Analog Electronics

Course No: AE-2

Lec: LC & Crystal Oscillators

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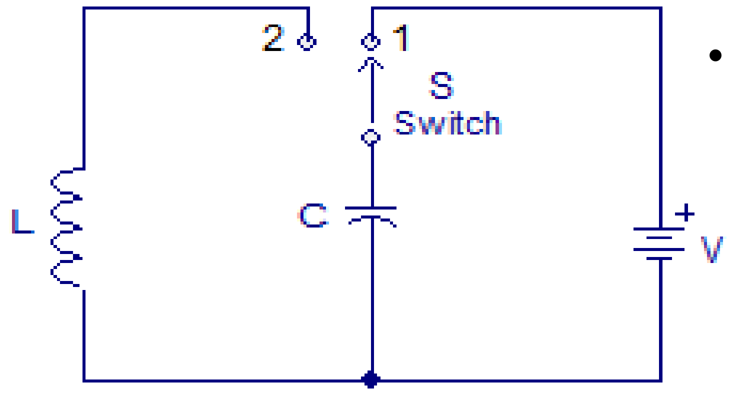
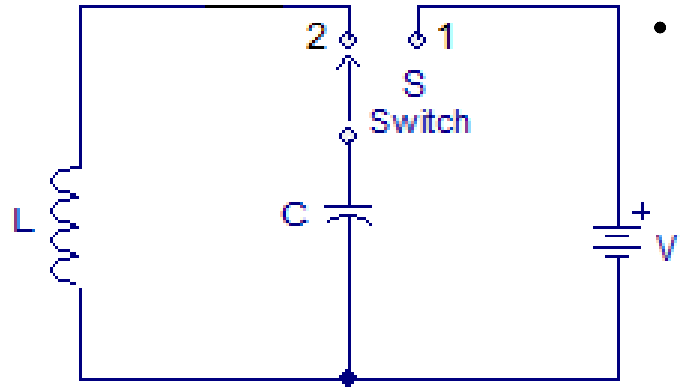
PDEU PANDIT DEENDAYAL ENERGY UNIVERSITY

Formerly **Pandit Deendayal Petroleum University**

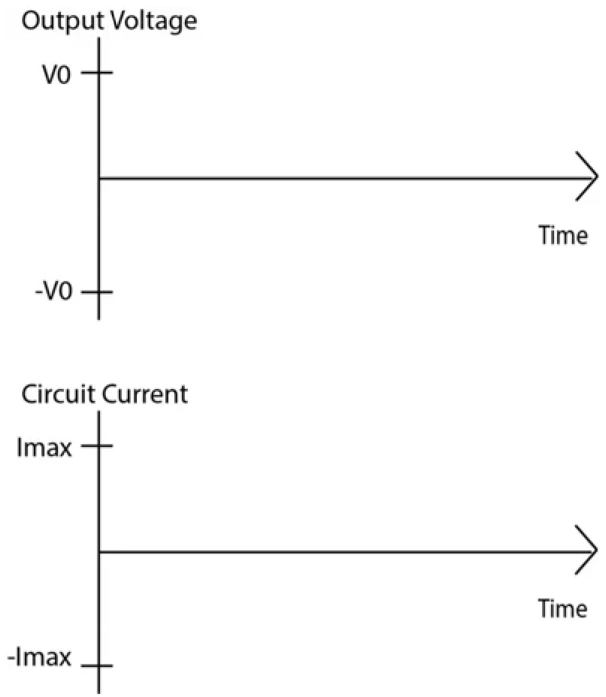
LC Tank Circuit:

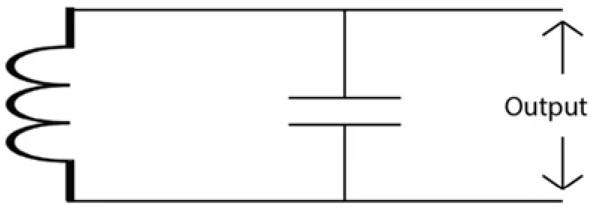


- Initially capacitor is not charged: $V_c(0^-) = 0$



- Continuous charging and discharging of capacitor and inductor

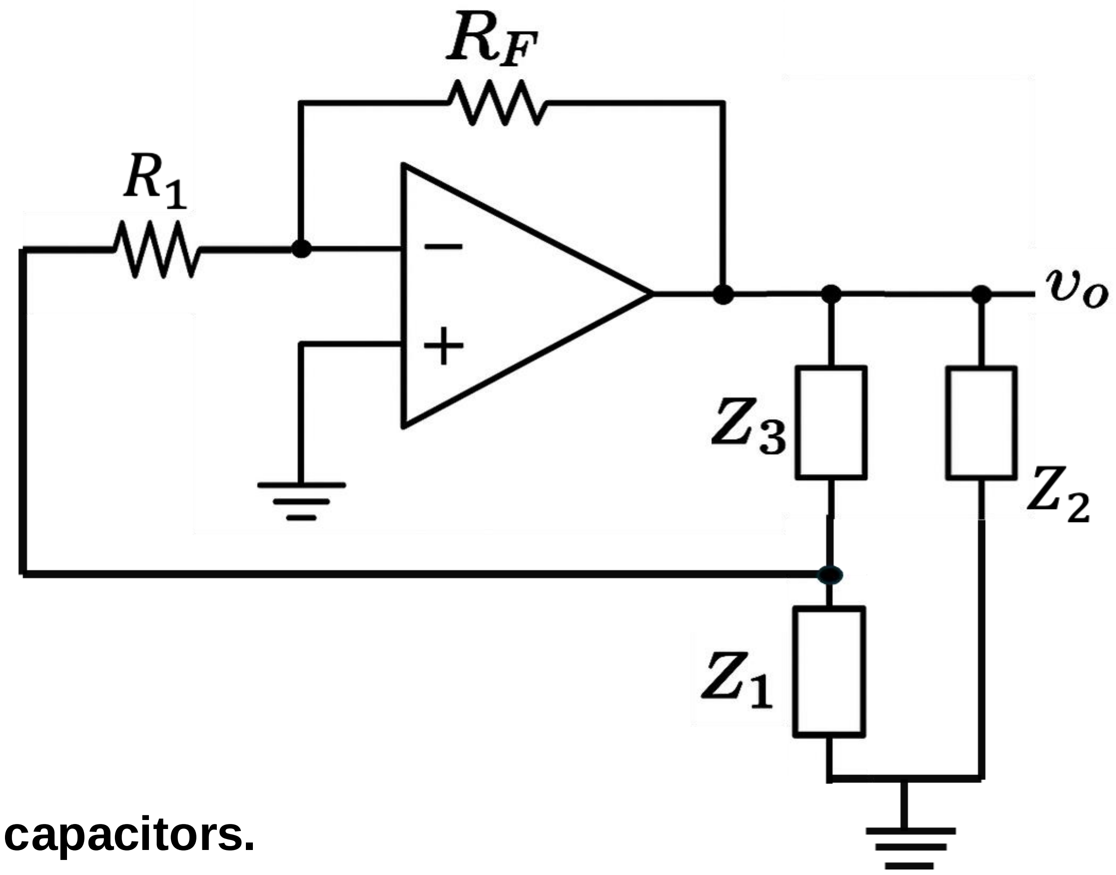




Tuned Oscillators Circuits: LC Oscillators

Tuned oscillators use a parallel LC resonant circuit (LC tank) to provide the oscillations.

- **The frequency selection network (Z_1, Z_2 and Z_3) provides a phase shift of 180°**
- **Output voltage is developed across Z_2 and feedback voltage is developed across Z_1.**
- **The amplifier provides additional shift of 180°**

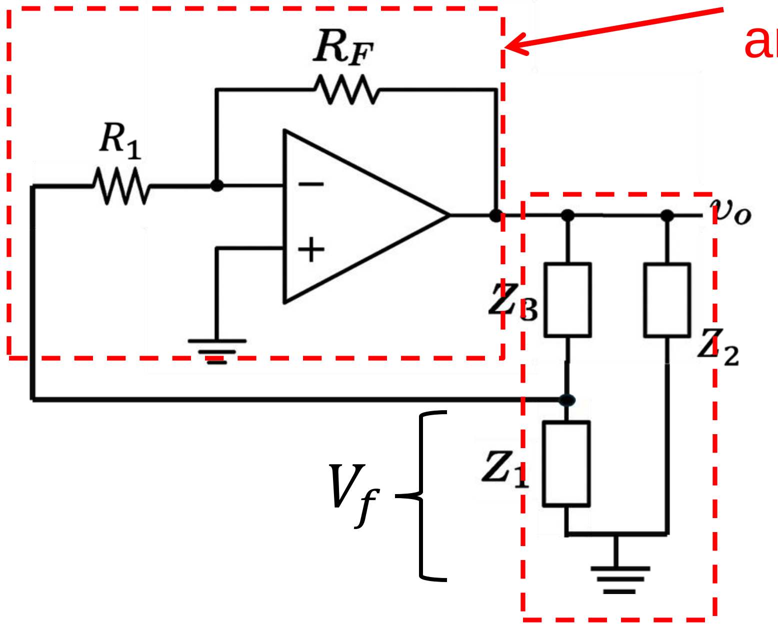


There are two common types:

Colpitts—The resonant circuit is an inductor and two capacitors.

Hartley—The resonant circuit is a tapped inductor or two inductors and one capacitor.

Generalized LC Oscillator:



OPAMP inverting amplifier (180º shift)

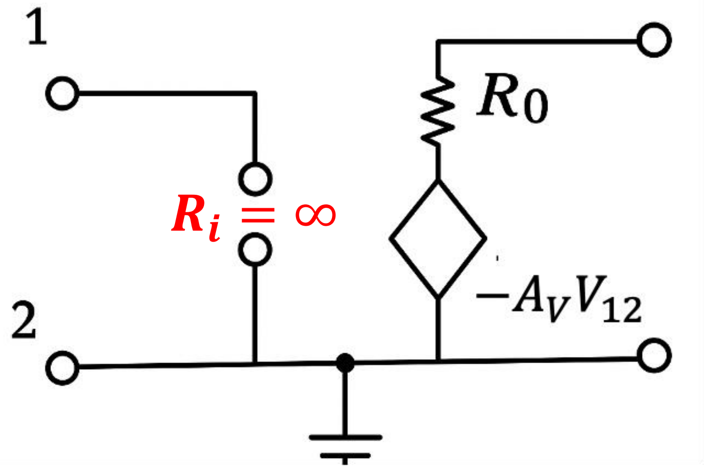
Oscillator frequency selector circuit (β)

$$V_f = \beta V_o$$

$$V_f = \frac{Z_1}{Z_1 + Z_3} V_o$$

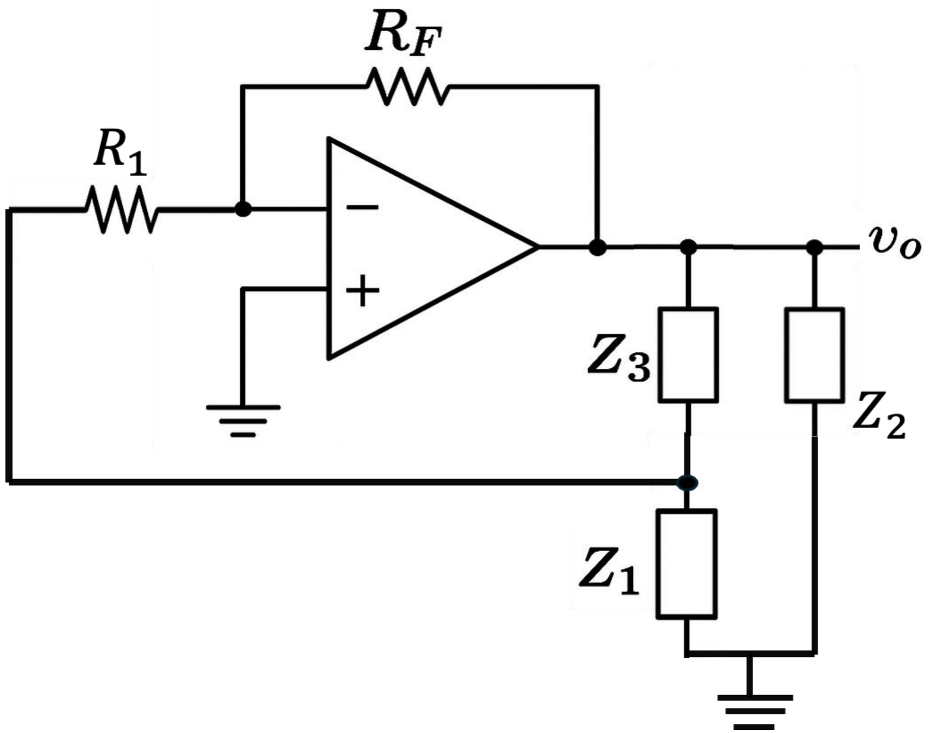
$$\boxed{\beta = \frac{Z_1}{Z_1 + Z_3}}$$

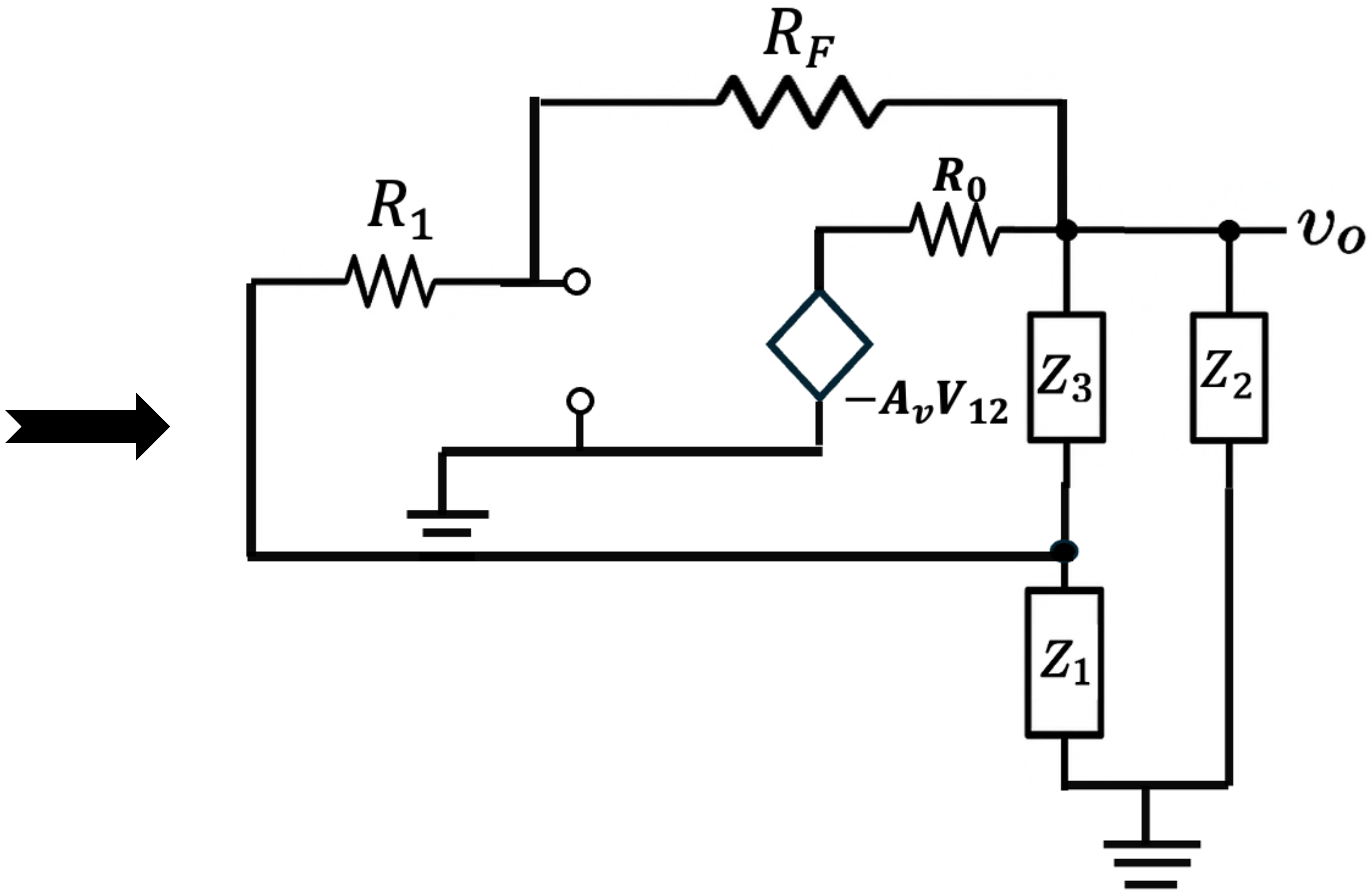
OPAMP's internal ckt:



- $\boldsymbol{R_i} = \infty$ (very high so we can reject)
- But $\boldsymbol{R_o}$is finite but low

Generalized LC Oscillator:





$$V_0 = -A_v V_{12} \times \frac{Z_l}{Z_l + R_0}$$

$$Z_l = Z_2 || (Z_1 + Z_3)$$

$$= \frac{Z_2 \times (Z_1 + Z_3)}{Z_1 + Z_3 + Z_2}$$

$$A = \frac{V_0}{V_{12}} = -A_v \times \frac{Z_l}{Z_l + R_0}$$

$$A = \frac{-A_v \times \ Z_2 \times (Z_1 + Z_3)}{R_0 \times (Z_1 + Z_3 + Z_2) + Z_2 \times (Z_1 + Z_3)}$$

$$\boxed{A = \frac{-A_v \times \ Z_2 \times (Z_1 + Z_3)}{R_0 \times (Z_1 + Z_3 + Z_2) + Z_2 \times (Z_1 + Z_3)}}$$

$$\boxed{\beta = \frac{Z_1}{Z_1 + Z_2}}$$

$$\boxed{A\beta = \frac{-A_v \times \ Z_2 \times Z_1}{R_0 \times (Z_1 + Z_3 + Z_2) + Z_2 \times (Z_1 + Z_3)}}$$

Let $Z_1, Z_2, Z_3 = j\,X_1, j\,X_2, j\,X_3;$

$$where\ X = \omega L, or(-\frac{1}{\omega C})$$

$$A\beta = \frac{A_v \times \ X_2 \times X_1}{jR_0 \times (X_1 + X_3 + X_2) - X_2 \times (X_1 + X_3)}$$

Aβ should be equal for sustained oscillation:

$$jR_0 \times (X_1 + X_3 + X_2) = 0$$

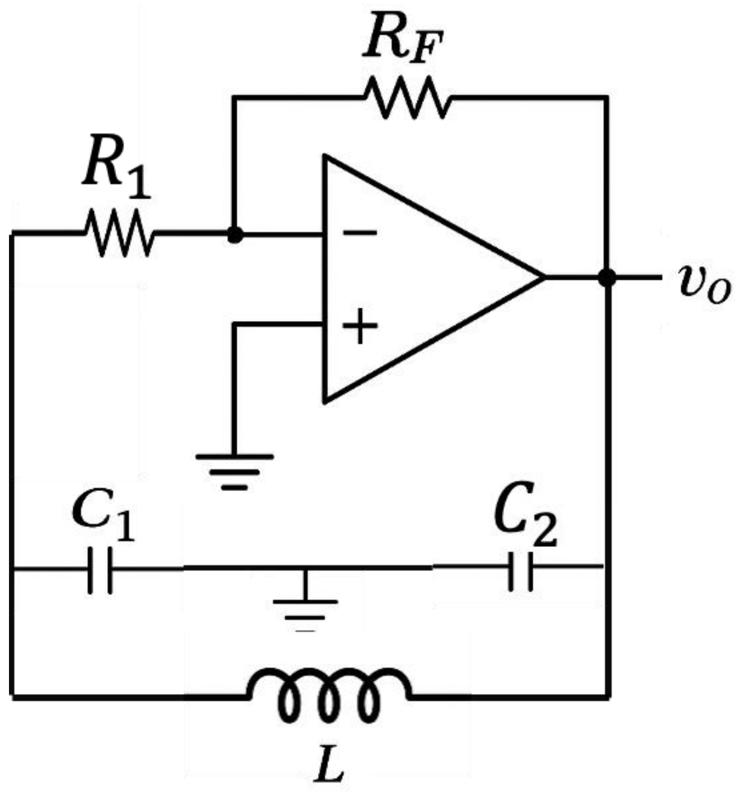
$$\Rightarrow \boxed{(X_1 + X_3 + X_2) = 0}$$

$$A\beta = \frac{A_v \times \ X_2 \times X_1}{-X_2 \times (X_1 + X_3)}$$

$$A\beta = \frac{A_v \times X_2 \times X_1}{-X_2 \times -X_2} = \frac{A_v \times X_1}{X_2}$$

$$\boxed{A_v = \frac{X_2}{X_1}}$$

Colpitt's Oscillator:



Z_1, $Z_2 \rightarrow$ Capacitors

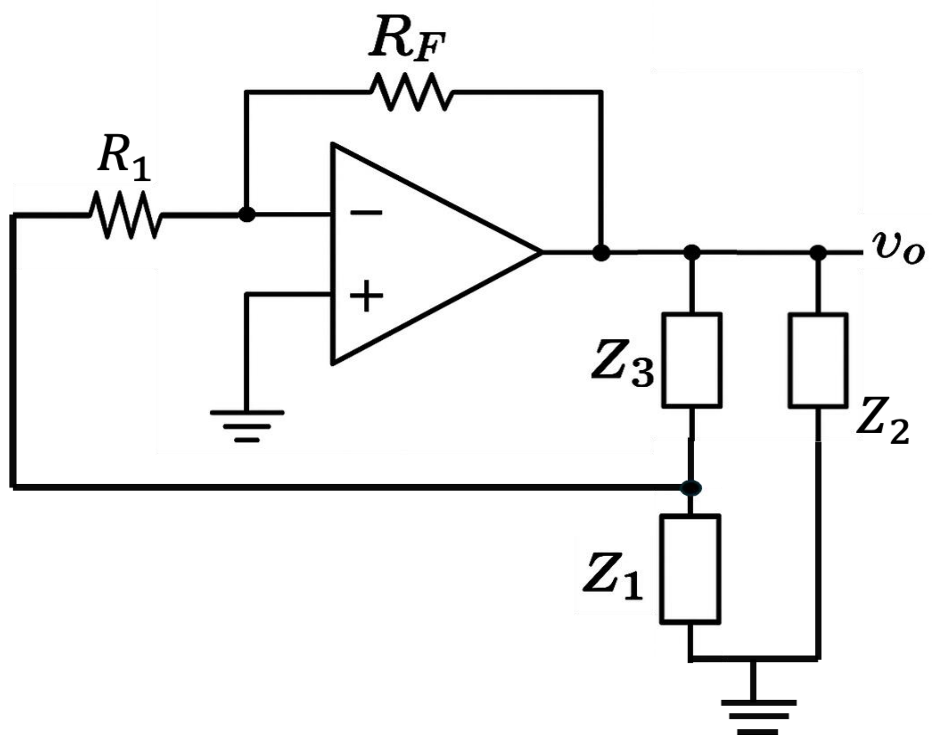
$Z_3 \rightarrow$ Inductor

Derive relation of f_0 !!

$$\Rightarrow (X_1 + X_3 + X_2) = 0$$

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

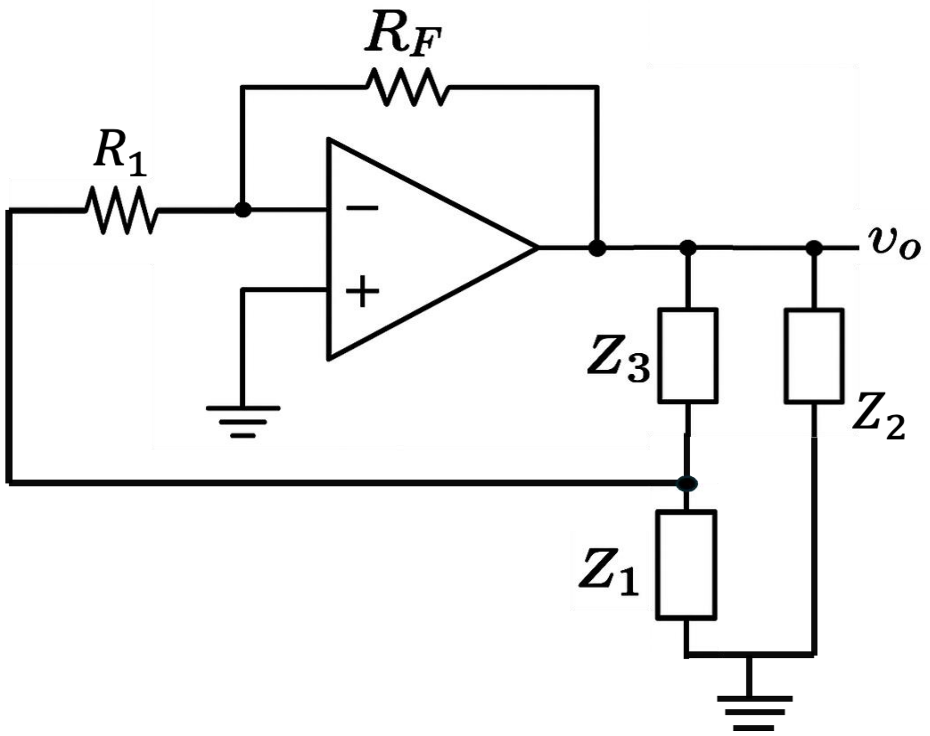
$$\boxed{f_0 = \frac{1}{2\pi}\sqrt{\frac{(C_1 + C_2)}{L C_1 C_2}}}$$



Hartley's Oscillator:

$Z_1, Z_2 \rightarrow$ **Inductor**

$Z_3 \rightarrow$ **Capacitors**



Derive relation of f_0 !!

$$\Rightarrow (X_1 + X_2 + X_3) = 0$$

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

$$\boxed{f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{C(L_1 + L_2)}}}$$

THE END.