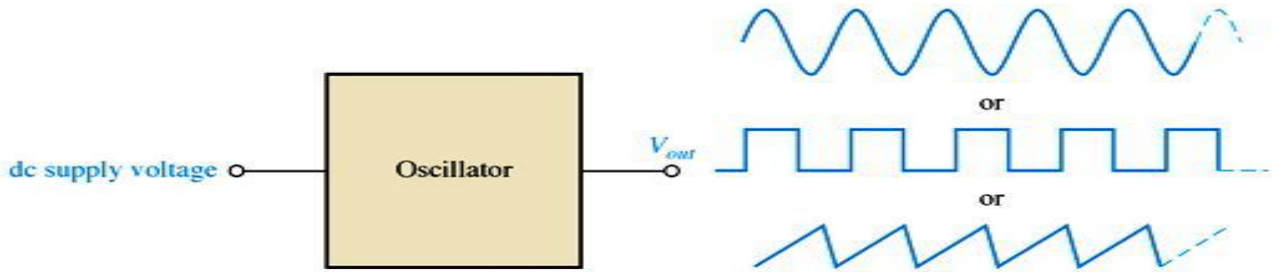
Oscillators

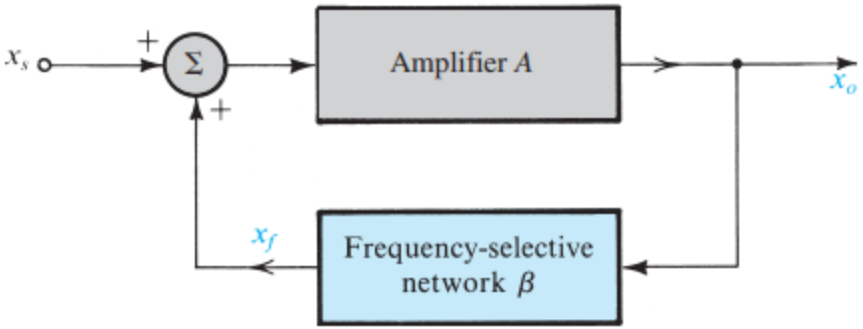
Oscillators

- Need arises for signals having prescribed standard waveforms
- Communications systems, digital systems (including computers), and test equipment make use of oscillators.

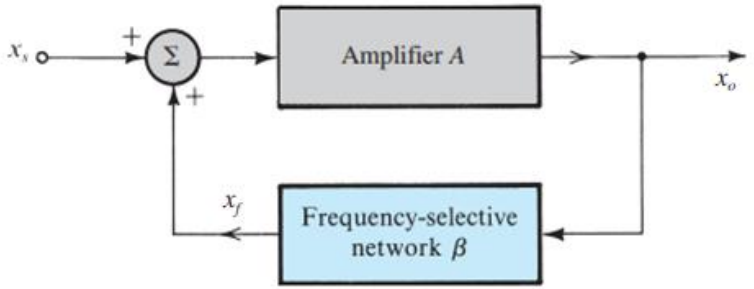


Oscillators

- Positive-feedback loop consisting an amplifier and an RC or LC frequency-selective network - generates sine waves utilizing resonance phenomena, are known as linear oscillators
- Circuits that generate square, triangular, pulse waveforms are called non-linear oscillators or function generators



Oscillator Feedback loop



Open-loop gain, $x_o = Ax_i$

Sample of output, $x_f = \beta x_o$

Input to amplifier, $x_i = x_s + x_f$

Gain of feedback amplifier, $A_f = \dfrac{x_o}{x_s}$

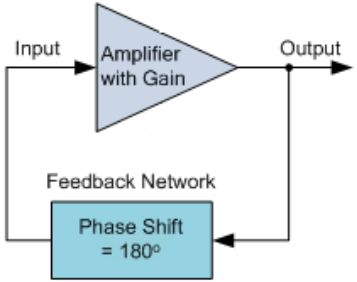
$$= \frac{x_o}{x_i - x_f} = \frac{Ax_i}{x_i - \beta A x_i}$$

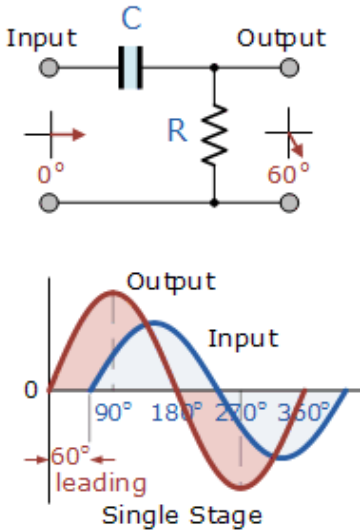
$$A_f = \frac{A}{1 - A\beta}$$

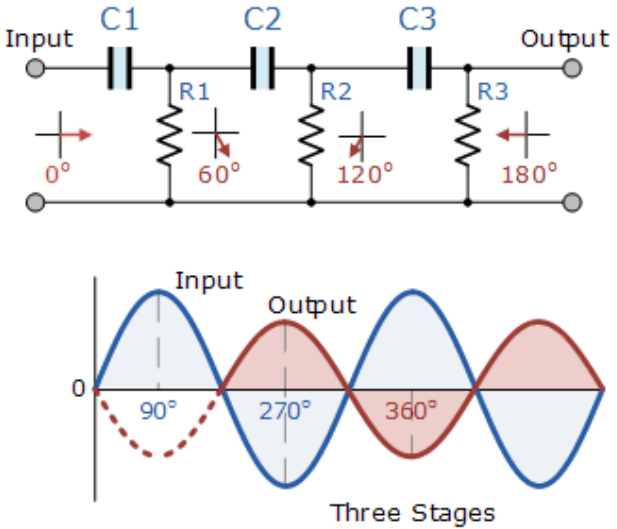
Barkhausen Criterion

- Condition for feedback loop to provide sinusoidal oscillations
  - The magnitude of the loop gain is unity, i.e., $|A\beta|=1$
  - The total phase shift around the loop is 0^0

RC Phase Shift Oscillator

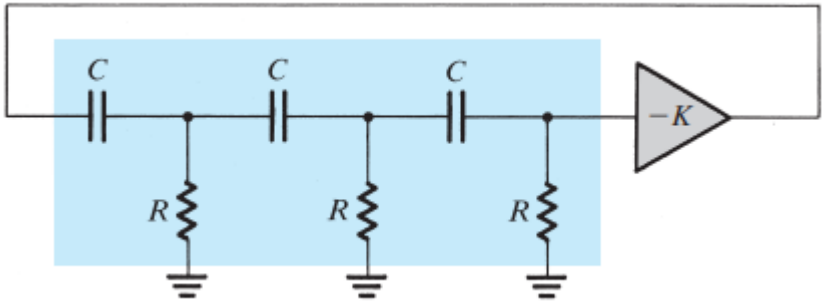






RC Phase Shift Oscillator

- The phase shift oscillator utilizes three RC circuits to provide 180º phase shift



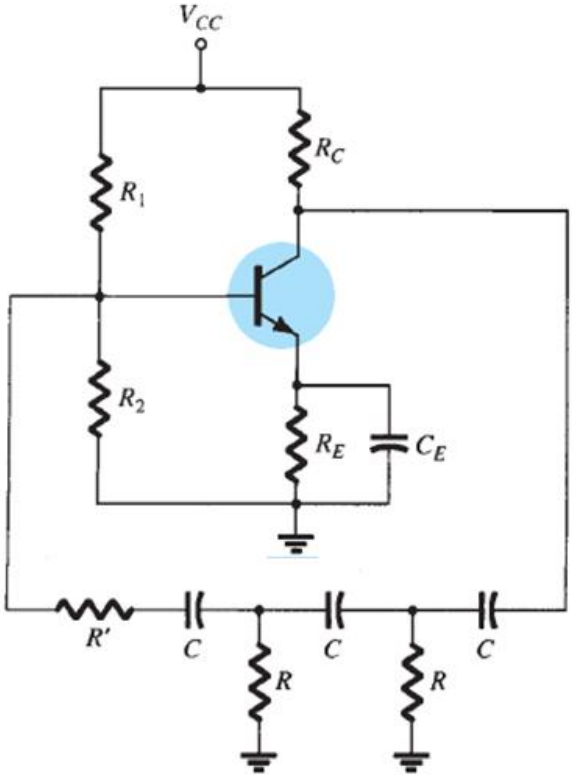
RC Phase Shift Oscillator

- The frequency of resonance is

$$f = \frac{1}{2\pi RC}\,\frac{1}{\sqrt{6 + 4(R_c/R)}}$$

- For sustained oscillation, $h_{fe} = 23 + \frac{29}{k} + 4\,\text{k}.$ where $k = \frac{R_C}{R}$

- The minimum value of h_{fe} is found equal to 56 when k = 1



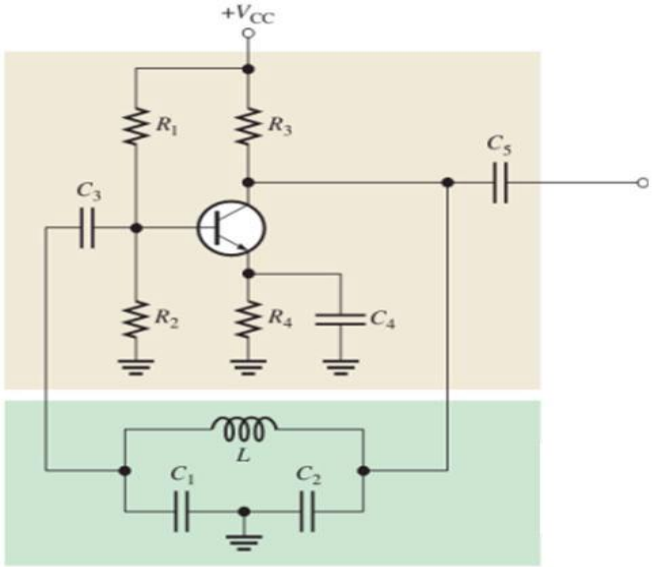
LC Oscillators

Colpitts Oscillator

- Uses an LC circuit in the feedback loop to provide the necessary phase shift and to act as a resonant filter that passes only the desired frequency of oscillation
- The frequency of resonance is

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

$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

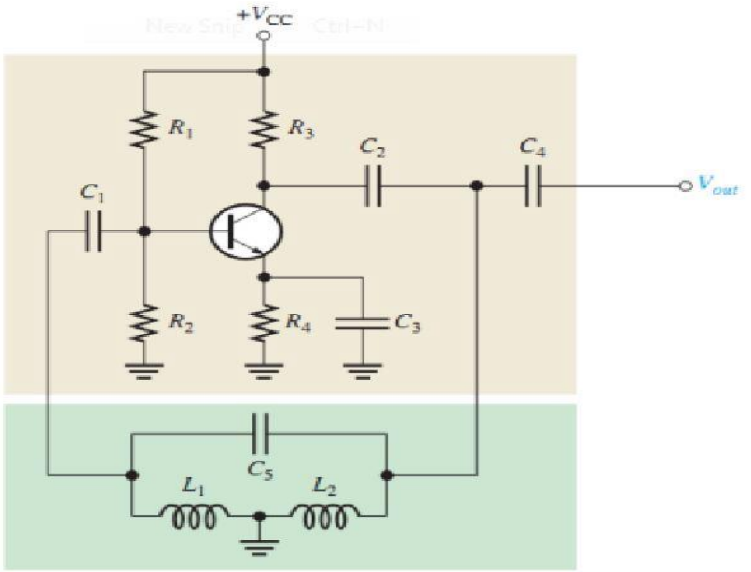


Hartley Oscillator

- Feedback circuit consists of two series inductors and a parallel capacitor
- The frequency of resonance is

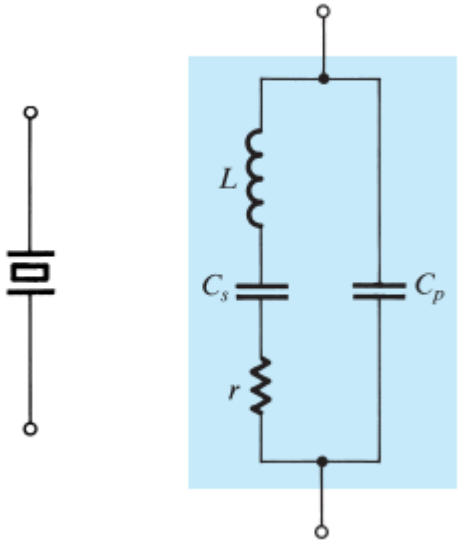
$$f_r = \frac{1}{2\pi\sqrt{L_T C}}$$

$L_T = L_1 + L_2$



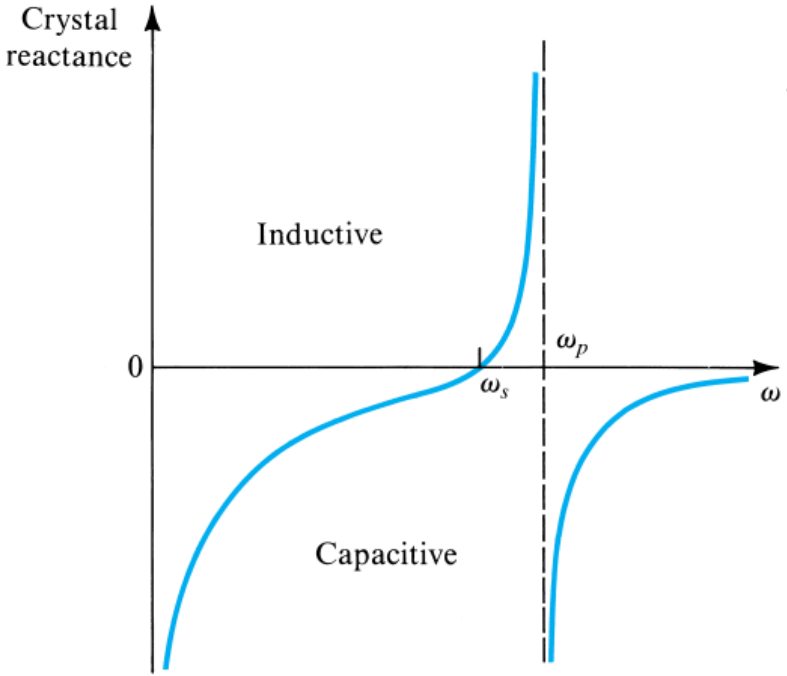
Crystal Oscillator

- A quartz crystal exhibits a very important property known as the piezoelectric effect.
- When a mechanical pressure is applied across the faces of the crystal, a voltage which is proportional to mechanical pressure appears across the crystal.
- Produces mechanical vibrations or oscillations when voltage is applied



$$Q \text{ factor} = \omega_0 L/r$$

Crystal Oscillator



Consists of two resonances such as series and parallel resonance, i.e., two resonant frequencies

series resonance at $\omega_s = 1/\sqrt{LC_s}$

parallel resonance at $\omega_p = 1 \Big/ \sqrt{L\left(\frac{C_s C_p}{C_s + C_p}\right)}$

$$\omega_p > \omega_s$$

$$\omega_0 \simeq 1/\sqrt{LC_s} = \omega_s$$

Crystal Oscillator