ignore this minus sign also that goes as part of this P naught. So, when we put it here then we have 1 by T integral 0 to T P naught square into sin square omega into x upon c minus t, d t that is we can get this P naught square outside this to integral 0 to T sin square omega into x upon c minus t, d t.

Now, the result of this one will depend will be depended upon the value of the capital T that we choose, if we choose capital T equal to if you are choosing capital T is equal to 1 upon f. In that case or if you want to write in terms of omega 2 pi upon omega in that case P r m s square will be equal to P naught by root 2 or so we can say that, the rms value this are not rms square we should say rms is like this or the squared of this rms values, that is p r m s square will be equal to this p naught by 2 P naught square upon 2. So, this is the wave we generally we can define the sound pressure which is a periodic signal.

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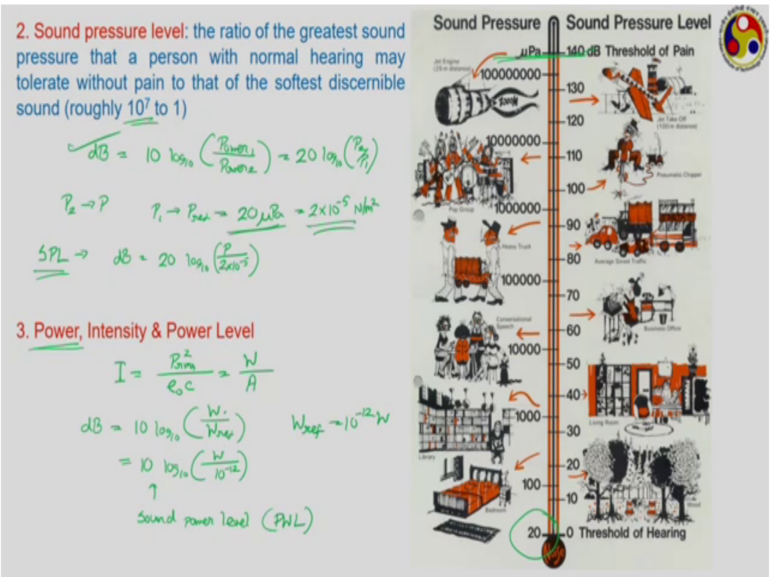

And another one which is a more important probably for practical operations that is a sound pressure level. Sound pressure level refers to the ratio of the sound waves in terms of some kind of reference sound pressure; the ratio of the greatest sound pressure that a person with normal hearing may tolerate without experiencing any kind of pain to that of the softest discernible sound that is generally referred as a sound pressure level.

If we see this particular chart in terms of decibel, then this is the threshold of hearing for sound, the 0 decibel or if we put in terms of pressure it is about 20 micro Pascal. And as we go along in the decibel level, then you can see a most of all normal activities like, the living room of a house or maybe in a general conversation, we are restricted to this decibel levels of 50 60 etcetera.

In a office also you can have in the range of 65, where as if you are talking about to an average street traffic it is in the range of 80 to 90 and the pub group or we can go to think about even largest sound levels j t engines taking off is much larger level of sound. So, which were not a practically these are not suggested for continuous exposure to and human ear, but if it is available only for short duration of time then our ear can easily tolerate this.

And this 140 decibel generally is taken as the limit of threshold of pain. So, if we take that then roughly we get a range of 10 to the power 7 about this sound pressure level. And if we define this ratio in terms of decibel then, the definition as per the standard definition of decibel will be 10 log base 10 of P 1 to P 2; where P 1 20 is a generally the designated sound pressure level or the sound pressure sound pressure corresponding with the one that you are doing the measurement and P 2 generally refers to certain kind of reference.

Or if we just relate this one ok, if we stick to actually we can defined we in terms of the definition of pressure, but commonly like in our module number 4 we have introduced this term decibel and there we have define this as a ratio power primarily. So, if we stick to that particular notation let us if we talk about this is power 1 and this as power 2, then power is generally for a sound wave is proportional to square of the corresponding sound pressure then this becomes 20 log 10 into P 2 upon P 1.

Commonly we this P 2 is the pressure sound pressure for which we are doing a measurement and P 1 is some kind of P reference based upon which we do the measurement. Now, we have to if we want an uniformity among of all kinds of measurement we have to choose a suitable reference, which we have to follow for any kinds of measurement situation.

Now that is taken as this particular value which is the threshold of hearing sound levels below this particular pressure generally we are not able to hear. So, this is taken as 20 micro Pascal or 2 into 10 to the power minus 5 neutron per meter square. So, our decibel for this sound pressure level now becomes 20 log base 10 P divided by 2 into 10 to the power minus 5 this much of decibel in sound pressure level. We can easily do this calculation now for any particular sound pressure and measure the corresponding sound pressure level with respect to this particular reference. Next definition on next term that comes into picture is power intensity and power level there were several terms that we are using.

Now, power you have mentioned is proportional to P square, intensity is generally referred as the ratio of P rms square, divide by rho naught into c where rho naught is the standard density of the medium or I should say the average density of the medium. And this can often be related to the acoustic power divided by the area over which this wave is propagating. So, W is the acoustic power which is proportional to P r m s square is used in the previous one also.

Again we need to choose certain kind of reference to if you want to represent this one in terms of some decibel with generally commonly do not represent intensity in terms of decibel. But the power is often is represent in a decibel kind of form just similar to this particular ratio. So, if we go by it then corresponding power in terms of decibel will be equal to 10 log base 10 into W for the major signal divide by W ref. And this W ref the most common choice for this reference power is 10 to the power minus 12 watt which closely resembles this particular pressure level.

So, this ratio becomes 10 log 10 w by 10 to the power minus 12, this much of decibel often this particular definition is called sound power level. And in short it again becomes SPL which is the sound pressure level this is our sound pressure level SPL and this is sound power level is to avoid the confusion with this term SPL we often write this one as P W L Power Working Level something like this.

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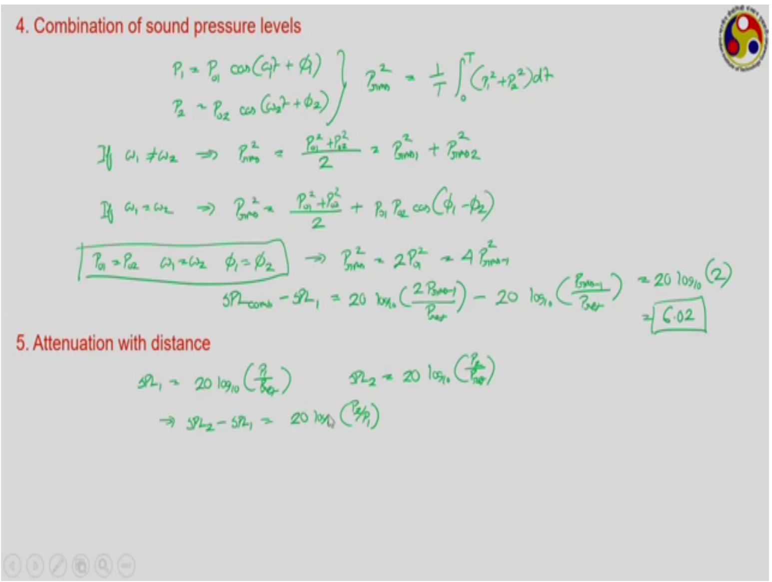

The next terminal come picture is combination of sound pressure levels, when we are talking about two different single tone sound waves coming to the same medium, then there will be some kind of interaction between them leading to a resultant signal. Now let us say we have a one signal P 1 coming in of the shape plus phi 1 and the or maybe omega 1 t and the another one P 2 is coming as let me write it clearly this constant just to separate them from each other P 01 this is P 02 cos omega 2 t plus phi 2.

So, they have different amplitudes and different frequencies as well as different wavelengths. So, if you are talking about a combination of both of them. Then in this medium p r m s square will be equal to 1 by T integral 0 to T p 1 square plus p 2 square dt; there are two possible scenarios if omega 1 and omega 2 are not equal to each other, in that case p r m s square becomes p naught 1 square plus p naught 2 square by 2 that is it becomes rms for the first signal squared plus rms for the second signal squared.

However when omega 1 is equal to omega 2, then we have a similar simpler situation then this P r m s square is directly P naught 1 square plus P naught 2 square upon 2, plus P naught 1 into P naught 2 into cos of phi 1 minus phi 2; this can easily be calculated following this particular integration. Now, if you are talking about a very special situation when two identical single tone waves are present in the same medium, that is we have P naught 1 is equal to P naught 2 omega 1 equal to omega 2 and phi 1 is equal to phi 2, in that case we have for this special situations P r m s square is equal to twice of P naught P 01 square that is 4 P r m s 1 square.

If we calculate the sound pressure level of the combined signal minus the sound pressure level for the first signal, then in this special case it will become 20 log 10 into 2 P r m s by P naught or P ref minus 20 log 10 P r m s 1 by P ref leading to 20 log base 10 of 2 into 6.02. So, for this special situation of two identical single tone signals in the same single tone sound waves into the same medium we have the sound pressure level to be equal to 6.02.

Similarly, we can also calculate for other special situations and one final case is attenuation in the distance. So, as we move along or move away from the source of the sound, there will be attenuation because the sound wave gets pried along all possible directions. So, that attenuation depends on the distance that we are covering for this quite often we have say, suppose we are talking about two distances. So, in one case or final signal is P 1 so corresponding sound pressure level at that particular location is 20 log 10 P 1 upon p ref in the other case sound pressure level for the second case is 20 log 10 P 2 upon P ref.

So, if we combine this two. SPL 2 minus SPL 1 then we have 20 log 10 into P 1 upon P 2 sorry I have taking SPL 2 upon SPL 1 then it should become P 2 upon P 1. And from there we can get an idea about the attenuation that is happening for this two locations 1 and 2 we can get a calculation going for this. So, these are the common parameters that we general use associated with the measurement of sounds the sound pressure level being the most important one.

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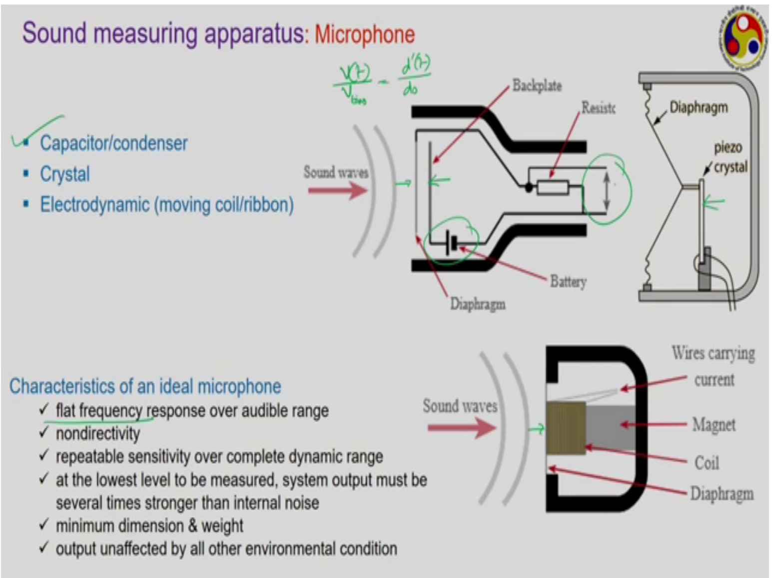

Now, let us quickly talk about if you sound measuring apparatus, particularly the microphone which is the most common kinds of apparatus. But any sound wave measuring apparatus generally has quite a few steps the microphone is almost universally present, which is the sensor, it senses the sound wave from the surrounding medium. Then that is being supplied to certain kind of data processing circuitry commonly a few amplifiers and filters and then finally, going to the read out portion where either it is a screen where the readings are shown or we may be having a recording device.

The microphone which is the most common types of sound measuring apparatus and generally in it not a very expensive one can be of three types; capacitors or condenser type microphones crystal based microphones and electro dynamic or moving coil or ribbon type microphones.

The capacitor type microphone is the most common one you definitely a seen this one in different locations and its working (Refer Time: 30:57) it is also very simple this something like this. Where as a sound waves comes to the device you have a diaphragm first. So, this is the diaphragm which starts vibrating on the impact of the sound wave. Now this diaphragm and this back plate together they form a form the capacitor. So, as the distance between them changes correspondingly the voltage output from this capacitor also changes generally, the thickness of the diaphragm is extremely small can often be in the range of 20 to 30 micron.

And also the gap between the diaphragm and the back plates also of the same order, hardly in the in the range of 30 40 micron, hardly more than that and correspondingly the voltage output that we are going to get that keeps on changing. Like, we can often relate the output voltage at a particular situation to the bias voltage comes because of this battery, which a provides the initial bias voltage and v t represent the final output voltage, which your sensing somewhere here.

Because of the change in the position of the diaphragm that becomes d prime t upon d naught here, d naught is the initial distance between the diaphragm and the backplate and d prime is the change distance or change separation between this. So, this is a very much a linear relation and as the distance changes correspondingly output voltage also changes and we can easily get a measurement which suitable scaling of course, easily get a measurement of the sound level.

So, this is the first type of measurement, this is the most common kinds of instrument that I have mentioned and also has several advantage I shall we coming back to that very shortly.

The second kind of instruments we can have is a crystal west where actually we have piezo electric crystal. Now, earlier in several cases we have encounter this piezo electricity which refers to the change in electrical properties or electrical output because of a change in pressure at this crystal is subjected to certain kind of pressure. The electrical output from this that changes and that output is generally proportional to the pressure of the sound wave.

So, a very simple working principle and we can keep this one in direct contact with the diaphragm in the element this crystal and we can easily get a high quality measurement. The third kind of possibilities in electrodynamic one, where we have a permanent magnet creating magnetic field, and there is a coil which is connected to this diaphragm.

Now, because of the movement of the diaphragm the coil keeps on moving around the permanent magnet accordingly and of course, where coils are charge by electrical current. So, the interaction between the permanent magnet field and this electro field created by this electromagnet that keeps on changing with the movement of the diaphragm. Accordingly we get certain kind of output signal which is directly proportional to the sound wave.

This particular configuration is a moving coil type that I have mentioned about, the microphone has several advantages, but before that which kind of microphone we should go for there are quite a few factors to be considered for that. Like, this is the characteristics that we want for my from an ideal microphone. So, we want a very flat response curve over the entire audible range which is unfortunate that is not possible for any of the instruments, but generally the capacitor or condenser type gives flat response over a large range of frequencies.

Then non directivity it should not be direct sensitive repeatable sensitivity over complete dynamic range; and the performance should be repeatable the damage on the diaphragm because of any sound impact that should be very minimum, at the lowest level to be measured sound output should be several times stronger than the internal noise this is very important, any system has some internal noise level. Now the smallest possible sound that we are looking to measure using this microphone; that should be several times stronger than this internal noise; so, that the effect of internal noise is not there at all.

The dimensions and weight of the device should be also quiet small and the output should be unaffected by other environmental condition, apart from the sound wave. Sound wave is definitely going to affect this, but other environmental conditions like temperatures or wind speed etcetera should not affect this. Now, if we come just look at all this three kinds of options generally, we will find that the capacitor and condenser type is the most efficient one or most the best one in general practice use purposes. Like it has very high input impedance and also excellent linear perform providing a quiet flat frequency response curve as I have mentioned over a wide range of frequencies.

It can maintain the calibration for long period of time, and at the range is quite wide for this, how were the problem with this capacitor type is, like any capacitor kind of instruments capacitor capacitance best instrument theirs a sensitive to the changes in pressure and surrounding temperature. And also their relatively fragile compared to the other two high polarizing voltage is required the requirement of this battery this active power source is one of the biggest disadvantage. For the crystal type the linearity is quite descent and another big advantage is their passive devices you do not need any active power source for them.

They are relatively rugged much much stand near compare to the capacitors based, how are they are less expensive as well. Problem is they can be relative to sensitive to vibration and required some kind of impedance matching device at the output side. The electrodynamic one that gives good linearity and again no active power source required, but they generally physically much larger system compared to particularly the microscope or microphone I should say the condenser type microphone.

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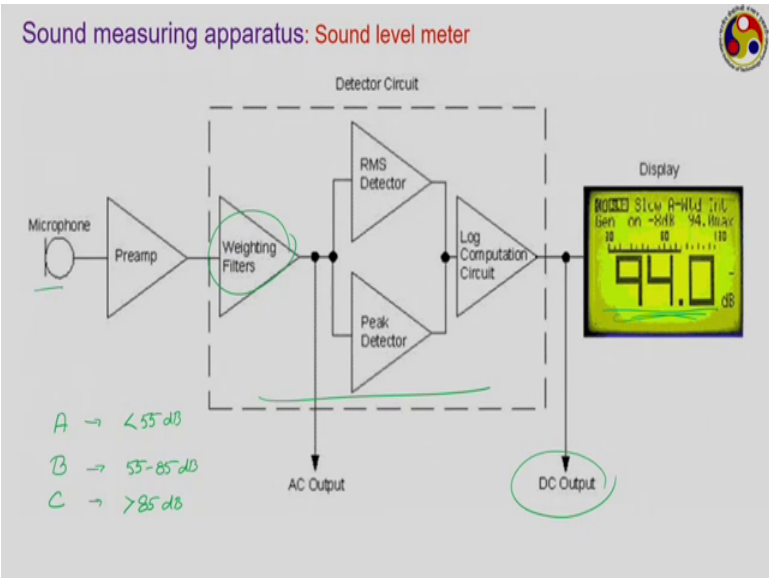

The second kind of device that we have is sound level meter which are used to measure the level of sound in commonly in decibel. You may have seen this one with the traffic inspectors, where they are trying to when they are looking to measure the sound level of some vehicle. Here also we have a microphone then who the corresponding signals passes to this waving filters and if you levels of amplifications to get the final display which can be either is DC output leading to a some kind of recording or can be a digital display.

Depending on the sound level, the correspondingly depend the magnet this particular magnitude the signals can be classified into three different categories. Category A, B and C the sound level categories a refers to sound waves having level less than 55 decibel C is greater than 85 decibel, B is in between that is 55 to 85 decibel.

So, depending on which sound level that you are in which level or which category you are going to go for the measurement, this internal circuitry can change a bit. And also as shown here the circuit is capable of giving both AC output and DC output.

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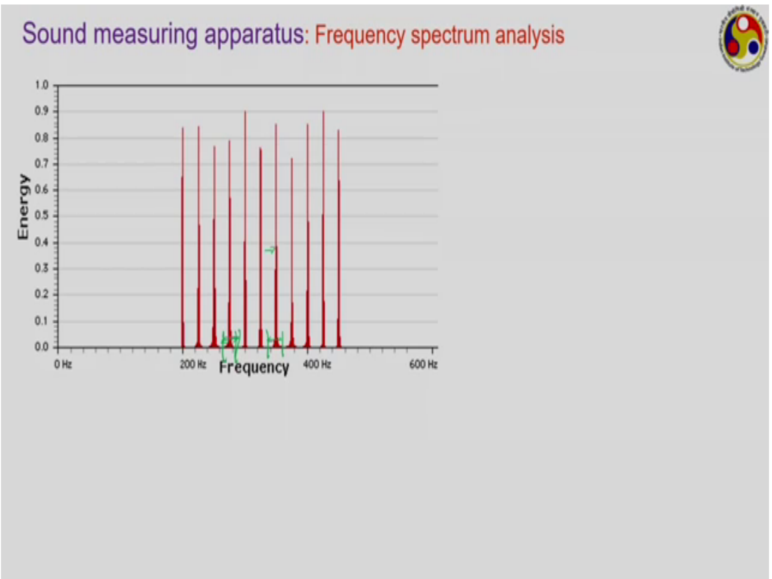

Next the frequency spectrum analysis, now from microphone or from this the circuit they talked about the sound level meter we can only get the amplitude of the power, but no information about the frequency; for which we have to go for this frequency spectrum analysis where the frequencies are plotted and the energy of the signal at different frequencies they are compared.

Generally some kind several band-pass kind of fielders are used. Like for this particular one only a filter within this particular band which allows with a signals to go through within this band that will be used similarly for this particular signal we may be using a band-pass think something like this.

Several kinds of analysis are possible for Fourier transformer this is one very common way of analyzing the frequency spectrum or to get the idea about the frequency response of your sound wave. Finally, these are the common sound measuring apparatus and therefore, I do not want to there are if you others also, but working principle remains more or less is the same, that is always the sound wave which is a pressure wave that hit certain kind of diaphragm. And the oscillation is transferred to the diaphragm and other diaphragm starts to oscillate that oscillation is sensed using suitable circuitry.

Now the sensing measure that keeps on changing or I should say the internal mechanism internal circuitry keeps on changing; however, the sensing side always we have certain kind of diaphragm kind of configuration.

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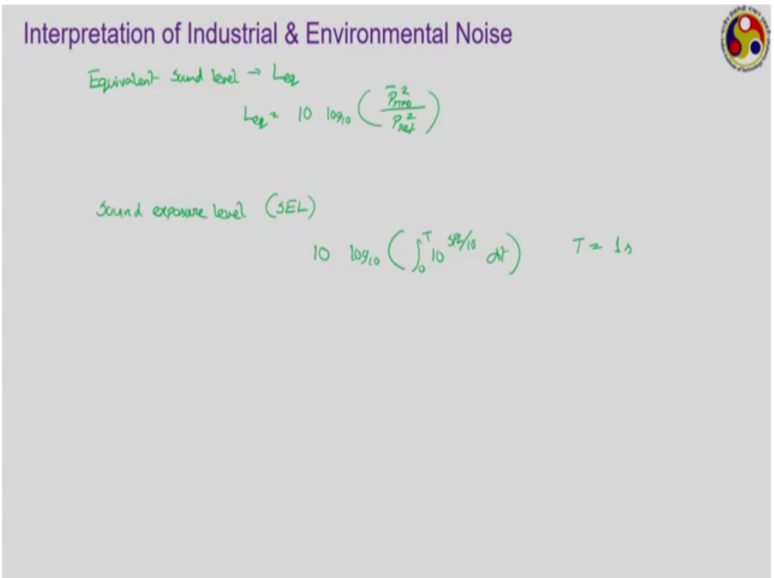

One final thing to talk about is the interpretation of industrial and environmental noise. Now noise is always present in any kind of signal and therefore, it is important to use certain parameter to get an idea about this noise. And therefore, we use something known as equivalent sound level. It is quite similar to the sound level that we have defined and it is early have a symbol equivalent. Now, this yield equivalent is defined as just like the previous case, now this P bar rms square refers to the or its relates to the noise signals.

So, it is a time refer is root means square sound pressure level for the noise and we can easily take the square out of this and L equilibrium can be calculated using the methods or the mathematical formulas that we have used earlier to get the define the sound pressure level. There are depending on which level you are working how much precision you want in your signal in the sensing of proper signal the value of L equilibrium is decided and accordingly we prepare the corresponding circuitry to suppress the noise in the final signal.

And there is also something known as sound exposure level, SPL or sorry sound exposure level now sound exposure level is defined as, another logarithmic definition integral 0 to T 10 into sound power level by 10 d t, where capital T is typically 1 second.

So, this is a when the noises of transient nature like a suppose you are standing at somewhere and then standing on a road and then automobile that passes by. So, when it is approaching you from one side, then sound will continuously keep on increasing corresponding noise will keep on increasing; and it will be maximum when it is closest view and as it starts going into the other direction again the sound keeps on reducing.

So, when you are dealing with a sound wave or sound signal of such transient nature, then we generally use this sound exposure level definition. So, I do not want to take it for any more forward in terms of sound level I have just given a few definition associated with aquatic measurements and the working principle of a microphone which is the most common instrument used for measurement of sound or corresponding acoustic signals.

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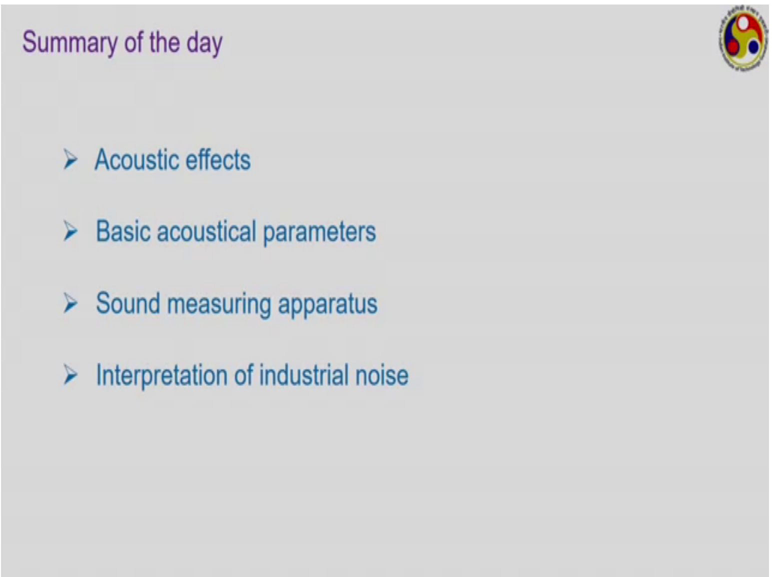

So, that takes us to the end of this particular lecture for I have talked about briefly very briefly I have talked about the acoustic effects, basic acoustical parameters particularly the sound pressure level. Then sound measuring apparatus microphone is the one that we have discussed in some detail and finally, we briefly got idea about the industrial noise or interpretation of the industrial noise by defining translate sound exposure level.

So, that is it what the day, I shall be having just one more lecture in this particular week where two or three more parameters will be discussed in brief, till then please go through the recording. So, go through this particular lecture and keep me a posting whatever you think of in this topic.

Thank you.