# ELECTRONIC CIRCUITS

D.Shiva Kumar

Assistant Professor

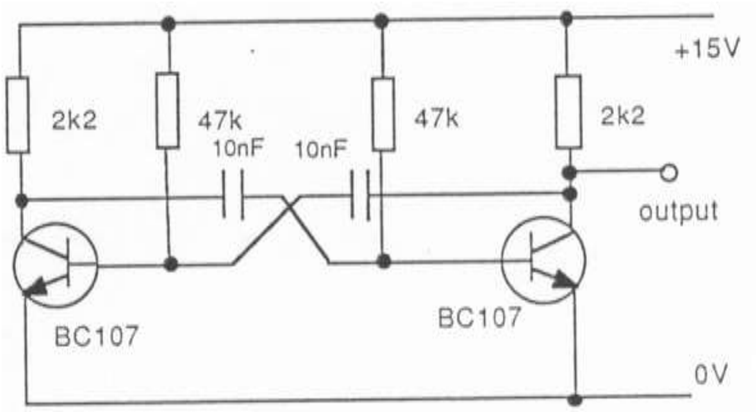
Department of ECE

Jyothishmathi Institute of Technology &
Science

# Multivibrators

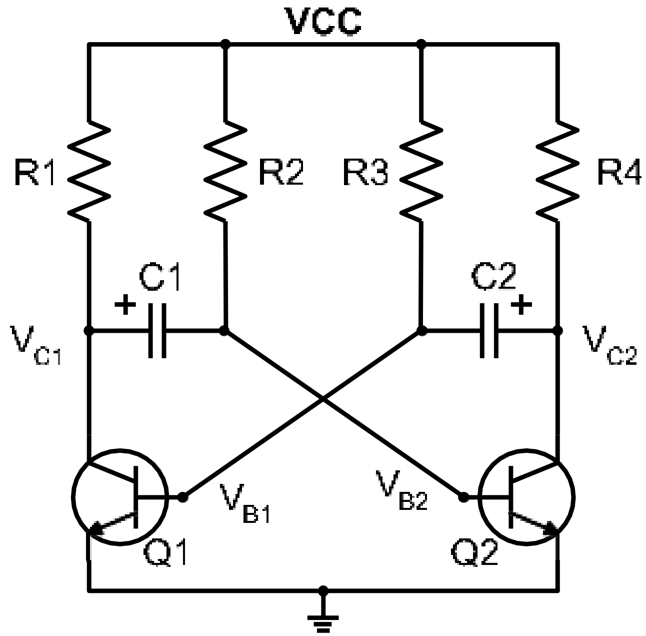
- A multivibrator is used to implement simple **two-state systems** such as oscillators, timers and flip-flops.
- Three types:
  - **Astable** – neither state is stable.
    Applications: oscillator, etc.
  - **Monostable** - one of the states is stable, but the other is not;
    Applications: timer, etc.
  - **Bistable** – it remains in either state indefinitely.
    Applications: flip-flop, etc.

# Astable Multivibrator




Circuit in Experiment A4

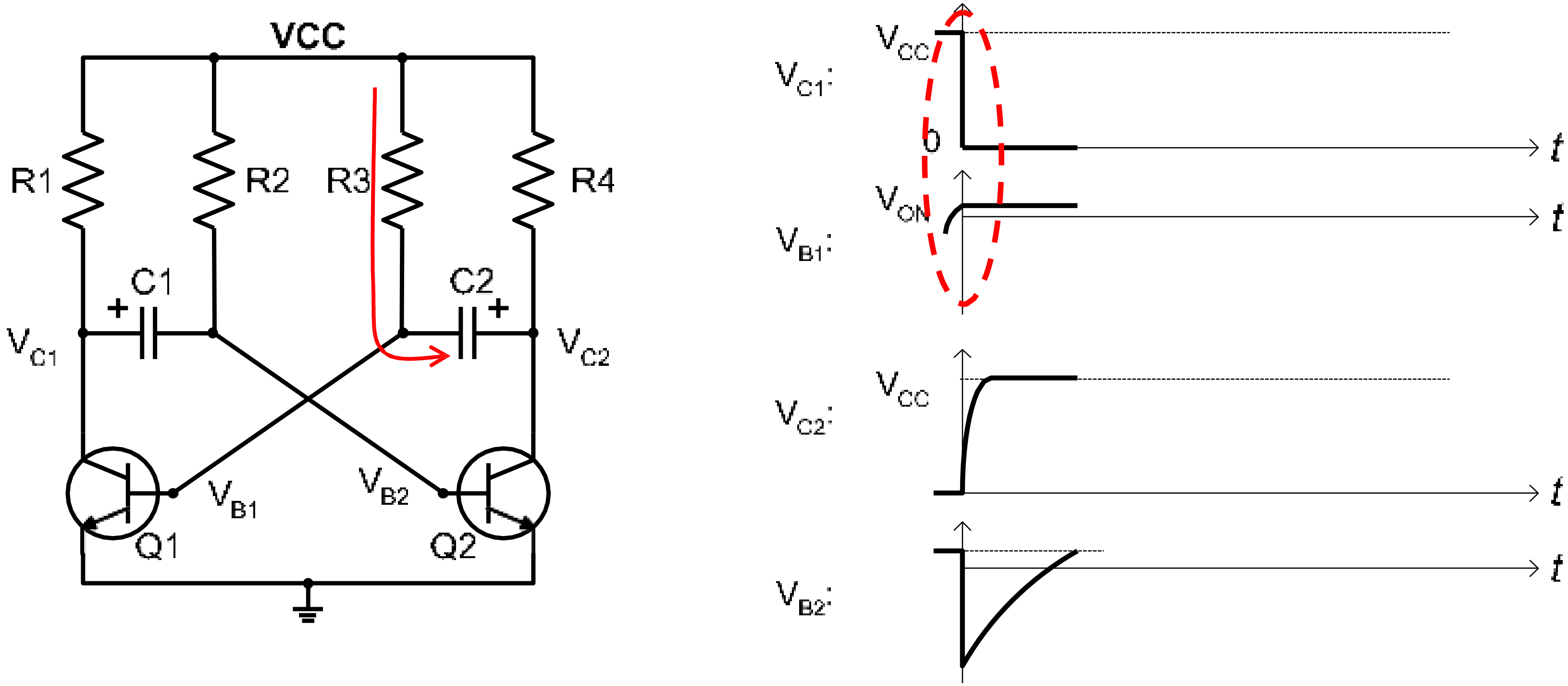
Redrawn




- Consists of two amplifying devices cross-coupled by resistors and capacitors.
- Typically, $R_2 = R_3$, $R_1 = R_4$, $C_1 = C_2$ and $R_2 >> R_1$.
- The circuit has two states
  - State 1: $V_{C1}$ LOW, $V_{C1}$ HIGH, $Q_1$ ON (saturation) and $Q_2$ OFF.
  - State 2: $V_{C1}$ HIGH, $V_{C2}$ LOW, $Q_1$ OFF and $Q_2$ ON (saturation).
- It continuously oscillates from one state to the other.

**M.Ramesh,ECE,**
**JITS**

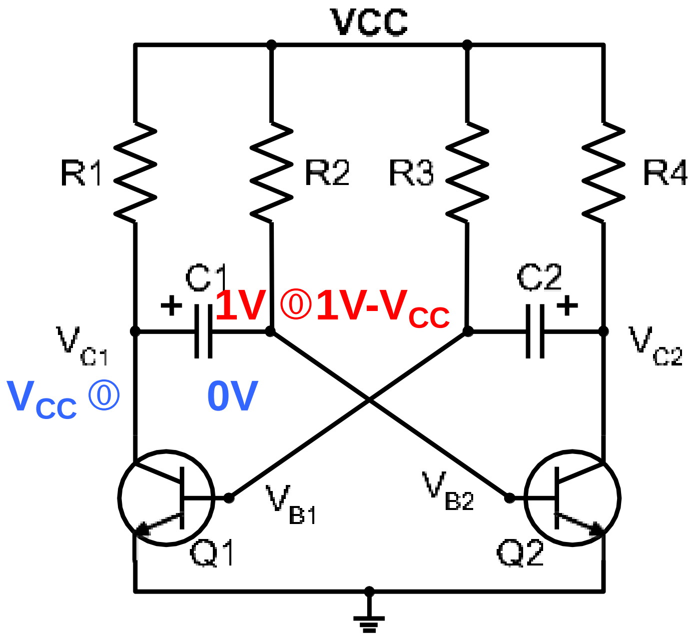
# Basic Mode of Operation

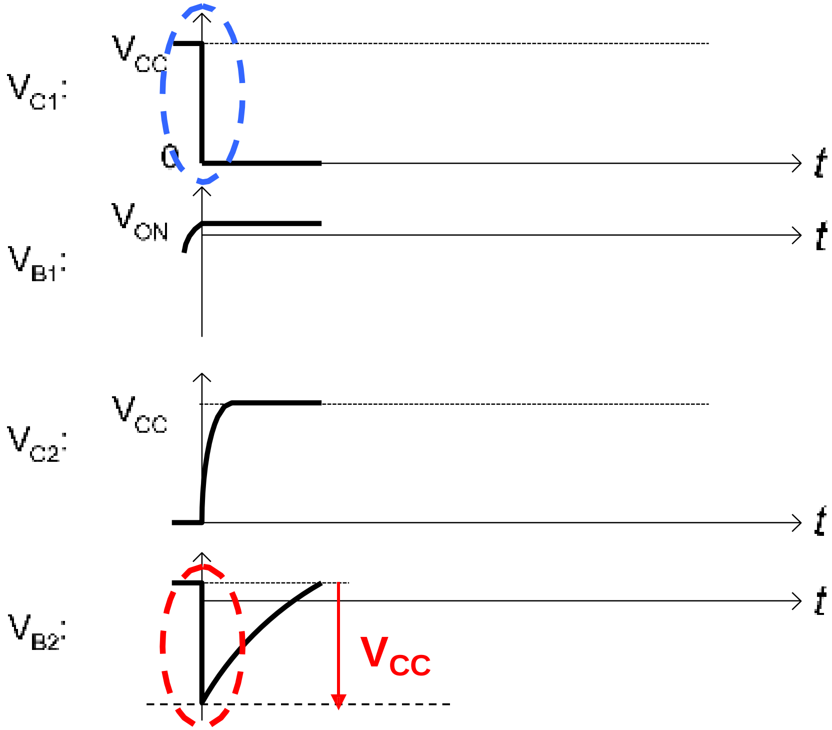



State 1:

- $V_{B1}$ charges up through $R_3$ from below ground towards $V_{CC}$.
- When $V_{B1}$ reaches $V_{ON}$ (of $V_{BE,}$ ≈1V), $Q_1$ turns on and pulls $V_{C1}$ from $V_{CC}$ to $V_{CESat} \approx 0$V.
- Due to forward-bias of the BE junction of $Q_1$, $V_{B1}$ remains at 1V.

# Basic Mode of Operation

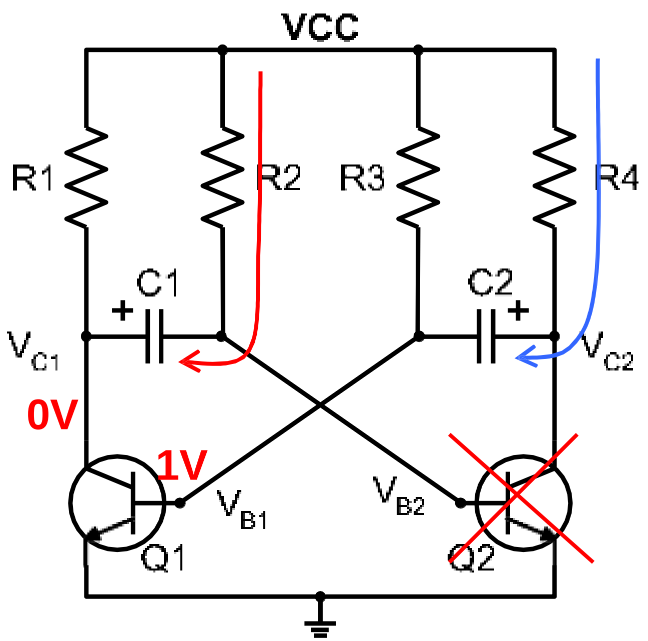


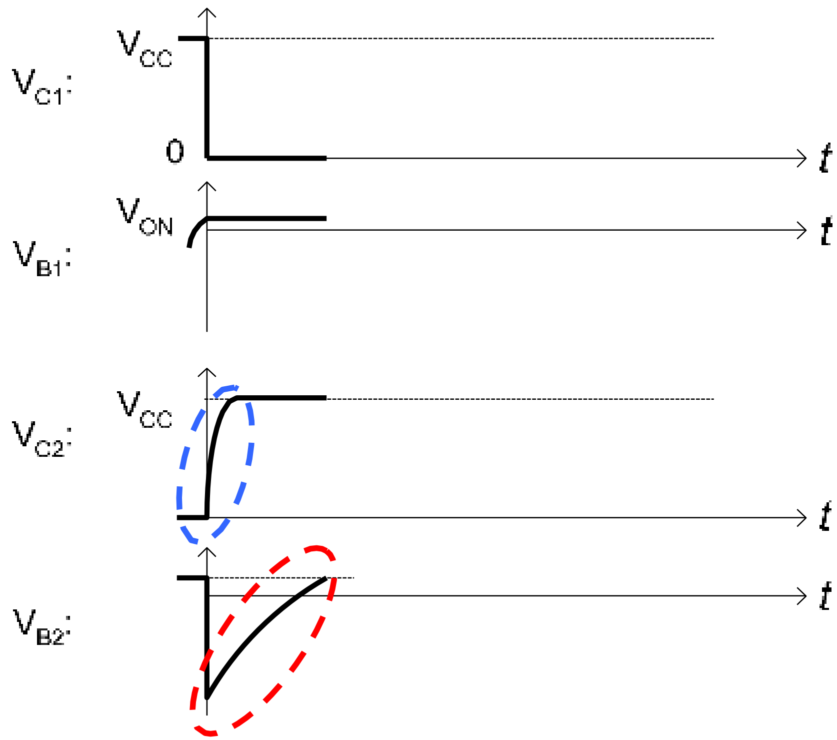




State 1 (cont'd):

- As $C_1$'s voltage cannot change instantaneously, $V_{B2}$ drops by $V_{CC}$.

# Basic Mode of Operation

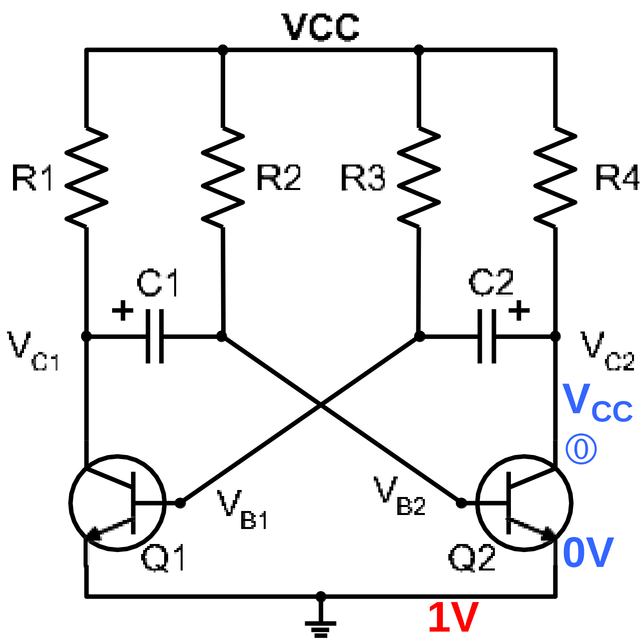


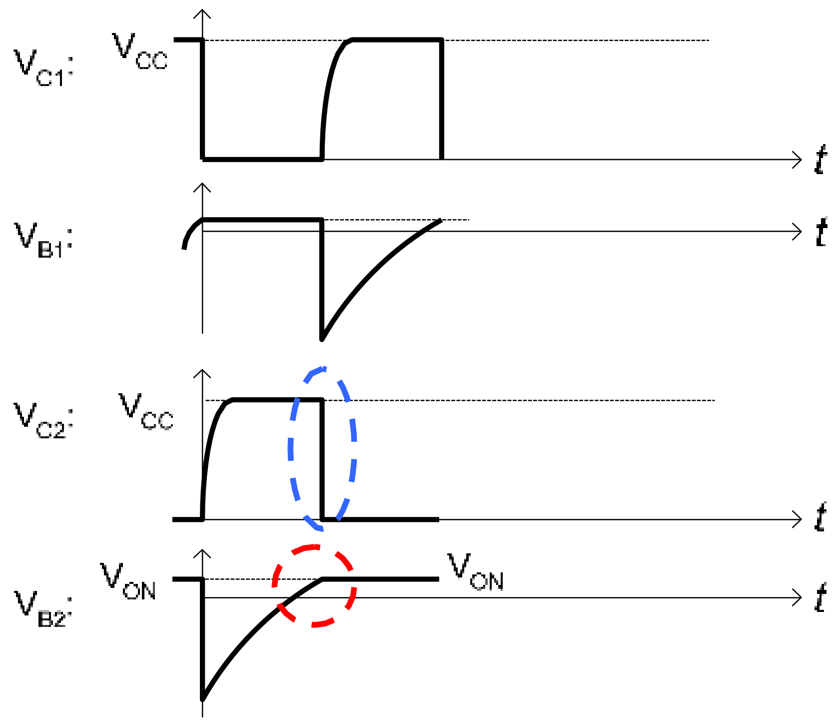




State 1 (cont'd):

- $Q_2$ turns off and $V_{C2}$ charges up through $R_4$ to $V_{CC}$ (speed set by the time constant $R_4C_2$).
- $V_{B2}$ charges up through $R_2$ towards $V_{CC}$ (speed set by $R_2C_1$, which is slower than the charging up speed of $V_{C2}$).

# Basic Mode of Operation

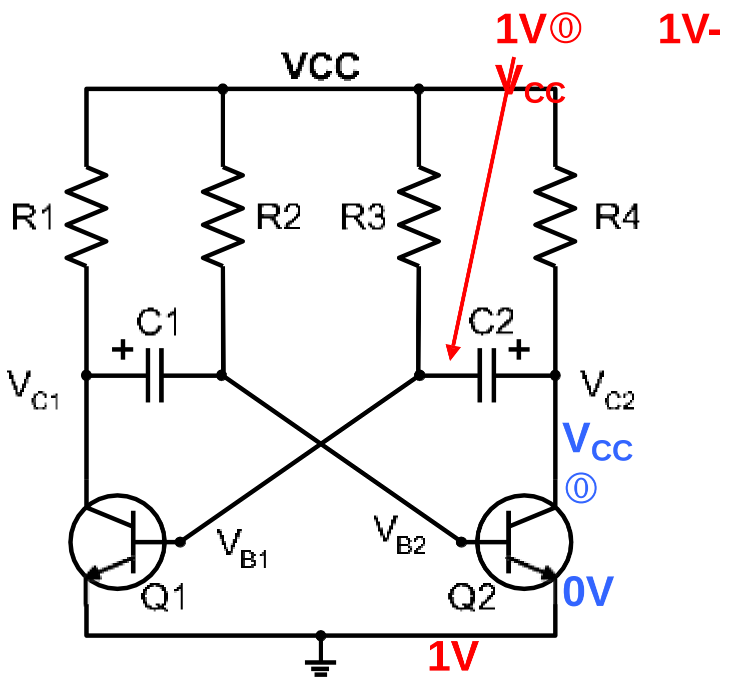


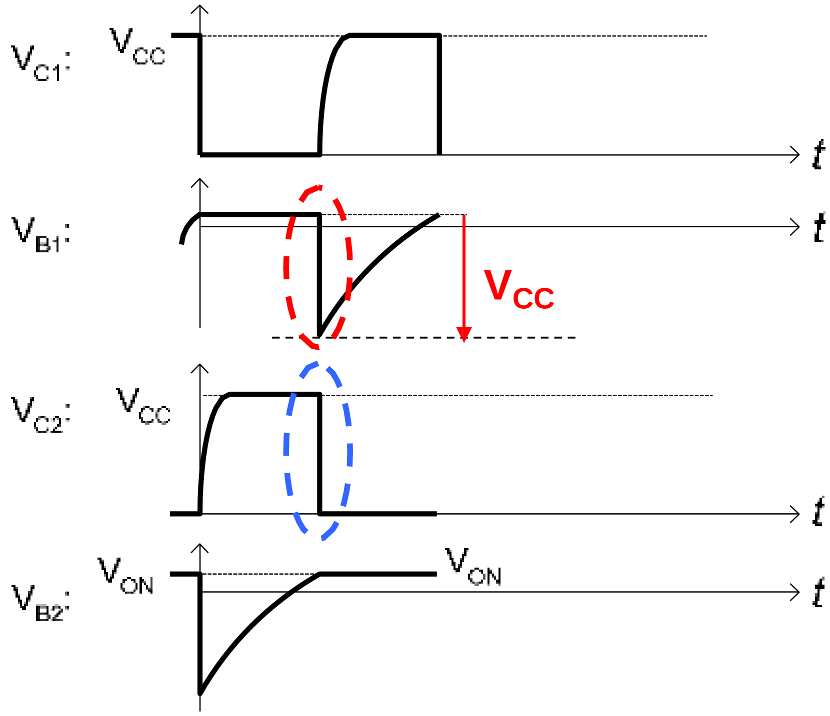




State 2:

- When $V_{B2}$ reaches $V_{ON}$, $Q_2$ turns on and pulls $V_{C2}$ from $V_{CC}$ to 0V.
- $V_{B2}$ remains at $V_{ON}$.

# Basic Mode of Operation

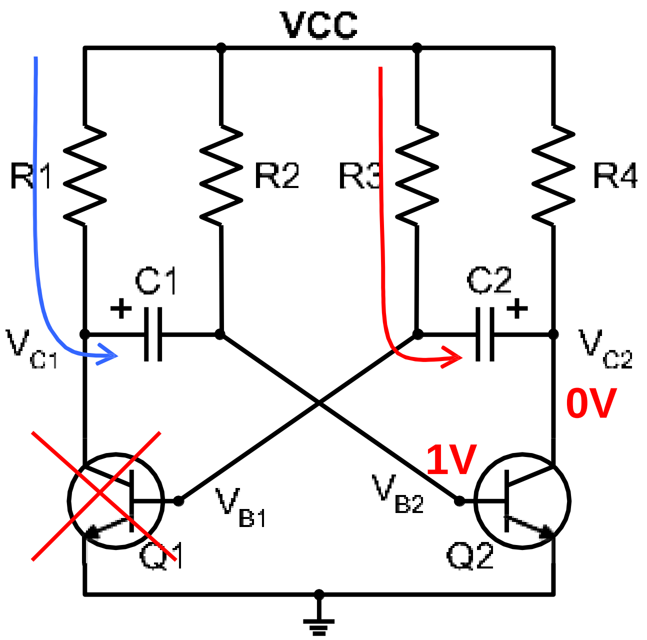


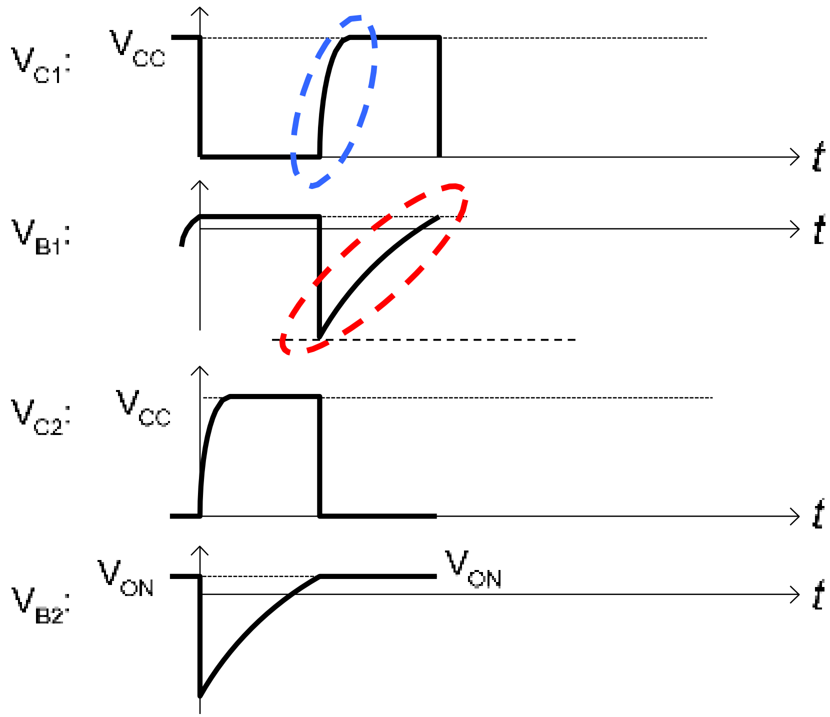




State 2 (cont’d):

- As $C_2$’s voltage cannot change instantaneously, $V_{B1}$ drops by $V_{CC}$.

# Basic Mode of Operation

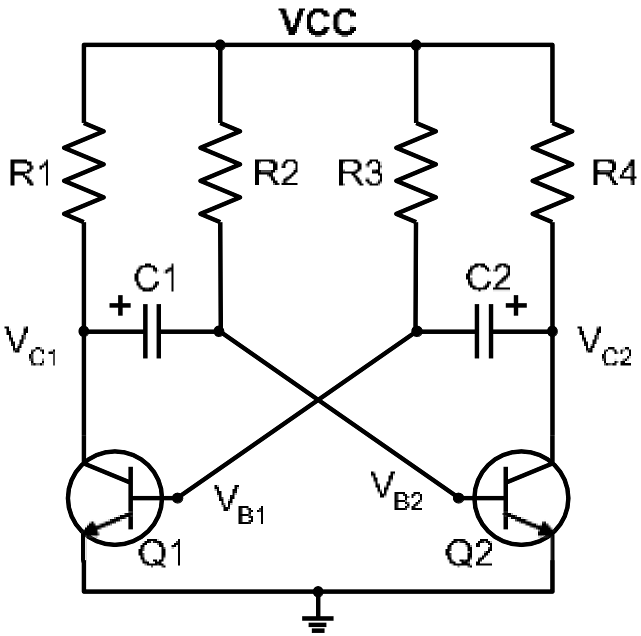


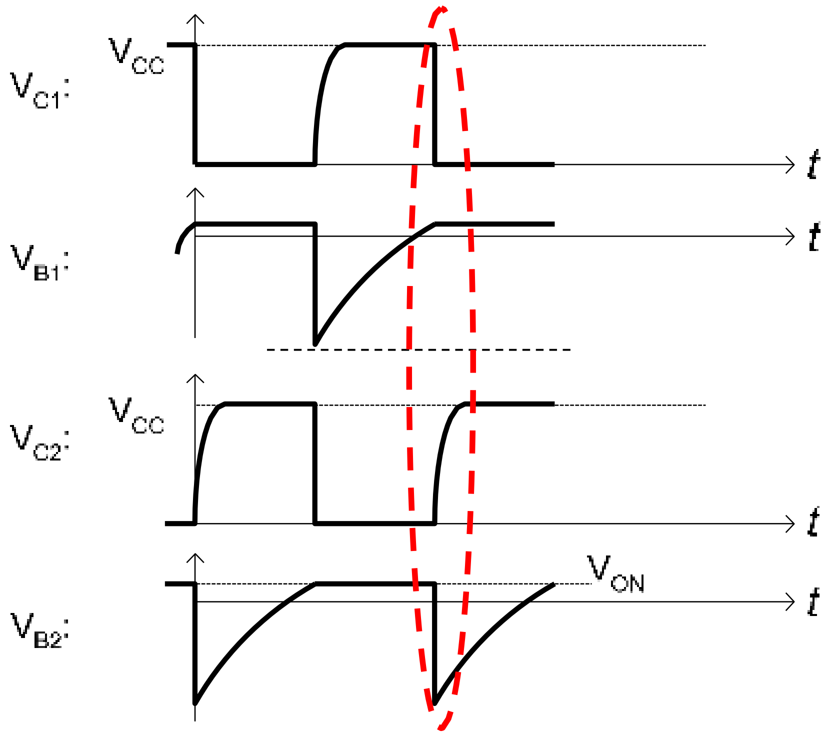




State 2 (cont'd):

- $Q_1$ turns off and $V_{C1}$ charges up through $R_1$ to $V_{CC}$, at a rate set by $R_1C_1$.
- $V_{B2}$ charges up through $R_3$ towards $V_{CC}$, at a rate set by $R_3C_2$, which is slower.

# Basic Mode of Operation



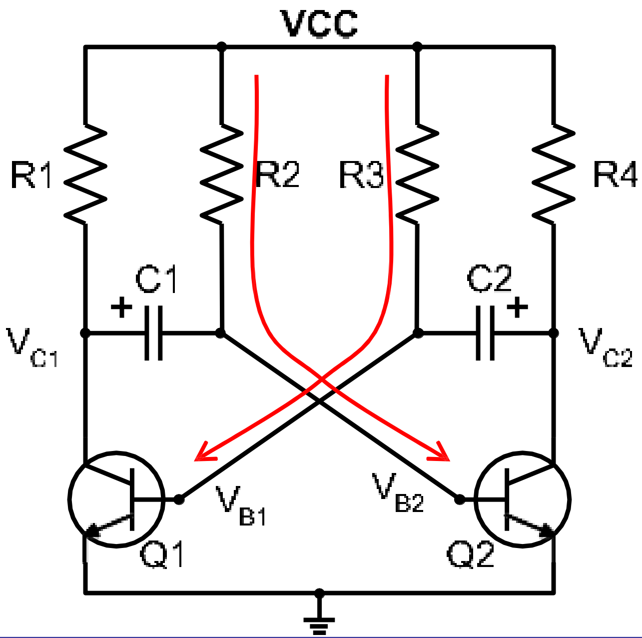




Back to state 1:

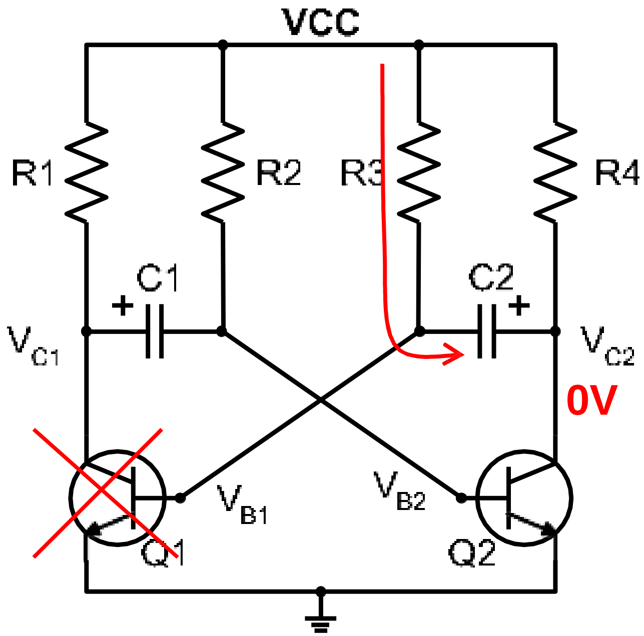
- When $V_{B1}$ reaches Von, the circuit enters state 1 again, and the process repeats.

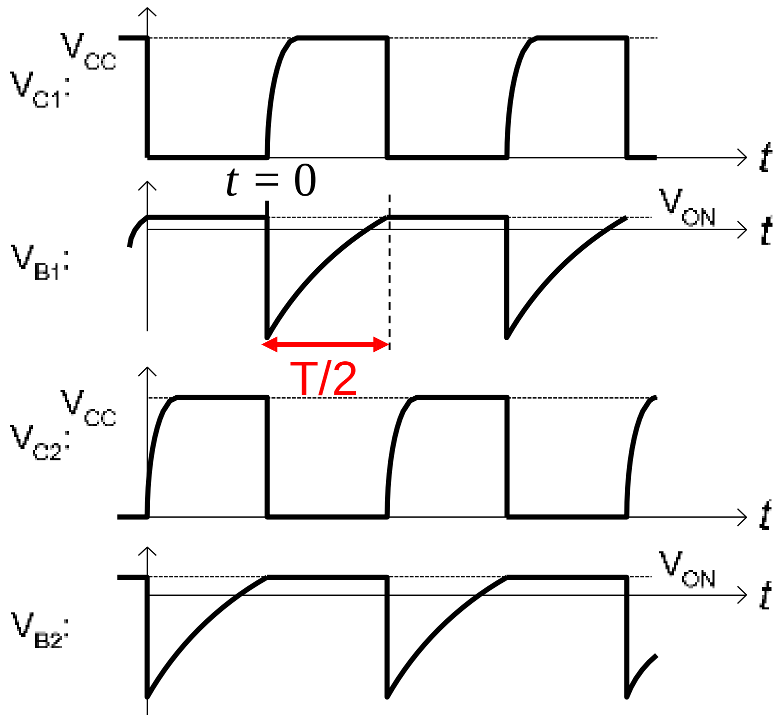
# Initial Power-Up

- When the circuit is first powered up, neither transistor is ON.
- Parasitic capacitors between B and E of $Q_1$ and $Q_2$ are charged up towards $V_{CC}$ through $R_2$ and $R_3$. Both $V_{B1}$ and $V_{B2}$ rise.
- Inevitable slight asymmetries will mean that one of the transistors is first to switch on. This will quickly put the circuit into one of the above states, and oscillation will ensue.



# Multivibrator Frequency




$$v_{B1} = (V_{ON} - V_{CC}) + (2V_{CC} - V_{on})(1 - e^{-t/R_3C_2})$$

$$\approx -V_{CC} + 2V_{CC}\,(1 - e^{-t/R_3C_2}) \qquad \text{for } V_{ON} << V_{CC}$$

At $t$ = T/2, $v_{B1}$=$V_{ON}$: $\quad V_{ON} = -V_{CC} + 2V_{CC}(1 - e^{-T/2R_3C_2})$

# Multivibrator Frequency

$$V_{ON} = -V_{CC} + 2V_{CC} \quad (1 - e^{-T/2R_3C_2})$$

$$\therefore V_{CC} \approx 2V_{CC} \quad (1 - e^{-T/2R_3C_2}) \qquad \text{for } V_{ON} << V_{CC}$$

$$\therefore 1 = 2(1 - e^{-T/2R_3C_2})$$

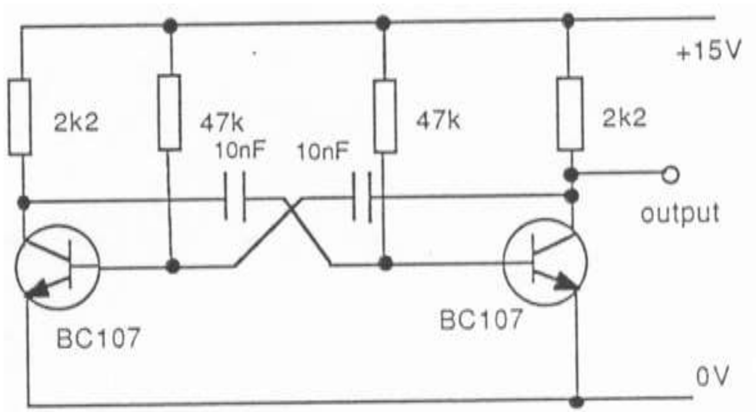
$$\therefore e^{-T/2R_3C_2} = 0.5$$

$$\therefore -\frac{T}{2R_3C_2} = -\ln 2$$

$$\therefore T = 2(\ln 2)R_3C_2$$

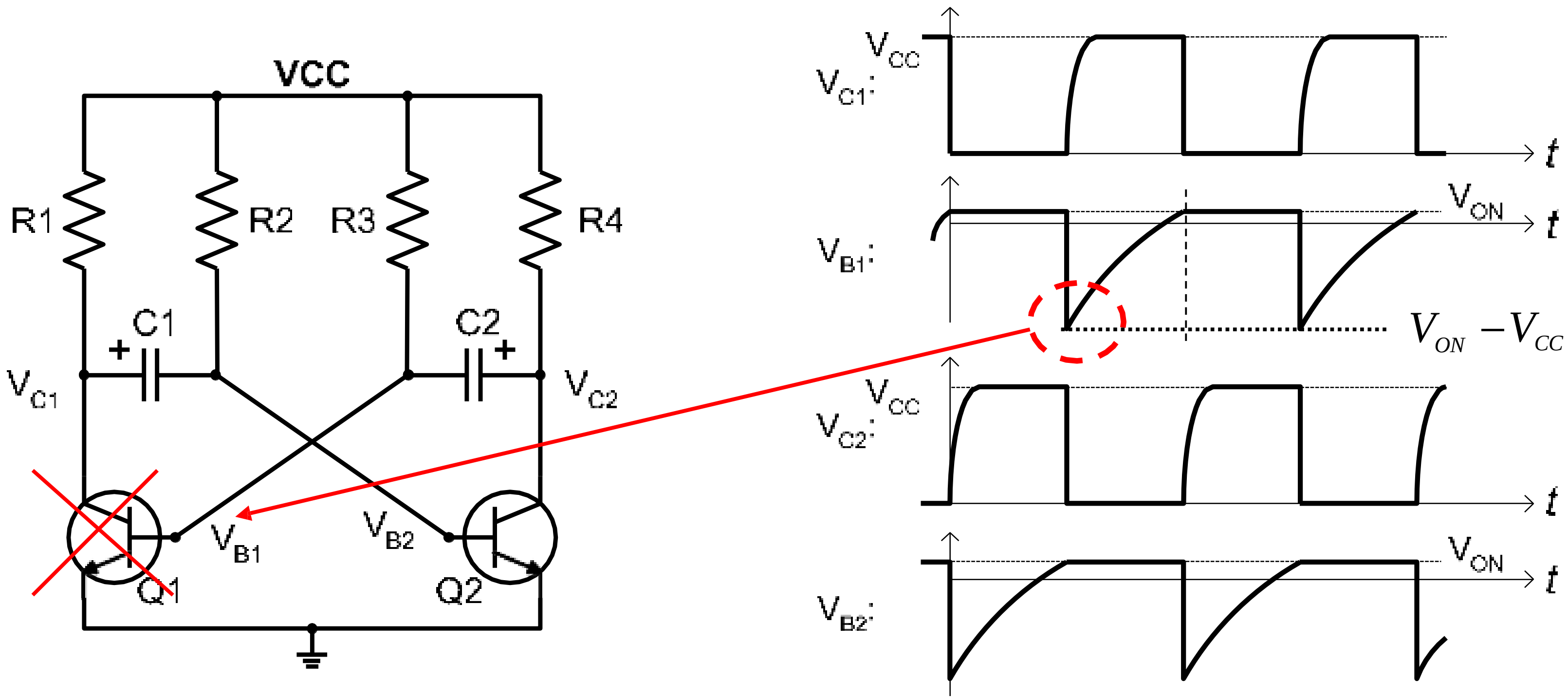
or

$$f = \frac{1}{2(\ln 2)R_3C_2}$$




For the above component values, f =1.53kHz.

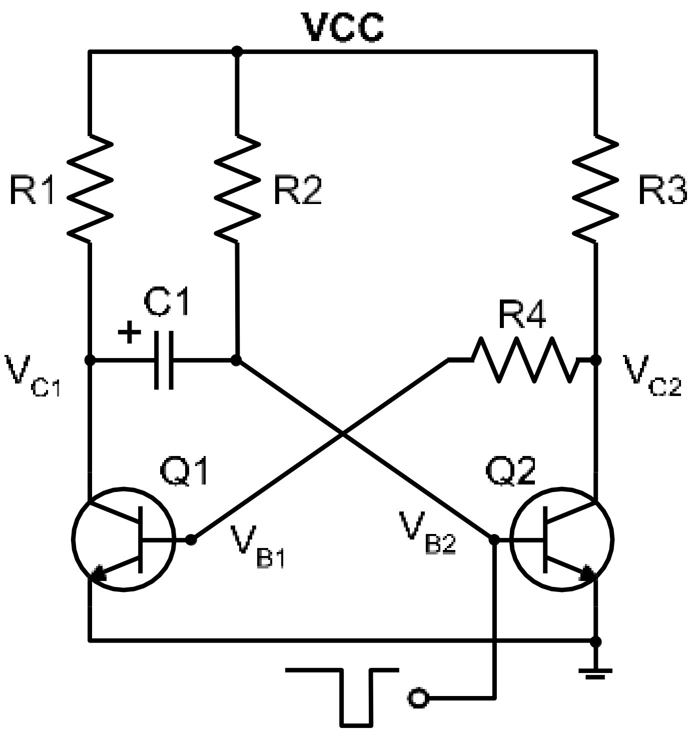
# Supply Voltage Limit




- When $V_{B1}$ is negative, BE junction of $Q_1$ is reverse-biased.
- Suppose the breakdown voltage of this junction is $V_{break}$ (positive). then to avoid breakdown,

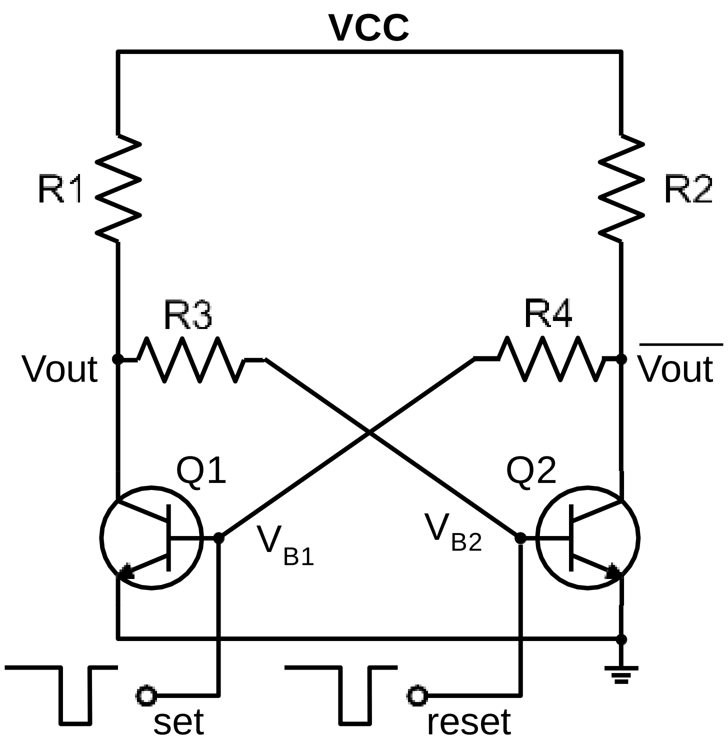
$$V_{ON} - V_{CC} > -V_{Break} \quad \Rightarrow \quad \boxed{V_{CC} < V_{ON} + V_{Break}}$$

# Mono-stable Multivibrator




- Capacitive path between $V_{C2}$ and $V_{B1}$ removed.
- Stable for one state (state 2 here)
  - $Q_1$ OFF and $Q_2$ ON
  - $V_{C1}$ High, $V_{C2}$ Low
- When $V_{B2}$ is momentarily pulled to ground by an external signal
  - $V_{C2}$ rises to $V_{CC}$
  - $Q_1$ turns on
  - $V_{C1}$ pulled down to 0V
  - Enter state 1 temporarily
- When the external signal goes high
  - $V_{B2}$ charges up to $V_{CC}$ through $R_2$
  - After a certain time T, $V_{B2}$=$V_{ON}$, $Q_2$ turns on
  - $V_{C2}$ pulled to 0V, $Q_1$ turns off
  - Enters state 2 and remains there
- Can be used as a timer

# Bi-stable Multivibrator




- Both capacitors removed
- Stable for either state 1 or 2
- Can be forced to either state by Set or Reset signals
- If Set is low,
  - $Q_1$ turns off
  - $V_{C1}$ ($V_{out}$) and $V_{B2}$ rises towards $V_{CC}$
  - $Q_2$ turns on
  - $V_{C2}$ ($/V_{out}$) pulled to 0V
  - $V_{B1}$ is latched to 0V
  - Circuit remains in state 2 until Reset is low
- If Reset is low
  - Similar operation
  - Circuit remains in state 1 until Set is low
- Behave as an RS flip-flop