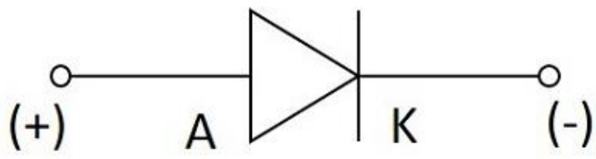
ANALOG ELECTRONICS

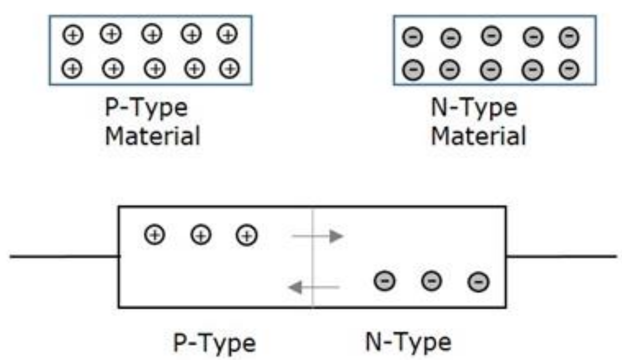
Diode

- A semiconductor diode is a two terminal electronic component with a PN junction. This is also called as a Rectifier.



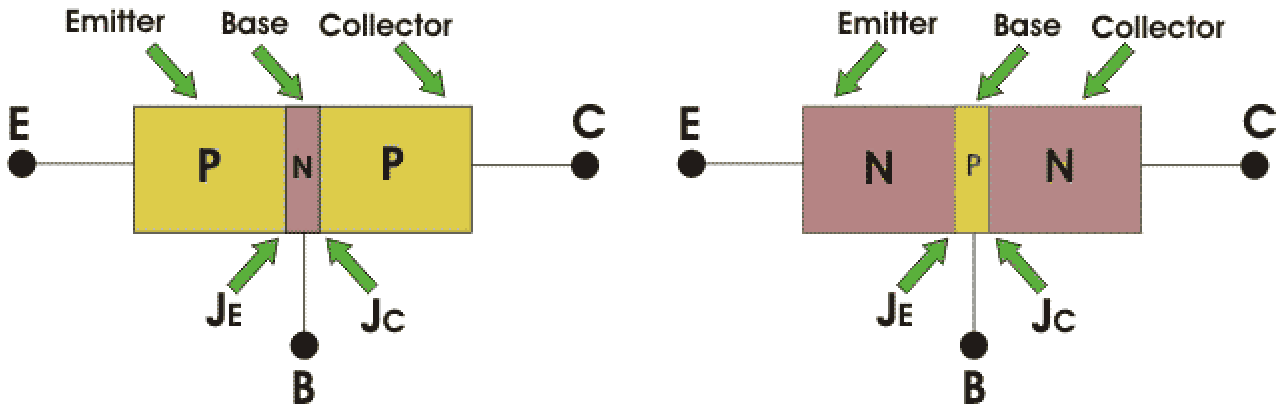
Symbol of a Diode

- Formation of a Diode - If a P-type and an N-type material are brought close to each other, both of them join to form a junction, as shown in the figure below.



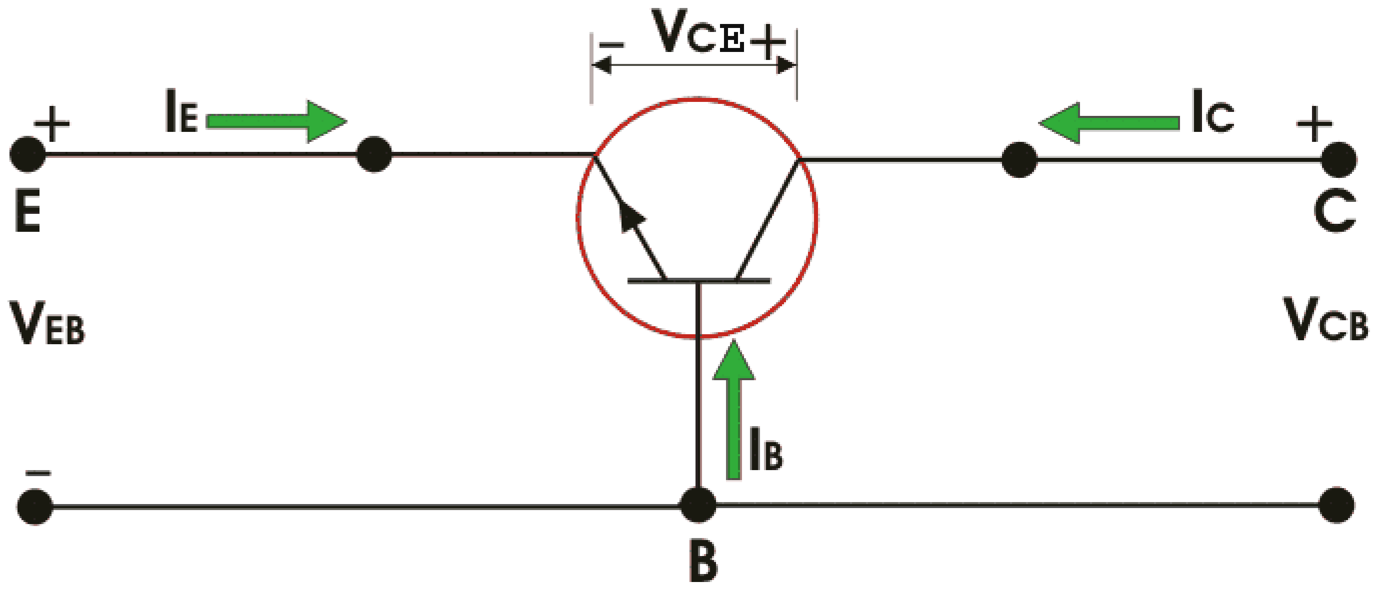
BJT

- A bipolar junction transistor is a three terminal semiconductor device consisting of two p-n junctions which is able to amplify or magnify a signal. It is a current controlled device. The three terminals of the BJT are the base, the collector and the emitter. A signal of small amplitude if applied to the base is available in the amplified form at the collector of the transistor. This is the amplification provided by the BJT.
- The basic diagrams of the two types of bipolar junction transistors mentioned above are given below



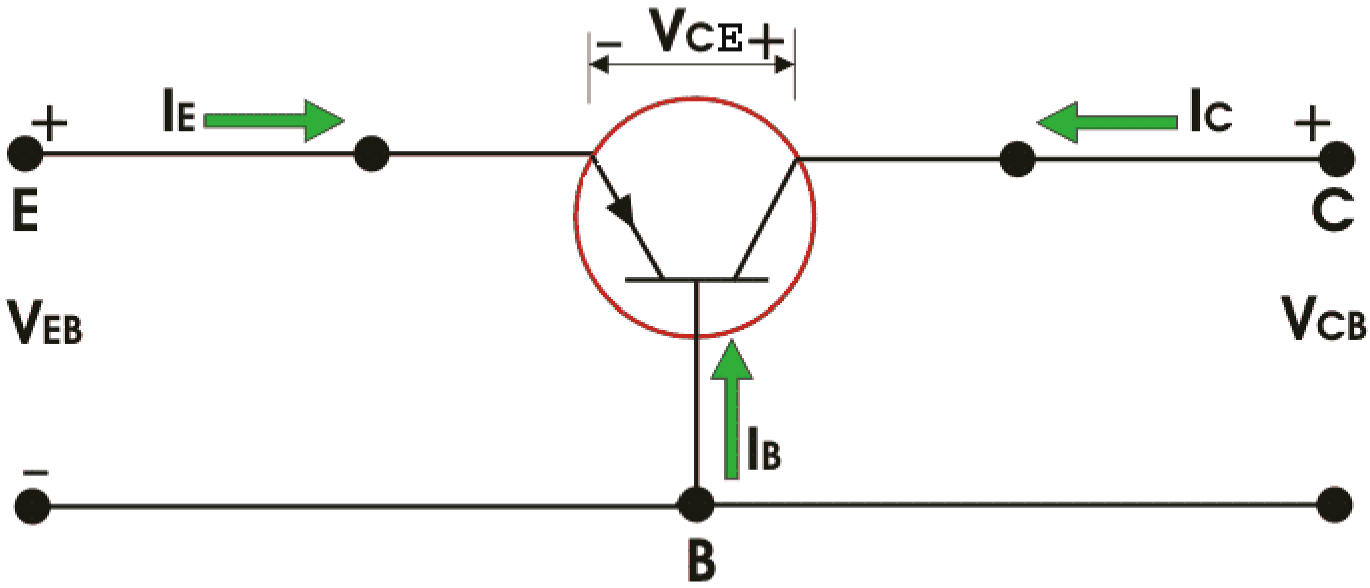
N-P-N Bipolar Junction Transistor

- **N-P-N bipolar transistor** one p-type semiconductor resides between two n-type semiconductors the diagram below a n-p-n transistor is shown -



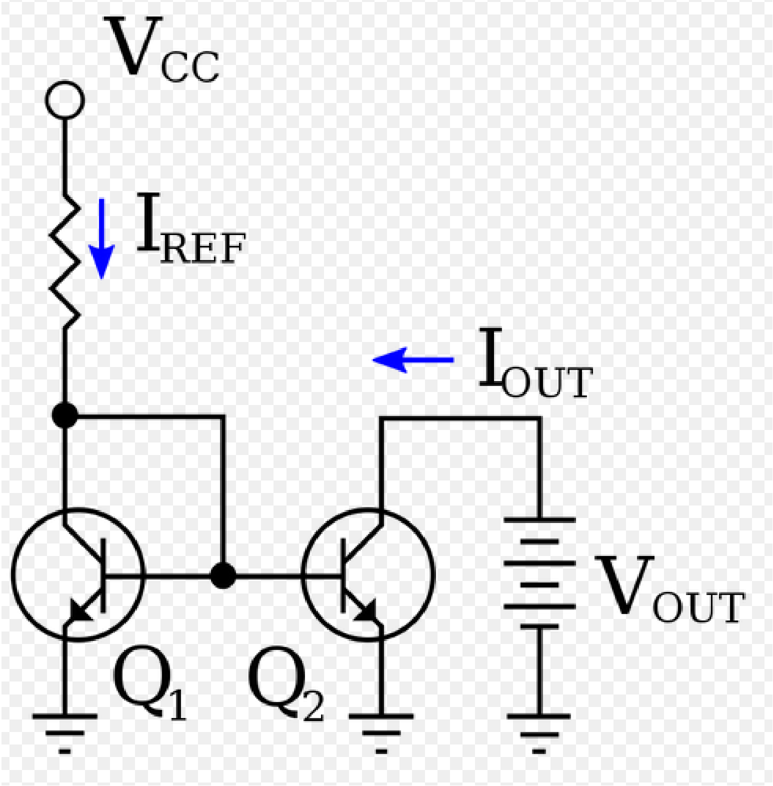
P-N-P Bipolar Junction Transistor

- P-N-P bipolar junction transistor a n-type semiconductors is sandwiched between two p-type semiconductors. The diagram of a p-n-p transistor is shown below



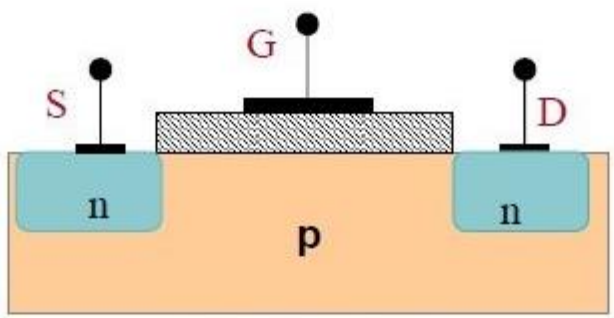
Current mirror

- A current mirror is a circuit designed to copy a current through one active device by controlling the current in another active device of a circuit, keeping the output current constant regardless of loading. The current being "copied" can be, and sometimes is, a varying signal current. Conceptually, an ideal current mirror is simply an ideal inverting current amplifier that reverses the current direction as well. Or it can consist of a current-controlled current source (CCCS). The current mirror is used to provide bias currents and active loads to circuits.



MOSFET

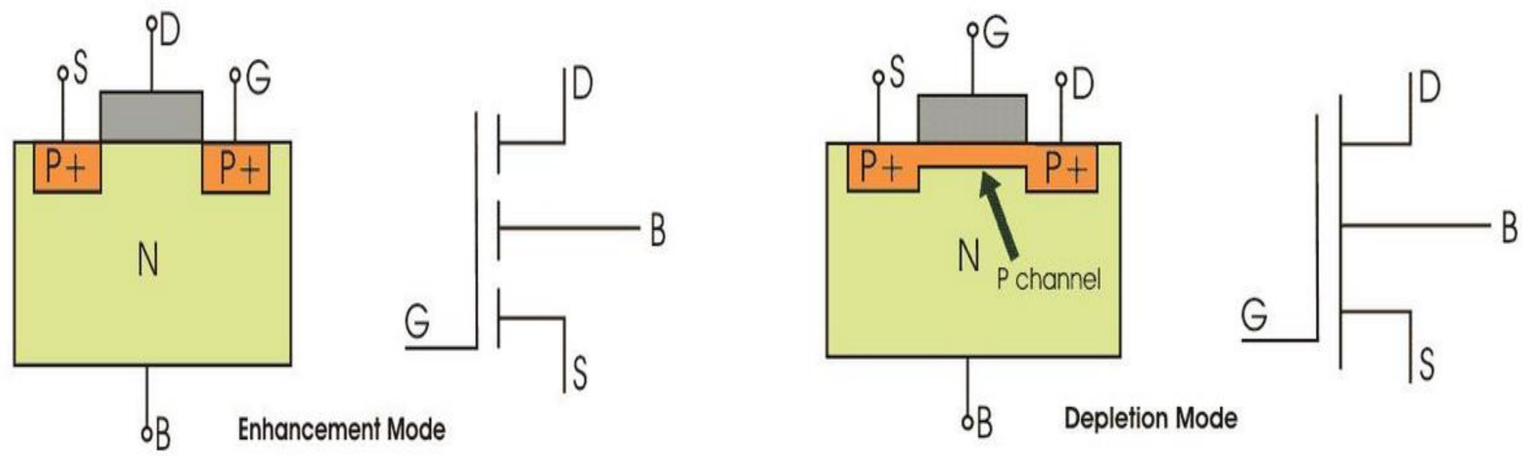
- A metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a field-effect transistor (FET with an insulated gate) where the voltage determines the conductivity of the device. It is used for switching or amplifying signals. The ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. MOSFETs are now even more common than BJTs (bipolar junction transistors) in digital and analog circuits.



MOSFET Structure

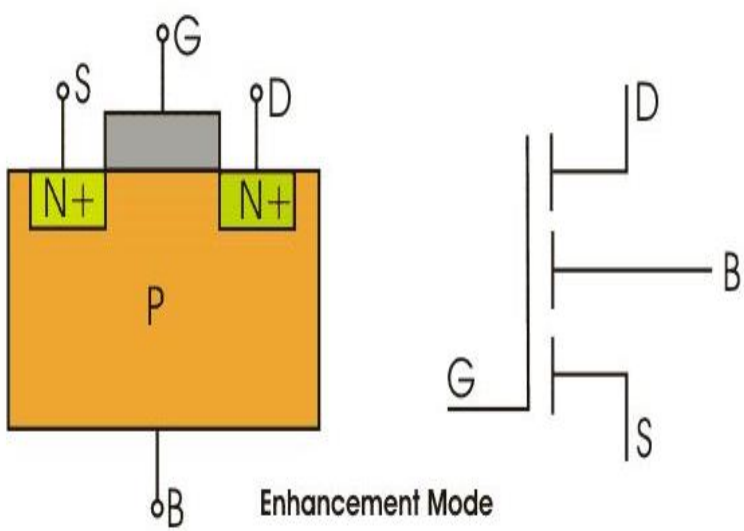
P-Channel MOSFET

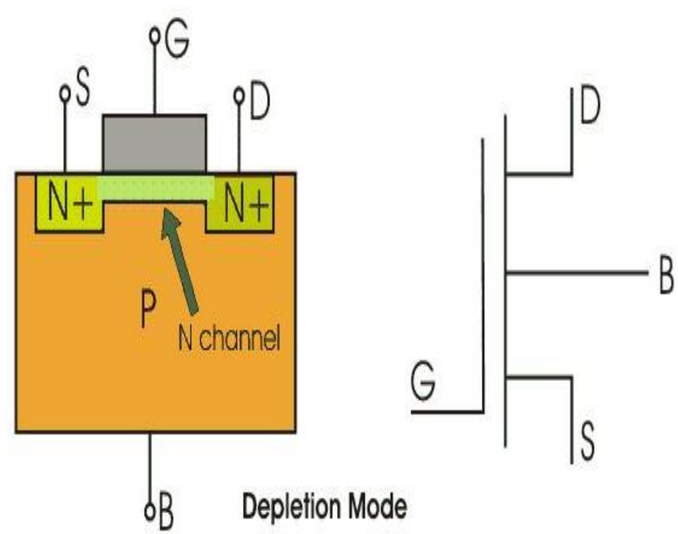
- The drain and source are heavily doped p+ region and the substrate is in n-type. The current flows due to the flow of positively charged holes also known as p-channel MOSFET. When we apply negative gate voltage, the electrons present beneath the oxide layer experience repulsive force and they are pushed downward in to the substrate, the depletion region is populated by the bound positive charges which are associated with the donor atoms. The negative gate voltage also attracts holes from p+ source and drain region into the channel region.



N-Channel MOSFET

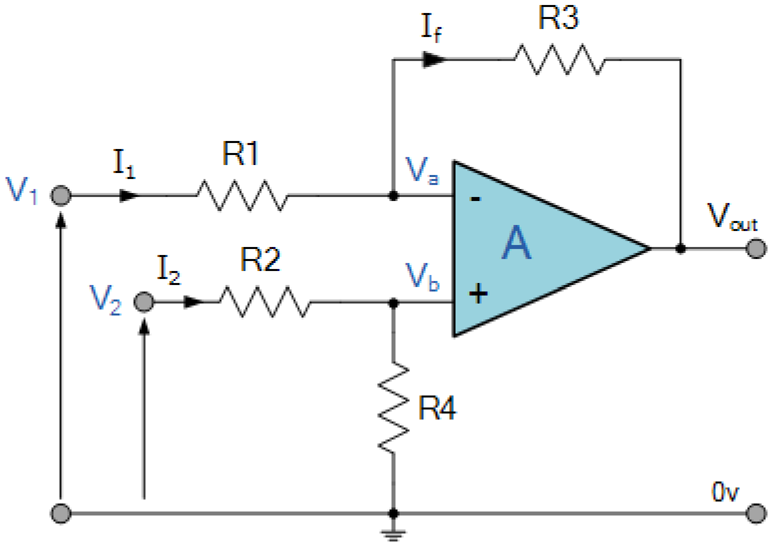
- The drain and source are heavily doped n+ region and the substrate is p-type. The current flows due to the flow of negatively charged electrons, also known as n-channel MOSFET. When we apply the positive gate voltage the holes present beneath the oxide layer experience repulsive force and the holes are pushed downwards in to the bound negative charges which are associated with the acceptor atoms. The positive gate voltage also attracts electrons from n+ source and drain region in to the channel thus an electron reach channel is formed.





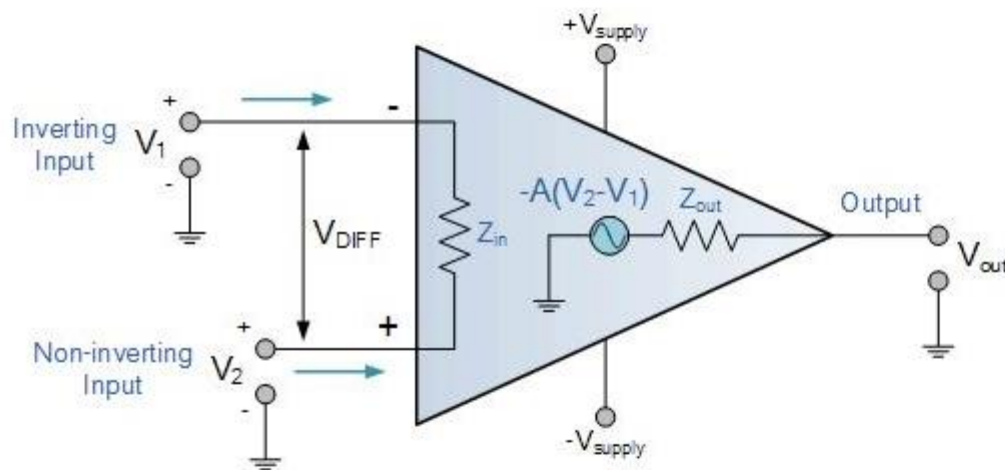
Differential Amplifier

- Then differential amplifiers amplify the difference between two voltages making this type of operational amplifier circuit a Subtractor unlike a summing amplifier which adds or sums together the input voltages. This type of operational amplifier circuit is commonly known as a Differential Amplifier configuration and is shown below:



Operational Amplifier

- An Operational Amplifier or op-amp is a voltage amplifying device designed to be used with external feedback components such as resistors and capacitors between its output and input terminals. It is a high-gain electronic voltage amplifier with a differential input and usually a single-ended output. Op-amps are among the most widely used electronic devices today, being used in a vast array of consumer, industrial, and scientific devices.



Op-amp operation

- The amplifier's differential inputs consist of a non-inverting input with voltage (V+) and an inverting input with voltage (V−). Ideally, an op-amp amplifies only the difference in voltage between the two, also called differential input voltage. The output voltage of the op-amp V_{out} is given by the equation,

$$V_{out} = A_{OL} (V_+ - V_-)$$

where A_{OL} is the open-loop gain of the amplifier.

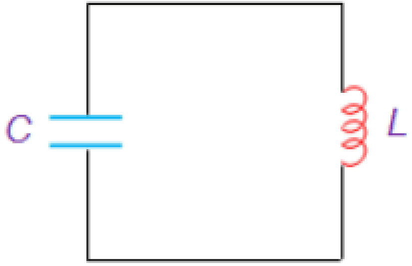
- In a linear operational amplifier, the output signal is the amplification factor, known as the amplifiers gain (A) multiplied by the value of the input signal.

Op-amp parameters

- Open-loop gain is the gain without positive or negative feedback. Ideally, the gain should be infinite, but typical real values range from about 20,000 to 200,000 ohms.
- Input impedance is the ratio of input voltage to input current. It is assumed to be infinite to prevent any current flowing from the source to amplifiers.
- The output impedance of the ideal operational amplifier is assumed to be zero. This impedance is in series with the load, thereby increasing the output available for the load.
- The bandwidth of an ideal operational amplifier is infinite and can amplify any frequency signal from DC to the highest AC frequencies. However, typical bandwidth is limited by the Gain-Bandwidth product. GB product is equal to the frequency where the amplifiers gain becomes unity.
- The ideal output of an amplifier is zero when the voltage difference between the inverting and the non-inverting inputs is zero. Real world amplifiers do exhibit a small output offset voltage.

Oscillators

- An oscillator is a circuit which produces a continuous, repeated, alternating waveform without any input. Oscillators basically convert unidirectional current flow from a DC source into an alternating waveform which is of the desired frequency, as decided by its circuit components.
- The basic principle behind the working of oscillators can be understood by analyzing the behaviour of an LC tank circuit shown in Figure 1 below, which employs an inductor L and a completely pre-charged capacitor C as its components. Here, at first, the capacitor starts to discharge via the inductor, which results in the conversion of its electrical energy into the electromagnetic field, which can be stored in the inductor. Once the capacitor discharges completely, there will be no current flow in the circuit.



Wien Bridge Oscillator

- The Wien bridge oscillator is an electronic oscillator and produces the sine waves. It is a two stage RC circuit amplifier circuit and it has high quality of resonant frequency, low distortion, and also in the tuning. Consider the very simple sine wave oscillator used by the RC circuit and place in the conventional LC circuit, construct the output of sinusoidal waveform is called as an Wien bridge oscillator. The Wien bridge oscillator is also called as a Wheatstone bridge circuit.
- It is a two stage amplifier with RC bridge circuit and the circuit has the lead lag networks. The lags at the phase shift are increasing the frequency and the leads are decreasing the frequency. In additional by adding the Wien Bridge oscillator at a particular frequency it becomes sensitive. At this frequency the Wien Bridge is balance the phase shift of 0°. The following diagram shows the circuit diagram of the Wienbridge oscillator. The diagram shows R1 is series with the C1, R3, R4 and R2 are parallel with the C2 to from the four arms.

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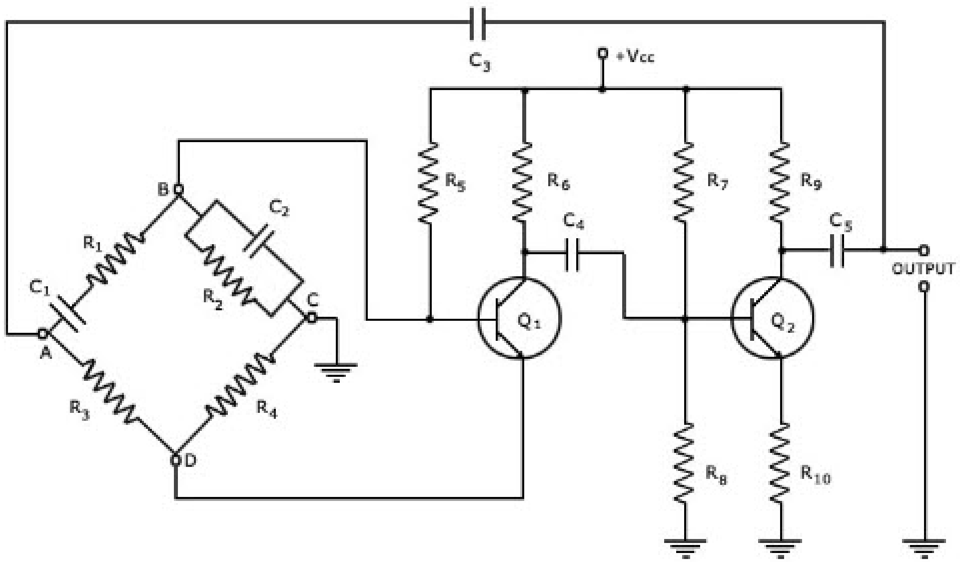
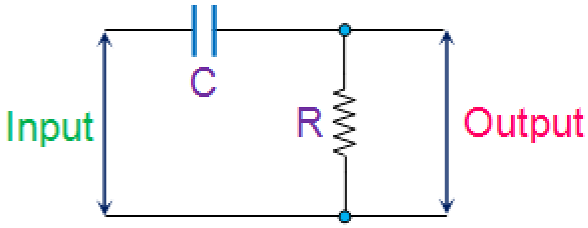


Wien Bridge Oscillator Circuit

From the above diagram we can see the two transistors are used for the phase shift of 360°and also for the positive feedback. The negative feedback is connected to the circuit of the output with a range of frequencies. This has been taken through the R4 resistor to from the temperature sensitive lamp and the resistor is directly proportional to the increasing current. If the output of the amplitude is increased then the more current is offered more negative feedback.

Phase Shift Oscillator

- RC phase-shift oscillators use resistor-capacitor (RC) network to provide the phase-shift required by the feedback signal. They have excellent frequency stability and can yield a pure sine wave for a wide range of loads.



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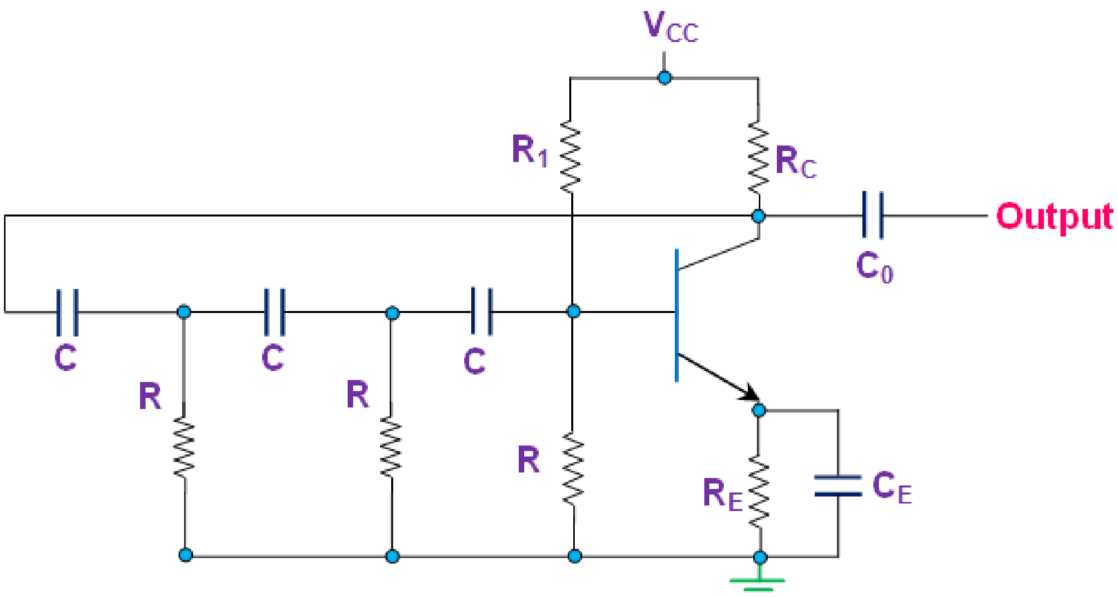

Figure 2 RC Phase-Shift Oscillator Using BJT

Here the collector resistor RC limits the collector current of the transistor, resistors R1 and R (nearest to the transistor) form the voltage divider network while the emitter resistor RE improves the stability. Next, the capacitors CE and Co are the emitter by-pass capacitor and the output DC decoupling capacitor, respectively. Further, the circuit also shows three RC networks employed in the feedback path.

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