Industrial Instrumentation

Prof. A. Barua
Department of Electrical Engineering
Indian Institute of Technology Kharagpur

Lecture - 40
Signal Conditioning Integrated Circuits

Welcome to the lesson 40 of industrial instrumentation. This lesson is basically, we will consider some of the signal conditioning circuits, which are available in IC chip form, as you know, that there are some sensors like LVDT thermocouple. We need some conditioning circuits in the case of LVDT. We need some circuits for null voltage reductions; we need some circuit for the phase compensation. Because in LVDT always, you know there is an input and output phase difference. So, that can be killed, only in the by using some signal conditioning SRP's, because in null voltage also I mean, we need some lead lag networks type of things for the phase. I mean compensation like means, if I want the input and output should be at the same phase right, because we need some excitation in the in the case of LVDT.

Now, similarly, we have also we have also in the case of thermocouple. We need cold junctions compensations for that reasons, we have already, we discussed some chip like, I AD 5 8 0 that has some advantages in AD f. So, but there are some more chip. I mean chips, came out which has as a better performance. Similarly, we will also discuss, this the current voltage to current convertor, which is also available in the chip form. One thing I should mention that you can do it with discrete component, but; obviously, if you use some CMOS chip, it will you will get some additional advantages. It is of the shelf devices, you can take an interface with your either ability or transducers, so for better results or better performance.

So, in this context we will, so this I mean, lessons is actually, signal conditioning integrated circuits right. So, basically signal conditioning circuits, we have already, defined already, discussed some filters, some amplifiers those things. We have already discussed some logarithm amplifiers antilogarithm amplifiers samples. And whole circuits all these things, we have discussed in this particular lesson. We will concern some of the self chips right, which are very handy. We can use it for our for signal conditioning purposes let us look at the contents.

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Contents are we will discuss fast LVDT signal conditioner, then we will look at cold junction compensator, because as you know that cold junctions has a problem in the case of thermocouple. Thermocouple, because it is I mean industrially a cold junction is not possible; that means, one junction cannot be put in a ice. So, there is always a variations of the one junction and measure junction accordingly. Whatever the temperature, we want to measure accordingly, it will vary, but cold junction cannot be put in a ice bath, it is not possible. So, for temperature change, I need some compensation, which will correct that temperature change right. So, that is a cold junction compensator.

And thirdly, we will consider the voltage to correct convertor in many situations. We will find that, we need to convert this voltage 0 to 5 volt, 0 to 10 volt to the 4 to 20 milliampere or 0 to 20 milliampere. So, that type of, because industry as I told you several times, that always we need 4 to 20 milliampere of signal conditioning currents. So, that type of situation can be handled only, if I have, if I have a power I mean current, because we never transmit the voltage in industries, always in any transmissions, we need current to transmit. So, in that type of situations we always want, we always want the current. So, any voltages, we converted it to the current domain, so standard practice 4 to 20 milliampere. So, we can it with a discrete components what; obviously, we can do better with the IC chip right. So, this all we discuss in this particular lesson, let us first look at the LVDT signal conditioner. Now, LVDT you know, that it how does it look? Let us make a brief, I mean re capsulations it will look like this.

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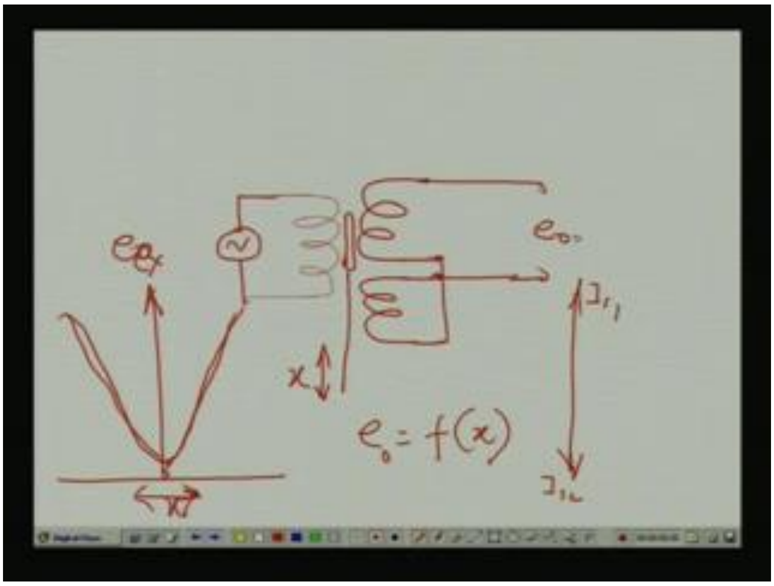

I have a primary, I have a 2 secondaries are there and I have a core inside is not, it that is our ability. So, I put a excitation here and I will get 2 secondary voltages here, This is the basic diagram of LVDT right. I put a displacement here, please note LVDT is electromechanical sensors and it basically, a displacement sensors directly, it is measuring displacement. But it can measure, so many other indirectly, it can measure pressure it can measure many other parameters right. So, the basic it is displacement, now, I am giving an excitation. So, all things, so all those things are I mean very, I mean deeply discussed or very widely discussed in the case of LVDT in the lesson of LVDT, but here. Actually I mean, I am making brief discussion to have a look re-capsulations of the LVDT.

Now, if I you see, if I this move this core up and down say there will be a linkage. If I put this LVDT up this core up there is more linkage, between primary and secondary. If I put it down, there will be more linkage between and this secondary right. So, 2 voltage I will find the voltage will be different now, if I put this in opposition in series opposition like this 1. So, what I will get the output voltage of a function of output voltage of a function of the displacement x at width positions, geometric width positions. I will get a null voltage I will get a 0 voltage rather as you get a 0 voltage, because these 2 out secondary this 2 voltage will cancel out each other. So, I will suppose to get a 0 voltage, but due to mismatch of the secondaries always. We will get some nonzero voltage right due to mismatch of the secondary, if I look at the two secondary I mean, looks like this.

Suppose this is 1, 1 current is I s 1 secondary current is I s 1 and 1 secondary current is 2 right. But you will find that the 2 current will exactly, not be the, it is very difficult to make a 2 identical magnetic circuits right. So, 2 voltages will never cancel out each other.

So, there will be a certain residual voltages, that voltage now, if I plot this LVDT as we know, this all things, we have discussed as I told, you several times x this is output voltage e naught. So, the response will be look like this one, it should be a straight line, because it is a linear straight line like this one. This is the output voltage, so if I make a displacement, if is measure the magnitude it will look like this one, because it is a AC voltage. So, I will get a amplitude, so this will be plotted clear? So, this will give you our basic LVDT. Now, you see there is always, some null voltage, which will appear, we have also shown there is an input output voltage. Sorry this will be ex I am sorry, this will be our, this will be our, so this will be actually ex excitation right.

Now, for this movement, you will always you will find there is a output voltage. And this excitation voltage, there is a phase difference between input and output, which is undesirable properties. Now, all these things, we will find the null voltage cancellation and always wherever you are using a LVDT. I need a separate excitation, voltage right separate, because it is like a bridge as you know, we use a Wheatstone bridge. Wheatstone bridge also need an excitation either DC or AC it does not matter, but in the case of LVDT since we are using transformer. So, always there is an excitation, so this can be easily avoided, if I use a particular chip available right. So, this excitation also inherently, you can vary the frequency of excitations right and I am getting output voltage, which is free from all this problems let us go back.

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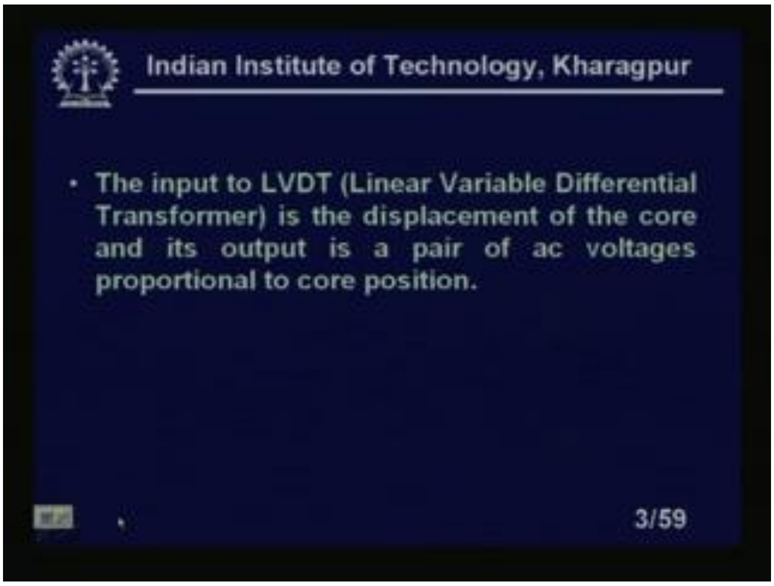

Now, the input to LVDT, which is linear variable differential transformer, is the displacement of the core. And it is output is a pair of ac voltages proportional to the core position, as we know this is basic LVDT.

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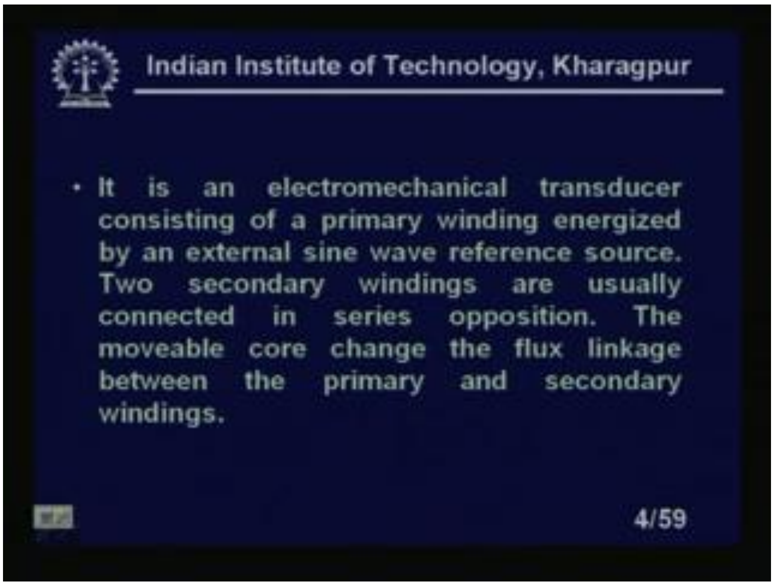

It is an electromechanical transducer consisting of a primary winding, energized by an external sine wave reference sources, external sine wave reference sources, please note always we need this source outside. And two secondary windings are usually, connected in the series opposition, this we have discussed in details. When we covered the LVDT the moveable core change the flux linkage between the primary and secondary windings, which is giving a non zero output voltage e naught.

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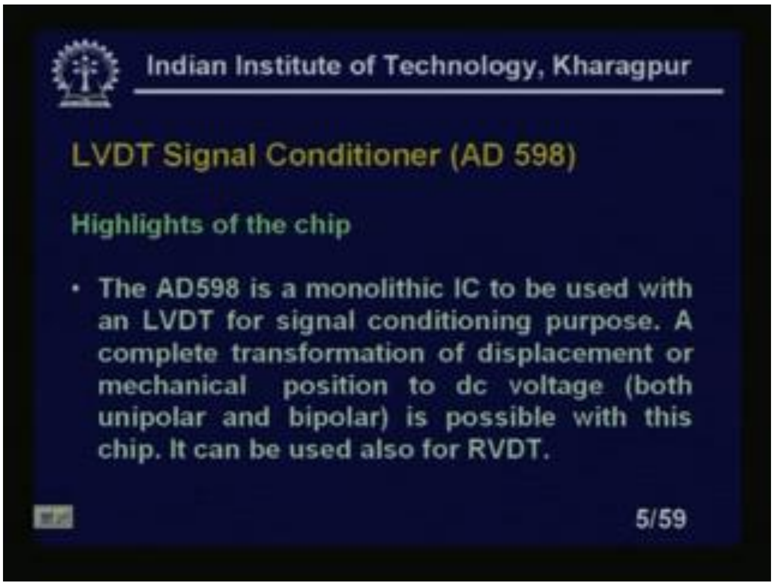

Now, LVDT signal conditioner circuit is AD598 it is highlights of the chip, what are those. So, the chip number AD598 developed by the analog devices. AD598 is the monolithic IC to be used with an LVDT for signal conditioning purpose a complete transformation of displacement. Or mechanical position to dc voltage both unipolar and bipolar is possible directly, because you we have seen that to make it sensitive phase sensitive I need a phase sensitive demodulator. So, those thing also can be, I mean eliminated, if I use this AD598.

So, this 3 most 3 most important things, which we need to use an LVDT, I need a first of all I need a source excitation voltage is necessary. I need is a null voltage I mean, null voltage reduction circuit that will make the null voltage 0. That means, at the geometric position 0 position there, should be the 0 null voltage thirdly. I need a phase sensitive demodulation circuits; that means, sensitive modulation circuit is something like, that on which side of the null position of the core lies. It will be deducted by the phase sensitive demodulation circuit; that means, if I look at.

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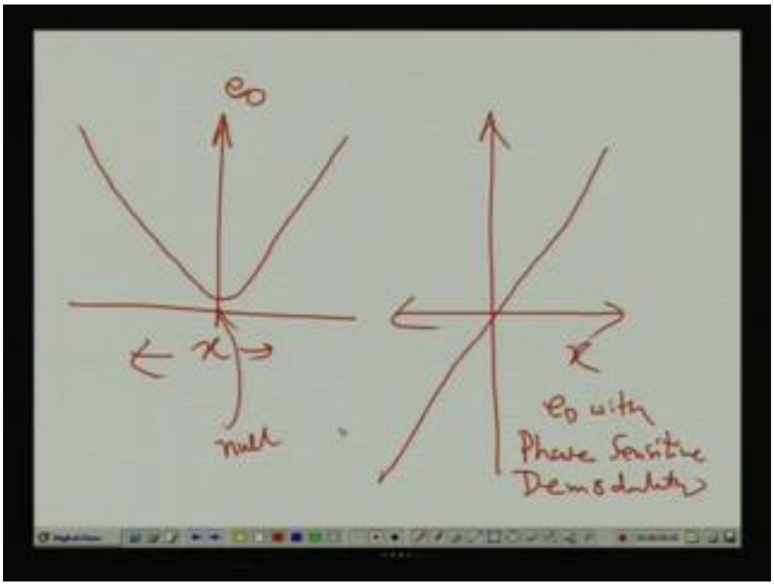

If I use an LVDT, you see that we have seen that, if I put a displacement x I will get a I mean circuit, I mean output like this one so on. You see on both this is a null position, this is a null position, this is a output voltage here on both side of the null, I am getting a non zero output voltage. So, it is very difficult by looking at a voltage, it is very difficult to tell on which side of the null actually the core lies. So, what I can do? I can do like this one. So, if I use a phase sensitive demodulation circuit, this is the circuit with output voltage e naught with phase sensitive demodulator phase sensitive, demodulator right if the output will look like this one clear.

So, for looking at the voltages or the polarity of the voltages, I can tell whether which side of the null the voltage lies. So, all these is incorporate or incorporated at AD598. So, it is a great I mean, so many external components will be saved by using a single chip. So, AD598 is the monolithic IC to be used with an LVDT for signal conditioning purpose a complete transformation of displacement or mechanical position or dc voltage. Both unipolar and bipolar is possible with this, it can used also for the RVDT rotational velocity displacement transducers, this also possible with this, I mean type of device with this type of chip.

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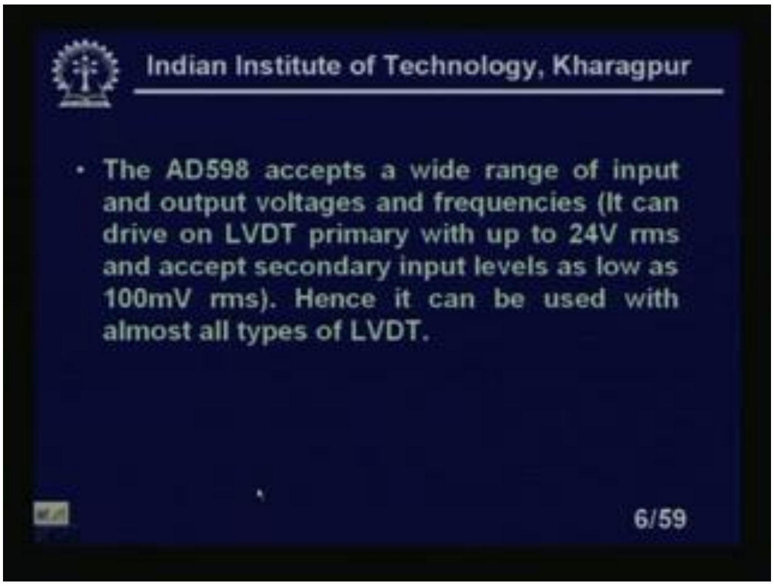

AD598 accepts a wide range of input and output voltages, these are all the features what it can and frequencies. It can drive on LVDT primary with up to 24 volt rms and accepts secondary input levels as low as hundred millivolt rms right. Hence, it can be used with almost all types of LVDT; that means, you please you see that LVDT and the primary can go up to 24 volt rms.

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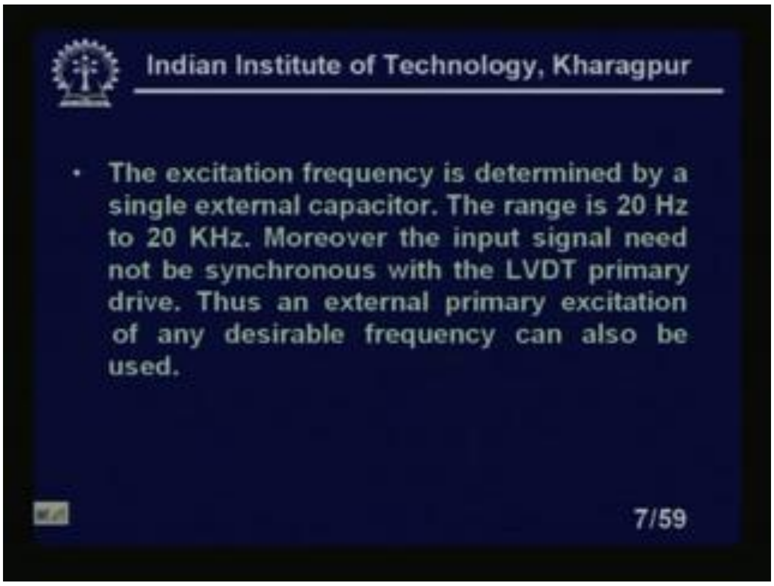

The excitation frequency is determined by a single external capacitor by using a single external. Which is outside the chip by excitation frequency of the LVDT can be I mean, determined by a single external capacitor the range is 20 Hertz to 20 kilo hertz. Moreover the input signal need not be synchronous with the LVDT, primary drive thus an external primary excitation of any desirable frequency, can also be used right this is another most important thing.

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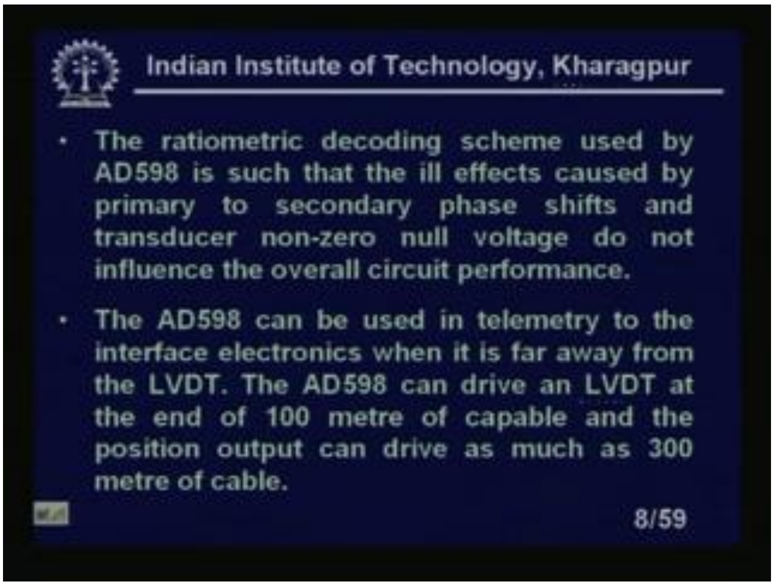

The ratiometric decoding scheme used by AD598 is such that, the ill effects caused by the primary to secondary phase shift. That I told you will be eliminated and transducer nonzero null voltage, do not influence the overall circuit performance. So, it will be independent of the non zero null voltage, which is obvious in all LVDT, because you cannot make 2 LVDT secondaries, exactly the same right. So, say a little I mean, I mean dissimilarities of the 2 secondaries will give us a non zero null voltage. This can be measured very easily in LVDT, if we use without any signal conditioning circuitry. AD598 can be used in telemetry to the interface electronics, when it is far away from the LVDT. And it can be drive it can drive an LVDT at the end of the 100 meters of capable and the position output can drive as much as 30 meter 300 meter of cable. I think it will be a cable if I am not wrong, so it will be a cable right.

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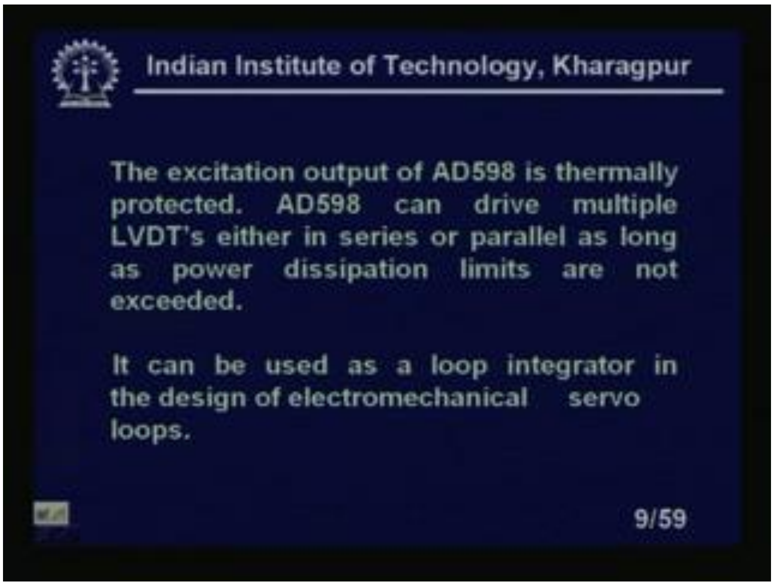

The excitation output of AD598 is thermally protected and AD598 can drive the multiple LVDT in either series or parallel as long as power dissipation limits are not exceeded. This is a great advantage you see the is same LVDT same chip can be used for several I mean, LVDT excitation. So, that is a great saving cost, it can be used as a loop integrator in the design of the electromechanical servo loops.

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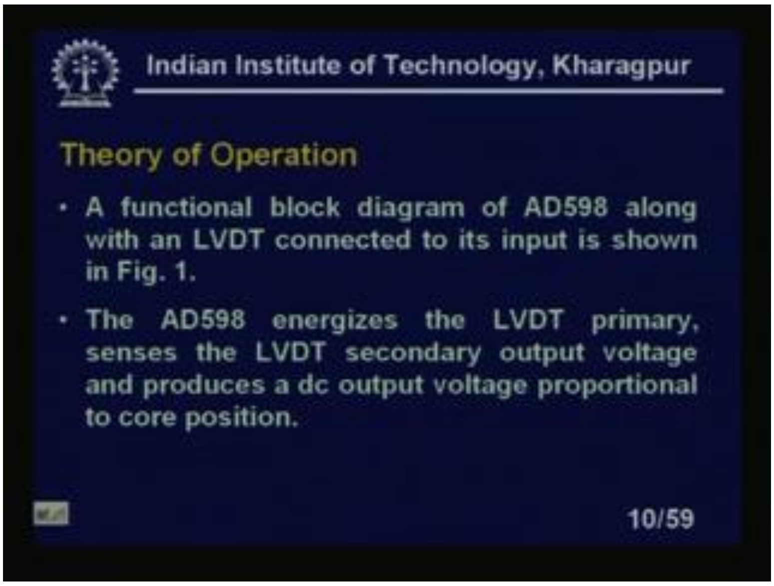

Theory of operation, let us look at a functional block diagram of AD is shown in the figure 1 and AD598 energizes the LVDT primary senses. The LVDT secondary output voltage and produces a dc output voltage, proportional to the core position, that is actually, ultimate result; that means, for different core positions; I need a dc output voltage. Why dc? Because I need a dc, because I have to make the phase sensitive on which side of the core, the on which side of the null position, the core lies that, I must know. So, that only can tell by the polarity of the dc voltage right.

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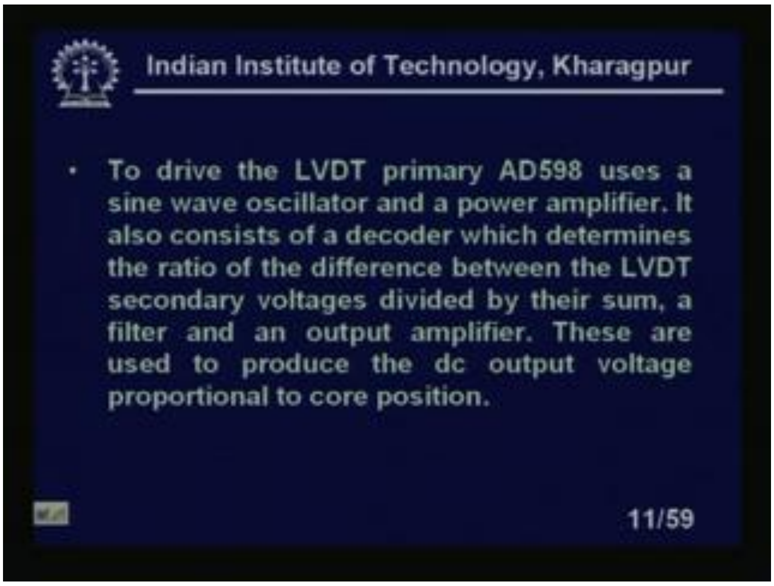

To drive the LVDT primary AD598 uses a sine wave oscillator and a power amplifier. It also consists of a decoder, which determines the ratio of the difference between the LVDT secondary voltage divided by their sum and a filter and an output amplifier. These are used to produce the dc output voltage proportional to the core position.

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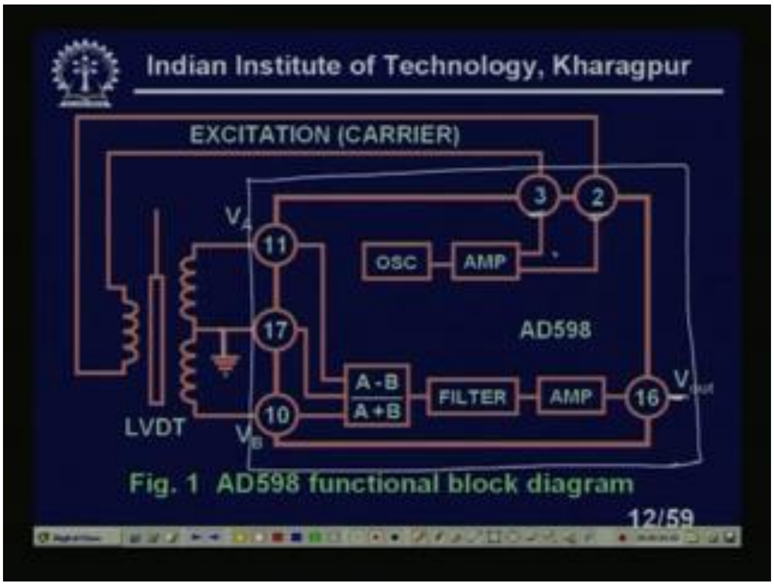

You see this is the block diagrams on the LVDT right LVDT our AD598, this is actually inside the chip. You can see this portion, this portion is inside the chip, this portion is inside the chip right and there are pin numbers 2 3. So, 2 and 3 will be connected to the primary of the LVDT and 10 11 and 17 will be connected to the 2 secondaries of the LVDT 10 and 11 are 2 extreme point of the secondaries. And one will be connected 2 secondaries are will be connected like this, as it is shown and it is grounded and these 2 signals are coming to an signal conditioning circuits which will make 2 signals. That means, A minus B divided by A plus B means; that means that is; that means, VA actually, it is VA minus VB divided by VA plus VB ratiometric principles as I told you.

So, this will make when the 2 voltages are equal; obviously, this should be 0 right; that means, output voltage will be 0. So, output voltage will come out as a 0 here a filters and amplifiers and this is an oscillator and amplifier to have a stable oscillation. What they do actually, in the case of LVDT they make first make a triangular generate a triangular wave. They generate a triangular wave then with the signal processing with they convert the triangular wave approximate sine wave. Because the triangular wave can be converted to a sine wave, then it is fit to the amplifier and it is fitting through the primary of the, this is the primary, this is the primary of the LVDT clear. Now, how you do it? You see that, if you can look at, it looks like this one.

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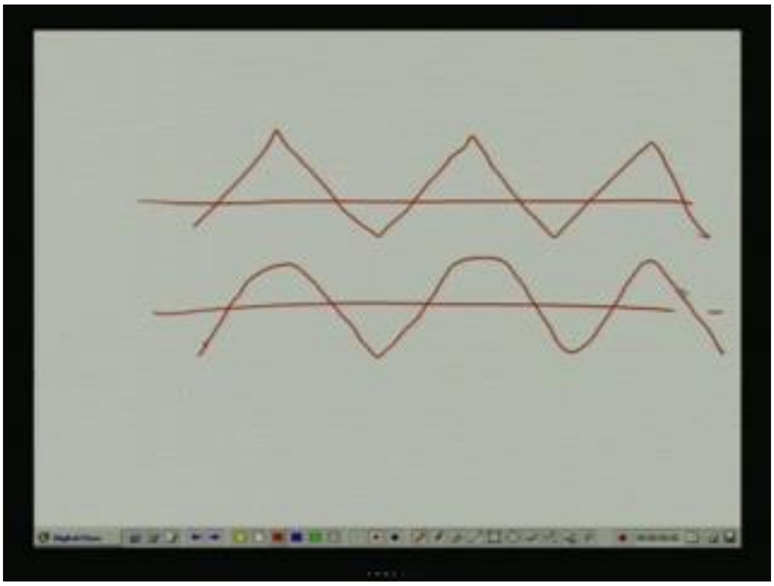

So, triangular waves are like this. So, with diode, I can what I can I can round of this value. So, it will look like this one like this one though it is not exactly, sine wave, but for most of the purposes, it will suffice. It is a continues form, there is error, if I look at there is a distortions and all these does not matter, it hardly matters, because nobody say that exactly use. We have to use the sine wave there right and this frequency of this is determined of this triangular wave is determine or the sine wave approximated sine wave is determined by an external capacitor clear right. So, this voltage will be divided by a A plus B, so it will give you the filter, this is the block diagram, but inside there is a much detail circuit.

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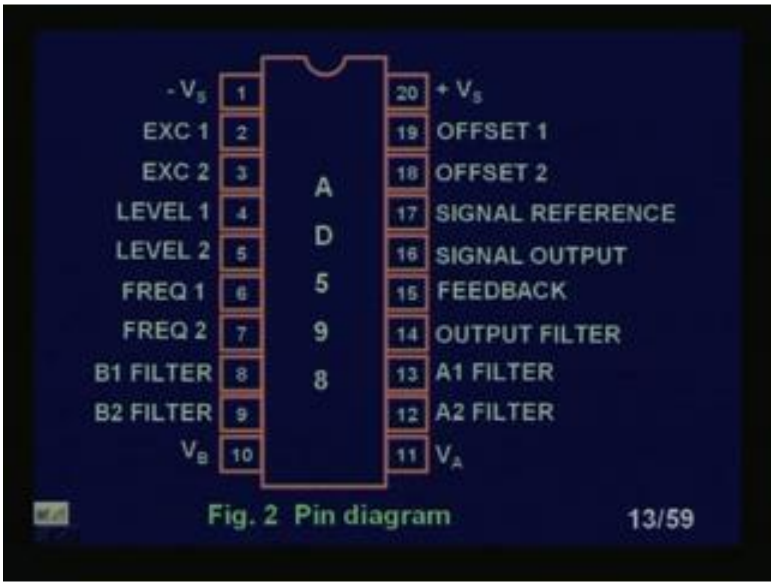

This is the chip pin diagrams, we can see it is a 20 pin DIP, there will be line packages. So, we have all the excitation lines 2 3 we have filter lines 8 9, we have a output filter then we have signal output. So, this basically, to excitations will go to primary and we have a dual supply V plus Vs and minus Vs either single ended. If you need single ended this is to be grounded; that means, if I need only unipolar. So, this is to be grounded and this output is signal output will come out, you can take the output filter also and signal differences right this is our pin diagram.

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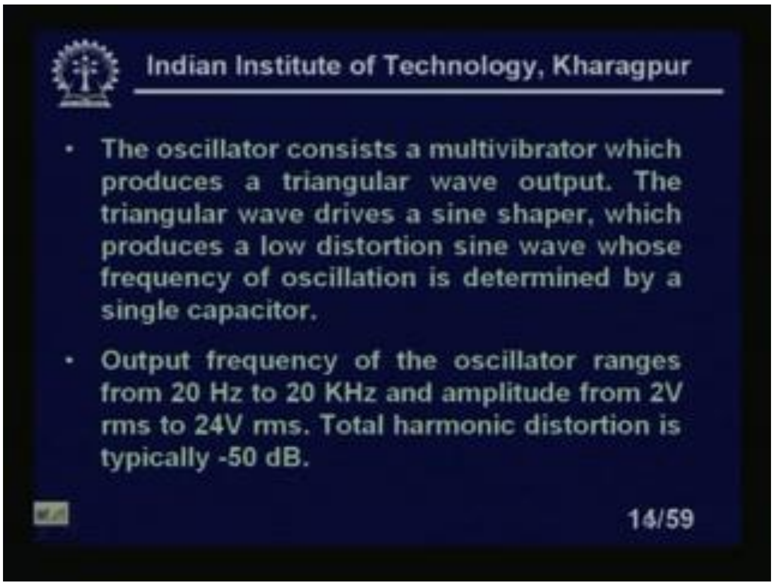

The oscillator consists of multivibrator, because multivibrator as you know multivibrator frequency. I can use wind bridge oscillators and all these things, but multivibrator frequency will be more stable. So, that is the reason they use multivibrator, which produce a triangular wave output the triangular wave drives a sign shaper. Which produces a low distortion sine wave who is frequency oscillation is determined by a single capacitor. So, I this one is not exactly, the low distortion side there are several distortions, it would not be a pure sine wave. So, there will be certain amount of distortion lies, there as I told you it does not matter much right. Output frequency of the oscillator or oscillator ranges from 20 Hertz to 20 kilohertz and the amplitude from 2 volt rms to 24 volt rms, total harmonic distortion is typically minus fifty db.

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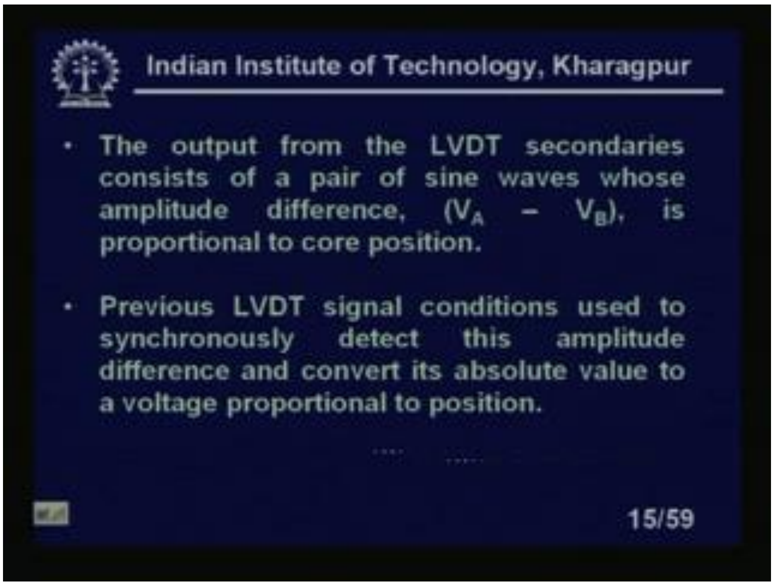

The output from the LVDT secondaries consists of a pair of sine waves, whose amplitude difference is VA minus VB and is proportional to core position. This will proportional to our core position, this always LVDT, we want like that. The previous LVDT signal conditioners whatever, because we knew already, we did this type of things. We made a lot of adjustments of the, we need a as I told you, we need some a some signal conditioners, circuit to kill the null voltage to kill the phase difference between input and output. Previous LVDT signal conditions a conditions conditioning circuits, rather used to synchronous used to synchronously detect this amplitude difference and convert the absolute valve to a voltage proportional to position.

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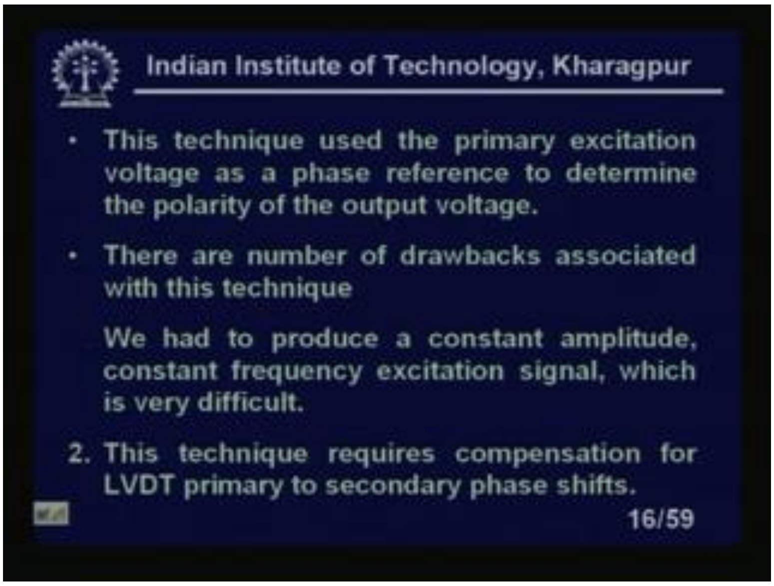

This technique is used the primary excitation voltage as a phase reference to determine the polarity of the output voltage. There are number of drawbacks associated with this technique. We had to produce a constant amplitude constant frequency excitation signal, which is very difficult; you see this is very important. While you are measuring with LVDT always, we are telling that the amplitude of the input voltage should remain constant right is not it? If the amplitude of the input voltage excitation, voltage falls then what will happen? Like this one, suppose if I tell that the it will happen what will happen? Suppose I have an LVDT.

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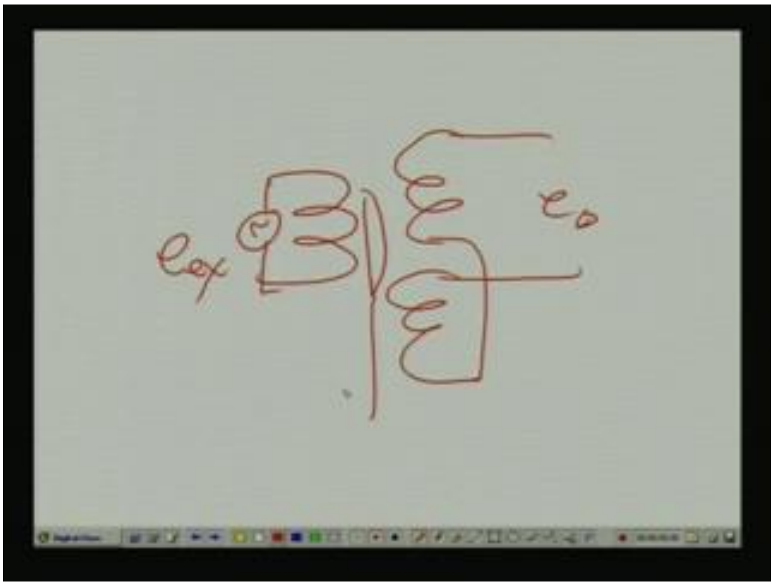

So, this voltage should remain constant excitation of the ex will remain, amplitude of the ex will should remain constant. It should have it constant frequency also, otherwise what will happen? If suppose for some reason this amplitude falls, this output voltage also will fall. Suppose this is series opposition output volt that is undesirable, because only the output voltage amplitude will tell me the exact position of the core. So, I will get some ambiguity, but that is not possible in this particular chip, because we are using ratiometric principle, they are using some ratiometric principle.

So, it does not matter I mean, if the input voltage frequency falls or rises automatically, output voltage will be independent of that. So, I do not need constant amplitude constant frequency signal right. Though, it is internally generated, but some reason or the other, if the amplitude falls it does not matter. This technique requires compensation for LVDT primary to secondary phase shifts this technique requires, compensation for LVDT primary to secondary phase shifts.

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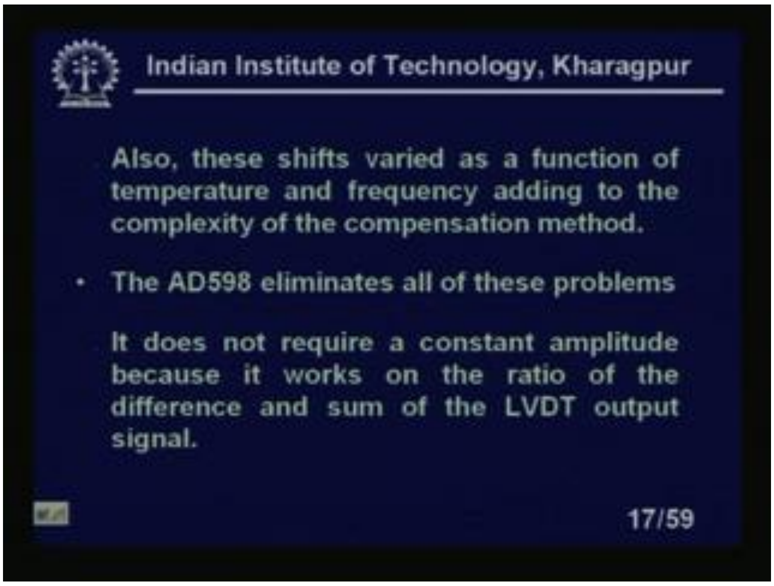

Also these shifts varied as a function of temperature and frequency adding to the complexity of the compensation method. So, this all thing can be avoided AD598 eliminates all of these problems, let us take 1 by 1. It does not require a constant amplitude, because it works on the ratio of the difference and sum of the LVDT output signal. So, automatically, it will cancel out right. So, any change any variations of the input excitation voltage frequency and the it will be automatically cancel out.

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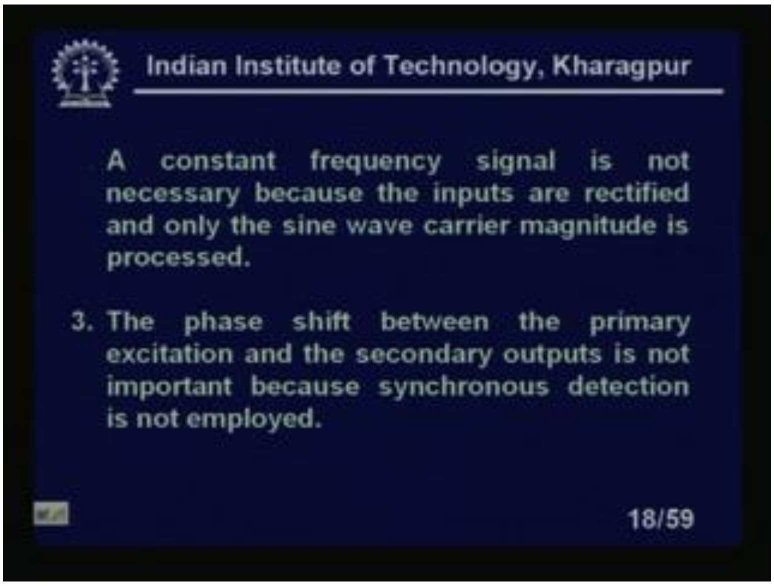

A constant frequency signal is not necessary, because the inputs are rectified only the sine wave carrier magnitude is processed. Input voltage will be rectified and the sine wave carrier signal will be processed. The phase shifts between the primary excitation and the secondary output is not important, because the synchronous detection is not employed right this is another advantage.

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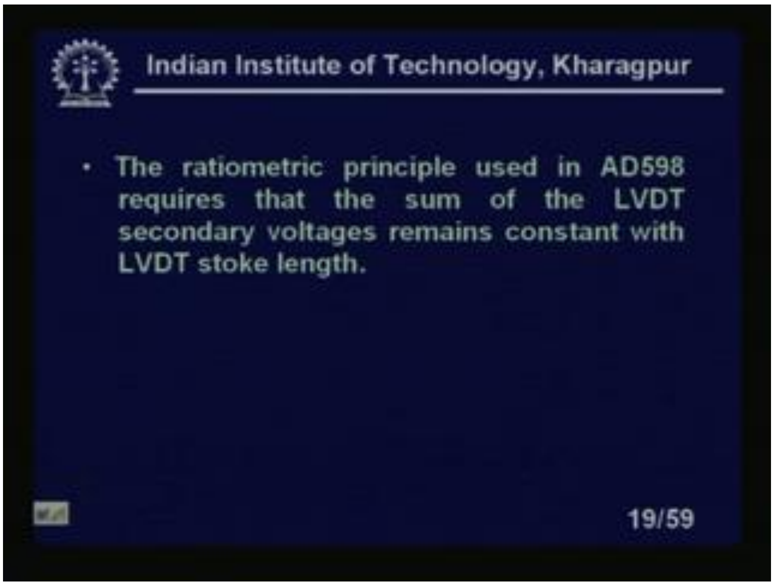

The ratiometric principle used in AD598 requires, that the sum of the LVDT secondary voltage remains constant with LVDT stoke length. Stoke length means, that length through, which the LVDT travels right that is called the stoke length.

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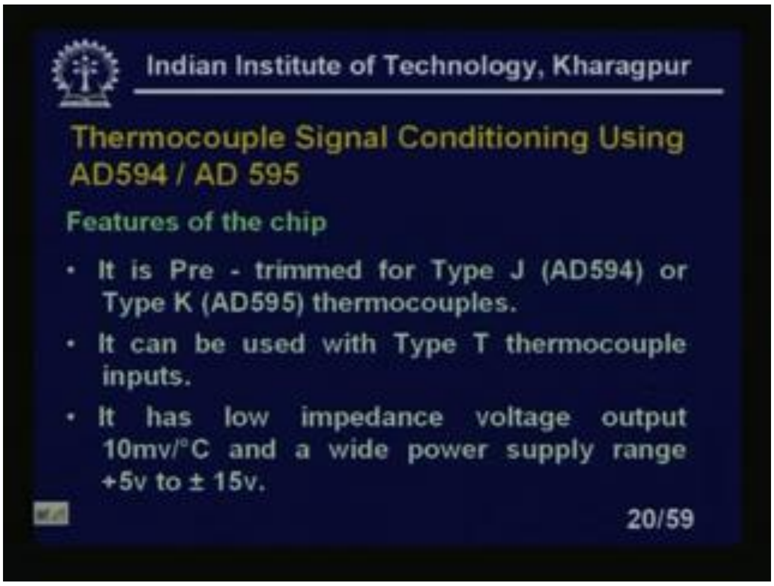

Now, next signal conditioning circuits, I am going to discuss is a thermocouple signal conditioners using AD594 and AD595. Because some I mean, thermocouple always, we have seen that we need a cold junction compensation is a headache for thermocouple. Because ambient temperature may vary, but that does not influence, my reading suppose, I am reading a thermometer with a thermocouple the temperature of 700 degree centigrade. If my ambient temperature varies from 5 degree to I mean 40 degree centigrade, it should not it should not influence my reading. So, that is only possible, if I use this type of I mean, cold junction compensation. Cold junction compensation chip was already, there with this improved chip compared to the, what whatever the cold junction compensation chips.

And it eliminates many additional circuitry which is necessary along with the AD590 or 5 8 0 and features of the chip, it is a pre-trimmed for J type or type K thermocouples. As you know, industry we always, called the thermocouple by J K SRT depends on the, what particular alloys they are using. So, it is pre-trimmed for for J type it is AD594 for K type, which is mostly widely used thermocouple in the industry. It can be used with type T thermocouples inputs also which is a platinum platinum rhodium thermocouple, platinum rhodium platinum thermocouple. I should say platinum rhodium is a positive voltage and negative I mean, platinum is the negative. It has low impedance voltage output of 10 millivolt per degree centigrade and a wide power supply range of plus 5 volt to plus minus 15 volt.

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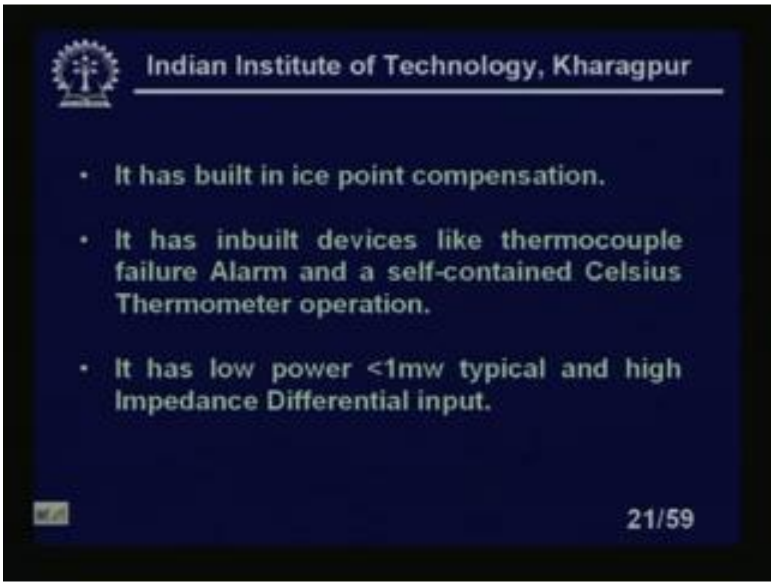

It has built in ice point compensation. It has inbuilt devices like, thermocouple failure alarm, because if the thermocouple junction open, so that some alarm should be given which is not there previous thermocouple. So, it will give some alarm, some voltage which can be energy which can be used to some trips of the alarm. So, that the, when the person the process know, that this thermocouple is out of order. And a self contained celsius thermometer operation is also possible direct readings of the thermometer in temperature degree centigrade is possible. There is another advantage, it has a low power, it is less than 1 millivolt typically and high impedance differential input is there. So, common mode noise problem can be immediately eliminated.

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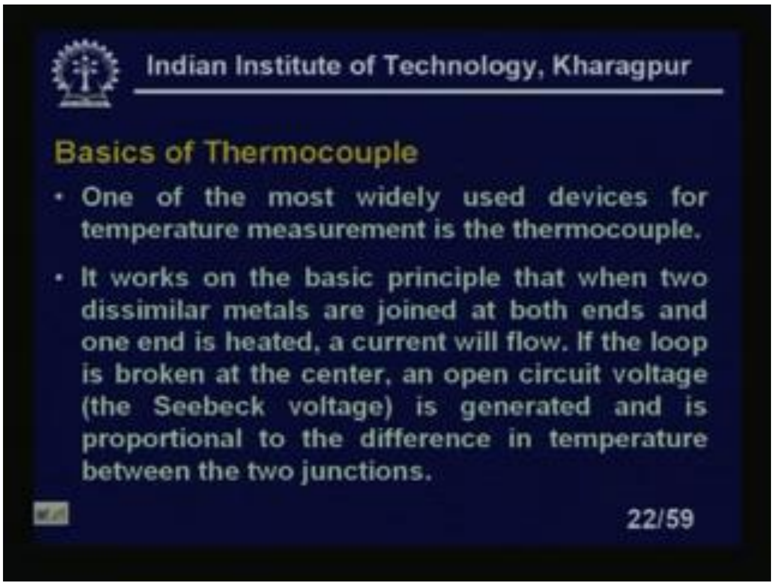

Basics of thermocouple, one of the most widely, used devices for temperature measurement is the thermocouple. It works on the basic principle, that when 2 dissimilar metals are joined at both ends, just have a short or brief recapitulations of the thermocouple. We are covered in details, but let us have a small discussion, because all this, chips are related to the thermocouple, this particular 2 chips what we talked about is related to the thermocouple. So, let us briefly discuss principles of thermocouple, it works on the basic principle that when two dissimilar metals are joined together at both ends. One end is heated a current will flow now, if the loop is broken at the center an open circuit voltage, see that voltage is generated. And is proportional to the difference in temperature between the 2 junctions we all know these thing right.

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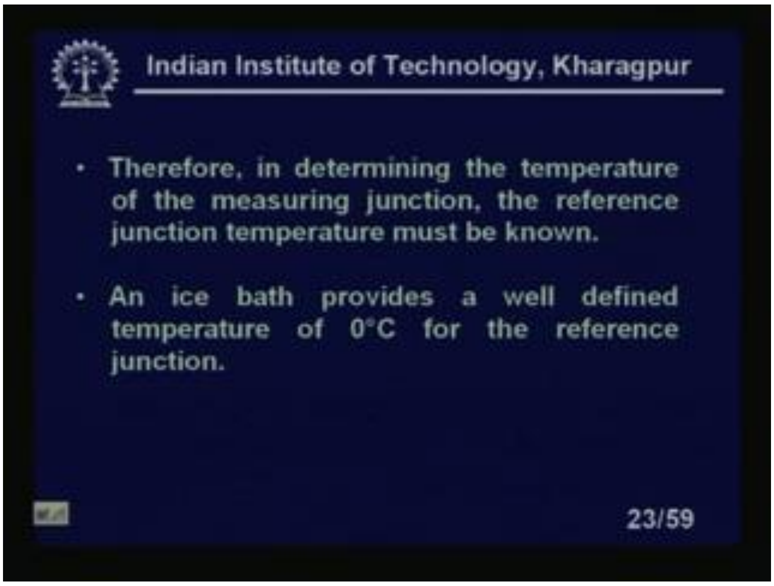

Therefore and in determining the temperature of the measuring junction, the reference junction temperature must be known right, because it is the difference of temperature, which will actually give us the voltage right? If the 2 thermometer, 2 junctions are the same temperature output voltage will be 0, right. So, the difference; that means the ice point or the reference junction temperature, which is not varying, which is supposed to be at the ambient temperature should be known. An ice bath provides a well defined temperature of 0 degree centigrade for the reference junction, but that is not possible in any process industry.

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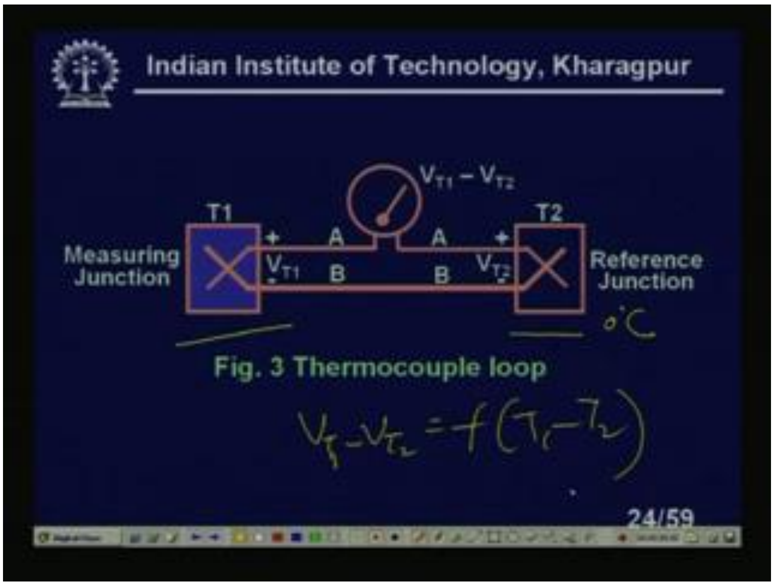

This we can see the thermocouple look, you see we have I have a measuring junction here right. I have a measuring junctions, let me take this one I have a measuring junction here, I have a reference junction which is at ice point at 0 degree centigrade degree centigrade? I have if; it is not if no voltmeter is connected, then what will happen? I will get a current through it, but I break it open circuits. So, I will get a voltage, so these voltage is proportional to the difference of the temperature T 1 and T 2. That means, the VT 1 minus VT 2 is the function of T 1 minus T 2 as the temperature is higher and higher temperature differences is higher and higher T 1 minus T 2 is higher and higher. I will get the higher valve of the voltage VT 1 minus VT 2, this is the basic I mean principles of the thermocouple.

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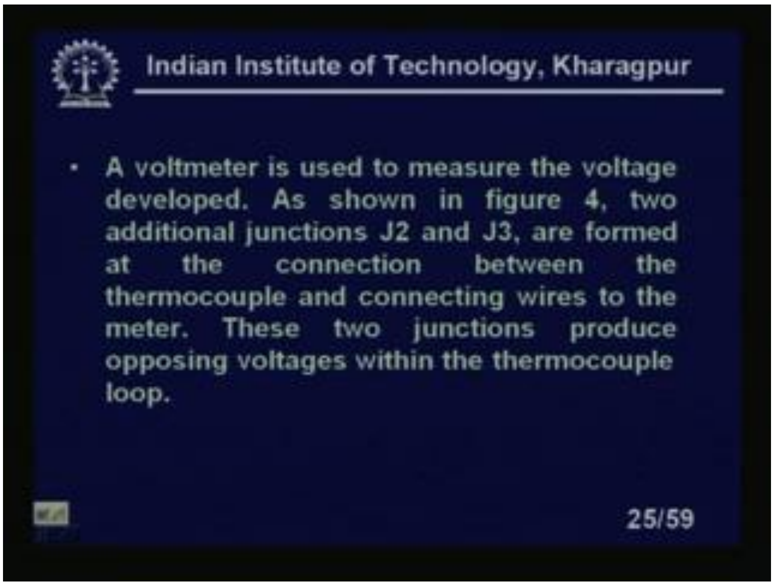

A voltmeter is used to measure the voltage developed as shown in the figure and 2 additional junction J 2 and J 3 are formed at the connection between the thermocouple connecting wires to the meter. Because that cold junction is not there in industry as I told. You excuse me these 2 junctions produce opposing voltage within the thermocouple loop right. So, one in most important things is that we have to this should be isothermal block I will show you in the next figure.

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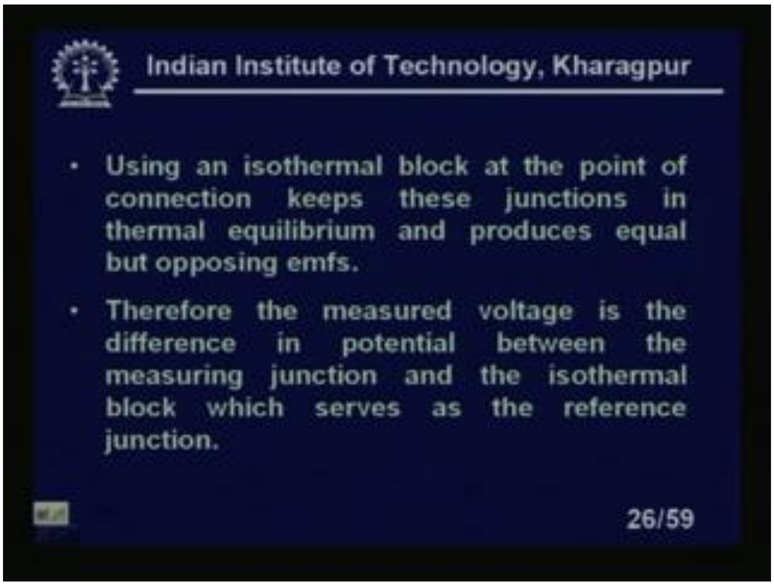

Using isothermal block at the point of connection keeps, these junctions in thermal equilibrium and produces the equal and opposing emfs. So, cancelling that, that will not that will not come in the net or to the I mean, voltages on net voltages. Therefore, the measured voltage is the difference in potential between the measuring junction and the isothermal block, which serves as the reference junction.

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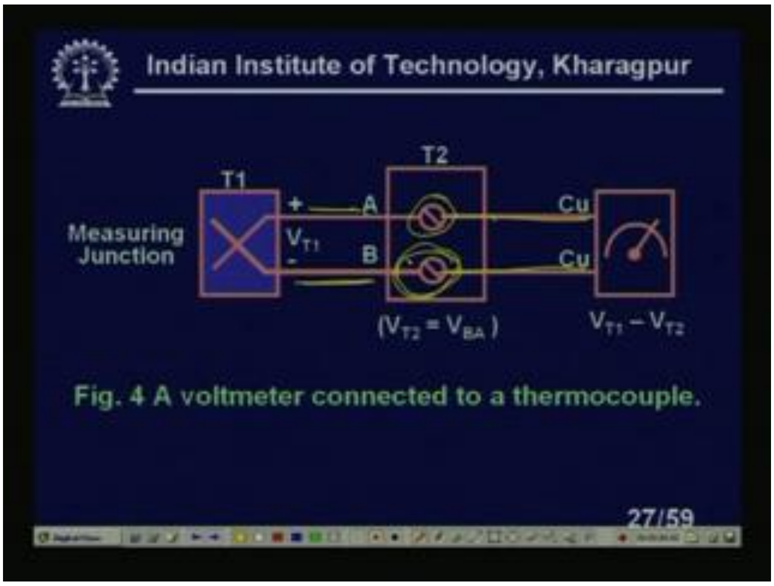

You see here, fine I have a thermocouple material A right, let me take this one. So, this is a this is a metal metal A, A I mean, is a alloy A is alloy B right, this is a measuring junctions. So, I have a, so usually, connecting wires are made of copper. So, if these 2 junctions the, because you see the metal A and copper there is 1 junction and this is another junction, this is one junction; this is another junction. So, for these 2 junctions are at the same temperature, that which can achieve this one by an isothermal block. So, there is no change in the net output voltage net, output voltage, we have measuring it with this one. Because we are connecting with the different wires so; obviously, if the different wire are connected dissimilar metal.

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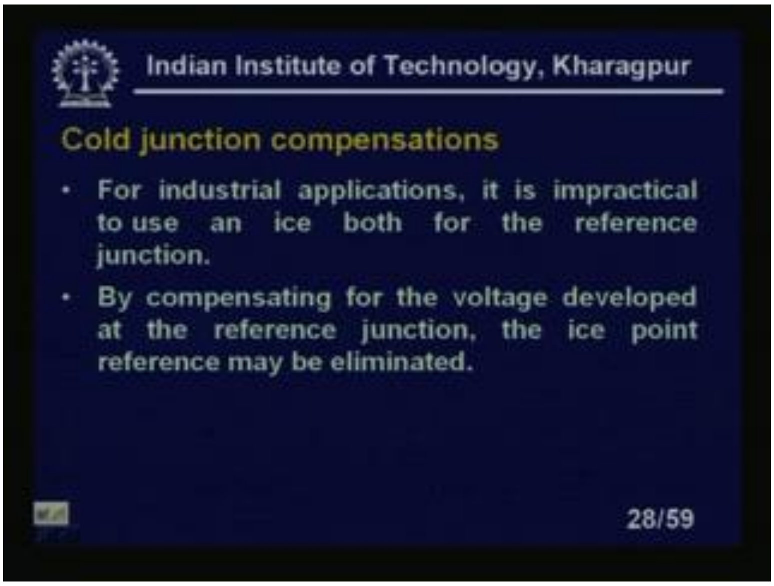

So, again thermocouple will be developed, this can be easily managed, if these 2 are put in a isothermal block, that is we talked about cold junction compensation for industrial application. It is impractical to use an ice bath for the reference junction it is not possible. I mean, so it will remain open, by compensating for the voltage developed at the reference junction. The ice point reference may be eliminated this is achieved by adding a voltage into the thermocouple loop equal, but opposite to that of the reference junction.

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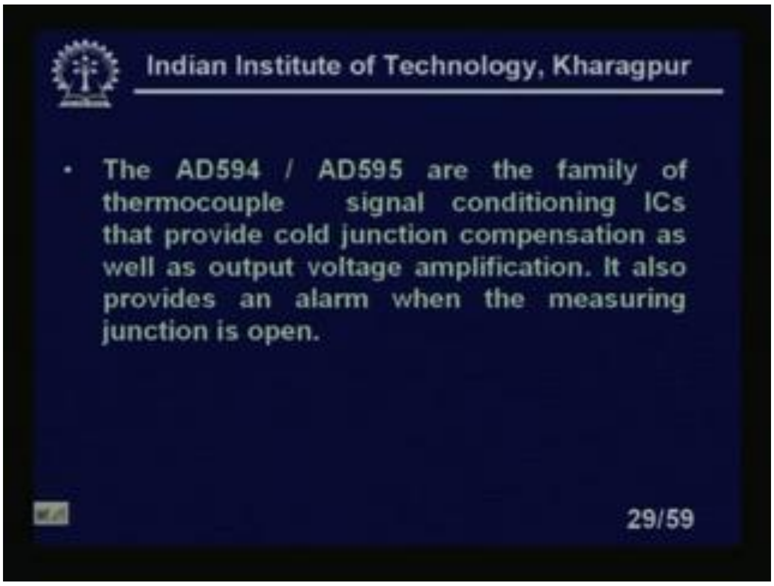

AD59 4 AD595 are the family of thermocouple signal conditioning ICs. That provide cold junction compensations as well as output voltage amplification, it also provides an alarm when the measuring junction is open; that means, the junction reference. I mean measuring junction is open for cut or some suppose, if it is made by welding. So, welding is broken, so I need some I need some alarm. So, that can be possible also with this particular chip.

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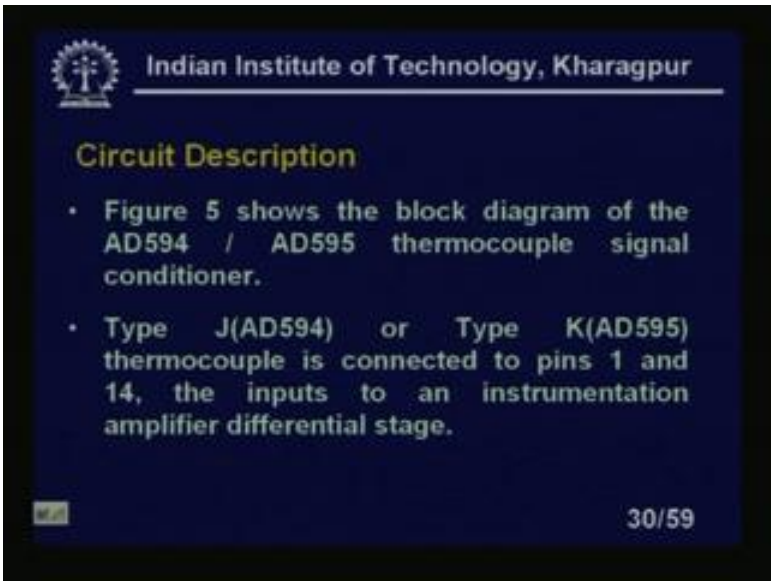

So, circuit description so; obviously, you can see that, it saves the lot I mean, I do not additional circuits to make all these to achieve all these extra features. Figure 5 shows a block diagram of the AD594 AD595 thermocouple signal conditioners. Type J, which is for I mean AD594 is to be used with the type J and type K is AD595 thermocouple is connected to the pins 1 and 14 and the inputs to an instrumentation amplifier differential stage.

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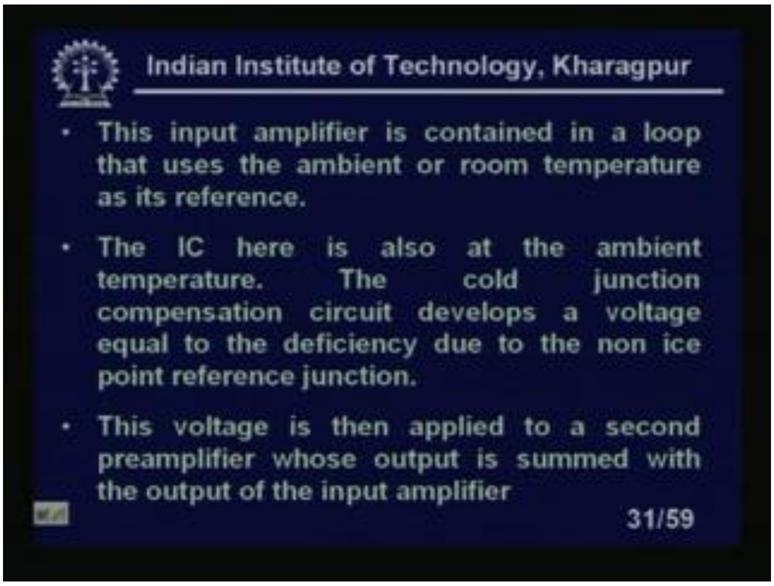

The input amplifier is contained in a loop that uses the ambient or room temperature as it is reference. The IC here is also at the ambient temperature and the cold junction compensations. Circuits develops a voltage equal to the deficiency due to the non ice point reference junction. The voltage is then applied to a second preamplifier, whose output is summed with the output of the input amplifier.

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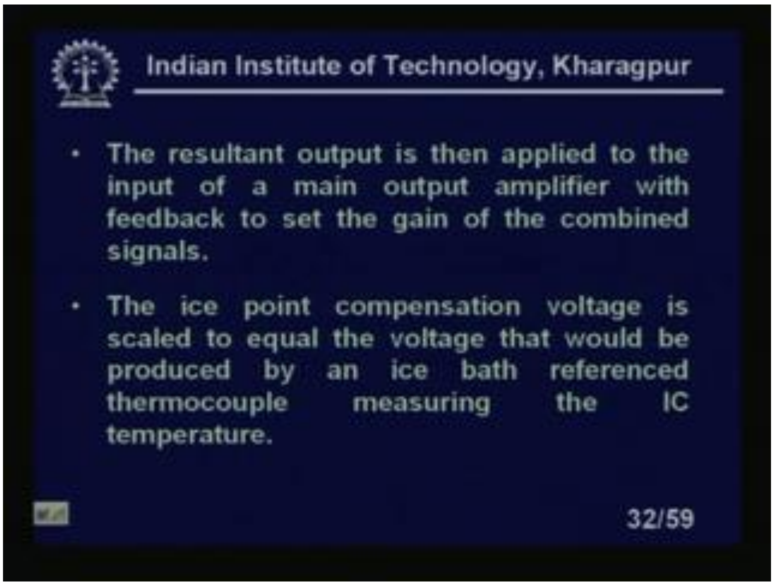

The resultant output is then applied to the input of a main amplifier with feedback to set the gain of the combined signals, I will show you all this in the circuit. The ice point compensation voltage is scaled to equal to the voltage that, would be produced by an ice bath referenced thermocouple measuring the ice temperature IC temperature. So, but this part is concerned, this is very similar to the, whatever the old chips we have used AD 5 9 0 right, though some additional features are there 580 is for stabilized cause 590 is actually thermocouple these are later versions.

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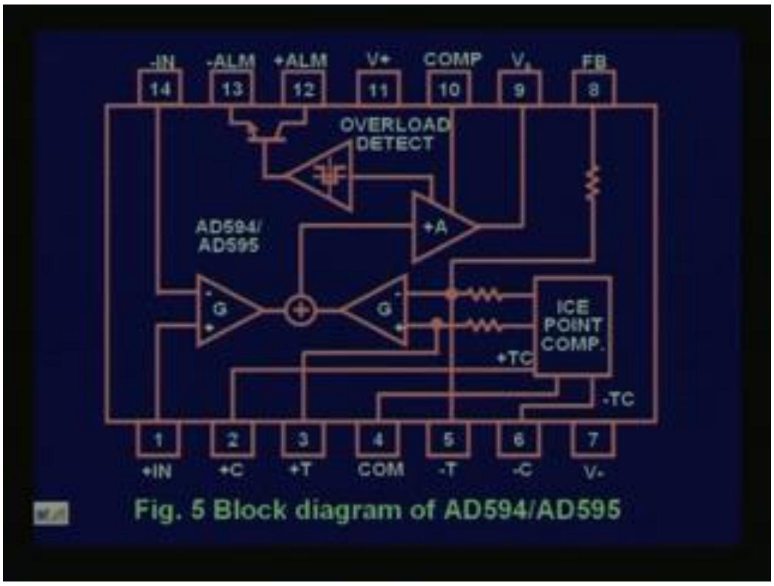

Fig. 5 Block diagram of AD594/AD595

This is our actual circuits, you can look at this is the thermocouple circuits right. You see here, so this is we have 1 amplifier here, another amplifier another amplifier here, this are summed up and coming to another amplifier, and see there this overload detection circuit. So, this will be give a alarm here, which is alarm transistors, we are using and some ice resistors are there. So, this is the complete block diagrams, our block diagrams inside. I should not say the detailed circuit diagram of the AD594 or 595, this is a block diagram of AD594 this is the factory trim. So, it has advantages; that means, I do not need additional capacitor I mean, additional resistance. Which are we need in the case of AD 5 9 0 there is a chart available for particular, Whatever the particular reference I, resistors we have to use, but this is not necessary here, it is already inside the chip.

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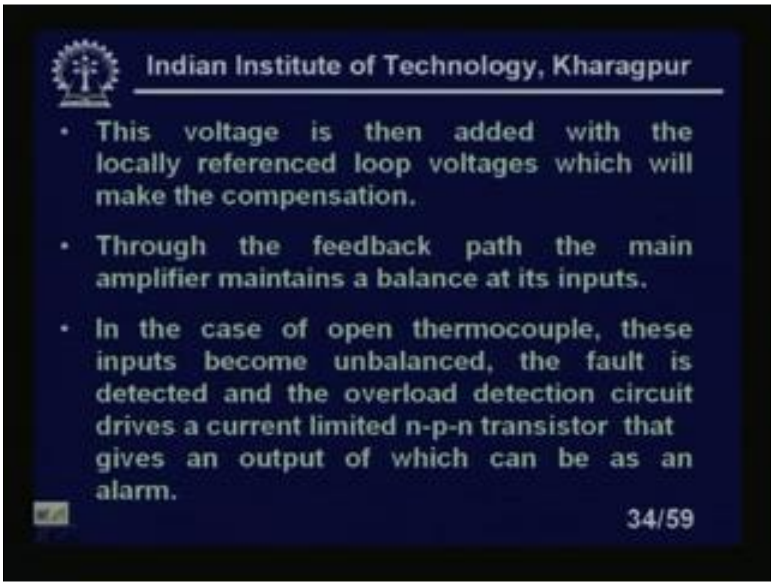

The voltage is then added with the locally referenced loop voltages, which will make the compensation right and though the feedback path through, the feedback path the main amplifier maintains a balance at it is inputs. In the case of open thermocouple, these inputs, become unbalanced and the fault is detected. And the overload detection circuit drives a current limited n-p-n transistor. That gives an output of which can be as an alarm which can be used as an alarm, which can be used I should say, which can be used which can be used as an alarm, right.

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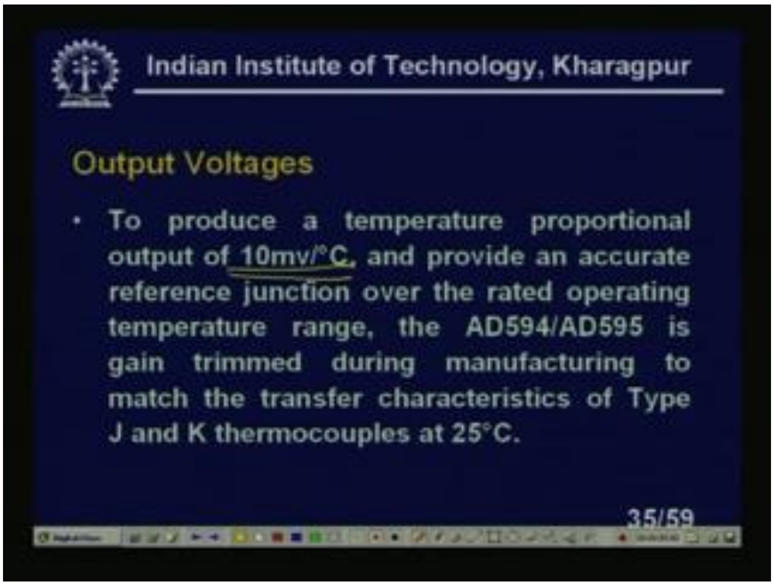

Output voltages: To produce a temperature proportional to output, you see that further advantage of this. One that I am getting in amplifications of 10 volt per degree centigrade, it is a quite high usually, you know that this thermoelectric power usually, I mean; that means, that sensitivity to thermoelectric is quite low. It varies typically, suppose from 60 degree 60 micro volt per degree centigrade to 12 micro volt per degree centigrade in the case of thermal constant. It is coming around 60 micro volt per centigrade whereas, in the case of platinum rhodium platinum thermocouple. It is 10 to 12 microvolt per centigrade, which is quite low, but here you see at the outputs. I am getting 10 volt per degree centigrade.

So, sensitivity is extremely, high you can see here 10 millivolt per degree centigrade. You can see here, this sensitivity is quite high. So, it is already, a signalled process and we are getting. So, much of sensitivity here, so the resolution; obviously, will increase. So, provide and to produce a temperature proportional output of 10 millivolt per degree centigrade provide an accurate reference junction. Over the rated operating temperature range AD594 AD595 is gained trimmed during the manufacturing to match the transfer characteristics of type J and K thermocouples at 25 degree centigrade.

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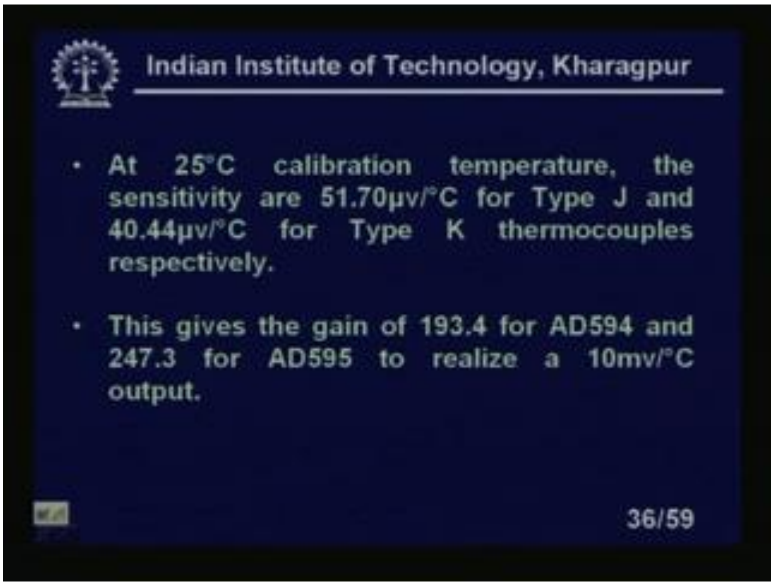

At 25 degree centigrade calibration temperature the sensitivity are 51.7 micro volt per degree centigrade, for type J and 40.44 microvolt per degree centigrade, for type K thermocouples respectively. This gives the gain of 193.4 or AD594 and 247.3 for AD595 to realize a realize a output of 10 millivolt per degree centigrade output.

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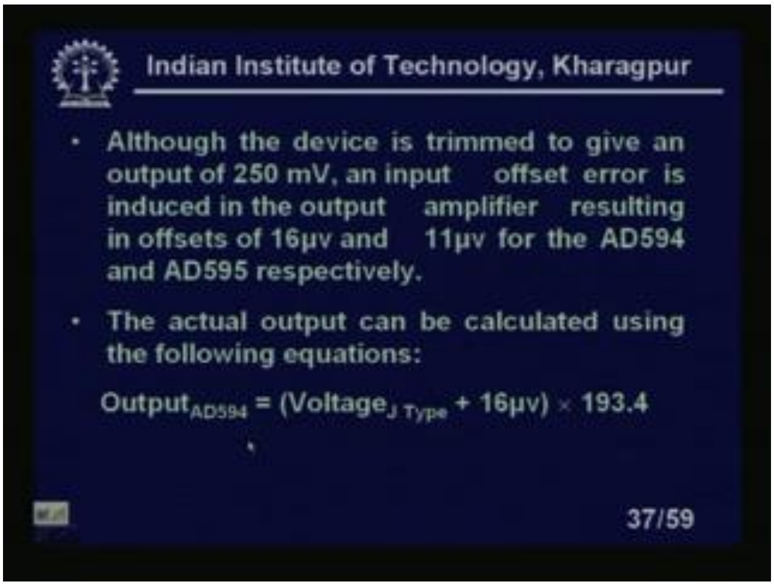

Although the device is trimmed to give an output of 25 to 50 millivolt an input offset error is induced in the output amplifier resulting in offset of 60 micro 16 microvolt and 11 microvolt for the AD594 and AD595 respectively. The actual output can be calculated, using the following equations now, what are the equations? Output of AD594 voltage J type plus 16 microvolt multiplied by 193.4. This is the actual output voltage I will get from this circuit. And in the case of AD595, I will get a output AD595 voltage K type plus 11 microvolt into 247.3.

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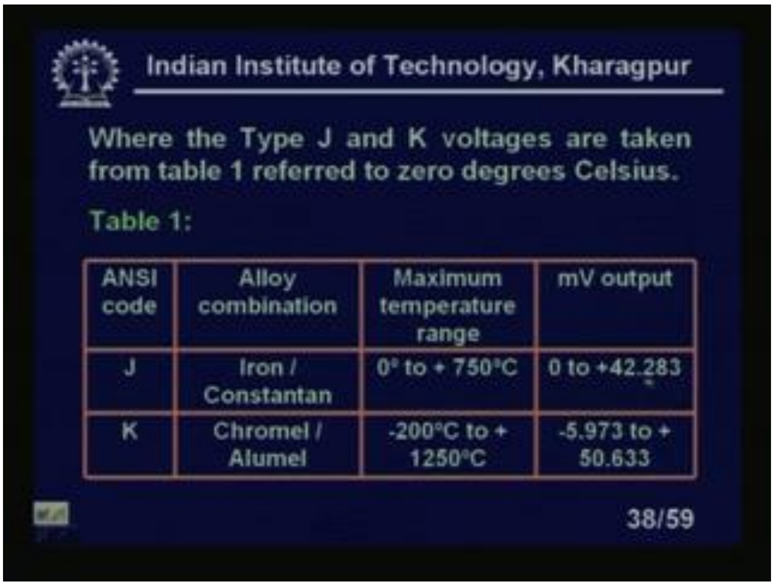

Where the type J and K voltages are taken from table 1 referred to 0 degree Celsius. Already, tables are available and for the reference, I am giving this table. So, it is J and K J is iron constantan and K is the chromel alumel this are the most widely, used thermocouple in industry. So, maximum temperature range 0 degree to 750 degree centigrade. So, within that range I am getting 0 to 40 42.283 millivolt and in this case 5.973 to 50.633 millivolt right. So, this is the range, I am getting of voltage swing I am getting.

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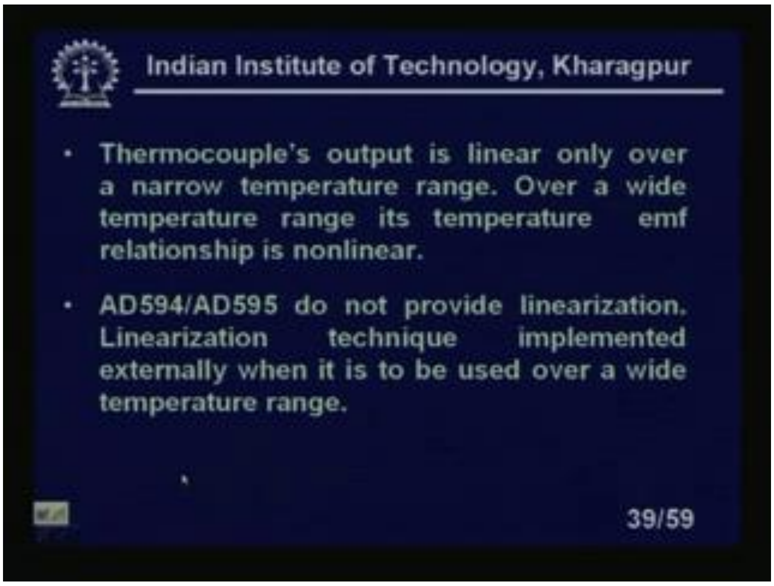

Thermocouple output is linear, only over a narrow temperature. That is you know thermocouple is non-linear devices over a short range only. I will get a linear characteristics, but however, it is a non-linear. So, you should take a wide range, if it is a if you can express at the polynomial equation, that I told you earlier also it looks like, if I take it is e naught sorry.

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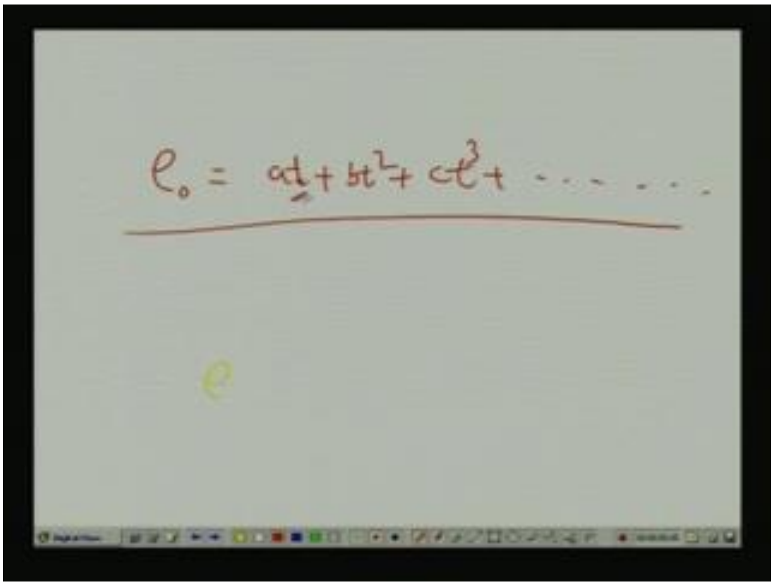

Output voltage e naught equal to at plus bt square plus ct cube right. So, it is the temperature created between the 2 junctions. So, it is the non-linear, you can see this one.

So, for only for sometimes, you will find it can be 7 degree polynomial sometimes, you will find it can be represented by a 8 degree polynomial. So, it is a highly non-linear devices, only in the case of platinum rhodium platinum thermocouple. You will find that it is 2 to third degree polynomial, it can be represented by. AD594 AD595 do not linearization, linearization technique implemented externally, when it is to be used over a wide temperature range.

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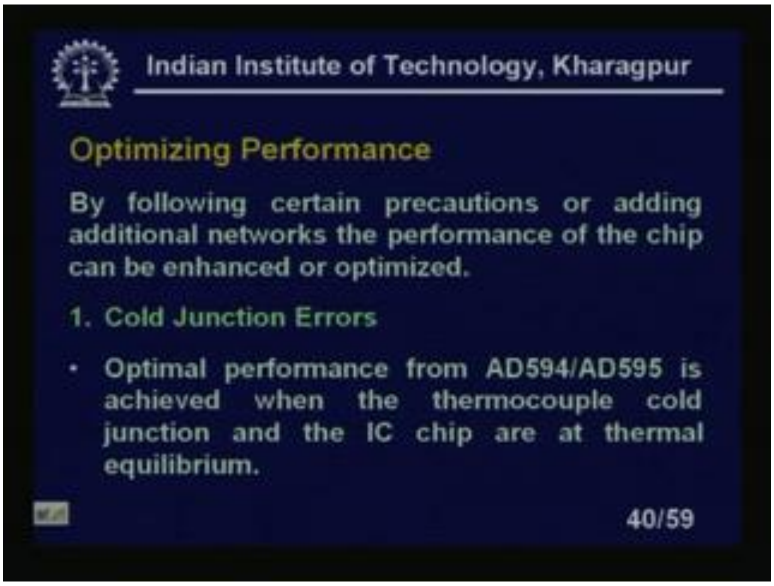

Optimizing performance by following certain precautions or adding additional networks the performance of the chip can be enhanced or optimized. Cold junction error; this one error, optimal performance from AD594, 5 9 5 is achieved when the thermocouple cold junctions and the IC chips are at the thermal equilibrium. It should be at the same I mean equilibrium; that means cold junctions. So, if you put usually, if I put AD594 and AD595 very close to the isothermal junction; that means, where I am taking the connecting the copper wire from the alloy of the alloy wire of the thermocouple. So, this will satisfy this statement cold junctions the cold junction errors will not be there.

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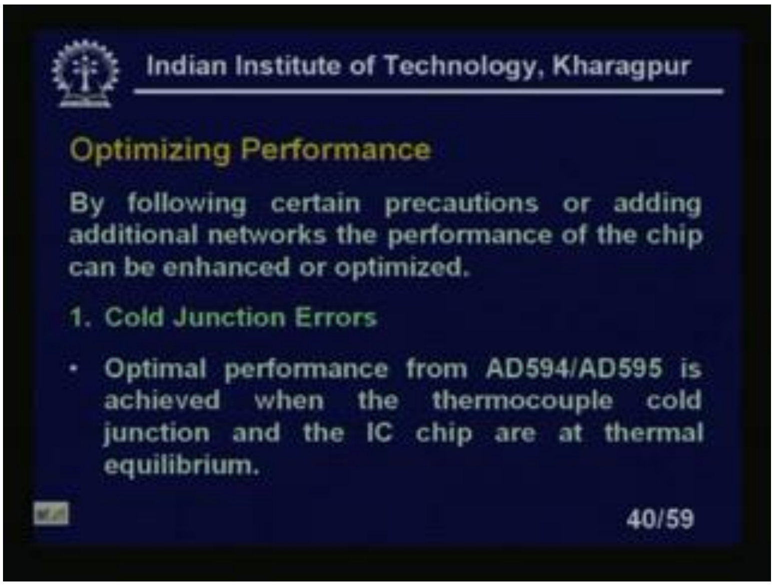

By avoiding the placement of heat generating devices or components near the chip, this can be achieved where you cannot. If I put for away any heat generating like, transformers or that type of things, that can be easily can be achieved this problem, can be easily solved. Soldering the proper soldering technique is to be implemented to bond the thermocouple to the printed circuit boards, proper I mean, typical clocks and whatever the thing; that means, there should not be that type of thing.

Cleaning the thermocouple wire to remove the oxidation, before soldering helps, because you see that thermocouple some thermocouple like, iron constantants are very prone to oxidation. So, that, so if I it is prone to oxidations, you must clean it the before soldering. Because 2 junctions is to be 2 wires is to be soldered either soldered and weld it. Whatever it may be even, if you can just tie like this 1, 2 wires it will work, but the, I need for physical strength, it need either soldering or welding. So, soldering if you do, you should first clean up those junctions, those portions then we weld or sold solder it.

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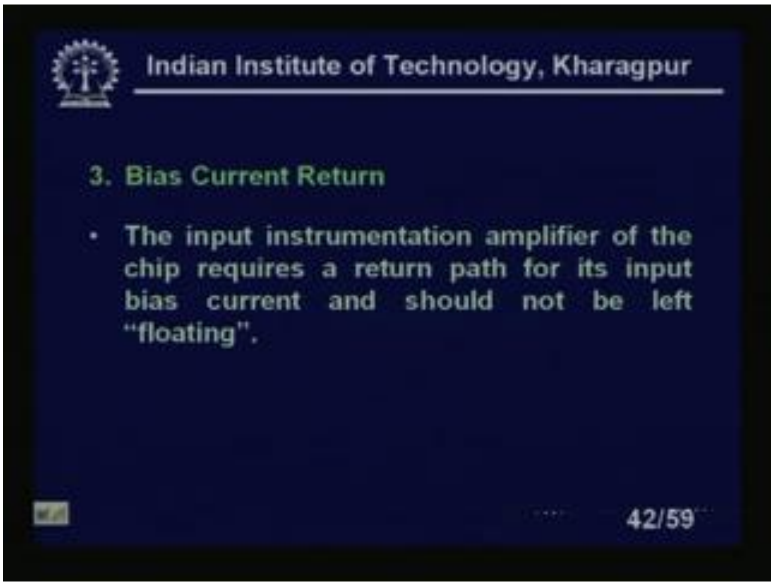

Basic current return the input instrumentation amplifier of the chip requires a return path for it is input bias current and this should be left floating.

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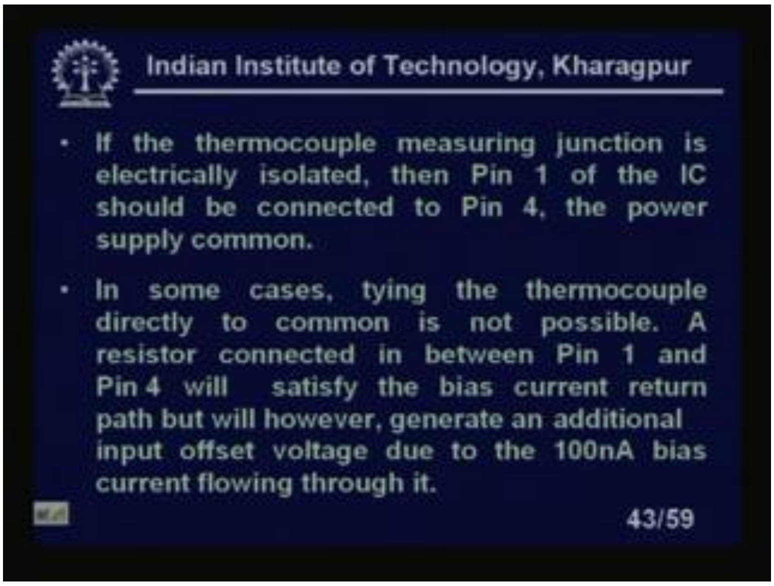

If the thermocouple measuring junction is electrically isolated then the pin 1 of the IC should be connected to pin 4 to power supply common. In some cases tying the thermocouple directly to the common is not possible a resistor is connected between pin 4 and pin 1. Will satisfy that bias current return path, but will however, generate an additional input offset voltage due to the one hundred nano ampere bias current flowing through it.

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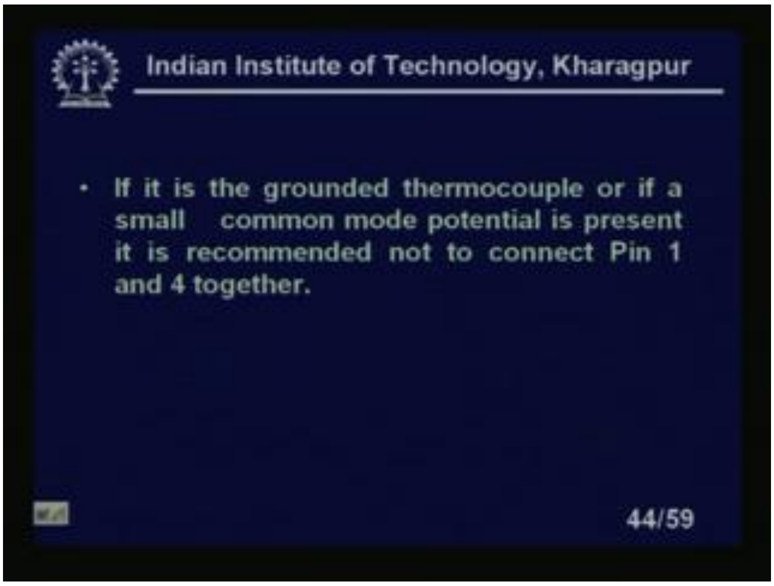

If it is the grounded thermocouple or if it is a small common mode potential is present it is recommended not to connect pin 1 and pin 4 together, right.

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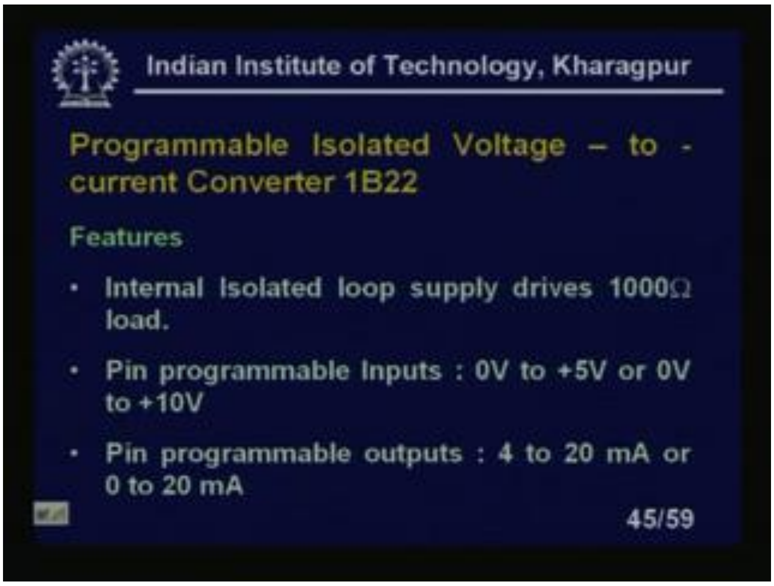

Now, last of this particular lessons we will discuss some programmable isolated voltage to current convertors 1B22. This is also many a places we need, because we cannot transmit current we cannot transmit voltage, we have to always transmit current. So, I need this type of convertor in many places whenever I am getting a signals pneumatic signals or anything which is to be converted into voltage first. Then to transmit to the actual point of control; that means, which is mostly over the PC.

So, I need a voltage to current convertor. So, all this things can be can be achieved by this chip 1B22. Let us look at the details of this one. Features; internal isolated loops supply drives 1000 ohm load. So, it has a large load it can be supplied. Pin programmable inputs I can have 0 to 5 volt or 0 to 10 volt input. I can have 20 to 5 volt usually typically you will find in process in industries will have two types of either 0 to 5 volt 0 to 10 volt output. I can have either 0 to 20 or 4 to 20. So, pin programmable outputs, pin programmable inputs and pin programable outputs 4 to 20 milliampere or 0 to 20 milliampere.

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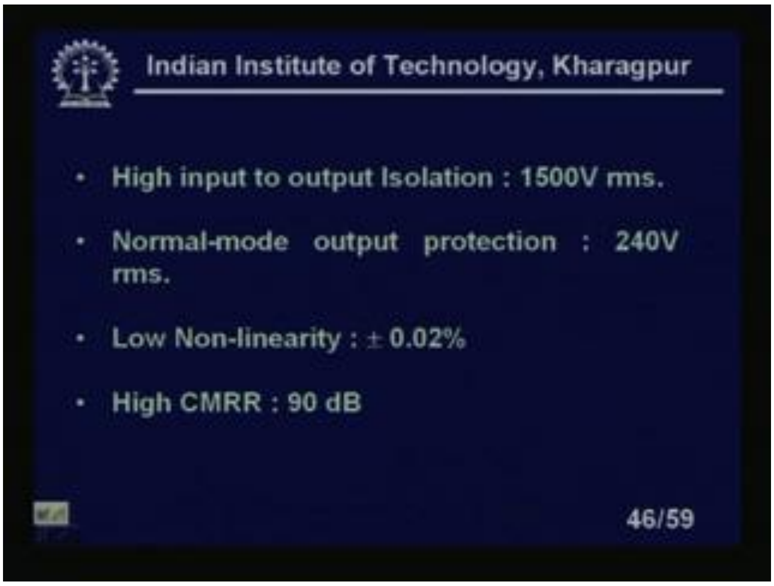

High input to output isolation high input to output isolation 1500 volt rms. So, it is a large isolation that is very much necessary to I mean to satisfy to protect my other instruments. Normal mode, output protection that is 240 volt rms. Low non-linearity it is plus minus 0.02 percent that is also greater advantage high CMRR it is 90 degree. So, common mode rejection ratio is quite high.

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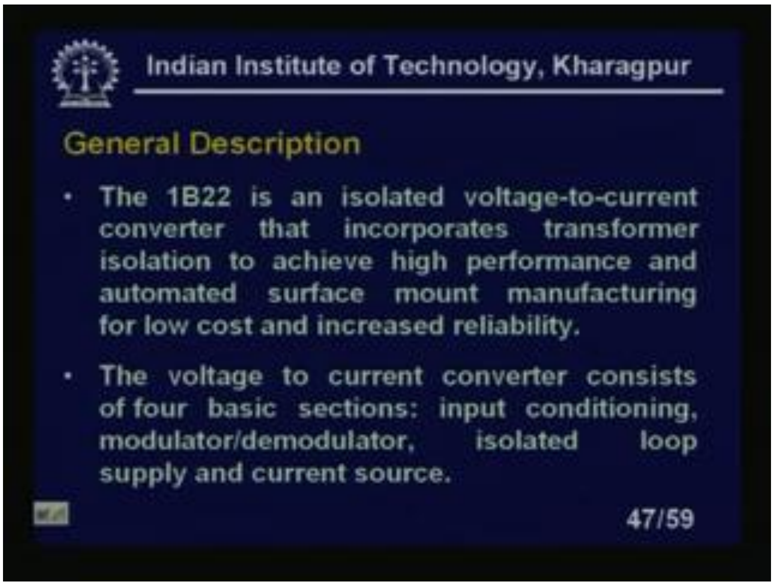

General description 1B22 is an isolated voltage to current convertor that incorporates transformers isolation to achieve high performance and automated surface mount manufacturing for low cost and increased reliability. The voltage to current convertor consists of 4 basic sections we have the input conditioning circuits; we have modulator demodulator; we have isolated loop and supply and current source this are the basic blocks.

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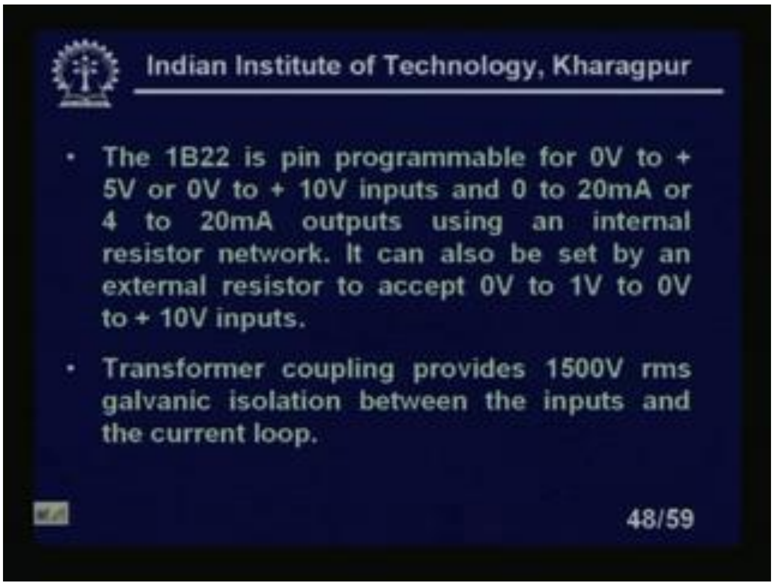

The 1B22 is a pin programmable for 0 volt to 5 volt or 0 volt to 10 volt inputs and 0 to 20 milliampere or 4 to 20 milliampere outputs using a internal resistor network. It can also be set by an external resistor to accept 0 volt to 1 volt or 0 volt to 10 volt input. The transformer coupling provides 1500 volt rms galvanic isolation between the inputs and the current loop.

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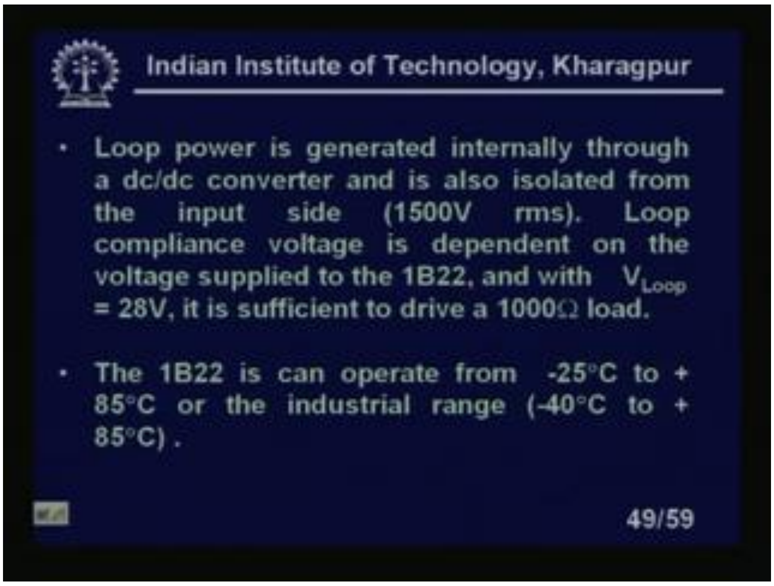

Loop power is generated internally through the dc dc convertor and is also isolated from the input side which is 1500 volt rms. Loop compliance voltage is dependent on the voltage supplied to the 1B22 that chip and with V loop equal to 28 volt it is sufficient to drive a one thousand ohm load. It can operate as a wide temperature range it a two type of I mean chip available once is for commercial, which is minus 25 degree centigrade to 85 centigrade industrial range is minus 40 degree centigrade to 85 degree centigrade.

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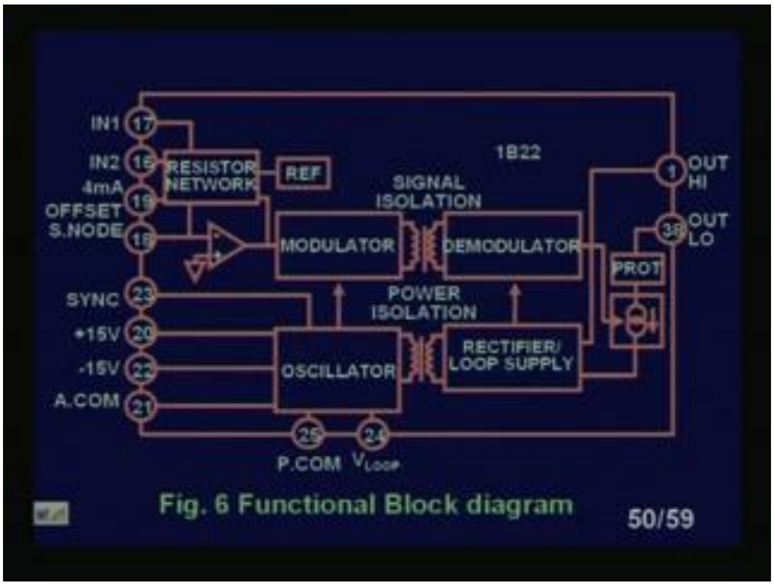

This is resistor network you see this is our basic block diagrams of our, this isolation you see the power isolation there is a signal isolation. So, all this isolation are there in this particular we have oscillators here this is our entire chip of this 1B22. This is an input input 1 and input 2, you can see which is coming the 4 milliampere is to be keep I mean this one.

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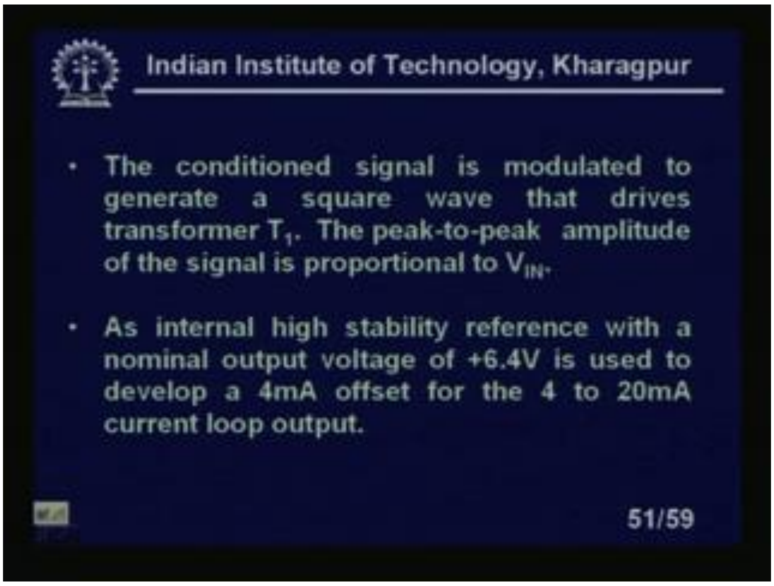

The conditioned the signal is modulated to generate a square wave, that drive the transformer T 1. The peak to peak amplitude of the signal is proportional to V IN. This is the transformer T 1 please note this is the transformer T 1 this is the transformer T 1 and this is the transformer T 2 this is the transformer T 1 and this is the transformer T 2. The conditioned signal is modulated to generate a square wave that drives the transformer T 1 the peak to peak amplitude of the signal is proportional to V IN right. So, that is actually we what we want a internal high stability reference with a nominal output voltage of six 6.4 volt is used to develop a 4 milliampere offset for the 4 to 20 milliampere of current loop output.

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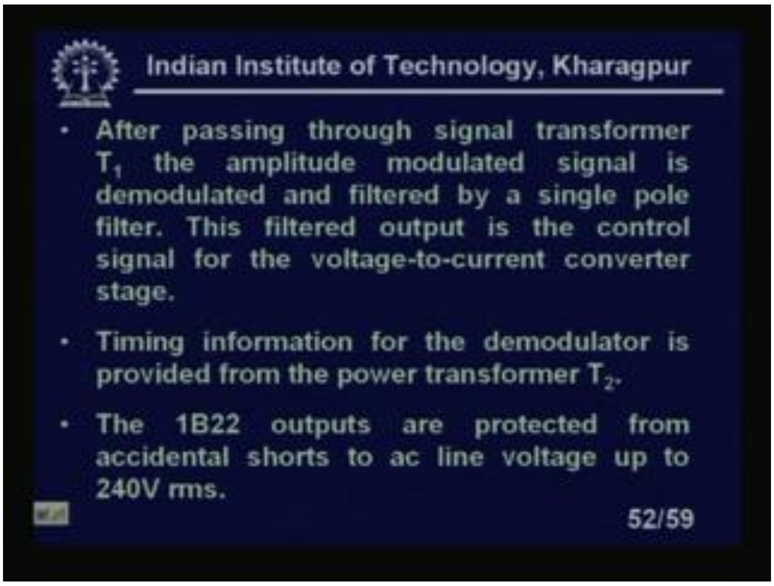

After passing to the signal transformer T 1 the amplitude modulated signal is demodulated and filtered by a single pole filter. That means, first order filter this filtered output is the control signal for the voltage to current convertor stage. Timing informations for the demodulator is provided from the power transformer T 2. The 1B22 outputs are protected from the accidental short circuit to ac line voltage up to 240 volt rms that is already I mean specified.

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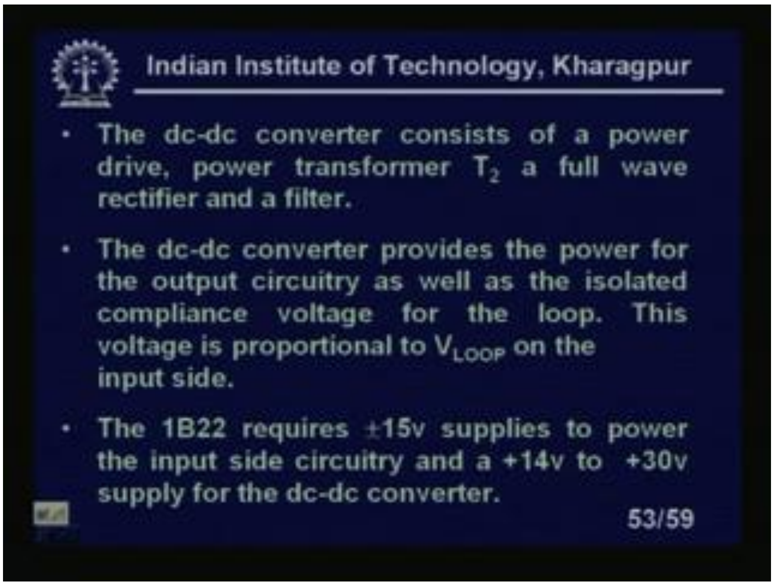

Now, dc to dc convertor consist of a power drive power transformer T 2 and a full wave rectifier and a filter right. Now, this dc to dc convertor provides the power for the output circuitry as well as the isolated compliance voltage for the loop and this voltage is proportional to V loop on the input side right. So, this will give everything this will give the our power supplies also. So, a dc to dc convertor is necessary. The 1B22 requires a plus minus 15 volt supplies to power the input side circuitry and plus 14 volt plus 30 volt supply for the dc to dc convertor.

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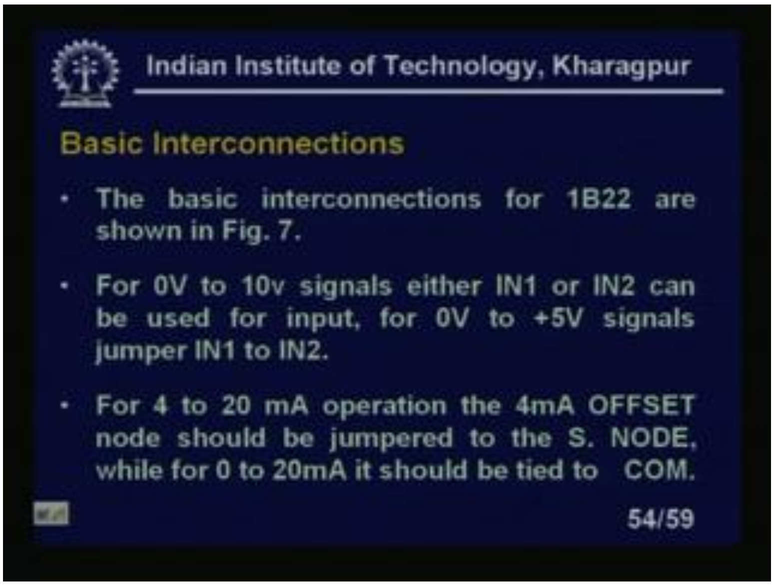

So, basic interconnections you can see here the basic interconnections are shown in figure next slide for 0 to 5 10 10 volt signals either IN 1 or IN 2 can be used for input for 0 volt 5 volt signals jumper IN 1 to IN 2. So, this is to be shorted for 4 to 20 milliampere the 4 milliampere this is also we call is the, I mean pre programable programable in that sense. That means, input is programmable and that is output, is programmable here for 4 to 20 milliampere operations. The 4 milliampere offset node, node should be jumped to the S node while for 0 to 20 milliampere it should be tied to the COM right, because 4 milliampere is not necessary.

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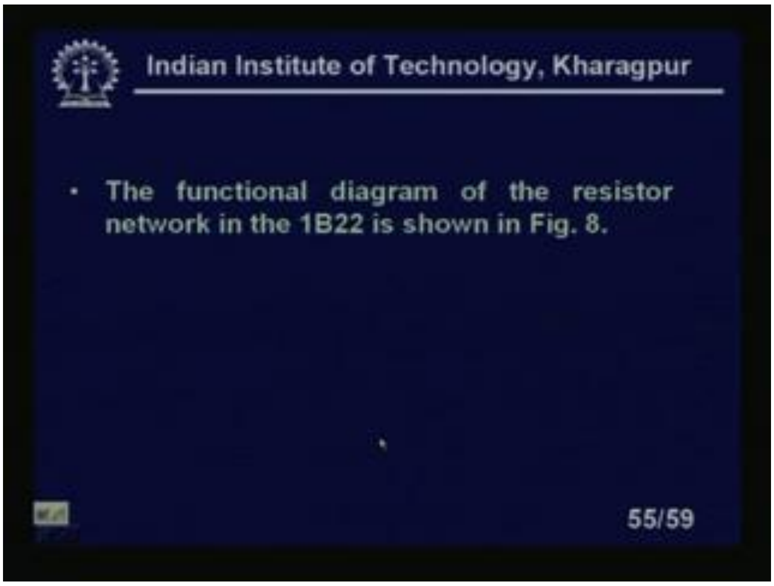

The functional diagram of the resistors networks in the 1B22 is shown in figure 8.

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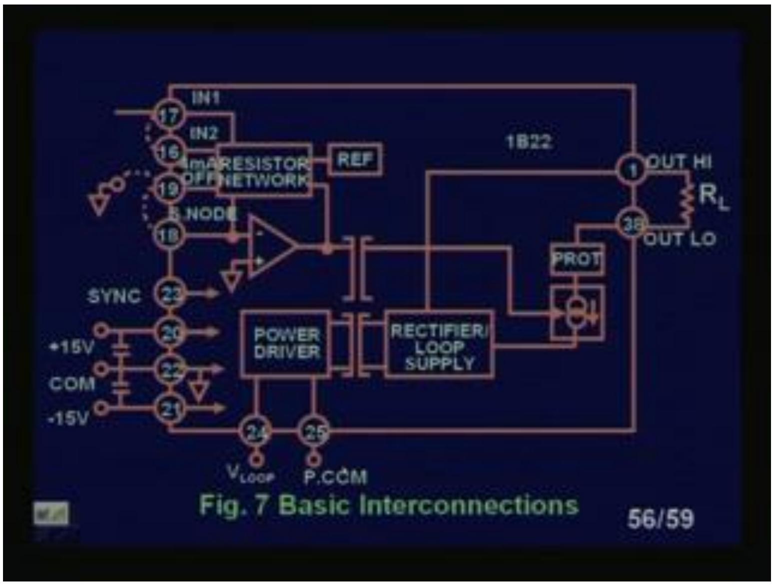

This is our functional diagrams you can see here how it works actually input 1 and input 2 these are resistor network 4 milliampere offset, we are using some capacitors here. So, we have a transformers we are showing like this one this are basic to transformer T 1, this is our T 2, this is a rectifier loop supply.

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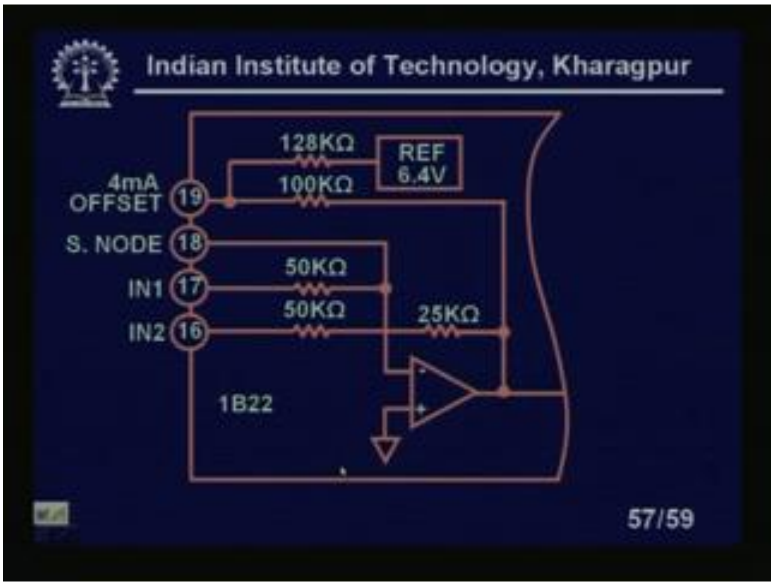

You can see here how the resistors networks are connected right? This is resistant networks in one B I mean this particular chip. What are internal networks? This are all inside the chip you can see where 6.4 volt reference voltage which can be generated by.

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Applications we have lot of applications; we have multi channel process controls; we are using this particular chip this multichannel process controls we can have a I mean process controls. We always need this conversion from 0 to 5 volt to 4 to 20 milliampere of current. So, that is possible A convertor current loop interfaces then we have analog transmitters and controllers where I have to transmit that signal many places even though it is digital. But the transmitter is analog, because to the computer when it will go it has a it I mean data acquisition systems are the input. So, it will convert in the digital domain, but before that the, from sensor through the transmitter it will go.

So, the transmitter itself this 4 to I mean this 1B22 should be incorporated within the transmitter. That means, which will converts like Ph suppose Ph whatever the voltage I will get that convert to the current of 4 to 10 milliampere that can be achieved there. Remote data acquisition systems; this also can be used, because it has a transmission capacity of about a large distance of 4 to 20 milliampere even the current is that can be sensed that can be used as a data acquisitions signal. So, all these features are there in the case of this particular chip this has several advantages this particular chip. Because always we are getting a stable 4 to 20 milliampere of current in this cases right. And with this I come to the end of this particular lesson.