Principles of Mechanical Measurements
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Lecture No. #11

We have seen previously what is an off bridge and what is the voltage output. At that time also, we have seen if there are two stresses or two changes in resistance then they have to find out whether it is increasing, whether there is increase in resistance or decrease in resistance or the polarity and accordingly those two resistances should be joined. That is what you have seen but we will explain again with an example.

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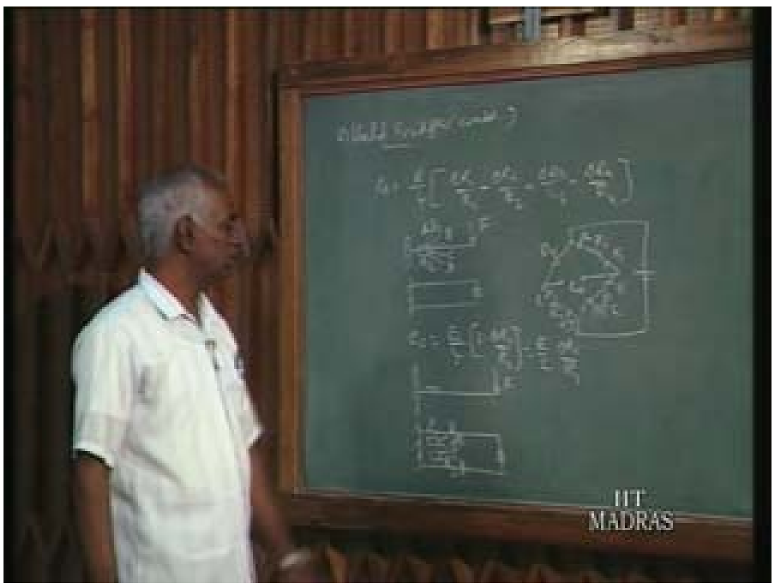

Suppose we consider a cantilever, this a load cell where the load can be loaded at the end of the cantilever and can be measured that is F is the force and it is acting at the end of the cantilever. So it deforms like this and for this I will draw the plan b also. This is the cantilever width and at the end we are applying the load. Now to get the signal proportional to force there are two possibilities. We can use only strain gauge, fix only one strain gauge and connect this terminal as R_1 in the circuit diagram of the bridge network that is one. That is Quarter Bridge, now for half bridge you should have two active arms as we have seen.

Now one more also can be put at the bottom, one more strain gauge we call it as R_1 and what should be this? That should be decided by the type of change of resistance that is what I want to demonstrate now. That is for this type of loading or a downward loading we have got that is at the top layer is tensile stress so tensile strain. So R_1 will be under tensile strain, now this is the bridge network to resistance.

So this is our R_1, this is R_2, R_3, R_4 we are picking up the output voltage. Up to one pair of upper corner we are giving the excitation voltage, other opposite pair we are using the output voltage. So R_1 we have fixed now which should be R_2 that depends upon the type of stress. Now what is the type of stress we have got or strain we have got? This is tensile for a cantilever at the top layer tensile, bottom layer will be compressive in strain, so compressive in that resistance will be a decrease. So for R_1 the resistance which is increased, for other one the resistance will decrease that is if you call increase in strain or tensile strain as positive then we should called negative strain or compressive strain as negative.

Now tensile strain gives rise to increase in resistance and also we know compressive strain decreases the resistance. So it is opposite polarity when resistance increases in one similarly at the same time the other strain gauge resistance is decreased. So opposite polarity you should connect it to adjacent arms. So it can be for R_1 adjacent terms is R_2 or R_4, R_4 also adjacent, R_2 also adjacent. So we will connect it to R_2. Now this will be R_2 terminal. Call these terminals AB for R_1 CD for R_2. So this will be AB terminal and this is CD terminal. So accordingly you connect it in the bridge and you will have the voltage output is equal to now E by 4 delta R_1 by R_1 and we know this tensile strain and compressive strain are equal in magnitude since though they are apposite in polarity. So twice magnitude will be same so twice delta R_1 by R_1. So it is equal to E by 2 so delta R_1 by R_1. So that is twice the sensitive of the quarter bridge.

So this is a case where the changes in resistances are opposite in polarity and example where it is similar in polarity. Same example we can take, we have got again a cantilever, force and instead of pasting it at the bottom we paste both of them at the top. So this is the plan view of the cantilever, this is the end view F so this is F now put the two strain gauges at the top itself. So two strain gauges at the top. Suppose if we call one strain gauge as R_1 what should be the other one? We should fix the number that is for this similar strains, similar changes should be connected that we had seen earlier which should be connected at the opposite arms. Now if R_1 is at the top then the other one should be R_3, this should be R_3. So if you call AB, terminals AB and the other terminals CD, now this is AB and now CD will become C and D.

So accordingly connect the other, the R_4 and R_2 will be constant resistances of 120 ohm whereas R_1 and R_3 are active arms. This is how we have to connect the bridge when we want to use the bridge in off bridge conditions. Off bridge conditions we can realize only if we know the strain directions positive strain, negative strain or positive change or increase in resistance or decrease in resistance or both of them increase in resistance. According we have to connect in bridge. This is what is very important and we know if we connect wrongly suppose the similar strain, both of them increases in resistance but instead of opposite suppose we connect it in the adjacent terms then what will happen? R_1 and R_2 they are positive but they are negative in sign so they cancel out, we will get zero voltage irrespective of the whole load we have got, irrespective of the force we have got. If we connect wrongly you have output voltage always zero irrespective of the magnitude of F and that is the property what we are making use of in temperature compensation, it is temperature compensation.

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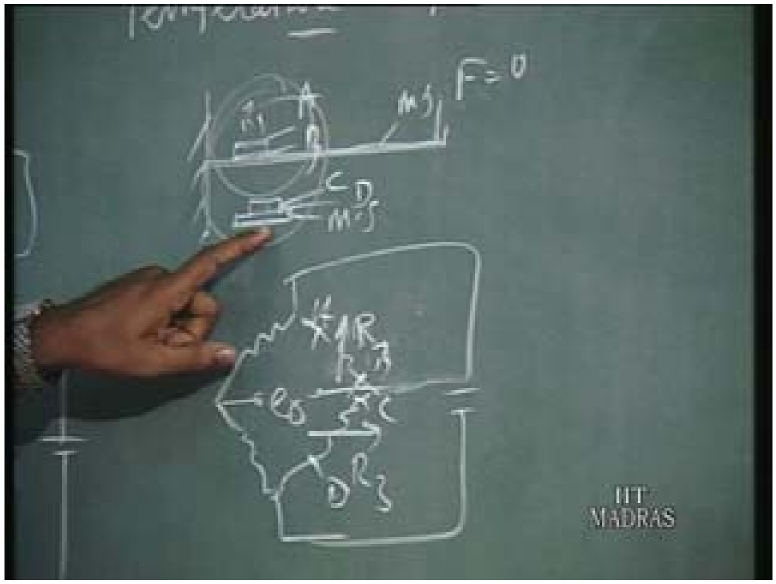

So what is temperature compensation? Suppose we have again with this example we can see, we have got a quarter bridge a cantilever and only one strain gauge is fixed here that is our R_1. We have to see when temperature compensation is required. Suppose the R_1 we have connected this in the bridge network R_1, this is the output voltage and this is the excitation voltage. Now R_1 is changing now R_1 will change when we change the input signal F, also when the input signal is zero suppose the surrounded temperature is increased say from 20 degree to 30 degree. Now we find due to temperature change itself we have got some output voltage here that is called sensitivity or error due to temperature. That is because the material which is making up the strain gauge wire that resistance of strain gauge wire increases whenever the temperature increases. So there is a resistance change but it is not due to F but it is due to temperature. Since it has changed from R_1 to R_1 plus delta R_1 so e_o will be appearing.

So how to compensate for this that is temperature compensation. Even though the temperature has increased we don't want to have any output since there is no input force. How that is obtained? For that you take the same material as the cantilever material. Suppose it is a mild steel take another mild steel strip and paste another strain gauge and now though all of should be subjected to the same temperature conditions. Now in this case now whatever be the change taking place in R_1 due to temperature that also will take place here but we want to cancel this effect here. So connect both of them in adjacent arms. This will be our dummy gauge so similar change instead of coming from opposite for increasing output, now we connect it in adjacent term. So this will be R_2 that is this terminal will be C and D this terminal AB. Now AB is the terminal of this and CD is the terminal for the compensating strain gauge but no load but it is just a dummy piece that's why it is called a dummy strain gauge. It is not loaded so the resistance change will be only due to temperature.

Here there will be resistance change due to the temperature as well as this but a temperature component of it since they are in adjacent terms they get canceled out whatever be the output we are getting in such a bridge it's only due to F. That is we are compensated for the temperature that is called temperature compensation. So the bad effect in increase sensitivity is well made use of in compensating the temperature effect in the off bridge condition. So this off bridge but actually it is a quarter bridge with a dummy gauge. So the disadvantage in one situation is made use of in other situations.

So just like in lubrication barring, friction is unwanted in barring but in clutches and breaks friction is required we have to make use of friction. Similarly where the sensitivity was cancelling earlier was made use of for the temperature compensation. That is regarding the off bridge condition.

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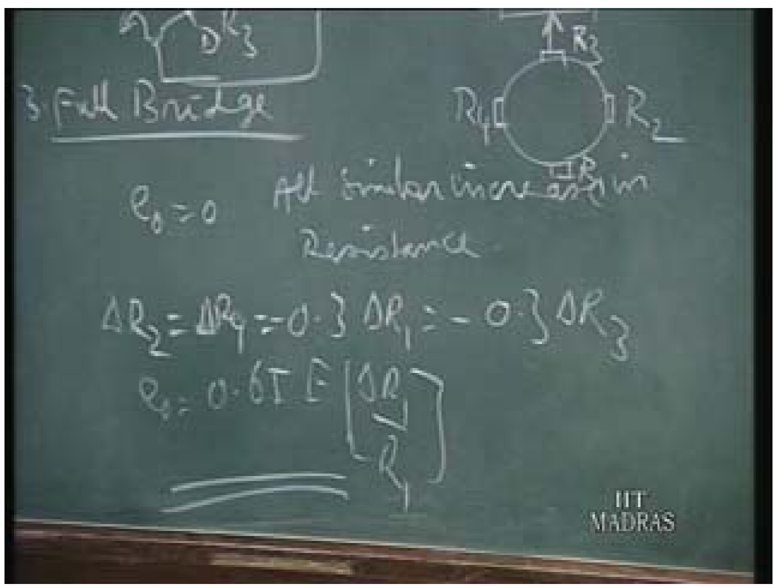

Now we go to full bridge that is the third configurations full bridge in which the bridge is made use of, Quarter Bridge, half bridge and full bridge. Full bridge means all the four arms are active that is what is known as full bridge. Now we assumed for derivation of this equation all the four arms are increased by delta R. R_1 increased to R_1 plus delta R_1, R_2 increased to R_1 plus R_2 plus delta R_2 and so on. So when all of them are positively increased or all the 4 arms are positively increased then we will find when each one is equal to each other or magnitude wise if they are each other then you will find two times it get added up, two times subtracted then net effect will be zero. So that means similar strain or similar changes in the resistances if we connect it in the bridge it will gives rise to e_o equals to zero. That is all similar increase in resistance that means we cannot connect like that then what are the configurations it is connected. For example we consider another load cell say column type load cell. So this is a round piece and now suppose it is subjected to loading say compressive loading and the problem here is if we connect all the 4 strain gauges axially that is one here, one there and one end view, one here.

If all the four are axially connected then for this load or tensile load all the four are equally strained or stressed or that means resistance will change equally in all directions in same direction on to the same amount, in that case we know e_o is zero. So don't connect all of them, don't paste all of them in the same direction, two of them axially and two of them transverse direction that length is 90 degree to this length. So that is called Poisson's configurations. That is two in axial direction, other two in 90 to the axial direction, transverse directions. So in that case we will have suppose R_1 and we want similar, if it is R_1 that R_3 it should be opposite because similar changes should be connected in opposite arms R_1 and R_2 are in opposite arms.

The other two will be transverse strain that is for tensile you will have compression, here compression means the transverse will be tensile in strain. So now R_1 R_2 and R_4, R_2 R_4 will be taking up the transverse strain or compressive strain or for a compressive axial strain they will take tensile strain that means delta R_2 is equal to delta R_4 is equal to 0.3 times Poisson's ratio for mile slip it is 0.3 then delta R_1 is equal to that is minus of 0.3 delta R_3. So 0.3 times the axial strain will be the other two transverse strains, so substituting this 0.3 in this, say delta R_1 and delta R_3 are tensile say axial strain and here minus of and here also minus and minus so 2.6 by 4 so e_o will be 0.65 E into delta R_1 by R_1 under this condition, the magnitude are same and the transverse strain are 0.3 times the axial strain. Then you will get the Poisson's configurations like this. For Poisson configuration e_o output will be 0.65 time that is little more than the off bridge. Now there is another usage for the full bridge in cantilever, again the cantilever is loading conditions.

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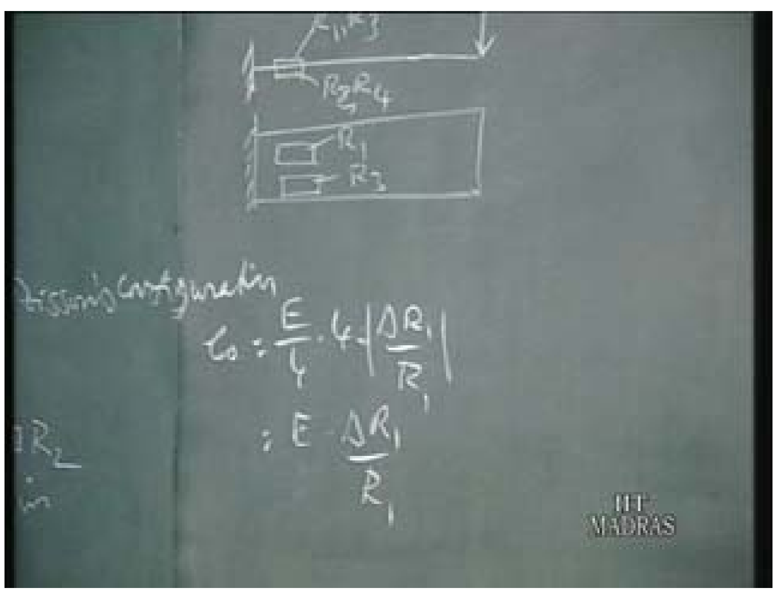

So there you can have 4 strain gauges with two of them in tension and two of them in compression. Suppose this is a cantilever where force is the input signal by pasting now I will now draw the plan of this cantilever.

Now we find two strain gauges are pasted at the top to take up for this type of loading tensile strain the other two strain gauges at the bottom. Now if it is R_1 this will be R_3 and the other two here at bottom will be R_2 and R_4, this is R_1 and R_3. That means R_1 and R_3 will be picking up the tensile strain that means they will be increasing in the resistance where as R_2 and R_4 will be decreasing in resistance when force F exist that is bottom layer compressive, top layer tensile for that type of loading. In that case the E by 4 into 4 times delta R_1 by R_1 where delta R_1 by R_1 is equal to minus delta R_2 by R_2 is equal to delta R_2 R_3 by R_3 is equal to minus delta R_4 bar because they are all equal in quantity, one magnitude same only polarity bottom gauges will be opposite then top. So in that case you get e_o is equal E into that is 4 times the sensitivity of quarter bridge E by 4 will be for quarter bridge; for full bridge it is four times sensitivity of the quarter bridge. So these are the configurations in which we have to use the equation profitably. So if we wrongly connect then you get e_o is zero that is very important.

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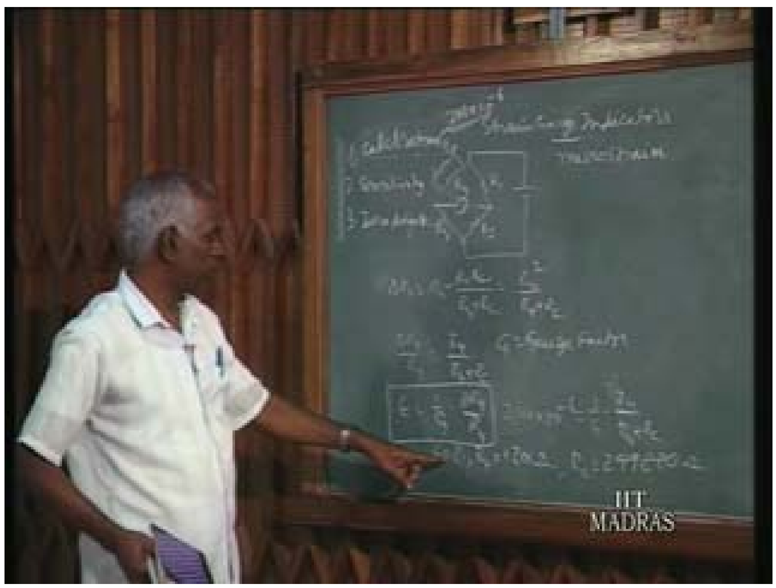

In the market we have the strain gauge indicators so called strain gauge indicators. Mostly made up of USA there if that is mainly meant for Quarter Bridge and if you paste it and connect it to the strain gauge to the meter, it will correct and it will give the readings in terms of micro strain 100 or 200, 300 micro strain. So micro that is 10 to the power minus 6 that is micro strain it gives readings. Such a strain gauge meters indicators or strain gauge meter or indicators are available in the market but there are few knobs there. One calibration, second sensitivity that is calibration sensitivity and zero adjustment. Three knobs are there in such a strain gauge indicators which give directly the strain as the reading. Whatever member where we have pasted the strain gauge that strain is indicated by the strain gauge meter. So what are these three knobs by that what we achieve in the strain gauge indicator that is what I am explaining. Suppose if any instrument before you make use of it we should calibrate the instrument whether it is giving the correct reading, without checking for the correctness of the reading there is no point in using that instrument.

Similarly the strain gauge indicator if we want to use it then give the power supply as indicated and then see whether the instrument gives the correct reading, this is called calibration. So for that use the calibration knob and close the knob. If you close the knob then you should get the reading 200 into 10 to the power of minus 6 this is what you are supposed to get in a particular instrument. If you don't get 200 adjust some knob. What you are doing actually at the time when you closing the switch, what is done inside? Actually there is a shunt resistance for one of the four arms, here for example of R_4 you have shunt resistance, when you press the knob calibration you are closing the switch. That means R_4 is changed to a new resistance, their combination of the two parallel resistance is R_4 R_c divided by R_4 into R_c divided by R_4 into R_c divided by R_4 plus R_c that is the equivalent resistance of two parallel resistances. So it is a now change in resistances will be R_4 minus the new resistance R_4 R_c by R_4 plus R_c is equal to R_4 squared over R_4 plus R_c that is the new resistance of the fourth arm.

So change in resistance always represent that probably we will see little later under displacement, a change in resistance always represent a particular value of strain. This strain we want to have 200 as reading then what should be the change in resistance. This is one by G, G is called gauge factor it is given by the manufacturer that is around two normally. So if for a 200 reading G is two, R four is 120 ohm as I told earlier what should be R_c? So R_c comes about 299880 ohm. Such a resistance is put there when you close this gauge immediately the resistance change is equal to a strain of 200. So you get whatever imbalance voltage say an change that is imbalanced that voltage is made into 200 by electrical circuit. If you don't get, adjust some knobs or some other knob that is what is indicated. So by calibration we are changing one of the arms and then getting the required reading. Then suppose if it is sensitivity then sensitivity adjustment is done. Again if you don't get the required reading you are supposed to adjust the…

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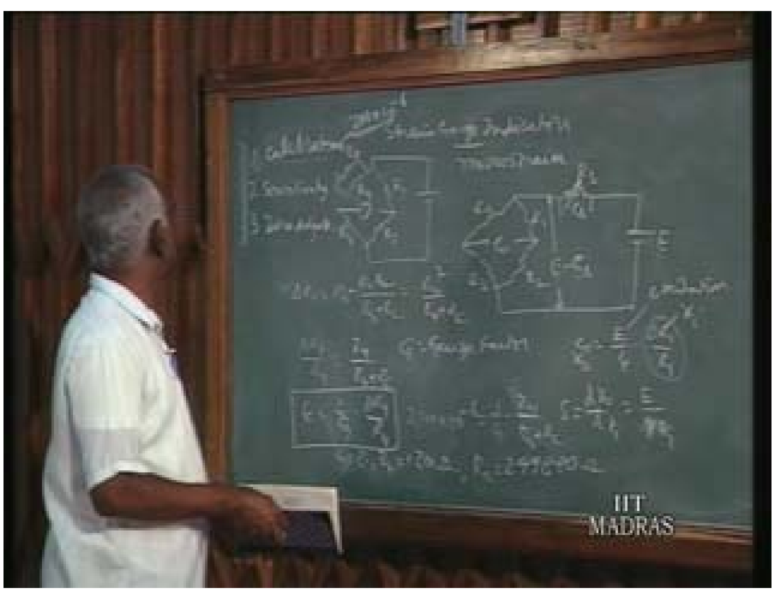

Suppose this is a bridge network, there is one more resistance in series we call it R_s and this is our excitation. This is R_1 R_2 R_3 R_4 and e_o is obtained here. So when sensitivity is to be adjusted we are adjusting one of the series resistance in excitation, series with excitation R_s is series in excitation. So when we change the resistance what happens actually the voltage drop is if you call e_s here this capital E, the net voltage actually used for excitation is E minus e_s this is what is the excitation voltage for the bridge. By changing R_s, E_s is varied hence E is varied. Now we know already the voltage output e_o is equal to E by 4 into delta R_1 by R_1 this is what you have learned under imbalanced condition of the bridge.

Now when these things are called this is our input signal delta R_1 is our input signal and this is the output signal. So if you call this x_o and this as x_i then dx_o by dx_i is equal to E by 4 R_1. That is R_1 is constant and E is the excitation voltage. So whenever we change the excitation voltage sensitivity is changed this is the equation hence we find with just putting a resistance series with the excitation we can vary the sensitivity of the bridge. So having higher value we will have the higher output voltage that is output voltage proportional to the excitation voltage by using the property we have changed the sensitivity. This is what we are doing; when we change sensitivity knob we are changing resistance in series with the excitation.

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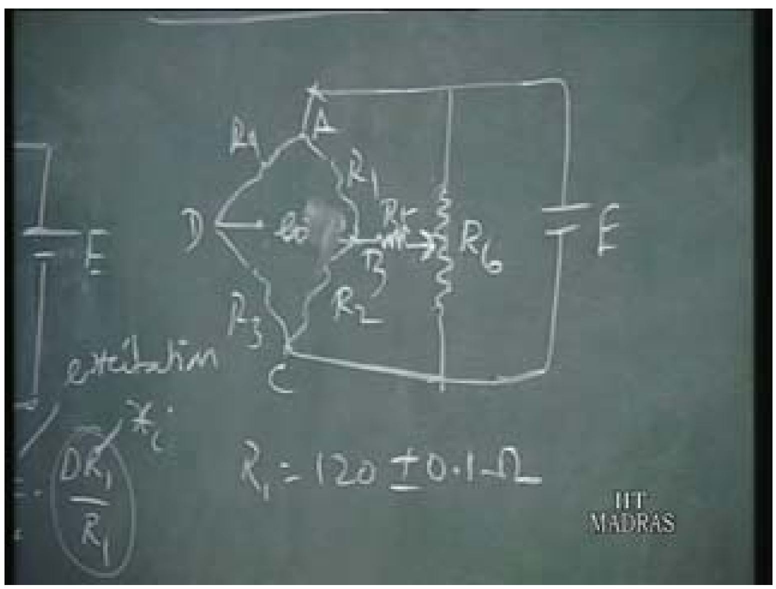

Then what is the zero adjustment? That is zero adjustment again bridge network or now we have two more resistances and one adjacent this is R_1 R_2 R_3 R_4. This is the output voltage e_o and here we have the excitation voltage E. Normally the four resistance which we have connected in bridge network, each one has got certain say R_1 is equal to 120 plus or minus 0.1 ohm. This is what is specified by the manufacturer, no strain gauge will be having exactly 120 ohm it will be varying some limit is there always, when we manufacturer the exactly we don't get.

All the four arms will have some such ranges and there will be some difference of resistances among the four arms. So even though we don't change any one of them by giving input signal say in a cantilever load cell we don't give any force but still the moment you connect them into a bridge and then given excitation voltage you will have e_0 not equal to zero that means they are not equal. How to make them equal that is what is done. The principle here is now the point A, if you call point A B C D A to B is our R_1 for R_1 now it is made up of R_1 and another part that is A to B it should go R_1 and another parallel path two parallel paths. In that suppose it is R_4, you call this R_5 this R_6, now R_6 will be somewhere in the middle, so R_6 by 2 is this side and bottom side R_6 by 2 half of the resistance. So the R_1 will be made up of equivalent R_1 is made up of R_1 in to R_6 by 2 plus R_5 divided by R_1 plus R_5 plus R_6 by 2 this is equivalent and when we move this up and down we are changing one of the resistances which decides the parallel, which decides the equivalent resistance. So by this we change two adjacent arms of the bridge is changed by moving this thereby we get the balance.

So any differences in arms will be made up by suitable moving up and down that is by changing two adjacent arms we get zero here. Then only we can make use of the bridge for reading any signal. So the zero adjustment should be done by adjusting this knob that is called zero adjustment. When you rotate the zero adjustment it is moving up and down there by the equivalent resistance of R_1 and R_2 are suitably changed to get zero reading. So that is all about regarding the DC bridge.

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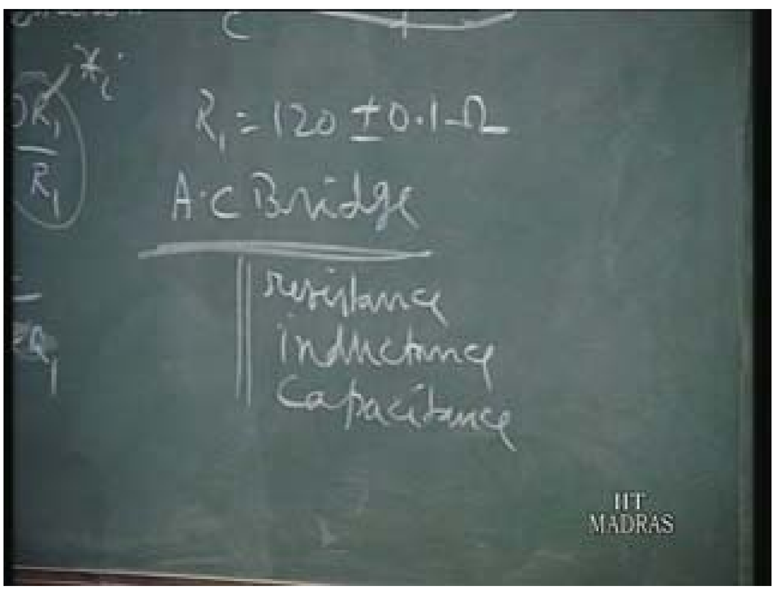

Now you have got AC bridge also in usage in mechanical measurements. Now AC bridge is made up of resistance, inductance and the capacitance. So these are the three passive elements in AC circuits now each arm previously it was made up of purely resistances it can be made up of any combination of these three basic elements.

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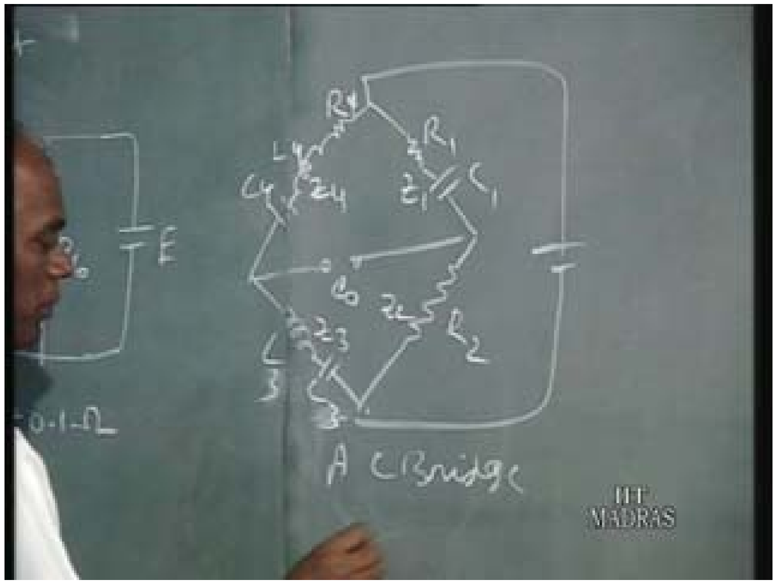

So resistance, inductance, capacitance. So resistance and capacitance alone so similarly you have got inductance and capacitance of any such combination its only resistance alone. So this is the AC bridge. So here we have got output, this is an AC bridge resistance, inductance so R, C, R so L, C so C, L, C, L and R so in any combinations can be thought of to get an AC bridge this is a typical AC bridge and here the condition for the balancing is previously we had a condition for balancing for DC bridge as ratio of adjacent arms. Here it can be also stated product of opposite arms so that is what we are using here for an AC bridge it's a product of opposite arms. Now if you call R_1, C_1, R_2, L_2, C_2, R_2 here L_3 the third arm this is regarding third arm and C_4, L_4, R_4 then each one is made up of impedance of is Z_1, Z_2, Z_3, Z_4 then the product of opposite arms Z_1 Z_3 is equal to Z_2 in to Z_4.

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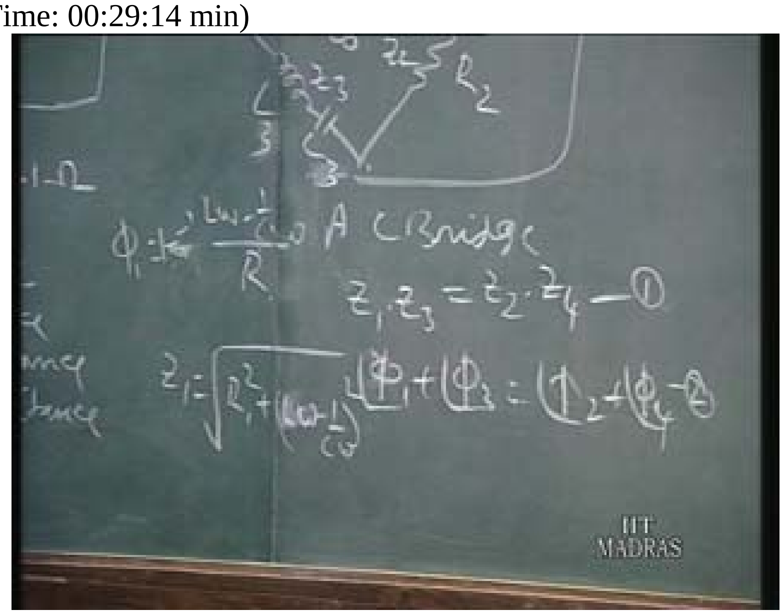

Instead of ratio of arms here it is written product of opposite arms. Previously it was ratio of adjacent arms for DC bridge but here it is product of opposite both are equal and now we have one more condition for AC bridge that is phase difference ϕ_1, plus ϕ_3 should be equal to ϕ_2 plus ϕ_4. See previously for DC Bridge only one condition should be satisfied of balancing but in AC you have two conditions, condition one and also condition two-phase difference also should be made above.

We know that Z_1 is equal to R_1 squared plus LC minus one by C omega, L omega for inductance whole squared so root of this, this is your Z_1 and ϕ_1 will be this ϕ_1 say ϕ_1 is equal to R_1 divided by tan minus one of R_1 by L omega minus one by C omega so this is the opposite. Phi is equal to tan minus one of L omega minus one by C omega divided by R that is reciprocal tan minus one of this. So these two conditions should be satisfied for AC Bridge so far we have seen the bridge network as signal conditioner that is the resistance change is converted in to voltage change that is what is achieved in the signal conditioner in this bridge network. Now we are going to learn the second signal conditioner that is amplifier.

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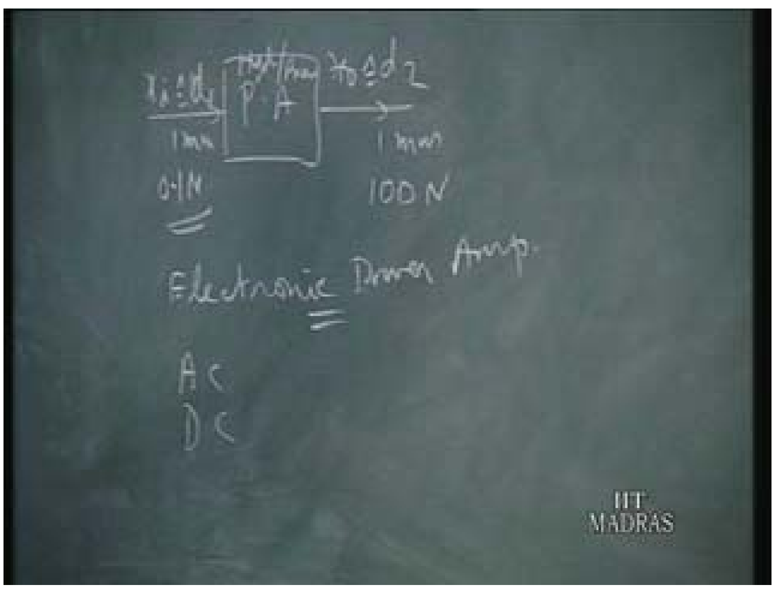

We already told amplifier is used to increase the power level of the signal. Normally in a bridge network like that voltage will be of the order of some millivolt 0.1, 0.2 millivolt something like that and the energy content of that signal is very small. So we naturally give the output of the bridge network to a power amplifier so that is use of these amplifiers. Now in case of mechanical signal displacement probably we can take the hydraulic power amplifier or pneumatic power amplifier where suppose this is power amplifier say hydraulic or pneumatic and we give one end say x_i is equal to say is equal to displacement say one mm and here the output also will be displacement say that is d_1 and d_2 this also may be one mm but this one mm from the say it's may be hydraulic stroke pneumatic power amplifier.

Suppose we are giving this one mm input signal to the hydraulic power amplifier, it gives rise to again one mm displacement but the force accompanying this displacement will be of the order of say 100 Newton, here it is order of 0.1Newton. This 0.1 mm input displacement was having a force of only 0.1 Newton whereas the output signal even though 1 mm it has moved but having a large force of 100 Newton. So that is use of the power amplifier even though displacement is same, energy level is very large hence when I use this force toxicity of valve or a valve or move any big mass that we can use it whereas this displacement cannot move any mass or any resistance they cannot overcome any resistance that is the main use.

So in mechanical measurements since we are converting the displacement signal in to a electrical signal later on when we want to increase the power level already electric signal is available so we normally go for electronic power amplifier but without the translating displacement in to electric voltage, if you want to inject power then go for hydraulic. Once you have converted in electrical quantity then it is easier to inject power by using electronic power amplifier. Under this we have got many power amplifiers AC amplifier and DC amplifier, charge amplifier and impedance transform amplifier, so many amplifiers are there.

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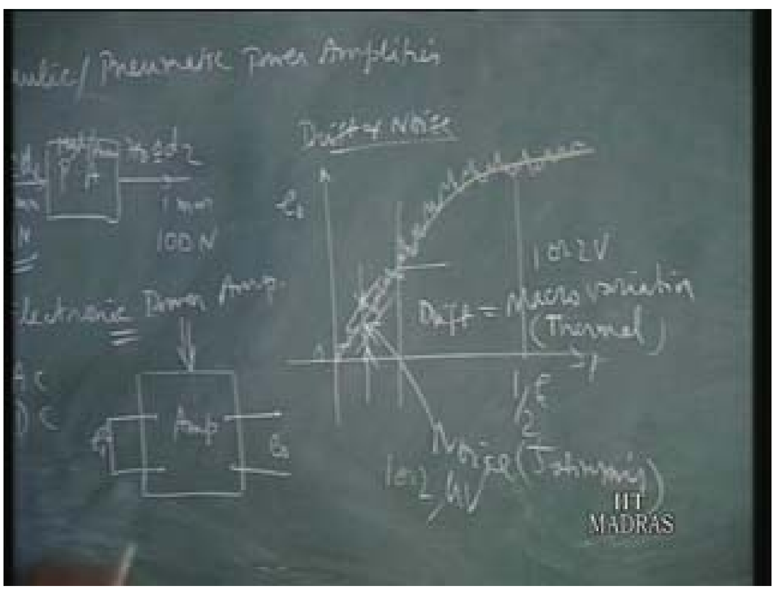

Main common problem of all this amplifiers is drift and noise these are the common problem in any amplifier. That is by this diagram you can understand suppose time and this is say output voltage of a bridge of an amplifier. Suppose amplifier if you present by this block and this is your input signal and this is going to be your output signal e_o and at time T is equal to zero you short circuit this input terminals then you’ll find that is you connect this amplifier, you put in to the plug where the domestic electric supply is connected to the amplifier.

Now you find e_o, if you plot the e_o versus time, you find it is varying somewhat like this. So it has got both micro variations that is it will be varying around this common value, it will be varying like this. So this is called drift, from zero it is increasing this is zero level so it is increasing, as time increases the drift increases and it gets stabilized after certain duration, this may be say one hour or half an hour; after half an hour it gets stabilized. So that is why in usage of any amplifier, you should not use it immediately after switching on the amplifier. You have to wait until the voltage output is stabilized then adjust it to zero so that it is in the balanced condition. It is brought to zero and then you give the input signal.

So drift is eliminated by adjusting the amplifier after certain settling time. Now that is the drift is the micro variation, it's called micro variation of the voltage because this voltage increases there not due to input voltage because of some it is called thermal, it is due the thermal in nature, drift is due to thermal in nature. due to heating of the elements some random flow of electrons takes place so it gives rise to some output voltage even though there is no input voltage and the other variation this is micro variation this is your noise, it is in terms of microvolt whereas drift is of the order of one or two volt whereas this is microvolt, so one or two microvolt but this is due to random flow of electricity it is called Johnson's noise sometimes called Johnson's noise.

It is due to random flow of electrons in the electronic elements say resistor or transistor or capacitor in this elements you will have the random flow electrons. So the noise will be there whenever we use all those elements whereas drift can be reduced after sometime. So drift is a slowing varying phenomena whereas the noise is high with a high frequency but with very low amplitude these are the two problems in any power amplifier and in an amplifier but certain amplifiers by the property they don't possess the drift, some of them have but all the amplifiers will have noise because noise is micro variation and it is due to random flow of electrons and all electronic elements are there, so noise is always there but drift is there in some amplifiers and some amplifiers it is not there.

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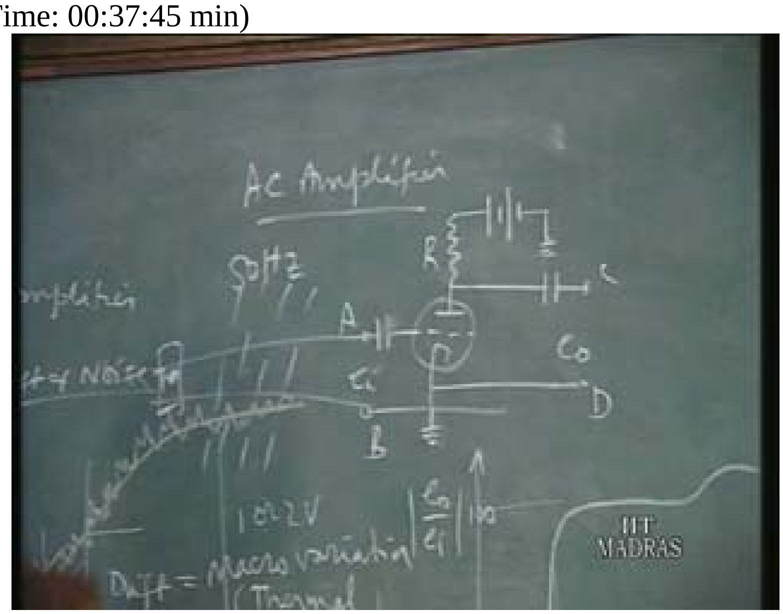

So we will see first AC amplifier. Under these headings we will know or we will learn only important points. As mechanical engineers or non-mechanical engineers we don't go in to the detail of the design of the circuits, under what situations we have to use, we have to select such amplifiers that alone or what are the silent features they are alone touched in this different types of amplifiers. In AC amplifier a crude form of AC amplifier in single stage is say for example an old tube type construction electronic valve and more or less same principle is there for the transistor. So this is our e_i, this is earthed and here the plate voltage and again earthed and we have the output voltage here with a resistance in series and the output voltage is taken so this is output voltage.

It's a simple amplifier circuit where this is resistance R and earthing these two things again they can be connected so this is a cathode and grid and anode this plate. It can be used for both AC and DC, such circuits can be used, e_i can be DC voltage or that is across terminals AB. AB we give and across terminal CD we will take the output voltage. So if you connect at the input and output side two capacitors like this then only AC component alone can get enter in to it, DC it will be simply blocked. Similarly only AC voltage alone will come out and the DC component cannot come out. So by connecting two capacitor in series at input and output we convert this simple circuit in to AC amplifier. In practice it will not be here, it will be because to reduce noise and all many more resistance capacitance will be there but it is a simple circuit. So here since the drift is a slowly varying phenomena that cannot come out because it will be filtered here drift though it is present it will be filtered here.

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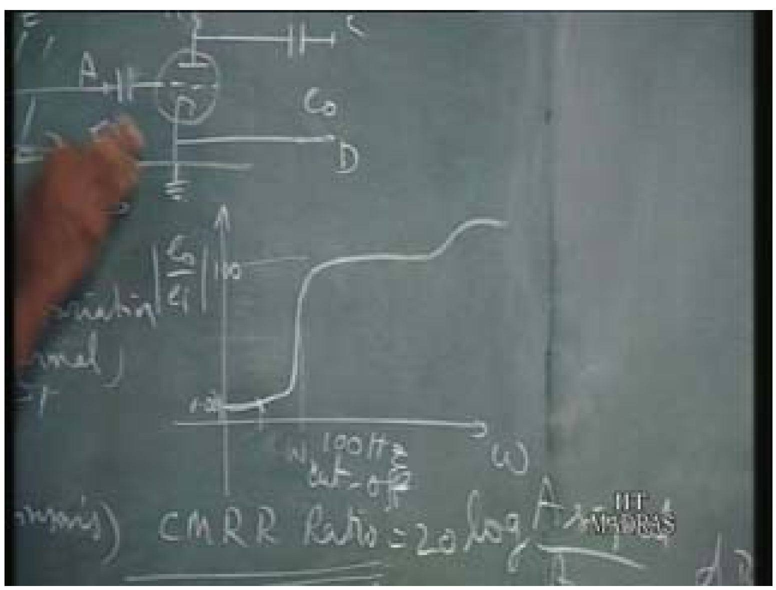

So we find the AC amplifier is drift free and also we find general characteristics of AC amplifier, if you call this e_i and e_o suppose it is AC amplifier its general characteristic is somewhat like this. Suppose it's omega and e_o by e_i mod the magnitude ratio if you plot, AC amplifier will be active only after this is cutoff, this is the cutoff frequency omega cutoff.

That is at a particular frequency there may not be any magnification of the e_i that is called cutoff frequency, above this frequency alone that is omega versus e_o by e_i that is gain of the amplifier. Gain of the amplifier will be there only above the cutoff frequency and this may be say 0.1 or 0.001. The e_o will be 0.001 or 0.1% percent e_i that its negligible whereas here it may be say 100 say 100 times gain is 100 or 1000. So we have got AC amplifiers with a fixed gains or adjustable gains and each AC amplifier has got a cutoff value. So between this and above this value alone it will be magnifying. That's another characteristics of this AC amplifier is the CM RR ratio, last R represent ratio but still is called CMRR ratio. It indicates the capacity of the AC amplifier to eliminate the noise signal. That is called CMRR ratio is called 20 log A signal by A noise, since the ratio is going to be very large that logarithmic scale is taken and it is called decibel so many decibel.

That is A signal is the amplified portion of the output of the AC amplifier coming from signal and the amplified voltage coming from noise signal, this ratio should be very large. that is suppose if it is 90 decibel suppose it is 90 CMRR ratio if it is 90 decibel that means the A signal is equal to 31600 times A noise so it is a good one. So the signal is much larger than the noise such CMRR ratio is there, that is the capacity of the amplifier to eliminate any noise entering in to the amplifier that is there only when you connect the wire to a transducer, this is a transducer; transducer at a long distance from the amplifier you have got long distance to the transducer and any nearby power line will produce some voltages on the wire carrying the signal.

Such a superimposed signal can be eliminated by having say another circuit that is given in one or two standard books. So by having another circuit this erroneous voltages allowed to drive current in two opposite direction and the differential is alone allowed here and such a difference due to this erroneous signal is negligible that is how we are able to eliminate the error source. Also due to a faulty earthing of this amplifier as well as the transducer that signal also can be eliminated by having such a special circuit as part of the amplifier circuit and then we eliminate the error source. Also we find if it is 50 hertz when amplifier is having omega cutoff corresponding to so 100 hertz suppose cutoff frequency for a particular amplifier is 100 hertz any error within 50 hertz will be lying somewhere here that will not be magnified at all.

In such situations we find AC amplifier is more suitable, if it is DC amplifier DC also will be amplified. This is the advantage of the AC amplifier that it has served a higher cutoff frequency so that any near the 50 hertz noise can be eliminated automatically by this and secondly since AC only can come out drift will not be there. So AC amplifier is a drift free and it can filter away the signal of less than the cutoff frequency especially the domestic power line, any noise due to domestic power line it can be cutoff that is the AC amplifier.

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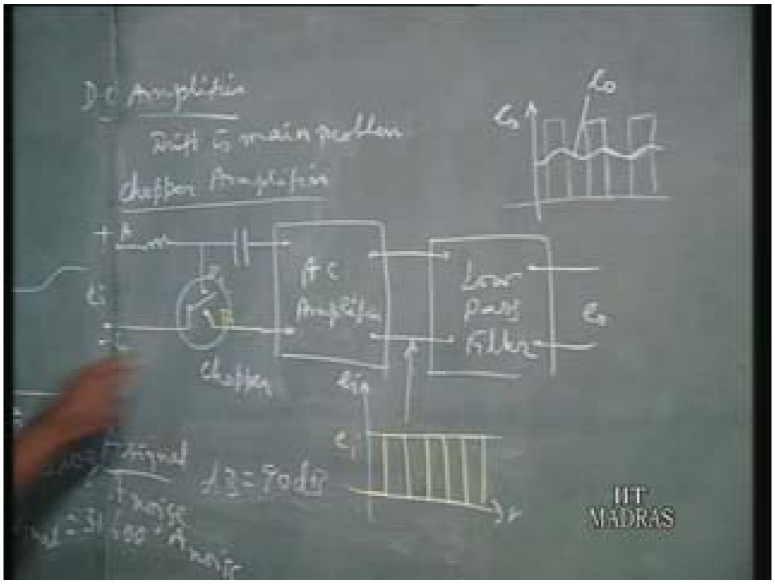

DC amplifier as I told same circuit with out capacitor, if you remove the capacitor it can be used for DC but problem with DC amplifier is it will have drift problem. As soon as we switch on the electrons will be flowing due to thermal phenomena and you have the output as we have explained and that means after sometime you have to balance it and bring it to zero. So when e_i is zero, e_o is zero then only the proportionate relation between e_i and e_o you cannot have any variation because signal will be lost. So drift is main problem in DC amplifier.

To overcome this nowadays people go for chopper amplifier. Chopper amplifier for amplifying DC signal. The chopper amplifier is somewhat like this, so this is plus and minus e_i is given here and this is the chopper, this is AC amplifier and a low pass filter, from low pass filter you get the output signal e_o. This is a chopper amplifier, here what is done is the DC voltage applied across say terminal AB is used by using a chopper so this is your e_i versus time. Originally it was DC voltage which is applied here but by using the chopper what we do is we alternatively connect this or the contact is alternatively made say between point P_1 and P_2. When it connect here, when this switch conduct P_1 the zero voltage is applied, when it conducts point two then full voltage is applied.

So alternatively zero and full voltage is applied it's a zero, full, zero, full so it is like this, the voltage is applied now this will be the e_i for the AC amplifier. So it is the DC voltage is converted in to an AC voltage and of course the square cross section or square waves or rectangular wave it is varying in nature depending upon frequency, the frequency of the input signal to AC amplifier is varied. Naturally this frequency will be higher than the cutoff frequency of the amplifier. So we find converting the DC in to AC signal by using a chopper and then this is a capacitor only the varying component alone will go capacitor and it is now AC amplifier is a drift.

So then we are getting so this same waveform here also but increase say 100 times increase the magnitude is 100 times increase then when it comes to this filter then you find this variations, see this variations by smoothen, so like that so finally we have e_o as this, this will be the e_o form that is smoothening effect will be obtained by having a low pass filter so the high and low variations is smoothened out by more or less a DC signal. So suppose a DC here is one volt this may be 10 volt. So the gain is 10 times what you are or 100 times. So we have got e_o so this is the process what is used for DC as DC amplifier. The problem of drift is overcome because we are using AC amplifier and we have converted the DC in to AC. So we have got the drift free, this whole thing is DC amplifier drift free DC amplifier.