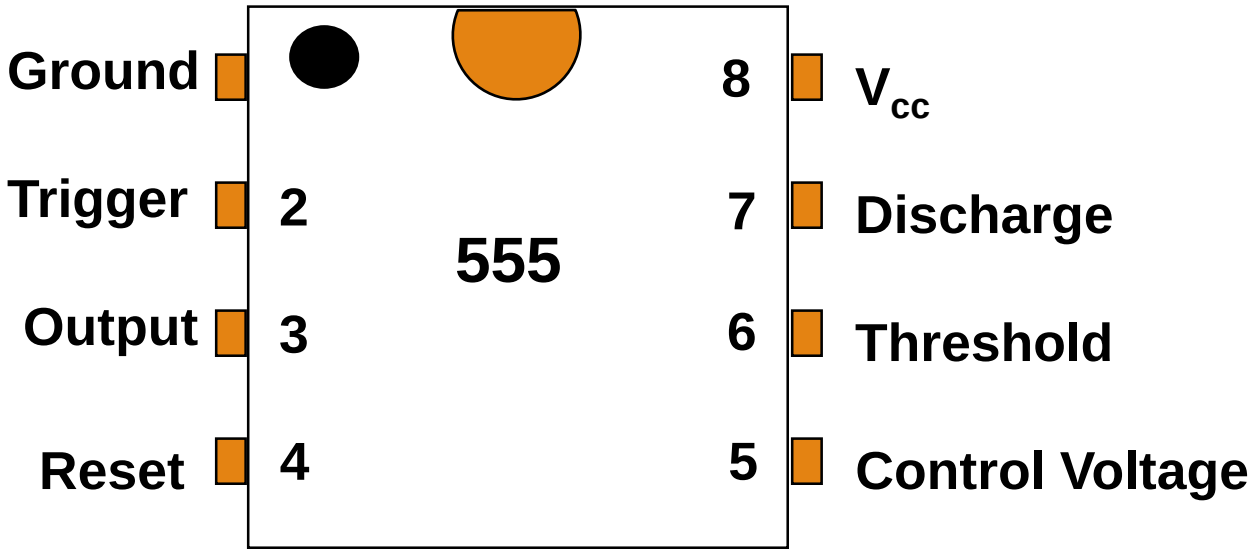
EE2-07: 555 IC Timer

Objectives

- To get familiarized with the LM 555 Timer IC and its usage.
- To design a monostable multivibrator circuit (“one-shot”).
- To design an astable multivibrator circuit (free-running oscillator).

555 Timer pin layout



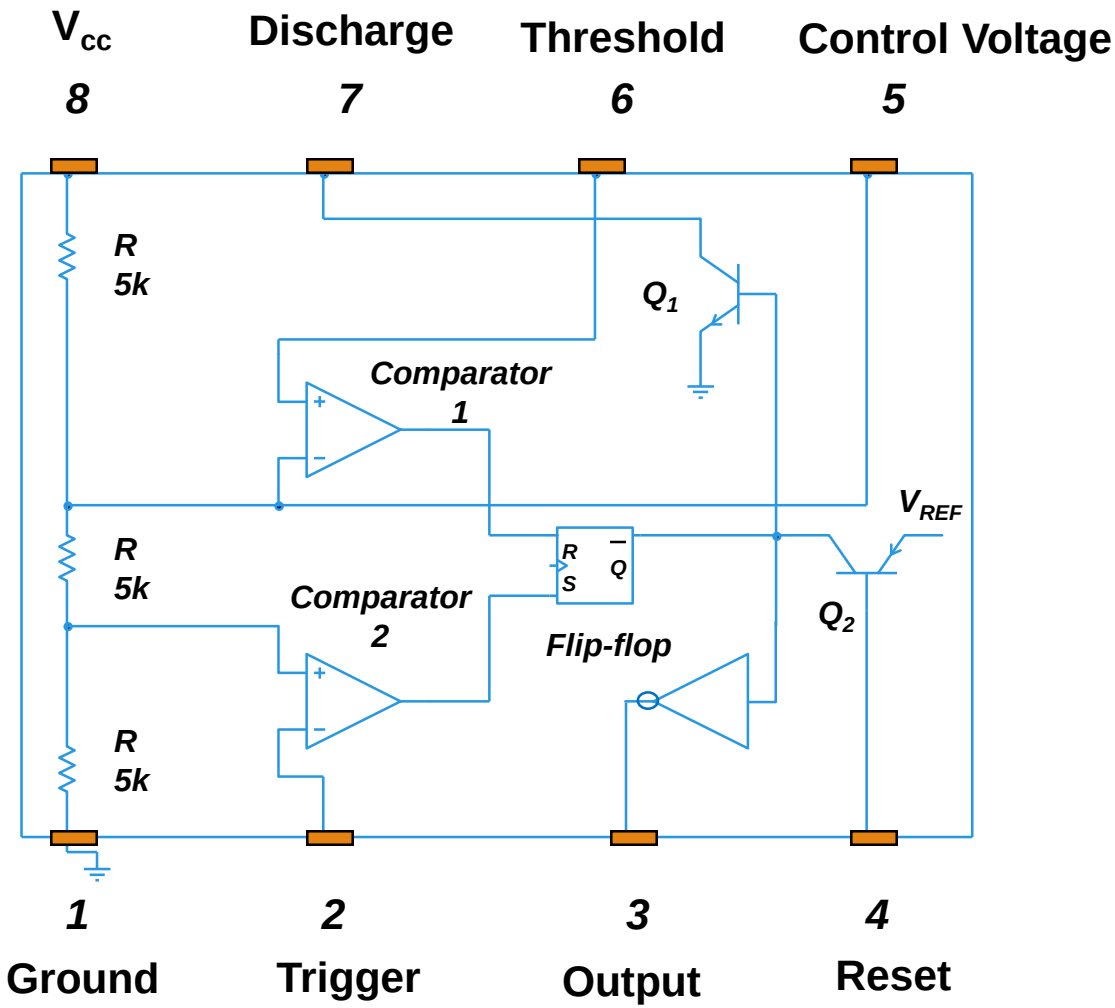
The **trigger** and **reset** inputs are active LOW inputs.

Output goes HIGH when triggered.

555 Timer specifications

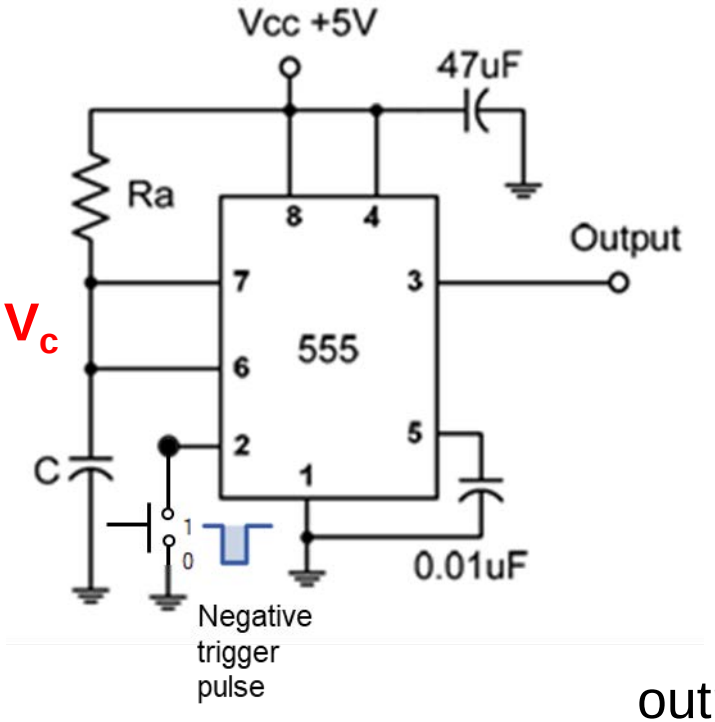
- Supply voltage: 4.5 V to 18 V
- Power dissipation: 600 mW
- Threshold current: 0.1 mA
- Trigger current: 0.5 mA
- Maximum output source/sink current: 200 mA

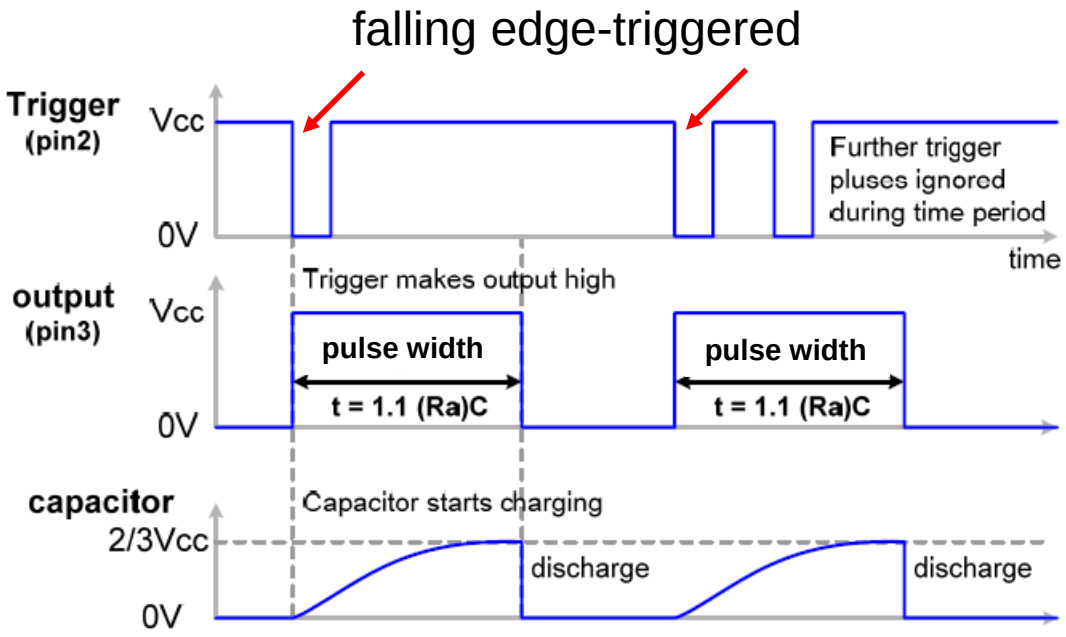
555 Timer functional block diagram



The output of a 555 timer is either HIGH (close to $+V_{cc}$) or LOW (close to GND).

1. Monostable multivibrator

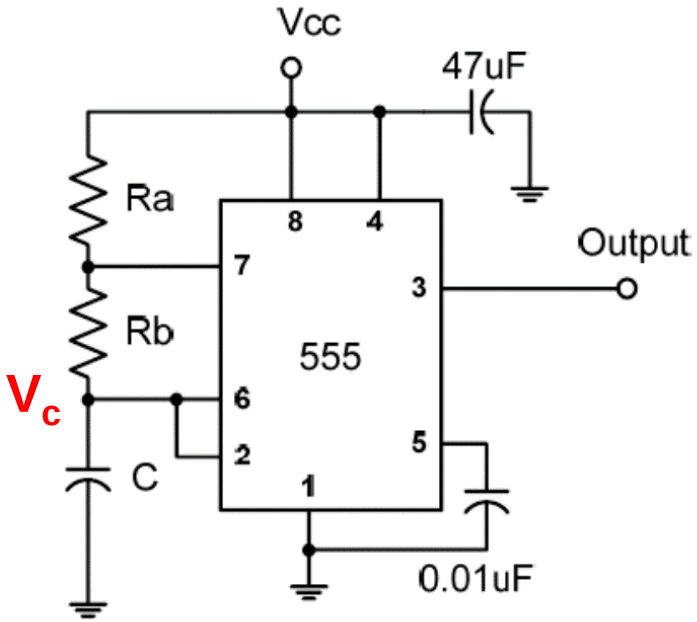


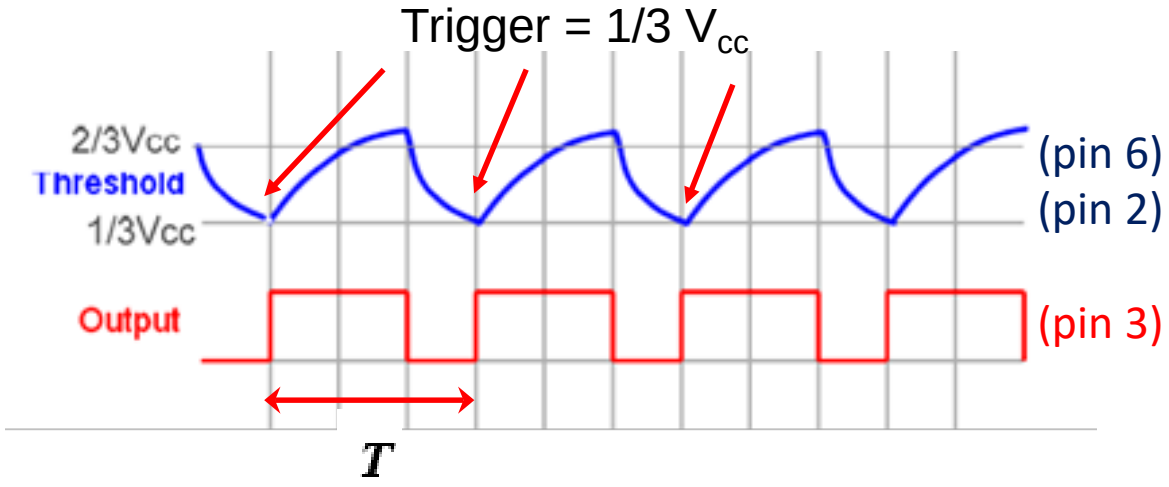


output pulse width: $t = 1.1(R_a)C$

Each time the 555 timer is triggered, the output will go HIGH for a specified amount of time, then it will return to LOW and await another trigger signal.

2. Astable multivibrator





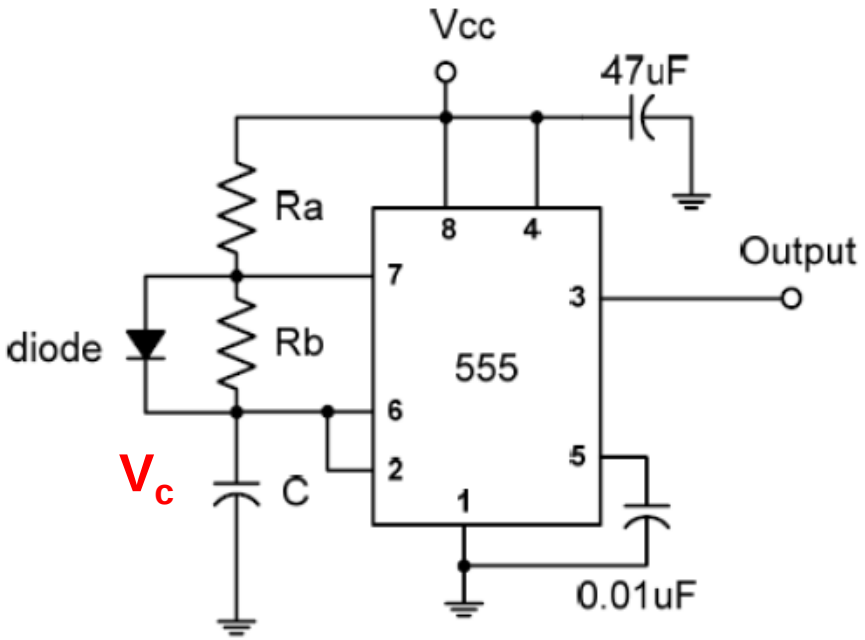
$$t_{high} = 0.693\ (R_a + R_b)C \qquad t_{low} = 0.693\ (R_b)C$$

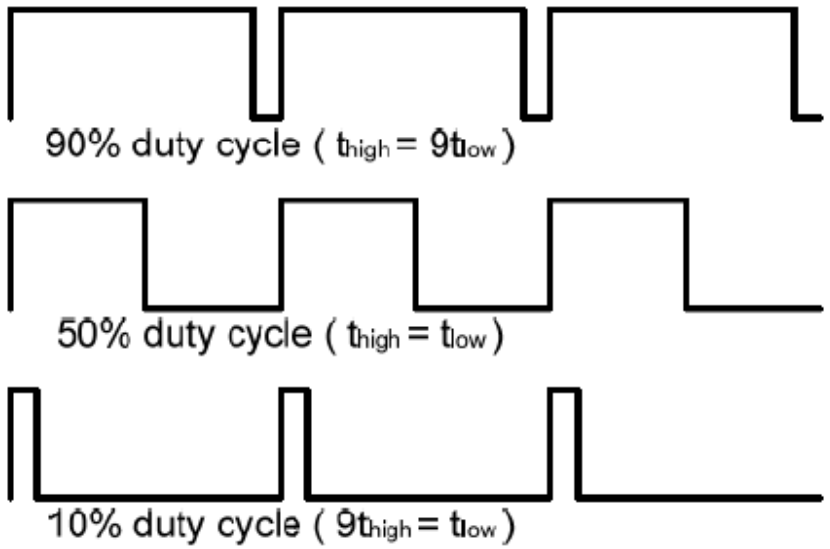
$$T = t_{high} + t_{low} \qquad f = 1/T = 1.44/(R_a + 2R_b)C$$

$$D = t_{high}/T = (R_a + R_b)/(R_a + 2R_b)$$

- The timer triggers itself periodically and becomes an oscillator, sending out a train of pulses.
- The duty cycle is always greater than 50%.

3. Astable multivibrator with a diode across R_b





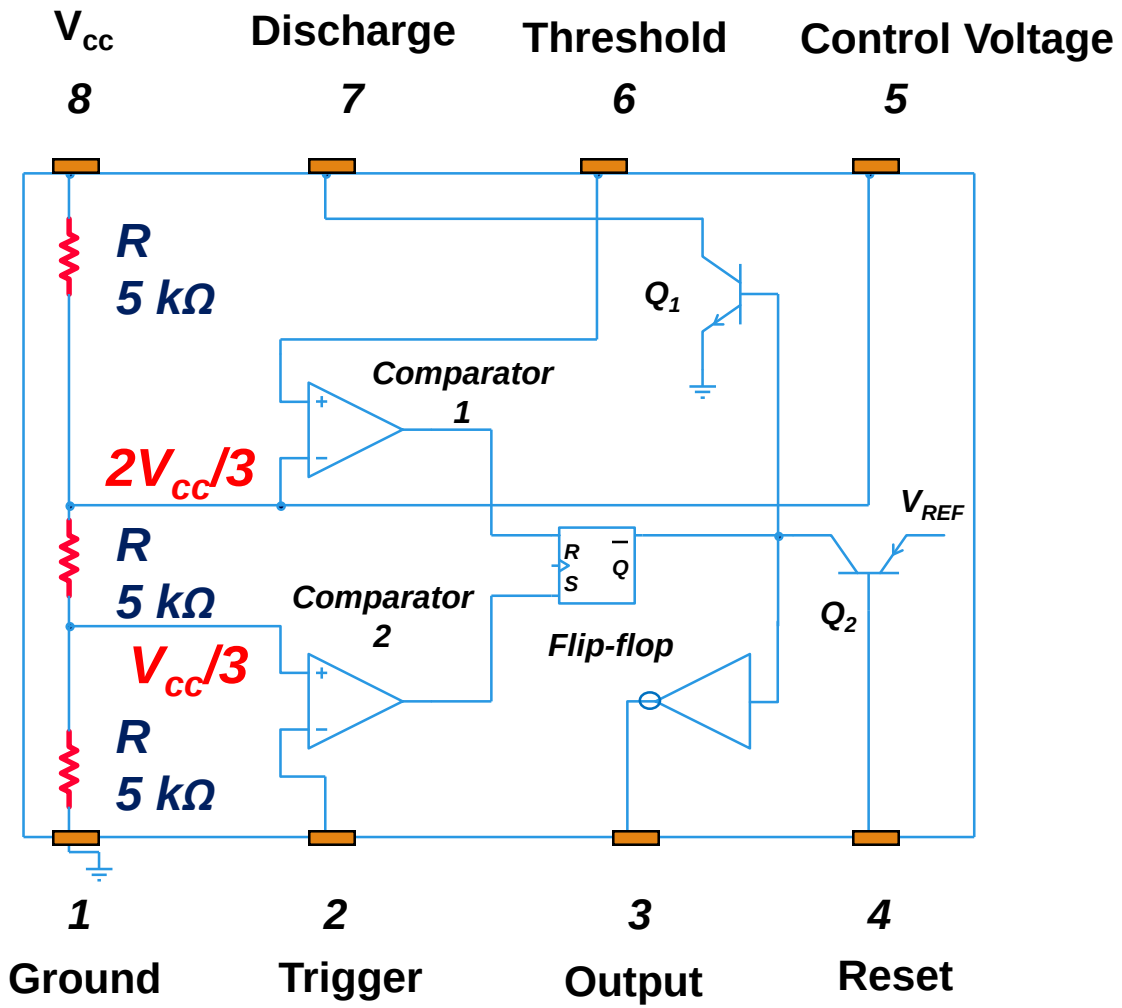
$$t_{high} = 0.693 \times R_a \times C$$

$$t_{low} = 0.693 \times R_b \times C$$

$$D = t_{high}/T = R_a/(R_a + R_b).$$

To achieve a duty cycle of less than 50% or any value, a signal diode can be added in parallel with R_b. This will bypass R_b during the charging period (HIGH) of the cycle.

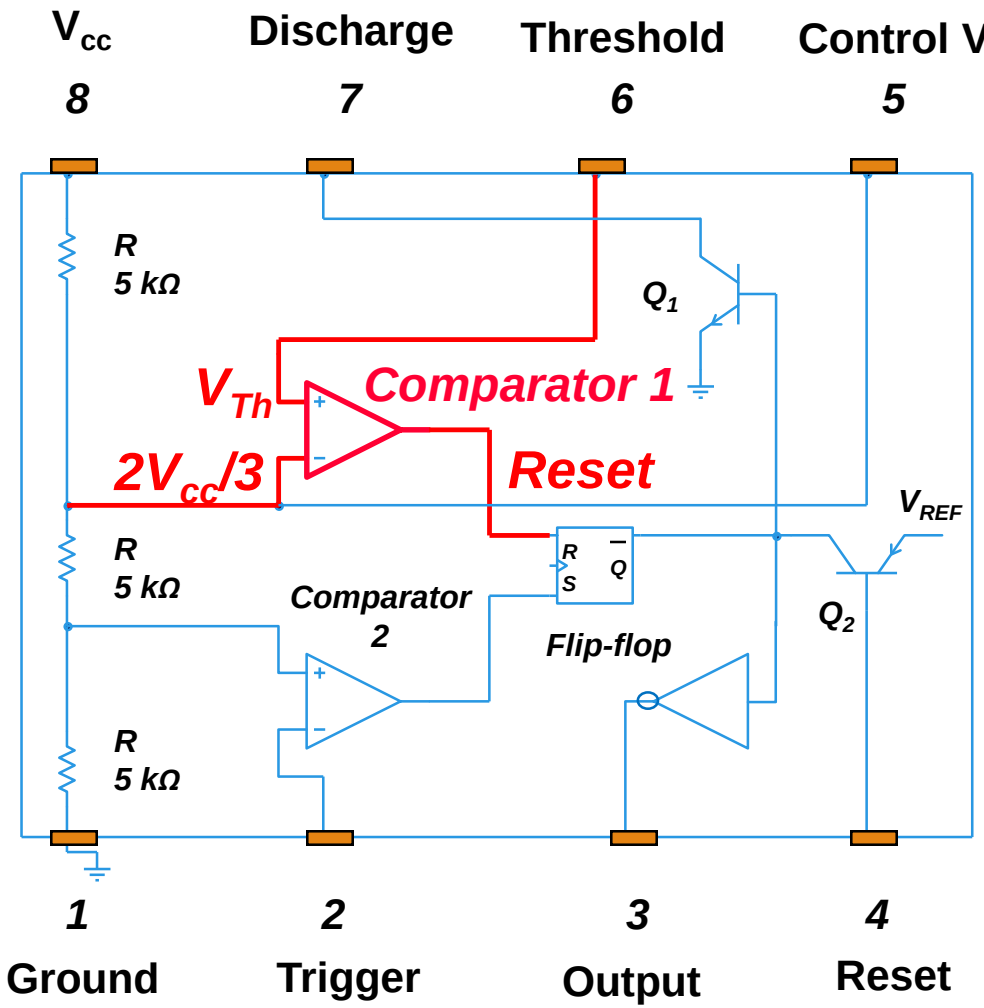
The voltage divider



Voltage Divider

Inside the 555 timer, there is a voltage divider that divides V_{cc} into thirds.

Voltage comparator 1 (Threshold vs. $2V_{cc}/3$)

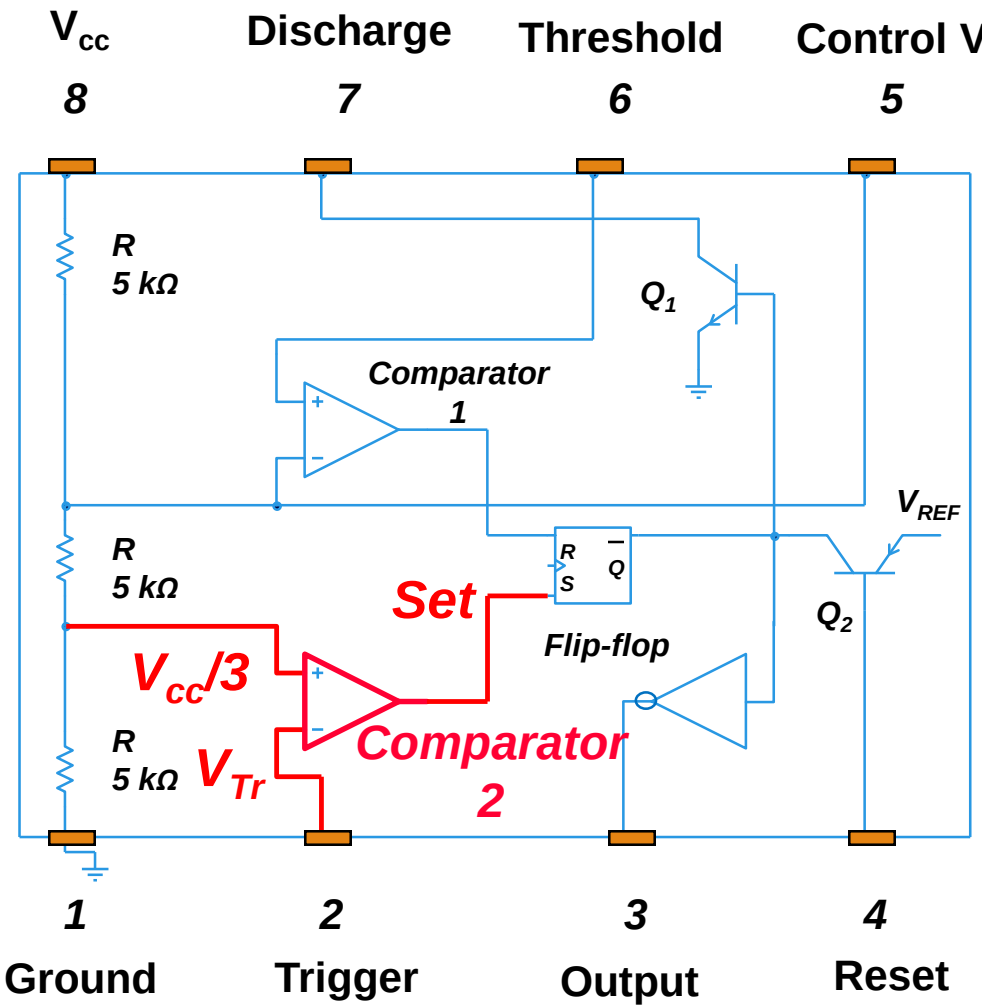


$V_{Th} \geq 2V_{cc}/3$

Reset = 1

The voltage comparator 1 compares the threshold (pin 6) with 2/3 V_{cc}.

Voltage comparator 2 (Trigger vs. $V_{cc}/3$)

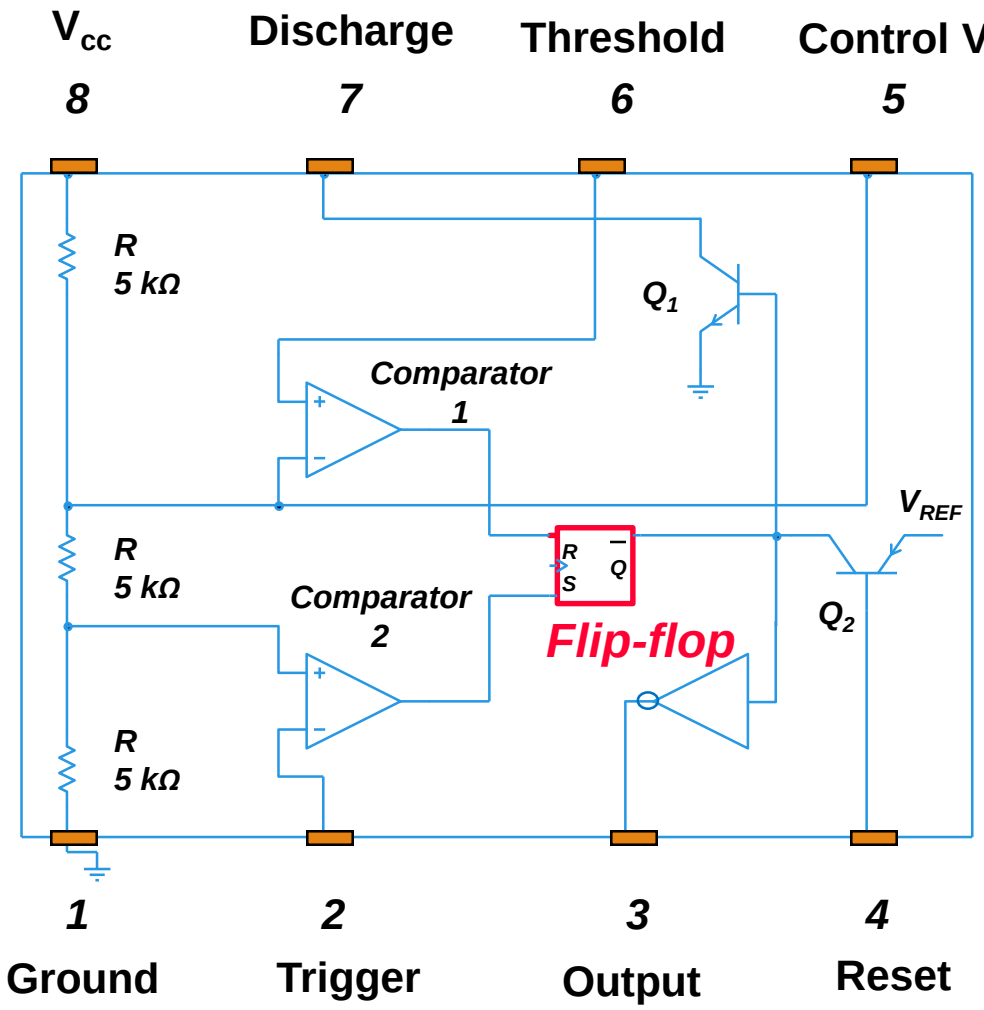


$V_{cc}/3 \geq V_{Tr}$

Set = 1

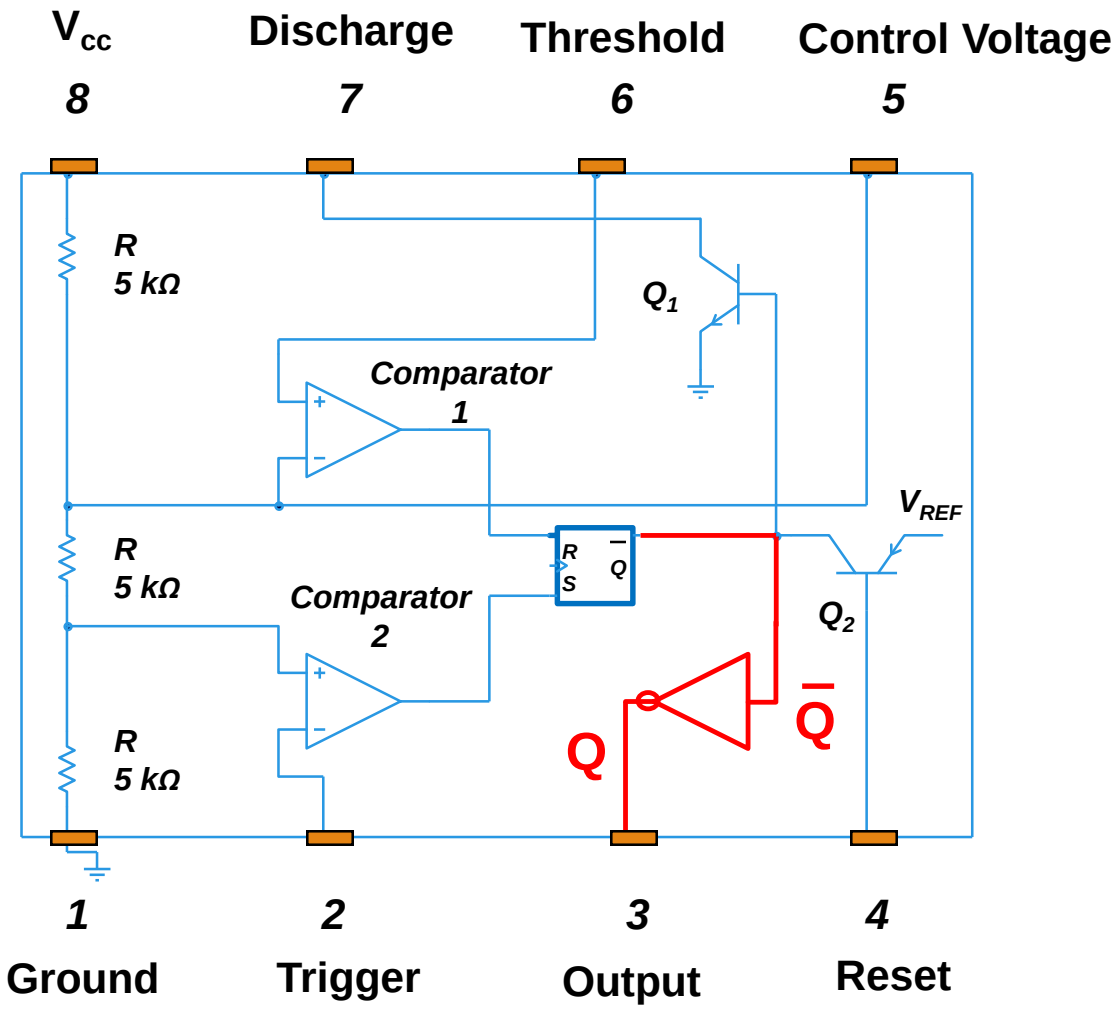
The voltage comparator 2 compares 1/3 V_{cc} with the trigger input (pin 2).

RS flip-flop

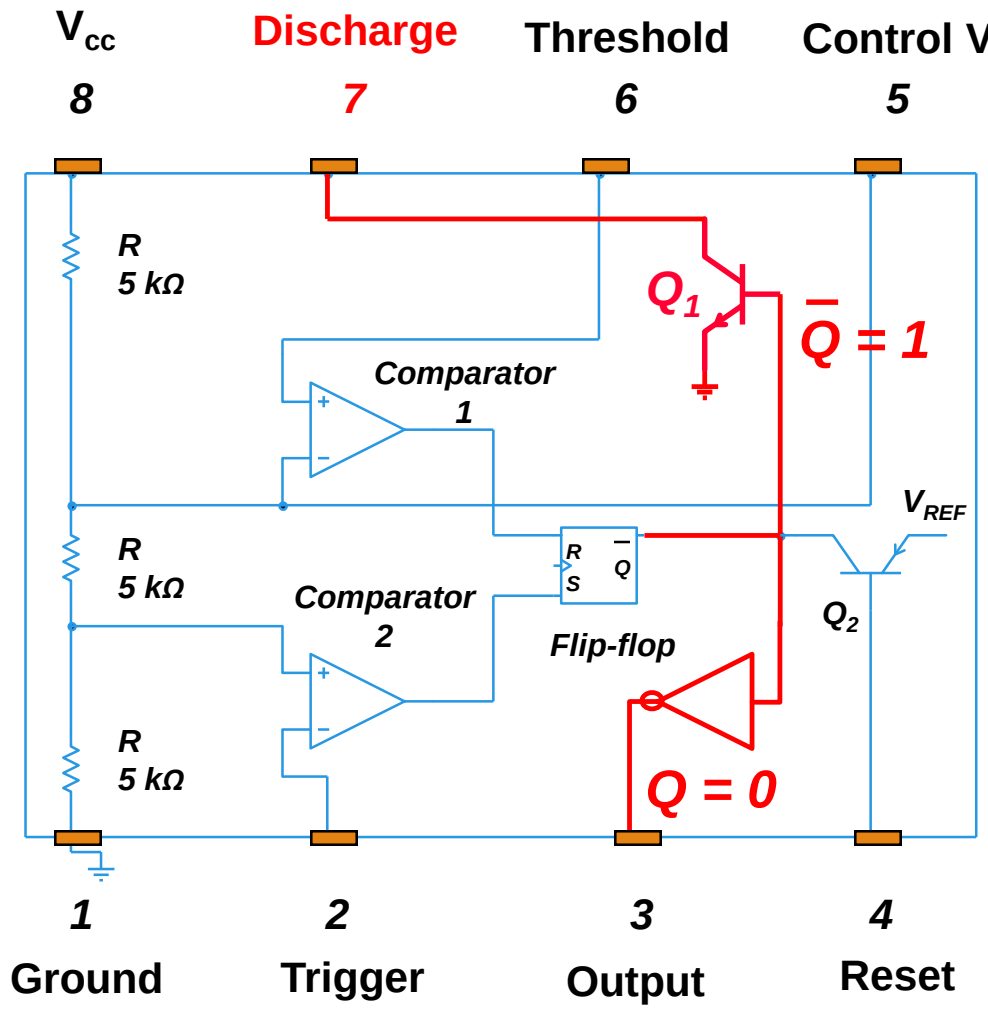


R	S	Q
0	0	No Change
0	1	1 (Set)
1	0	0 (Reset)
1	1	Not Allowed

Inverted-output buffer



Discharge transistor (Q_1)

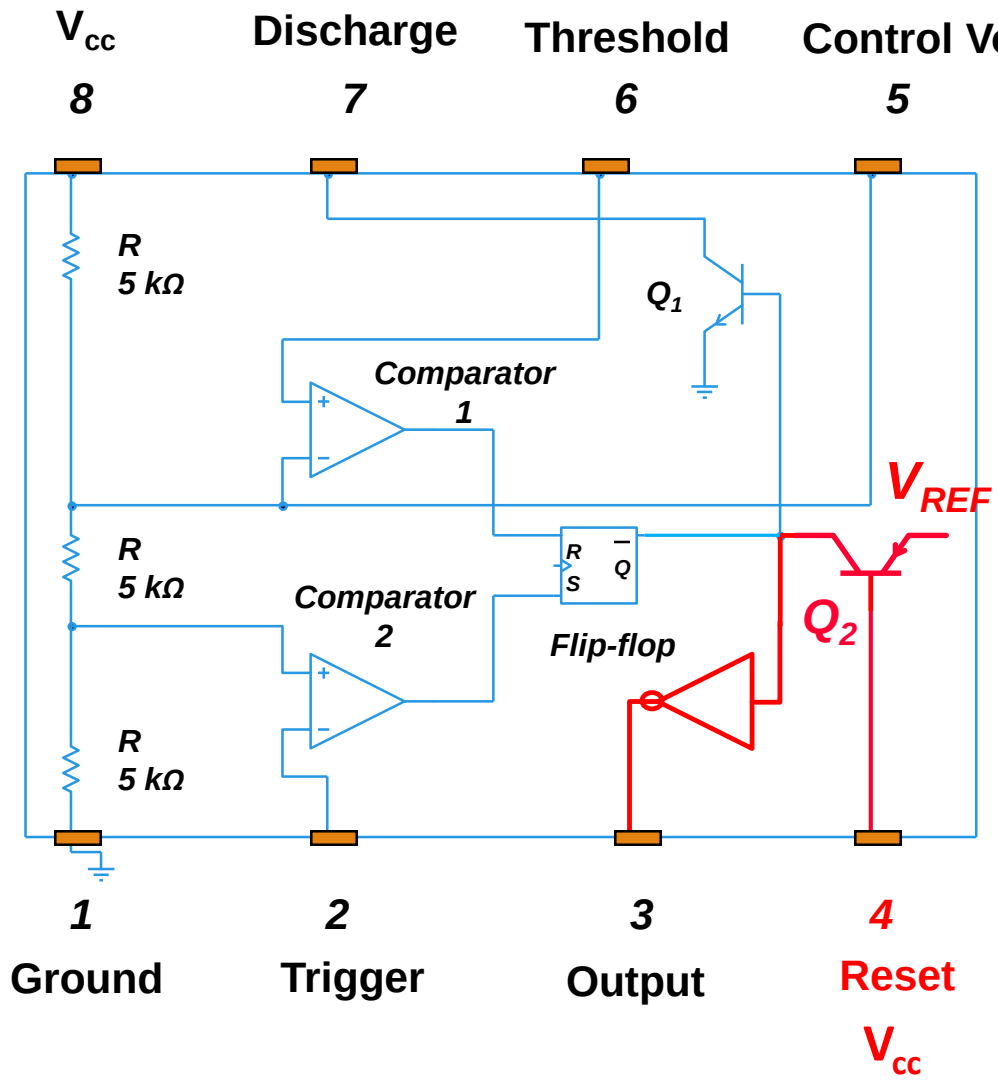


ON when $\overline{Q}$ is HIGH (V_{CC})

Discharge (Output = 0)

OFF when $\overline{Q}$ is LOW (0 V)

Reset Transistor (Q_2)

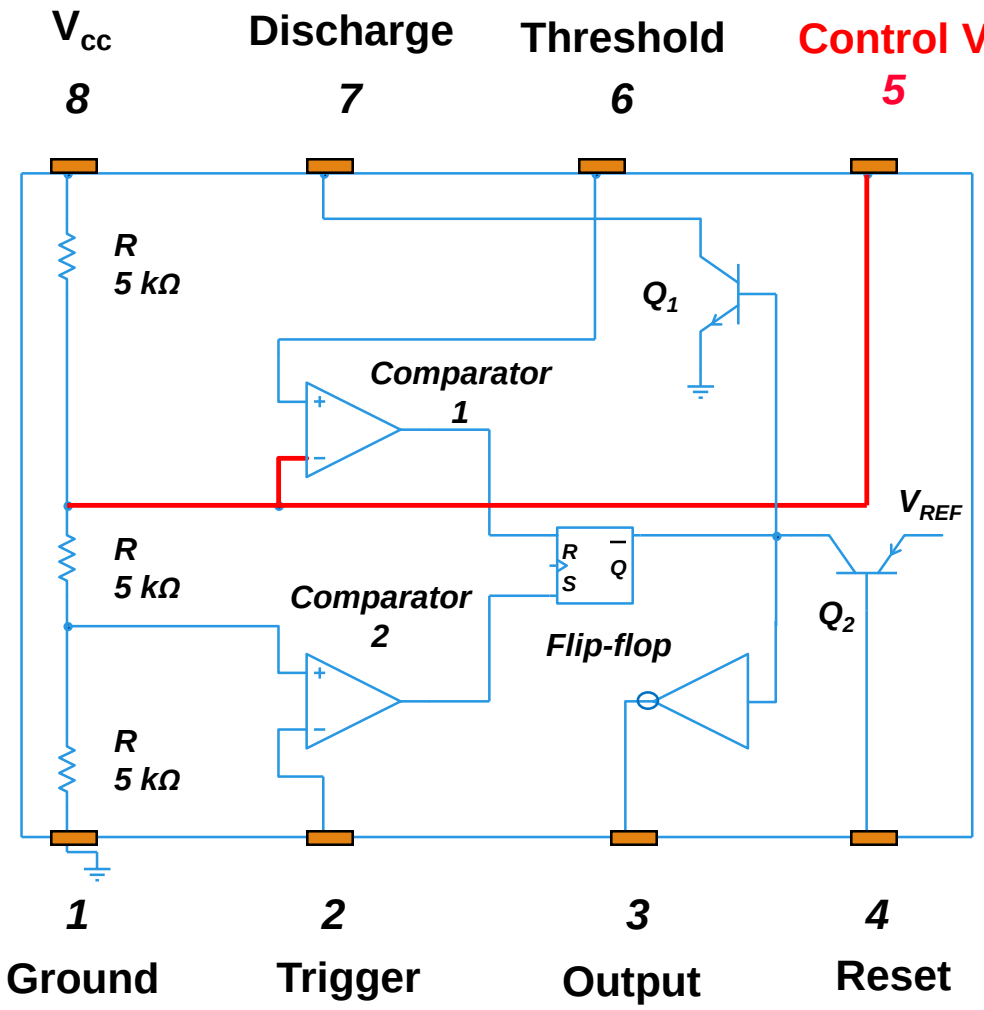


V_{REF} is slightly less than V_{cc}.

OFF when
$V_4 > V_{REF}$ (V_{cc})

ON when
$V_4 < V_{REF}$ (0 V)
➡ **Reset (Output = 0)**

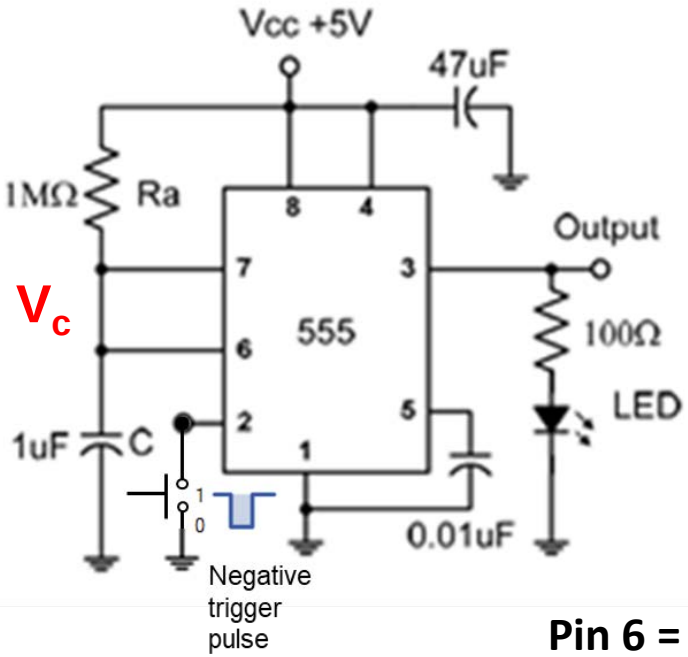
Control voltage

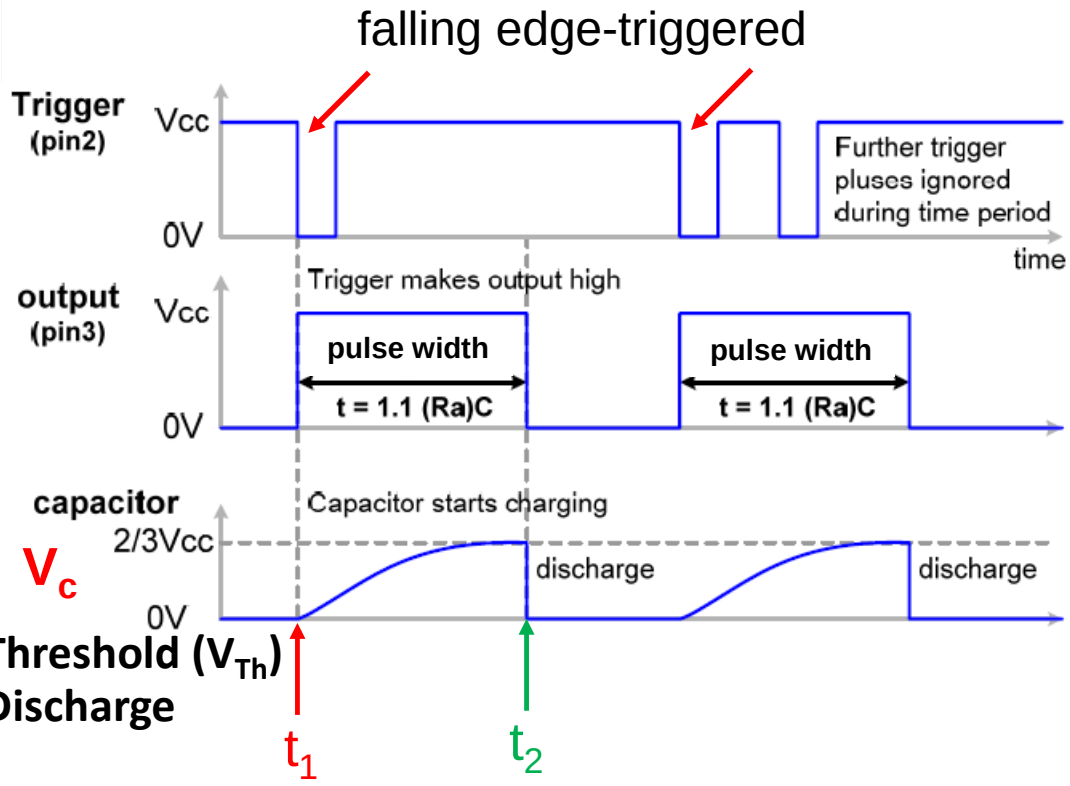


Control Voltage is connected to ground through a capacitor if not use.

The capacitance of 0.01 μ F is recommended.

P1 Monostable multivibrator



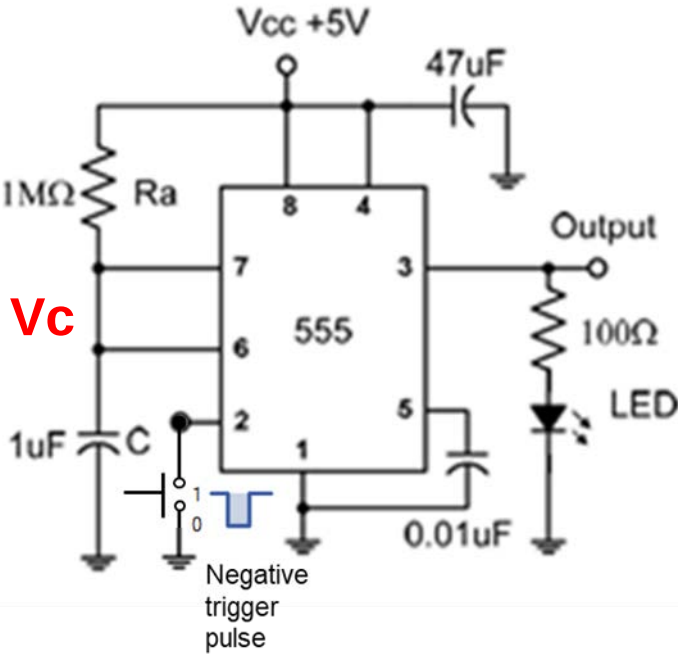


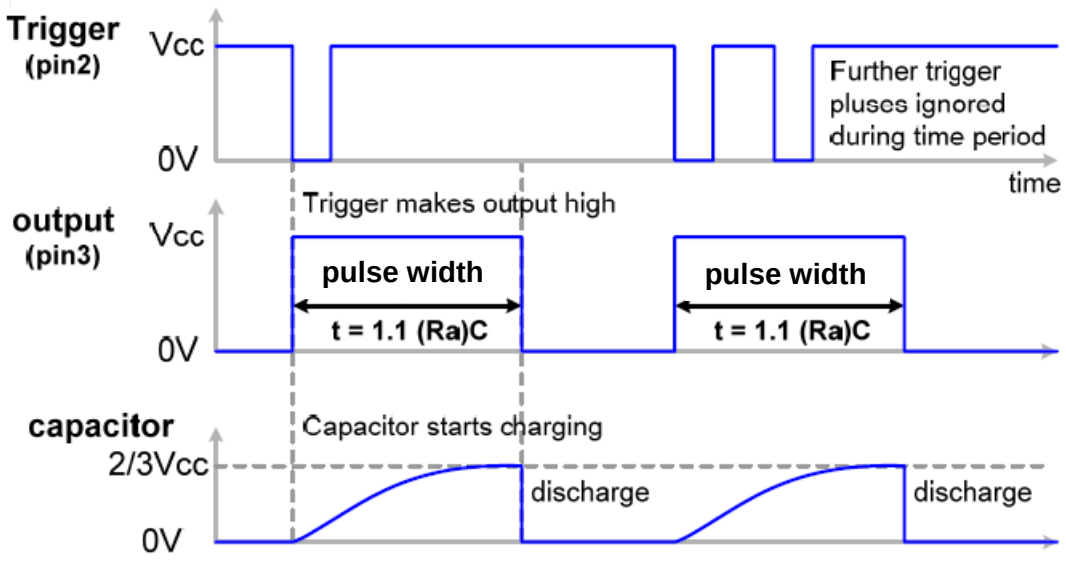
$t = t_1$: $V_{Th} < 2V_{cc}/3$, $V_{cc}/3 > V_{Tr}$ (0 V) — *R = 0, S = 1, Q = 1, Output = V_{cc}; Q_1 is OFF (capacitor charging)*

$t_1 < t < t_2$: $V_{Th} < 2V_{cc}/3$, $V_{cc}/3 < V_{Tr}$ (V_{cc}) — *R = 0, S = 0, no change*

$t = t_2$: $V_{Th} = 2V_{cc}/3$, $V_{cc}/3 < V_{Tr}$ (V_{cc}) — *R = 1, S = 0, Q = 0, Output = 0; Q_1 is ON (capacitor discharging)*

P1 Monostable multivibrator



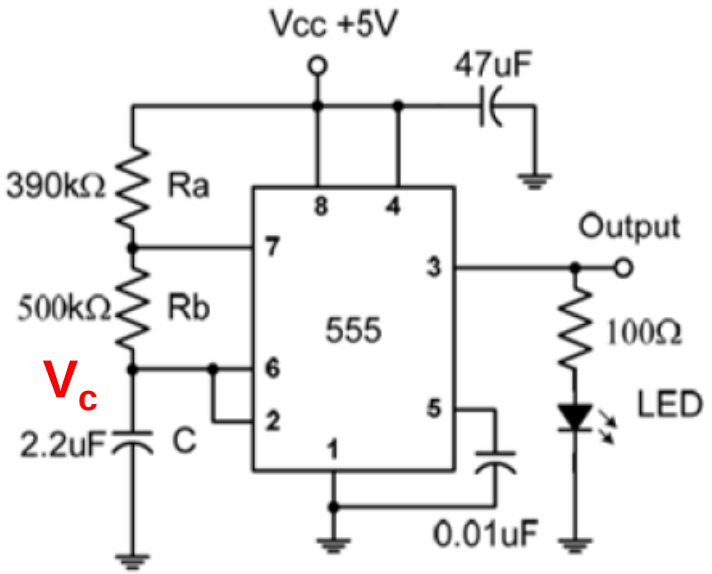


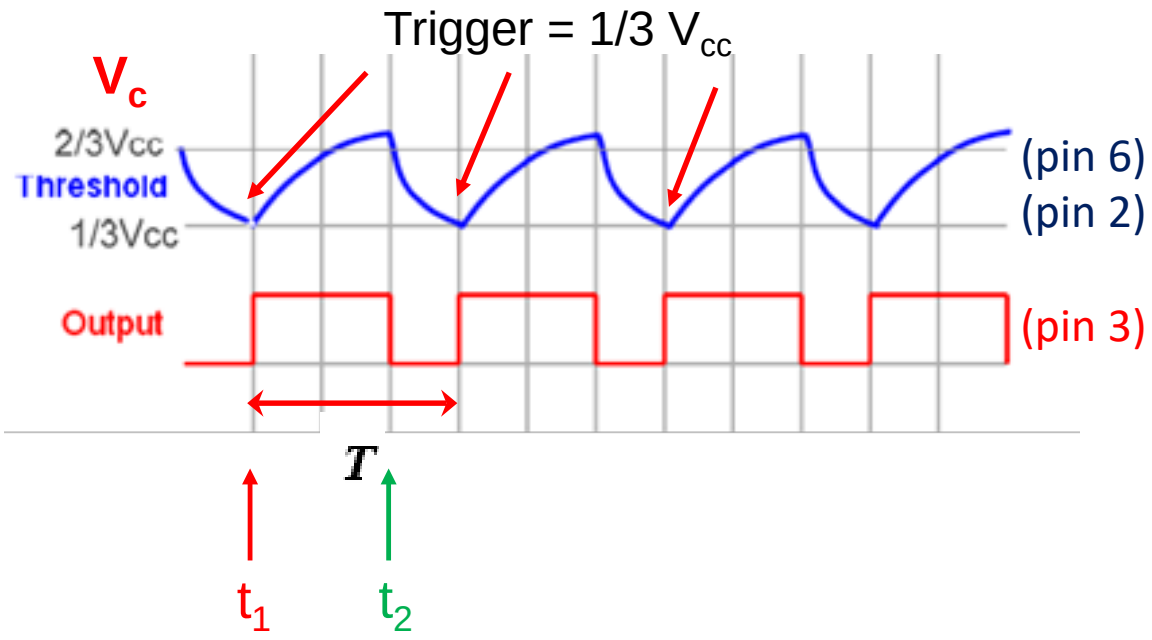
output pulse width: $t = 1.1(R_a)C$

R1 (10 points)

- Sketch the trigger signal, the voltage signal across the capacitor (Vc), and the output signal.
- Measure the output pulse width and compare the result with the theoretical value.
- Observe and describe the LED on/off behavior.

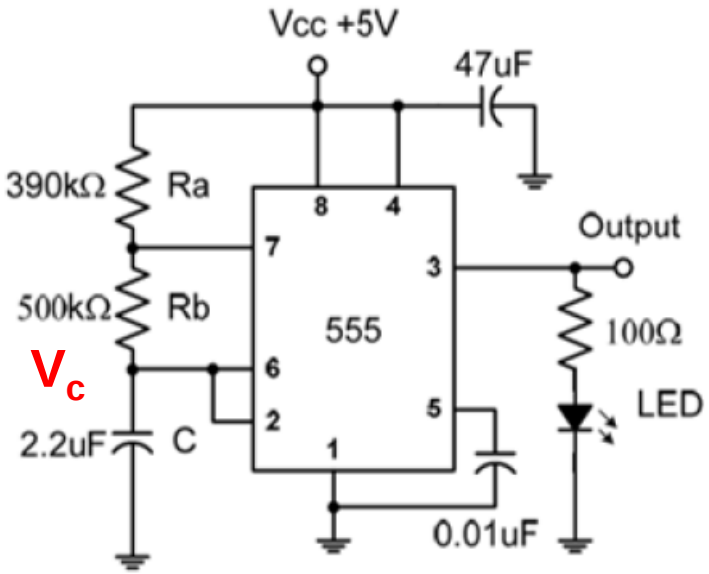
P2 Astable multivibrator (C = 2.2 µF)

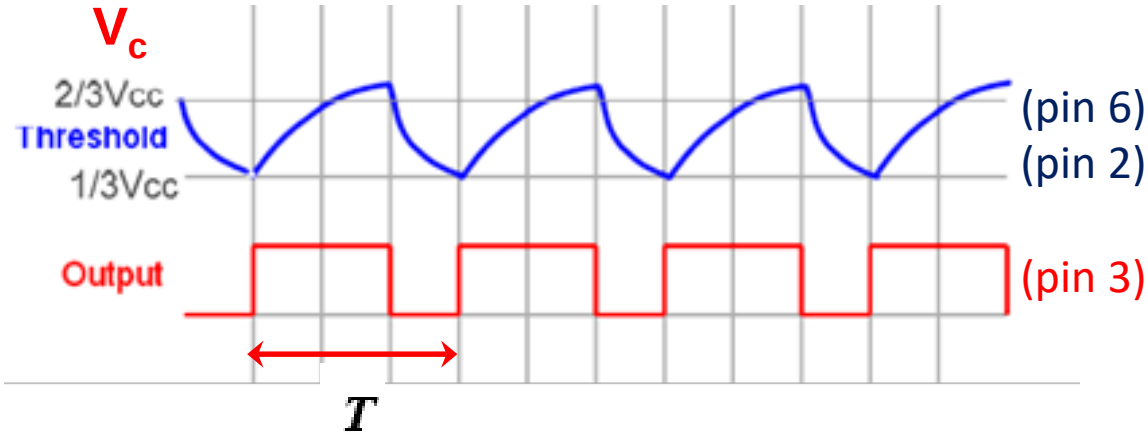




$t = t_1$:	$V_{Th} = V_{Tr} = V_{cc}/3$	***R = 0, S = 1, Q = 1, Output = V_{cc}*** ***Q_1 is OFF (capacitor charging)***
$t_1 < t < t_2$:	$V_{Th} < 2V_{cc}/3$ $V_{cc}/3 < V_{Tr}$	***R = 0, S = 0, no change***
$t = t_2$:	$V_{Th} = V_{Tr} = 2V_{cc}/3$	***R = 1, S = 0, Q = 0, Output = 0*** ***Q_1 is ON (capacitor discharging)***

P2 Astable multivibrator (C = 2.2 µF)





$$t_{high} = 0.693\,(R_a+R_b)C \qquad t_{low} = 0.693\,(R_b)C$$

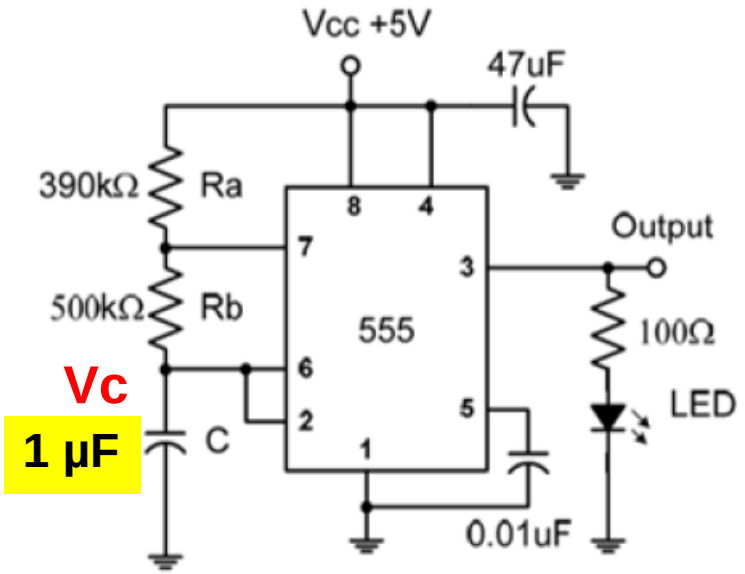
$$T = t_{high} + t_{low} \qquad f = 1/T = 1.44/(R_a+2R_b)C$$

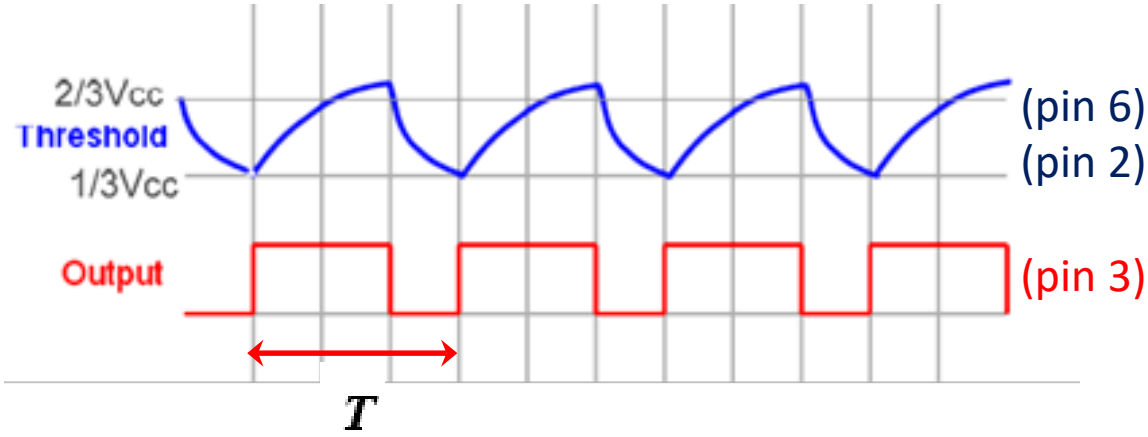
$$D = t_{high}/T = (R_a + R_b)/(R_a + 2R_b)$$

R2 (10 points)

- Sketch the voltage signal across the capacitor (V_c) and the output signal.
- Measure the time intervals for a HIGH output (t_{high}) and a LOW output (t_{low}).
- Determine the duty cycle, the period, and the frequency and compare the results with the theoretical values.
- Observe and describe the LED on/off behavior.

P3 Astable multivibrator (C = 1 µF)

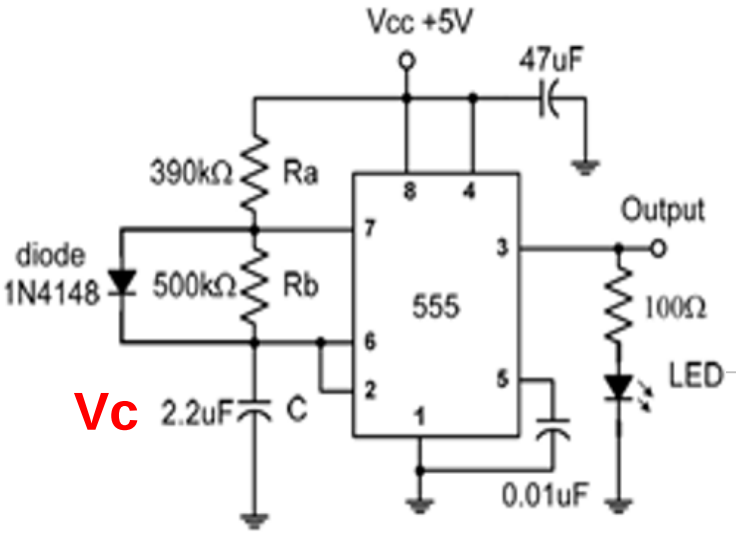


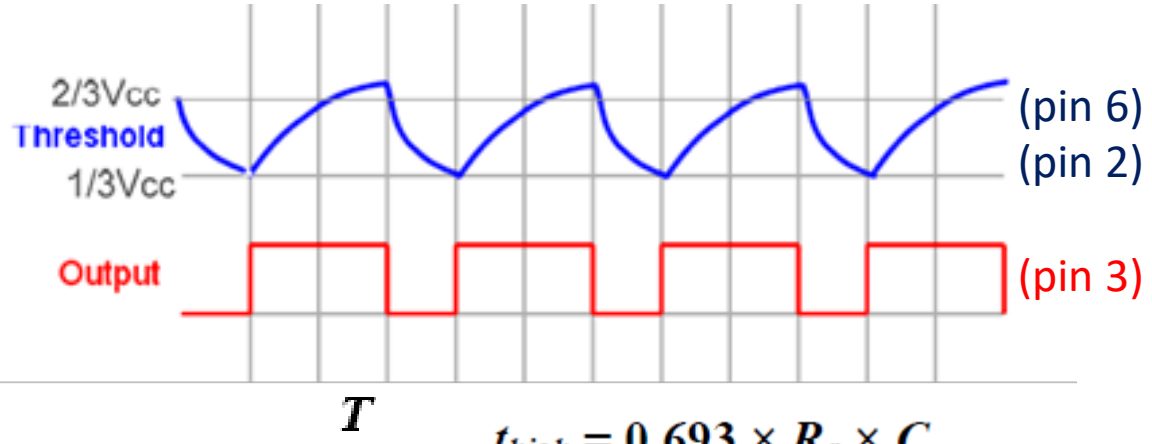


R3 (10 points)

- Sketch the voltage signal across the capacitor (V_c) and the output signal.
- Measure the time intervals for a HIGH output (t_{high}) and a LOW output (t_{low}).
- Determine the duty cycle, the period, and the frequency and compare the results with the theoretical values.
- Observe and describe the LED on/off behavior.
- Discuss the experimental results obtained from R2 and R3.

P4 Astable multivibrator with a diode across R_b





$$t_{high} = 0.693 \times R_a \times C$$

$$t_{low} = 0.693 \times R_b \times C$$

$$D = t_{high}/T = R_a/(R_a + R_b).$$

R4 (10 points)

- Sketch the voltage signal across the capacitor (V_c) and the output signal.
- Measure the time intervals for a HIGH output (t_{high}) and a LOW output (t_{low}).
- Determine the duty cycle, the period, and the frequency and compare the results with the theoretical values.
- Observe and describe the LED on/off behavior.

Note:

- **Use a 10x probe to measure the voltage across the capacitor C (V_c).**
- **Make sure that electrolytic capacitors have a correct polarity.**

FINAL REPORT

Write a report on how this experiment is performed which should include the followings:

1. Describe the operation of each circuit.

2. Discuss the waveforms obtained at each section.

3. Discuss about the results obtained from R2 and R3.

4. Discuss about the results obtained from R2 and R4.

QUESTIONS

Q1 Describe the difference(s) between a square wave and a rectangular wave.

Q2 Consider the circuit in Figure 11, if we want the LED to be ON for 2 s and OFF for 2 s, what would be the values of the resistors R_a and R_b?