Mechanical Measurements and Metrology

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Module -2
Lecture - 23
Pressure Measurement (contd)

This will be lecture number 23 on the series of Mechanical Measurements. Towards the end of the last lecture we were in fact looking at the measurement of displacement which is a result of a pressure being applied on a diaphragm or bellows type of arrangement and this displacement is measure using what is called as Linear Variable Differential Transformer or in short we call it the LVDT.

So we just started looking at the theoretical functioning or the theory behind the functioning of the LVDT. Let us continue our discussion on LVDT and also look at what is used as a practical LVDT circuit. Then let us take a look at gauges which depend on the capacitance between two electrodes, the space between that is filled with an dielectric and if the distance between the two electrodes changes then it gives rise to a change in the capacitance and this change is brought about by the application of pressure. For example, it could be a diaphragm gauge which basically is a capacitance type transducer. So we will look at principles in the circuitry appropriate to that and then we will close the discussion on the different types of pressure transducers by taking a look at a simple example which is a diaphragm gauge example and let us call it example 24.

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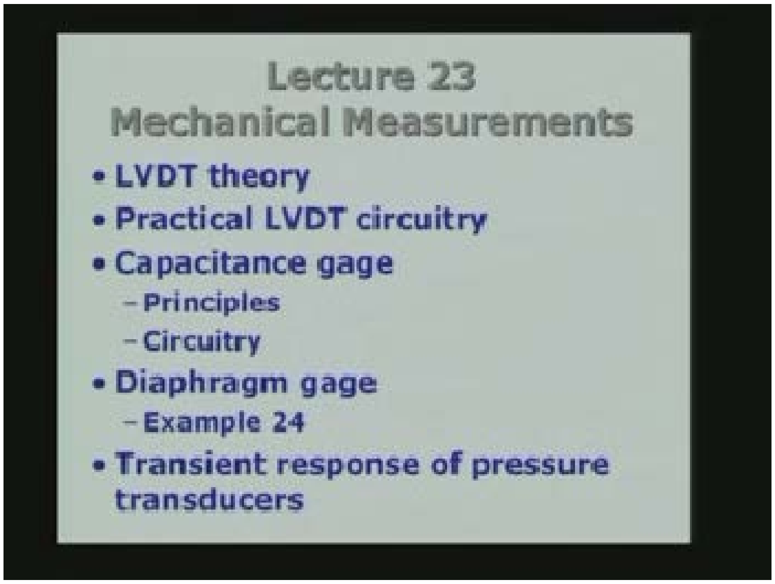

Now let us look at the LVDT theory and practical circuitry look at the capacitance gauge how it works and then some examples.

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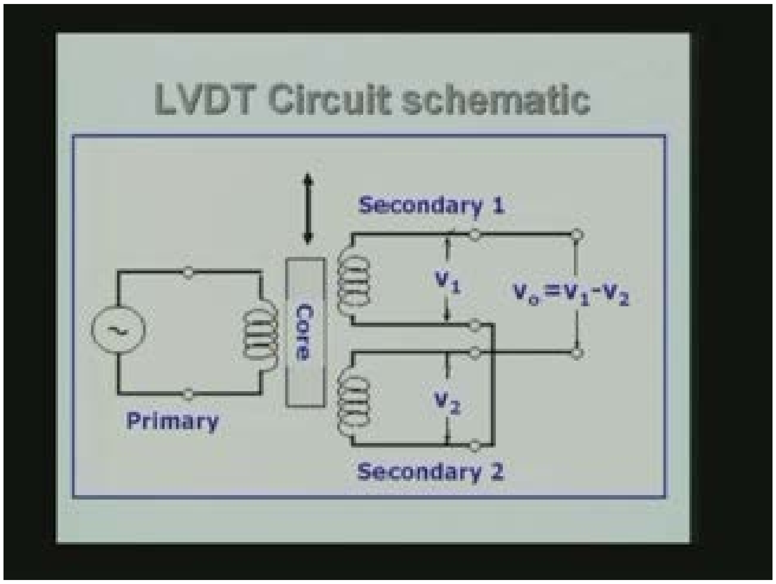

Therefore here is a LVDT and in the LVDT essentially there is a primary coil here and there are two secondary coils and there is a core which is capable of moving up and down and this is the one which moves with the pressure transducer which gives rise to a movement of the core either in the downward direction or the upward direction as the case may be. This primary coil is energized using a high frequency AC usually for a several kilo hertz. It gives rise to two voltages on the secondary coil, V_1 for the coil up here and V_2 for the coil down here. These are two AC voltages which are going to come out and in fact if you are able to measure the difference between these two AC voltages by putting the secondary back to back you see that the output voltage is V_1 minus V_2. This V_1 minus V_2 is going to be proportional to the displacement of the core and of course this displacement has been come about because of the pressure being applied in the pressure transducer.

There are some draw backs in just measuring the two differences between voltages. Here we notice that the output voltage here will be 0 if V_1 and V_2 are equal when the core is symmetrically placed with respect to the two secondary coils. If the symmetric condition is disturbed, you are going to get an output here and if the core moves upwards the secondary one will produce a higher voltage compared to the secondary two and therefore this will be a positive AC signal and if the core moves downwards it will be exactly the opposite. So the phase of the output V_0 with respect to the phase of the primary excitation voltage depends on whether V_1 is greater than V_2 or V_2 is great than V_1 as the case may be. This particular circuit is not adequate for practical purposes so we will see how a practical circuit can be made which is going to be helpful in measuring the signal.

Therefore the output of an LVDT excited by an AC supply, so, we have the output, either it is positive, on this side is the positive output and on this side is the negative output with respect to x is equal to 0. There is a change in the phase that is what is important. The phase angle changes from 0 to 180 or minus 180 in this case when you change the displacement from this side to this side. But essentially it is a linear output which follows a relationship showed by this red straight line either on the positive side or on the negative side.

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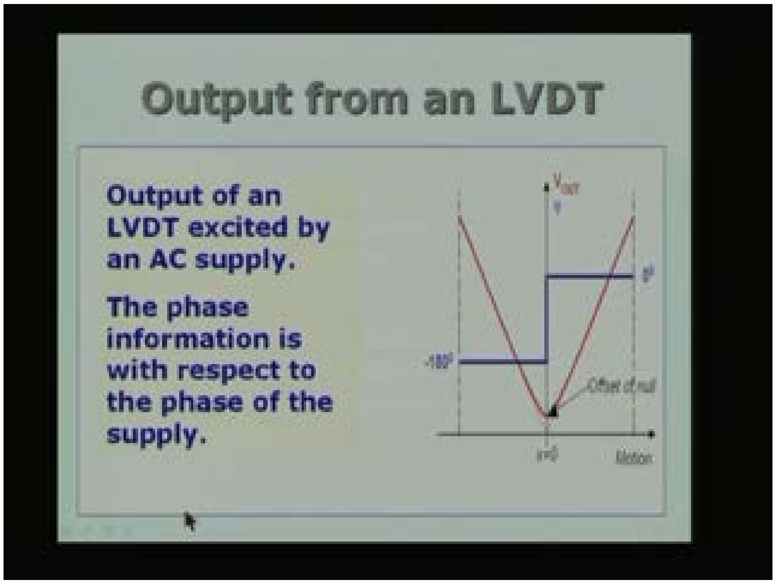

Here is the block diagram of LVDT signal conditioner. Signal conditioning means that a transducer is producing some effect which is in the form of either a current or a voltage and the magnitude of the voltage or magnitude of the current may be very small in which case we will have to condition the signal. It may be in the form of AC signal in which case I would like make it into DC signal for example. So, signal conditioning in general means many things. It may be amplification that means you are going to increase the magnitude of the output to make it readable by using a simple meter or it can also mean that you are converting it from AC to DC called as demodulation.

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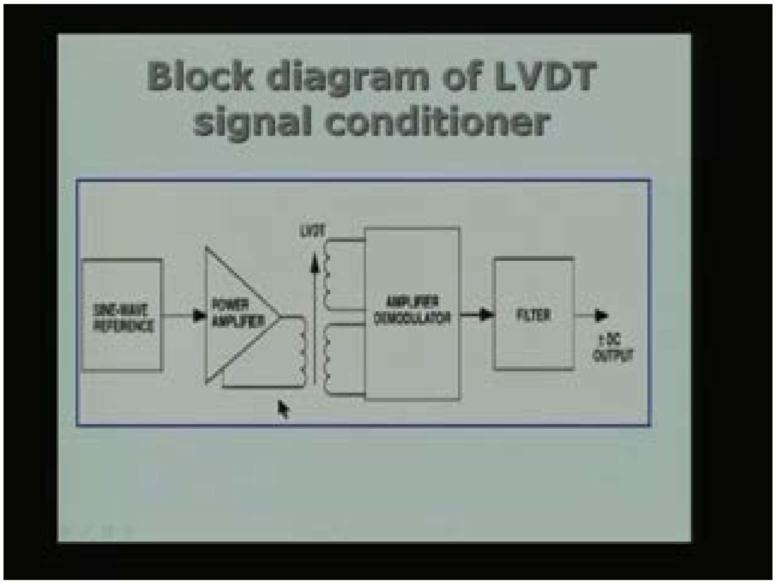

Therefore the amplifier plus demodulator is what is on the secondary side. As you can see here there are two secondary windings and two secondary voltages are going to come out. The sin wave reference is going to drive the primary through a power amplifier because the primary requires a large current in which case a power amplifier is required because it has to drive the current through this circuit and the two secondary voltages which appear here are in AC form alternating form just like the input wave form because the transformer is an AC instrument which will magnify AC voltage or modify the AC voltage applied on the primary and give rise to a secondary AC voltage. So the difference between these two is what I am interested in. But I want to first convert it to a DC signal by demodulation and then use a filter to remove the ripple and then you get a DC output which may be either positive or negative depending on which way the core has been moved. If it moves in one direction it may be a positive value here and if it moves in the other direction it will be negative value.

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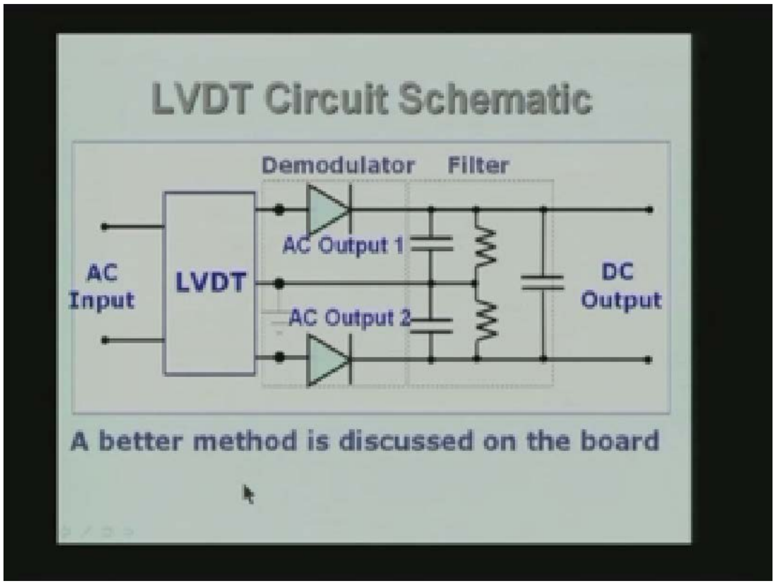

Let us look at how this can be accomplished by looking at a simple schematic of a circuit which can used for this purpose. So I have the AC input, the AC input is between these two terminals which are the primary terminals of the LVDT. The LVDT is here in a blocked fashion. It has got two outputs one across the top coil and the other one across the bottom coil. I am assuming that the middle one is ground, this is ground here and therefore there is a AC voltage appearing here which I call it as AC output number one and there is an AC output two appearing at the bottom.

I am using two diodes. This diode is a half wave rectifier. The output on this side is going to be one sided because it is a demodulator that means it is going to remove one part of the wave, either the lower part or the upper part so what I get here is a DC voltage or a wave which is going to go only in the positive direction or the negative direction and similarly here. And if I am using these two in opposed fashions, I will get the top going wave here and the bottom going wave here. And here this is the filter element, this filter is going to remove the AC component and the AC component will actually go to the ground and the DC component will appear across the output here.

Therefore this is a very simple arrangement where I have two half wave rectifiers, one for the output across the coil number one and another for the output across the coil number two and then I am going to use a filter and then get the DC output. So you have AC input coming here if necessary through a power amplifier the LVDT and the LVDT gives two outputs when there is a movement of the core with respect to its null position then either this voltage or this voltage will be higher and accordingly the DC output will show either a positive or a negative sign.

Let us find a better way of doing it by using a full wave rectifier and let us look at how it is going to be appearing. Now let us look at the secondary one and the same will be similar for secondary two. The secondary coil is here and we are going to connect a full wave rectifier bridge as the demodulator. So I am going to have four diodes, and I have a load resistance across that. So the voltage is actually picked out across this output, let me call it output number 1. Similarly, for the secondary coil 2, I will exactly do the same kind of a thing at the bottom. This is the output of the top one. So if I look at the AC output 1 it will show something like this, this is output 1 and what comes as the output here will be a full wave rectifier so I will get something like this.

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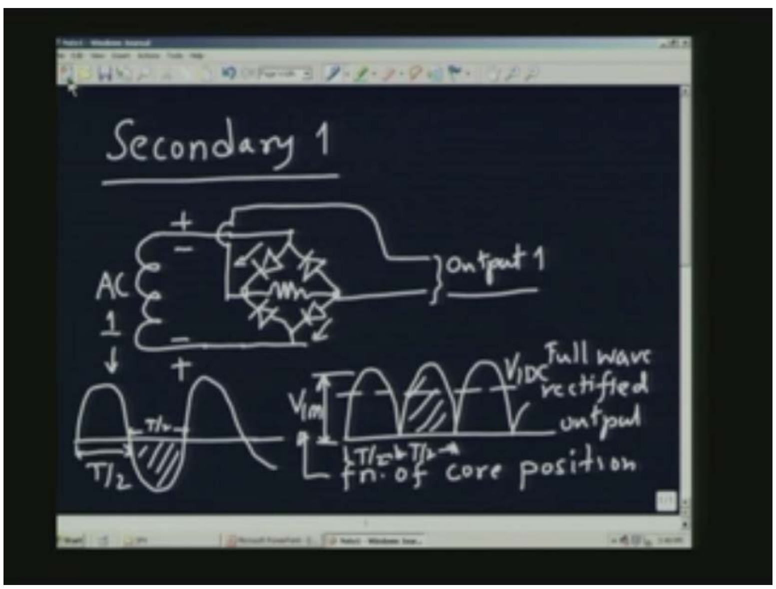

This is the full wave rectified and rectified means it is on one side only the output. And this magnitude here we will call it as $V_{maximum}$ .V_{1m} or $V_{1maximum}$ will depend on the function of the core position. So, if the AC wave is coming here if this is positive with respect to this, this diode will conduct so the signal will pass through like that. If this becomes negative and this becomes positive the other two diodes are going to do the conduction. That is why the output is going to appear for the first half cycle this corresponds to this T by two here, and this will correspond to this half cycle this will be T by two which is something like this. Therefore this portion has become this portion, it has been inverted or rectified and that is what a full wave rectifier is.

Therefore in the previous sketch you saw, there if I have had only half wave rectification the alternate ones will be missing. So if I pass this wave through a filter which is going to remove all the high frequency components what you will get is you will get only the mean value so the mean will pass through so the average value will be something like this. This is the average of the V_{1DC} which is going to pass through and the rest of the thing is going to be removed.

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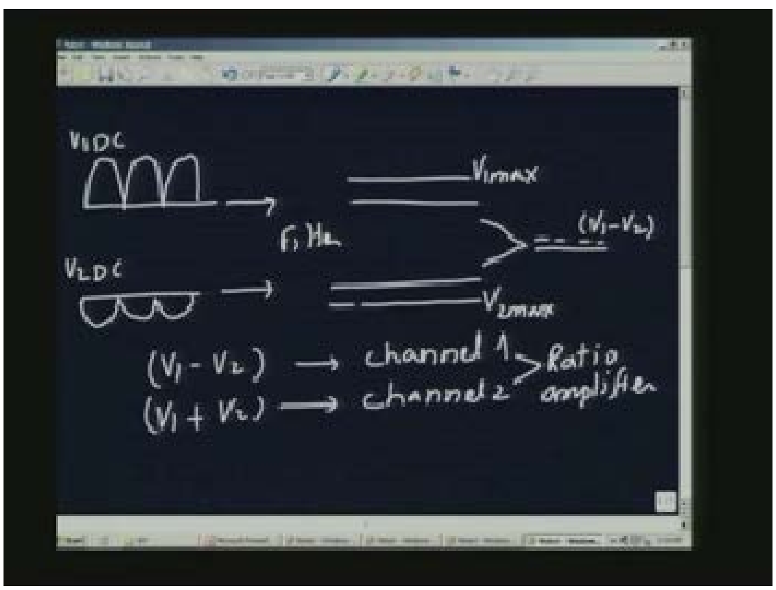

Therefore here you have V_{1DC} this is coil 1 and coil 2 will give you V_{2DC} this is the second coil. So if I take the difference V_{1DC} minus V_{2DC} this will be your output for a given displacement of the core. So if the displacement is more towards the coil 1 that is away from the null position if it goes more closer to coil 1 this will be greater than this thing then this will be positive and if I have a displacement in the opposite direction I will get a negative value. So this voltage will change sign.

In the previous figure you saw, you had a linear variation both for the positive as well as the negative displacement of the core and this follows a linear relationship as indicated there and this voltage is proportional to the pressure difference and the pressure difference has given rise to a certain displacement which is a linear relationship. Therefore the voltage difference between these two is proportional to the pressure difference. So we will say that this V_{1DC} minus V_{2DC} is proportional to delta P. This is the important thing. Now let us look at a slight improvement in this circuitry.

Suppose, I have a V_{1DC},V_{2DC} how does it come about? It comes about because we have V input AC. The magnitude of V_{1DC} is proportional to V input AC. So, for some reason if the AC input changes slightly then this will change because in a transformer if you apply a larger voltage on the primary side the voltage on the secondary side is going to follow it, it is going to increase slightly and if it decreases then it is going to decrease slightly. So, if I do the following, if I take V_{1DC} minus V_{2DC} and divide it by V_{1DC} plus V_{2DC} if it is proportional to input AC signal all these are going to increase by the same or decrease by the same fraction. So you see that this ratio is independent of input AC magnitude. The difference between the voltage V_1 and V_2 on the DC side divided by the sum of these two or the proportion to the average of the two this is independent of the input AC magnitude. That means even the input AC signal changes slightly either on the higher side or on the lower side it is not going to make any difference. Therefore normally what is done in the circuitry is to measure this. This is what is indicated and this is what is measured. So we have to take the sum and the difference then combine together to get the voltage. Now, from coil 1 I have got this and from coil 2, I have got this, this is V_1,this is V_2, DC and DC because I have rectified or demodulated and I am going to pass it through a filter so what I will get is a voltage like this, this is $V_{1maximum}$ and this is $V_{2maximum}$ and what you see here is the difference between these two so it will be either a small voltage which is positive. This is V_1 minus V_2 and the difference is going to appear. I can also have another channel through which I calculate the V_1 plus V_2. So we have V_1 minus V_2 in one channel and V_1 plus V_2 I can have another channel and then take the ratio called as the ratio amplifier. You can take the ratio of the two signals.

Basically this is what is going to be done in the case of LVDT transducer which is connected to a pressure transducer. The pressure transducer is going to communicate the change or the displacement which is due to the pressure difference. It is going to communicate to the core of the LVDT and the core of the LVDT is going to create two AC voltages. These two AC voltages are demodulated to get two DC voltage outputs. They are filtered to get only the mean values and these mean values are subtracted in one channel added in the second channel and the ratio is taken and the ratio is now independent of the variations in the input voltage. That is why basic reason why we want to do this. This is going to give you a signal which is going to vary with delta P.

Here is a different type of pressure transducer. Here let us look at a capacitance pressure transducer just to indicate the nature of the capacitance transducer. It essentially consists of a diaphragm as indicated here. It is only a schematic and the actual pressure transducer may not look anywhere like this. It just to explain the basic principle of the capacitance pressure transducer I have written like this.

There is a diaphragm and there is an anvil which is fixed. And there is a small gap between the diaphragm and the anvil. Usually the gap is very small. The gap may be much less than a millimeter. And also remember that the diaphragm is going to undergo a very small displacement. It is not going to displace too much. It is going to be a very small displacement. So this variable gap which is the gap between the diaphragm and the anvil is full of some dielectric, in most cases either vacuum or air. And the capacitance of this, if you treat the diaphragm as one of the electrodes and the anvil as the other electrode there is a capacitance between these two, there is a capacitance between the two electrodes and this capacitance is a function of the gap, and the gap is dependant on the pressure because if we increase the pressure the diaphragm is going to displace and the gap is going to reduce thereby changing the capacitance.

So the capacitance pressure transducer changes the pressure to a displacement and the displacement is going to create or change the capacitance of an element, in this case between the diaphragm and the anvil and I am going to measure this change in capacitance and if I measure the change in capacitance I can now go back and say that the changed capacitance or the change in capacitance is proportional to delta P which gave rise to it. So the pressure is influenced or inferred from the measurement of capacitance change which is a consequence of the change in the position of the diaphragm or the change in the displacement or the change in the shape of the diaphragm that gives rise to a displacement and that in turn gives rise to a change in the capacitance. Therefore the capacitance change and the delta P are related to each other. Now let us look at the basic theory of the capacitance transducer.

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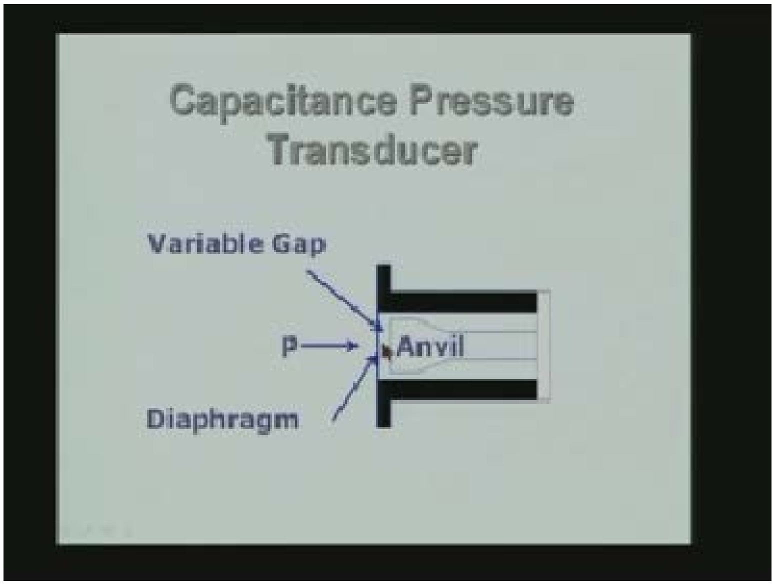

Let us look at the basic theoretical framework of the capacitance transducer. So, for example, if I take a parallel plate capacitor so I have two plates parallel to each other. These are two parallel plates, plate two and plate one, these are conducting plates and in between you have a gap equal to a distance d, the area is A and here area is also equal to A and we have a dielectric in between so this gap is full of a dielectric and in most applications of the pressure transducer it may be simply air or it may be a some other fluid which may be present.

The different materials which may be present here change the capacitance of the capacitor, because of the property of the particular dielectric medium which is going to be present there. Here is an expression for the capacitance. Capacitance C is given by 0.0885 K times area by distance where I have area A is in cm square, d in centimeters and C will be in 10 power minus 12 Farad or in Pico Farad. This formula is adjusted such that you get the result. If you substitute area in square centimeters the distance between two plates in centimeters and there is an extra term here called the dielectric constant.

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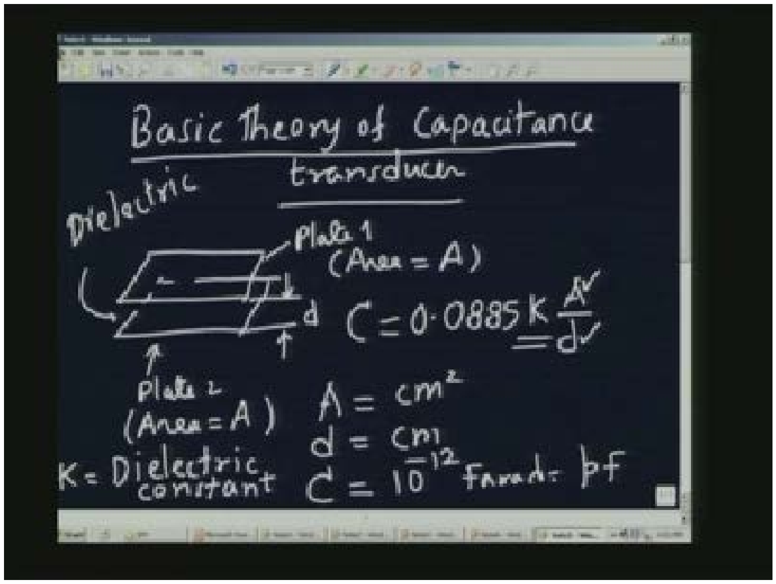

The dielectric constant is the ratio of two things. It is also called the dielectric ratio. Any medium is characterized by what is called the permittivity and the usual symbol use is epsilon. And if it is vacuum it is called the epsilon subscript 0 and it is a value of something roughly equal to 8.85 into 10 to the power minus 12F by meter. This is a known value for vacuum and for air also it is very close to this. And the value K which we have here is nothing but epsilon divided by epsilon$_0$. This is called the relative permittivity. This epsilon does not occur in the fundamental law which gives forces between two charges. It comes from the equation of electro dynamics.

K is a relative permittivity. That means it compares the value of epsilon for the medium which is epsilon not for vacuum. Vacuum of course is equal to one by definition, air at one atmosphere depends on the pressure this is 1.00059 and said it is almost approximately equal to one for air. But if you increase the pressures to hundred atmospheres it becomes 1.0548 so you see that it is pressure dependent.

A few other interesting cases are glasses, the different types of glasses. It may go from 5 to 10, mica 3 minus 6, mylon 3.1. For example, if you take PVC it is 3.18 and so on. When capacitances are made in practice we use different dielectrics. You can see here that the value of the capacitance is proportional to the dielectric constant multiplied by A by d multiplied by that .00085. So if you want to get a larger value of capacitance you fill the gap between the two electrodes with a material of higher dielectric constant and that is the reason why these materials are used.

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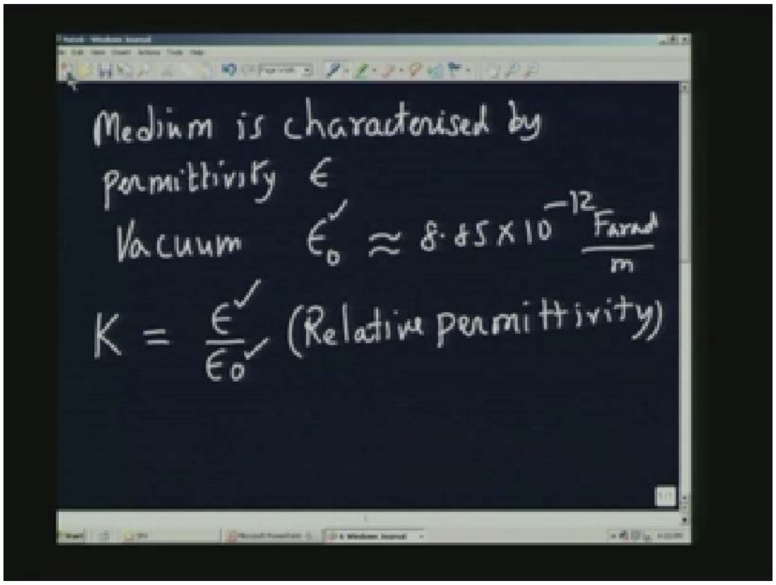

If you use a glass for example you can get about ten times the capacitance. For a given area and the distance between the two plates I can increase the capacitance by choosing the particular material which is used as a dielectric between the two electrodes. So, mica is 3 to 6. All these are mica capacitances available in the market commercially. When you want to go and buy and use it for your secured purposes you can have capacitance of mylon or mica or PVC etc.

The reason why we have this is because they are going to give you different values of capacitance. For a given size of the capacitor we can increase the capacitance by having a material like this. You can also see that air or vacuum are more or less equal to each other that is almost close to 1. Therefore that is the lowest capacitance you are going to get with air as the medium between the two electrodes. Between the two plates if you have air as the medium it is almost like the minimum value which you will get for that particular size A and for the gap d you will get the smallest so in this equation we have C equal to some constant 0.0885 K times A by d. Once you have chosen the dielectric constant or the material between the two plates this is going to be a constant. In the case of the pressure gauge the area is fixed, this is fixed.

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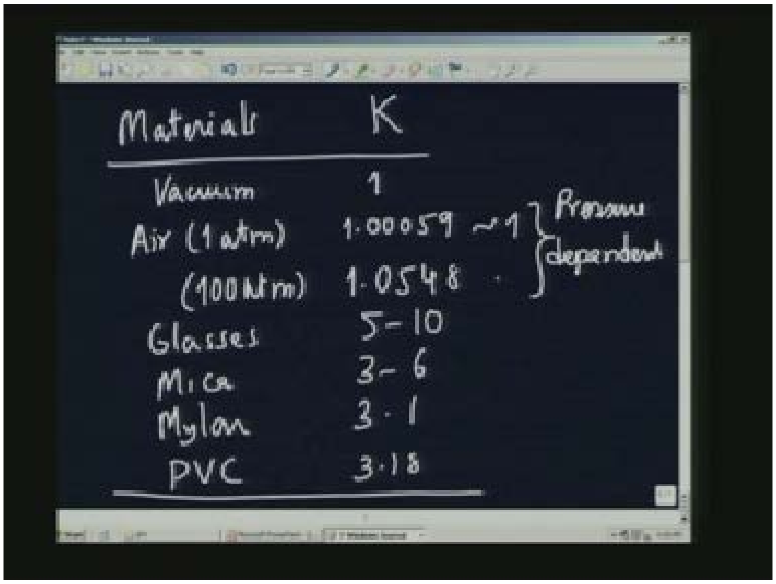

In other words, we can say that C is equal to K_1 by d because all others are constant. So 0.885 K (A) I can call as K_1. Therefore this becomes C is equal to K1 by d. Here we can use logarithmic differentiation so the change in the capacitance dC by C is equal to minus dd by d may be I should say d_i which is the differential symbol as the distance. I can even write it as delta C by C because we are going to talk about small changes in the value of d_i by di. This is just distinguishing between the derivative symbol or the d here and the d there. So this is your fundamental equation.

The change in the capacitance with respect to the capacitance is simply the negative of the change in the distance between the two divided by d. So, if d decreases the capacitance increases and if d increases the capacitance decreases which is of course true. So you can also see here that C is equal to A by d this is in denominator and if d increases C will decrease and the vice versa. That means the relative change in capacitance is proportional to the relative change in the distance between the two electrodes with is a negative sign.

And if you remember the numerator is proportional to delta P. In the diaphragm gauge the diaphragm is going to undergo a change in the shape and the magnitude of the deflection is proportional to the pressure difference across the diaphragm. Therefore essentially what we are doing is measuring the change in the capacitance and relating it to the change in the pressure or the difference in the pressure.

Here is a simple example. Here A is equal to 1 sq cm and d is 0.3 millimeters where we are going to have a very small distance between the two plates. In fact I can calculate the value of C which is given by 0.0885, if I use air K is almost equal to 1 so let it be 1 here, the area is 1 by d which is 0.3 so many Pico Farad and this will come to about 2.95pF. This is a very small capacitance. We are talking about small capacitance.

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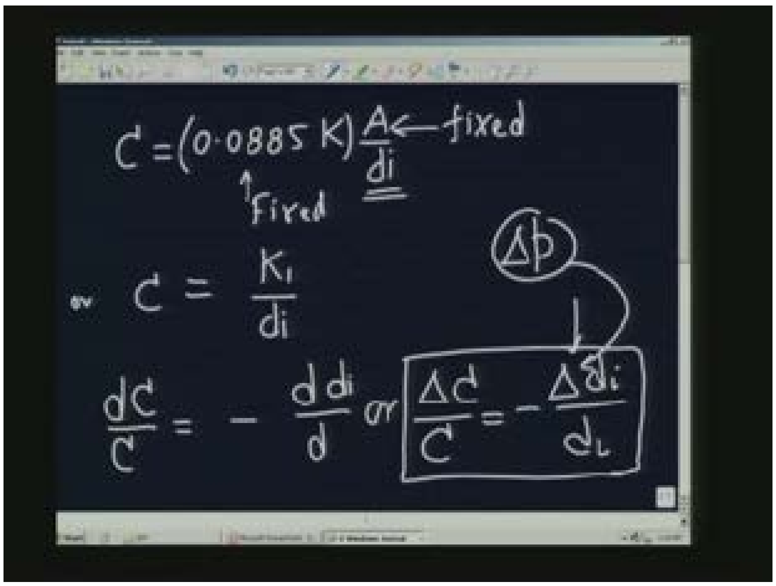

And if you look at the sensitivity of that it is nothing but the rate of change of capacitance with respect to the distance between them. So, the sensitivity S is nothing but minus 0.0885 divided by it is nothing but the derivative with respect to, so this becomes 0.03, this should be 0.03 millimeter I have to make it (0.03) whole square this is the derivative and this will be in pF by cm. This comes to about minus 98.33 pF by cm. So it is the rate of change of C with respect to the distance the derivative and this is nothing but the influence coefficient.

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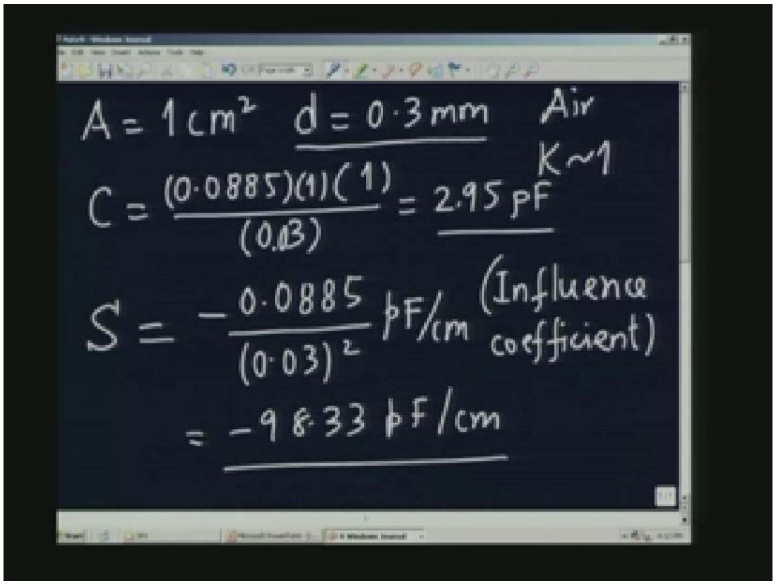

Or it says how big is the change in the capacitance for a change in the distance between the two electrodes. So this basically characterizes the particular diaphragm gauge if we know the material. Of course, in this case, I have taken air as the intervening medium. If I know the initial gap between the two plates this is the initial gap and if this initial gap changes by a small amount because of the application of the pressure the change in the capacitance will be given by the expression, S is equal to minus 98.33 pF by cm.

Now let us look at the circuit which will use for measuring the capacitance change. Here is a schematic of a possible circuit for this case. And towards the left of the diagram you have a chamber in the form of a hollow cylinder and we have the diaphragm right in the middle which is this.

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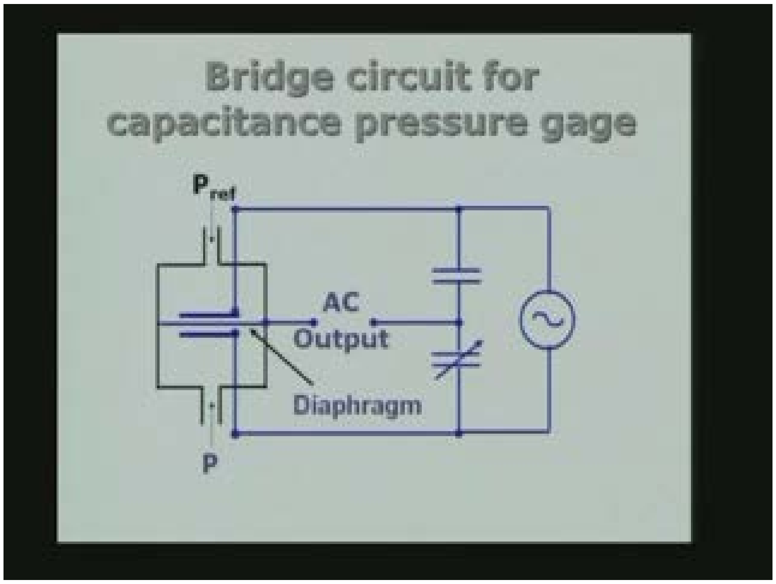

One side of the cylinder is subjected to pressure which is a reference pressure, which may be an atmospheric pressure or it may be the vacuum depending on the application. On the other side, I am going to apply the pressure which I want to measure. So essentially this diaphragm is going to be subjected to a higher pressure on this side and lower pressure this side or the vice versa. So there is a pressure difference across this diaphragm. So this diaphragm is going to undergo a small displacement. And now I have got two fixed plates which are very sturdy and which are not going to undergo any change in their positions because of the applied pressure and these two are the two electrodes now.
You can even call it as two parallel plates.

Actually there is a diaphragm plus the top plates forms one capacitor. The diaphragm in the lower plate forms the second capacitor. In fact there are two capacitances here. One of them is subjected to the reference pressure on one side and the other capacitance that is on the other side we have the higher pressure or lower pressure which we want to measure. And what is happening is, if the diaphragm undergoes a change in its position, for example, if it moves up, it is going to reduce the gap between the top plate and the diaphragm and it is going to increase the distance between the diaphragm and the bottom plate. So one of the capacitance is going to increase because this is going closer to that and it is going farther from the lower one so the capacitance is going to decrease. So you see that if there are two capacitances here one capacitance is going to change in the positive direction and the other one is going to change in the negative direction because of the displacement.

Now I am going to connect the two capacitances here, like one at the top and the other one at the bottom. This may be a variable capacitance. Initially when the pressures are same on the two sides that is the reference as well as this side there is no change in the position of the diaphragm and it should indicate null. That means I am going to vary this capacitance such that these capacitance the top capacitance and the bottom capacitance this and this which are going to form a bridge circuit are all going to be in balance.

In fact you can see here that I have connected an AC source across this. Usually a high frequency AC is used for this excitation. So what you get here is an AC output, just like in the case of LVDT. In LVDT also we had a similar situation. Of course it was because of the transformer action but here we have two capacitances which are going to be out of balance and therefore the change in the top capacitance and the bottom capacitance because of the pressure difference across the diaphragm is going to drive this AC bridge out of balance and therefore it gives you an AC output.

Actually this AC output can be demodulated like what we indicated in the case of LVDT. Convert it to a DC signal it may be amplified to finally give you an output which is proportional to the pressure difference across the two sides of this diaphragm. So again you see that the displacement of the diaphragm has been converted to the change in the capacitance and that has given rise to an imbalance in the circuit and this imbalance is going to give rise to an AC output, this AC output may be either directly measured or it can be demodulated and amplified to give you a DC signal. So, that DC signal is going to be proportional to the delta P across the transducer. This is the basic way the capacitance pressure gauge is going to be used.

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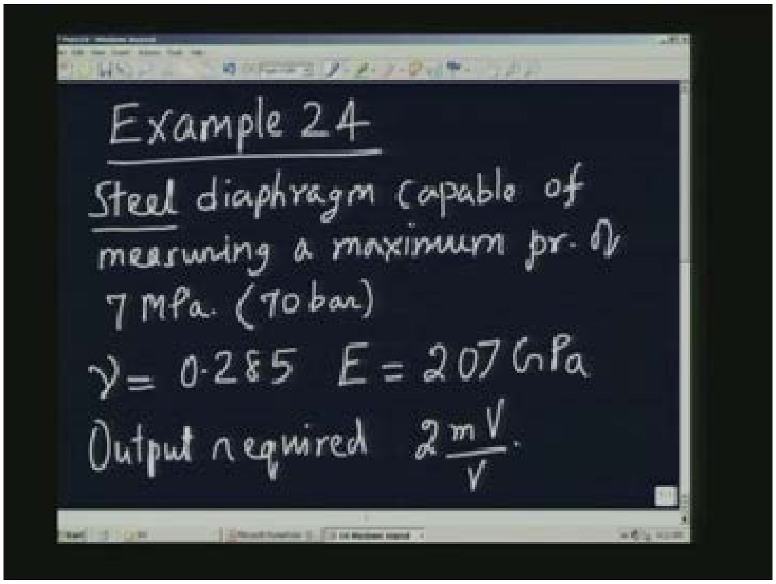

This entire discussion covers the study on the different types of transducers used for measurement of pressure. Here is a simple example of a diaphragm gauge. This is example 24. Let us look at the case of a diaphragm gauge. We are talking about a steel diaphragm gauge, a diaphragm made of steel, and I want to find out the size of this diaphragm, the thickness of the diaphragm required for a particular application. This is a steel diaphragm capable of measuring a maximum delta P of a maximum pressure of 7MPa that is 7MPa which will be something like seventy bars, it is a large pressure. So we will assume that the steel material as a Poisson ratio of 0.285 and the Young's Modulus E is equal to 207 Gigapascals. These are assumed for the materials we have chosen for the diaphragm. So the idea is find out what should be the size of the diaphragm. This is the design requirement 2 mV by V this is the performance requirement at this particular pressure 7MPa.

Of course when we are measuring a pressure like 7MPa it does not matter whether we call it a gauge pressure, absolute pressure and so on because the difference is very small. We are talking about very small difference between the atmospheric pressure and the air pressure. There is a very large gauge pressure absolute pressure and there is not much of a difference in terms of its value.

Performance of a diaphragm gauge:

We have looked into some relationships. Let us use those relationships to workout the numbers and in other words get some idea about what is going to be the requirement for a pressure gauge of this particular type.

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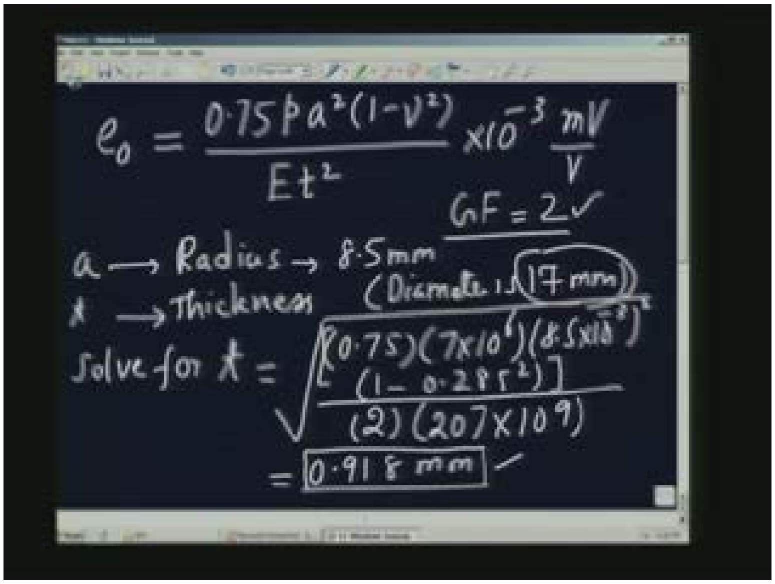

So, if you go to a manufacturer and buy a pressure gauge which is capable of 7MPa and this particular output in terms of 2 mV by V it is possible that the diameter, the thickness and so on will again be the numbers which we are going to talk about. The output of the gauge in terms of mV by V was given as 0.75 pa square (1 minus nu) square by Et square (10 power minus 3). So mV by V this is one equation. This assumes that the gauge factor is 2. This gauge factor is for the measurement of the displacement which is done by using a strain gauge and that strain gauge has got a strain gauge factor of 2. This has nothing do with the diaphragm we are talking about. It has something do with the external specification which is already given to us.

In this case you see that the value of a is to be determined, t is to be determined there are two quantities, this is the radius of the foil and this is thickness. So what I will do is I will fix one of them or I will choose one of them which is reasonable and then try to find out the other value because of them cannot be independently determined but one of them has to be chosen. So I will choose the value of the diameter or the radius to be given so that I can determine the other one. So I am going to use 8.5 mm as the value of a or the diameter is 17 mm.

I will take the radius as 8.5 millimeters and plug in the value of a here, this p is nothing but the maximum pressure which is 7MPa so all I have to do is to solve for t. For a 17 mm diameter diaphragm we solve for t to get, this will be the square root of 0.75 p is 7MPa which is 7(10 power 6P), a square is (8.5 into 10 power minus 3) whole square (1 minus 0.285 square) is the Poisson ratio. So this whole thing is divided by the e_0 where e_0 is 2 which is given as 2mV by V(207 Gigapascals into 10 power 9) so this whole thing gives you the value of 0.918 mm. So the thickness of the diaphragm gauge is given by this quantity.

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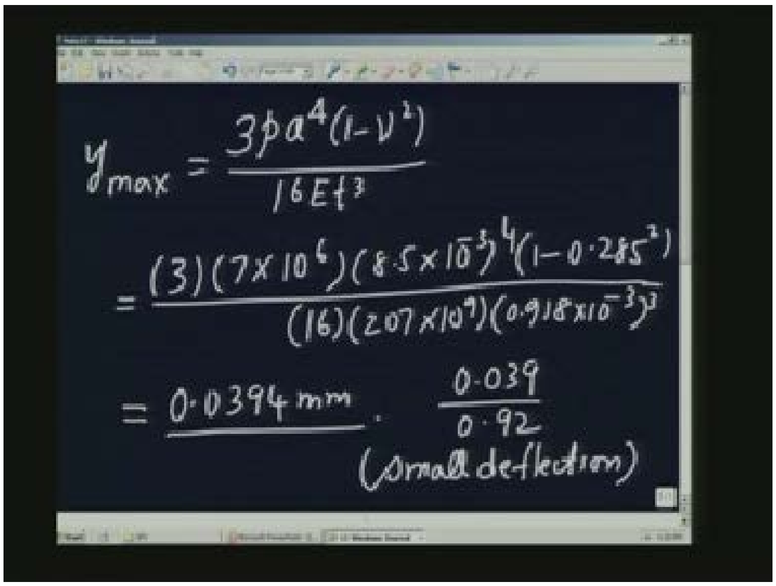

So we have a 17 mm diameter gauge almost like 1 mm thickness of diaphragm because the pressure level we are measuring is also quite large. Now let us find out what will be the central deflection.

The diaphragm is held fixed at the periphery and therefore it is going to bulge out. And the maximum deflection occurs at the center and we are now talking about the central deflection which is given by 3pa to the power 4 into 1 minus nu square by 16 Et cube. This will be 3 into 7 into 10 to the power 6 (8.5 into 10 power 3) to the whole power 4,1 minus 0.285 whole square divided by (16) (207 into 10 power 9) that is 207 Gigapascals and t cube (0.918 into 10 power of minus 3) whole power 3 and this comes to 0.0394 mm and when I represent it in the millimeter form it comes to 0.03 and the thickness of the material is 0.918 mm so this is 0.039 by 0.092 which is very small so it is a small deflection. Actually this is maximum deflection.

The deflection will be smaller everywhere else, it is in the center of the plate that this larger deflection has taken place. The other deflections are even much smaller. In fact I can also calculate the natural frequency of this particular gauge because it becomes necessary to know what the frequency is at which we are using because if you are measuring the time varying pressure you cannot subject this to a pressure which varies very close to its natural frequency because it will damage the diaphragm completely. So we already have the formula for the natural frequency so all I have to do is to use the appropriate expression this will be 0.469 t by a square to the square root of E by the density multiplied by (1 minus nu square).

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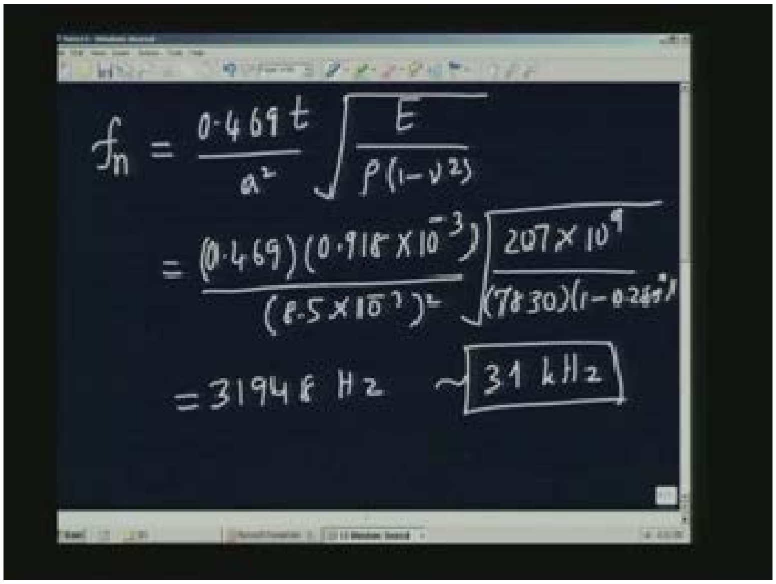

So I will just plug in the values (0.469)(0.918 into 10 power minus 3) by (8.5 into 10 power minus 3) whole square, root of 207 into 10 power by (7830)(1 minus 0.285 square) this will come to 31948 Hz so 31kHz. Obviously the frequency will be quite large because there is a small diaphragm. If the thickness decreases this will decrease and if thickness increases, it will increase and a square is appearing in the denominator, the smaller the diaphragm the higher the frequency. Therefore you see that the natural frequency of the diaphragm is very high.

In principle if I am going to use a diaphragm gauge of this type I can probably subject it to a transient which is just probably half of, for example 10kHz or 20kHz where there should be no problem in using this. So the frequency at which it can be operated, if you are going to use it for measuring time varying signal it is partly determined by the natural frequency of the gauge itself.

Normal electrical input and output of pressure transducers are given here to give an idea as to what we do in practice. The standard input is between 5 and 24V DC for amplified voltage out transducers where you are going to get the output in terms of voltage. In many applications we also use an output in the form of a current. This is especially in process applications. So we use 8 to 30V DC as the input for 4 to 20mA current output.

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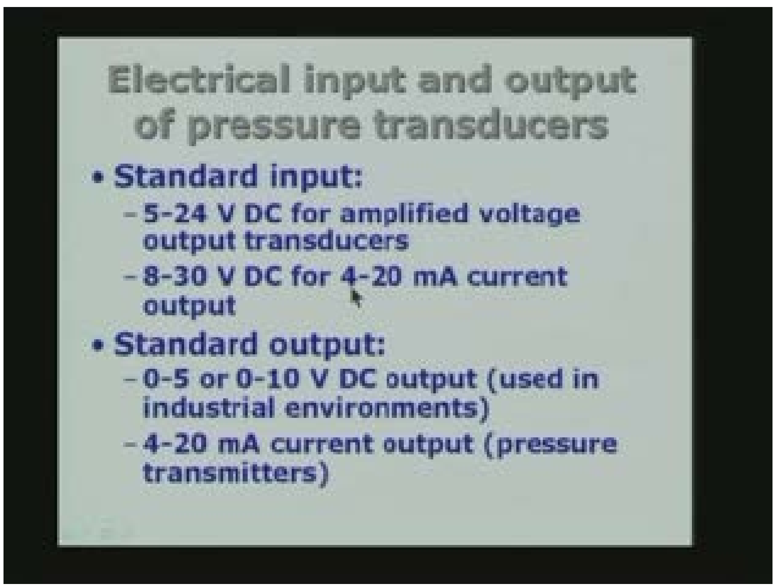

Now the question is immediately asked as how do we get an AC. Obviously when we use the DC voltage as the input we have to have an oscillator or some such arrangement which will give an AC excitation voltage in the case of gauges which requires AC voltage. So the standard input will be 5 to 20V for DC amplified or amplified voltage output transducers and for current type instrument it is 8 to 30V DC. And the standard output will be either 0 to 5V, or, 0 to10V DC used in industrial environments and in the case of process applications we usually use 4 to 20mA.

If the current output of the instrument or the transducer is 4mA it corresponds to 0 or minimum value of the pressure or whatever process parameter we are measuring. Then 20mA will correspond to the largest value which you can measure with that instrument. So this is the maximum 20mA and 4mA will be minimum. And if it output current is 0 that means that there is a damage to instrument that means there is some problem with the instrument. So, the way to recognize that there is any problem with the instrument is to see whether it is giving 4mA when there is a delta P is equal to 0 or not. If it is giving 0 for some reason then you can immediately come to the conclusion that there is some problem in the circuitry.

Here are one or two reasons why we do that. Transient behavior of pressure measuring instruments is needed to understand how they will respond to transient pressure if the pressure is varying with respect to time. And sometimes measurement of transient time or varying pressure requires a proper choice of the instrument and the instrument parameters. And the coupling element which goes between the transducer and the measurement point that also needs to be looked into.

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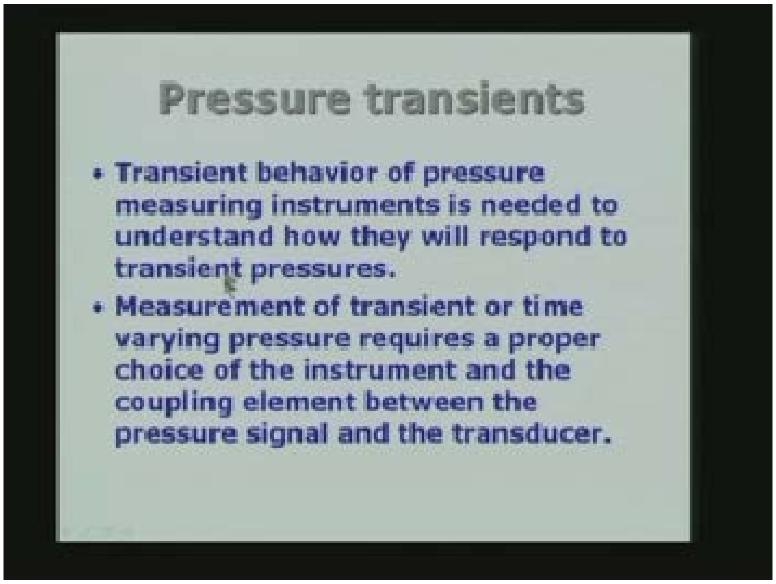

So from these reasons, it is necessary to understand how a transducer is going to behave when you have a time varying pressure applied on it. Thank you.