Basic Electronics
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Module - 4
Operational Amplifier (Op-Amp)
Lecture - 7
Positive feedback and oscillation

In the last class we have discussed about negative feedback in a circuit using op-amp. In that case the output voltage which was fed back to the input via a feedback circuit was added negatively or it was subtracted. Today let us discuss about a positive feedback. Here the signal from the output is fed to the input and is added to the input signal.

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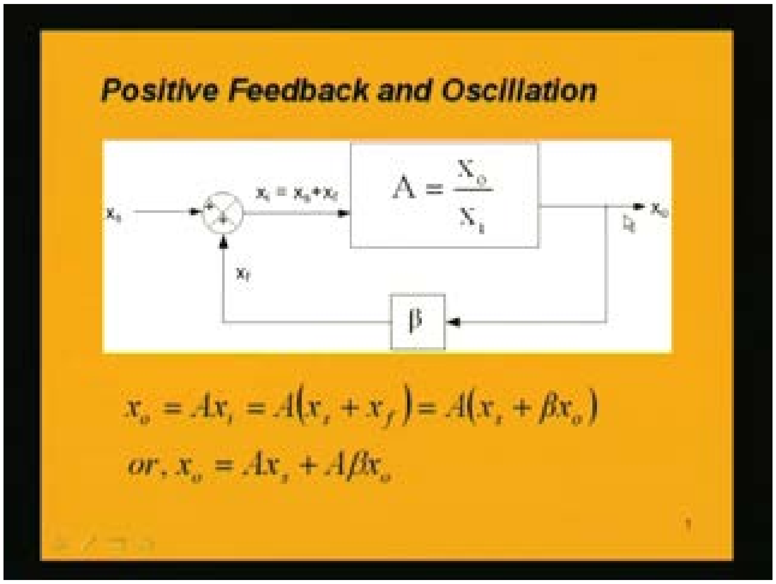

This circuit here or the block diagram here is about a positive feedback where the input signal is x_s or the supply signal and the output signal x_o is obtained after amplification and that amplified gain is say A, which is giving the gain between the output signal and the input signal; X_o by X_i is A and the output signal x_o is fed to the input by a block or a network whose gain is beta. Here the feedback signal after passing through beta is added with the supply signal x_s and so the signal before the amplifier becomes x_s plus x_f, x_s

being the supply signal and x_f being the feedback signal. If we analyze this block diagram representation we get that the output signal x_o is A times of the input signal x_i that input being the input before this block A and x_i is nothing but x_s plus x_f and so, we can write it as x_o is equal to A into x_s plus x_f is nothing but x_s plus beta times of x_o. Because if we consider this block, it is having an input coming from the output signal x_o and its output is x_f and that x_f is nothing but beta times of x_o.

Simplifying this expression if we now take this x_o equal to A into x_s plus beta times of x_o, we get finally that x_o is equal to A times x_s plus beta into A into x_o, where, I am just opening this bracketed form of expression.

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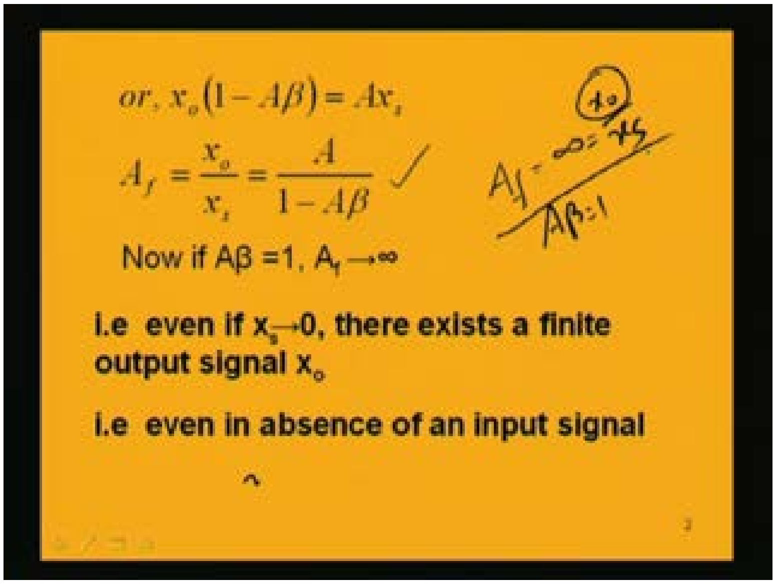

Now we are simplifying by taking x_o common and that becomes 1 minus A times beta into x_o equal to Ax_s and so finally we get the gain of the whole circuit or whole amplifier as x_o by x_s, the output divided by this supply signal x_s and that is obtained as A by 1 minus A beta. This expression of A by 1 minus A beta giving the gain of this feedback amplifier is having positive feedback. Here A_f is denoting the gain of the whole feedback amplifier. If we consider this gain and the expression A beta in the denominator, if we can make A beta equal to 1, then the denominator expression becomes zero. So, this gain

A_f becomes infinity. The gain A_f infinity means that x_o by x_s is infinity and if we consider a finite output then the source signal has to be zero, because only then this infinite gain can be realized which is x_o by x_s. If A beta becomes 1, then the gain becomes infinity meaning that x_o by x_s is infinity.

x_0 is a finite output signal. If we consider the output signal to be finite, then it has to be that the supply signal x_s will be zero. The meaning is that even if the x_s signal is zero even then there exists a finite output signal x_o; meaning is that we will get an output signal even though there is a zero source or even if there is no input signal we are getting an output signal when this condition A beta equal to 1 is met. This has a very important implication. We are going to get an output signal even in the absence of an input signal means we are going to generate an output signal which is the basis of wave form generators.

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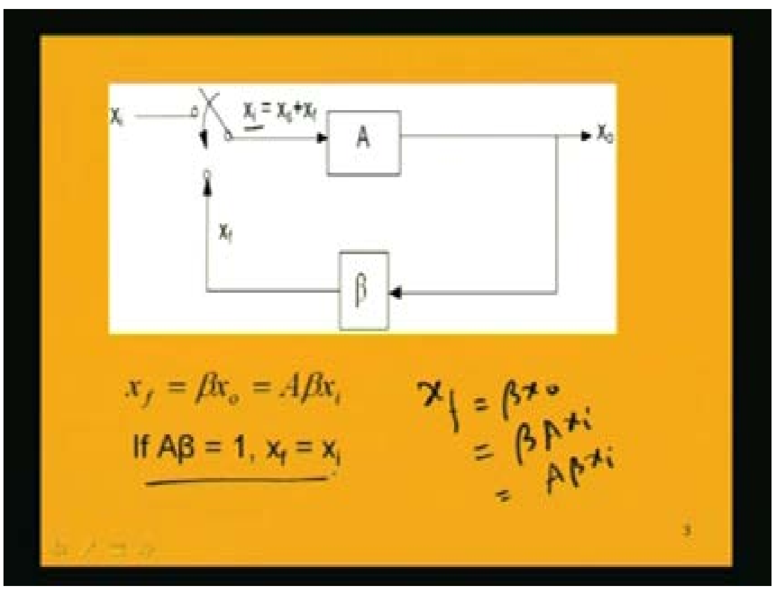

If we look into the block diagram again, here in this block diagram which we have now taken x_o, the output signal is equal to A times of x_i and this feedback signal x_f is equal to beta times of x_o. If we consider the feedback signal x_f, we can write it as beta times of x_o and x_o is nothing but A times of x_i. So, I get x_f is equal to A beta into x_i meaning that we are getting the feedback signal which is A beta times the input signal x_i. Input signal x_i is at this point which is before the amplifier A. Now if A beta is made 1, then we get the feedback signal equal to the input signal.

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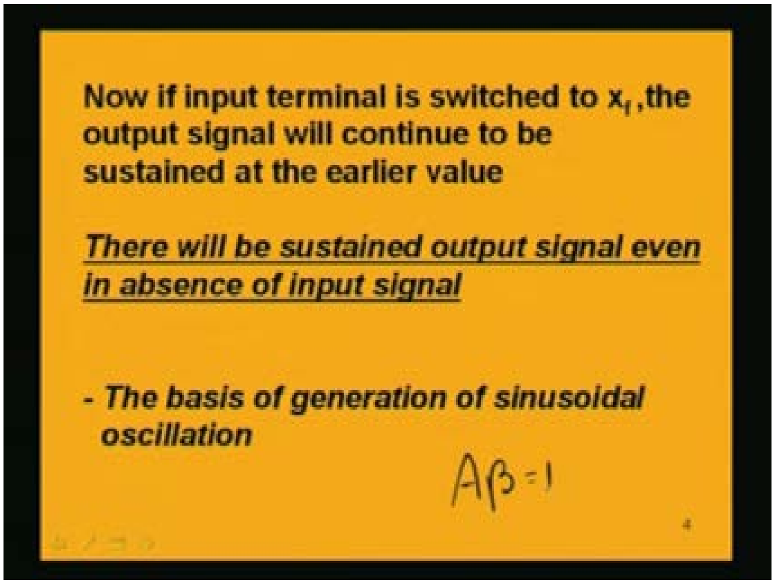

Now, if we switch the input terminal to x_f or the feedback signal then what happens? Here if we consider it like a switch and we are making this switch x_i closing it to x_f. That means this side is closed now.

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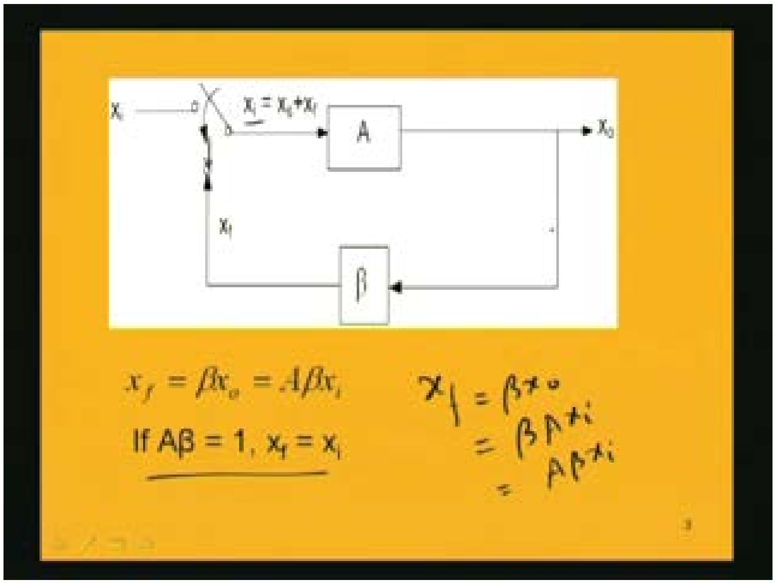

Then x_f and x_i are equal which means this block which is now a closed loop, it will give the output signal x_o and the signal which is x_i is equal to the feedback signal; same feedback signal that we are getting from the output is fed as input to the amplifier. So the output signal will continue to be sustained at the earlier value because the input signal is same as the feedback signal whatever the feedback signal we are getting from the output, the same feedback signal is given as input to the block A and that block is outputting the output signal x_o which is A times of x_i or A times of x_f.

We are now making the A beta is equal to 1. Then same feedback signal as input is coming and we are getting sustained oscillations or we are getting the output sustained at the previous value; it will continue to be the same output signal.

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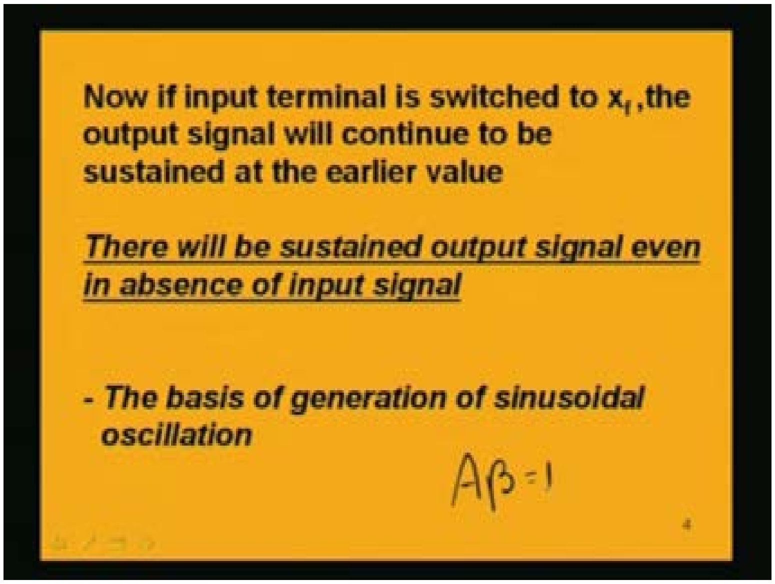

That is the basis of the generation of sustained output signal even in the presence of an input source or an input supply signal. The basis of this wave form generation is that we have to make the loop gain A beta equal to 1. This A beta equal to 1 means the product of the amplifier gain and the gain of the feedback network which we are going to use that product should give a value of 1 in this positive feedback amplifier.

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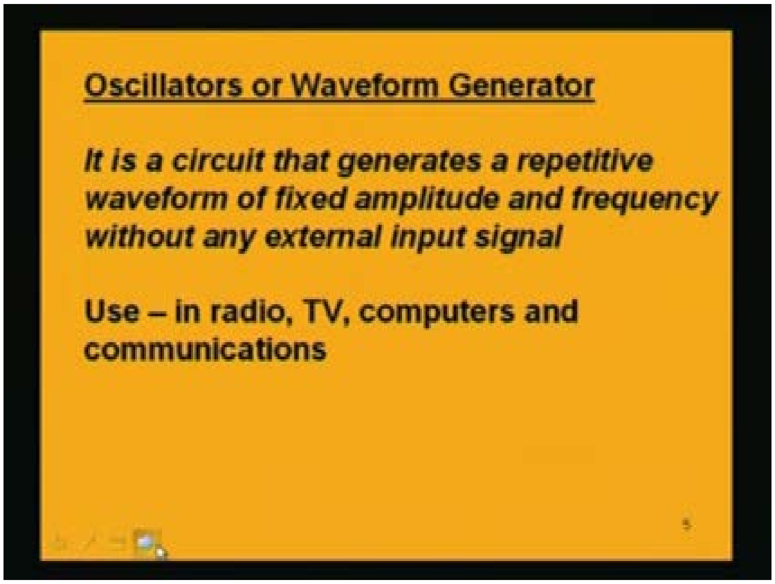

Now, the circuit which is generating the oscillations even in the absence of an input signal is generally known as oscillator or wave form generator and this circuit will be producing a repetitive wave form of fixed amplitude and frequency without any external input signal. That means we will get at the output a sustained oscillation of fixed gain or fixed amplitude and frequency even though there is no source at the input and this oscillator is used in many devices like in radio, TV, computers and communications; wherever we require such generation of a signal then we have to use this oscillator.

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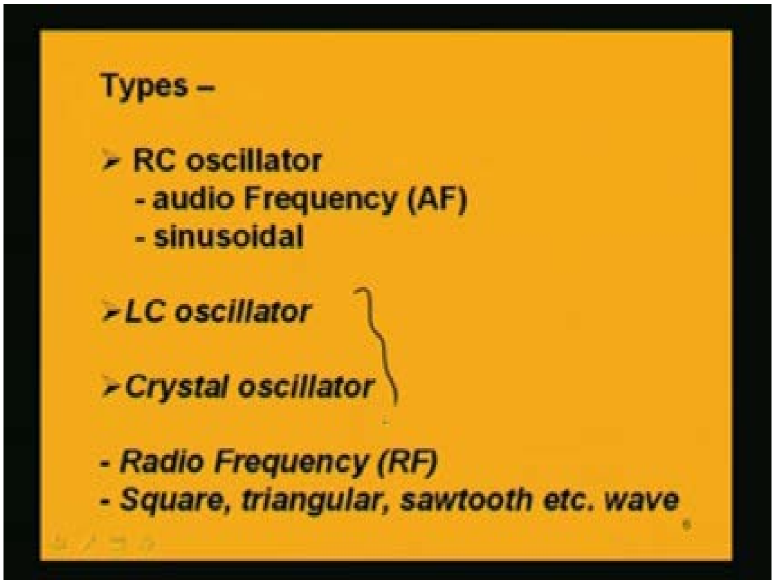

There are various types of oscillators. Depending upon the components being used they can be classified as RC oscillator, LC oscillator, crystal oscillators, etc. RC oscillator as the name suggests, is using R and C components, resistance and capacitance, and this RC oscillator is generally producing wave form at audio frequency that is 20 Hertz to 20 kiloHertz frequency range is the range of frequency that can be obtained in the wave forms and it will generate sinusoidal wave forms. In RC oscillator using this RC component along with an amplifier, there will be two components. The basic components are: one is an amplifier and the other is the feedback network and in that feedback network if R and C components are used, we will get RC oscillator which is the oscillator that gives the sinusoidal wave forms at audio frequency and there are other oscillators like LC oscillator where inductance and capacitance are used as well as crystal oscillators, where crystals are used.

Generally these two types of oscillators, LC and crystal oscillators are used for generating wave forms at radio frequency, which is a very high frequency. Wave form generation can be possible using LC and crystal oscillator and there may be different shapes that are possible using this LC and crystal oscillators which may be triangular, square or sawtooth wave forms etc.

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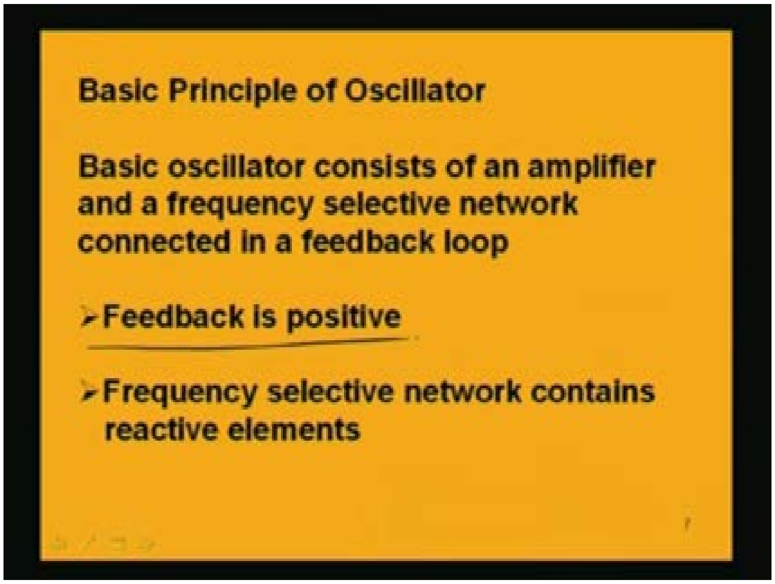

Now we will discuss RC oscillators which are used for obtaining wave forms at audio frequencies. So, the basic principle of oscillator as we have now got that the loop gain must be made to be equal to 1 and the circuit of the basic oscillator consists of an amplifier as well as a feedback network which is the frequency selective network. This frequency selective network is connected in the feedback loop and here one important thing to be remembered is that the feedback signal will be added positively. That means the feedback is positive; the feedback signal will be added to the input signal in a positive way and as there is a frequency selective network, this frequency selective network will use components which are not purely resistive. That means we will have reactive components in the feedback network.

The feedback network which is used for frequency selecting is a network which will be using components like resistance, capacitors which are not only resistive but has reactive parts also. Reactive components are also there, like capacitance in the feedback network. We again revisit the block diagram for representation of the oscillator.

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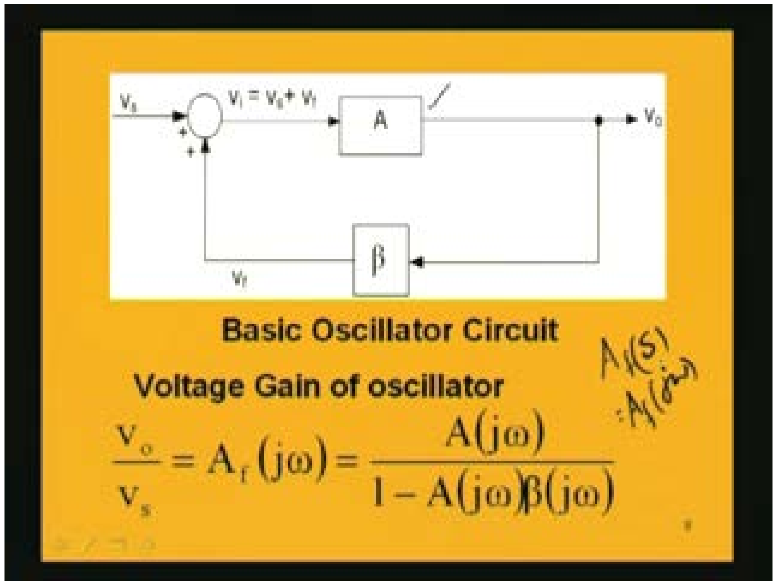

The main components as we have now noted is that one is the amplifier and generally we will use op-amp and here we will discuss oscillator using op-amp and apart from op-amp which is the amplifier having gain, say A, this is the block of this op-amp that is the amplifier. We will have in the feedback loop one frequency selective network which is denoted by this gain beta. So, in this loop the output voltage is V_o and this voltage is fed back to the input by this feedback network having the gain beta. The feedback signal which is obtained at this point after passing through this beta is V_f and that V_f is added positively to the input. The input signal which is obtained and passes through the gain A is V_s plus V_f that is the supply signal V_s and V_f.

We are now discussing a block diagram representation where we are showing a signal V_s just for easy analysis. But mind it that in this oscillator even in the absence of a signal, we will get the output wave form. But here we are considering a block diagram having a signal V_s for realizing the condition. If we consider the voltage gain, the voltage gain of the oscillator V_o by V_s, it is given by A_f and we are using a bracketed form j omega. That is A_f of j omega we are writing because the voltage gain of the oscillator will be dependent on the components which will have reactive components also. It will be written in frequency domain; that is why it is written as j omega. j omega is nothing but the quantity s. It denotes that it is a frequency domain quantity. We are writing $A_{f(s)}$. Basically $A_{f(s)}$ is nothing but j omega, omega being the frequency.

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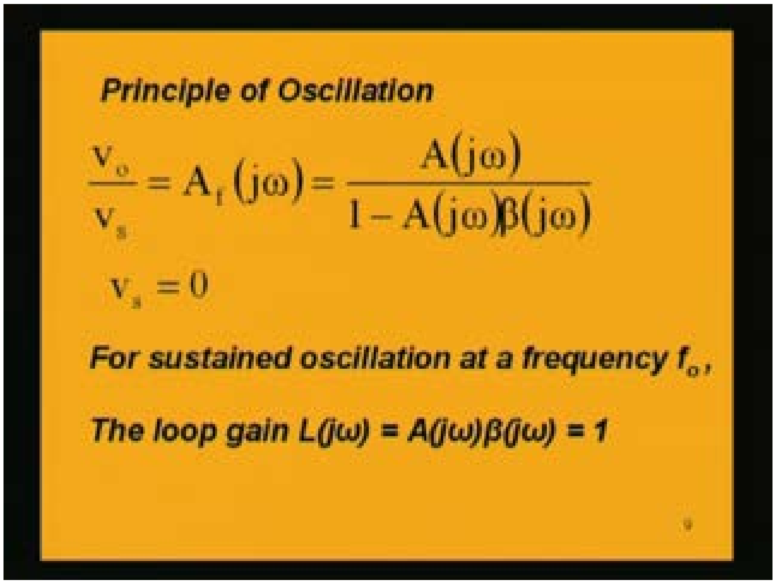

The principle of oscillation, as we have already found, should be such that the overall loop gain A beta must be equal to 1. Then even in the absence of a source or a supply, we will able to get output wave form being generated and so for sustained oscillations at a frequency say f_o that condition of A beta must be equal to 1. Then at that frequency f_o, where this condition is being met the output wave form, the sinusoidal wave form will be generated. Basically we have to find out that condition and from that condition we will arrive at the frequency of generation of the wave form. That is what we are going to derive today. Given an oscillator circuit which will generate the output sinusoidal wave form using RC feedback components, we will try to obtain that frequency of oscillation from our condition that the loop gain A beta must be equal to 1. Then only we will get the sustained oscillations at that frequency.

One point that may be coming to your mind is that without the presence of any input signal how can we generate an output wave form? Basically the starting point of generation is a very small voltage which is generated from noise. Because of the presence of the components like resistors and conductors, there will be random movement of electrons which will contribute to generation of an electrical noise. Although very small in magnitude, at a frequency omega$_o$ that will be the starting point of generation and after it is initialized, in the loop it will continue as a regenerative effect and the oscillations will be sustained by feeding back in that loop and continuing in that loop. But there is a starting point and that starting point is initialized from randomly obtained electrical noise and if we consider the power because something can be obtained at the expense of something only because we are not able to generate energy, only we are converting from one from to the other.

What we are spending here is the DC power because, the amplifier circuit whatever we are using is driven by a DC source. So, at the expense of the DC power only we are able to get the AC power. The electrical power that will be obtained for this waveform which is being generated that power it will derive from the DC power which is supplied. Only it will be converted from one form to the other.

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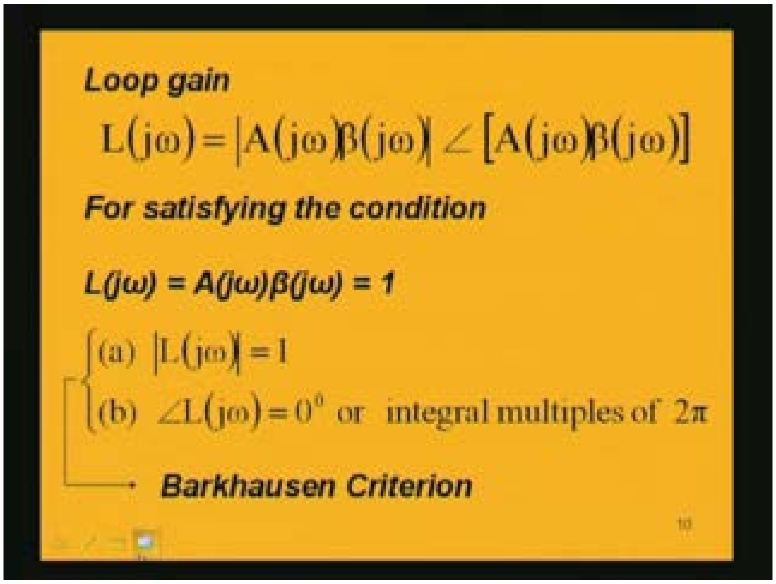

If we consider the loop gain, L jomega is A jomega into beta jomega and as it is frequency, the main term, we know there will be two components. One will be the real part and one will be the imaginary part which contributes to two physical parameters that is the magnitude of the gain and phase angle. The quantity L jomega or the loop gain A jomega beta jomega has one magnitude term and a phase term or angle term and that is denoted by these two quantities. The magnitude quantity is given by the magnitude symbol and the phase quantity or the angle quantity is given by this angle expression.

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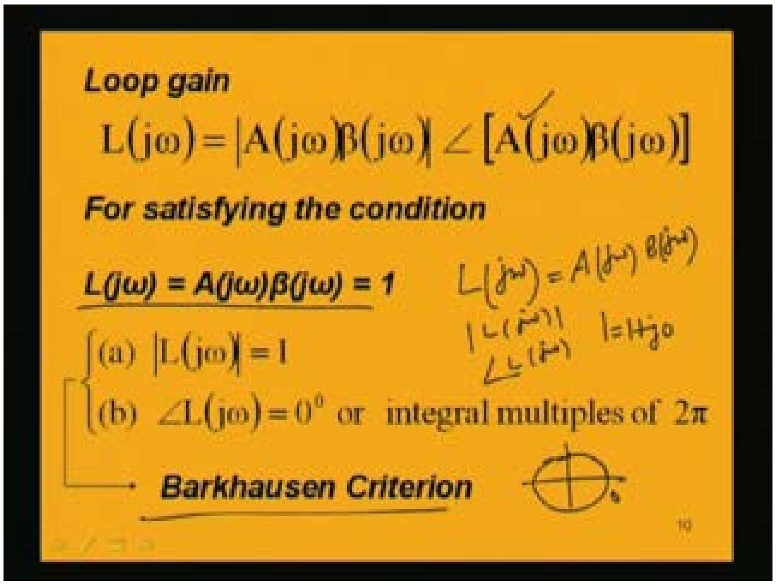

For satisfying the condition that A beta equal to 1, L jomega is A jomega beta jomega. As it has two components, one is the magnitude, L jomega, and one is the angle L jomega. That means magnitude of this A jomega beta jomega and angle of this A jomega beta jomega if this condition is to be made as it is a complex quantity having real and imaginary parts or magnitude and angle part, equalizing to 1 means equalizing to 1 plus j zero. Basically 1 is nothing but 1 plus j zero which contributes to a magnitude term of 1 and the angle if we consider the angle is zero; tan inverse of zero. That is imaginary by real part, zero by 1 is zero. So, tan inverse of zero is zero or integral multiples of 2 pi; because zero 2 pi, then all other integral multiples will have the same angle or same phase part. We will have to satisfy these two conditions that magnitude is 1 and the angle is zero or integral multiples of 2 pi because we know that if we consider the polar coordinates, zero will have tan zero and again 2 pi, 4 pi like that. So this condition is known as Barkhausen criterion. The criteria that magnitude must be equal to 1 and angle must be equal to zero or integral multiples of 2 pi that is given or this criteria is given by Barkhausen and that is known as Barkhausen criterion.

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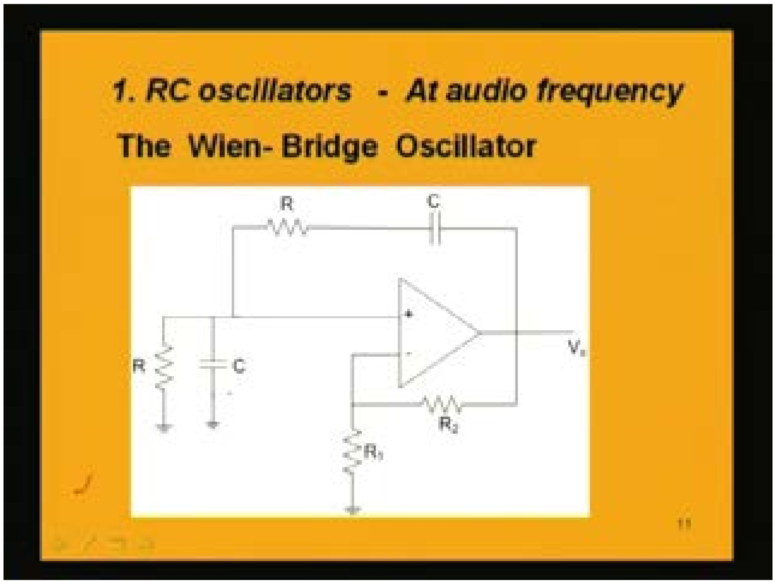

Now let us consider a practical oscillator circuit using op-amp and the frequency selective network or beta network as it is called. We are going to discuss about only RC oscillator that is using the components resistive and capacitance in the feedback network and using an op-amp as active device. We know that this oscillator will be producing or generating sinusoidal oscillations at audio frequency. One example of this RC oscillator is Wien bridge oscillator.

The circuit diagram for Wien bridge oscillator is shown here. Here this is the op-amp which is having a gain say A and here as the connection of this op-amp is showing it is an amplifier which is a non-inverting amplifier because the negative terminal if you see that resistive network is connected which is composed of R_1 and R_2 and at the positive terminal we are getting a feedback voltage which is coming from the output V_o by the network having these components R and C here and here. In this circuit we are having two basic things as required. One is the op-amp and the other is the feedback network and the op-amp is connected in the way of a non-inverting amplifier.

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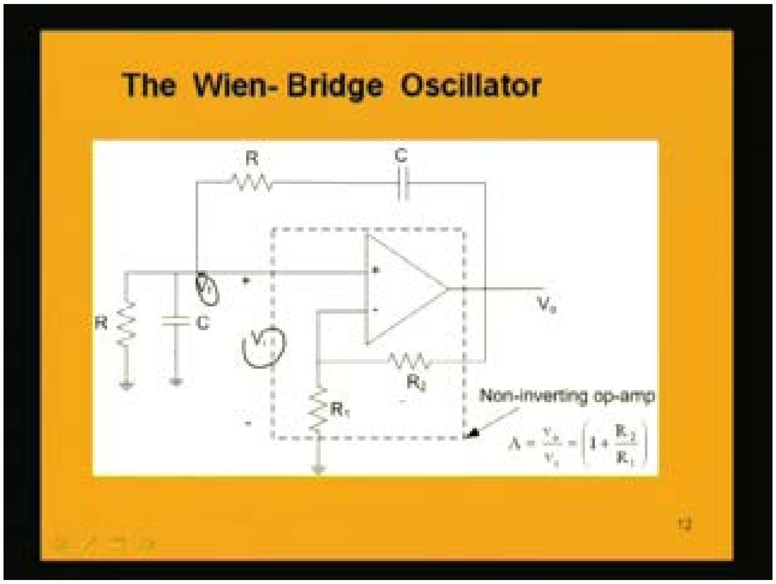

If we see only this op-amp part, the non-inverting amplifier part, here let us consider the voltage here which is coming from the output via this feedback network as V_f. That V_f is the input voltage to this op-amp because at this point this voltage available is V_f, which is the feedback voltage from V_o and that is the input voltage given to this non-inverting op amp at the positive terminal and the feedback is added positively to the op-amp. You can see that this positive terminal is having the voltage V_f, so, it is a positive feedback example. If we consider only this dashed part which is a non-inverting op-amp, it is a having a gain A which is V_o by V_i and as we know already non-inverting op-amp has a gain of 1 plus the feedback resistance R_f by R_1 and here we are using the feedback resistance R_2 and so the gain will be 1 plus R_2 by R_1. That is the gain of the of the non-inverting amplifier part.

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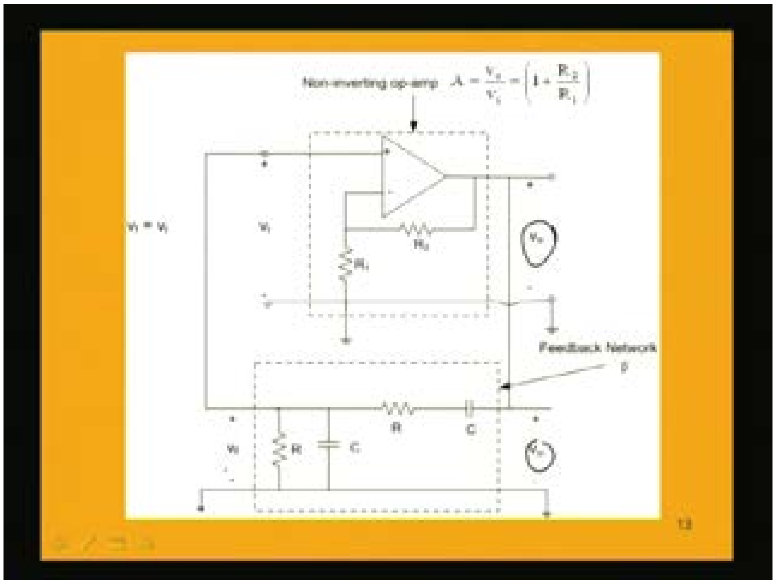

Now we redraw the circuit and try to understand it. How the feedback is being obtained and how it is being added up to the input? Let us redraw it again and we are showing the op-amp having the non-inverting connection and the feedback network separately by this dashed block. Here the non-inverting op-amp is this portion, where the output voltage obtained is V_o, input voltage is V_i and this R_1 and R_2 are the resistances which are connected to this op-amp. The V_i is actually coming from the feedback voltage and that feedback voltage is obtained by this feedback network which is obtained using R and C components and the R and C components are arranged in this fashion.

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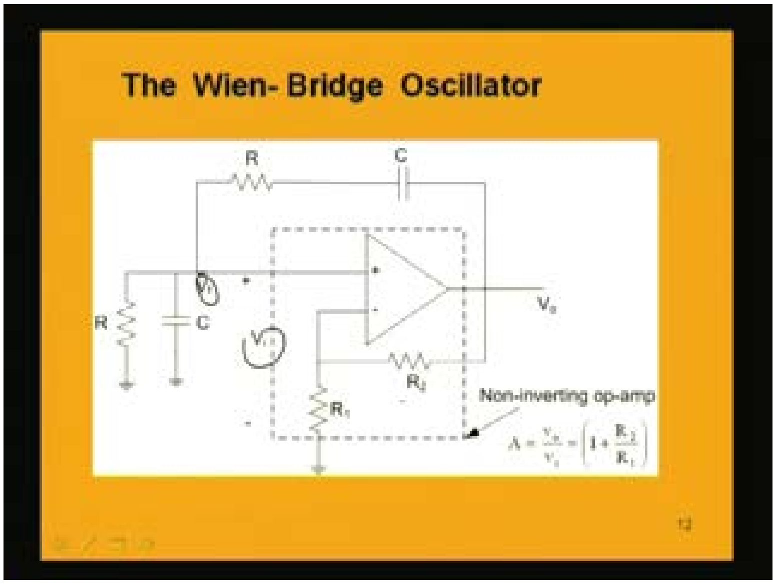

The same network which we discussed here we are just drawing it separately again for easy understanding. If we consider this point and see the connection that is the feedback voltage V_f is obtained at this point which is the input to this non-inverting op-amp and this R and C is in series and this R and C are in parallel. So, the point of connection is here and that is here (Refer Slide Time: 30:21). This R and C are in parallel and this R and C are in series. This point is ground, this point is ground. So, this voltage V_o is the voltage which is fed back by this whole network of feedback and added positively to the op-amp. Now we can find out what will be the feedback voltage because as we have this resistance and capacitance network which can be simplified to obtain the voltage feedback V_f in terms of the output voltage V_o. So, let us do that.

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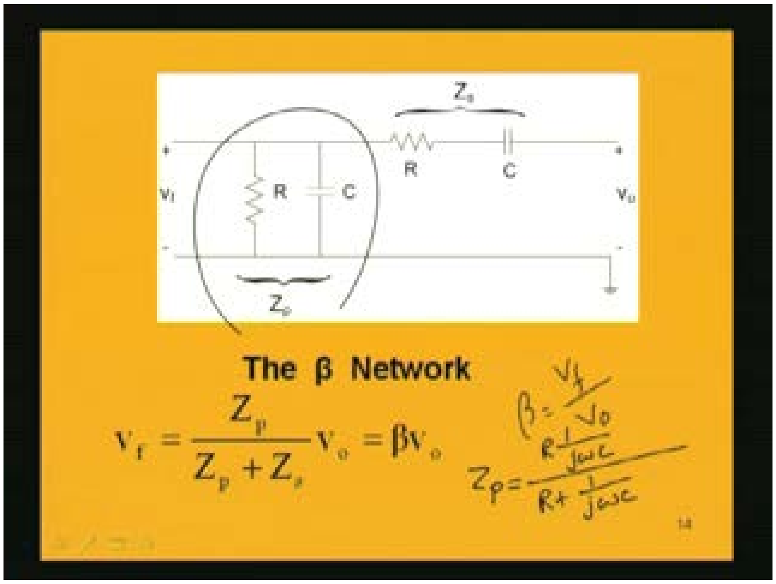

We will find out what will be the feedback voltage? Let us draw this feed back network alone having the resistance, capacitance and this network is having the resistance R and C which are in series and this R and C are in parallel. We are naming the series resistance and capacitances having series impedance Z_s. The two parallel ones that means resistance R and capacitance C which are in parallel they are contributing to an impedance Z_p. This is the feedback network alone. Voltage which we are having as input to this feedback network is V_o and it is outputting the voltage V_f. So, this is input and this is output basically for this feedback network.

What will be the output voltage? If we consider input as V_o what will be the output, V_f? This is very simple because the voltage division is taking place and the voltage V_o is divided into two components as per voltage division. So, the voltage which is available across this parallel impedance, that is our interest, which is V_f. What is V_f? V_o into Z_p divided by Z_p plus Z_s and Z_p by Z_p plus Z_s that is the beta or the gain of the feedback network. Because beta is nothing but V_f by V_o, output V_f by V_o is the gain of the feedback circuit and that is denoted by beta and if we find out from this voltage division, V_f by V_o is equal to Z_p by Z_p plus Z_s.

Now we are writing Z_p and Z_s in terms of the resistance and capacitances. What is Z_p? This parallel impedance between R and C is equal to R into 1 by jomega C by R plus 1 by jomega C because these two are in parallel. So, R into 1 by jomega C by R plus jomega C is Z_p.

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Similarly we can get the series impedance between R and C. As they are in series it is simply R plus 1 by jomega C. so we can now simplify the beta which is equal to Z_p by Z_p plus Z_s.

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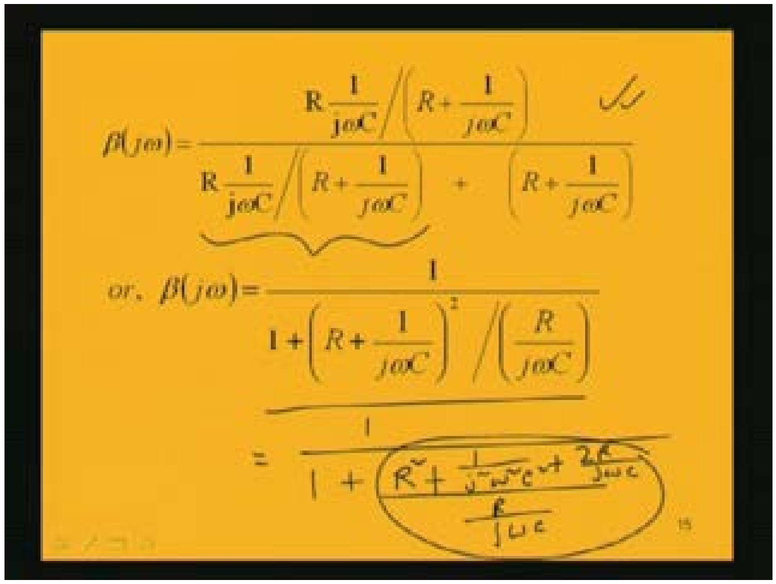

Replacing the term Z_p and Z_s here, we get Z_p equal to R into 1 by jomega C by R plus 1 by jomega C and Z_p plus Z_s in the denominator. So, Z_s is R plus 1 by jomega C. So, this is the whole expression for beta. Now to simplify this expression we just multiply both numerator and denominator by the term R into 1 by jomega C by R plus 1 jomega C inverse. That is we want to get rid of this term. So, I am going to multiply it by the reciprocal of this term. So, the numerator will be 1 and this part will be 1 plus this part has to be multiplied by R plus 1 by jomega C divided by R into 1 by jomega C. So, the whole expression will be 1 by 1 plus this will be square and divided by R by jomega C.

So, we have to now concentrate on this expression. We want to basically find out that frequency at which the condition of Barkhausen criteria will be met. For that basically what we want is that A beta should be equal to 1. This expression can be further simplified because we can now just expand this term. That will be equal to 1 by 1 plus this denominator, denominator has this part, square. So, it will be R square plus 1 by j square omega square C square plus 2 R by jomega C divided by R by j omega C. We again multiply the numerator and denominator of this lower term, this term by jomega C by R.

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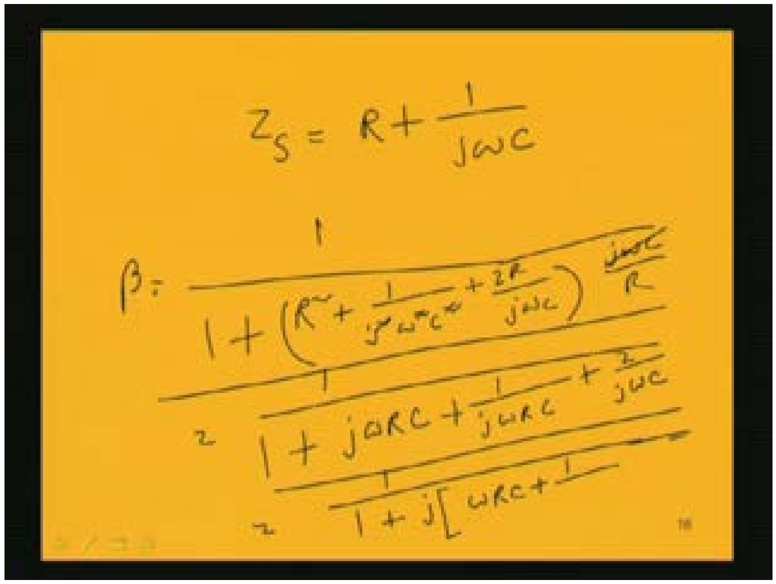

Then we get beta equal to 1 by 1 plus this term will be R square plus 1 by j square omega square C square plus twice R by jomega C into jomega C by R. So, we get finally 1 by 1 plus if we multiply this it will be jomega RC plus this 1 by jomega square means minus 1 or we can cancel one term here. So, it will be 1 by jomega RC plus this R and this R goes; so, 2 by jomega C. We can write finally, j can be taken to be common and it will be omega RC plus 1. If I multiply by j that is if we take common this j then 1 omega RC or even if we rationalize the lower term, then we can get finally that beta term will be equal to 1 by 3 plus j into omega RC minus 1 by omega RC.

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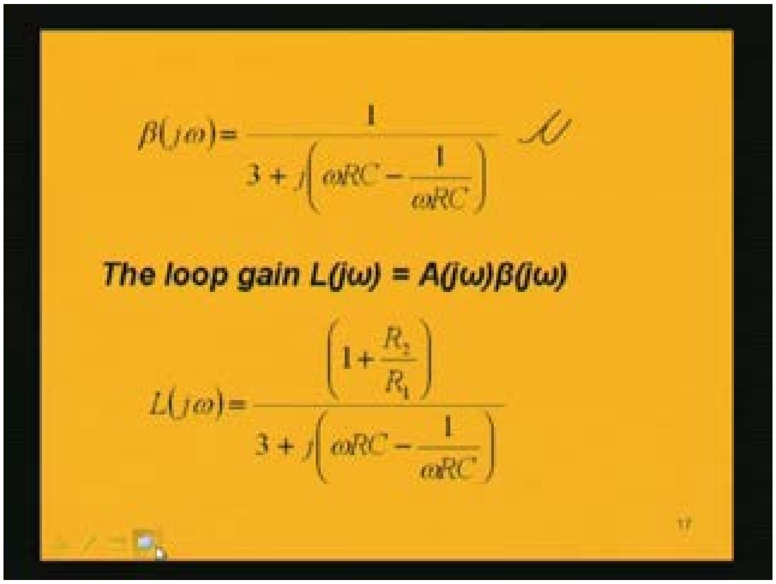

This you can obtain by simplifying this expression for beta (Refer Slide Time: 38:55). If we now see the expression for beta, we want to achieve that A beta equal to 1 or the loop gain should be equal to 1. What is A into beta that I will substitute. A is the gain of the non-inverting amplifier and 1 by 1 plus R_2 by R_1 that is the gain of this non-inverting amplifier A. So, 1 plus R_2 by R_1 into this term so this is the loop gain.

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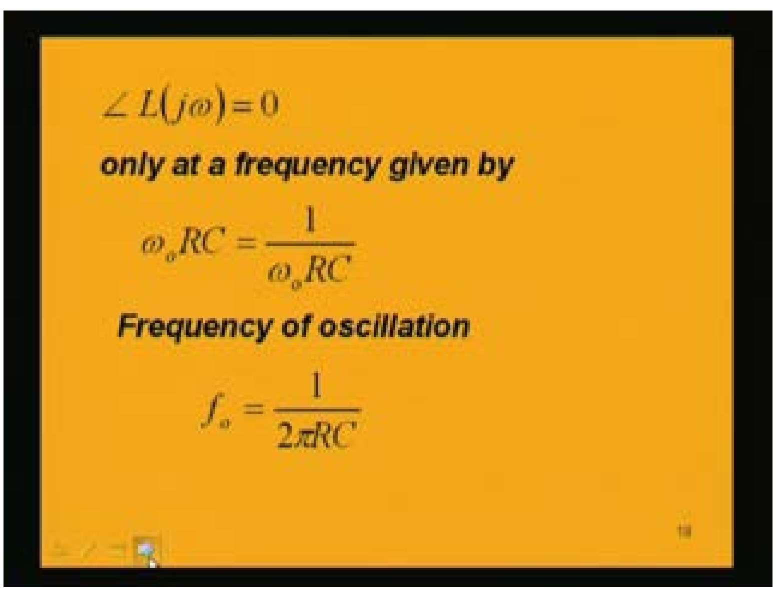

If we have to satisfy the Barkhausen criterion, then our criteria is that we have to get the angle as zero and we have to get the magnitude as 1 at the particular frequency; that frequency we have to obtain. First of all applying this criterion that we have to get angle to be equal to zero, if we look into this expression this angle is what?

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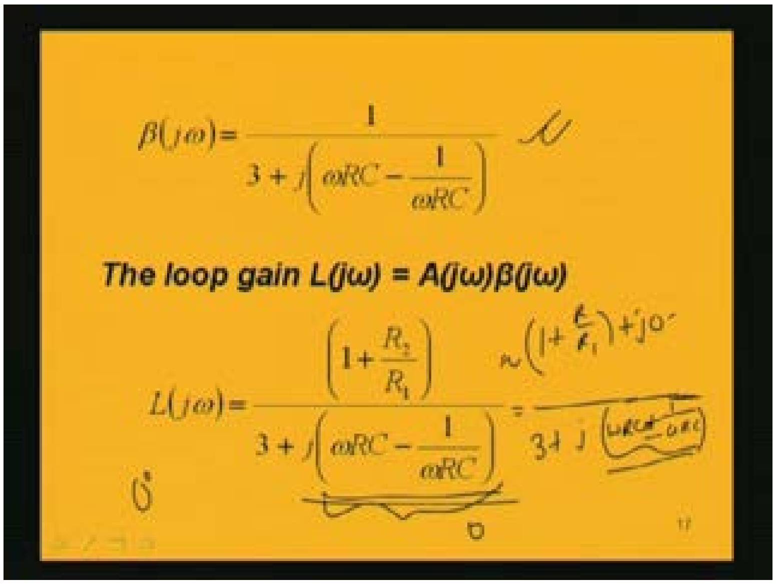

This angle if we find out the numerator term has tan inverse. This term has a zero angle and the denominator term has an angle of tan inverse. If we consider this angle here what is this angle? It is basically 1 plus R_2 by R_1. This is the real part and the imaginary part is zero and here it is 3 plus jomega RC minus 1 by omega RC. If the angle has to be made zero then this part has to be zero because then only we will get overall zero angle because the numerator has already zero angle. Tan inverse of zero by this is zero and the denominator has an angle of tan inverse of this part divided by 3. But that value will be zero only when this whole imaginary part component has a zero value. That means the criteria which is to be satisfied is that this part will have to have a zero value so that overall angle becomes zero.

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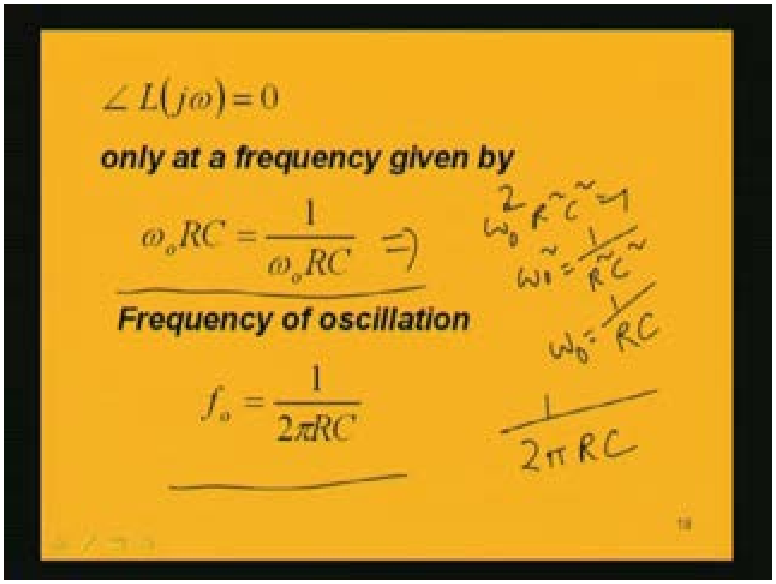

Putting the condition that at that frequency where it will be met, let us name that frequency as omega$_0$; so, at that frequency omega$_0$, the imaginary part must be equal to zero in order to contribute to zero angle to meet the Barkhausen criterion. To get that condition if that term has to be made zero, that means if this has to be made zero, then omega RC must be equal to 1 by omega RC. At a particular frequency omega$_0$, we must have this condition that omega$_0$ RC equal to 1 by omega$_0$ RC and that gives the frequency of oscillation as omega$_0$ can be found out; omega$_0$ square R square C square equal to 1; this is the condition. From that we can find out the frequency of oscillation. The frequency of oscillation omega$_0$ square is equal to 1 by R square C square. So, omega$_0$ is equal to 1 by RC. If we consider the frequency only, not in angular frequency, so frequency is in Hertz or kiloHertz we have to divide it by 2 pi. So, 1 by 2 pi RC; that is the frequency of oscillation at which the condition is met.

We have to get this condition at this frequency and if this frequency is giving that condition then we have to meet the magnitude criteria also at the frequency.

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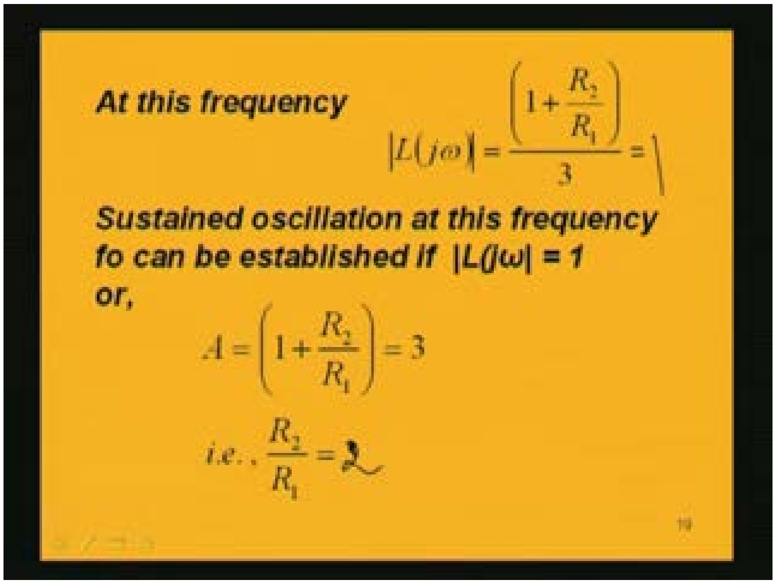

What is the magnitude of this loop gain? If we consider the magnitude now for this frequency because this part is zero (Refer Slide Time: 43:31), at this frequency f_o so the magnitude will be simply 1 plus R_2 by R_1 divided by 3. This is the loop gain magnitude. Loop gain magnitude L jomega is equal to 1 plus R_2 by R_1 by 3. We know that this has to become 1 in order to give sustained oscillations. Keeping that condition in mind now let us make this whole magnitude term equal to 1. That means 1 plus R_2 by R_1 must be equal to 3. If this has to made 1 then 1 plus R_2 by R_1 is equal to 3. What we get now finally R_2 by R_1 is equal to 3 minus 1. R_2 by R_1 is equal to 2. If we have to get sustained oscillations at a frequency using that Wein bridge oscillator, then the op-amp which we are going to use in the non-inverting configuration must have the resistance ratio such that R_2 by R_1 must be equal to 2. We can take R_2 is equal to 2 times of R_1. So, that will be the criterion which has to be met in order to get the sustained sinusoidal oscillations using Wien bridge oscillator.

Now we consider another type of oscillator. Phase shift oscillator is another type RC oscillator.

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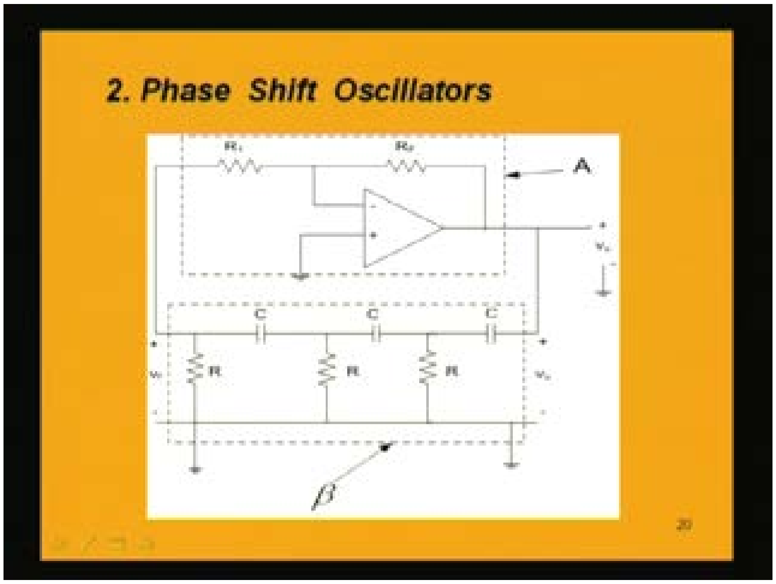

Here the name phase shift is given because the criterion which is satisfied here is that 360 degree should be the angle of the loop gain. A beta must be having an angle of zero or integral multiples of 2 pi. So, here angle is taken as 2 pi; 360 degree or zero means the similar thing. Here what is the principle of operation or principle which is followed in this phase shift oscillator is that 180 degree phase shift is obtained by the amplifier and then another 180 degree phase shift is obtained by the feedback network.

Overall phase shift or overall angle will be 360 degree for the whole oscillator and the configuration of this phase shift oscillator is the use of R and C only as it is an RC oscillator and here the op-amp which is used is having an inverting type of configuration. This is the difference from the earlier one. So, here is an inverting configuration. This is having the voltage here at the negative terminal and this voltage is the feedback voltage which is obtained from the feedback network having this gain beta and here the configuration of this feedback network is similar configuration, using R and C as shown here.

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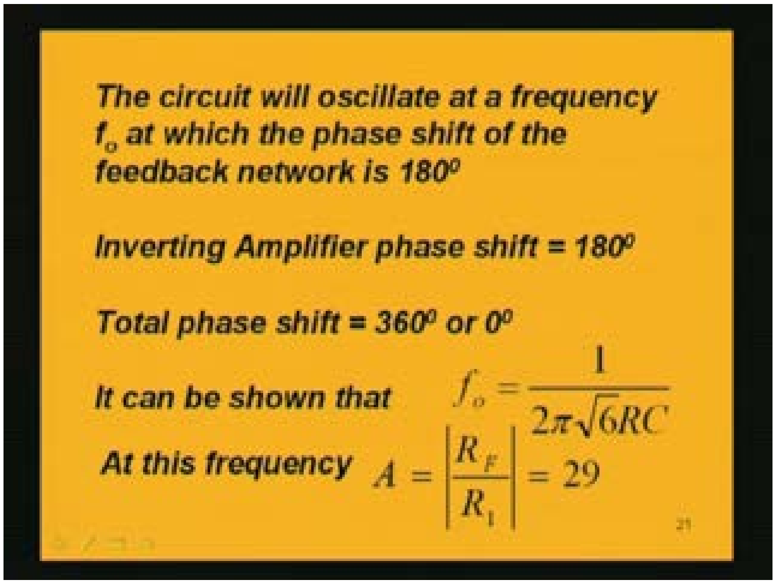

This oscillator circuit will be oscillating or will be causing oscillations at a frequency f_o at which the feedback network has a phase shift of 180 degree and inverting op-amp is already having 180 degree phase shift. Total phase shift is 360 degree or zero degree; that is the principle which is followed here. Now we can easily show that the frequency at which we will be obtaining the 180 degree phase shift is f_o and that f_o is 1 by 2 pi root over 6 into RC.

This can be obtained by considering this circuit (Refer Slide Time: 48:13) and finding out the feedback network gain V_f by V_o that is equal to beta. For finding the value of beta, we have to consider this feedback circuit alone and we can use Kirchhoff's current law, because here as you can see that at this junctions or nodes we have different voltages available. Because this is the input coming to this feedback network and this voltage here, this voltage here and this voltage here if we go on finding out by using Kirchhoff's current law or the node equations, we can show that finally the value of beta whatever we will be obtaining that feedback network gain, beta will be having 180 degree phase shift. We know that the inverting op-amp configuration that is being used here is having already 180 degree phase shift, because the output voltage is having a negative sign minus R_f by R_1 is the gain of the inverting op-amp. Here inverting op-amp is used.

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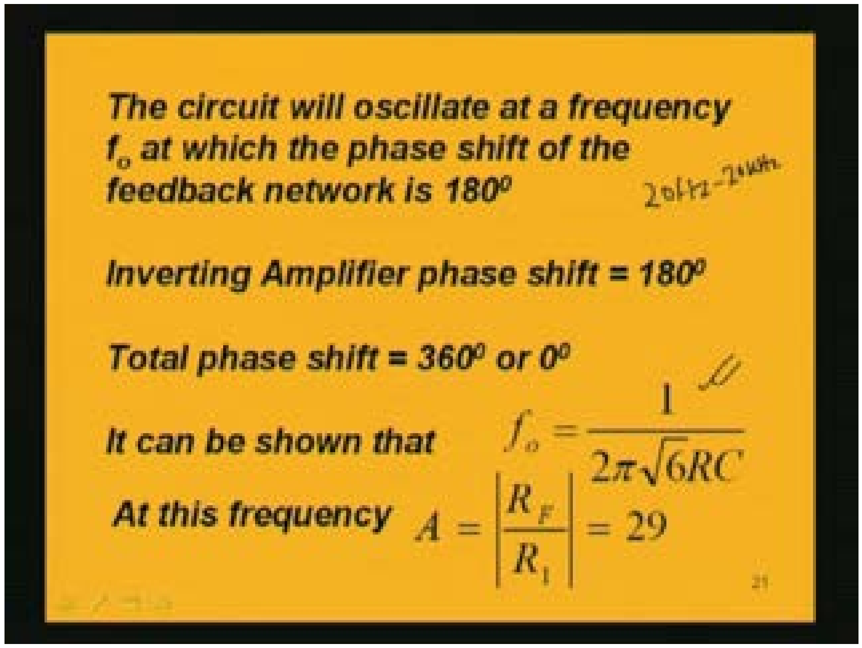

The overall oscillator will have a 360 degree phase shift and that frequency at which we obtain this 180 degree phase shift for the feedback network can be shown to be equal to 1 by 2 pi root 6 into R into C and at this frequency the gain of the op-amp can be shown to have a value of 29; that is R_f by R_1 magnitude if we consider because already phase will be 180 degree that means it will have a negative sign, but if we consider the gain only that gain will be 29. So, in this phase shift network we also get the sinusoidal oscillations or sustained oscillations and the frequency of oscillation is only audio frequency. That is we get 20 Hertz to 20 kilo Hertz frequency of oscillation in this type of oscillator using RC network.

If we want to get very high frequency oscillations at the output then we have to go for LC or crystal oscillators because crystals we will have to use for getting the radio frequency oscillations. This type of oscillator which we are discussing till now that is RC type of oscillators can only generate the audio frequency oscillations and the main principle as we have seen here is that it is a positive feedback oscillator where we add the output voltage by a feedback network to the input where the output voltage is added positively to the input and it is regenerative in nature. That is why we are able to get the output even if we do not have any source at the input. As I have mentioned that the starting point of oscillation will be noise voltage only but once it is initialized with a very small noise voltage it can go on regeneratively and it will give the output voltage at constant magnitude.

What is assumed here is that we are making A beta exactly equal to 1. That means if the value of A beta magnitude is less than 1 or greater than 1, we will not be able to achieve that sustained oscillations. What will happen if we are not getting exactly 1 but it is less than 1? Suppose A beta is equal to say less than 1 we are getting then the oscillations will die out. It will not be sustained with constant amplitude but it will be dying out. But if A beta is greater than 1, then the magnitude of the gain will increase and finally it will reach saturation and that is why we have to maintain the value of A beta as 1. But this is one difficult situation to meet practically because of the deviations occurring in the resistance values etc., or due to temperature or other effects. Even though we have designed it to give you the value of A beta equal to 1, it may not be maintained afterwards because of the environmental factors present. That is temperature, etc., may change the values of the resistances or other components that we have selected. Basically it is a difficulty in maintaining the value of the A beta equal to 1. So it is not so simple circuit as we have shown here.

There has to be some compensation for the practical difficulties and that is why we have to go for other adaptive methods for maintaining the oscillations in a sustained manner and preventing them from dying out or even going into saturation. So there are basically improving methods but we are only discussing the basic oscillator circuit from the principle of operation that is the principle which we have to maintain. But practical circuits may have other improving methods to maintain it at a constant sustained oscillation or constant magnitude oscillations at a particular frequency.

The circuit which we discussed today is about generation of sinusoidal oscillations using a very important criterion called Barkhausen criterion and the basic principle is that we have feedback which is positive in nature. This is positive feedback mechanism which is finally giving the sustained oscillations and these oscillations or the sinusoidal waveforms which we generate via this type of oscillators are useful in various applications where you have to use audio frequency sinusoidal oscillations; for example TV, radio and many other circuits and there are other types of oscillators. But we only have to remember the basic principle of Barkhausen criterion and then we can very easily solve the circuit to give us the required sinusoidal oscillations.