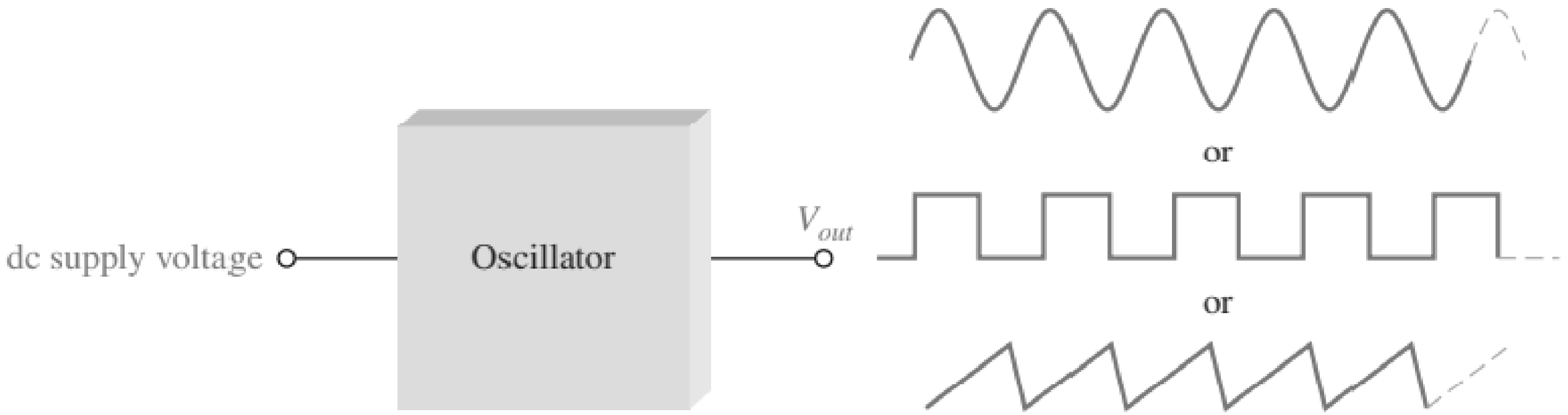
Oscillators

Oscillators

- Oscillators are electronic circuits that generate an output signal without the necessity of an input signal.
- Converts electrical energy from the dc power supply to periodic waveforms.
- They are used as signal sources in all sorts of applications.
- Different types of oscillators produce various types of outputs including sine waves, square waves, triangular waves, and sawtooth waves.
- Sinusoidal oscillator operation is based on the principle of positive feedback, where a portion of the output signal is fed back to the input in a way that causes it to reinforce itself and thus sustain a continuous output signal.

Oscillators



The basic oscillator concept showing three common types of output waveforms: sine wave, square wave, and sawtooth.

Oscillators

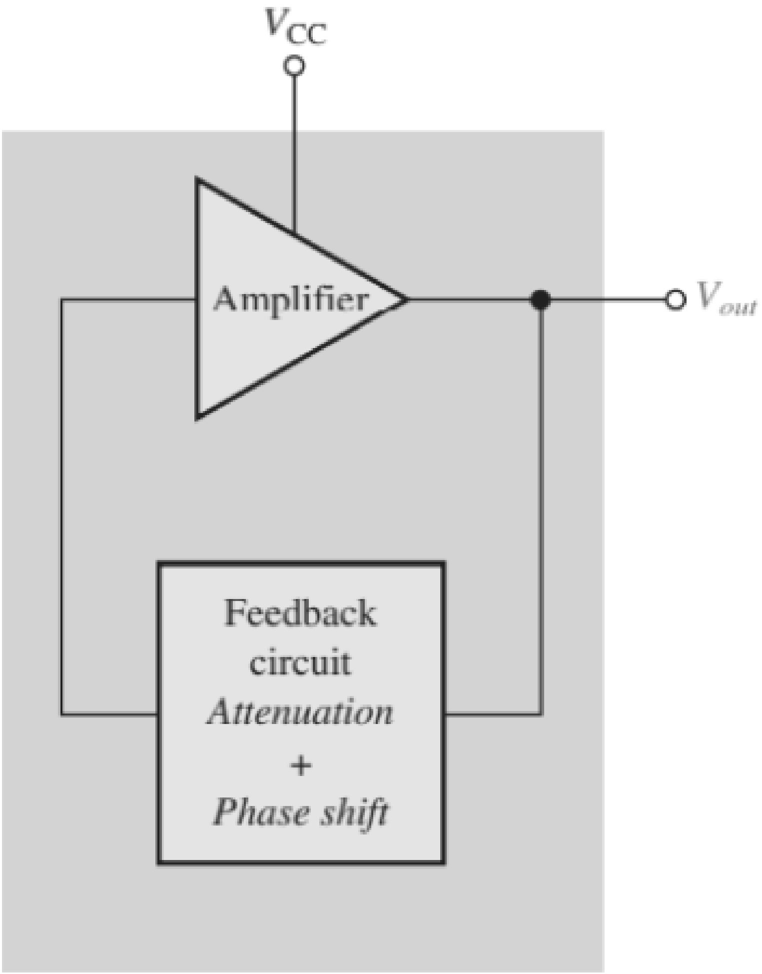
Two major classifications for oscillators:

a) Feedback oscillators

b) Relaxation oscillators

Feedback Oscillators

- A type of oscillator which returns a fraction of the output signal to the input with no net phase shift, resulting in a reinforcement of the output signal.
- After oscillations are started, the loop gain is maintained at 1.0 to maintain oscillations.
- A feedback oscillator consists of an amplifier for gain (either a discrete transistor or an op-amp) and a positive feedback circuit that produces phase shift and provides attenuation.



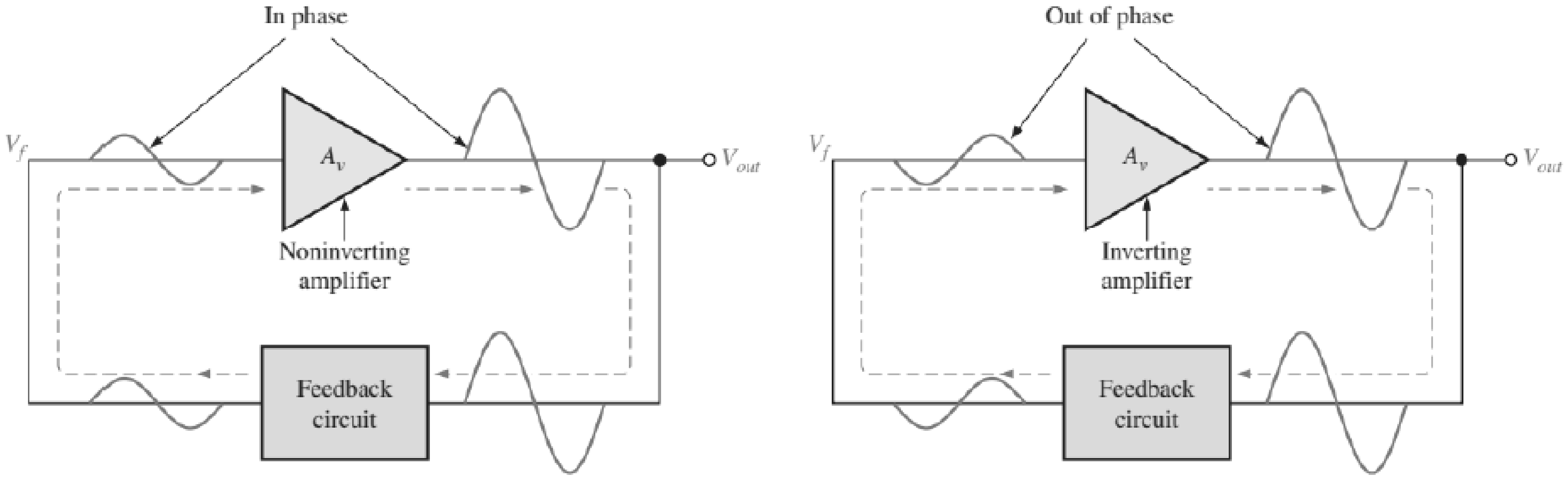
Oscillator

Relaxation Oscillators

- A type of oscillator that uses an RC timing circuit to generate a waveform, instead of feedback, that is generally a square wave or other non-sinusoidal waveform.
- Typically, a relaxation oscillator uses a Schmitt trigger or other device that changes states to alternately charge and discharge a capacitor through a resistor.

Positive feedback

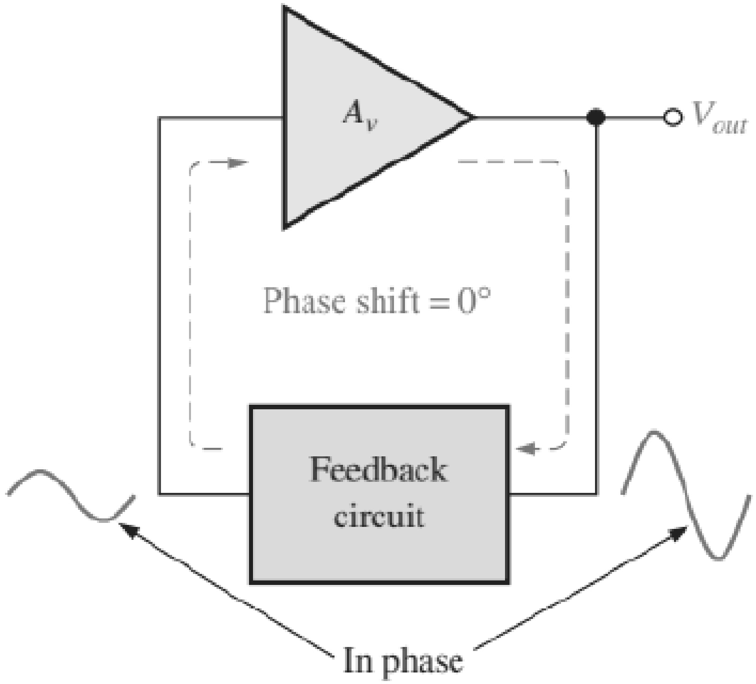
- Characterized by the condition wherein a portion of the output voltage of an amplifier is fed back to the input with no net phase shift, resulting in a reinforcement of the output signal.

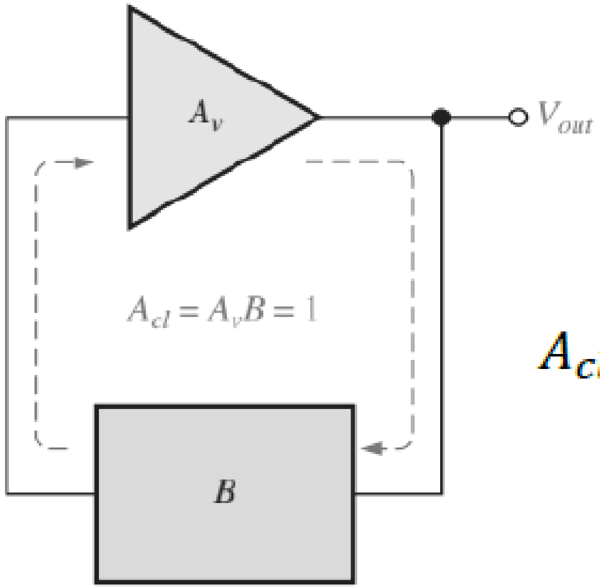


Conditions for Oscillation

- Two conditions are required for a sustained state of oscillation:

1) The phase shift around the feedback loop must be effectively 0°.
2) The voltage gain Acl , around the closed feedback loop (loop gain) must equal 1 (unity).



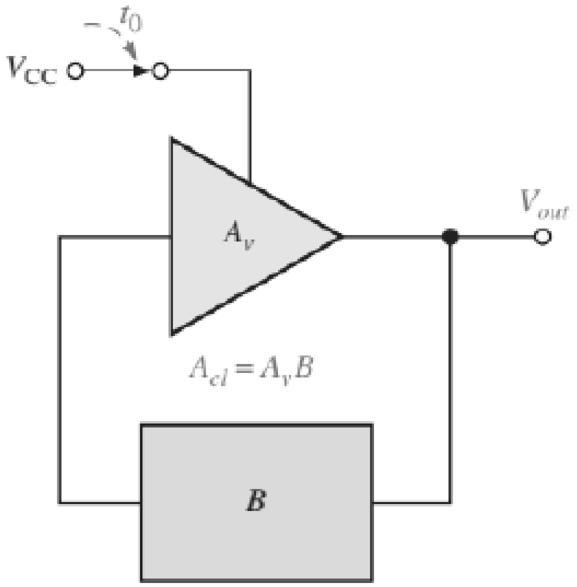


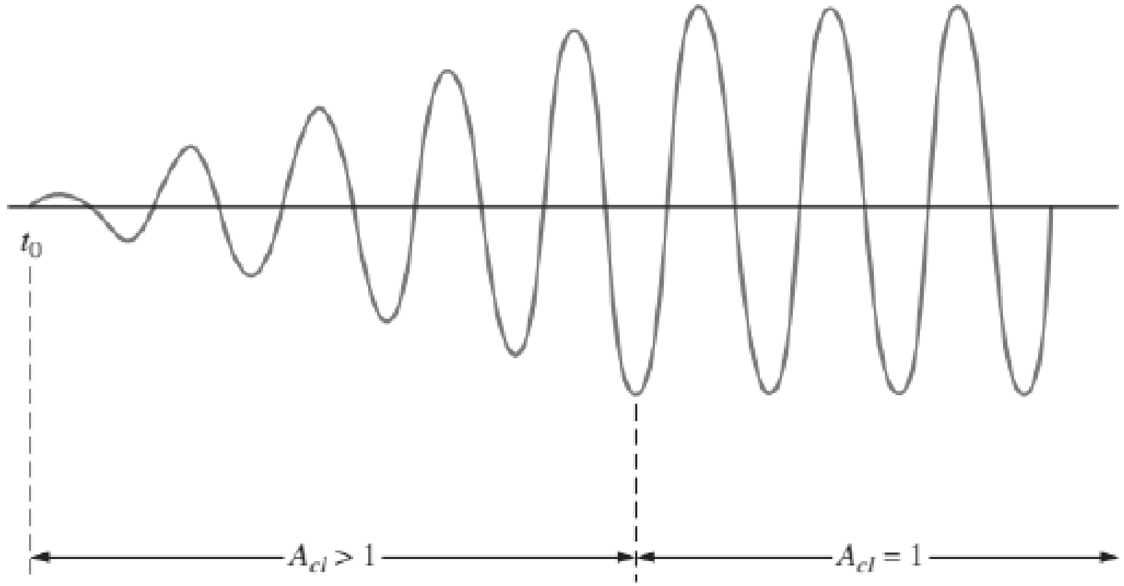
$$A_{cl} = A_v B$$

Start-Up Conditions to Oscillate

For oscillation to begin, the voltage gain around the positive feedback loop must be greater than 1 so that the amplitude of the output can build up to a desired level.

The gain must then decrease to 1 so that the output stays at the desired level and oscillation is sustained.





Oscillators with RC Feedback Circuits

Three types of feedback oscillators that use RC circuits:

1) Wien-bridge oscillator
2) Phase-shift oscillator
3) Twin-T oscillator

Wien Bridge Oscillator

The standard oscillator circuit for all freq. in the range of 10 Hz to about 1 MHz.

It is the most frequently used type of audio oscillator as the output is free from circuit fluctuations and ambient temp.

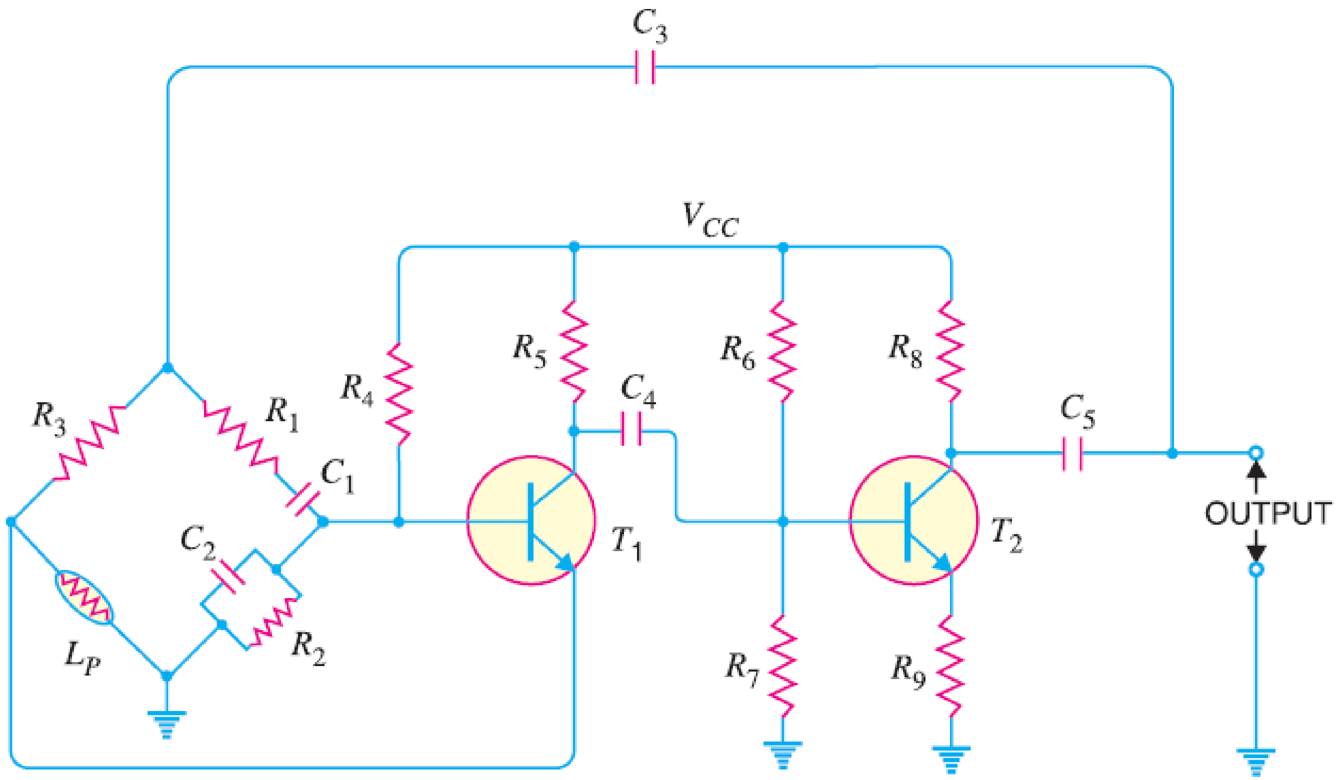
Frequency of Oscillations (f_r):

$$f_r = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}}$$

If $R_1 = R_2 = R$ and $C_1 = C_2 = C$

Then,

$$\boldsymbol{f_r = \frac{1}{2\pi RC}}$$

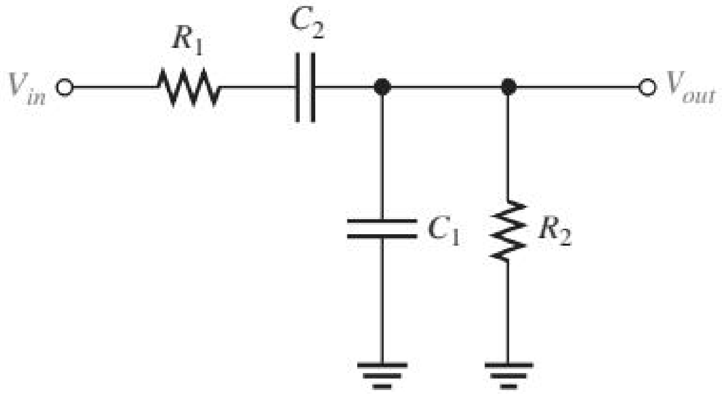


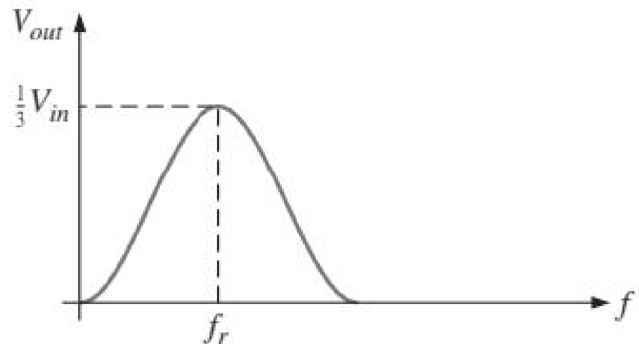
Wien-Bridge Oscillator

A fundamental part of the Wien-bridge oscillator is a lead-lag circuit like that shown in the figure.

$R1$ and $C1$ together form the lag portion of the circuit; $R2$ and $C2$ form the lead portion.

The lead-lag circuit has a resonant frequency, $\boldsymbol{fr}$, at which the phase shift through the circuit is 0º and the attenuation is 1/3. Below $\boldsymbol{fr}$, the lead circuit dominates and the output leads the input. Above $\boldsymbol{fr}$, the lag circuit dominates and the output lags the input.





Wien Bridge Oscillator

Advantages

- It gives constant output.
- The circuit works quite easily.
- The overall gain is high because of two transistors.
- The frequency of oscillations can be easily changed by using a potentiometer.

Disadvantages

- The circuit requires two transistors and a large number of components.
- It cannot generate very high frequencies.

Example

In the Wien bridge oscillator shown in Fig. 14.18, $R1 = R2 = 220\ k\Omega$ and $C1 = C2 = 250\ pF$. Determine the frequency of oscillations.

Ans.

2892 Hz

Phase Shift Oscillators

The phase shift network consists of three sections R1C1, R2C2 and R3C3. At some particular frequency f_r, the phase shift in each RC section is 60°, total of 180°.

Frequency of Oscillations (f_r):

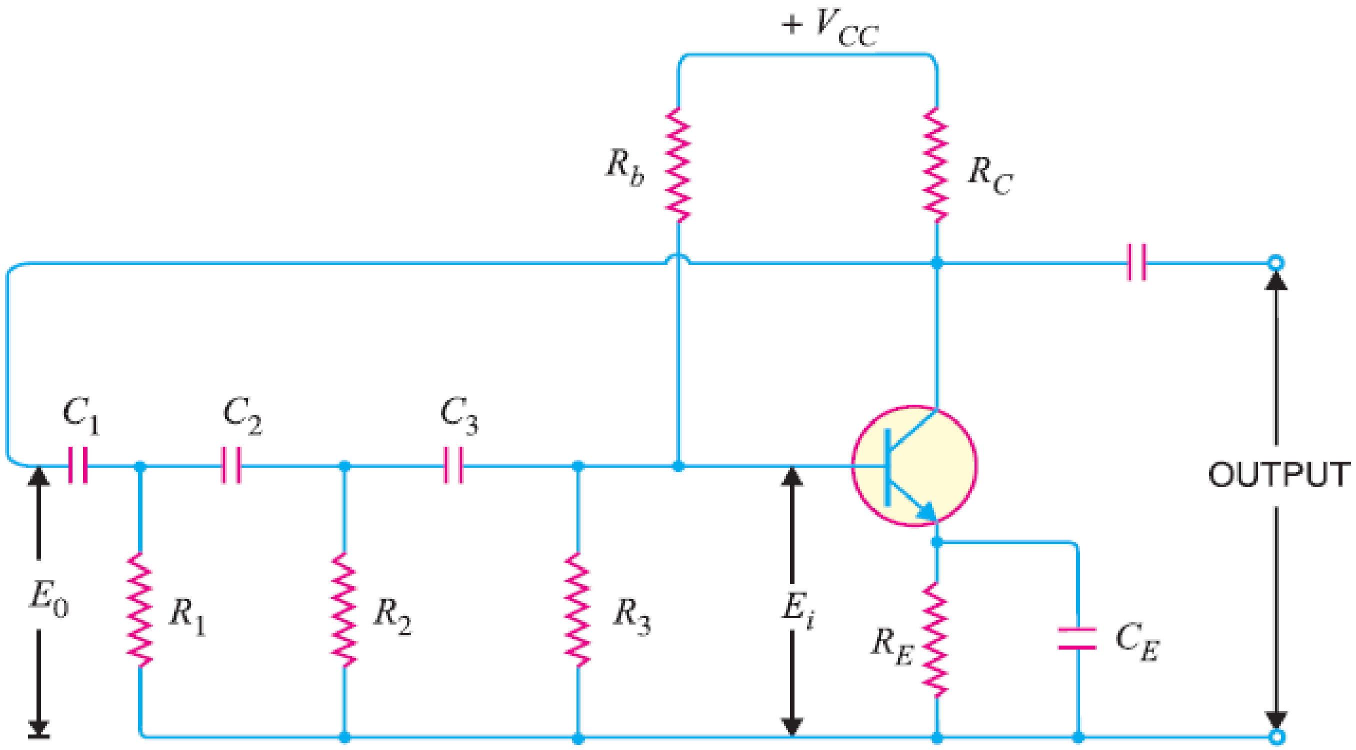
$$f_r = \frac{1}{2\pi RC\sqrt{6}}$$

Where:

$$R_1 = R_2 = R_3 = R\ ;\ C_1 = C_2 = C_3 = C$$

Feedback Fraction (β):

$$\beta = \frac{V_f}{V_0} = \frac{E_i}{E_0} = \frac{1}{29}$$



Phase Shift Oscillators

Advantages

- It does not require transformers or inductors.
- It can be used to produce very low frequencies.
- The circuit provides good frequency stability.

Disadvantages

- It is difficult for the circuit to start oscillations as the feedback is generally small.
- The circuit gives small output.

Example

In a phase shift oscillator, R1 = R2 = R3 = 1MΩ and C1 = C2 = C3 = 68 pF. At what frequency does the circuit oscillate ?

Ans.

954 Hz

Example

A phase shift oscillator uses 5 pF capacitors. Find the value of R to produce a frequency of 800 kHz.

Ans.

16.2 kΩ

Twin-T Oscillator

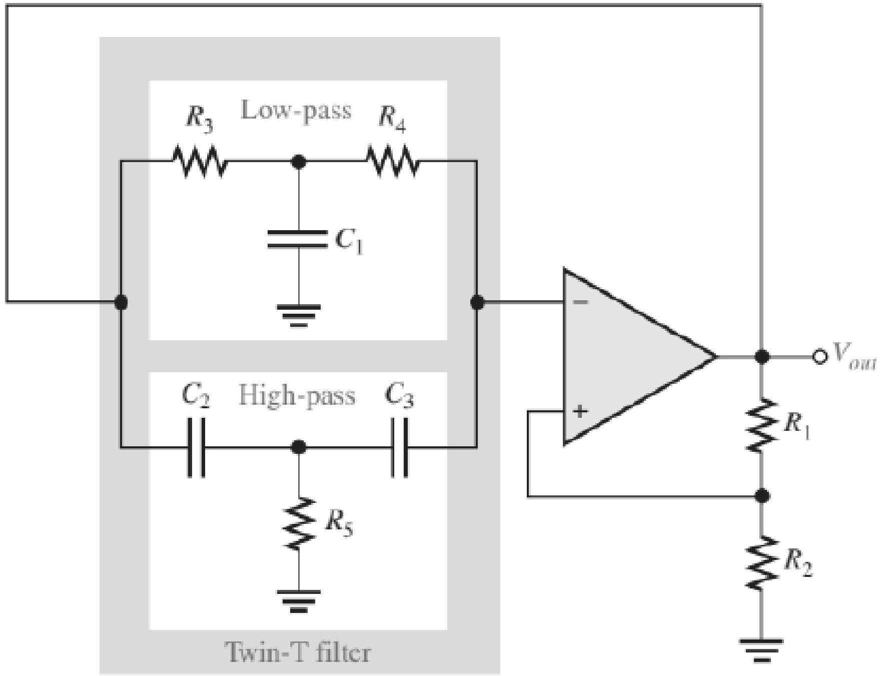
It is called the twin-T because of the two T-type RC filters used in the feedback loop.

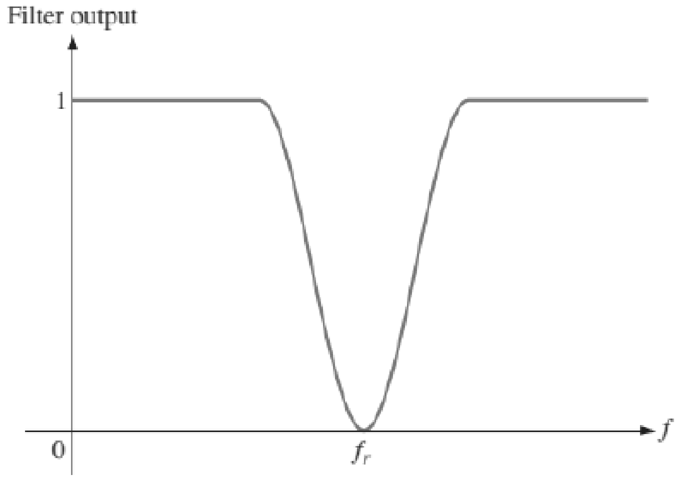
One of the twin-T filters has a low-pass response, and the other has a high-pass response.

The combined parallel filters produce a band-stop or notch response with a center frequency equal to the desired frequency of oscillation, $\boldsymbol{fr}$.

Oscillation cannot occur at frequencies above or below $\boldsymbol{fr}$ because of the negative feedback through the filters.

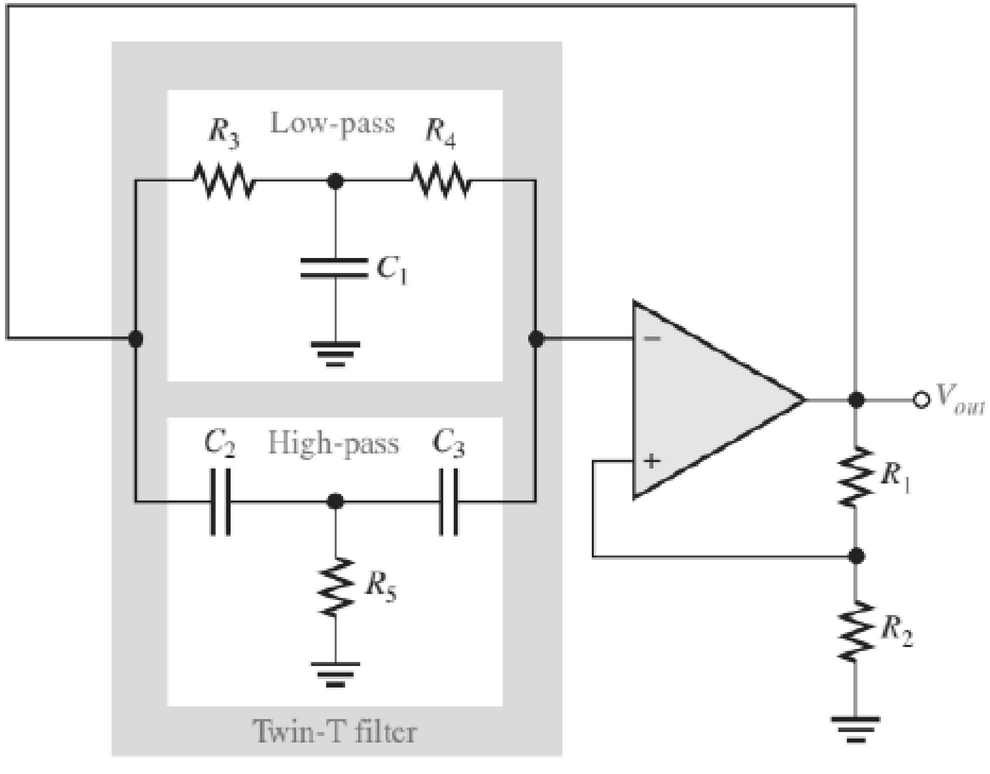
At $\boldsymbol{fr}$, however, there is negligible negative feedback; thus, the positive feedback through the voltage divider ($\boldsymbol{R1}$ and $\boldsymbol{R2}$) allows the circuit to oscillate.



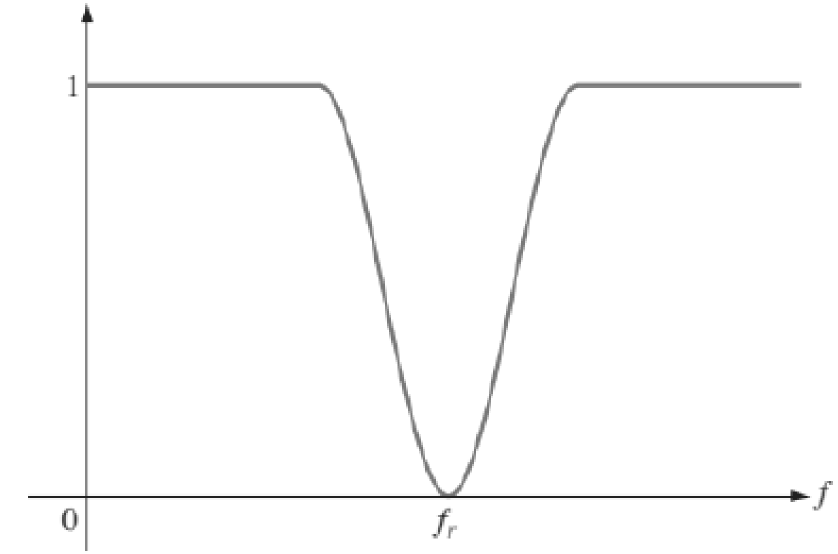


Twin-T Oscillator

- It is called the twin-T because of the two T-type RC filters used in the feedback loop.
- One of the twin-T filters has a low-pass response, and the other has a high-pass response.



(a) Oscillator circuit



(b) Twin-T filter's frequency response curve

Twin-T Oscillator

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