Oscillator

- Introduction of Oscillator
- Linear Oscillator
  - Wien Bridge Oscillator
  - RC Phase-Shift Oscillator
  - LC Oscillator
  - Crystal Oscillator
- Stability

Oscillators

Oscillation: an effect that repeatedly and regularly fluctuates about the mean value

Oscillator: circuit that produces oscillation

Characteristics: wave-shape, frequency, amplitude, distortion, stability

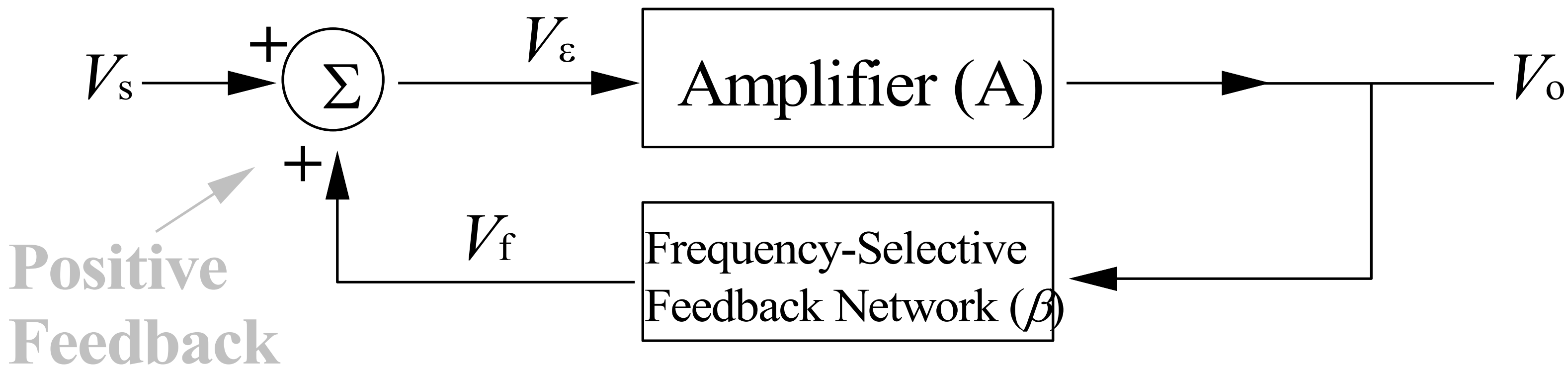
Application of Oscillators

- Oscillators are used to generate signals, e.g.
  - Used as a local oscillator to transform the RF signals to IF signals in a receiver;
  - Used to generate RF carrier in a transmitter
  - Used to generate clocks in digital systems;
  - Used as sweep circuits in TV sets and CRO.

Linear Oscillators

1. Wien Bridge Oscillators
2. RC Phase-Shift Oscillators
3. LC Oscillators
4. Stability

Integrant of Linear Oscillators

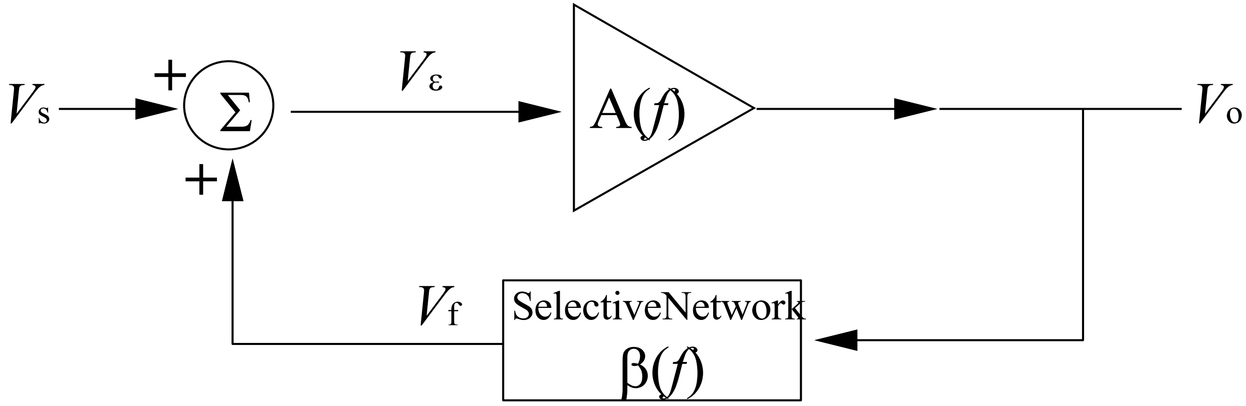


For sinusoidal input is connected
"Linear" because the output is approximately sinusoidal

A linear oscillator contains:

- a frequency selection feedback network
- an amplifier to maintain the loop gain at **unity**

Basic Linear Oscillator



$$V_o = AV_\varepsilon = A(V_s + V_f) \quad \text{and} \quad V_f = \beta V_o$$

$$\Rightarrow \frac{V_o}{V_s} = \frac{A}{1 - A\beta}$$

If $V_s = 0$, the only way that V_o can be nonzero is that loop gain $A\beta=1$ which implies that

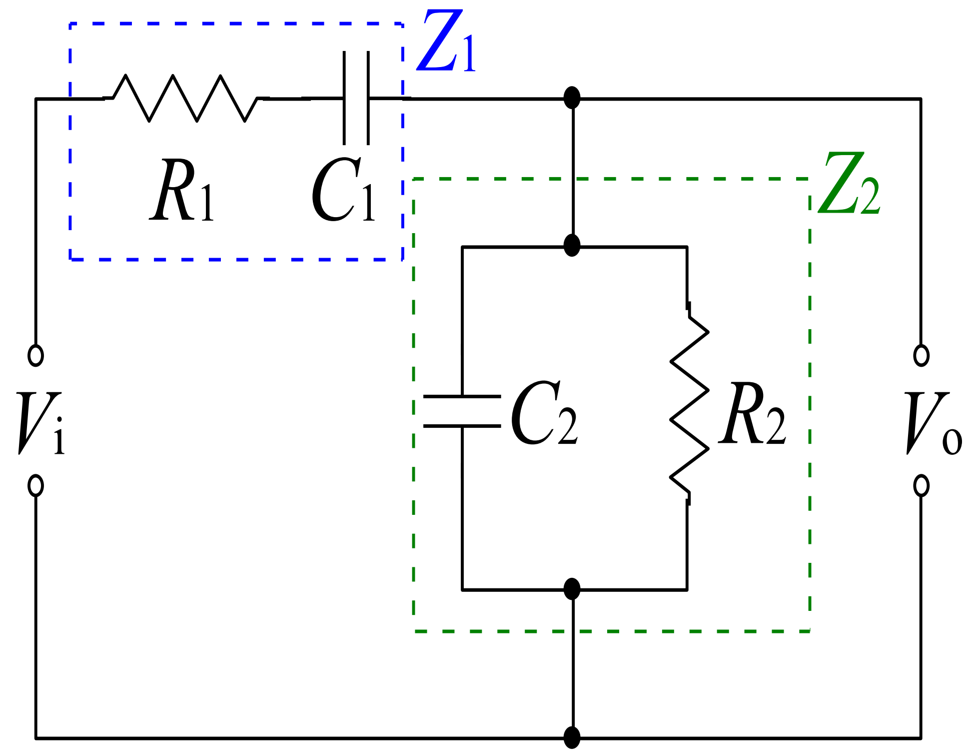
$$|A\beta| = 1$$

$$\angle A\beta = 0$$

(Barkhausen Criterion)

Wien Bridge Oscillator

Frequency Selection Network



Example

By setting $\omega = \frac{1}{RC}$, we get

Imaginary part = 0 and $\beta = \frac{1}{3}$

Due to ***Barkhausen Criterion***,

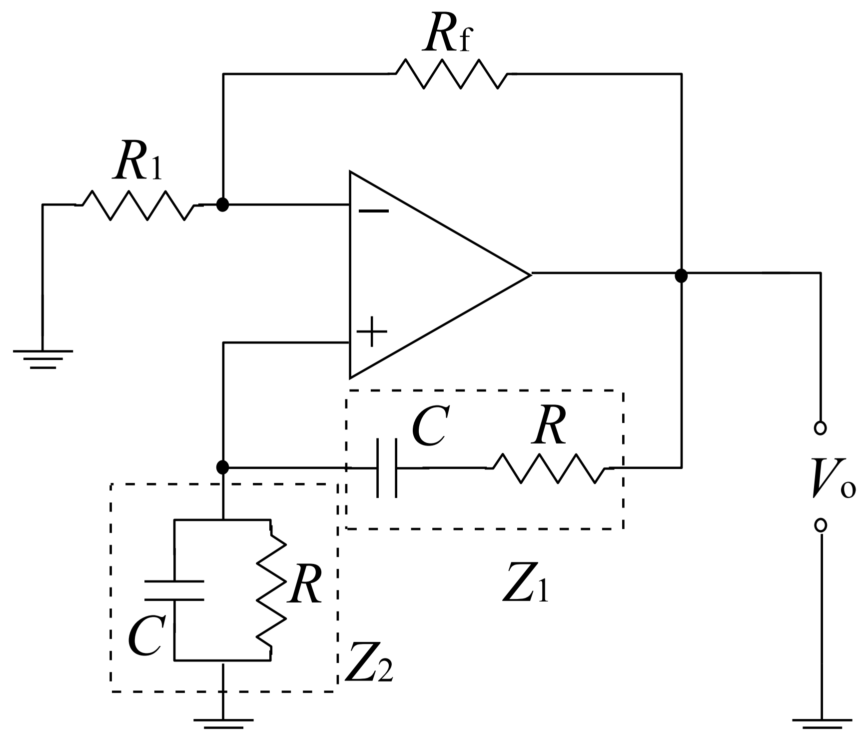
Loop gain $A_v\beta=1$

where

A_v : Gain of the amplifier

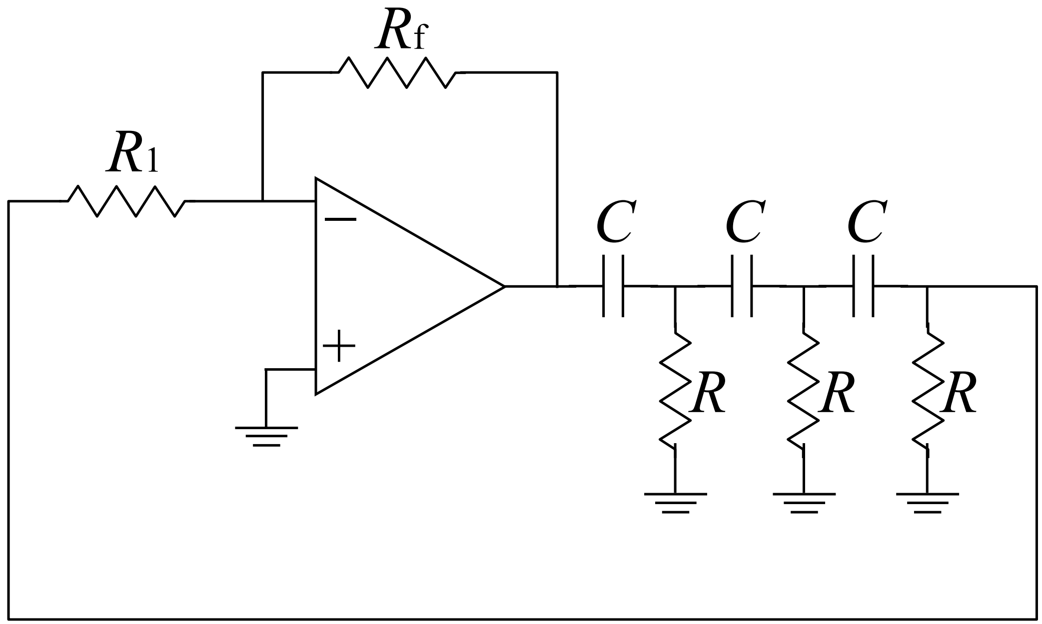
$$A_v\beta = 1 \Rightarrow A_v = 3 = 1 + \frac{R_f}{R_1}$$

Therefore, $\frac{R_f}{R_1} = 2$



Wien Bridge Oscillator

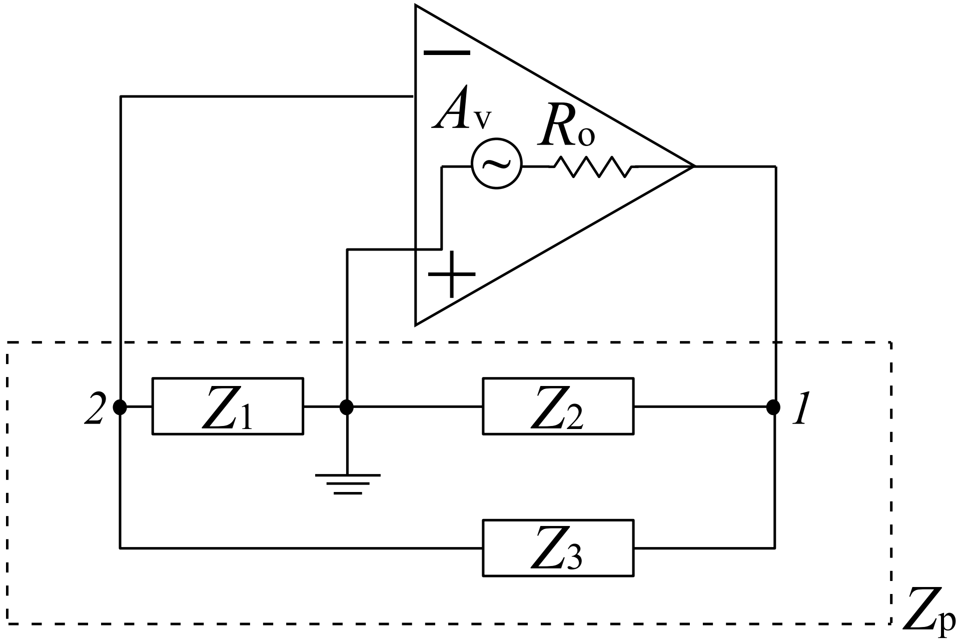
RC Phase-Shift Oscillator



- Using an inverting amplifier
- The additional 180° phase shift is provided by an RC phase-shift network

LC Oscillators

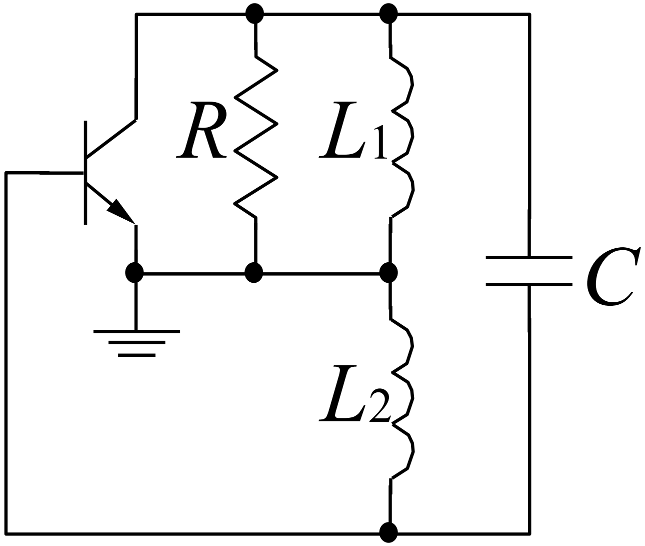
- The frequency selection network (Z_1, Z_2 and Z_3) provides a phase shift of 180^o
- The amplifier provides an addition shift of 180^o



Two well-known Oscillators:

- Colpitts Oscillator
- Harley Oscillator

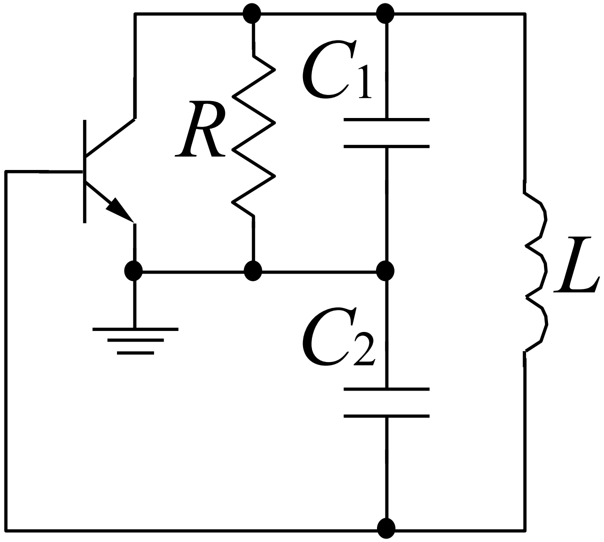
Hartley Oscillator



$$\omega_o = \frac{1}{\sqrt{(L_1 + L_2)C}}$$

$$g_m = \frac{L_1}{RL_2}$$

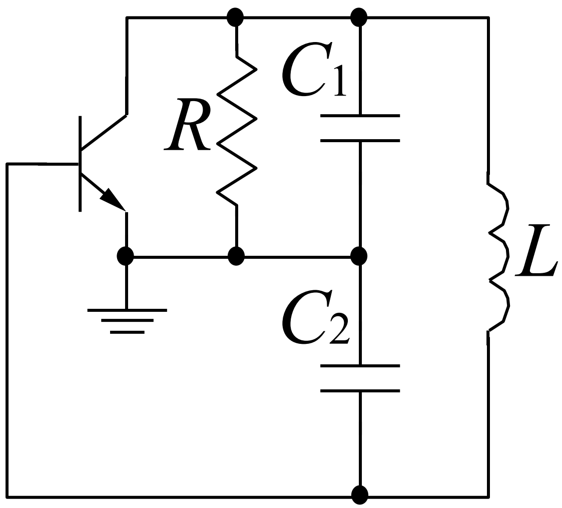
Colpitts Oscillator



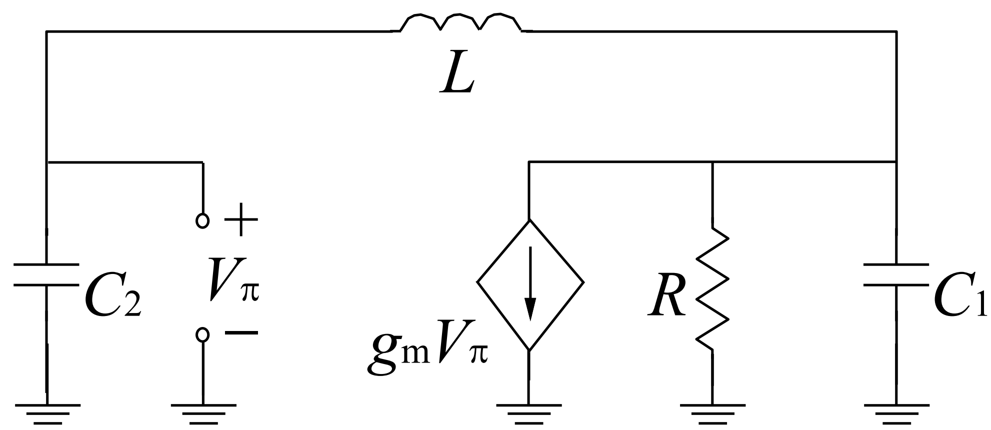
$$\omega_o = \frac{1}{\sqrt{LC_T}} \qquad C_T = \frac{C_1 C_2}{C_1 + C_2}$$

$$g_m = \frac{C_2}{RC_1}$$

Colpitts Oscillator



Equivalent circuit

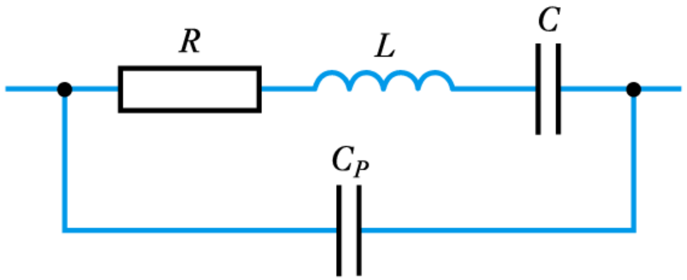


In the equivalent circuit, it is assumed that:

- Linear small signal model of transistor is used
- The transistor capacitances are neglected
- Input resistance of the transistor is large enough

- **Crystal oscillators**
  - **frequency stability** is determined by the ability of the circuit to select a particular frequency
  - in tuned circuits this is described by the **quality factor, Q**
  - **piezoelectric crystals** act like resonant circuits with a very high Q – as high as 100,000

(a) Circuit symbol



(b) Equivalent circuit

- A typical crystal oscillator