SNS COLLEGE OF TECHNOLOGY

Kurumbapalayam (Po), Coimbatore – 641 107

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICSAND COMMUNICATION ENGINEERING

COURSE NAME : 19ECB201-ANALOG ELECTRONIC CIRCUITS

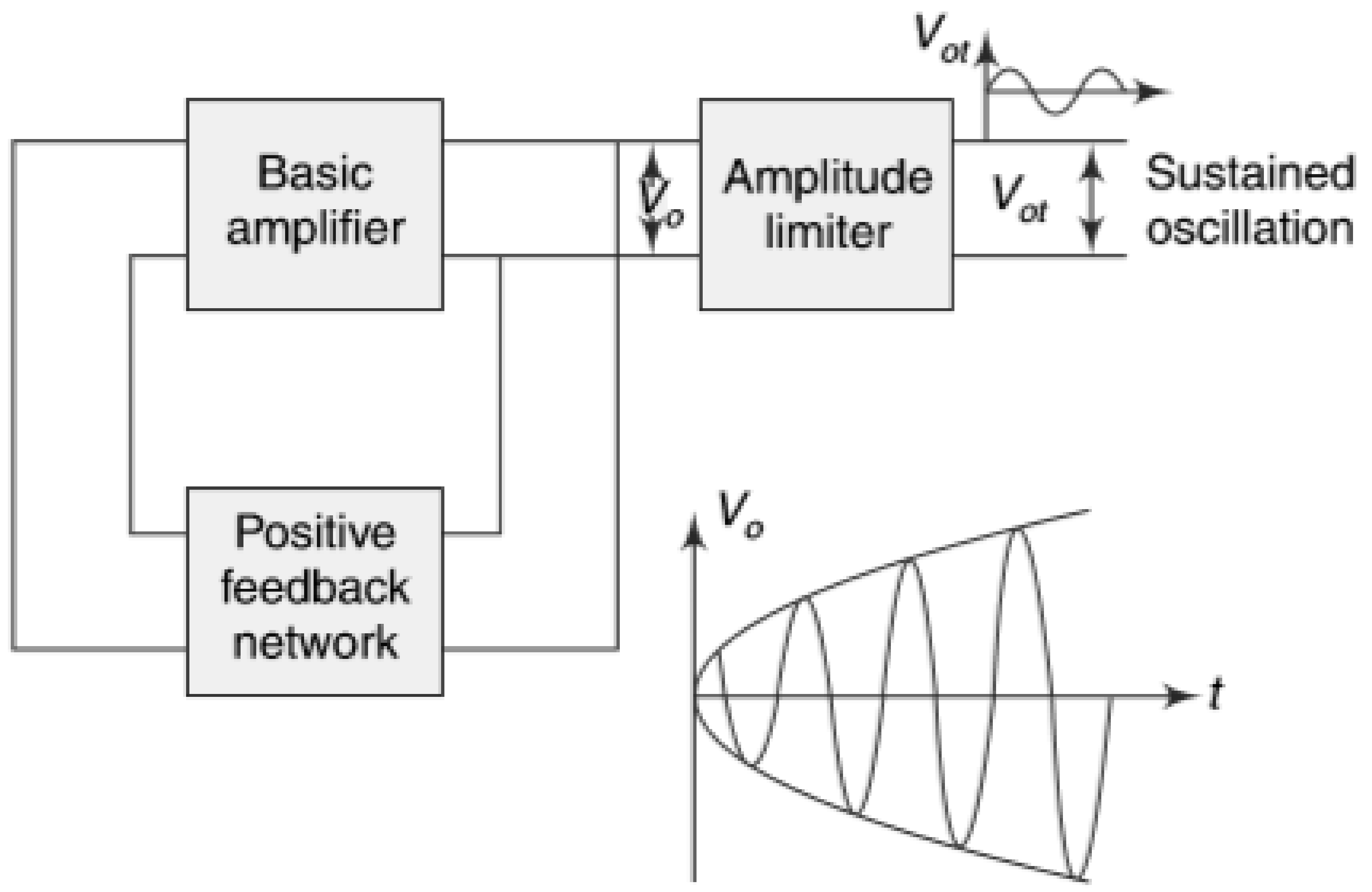
II YEAR /III SEMESTER

Unit 4- OSCILLATORS & MULTIVIBRATOR CIRCUITS

Topic 2 : Hartley Oscillator

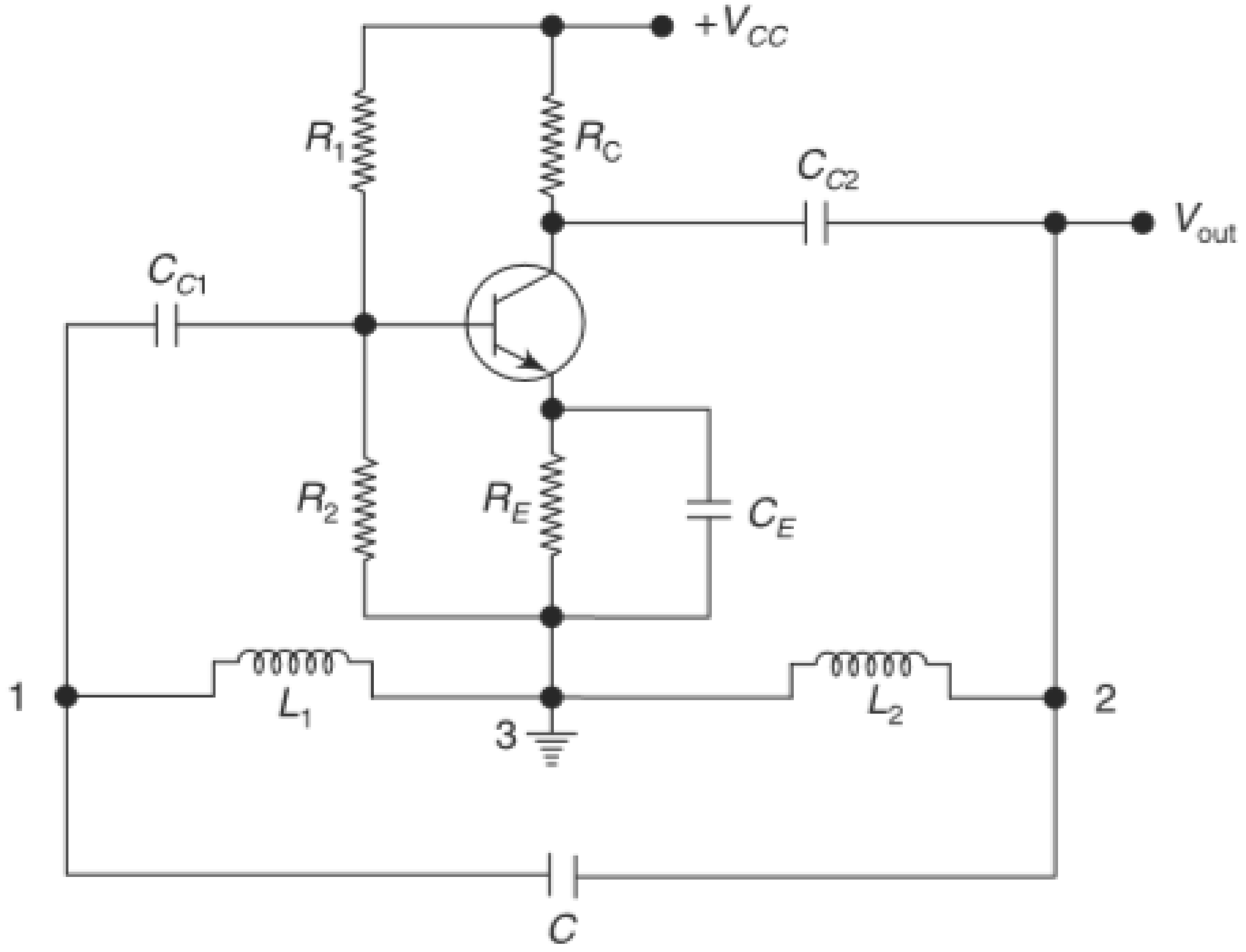
Need for Oscillators

- Communication Systems
- Control signals

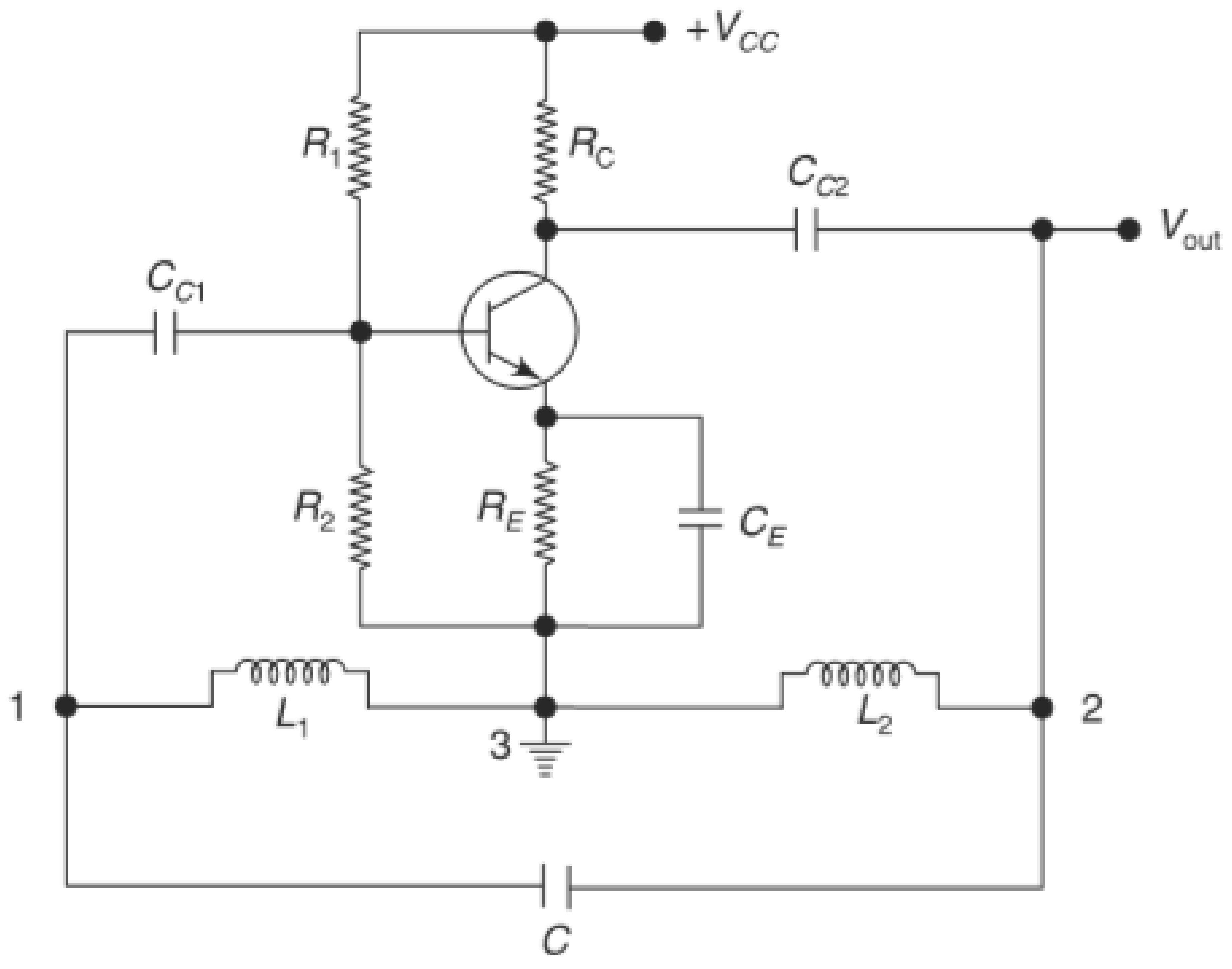


Hybrid Oscillator Circuit

- NPN transistor
- Conditions for oscillations
- Positive Feedback

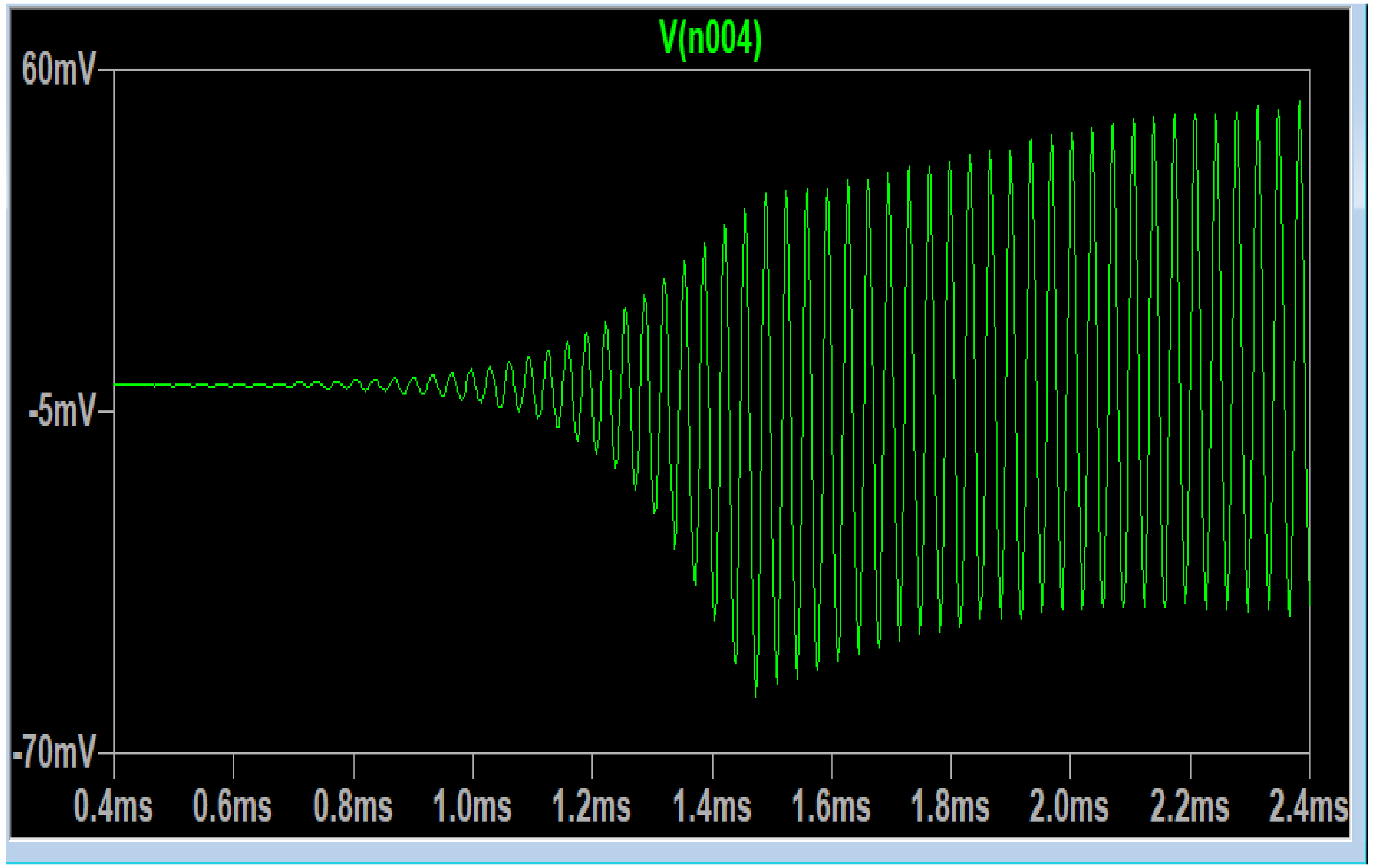


Mechanism of Start of Oscillation



Stabilization of Amplitude

Amplitude Limiting

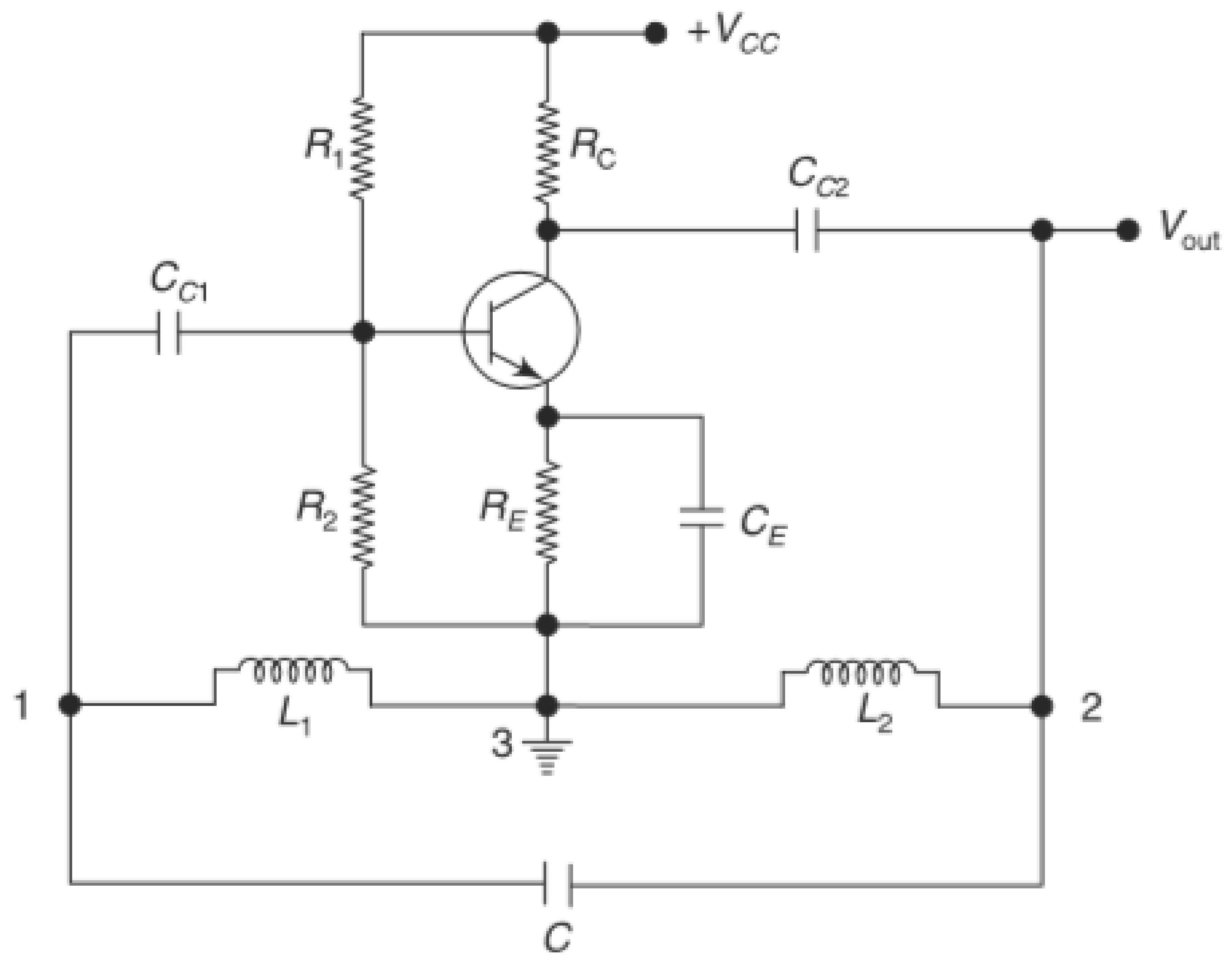


Frequency of Oscillation

$$Z_1 = j\omega L_1 + j\omega M$$

$$Z_2 = j\omega L_2 + j\omega M$$

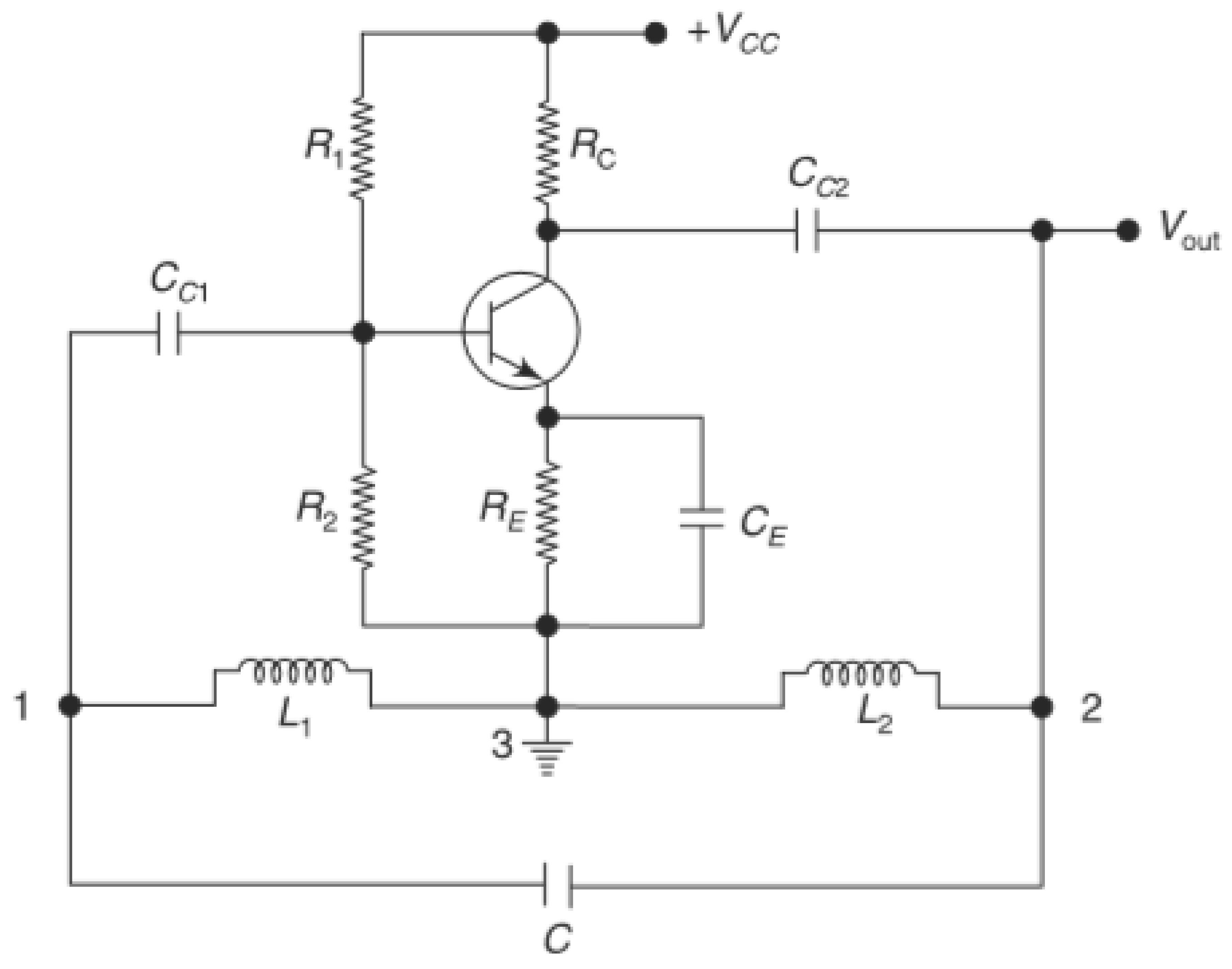
$$Z_3 = \frac{1}{j\omega C} = \frac{-j}{\omega C}$$



Frequency of Oscillation

General Equation of Oscillation

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

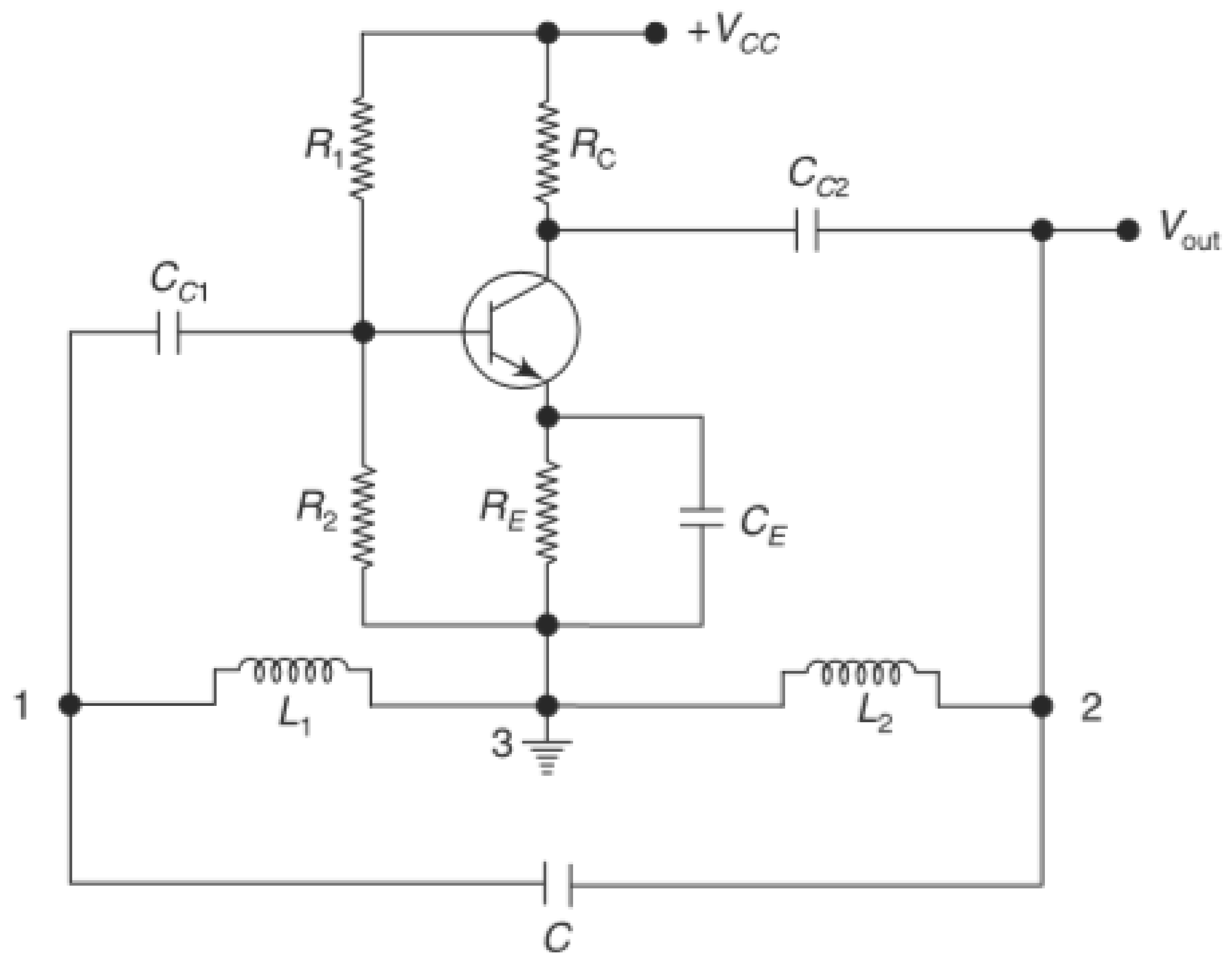


Frequency of Oscillation

$$j\omega h_{ie}\left[L_1 + L_2 + 2M - \frac{1}{\omega^2 C}\right] - \omega^2(L_1 + M)\left[(L_2 + M)(1 + h_{fe}) - \frac{1}{\omega^2 C}\right] = 0$$

Frequency of Oscillation

$$f_o = \frac{\omega_o}{2\pi}$$

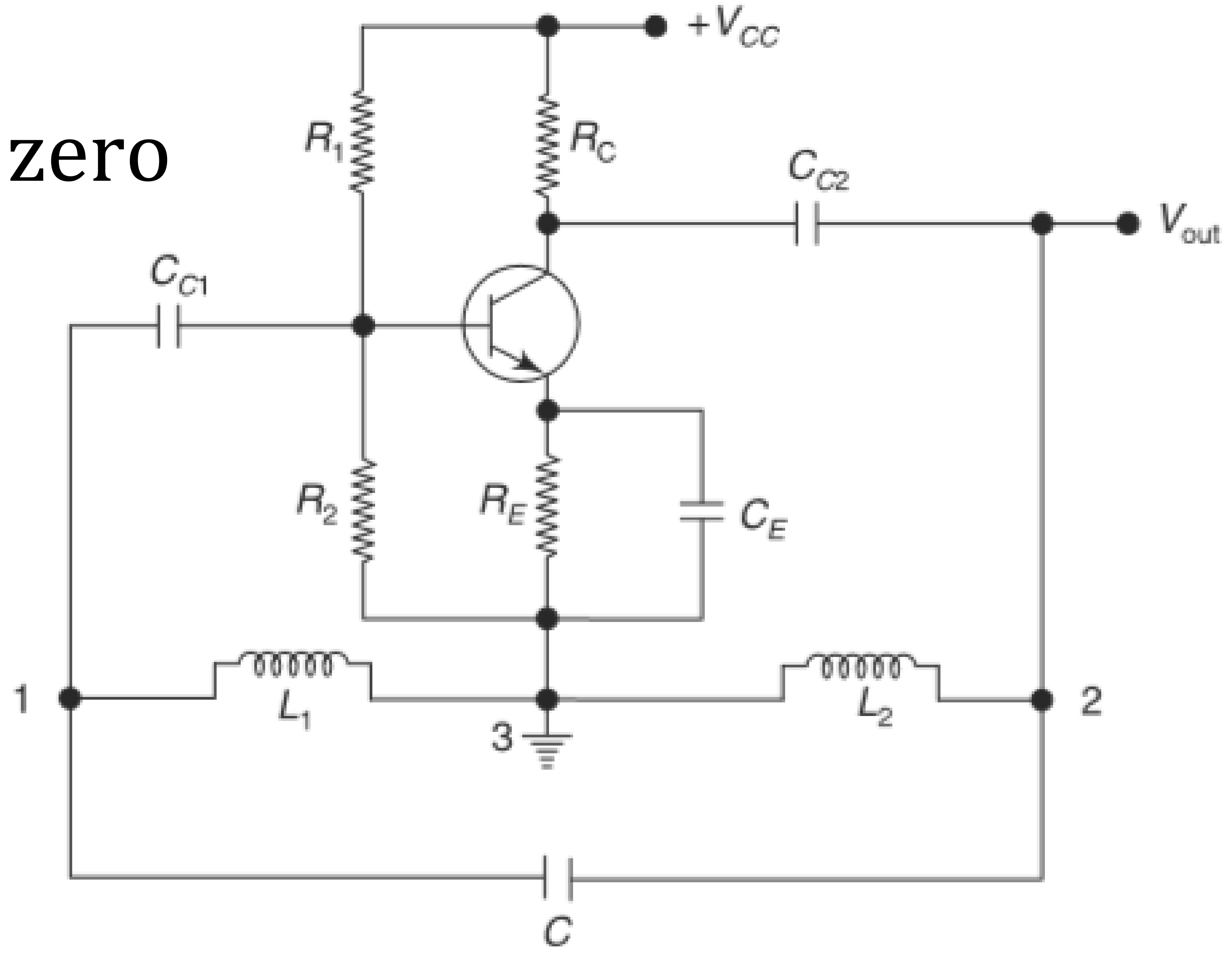


Frequency of Oscillation

For calculating the frequency of oscillation

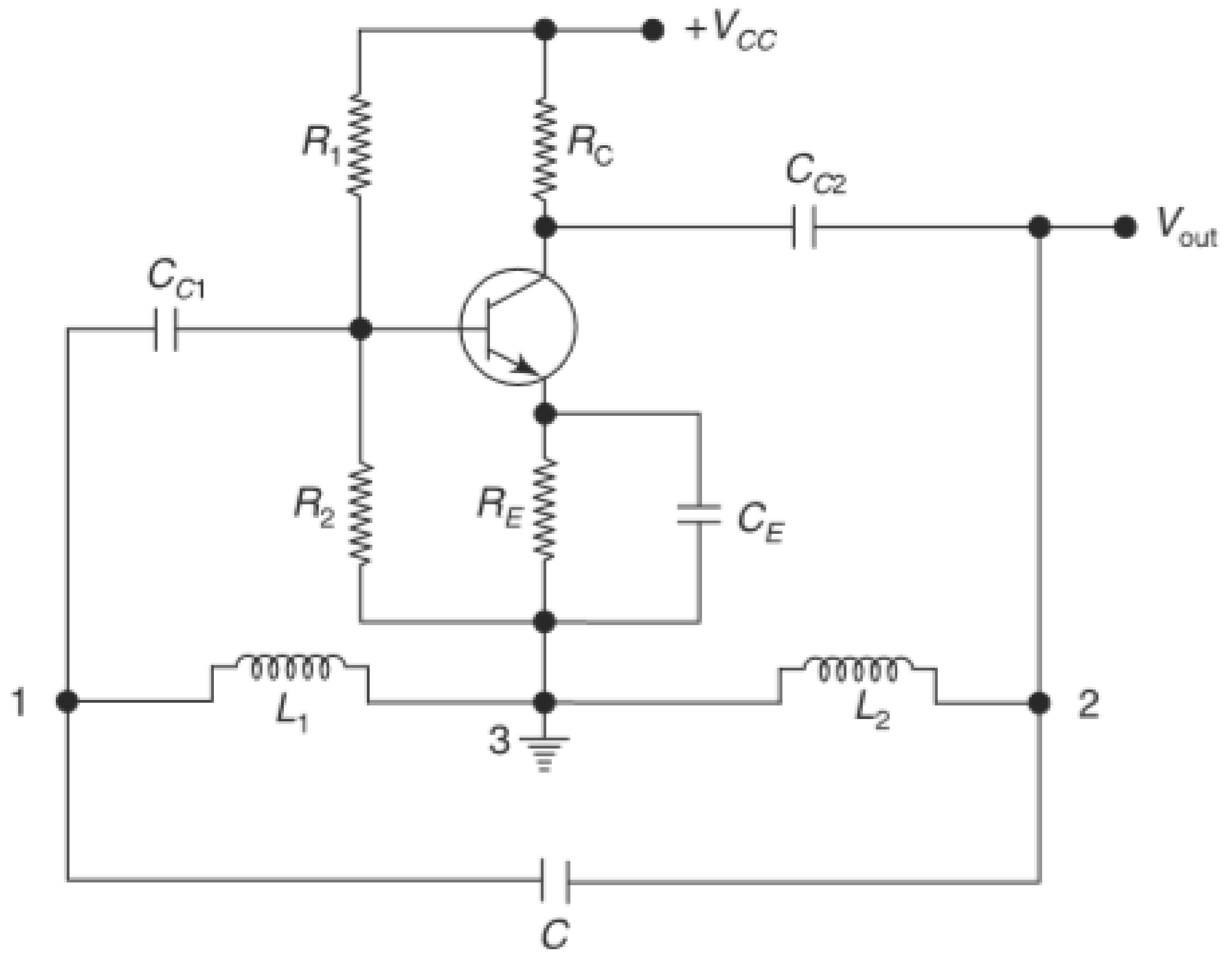
Equate the imaginary part of the basic equation to zero

$$\left[L_1 + L_2 + 2M - \frac{1}{\omega_o^2 C}\right] = 0$$



Frequency of Oscillation

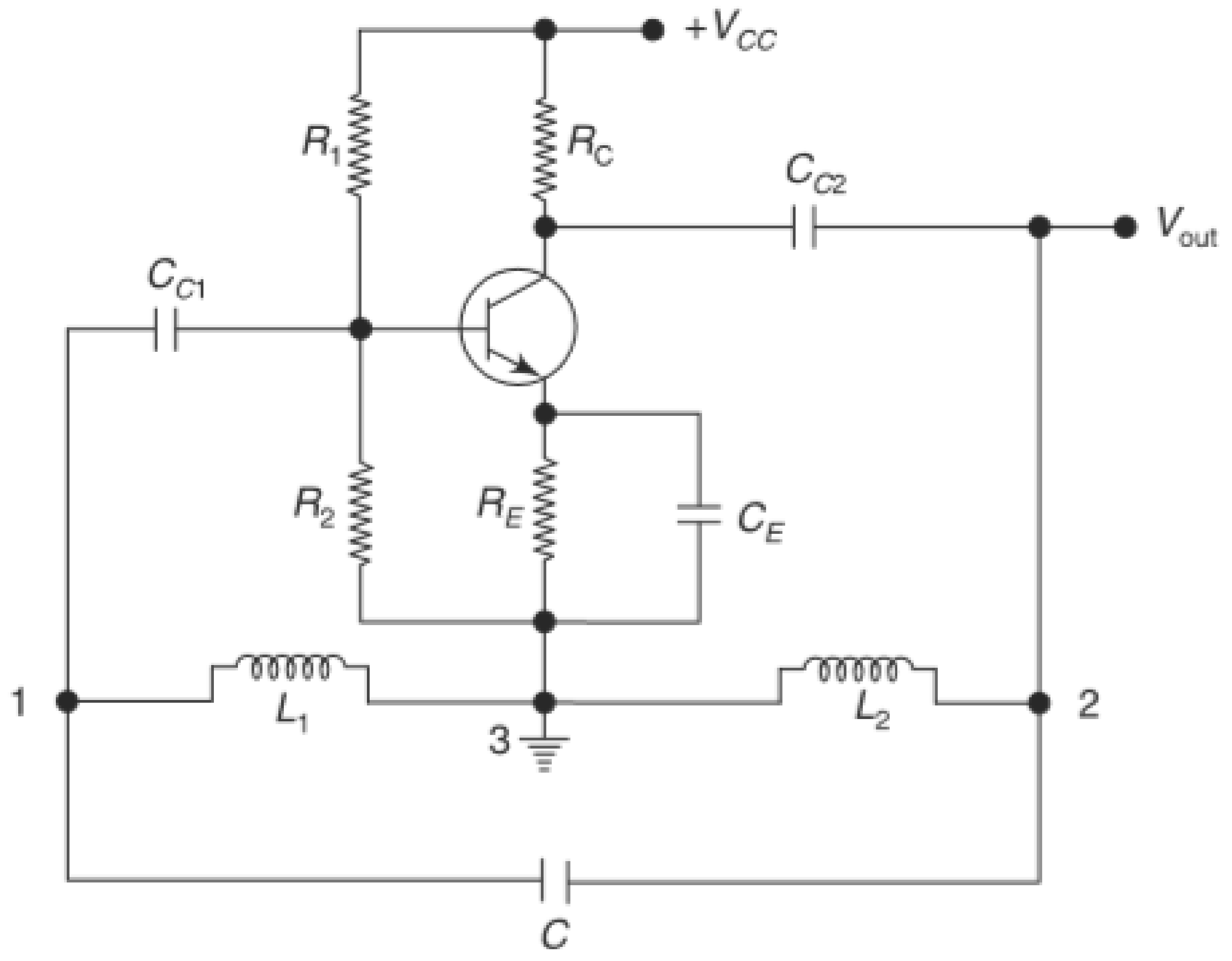
$$f_o = \frac{\omega_o}{2\pi} = \frac{1}{2\pi\sqrt{(L_1 + L_2 + 2M)\,C}}$$



Conditions for Maintenance of Oscillation

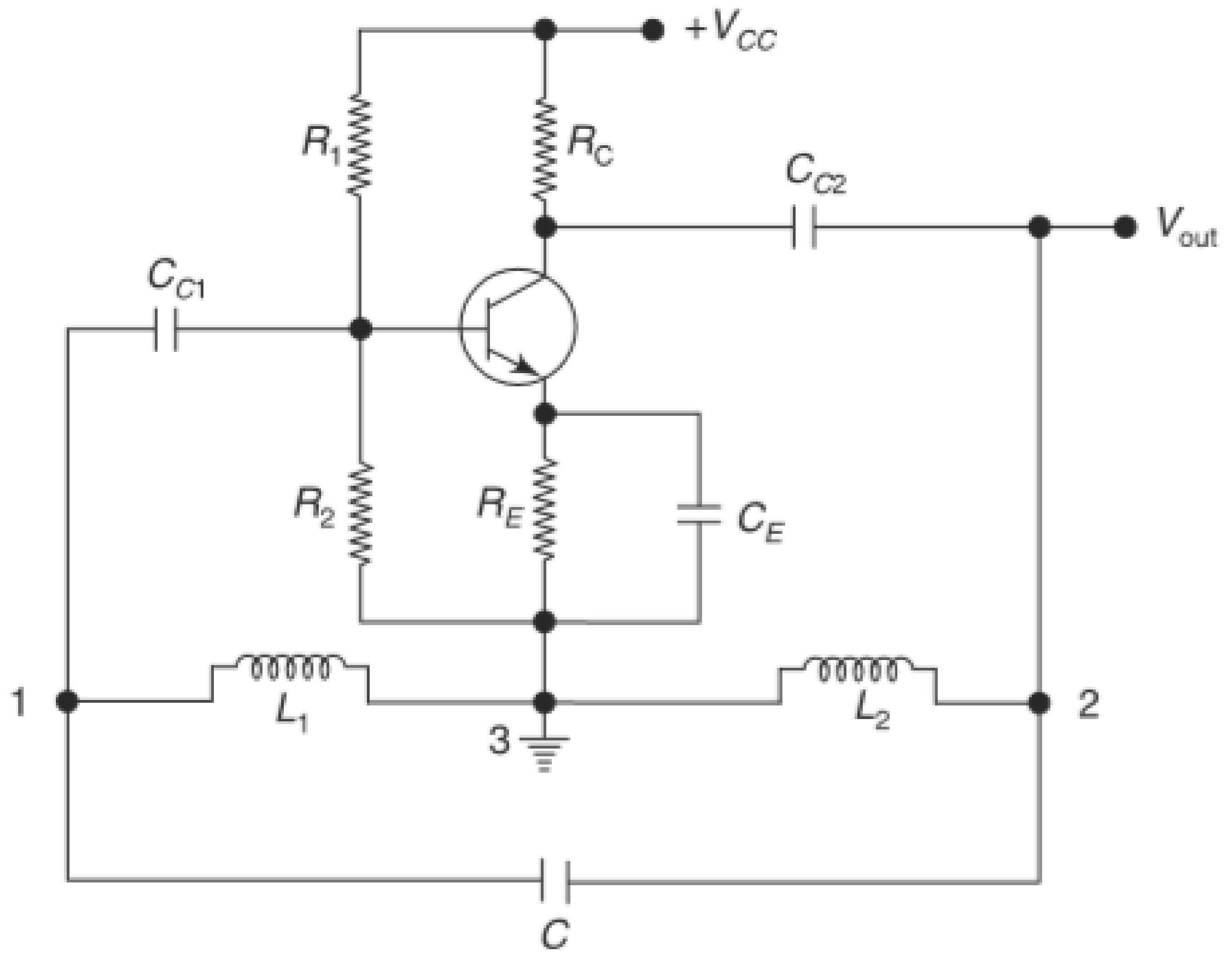
For obtaining the conditions for maintenance of oscillation equate the real part of the basic equation to zero

$$\left[(L_2 + M)(1 + h_{fe}) - \frac{1}{\omega_o^2 C}\right] = 0$$



Conditions for Maintenance of Oscillation

$$h_{fe} = \frac{L_1 + M}{L_2 + M}$$



Derivation **Basic eqn**

$$h_{ie}(Z_1+Z_2+Z_3) + Z_1 Z_2(1+h_{fe}) + Z_1 Z_3 = 0 \rightarrow (1)$$

$$Z_1 = X_L L_1 + X_L M$$

$$Z_1 = j\omega L_1 + j\omega M$$

$$Z_2 = j\omega L_2 + j\omega M$$

$$Z_3 = X_C = \frac{1}{j\omega C} = \frac{-j}{\omega C}$$

Sub in (1)

$$h_{ie}\left(j\omega L_1 + j\omega M + j\omega L_2 + j\omega M - \frac{j}{\omega C}\right) + (j\omega L_1 + j\omega M)(j\omega L_2 + j\omega M)(1+h_{fe}) + (j\omega L_1 + j\omega M)\left(\frac{-j}{\omega C}\right) = 0$$

$$j\omega h_{ie}\left(L_1 + L_2 + 2M - \frac{1}{\omega^2 C}\right) + j\omega(L_1+M)\, j\omega(L_2+M)(1+h_{fe}) + j\omega(L_1+M)\left(\frac{-j}{\omega C}\right) = 0$$

$$j\omega h_{ie}\left(L_1 + L_2 + 2M - \frac{1}{\omega^2 C}\right) - \omega^2(L_1+M)(L_2+M)(1+h_{fe}) + (L_1+M)\left(\frac{1}{\omega^2 C}\right) = 0$$

Derivation

$$j\omega h_{ie}\left(L_1+L_2+2M-\frac{1}{\omega^2 C}\right)$$
$$-\omega^2(L_1+M)(L_2+M)(1+h_{fe})$$
$$+(L_1+M)\left(\frac{1}{\omega^2 C}\right)=0$$

$$j\omega h_{ie}\left[L_1+L_2+2M-\frac{1}{\omega^2 C}\right]$$
$$-\omega^2(L_1+M)\left[(L_2+M)(1+h_{fe})-\frac{1}{\omega^2 C}\right]=0$$

To cal. the freq. of operation Equate the img. term ~~to zero~~

$$j\omega h_{ie}\left[L_1+L_2+2M-\frac{1}{\omega^2 C}\right]=0$$

$$L_1+L_2+2M-\frac{1}{\omega^2 C}=0$$

$$L_1+L_2+2M=\frac{1}{\omega^2 C}$$

$$\omega^2 C=\frac{1}{L_1+L_2+2M}$$

$$\omega^2=\frac{1}{C[L_1+L_2+2M]} \rightarrow (2)$$

$$\omega=2\pi f$$

$$f=\frac{1}{2\pi\sqrt{C[L_1+L_2+2M]}}$$

Derivation

conditions for maintenance of oscillation

Equate Real Part = 0

$$-\omega^2(L_1+M)\left[(L_2+M)(1+h_{fe}) - \frac{1}{\omega^2 C}\right] = 0$$

$$(L_2+M)(1+h_{fe}) = \frac{1}{\omega^2 C}$$

$$\omega^2 C = \frac{1}{(L_2+M)(1+h_{fe})} \rightarrow (2)$$

$$f = \frac{1}{2\pi\sqrt{C((L_2+M)(1+h_{fe}))}}$$

sub (2) in (1).

$$\omega^2 C = \frac{1}{[L_1+L_2+2M]}$$

$$\frac{1}{(L_2+M)(1+h_{fe})} = \frac{1}{[L_1+L_2+2M]}$$

Derivation

$$\frac{(L_2+M)(1+h_{fe})}{[L_1+L_2+2M]} = 1$$

$$\frac{(L_2+M)(1+h_{fe})}{[L_1+M+L_2+M]} = 1$$

$$\frac{[L_1+M+L_2+M]}{[L_2+M][1+h_{fe}]} = 1$$

$$\frac{[L_1+M]+[L_2+M]}{[L_2+M][1+h_{fe}]} = 1$$

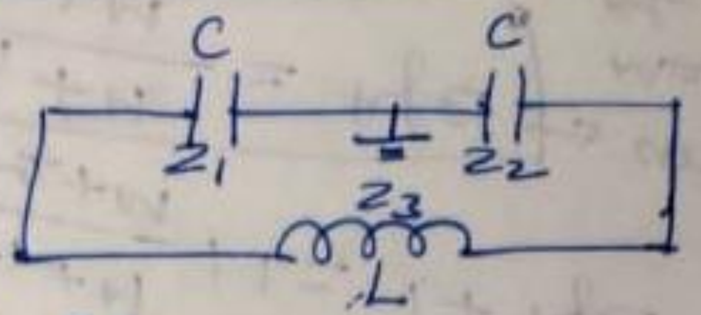
$$\frac{[L_1+M]}{[L_2+M][1+h_{fe}]} + \frac{1}{[1+h_{fe}]} = 1$$

$$\frac{1}{(1+h_{fe})}\left[\frac{L_1+M}{L_2+M} + 1\right] = 1$$

$$\frac{L_1+M}{L_2+M} + 1 = 1 + h_{fe}$$

$$\boxed{\frac{L_1+M}{L_2+M} = h_{fe}}$$ → condition for maintenance of oscillation

Colpitts Oscillator



2C
1L

Basic equ

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

$$Z_1 = X_{C_1} = \frac{1}{j\omega C_1} = \frac{-j}{\omega C_1}$$

$$Z_2 = X_{C_2} = \frac{1}{j\omega C_2} = \frac{-j}{\omega C_2}$$

$$Z_3 = X_L = j\omega L$$

$$h_{ie}\left(-\frac{j}{\omega C_1}-\frac{j}{\omega C_2}+j\omega L\right)+\left(\frac{-j}{\omega C_1}\right)\left(\frac{-j}{\omega C_2}\right)(1+h_{fe})$$

$$+\left(-\frac{j}{\omega C_1}\right)(j\omega L)=0$$

$$j\omega h_{ie}\left(\frac{-1}{\omega^2 C_1}-\frac{1}{\omega^2 C_2}+L\right)-\frac{(1+h_{fe})}{\omega^2 C_1 C_2}$$

$$+\frac{L}{C_1}=0$$

Derivation

$$-j\,h_{ie}\left(\frac{1}{\omega C_1}+\frac{1}{\omega C_2}-\omega L\right)+\left(\frac{(1+h_{fe})}{\omega^2 C_1 C_2}-\frac{L}{C_1}\right)=0$$

→ Equate img. part to zero

$$h_{ie}\,j\omega\left(-\frac{1}{\omega^2 C_1}-\frac{1}{\omega^2 C_2}+L\right)=0$$

$$-\frac{1}{\omega^2 C_1}-\frac{1}{\omega^2 C_2}+L=0$$

$$L=\frac{1}{\omega^2 C_1}+\frac{1}{\omega^2 C_2}$$

$$L=\frac{1}{\omega^2}\left[\frac{1}{C_1}+\frac{1}{C_2}\right]$$

$$\omega^2=\frac{1}{L}\left[\frac{1}{C_1}+\frac{1}{C_2}\right] \rightarrow (1)$$

$$\omega = 2\pi f$$

$$f=\frac{1}{2\pi}\sqrt{\frac{1}{L}\left[\frac{1}{C_1}+\frac{1}{C_2}\right]}$$

Derivation

$$f = \frac{1}{2\pi}\sqrt{\frac{C_1 + C_2}{L C_1 C_2}}$$

→ f depends only on 3 elements belong C_1, C_2 & L, (ie) f/b n/w.
not on the amplifier (ie) transistor

conditions for maintenance of oscillation

Equate real part to zero

$$-\frac{(1+h_{fe})}{\omega^2 C_1 C_2} + \frac{L}{C_1} = 0$$

$$\frac{L}{C_1} = \frac{1+h_{fe}}{\omega^2 C_1 C_2}$$

$$\omega^2 = \frac{(1+h_{fe})}{L C_2} \rightarrow (2)$$

$$f = \frac{1}{2\pi}\sqrt{\frac{(1+h_{fe})}{L C_2}}$$

Derivation

sub (3) in (1)

$$\frac{(1+h_{fe})}{L C_2} = \frac{1}{L}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\frac{1+h_{fe}}{L C_2} = \frac{C_1 + C_2}{L C_1 C_2}$$

$$1 + h_{fe} = \frac{C_1 + C_2}{C_1}$$

$$1 + h_{fe} = 1 + \frac{C_2}{C_1}$$

$$\boxed{h_{fe} = \frac{C_2}{C_1}}$$

Assessment 1

List the advantages and disadvantages of Hartley oscillator

References

Electronic Devices and Circuits By Salivahanan

Thank You