LC oscillators:

General form of LC oscillators:

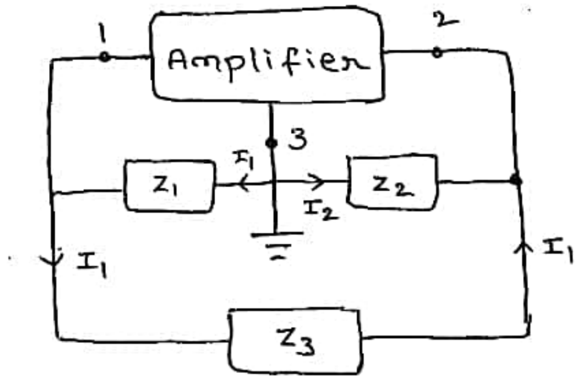
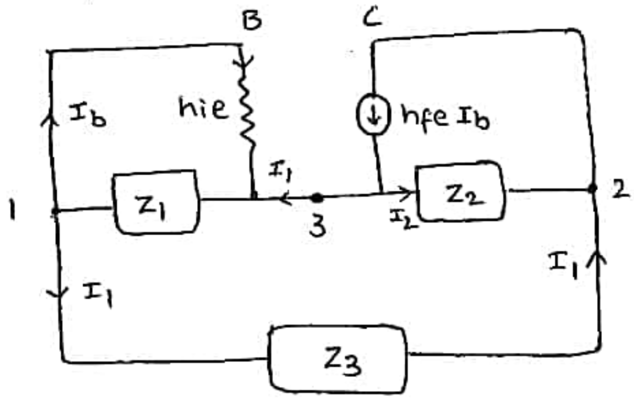


Fig a: General form of an oscillator



Fig(b): It's Equivalent ckt

In the general form of oscillator shown in fig above, any of the active devices such as transistor, FET, and operational amplifier may be used in the amplifier section.

Z_1, Z_2 and Z_3 are the reactive elements constituting the feedback tank circuit which determines the frequency of oscillation. Here Z_1 and Z_2 serve as a.c voltage divider for the output voltage and feedback signal. Therefore the voltage across Z_1 is the feedback signal. The frequency of oscillation of LC oscillator is

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

The inductive and capacitive reactances are represented by Z_1, Z_2 and Z_3. In fig(a) the output terminals are 2 and 3, and input terminals are 1 and 3. Fig (b) gives the equivalent circuit of fig(a).

Load Impedance :

Since z_1 and the input resistance hie of the transistor are in parallel, their equivalent impedance z' is given by $z' = z_1 || hie$

$$\frac{1}{z'} = \frac{1}{z_1} + \frac{1}{hie} \Rightarrow z' = \frac{z_1 hie}{z_1 + hie} \longrightarrow (1)$$

Now the load impedance z_L between the output terminals 2 and 3 is the equivalent impedance of z_2 in parallel with the series combination of z' and z_3.

Therefore

$$Z_L = z_2 || (z' + z_3)$$

$$\frac{1}{Z_L} = \frac{1}{Z_2} + \frac{1}{z' + z_3}$$

$$\frac{1}{Z_L} = \frac{1}{Z_2} + \frac{1}{\frac{z_1 hie}{z_1 + hie} + z_3}$$

$$\frac{1}{Z_L} = \frac{1}{Z_2} + \frac{z_1 + hie}{hie(z_1 + z_3) + z_3 hie}$$

$$\frac{1}{\cancel{Z_L}} = \frac{1}{\cancel{Z_2}} + \frac{\cancel{z_1} + \cancel{h}ie}{}$$

$$\frac{1}{Z_L} = \frac{hie(z_1 + z_3) + z_1 z_3 + z_1 z_2 + hie\, z_2}{z_2 [hie(z_1 + z_3) + z_1 z_3]}$$

$$\frac{1}{Z_L} = \frac{hie(z_1 + z_2 + z_3) + z_1 z_2 + z_1 z_3}{z_2 [hie(z_1 + z_3) + z_1 z_3]}$$

$$Z_L = \frac{z_2 [hie(z_1 + z_3) + z_1 z_3]}{hie(z_1 + z_2 + z_3) + z_1 z_2 + z_1 z_3} \longrightarrow (2)$$

Voltage gain without feedback is given by

$$A_V = \frac{-h_{fe} Z_L}{h_{ie}} \longrightarrow (3)$$

Feedback fraction β

The output voltage between the terminals 3 and 2 in terms of the current I_1 is given by

$$V_o = -I_1 (z' + z_3) = -I_1 \left[\frac{z_1 h_{ie}}{z_1 + h_{ie}} + z_3 \right]$$

$$V_o = -I_1 \left[\frac{z_1 h_{ie} + z_1 z_3 + z_3 h_{ie}}{z_1 + h_{ie}} \right]$$

$$V_o = -I_1 \left[\frac{h_{ie} (z_1 + z_3) + z_1 z_3}{z_1 + h_{ie}} \right] \longrightarrow (4)$$

The voltage feed back to the input terminals 1 and 3 is given by

$$V_{fb} = -I_1 z' = -I_1 \left[\frac{z_1 h_{ie}}{z_1 + h_{ie}} \right] \longrightarrow (5)$$

Therefore the feedback ratio β is given by

$$\beta = \frac{V_{fb}}{V_o} = I_1 \left[\frac{z_1 h_{ie}}{z_1 + h_{ie}} \right] \left[\frac{z_1 h_{ie}}{h_{ie}(z_1 + z_3) + z_1 z_3} \right] \frac{1}{I_1}$$

$$\beta = \frac{z_1 h_{ie}}{h_{ie}(z_1 + z_3) + z_1 z_3} \longrightarrow (6)$$

Equation for the oscillator

For oscillation we must have

$$A_V \beta = 1$$

Substituting the values of A_v and β, we get

$$\left(\frac{-h_{fe}\, Z_L}{h_{ie}}\right)\left(\frac{Z_1 h_{ie}}{h_{ie}(Z_1+Z_3)+Z_1Z_3}\right) = 1$$

$$\frac{h_{fe}\, Z_2\left[h_{ie}(Z_1+Z_3)+Z_1Z_3\right]}{\left[h_{ie}(Z_1+Z_2+Z_3)+Z_1Z_2+Z_1Z_3\right]}\left(\frac{Z_1}{h_{ie}(Z_1+Z_3)+Z_1Z_3}\right) = -1$$

$$\frac{h_{fe}\, Z_1 Z_2}{h_{ie}(Z_1+Z_2+Z_3)+Z_1Z_2+Z_1Z_3} = -1$$

$$h_{ie}(Z_1+Z_2+Z_3)+Z_1Z_2+Z_1Z_3+h_{fe}Z_1Z_2 = 0$$

$$h_{ie}(Z_1+Z_2+Z_3)+Z_1Z_2(1+h_{fe})+Z_1Z_3 = 0$$

This is the general Equation for the oscillator.