Lecture – 06
Electronic Modules for Industrial Applications using Op-Amps

Welcome, to this module and this is in continuation with our last module. So, the idea here is that, we are looking at the summary, of indicator circuits, MOSFETs, op- amps, and their applications. The reason of revising this particular slide is that, we can use the, the knowledge that we acquire, either in the last course, or in the present modules for practical applications of op- amps. So, to understand the op amps, we need to understand the theory of op amp. Right? And that's why we are looking at the characteristics, and the parameters, of the op amps. So, in the last module what we have discussed, we are discussed, oscillators. Right? And in oscillators, we have seen that there are several kind of oscillators depending on the wave forms, depending on the frequency, depending on the components used, depending on the feedback, and then we have also seen the Barbizon criteria. Right? Where we require, the mode of a into beta, that is gained into feedback factor, should be greater than equal to 1 or, end actually not or its end. The phase shift, that is the output signal, that is feedback to the input, the phase of that output signal, that is fed back to the input, should match the input signal phase .Right? That means that feedback phase should be 0 or 360 degree, then after that we have seen RC oscillators. Right? So, an oscillator, we have seen, RC facing oscillator, how we can how, we can phase shift of, 180 degree signal, from the output of the inverting amplifier using RC network. And then we have also seen when we just later where, where there is no need of phase shift, and that RNC, which has a frequency sensitive arm by, changing the value of RN C, we can change the frequency. Right? So, we have also discussed that, the if I ,if I, if I go and use LNC, instead of RNC, that means inductor and capacitor then the oscillators, can be used for high frequency applications. Right? So, what are high frequency applications? And how, we can design LC oscillator? So, let us see today, how we can design LC oscillators. So, if you see

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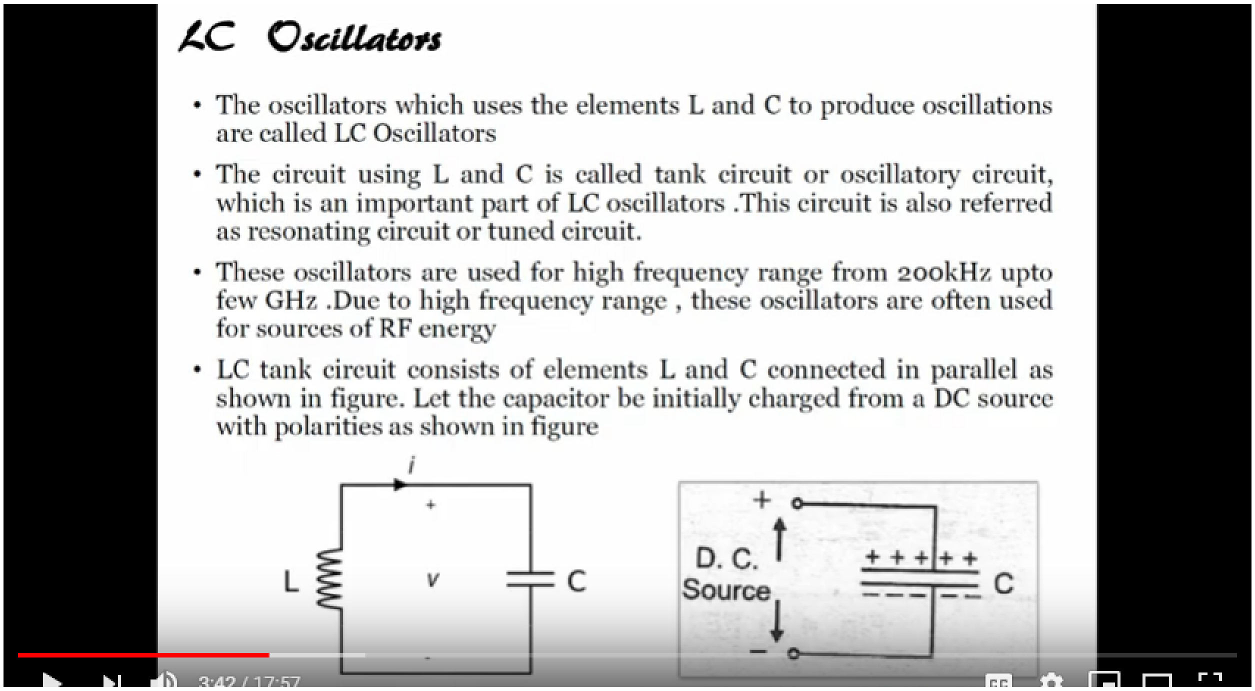

on the screen, what you see that, the oscillators which use the element l and c, to produce oscillations, are called, 'LC oscillator'. The circuit uses L and, C in is called, 'Tank or circuit or oscillator circuit', which is an important part of, LC oscillator. This circuit is also referred to as resonating or tuned circuit. Right? So, you can see on the left side, L inductor, and capacitor this is a circuit used for oscillation, in the LC oscillator this, oscillators, are used for high frequency range like, we discussed from 200 kilo, Hertz to few key gigahertz. Now, since the frequency range is high, these oscillators are also referred as, RF or sources, for RF energy, or resources of RF energy, LC tank oscillator circuit consists of L and C, connected in parallel as shown in the figure, let us let the capacitor we initially charge from a DC source, which polarity as shown in figure so, supposedly C source, is there and we are charging the capacitor in the polarity shown in figure, what will happen Right?

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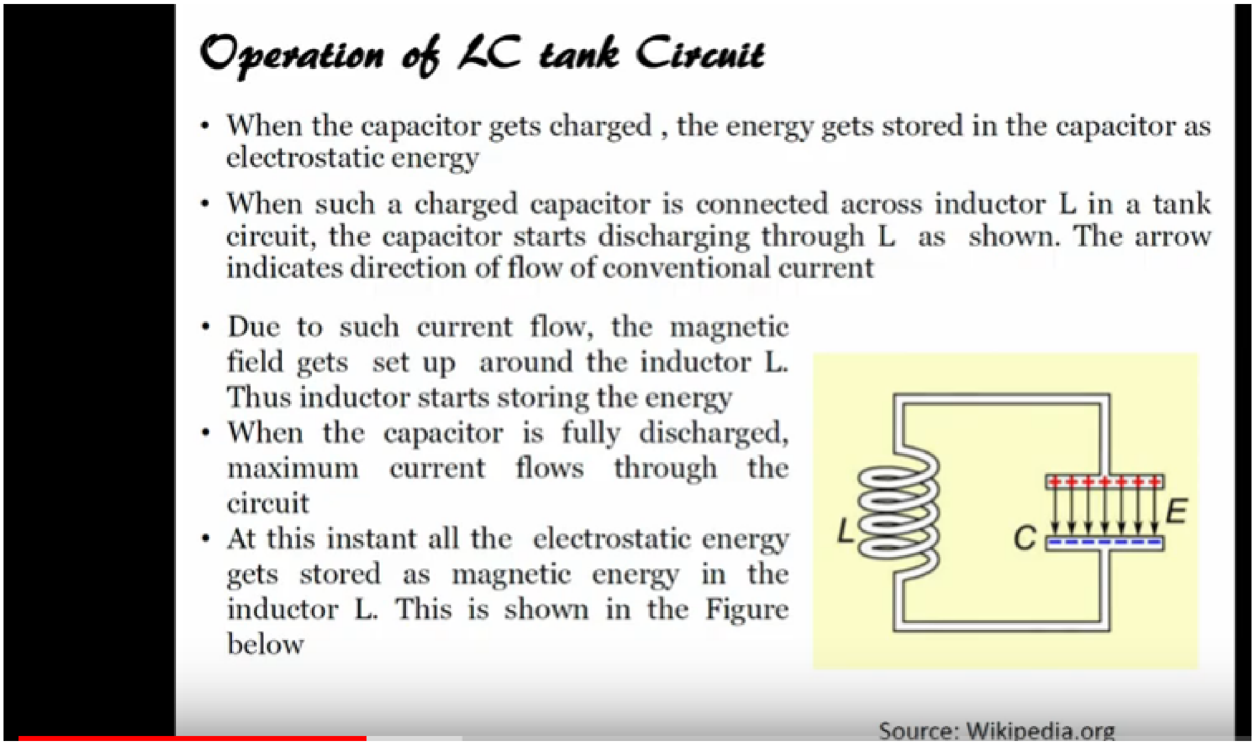

So, when the capacitor discharges when the capacitor discharges, the energy that is stored in this capacitor. Right? When the capacitor charge is let us said first when it charges what happens so, any charge is the energy stored in the capacitor is a electrostatic energy. Right? And when such a capacitor is connected across an inductor, then what we'll have, what will happen? The capacitor will start discharging so, when it starts discharging, through L. Right? The magnetic field cell gets set up, around the inductor, and thus inductor starts, storing the energy. Right? So, when capacitor is fully, discharged maximum current flows, through the circuit, at this instant all electrostatic energy is converted to magnetic energy, or stored as a magnetic energy, in the inductor.

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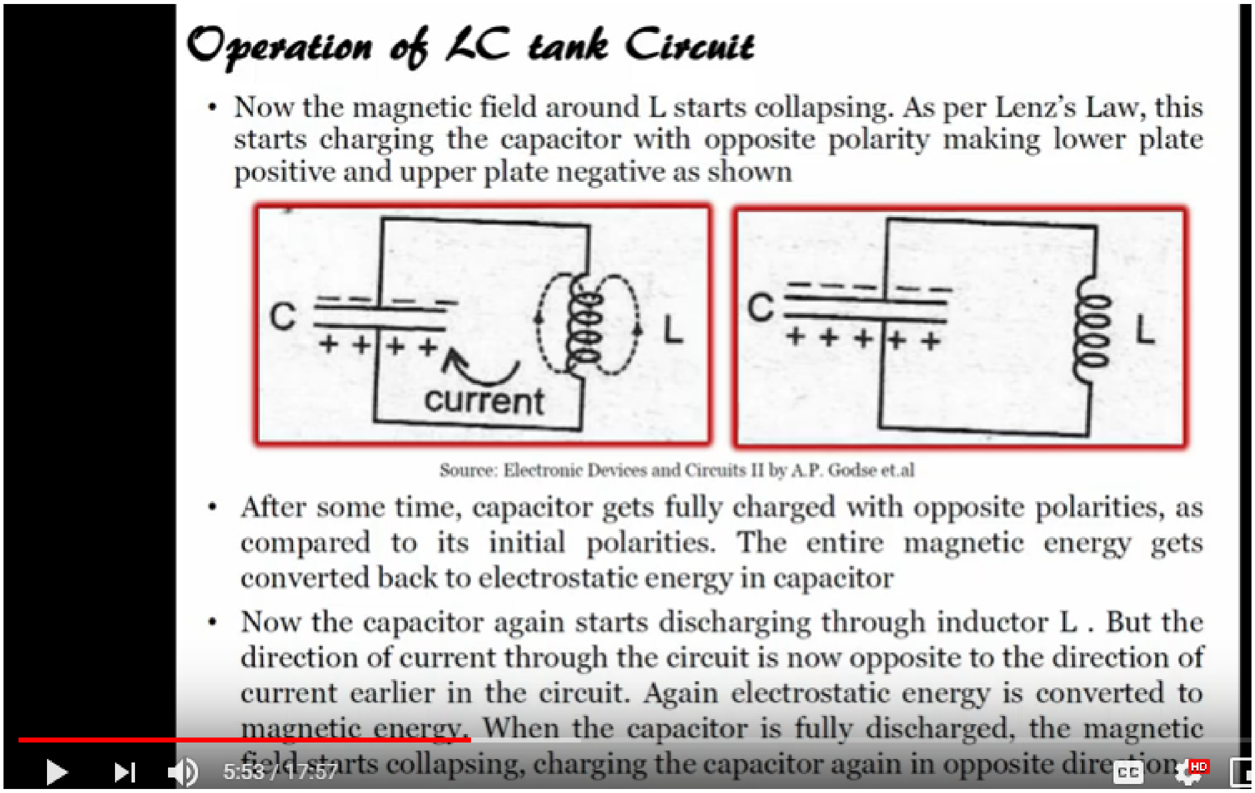

Now, when the magnetic field around L starts collapsing, what will happen? As per Lenz law, this charge charging the capacitor with the opposite polarity. Right? So, now when this charge this starts collapsing, the capacitor will start charging in the opposite polarity. Right? Making lower plate more positive and upper plate negative. Right? Now, again after some time when capacitor fully gets charged, it will start discharging, and with the opposite polarities as compared to its initial polarities. Right? Initially it was plus on the top plate, minus and then bottom plate, now it is plus on the bottom plate, minus on the top plate so, now it is discharging with the opposite polarity compared to its initial polarity, and the entire magnetic energy gets converted to electrostatic energy in capacitor Wow, that is earlier we have seen and now, the electrostatic energy, when it starts discharging is converted to magnetic energy once again. Right? So, it is from when inductor discharges, it is electrostatic energy that is stored in the capacitor where the capacitor discharges, in the magnetic energy that is stored in the inductor. Right? And this keeps on, this keeps on, continuation until end and because, of this what will happen? What will happen? That

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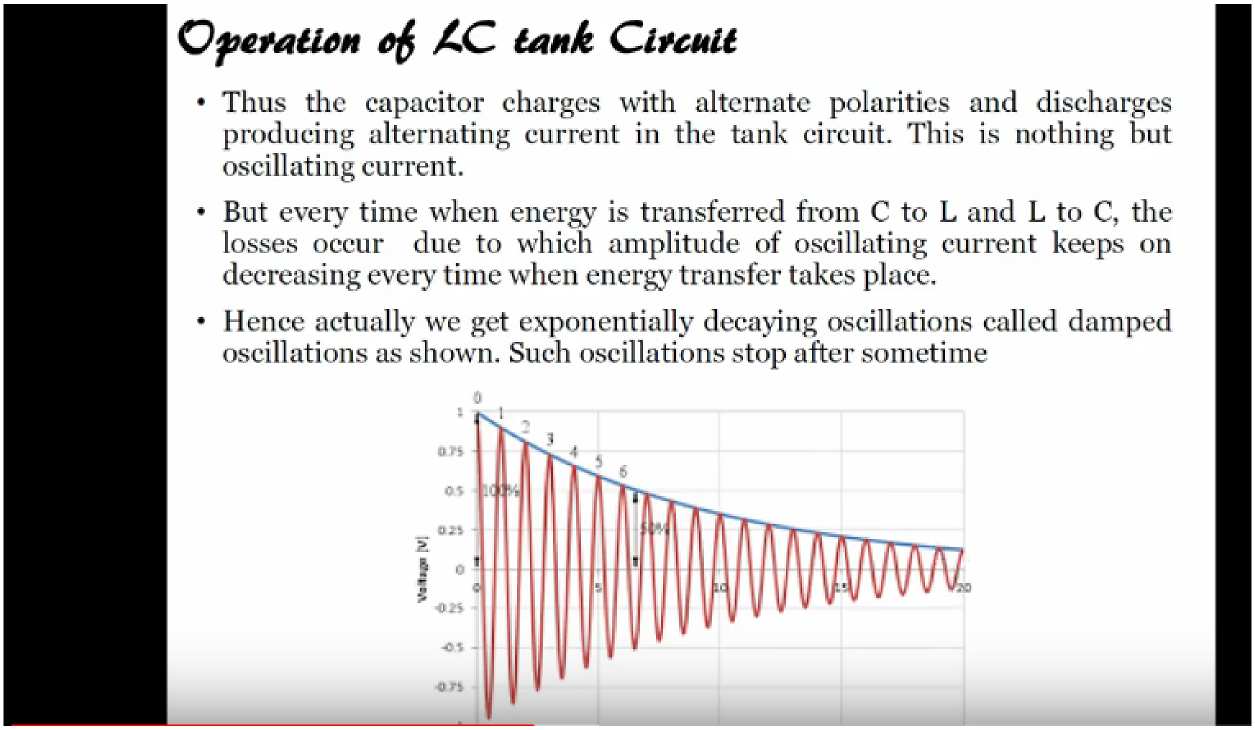

Every time, when this transfer of energy occurs. Right? There is a loss, and this loss causes the amplitude of the oscillating current decreasing, see this loss because, of the inductor charging, and capacitor discharging, and capacitor charging, and inductor discharging, and again this goes on continuation what happens? Every time this discharge and charging happens, there is a loss in the circuit and this results in the lower oscillation amplitude of oscillations, gets down as you can see here, and current keeps on decreasing. Right? So, actually we get an exponential decay as you can see, from the figure oscillations and these are called damped oscillations, these are called the damped oscillations. Right? So, such oscillations stop after some time of course. Right? So, initially, you can see, and then it's after some time you can see, that these oscillations are on the edge of dying. Right? And the edge of dying.

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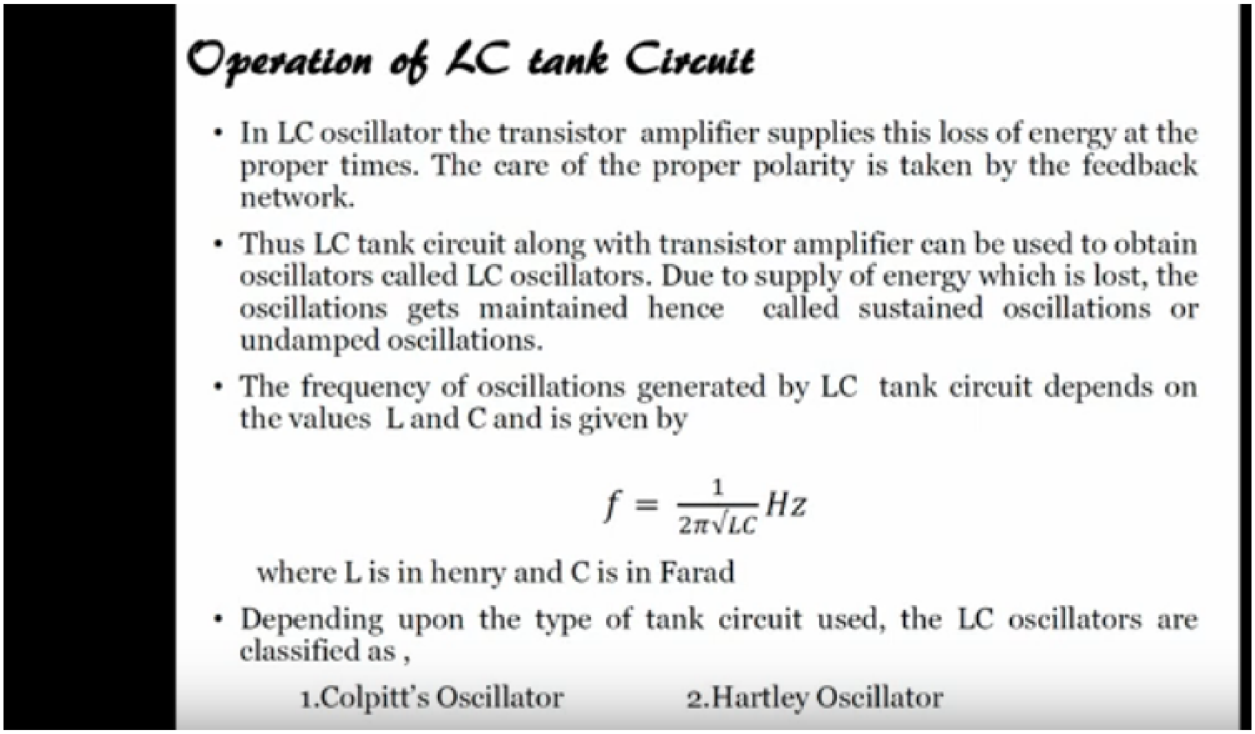

So, what will be what we can do? Right? What we can do? So, in LC oscillator, the transistor amplifier supplies, this loss of energy at proper time so, if I have a transistor amplifier then, the energy that is lost during the charging and discharging, of the inductor and capacitor. Right? Can be compensated using the transistor amplifier. Right? The LC, circuit along with on this amplifier can be used, can be used to obtain oscillators, called LC oscillators due to supply of energy which is lost the oscillation gets maintained in hence, called sustained oscillation or undammed oscillation. Here the frequency, of oscillation generated by, LC is given by, F equals to 1 by 2 pie root LC. Right? Where l is in Henry and c is in farad, depending on the type of tank circuit there's also letters are classified into two categories one is called Colpitt's oscillator, another one is called hardly oscillator,

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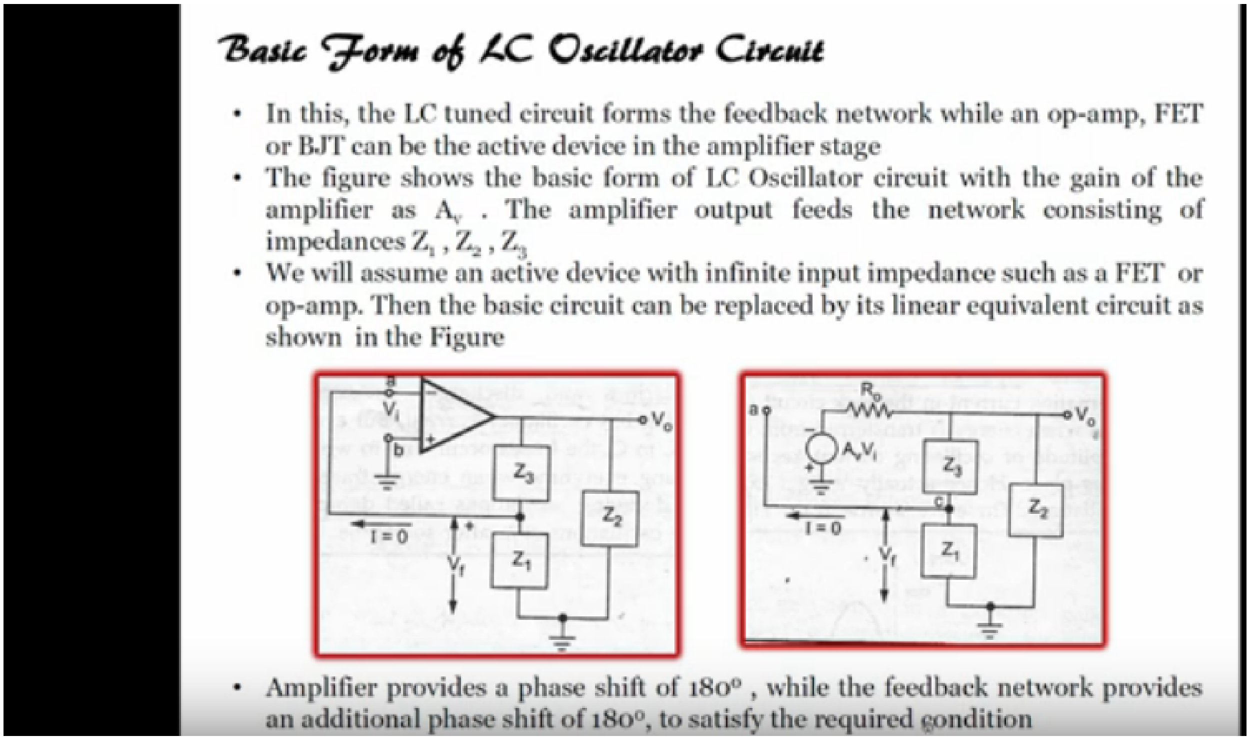

Now, LC or circuit forms of feedback network while an op-amp, or FET, or BJT can be active device, the figure shows here you can see, the left side of the figure. Right? Shows form of L so, later with gain of amplifier AV. All Right? Amplifier output feeds a network consisting of impedance is Z 1, Z 2, and Z 3, we will assume that active device, with infinite input impedance such as FET. Right? Or op-amp and then the basic circuit can be, replaced by linear equivalent circuit so, if I want to replace this by, linear equivalent circuit I can draw like this. Right? Say its input impedance is infinite. Right? And amplifier provides a phase shift of 180 degree because, it's a inverting terminal we are applying the signal. Right? Well the feedback network provides this phase shift of poly so, here the feedback network that we are, we are designing, or will be using, will provide another phase shift of 180 degree, to satisfy the required solution that is a that total phase shift should be 360 degree.

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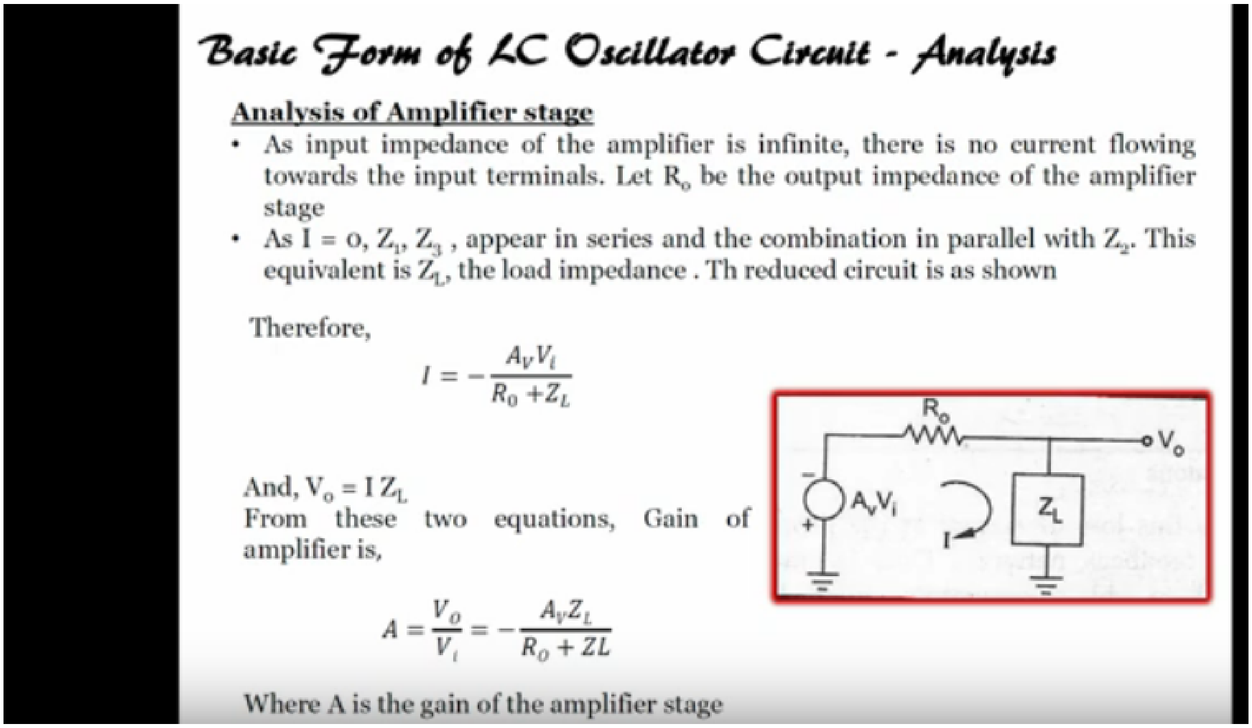

So, if we analyze, this amplifier stage, if we analyze this amplifier stage, what we get, what we get is that I equals to minus AVVI upon RO ZL, RO PLUS ZL, you can see from here. Right? And using the equation. Right? What we can get gain. Of the amplifier VO By, VI equals to a AVZL upon RO plus ZL, where a is the gain of the amplifier stage. Right?

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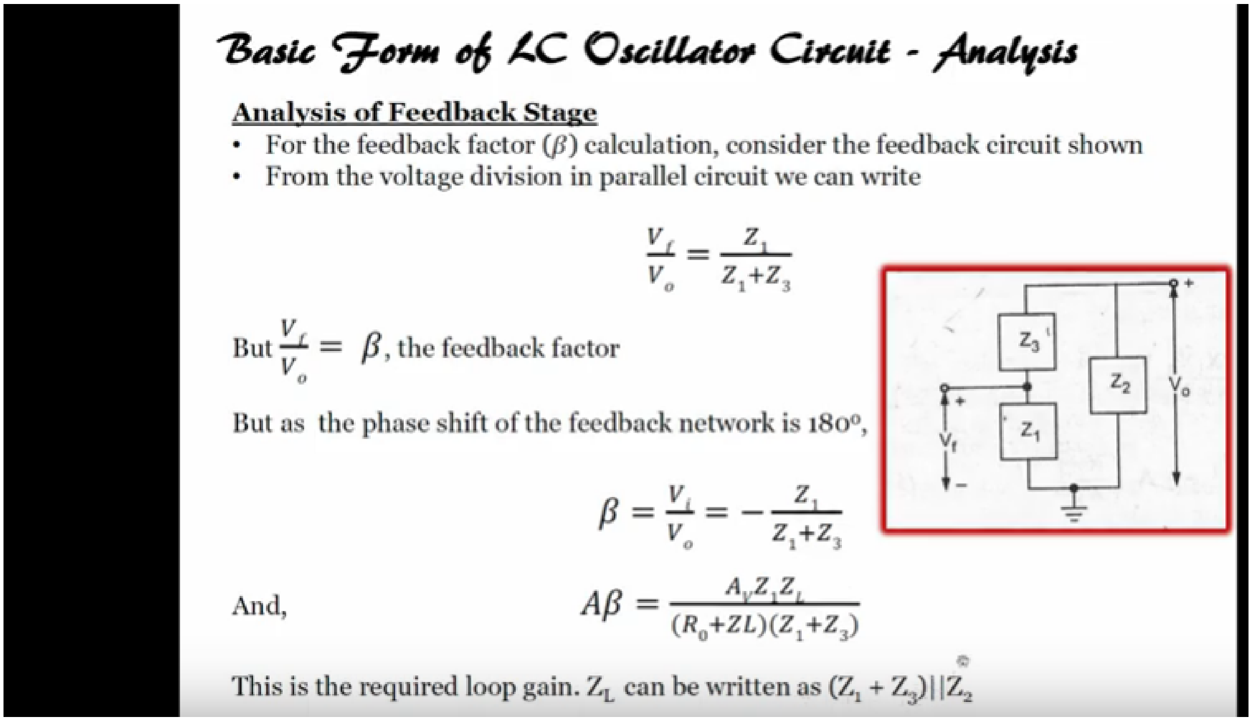

So, further when we analyze, what we get, we get beta equals to VI by, VO and that will be nothing but Z 1 upon Z 1 plus Z 3 in terms of minus, that is 180 degree, phase shift so, a beta would be this formula so, this is the required loop gain, this is a required loop gain ZR can be written as Z 1 plus Z 3 parallel to C 2 you can see here. Right?

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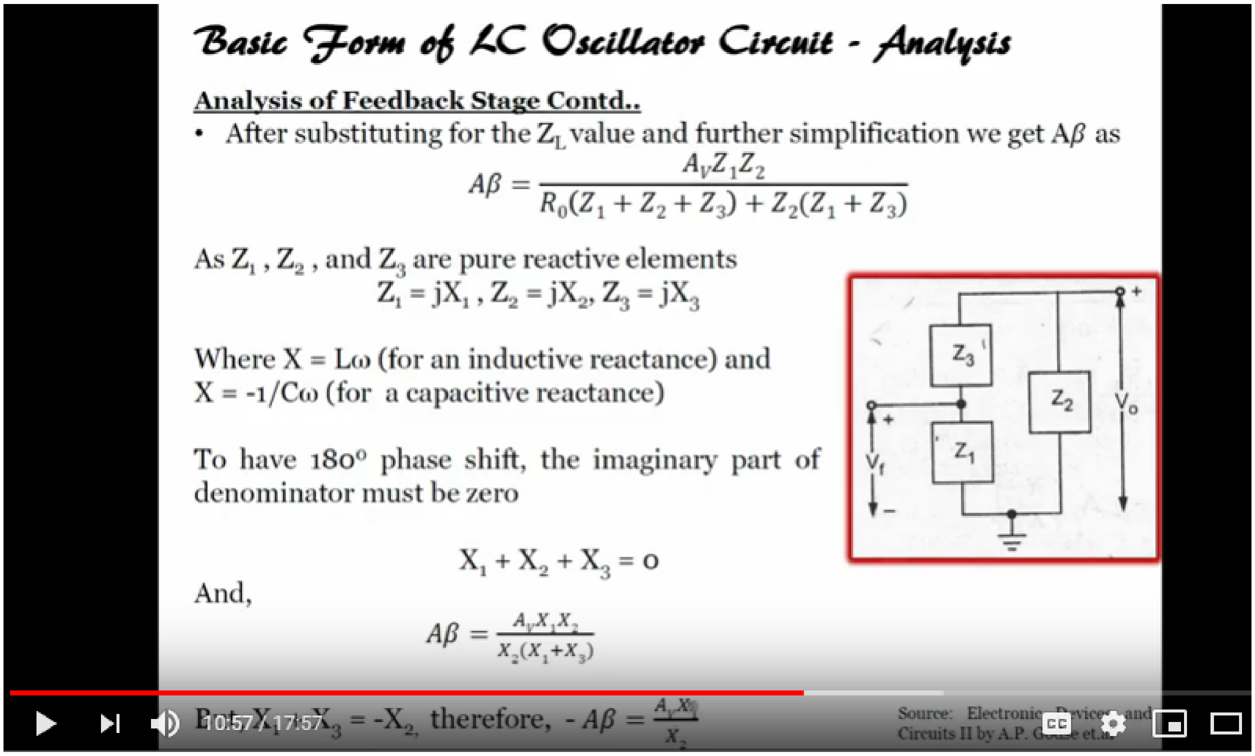

So, if you substitute what we get, we substitute, then finally, when we, when you solve this equation, when you solve this equation, what you get? You get is, that you're a beta. Right? Will be AV x1, by x2, AV x1, by x2 and a B must be positive. Right? Here what we see is, is minus a into beta ,minus a into beta, the last line we see that when we derive this, when we solve this we get minus a beta equals to AV x1, by x2 but it cannot be minus. Right? It should be a minus a, B should be positive and must bigger than or equal to unity. Right? We have seen that it is focusing criteria so, as a B is positive minus a beta will be positive only when, only when x1 and, x2 will have same sign. Right? If an x1, x2 have sales sign then only minus a beta can be positive. Right? This indicates that x1 and, x2 should be of same type of reactances, you see here again minus a beta equals to AV, into x1 by, x2 but minus a beta should always, be greater than equal to 1, that means x1 and, x2 should be same reactances. Right?

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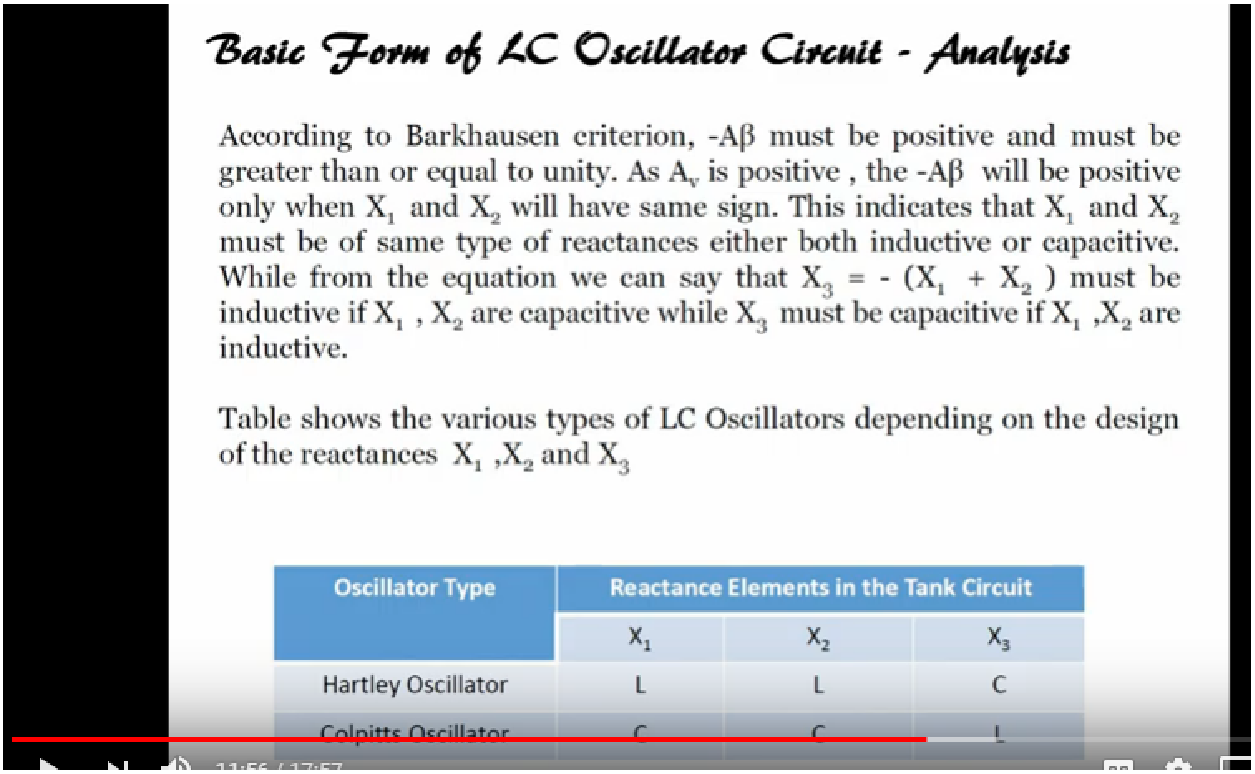

Should behave same type of reactances so, either it we can use x1 and, x2 as inductive, or we can use x2 and, x2, x1 and x2 is capacitive. Right? Either x1 or, x2 as inductive, or capacitive. while we can also say that x3 equals 2 minus X 1 as, oh so, that means that if x1 and, x2 are capacitive x3, should be inductive and if x1 and, x2 are inductive, X 2 should be, x3 should be, capacitive. Right? So either X 1 and X 2 are inductive then X 3, X capacitive X 3 if X 1 and, X 2 are capacitive then X 3 should be inductive. Right? Vice versa so, if X 4 and, X 2 are inductive and X 3 is capacitive it is hardly oscillator, and if X 1 and, X 2 are capacitive and X 3 is inductive it is called pitch oscillator, Right? We have seen this

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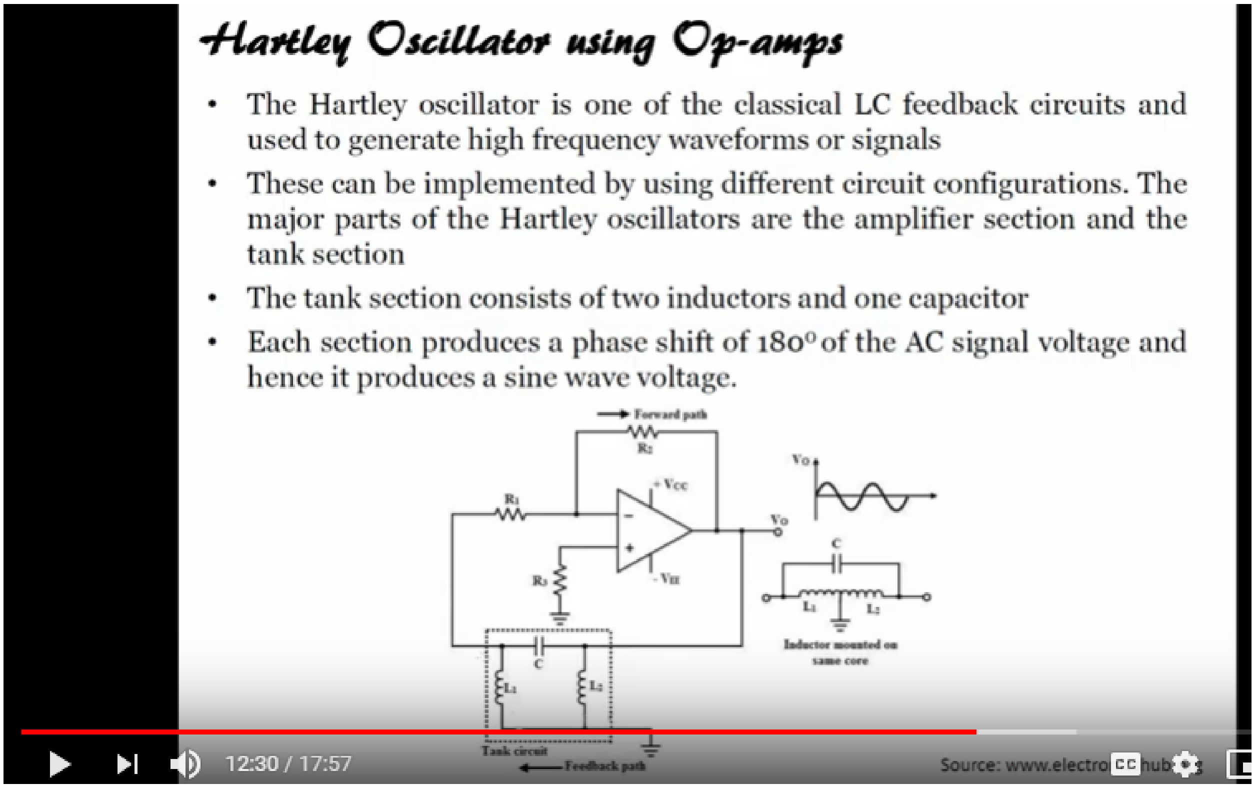

Now, if I want to design hudley oscillator, if I want to design hardly oscillator, then this is the way to design hardly oscillator, this is a tank circuit as we know Right? And this can be implemented by, by using two inductors and, one capacitor each section produces a phase shift of 180 degree Right? Each section produces 180 degree and, hence it produces a sine voltage Right? And produces a sine wave voltage.

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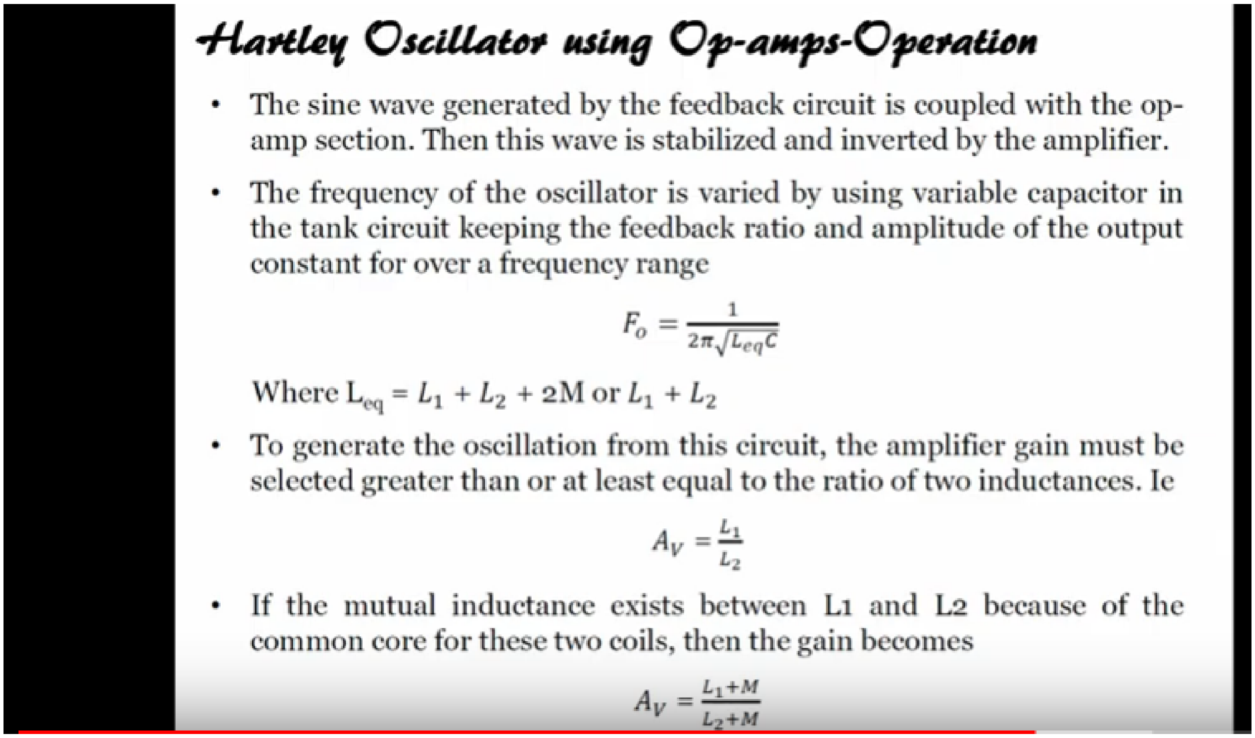

Here we know, that the FO equals to, 1 upon 2 phi, under root of l, equivalent into c. Right? Because, there are inductors l1 and l2. So, when, where is L equivalent l equivalent is nothing but L 1 plus L 2, plus, 2 m, or L 1 plus, L 2 to generate oscillation, from this circuit, the amplifier must have be selected not less least equal to the ratio of, two inductances Right? That means that the amplifier gain should be at least equal to L 1 by, L 2 so, it should be greater than or equal to okay? So, be greater than or equal to the ratio of L 1 and, L 2 if there is a mutual inductance, if there is a mutual inductance that exists between 11 and L 2. Right? Because, of the common core then the gain becomes L 1 plus, M by, L 2 plus L.

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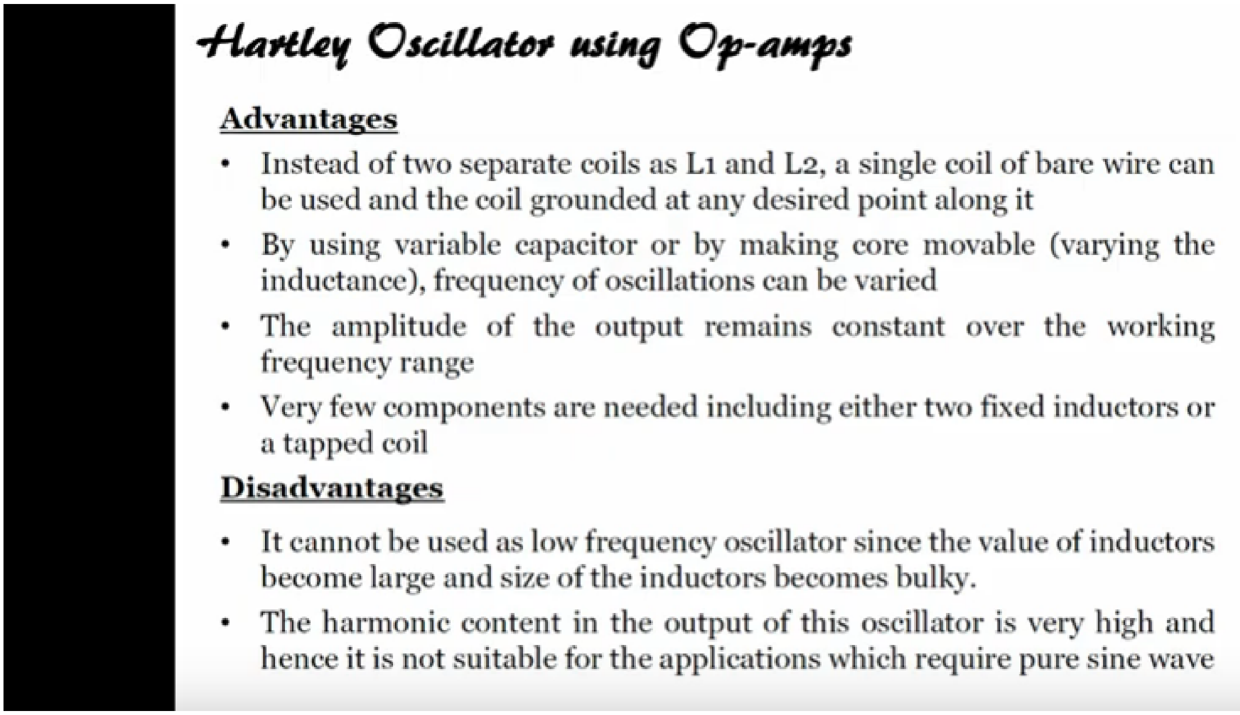

So, what is the advantage of this oscillator? The advantage is that instead of two separate coils as L 1 and, L 2 a single coil of a bare wire can be used, and the coil can be grounded, at any desired point second is by using variable capacitor or by making core movable frequency oscillations can be varied. Right? There's another abundant amplitude of the output, remains constant, over the frequency range, and finally very few components are required for including either to fix inductors or a tip coil but, there are few limitations what are limitations? It cannot be used for low frequency oscillation. Right? Since the value of inductors becomes large, and size of the inductor becomes Bulky. Right? It's obvious correct the harmonic content in the output of this oscillator is very high and hence it is not suitable for application which requires pure, sine wave there is harmonic oscillations that limits its use for pure sine,

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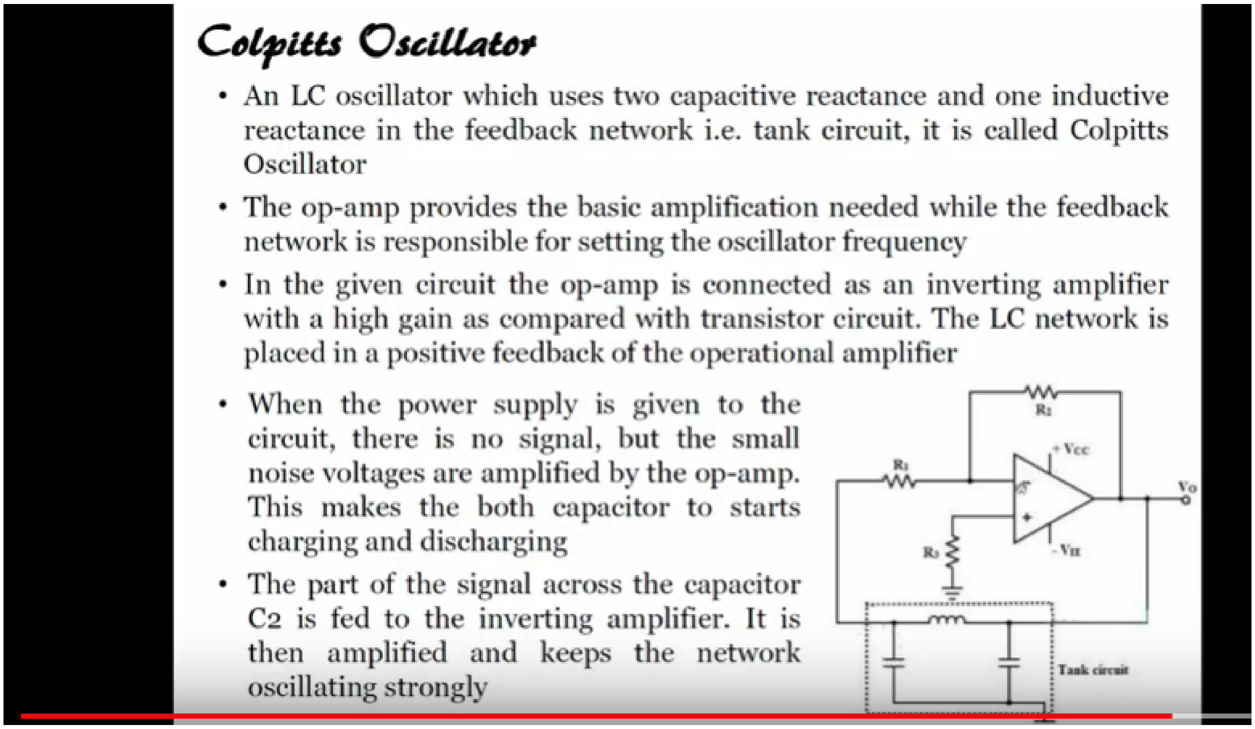

Corpus oscillator, next is a corpus letter here, we are using two capacitors and one inductor in this oscillator like we see here. In the tank circuit, there are two capacitors. Right? And one inductor so, here the open provides the basic amplification needed with the feedback Network in the given circuit op amp is connected as inverting amplifier, the high gain is compared with transistor circuit, when the power supply is given to the circuit, there is no signal. Right? Initially there is no signal but a small noise voltage are amplified with the help of amplifier op –amp, repair this makes the both capacitors to charge and, discharge Right? The part of signal across the capacitor C 2 is fed to the inverting amplifier. Right? Here it is fed back to the inverting amplifier, and then amplified and keeps a network oscillating strongly Right? So, initially through the noise voltage, we're amplifying the noise voltage, with the help of amplifier, it is fed back to the tank circuit and the part of signal is fed back to the amplifier and there is a strong oscillations, which causes strong oscillations.

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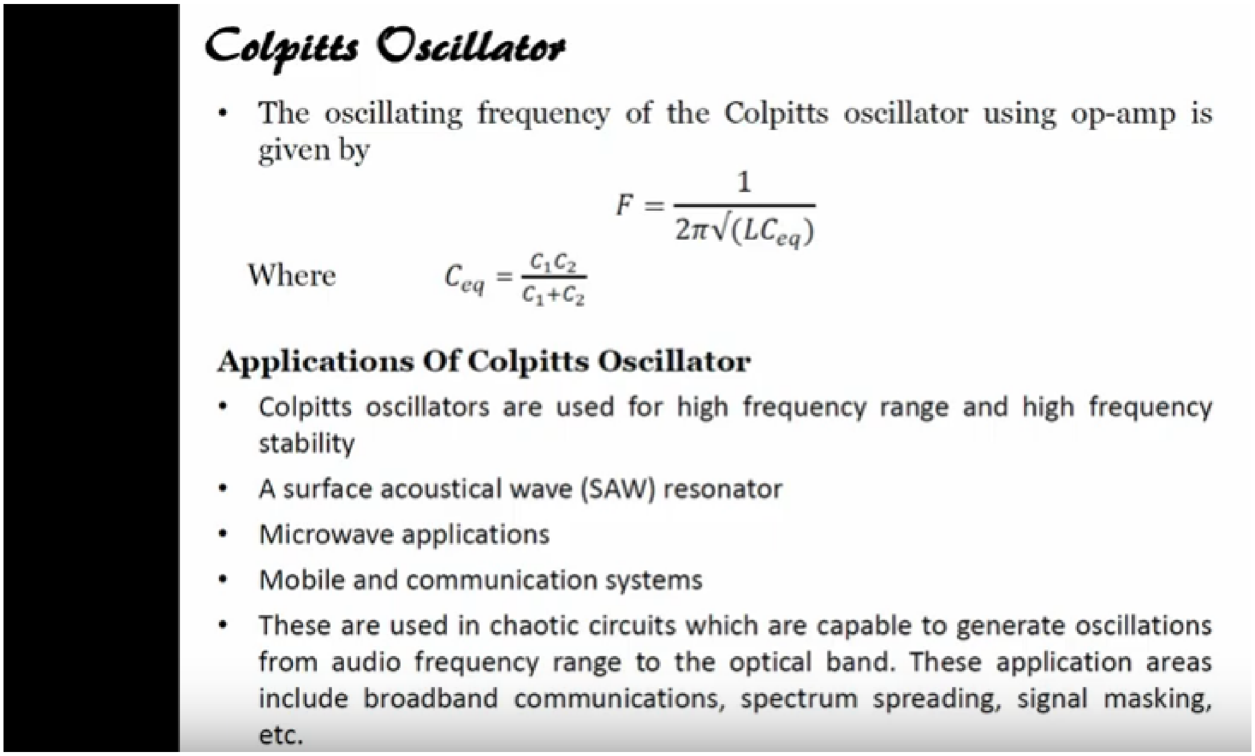

here we have same formula but instead of L equivalent here, we have frequent and we know that C equivalent is nothing, but C 1, C 2, by C 1 plus C 2. So ,what are the applications of Colptits, oscillator Colpitts oscillator z' are used for high frequency range, in high frequency stability Right? It can also be used as a saw, resonator resurface acoustical real resonator used in micro applications mobile communications. Right? And these are used in chaotic circuits, which are capable to generate oscillation from audio frequency to the optical band; the application area includes broadband communication spectrum spreading, signal masking, etc.

So, this was the end of this particular summary of the oscillators. Right? So, if you recall, we have just understood. Right? from the indicator circuit quickly. Right? Then we went to op-amp its characteristics then we saw a few implicants, then we saw oscillators. Right? And we also saw, filters, as also saw filters now, in the in the next module, in the next module are or rather in the next lecture, we will see how we can implement design, and implement circuits using operation amplifier and like I said slowly, and gradually yeah, you will, you will understand when you, when you, read from my earlier course till now, we are slowly, and gradually increasing the tempo Right? We're increasing the tempo the reason is that we should start from basic. Right? Understand the concept grab it, and then move on to applying it so, you will see in this particular applications of op-amp, it is little bit complicated than the earlier practical's that we have seen in the last course. Right? And finally we are, actually designing a signal conditioning device, for measuring ECG, as well as heart rate. Right? And, and that is a really complicated project. So, let's see how, we go further in the next lectures, I'll see in the next lecture. Till then, you just go through all the modules. Right? Keep your basic strong. Right? Refresh it, even you know it, it is always good to refresh. Right? I'll see you next class. Till then, you take care bye.