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Oscillators.

An oscillator is a circuit which produces a continuous, repeated, alternating wave-form (a.c) without any input.

Oscillators basically convert unidirectional current flow from a d.c. source in to an alternating waveform which is of the desired frequency, as decided by its circuit components.

Positive feedback.

Fig. shows the block diagram of an amplifier with positive feedback applied.

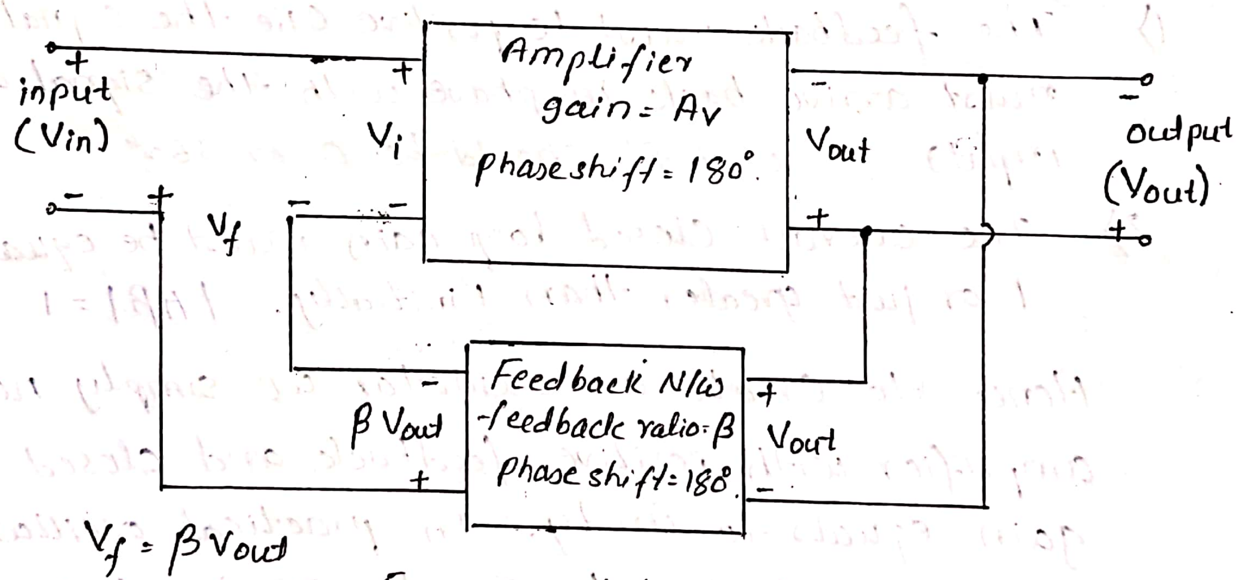


Fig. Amplifier with positive feedback.

Note that the amplifier provides a phaseshift of 180° and the feedback network provides a further phaseshift of 180°. Therefore the overall phaseshift is 360° or 0°.

The overall voltage gain, G is given by

$$G = \frac{V_{out}}{V_{in}}$$

By KVL at input.

$$V_i = V_{in} + \beta V_{out}$$

Thus, $V_{in} = V_i - \beta V_{out}$ and

$V_{out} = A_v \times V_{in}$ $\quad \because A_v = \dfrac{V_{out}}{V_i}$

$$\therefore G = \frac{A_v \times V_i}{V_i - \beta V_{out}} = \frac{A V_i}{V_i - \beta A_v \times V_i}$$

Thus $\boxed{G = \dfrac{A_v}{1 - \beta A_v}}$

This shows that with positive feedback overall gain G of the amplifier increases.

* Conditions for oscillations. (Barkhausen Criterion)

Conditions for oscillations are.

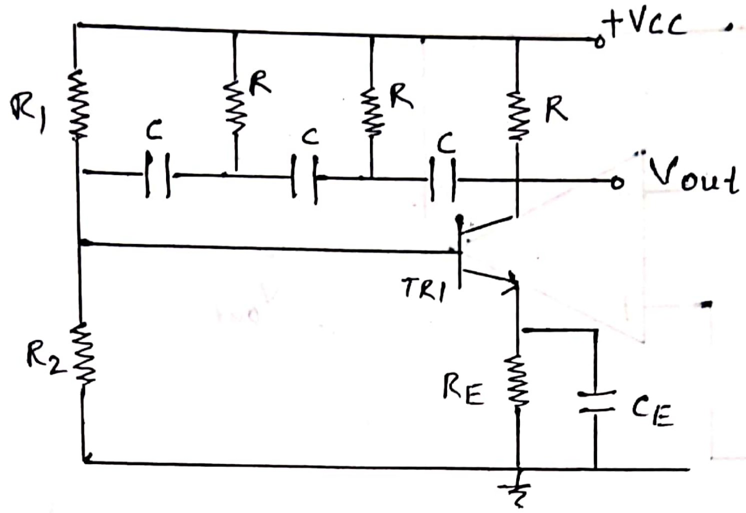
1) The feedback must be positive (i.e the signal fedback must arrive back in-phase with the signal at the input). phase shift should be 0° or 360°

2) The overall closed loop gain must be equal to 1 or just greater than 1 initially. $|A\beta| = 1$

Hence to create an oscillator we simply need an amplifier with positive feedback and closed loop gain equals to unity. In practical oscillator, it is not necessary to supply an input signal to start oscillation, Instead oscillations are self starting and begin oscillations as soon as dc power is applied.

Ladder network oscillator.

A simple phase-shift oscillator based on a three stage R-C ladder network is shown in fig.



TR_1 operates as common-emitter amplifier stage with R_1 and R_2 providing base bias and R_E and C_E providing emitter stabilization.

The total phaseshif provided by the R-C ladder network is 180° at the frequency of oscillation. The transistor provides the other 180° phase shift in order to realize an overall phase shift of 360° or 0°.

The frequency of oscillation of the circuit shown in fig. is given by

$$f = \frac{1}{2\pi\sqrt{6}\,RC} \text{ Hz.}$$

The loss associated with ladder network is 29. Thus the amplifier must provide at least gain of 29 in order for the ckt to oscillate.

Ex: Determine the frequency of oscillation of a three-stage ladder network oscillator in which $C = 10\,nF$ & $R = 10\,k\Omega$.

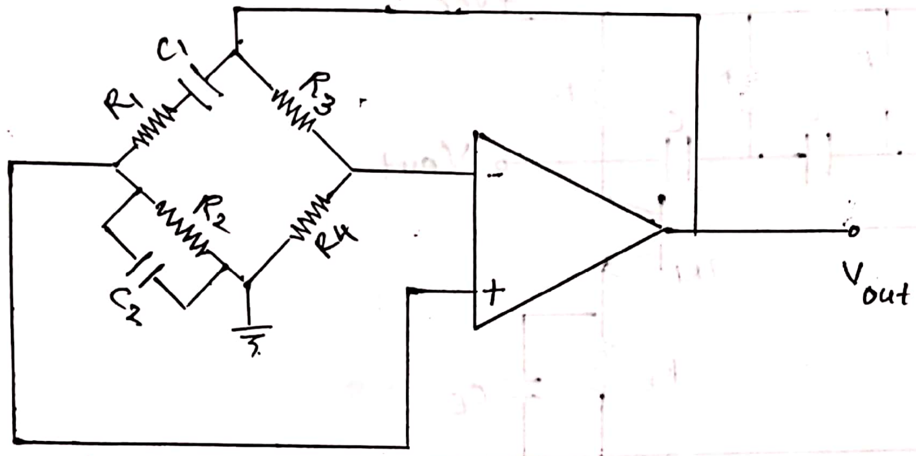
Soln: W.K.T.

$$f = \frac{1}{2\pi\sqrt{6}\,RC} = \frac{1}{6.28 \times 2.45 \times 10 \times 10^{-9} \times 10 \times 10^{3}}$$

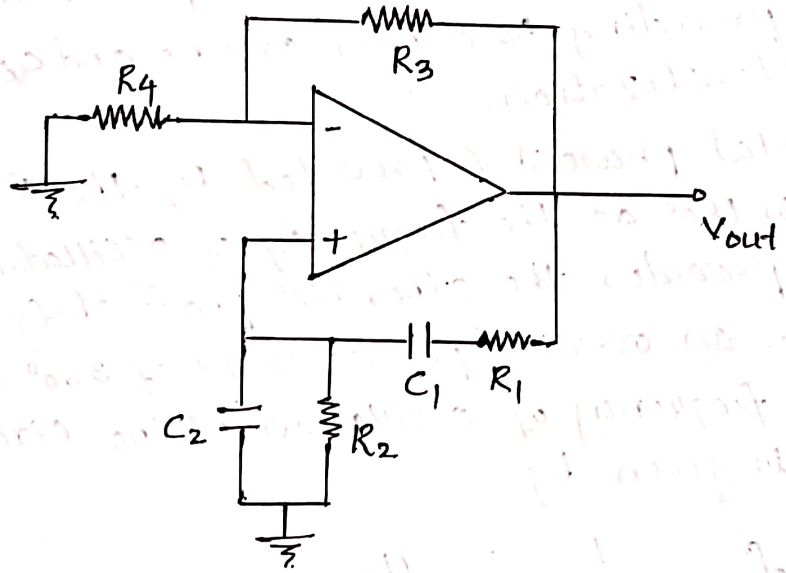
$$= 647 \text{ Hz.}$$

Wien Bridge Oscillator.

The wien bridge oscillator is shown in fig. below.



OR



The feedback network comprises of a wien bridge circuit. The opamp is used in non inverting configuration. Oscillation occurs at the frequency for which the phase shift through wien bridge is 0°, because amplifier is in non inverting mode.

when $R_1 = R_2$ and $C_1 = C_2$, the frequency of oscillation is given by.

$$f = \frac{1}{2\pi RC} \text{ Hz.}$$

Ex: In wien bridge oscillator if $C_1 = C_2 = 100nF$, determine the output frequencies when i) $R_1 = R_2 = 1k\Omega$ & ii) $R_1 = R_2 = 6k\Omega$.

Soln: i) when $R_1 = R_2 = 1k\Omega$.

$$f = \frac{1}{2\pi RC} \quad \text{where } R = R_1 = R_2 \text{ and } C = C_1 = C_2$$

$$\therefore f = \frac{1}{2\pi \times 1 \times 10^3 \times 100 \times 10^{-9}} = 1.59\ kHz.$$

ii) when $R_1 = R_2 = 6k\Omega$

$$f = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 6 \times 10^3 \times 100 \times 10^{-9}} = 265\ Hz.$$

* Multivibrator

An electronic circuit that produces a non-sinusoidal waveform as its output is known as a multivibrator. The waveform are basically a square wave, rectangular wave etc.

The basic types of multivibrator are:

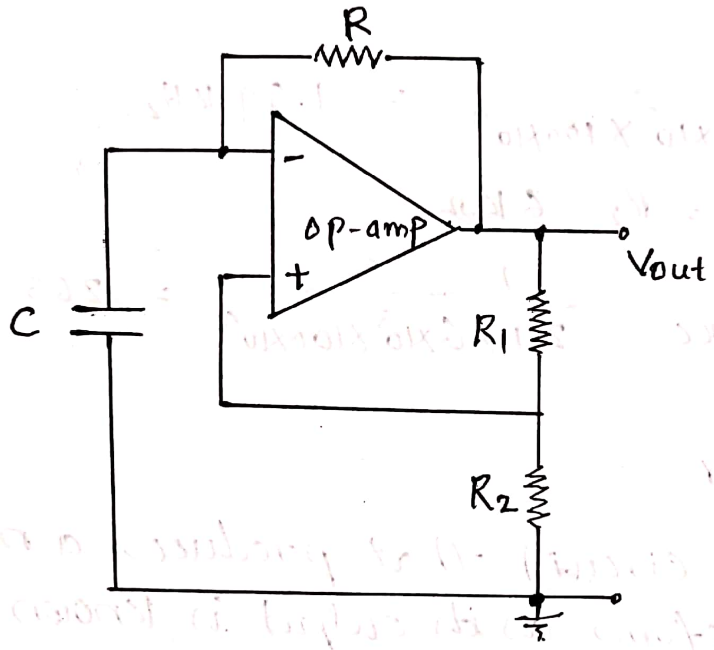
a) Astable multivibrator that provide a continuous train of pulses. These are also referred to as free-running multivibrators.

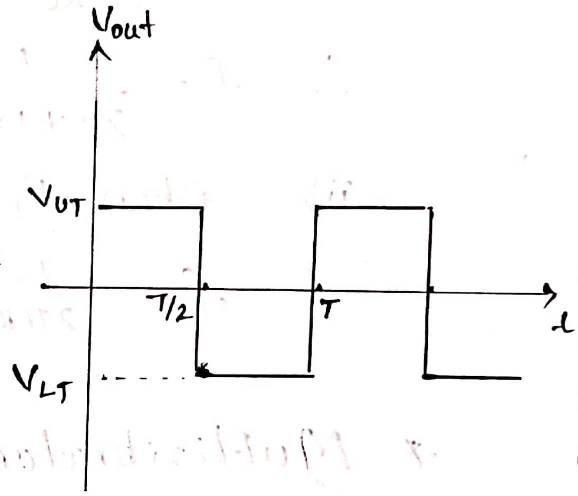
b) monostable multivibrators that produce a single output pulse. They have one stable state and thus some-times also referred to as ~~one-shot~~ 'one-shot'.

c) Bistable multivibrators that have two stable states and require a trigger pulse or control signal to change from one state to other.

* Single-stage astable oscillator

A simple form of astable oscillator that produces a square wave output can be built using just one op-amp, as shown in fig.





The circuit employs positive feedback with output fed back to the non-inverting input via the voltage divider formed by R_1 and R_2

The upper threshold voltage will be given by

$$V_{UT} = V_{cc} \times \frac{R_2}{R_1+R_2}$$

The lower threshold voltage will be given by

$$V_{LT} = -V_{cc} \times \frac{R_2}{R_1+R_2}$$

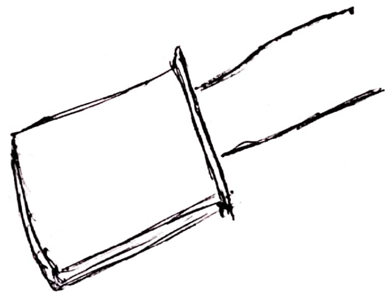
Finally, the time for one complete cycle of the output waveform produced by the astable oscillator is given by.

$$T = 2RC \ln\left(1+2\left(\frac{R_2}{R_1}\right)\right)$$

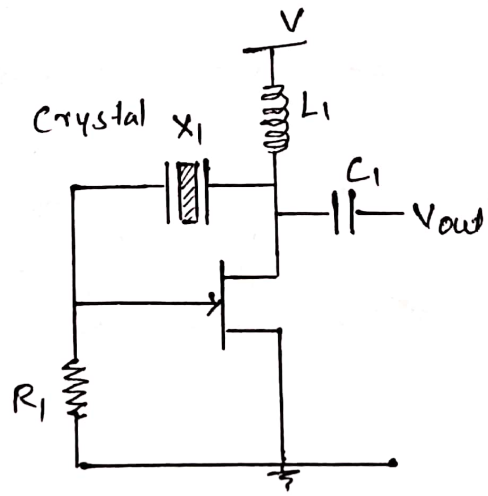
Frequency, $F = \frac{1}{T}$

* Crystal Controlled Oscillator.

A crystal osillator is an electronic oscillator circuit that uses piezoelectic effect of crystal material to create an electrical signal with constant frequency. A quartz crystal can be used as the frequency determining element. The quartz crystal (a thin slice of quartz in hermetically sealed enclosure) is shown in fig. vibrates whenever a potential



difference is applied across its faces. This phenomenon is known as the piezoelectric effect. The frequency of oscillation is determined by the crystals 'cut' and physical size. Crystal oscillator provides stabilized frequency of oscillations. Fig shown below is a simple crystal oscillator circuit.



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