The Signal Generators and Wave Shaping Circuits

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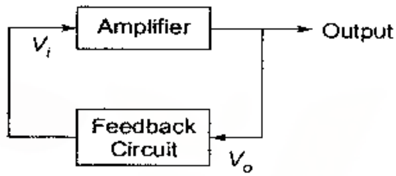
Oscillators

The oscillators are positive feedback amplifier in which the part of output is feedback to the input via feedback circuit.



The gain, $$\frac{V_o}{V_i} = \frac{A}{1 - A\beta}$$

$\because$ $V_i = 0$ (Noise)

$$A\beta = 1 \quad \text{or} \quad 1\angle 0^\circ \simeq \angle 360^\circ$$

Barkhausen criterion

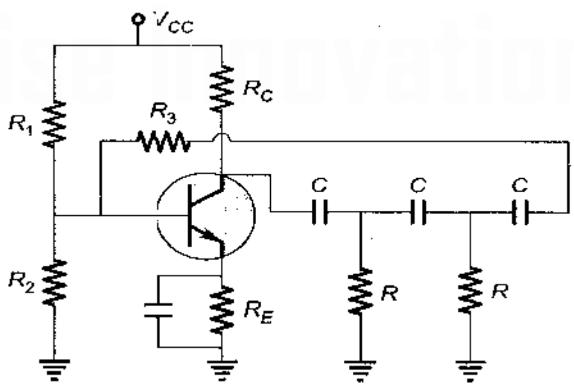
- The magnitude of loop gain Aβ must be atleast 1.
- The total phase shift of the loop gain Aβ must be equal to 0° or 360°.

Oscillator Types

Type of Component	Frequency of oscillation	Waveform generated
RC oscillator	Audio frequency	Sinusoidal
LC oscillator	Radio frequency	Square wave
Crystal oscillator	Radio frequency	Triangular wave sawtooth wave etc.

RC Phase Shift Oscilltor

RC phase shift oscillator using BJT



- Frequency of oscillation is

$$\omega = \frac{1}{RC\sqrt{4K+6}} \quad ; \quad f = \frac{1}{2\pi RC\sqrt{4K+6}}$$

where, $K = \frac{R_C}{R}$

Note:

- For transistor to work as oscillator

$$h_{fe} \geq \left(4K + 23 + \frac{29}{K}\right)$$

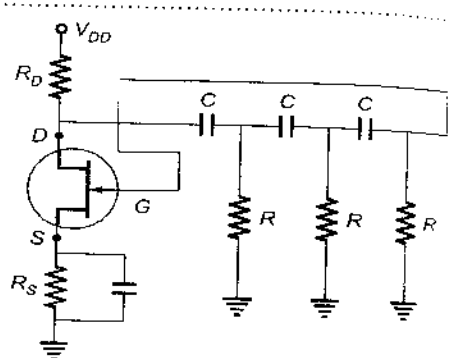
- $h_{fe\,(min)} = 44.5$.

RC Phase Shift Oscillator using FET

- Frequency of Oscillation

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

$$\beta = -\frac{1}{29} \text{(feedbook factor)}$$



Note:

Amplification factor for FET to work as an Oscillator is $\mu \geq 29$.

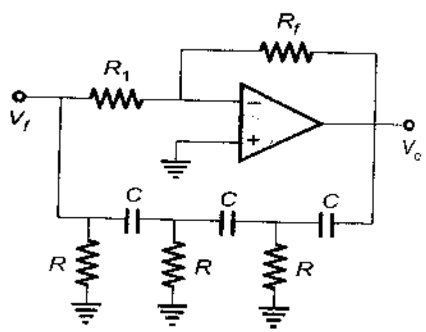
RC Phase Shift Oscillator using Op-Amp

- Feedback factor

$$\beta = \frac{V_f}{V_o} = -\frac{1}{29} \text{(for oscillation)}$$

- Frequency of oscillation

$$f = \frac{1}{2\pi RC\sqrt{6}}$$



Note:

$R_f \geq 29R_1 \rightarrow$ for oscillation.

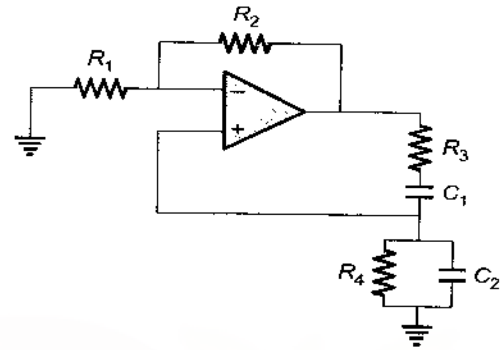
Wein Bridge Oscillator

- Frequency of oscillation

$$f = \frac{1}{2\pi\sqrt{R_3R_4C_1C_2}}$$

if $R_3 = R_4 = R$
and $C_1 = C_2 = C$

then $f = \frac{1}{2\pi R.C}$



Remember:

- $\beta = \frac{1}{3}$ for oscillation.
- $R_2 \geq 2R_1$ for oscillation.

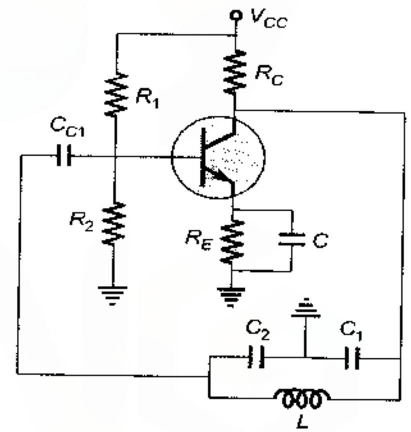
LC Oscillator

Colpitt's Oscillator

- Frequency of oscillation

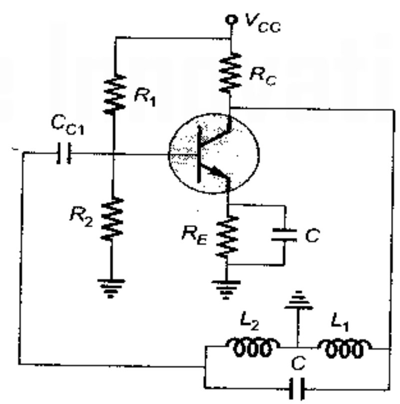
$$f = \frac{1}{2\pi\sqrt{L\left(\frac{C_1C_2}{C_1 + C_2}\right)}}$$

and $g_mR_C \geq \frac{C_2}{C_1}$



Hartley Oscillator

- If in place of C_1, C_2 there is L_1 and L_2 and inplace of L there is C then it becomes Hartley Oscillator.



- Frequency of oscillation for Hartley Oscillator is

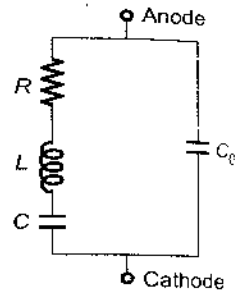
$$f = \frac{1}{2\pi\sqrt{C(L_1 + L_2)}} \quad \text{and} \quad g_m RC \geq \frac{L_1}{L_2}$$

Clapp Oscillator

- If in Colpitt oscillator circuit inductor is replaced by a variable capacitor (C_3) then frequency of oscillation becomes

$$f = \frac{1}{2\pi\sqrt{LC_3}} \quad \text{it happens if} \quad \left(\frac{C_1}{C} >> 1\right) \quad \text{and} \quad \frac{C_1}{C} >> \frac{C_1}{C_2}$$

Crystal Oscillator



- It is electrical equivalent circuit is
- Series resonance frequency

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

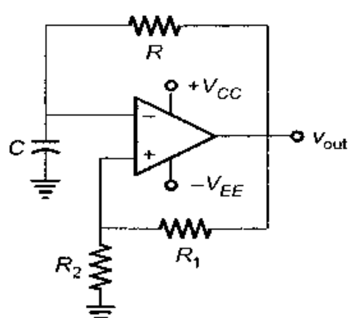
- Parallel resonance frequency

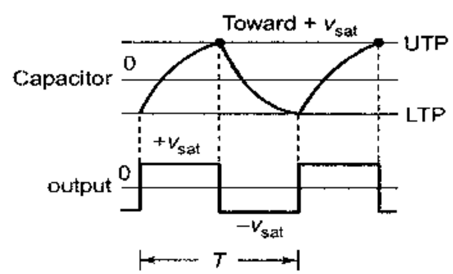
$$f_p = \frac{1}{2\pi\sqrt{LC_{eq}}} \quad \text{where,} \quad C_{eq} = \frac{CC_0}{(C + C_0)}$$

Note:

Frequency of oscillation is chosen between f_p and f_s.

Relaxation Oscillator





Time period of output signal

$$T = 2RC\, ln\left(\frac{1 + B}{1 - B}\right)$$

where, R = Feedback resistance ; B = Feedback fraction

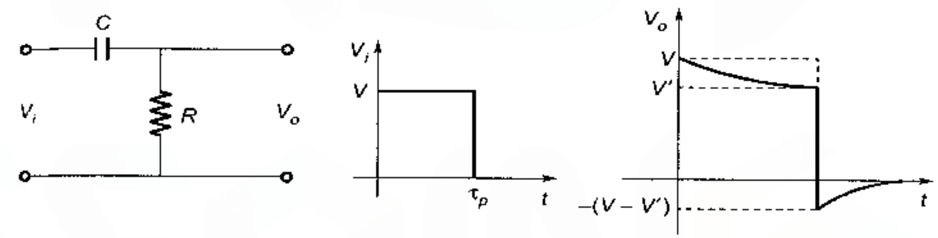
Note:

- Linear oscillator generates sinewaves utilizing resonance phenonmenon.
- Non linear oscillators or function generators generate square-wave, triangular wave, pulses etc. waveforms. They uses function blocks as multivibrators.
- Relaxation oscillator and UJT oscillator are non-linear oscillator.
- The oscillators which uses a tunnel diode or UJT posseses a current voltage characteristic curve of negative slope within some range of operation are known as negative resistance oscillator.
- Wein's Bridge oscillator is a variable frequency oscillator.

Linear Wave Shaping Circuits

High Pass RC Circuit

Pulse response of high pass R.C circuit



$(V - V')$ is called tilt or sag.

$$\% \text{ tilt} = \frac{V - V'}{V} \times 100\%$$

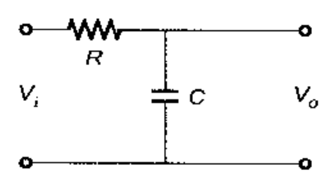
Note:

Sag or tilt will be obtained if $RC >> \tau_p$.

- If input is a square wave of time period T then

$$\% \text{ tilt} = \frac{\pi f_L}{f} \times 100 \quad \text{where,} \quad f_L = \frac{1}{2\pi RC} \quad \text{and} \quad f = \frac{1}{T}$$

Low Pass RC Circuit



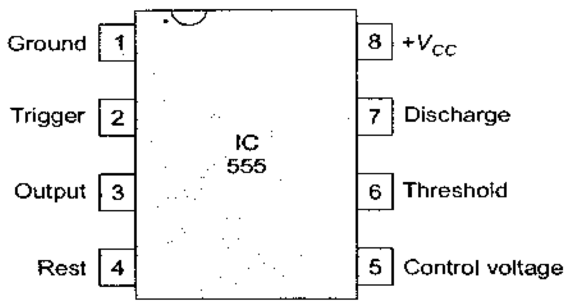
- Rise time $\boxed{t_r = \dfrac{0.35}{f_H} \text{ (rise from 10\% to 90\%)}}$

  where, $\boxed{f_H = \dfrac{1}{2\pi RC}}$

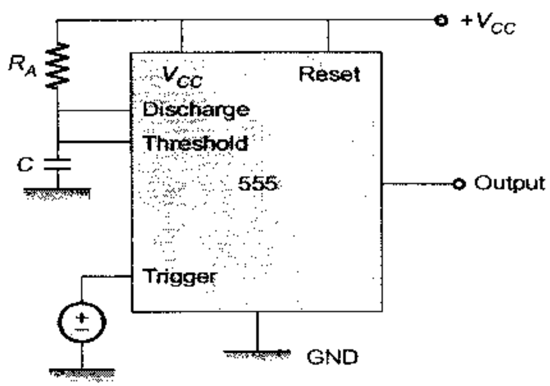
555 Timer

The 555 is a timing circuit that can produce accurate and highly stable time delays or oscillation.

555 Timer Pin Configuration



Monostable Multivibrator

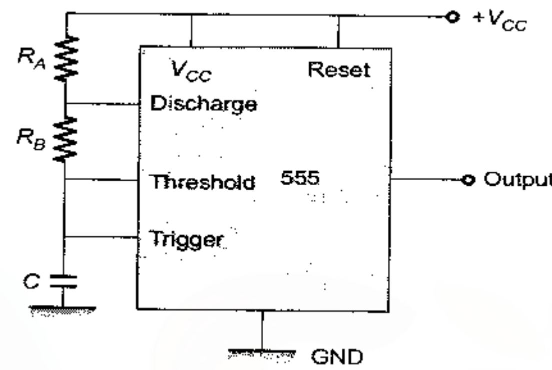


$$\boxed{T = RC\ ln(3) = 1.1\,RC}$$

Note:

The main applications of monostable multivibrator are pulse width modulator, linear ramp generator, frequency divider, pulse strechter etc.

Astable Multivibrator



$$\boxed{T = \tau\, ln(2)}$$

- Charging time constant, $\boxed{T_C = 0.693(R_A + R_B)C}$
- Discharging time constant, $\boxed{T_D = 0.693\ R_B C}$
- Total time, $\boxed{T = T_C + T_D = 0.693\ (R_A + 2R_B)C}$
- Duty cycle, $\boxed{D = \dfrac{T_C}{T_C + T_D} \times 100\% = \dfrac{R_A + R_B}{R_A + 2R_B} \times 100\%}$

Note:

The main applications of astable are square-wave generator, voltage control oscilltor, FSK generator, free running oscillator etc.

Remember:

- Duty cycle (D) > 50%. (Because $T_C > T_D$)
- By placing a diode parallel to R_B and making $R_A + R_f = R_B$, we get square wave output of duty cycle 50%.

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