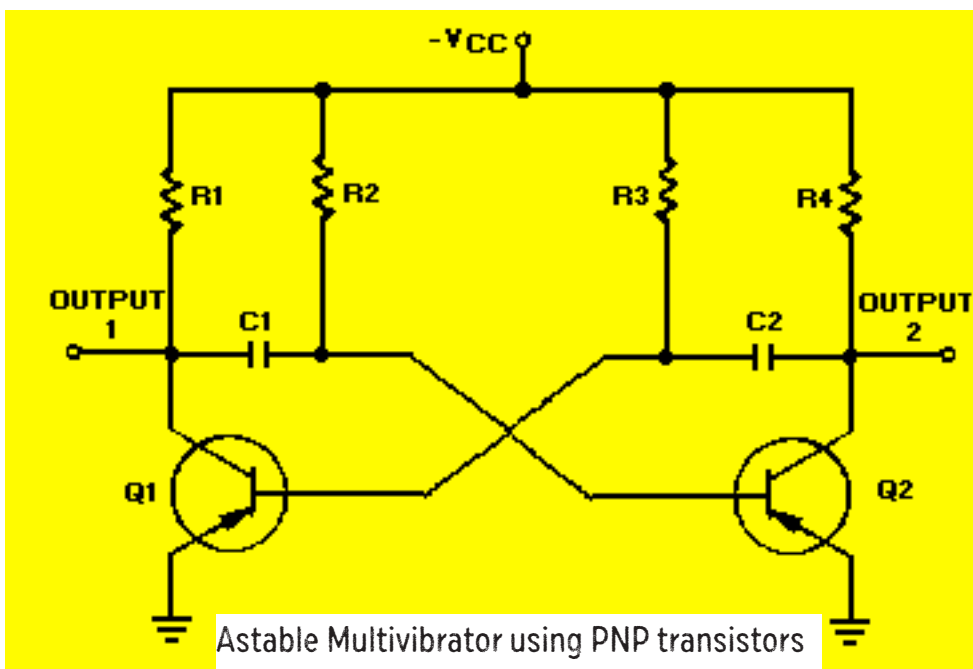


Multivibrator

with Greg Moore 2019

The type of circuit most often used to generate square or rectangular waves is the multivibrator. A multivibrator, as shown below, is basically two amplifier circuits arranged with regenerative feedback. One of the amplifiers is conducting

when the transistor is driven into saturation, its collector voltage will be about 0 volts. A circuit that is designed to go quickly from cutoff to saturation will produce a square or rectangular wave at its output. This principle is used in multivibrators.



while the other is cut off. When an input signal to one amplifier is large enough, the transistor can be driven into cutoff, and its collector voltage will be almost V_{CC} . However,

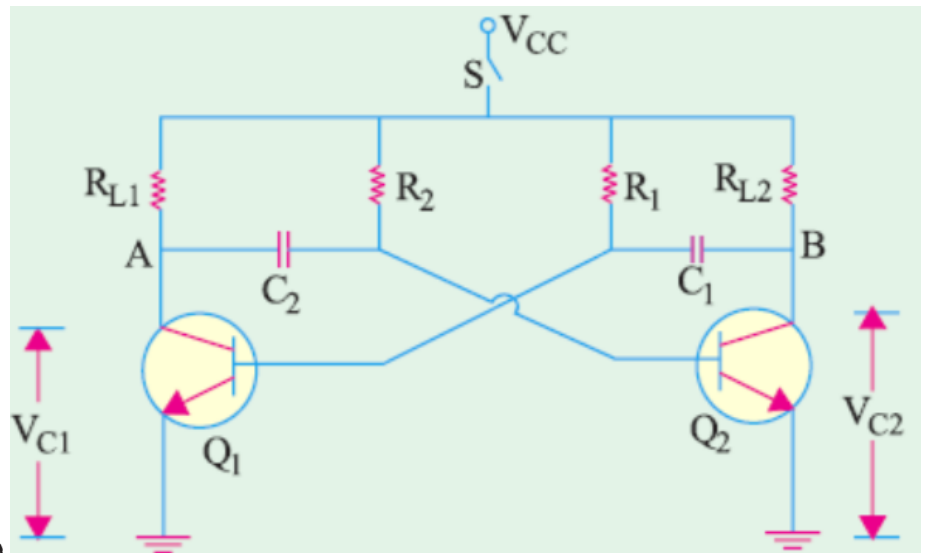
Multivibrators are classified according to the number of steady (stable) states of the circuit. A steady state exists when circuit operation is essentially constant; that is, one transistor remains in conduction and the other remains cut off until an external signal is applied. The three types of multivibrators are the ASTABLE, MONOSTABLE, and BISTABLE.

The astable circuit has no stable state. With no external signal applied, the transistors alternately

switch from cutoff to saturation at a frequency determined by the RC time constants of the coupling circuits. The monostable circuit has one stable state; one transistor conducts while the other is cut off. A signal must be applied to change this condition. After a period of time, determined by the internal RC components, the circuit will return to its original condition where it remains until the next signal arrives. The bistable multivibrator has two stable states. It remains in one of the stable states until a trigger is applied. It then FLIPS to the other stable condition and remains there until another trigger is applied. The multivibrator then changes back (FLOPS) to its first stable state.

These notes are partly from Tpubs who had a wonderful series of

books for electronics training in the 1960s and 70s. The circuit diagram with the PNP transistors kind of gives that away. However PNP are just as relevant today in many situations where we only have a negative supply to work from. Mostly though you would encounter or build +ve supply objects with NPN transistors today. Shown below is the more commonly seen NPN variety needing a positive voltage rail. The outputs are always



taken from one or both collectors.

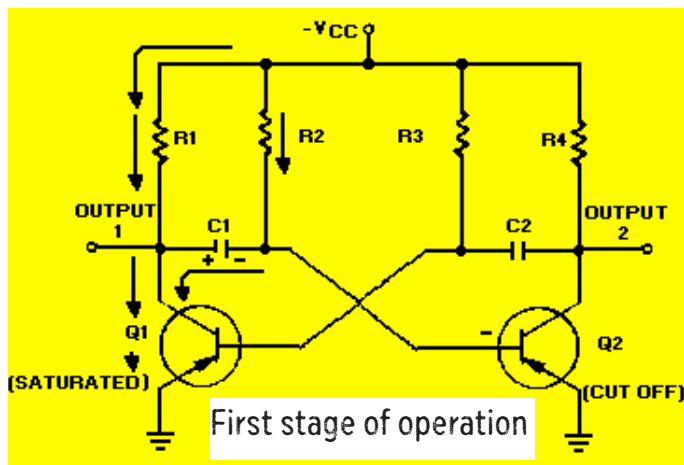
Astable Multivibrator

An astable multivibrator is also known as a FREE-RUNNING MULTIVIBRATOR. It is called free-running because it alternates between two different output voltage levels during the time it is on. The output remains at each voltage level for a definite period of time. If you looked at this output on an oscilloscope, you would see continuous

square or rectangular waveforms. The astable multivibrator has two outputs, but NO inputs.

Looking at the multivibrator on page 1 again we see it's an astable multivibrator. The astable multivibrator is said to oscillate. To understand why the astable multivibrator oscillates, assume that transis-

tor Q1 saturates and transistor Q2 cuts off when the circuit is energized. This situation is shown in the figure below.

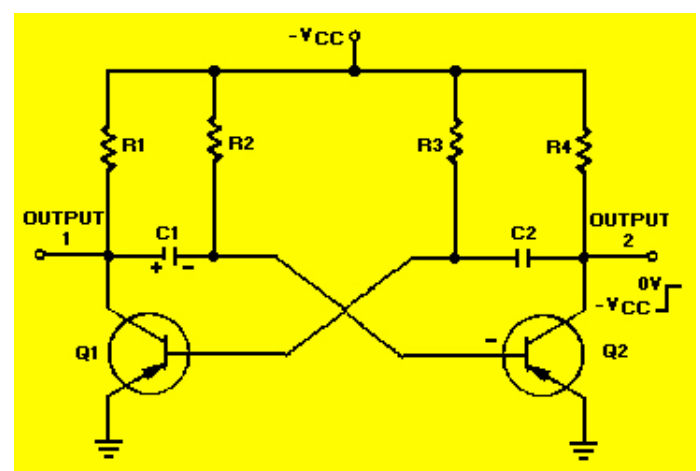


We assume Q1 saturates and Q2 is in cutoff because the circuit is symmetrical; that is, $R1 = R4$, $R2 = R3$, $C1 = C2$, and $Q1 = Q2$. It is impossible to tell which transistor will actually conduct when the circuit is energized. For this reason, either of the transistors may be assumed to conduct for circuit analysis purposes. Essentially, all the current in the circuit flows through Q1; Q1 offers almost no resistance to current flow. Notice that capacitor C1 is charging. Since Q1 offers almost no resistance in its saturated state, the rate of charge of C1 depends only on the time constant of R2 and C1 (recall that $TC = RC$). Notice that the right-hand side of capacitor C1 is connected to the base of transistor Q2, which is now at cutoff.

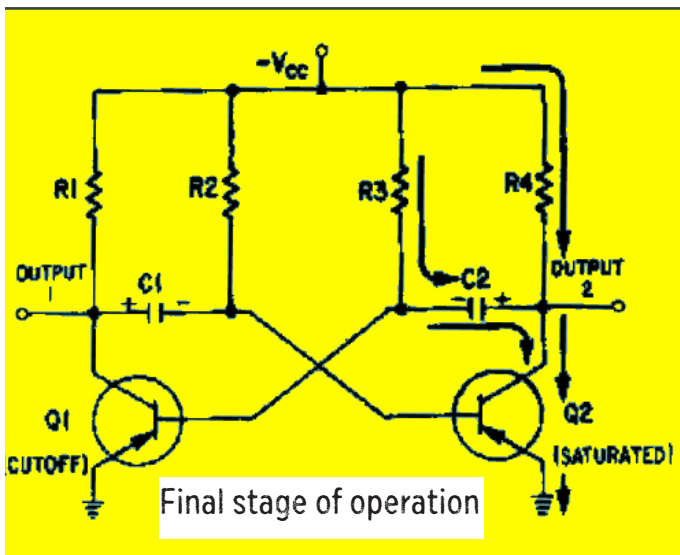
Let's analyze what is happening. The

right-hand side of capacitor C1 is becoming increasingly negative. If the base of Q2 becomes sufficiently negative, Q2 will conduct. After a certain period of time, the base of Q2 will become sufficiently negative to cause Q2 to change states from cutoff to conduction. The time necessary for Q2 to become saturated is determined by the time constant $R2C1$.

The next state is shown below.



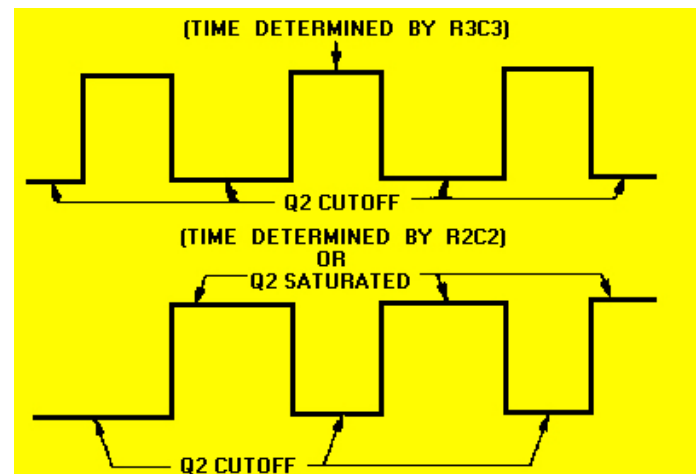
The negative voltage accumulated on the right side on capacitor C1 has caused Q2 to conduct. Now the following sequence of events takes place almost instantaneously. Q2 starts conducting and quickly saturates, and the voltage at output 2 changes from approximately -VCC to approximately 0 volts. This change in voltage is coupled through C2 to the base of Q1, forcing Q1 to cutoff. Now Q1 is in cutoff and Q2 is in saturation. This is the circuit situation shown in figure on the next page. Notice that in the



final stage of operation, the circuit is the mirror image of the first stage of operation. In the circuit above the left side of capacitor C2 becomes more negative at a rate determined by the time constant $R3C2$. As the left side of C2 becomes more negative, the base of Q1 also becomes more negative. When the base of Q1 becomes negative enough to allow Q1 to conduct, Q1 will again go into saturation. The resulting change in voltage at output 1 will cause Q2 to return to the cutoff state.

Look at the output waveform from transistor Q2, as shown lower in the timing diagram on this page. The output voltage (from either output

of the multivibrator) alternates from approximately 0 volts to approximately $-V_{CC}$, remaining in each state for a definite period of time. The time may range from a microsecond to as much as a second or two. In some applications, the time period of higher voltage ($-V_{CC}$) and the time period of lower voltage (0 volts) will be equal. Other



applications require differing higher- and lower-voltage times.

For our study we will concentrate on both the NPN and the PNP and their timing diagrams showing Q1 base and collector and Q2 base and collector.

Notes unfinished, more to follow

