# Electrical Engineering Technology

# EET 157

## Electronics Circuit Analysis

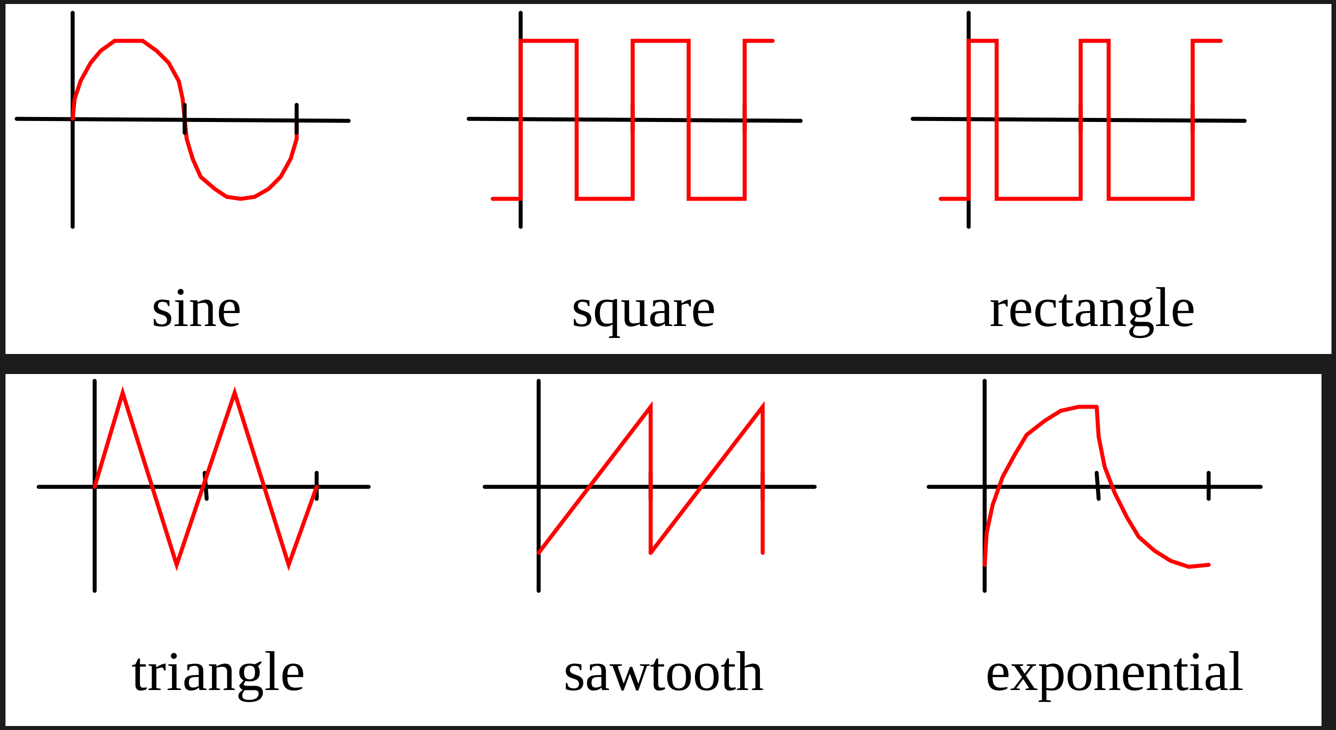
# 05

Revised by Dr. Athula Kulatunga

# Overview

- Multivibrators
- 555 Timer
- 555 Timer Monostatble Multivibrators
- 555 Timer Astable Multivibrators

# Waveforms



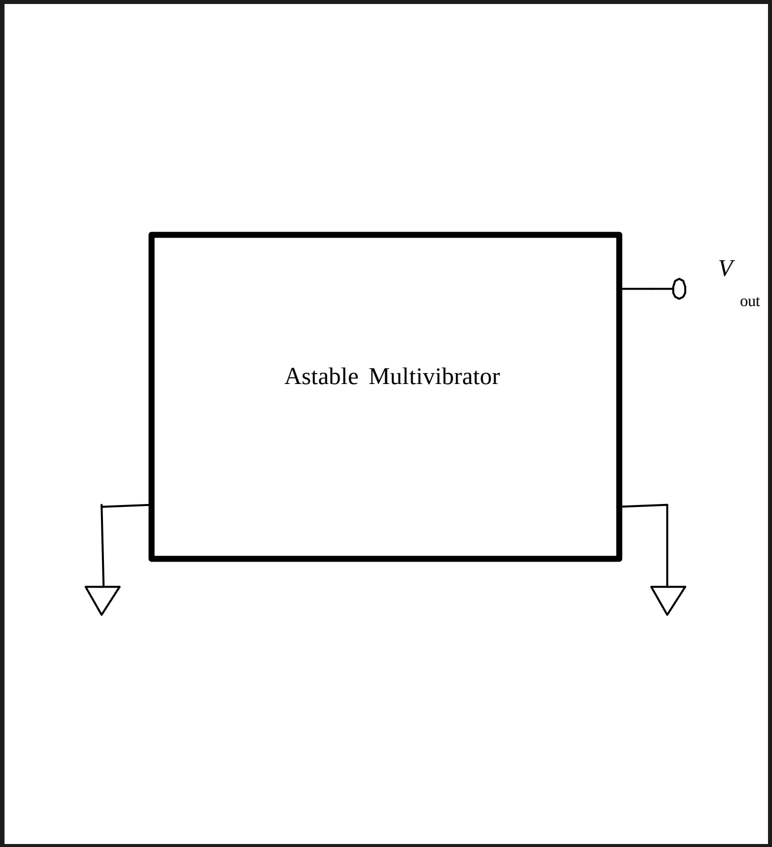

***A dc source can be used to generate all the above shapes***

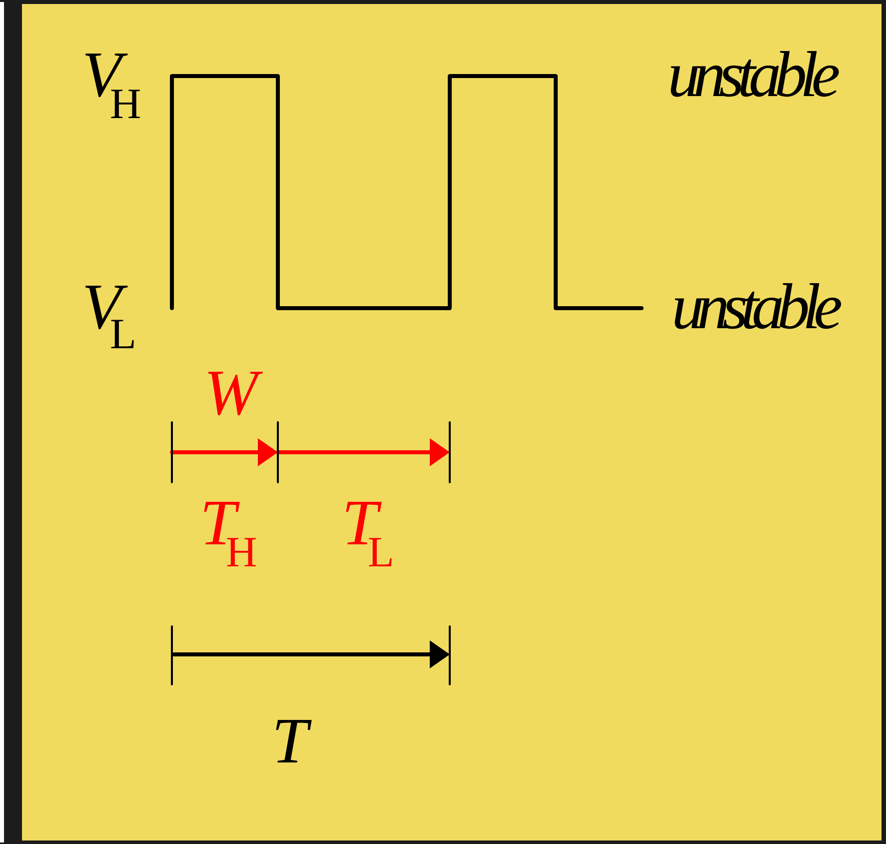
# Multivibrators

Pulse generators

| Types | Characteristics |
|---|---|
| Astable or free-running | *no stable state* |
| Monostable or one shot | *one stable state* |
| Bistable | *two stable states* |

# Astable or Free-running



# Duty Cycle

Defined for rectangular waveforms

$$D = \frac{W}{T} \times 100\%$$

**Square wave has 50% duty cycle.**

**Why?**

# Duty Cycle Example 1

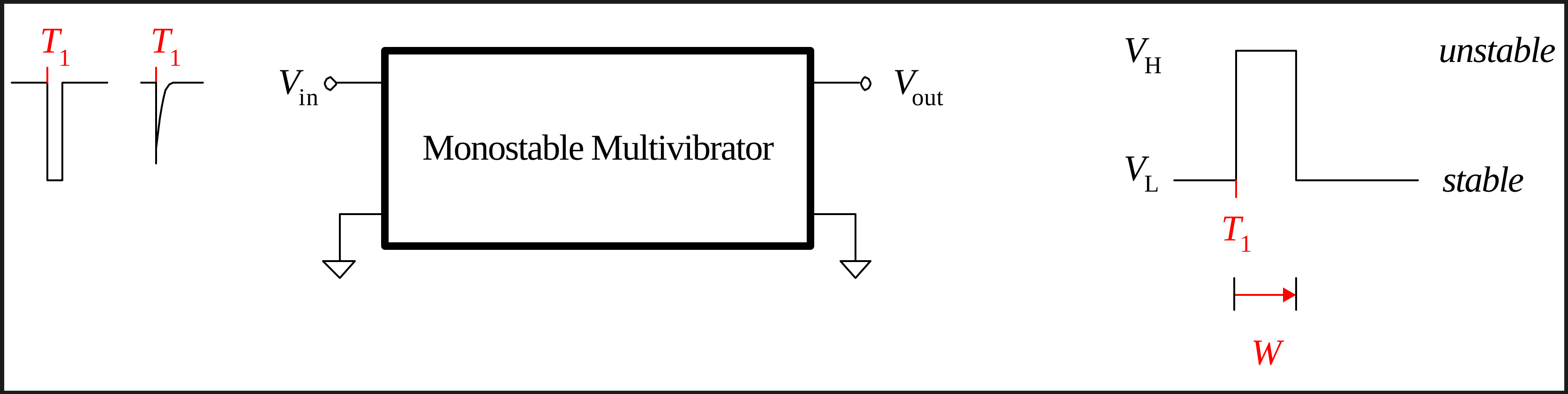
A rectangular signal is high for 4 ms and low for 6 ms. Find the signal's period, pulse width, duty cycle, and frequency.

# Duty Cycle Example 2

A rectangular waveform has a frequency of 1k Hz and a duty cycle of 60%. Find the signal's repetition rate, period, and pulse width.

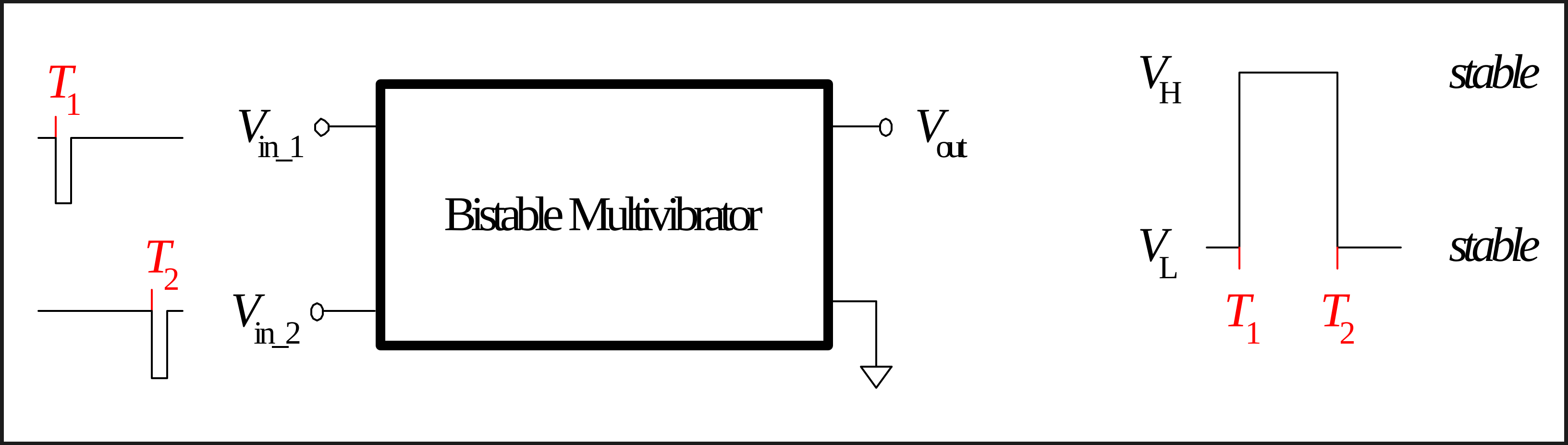
# Monostable Operation

The **monostable multivibrator produces a well-defined pulse out for an input signal that may not be well defined (a narrow pulse or a spike)**

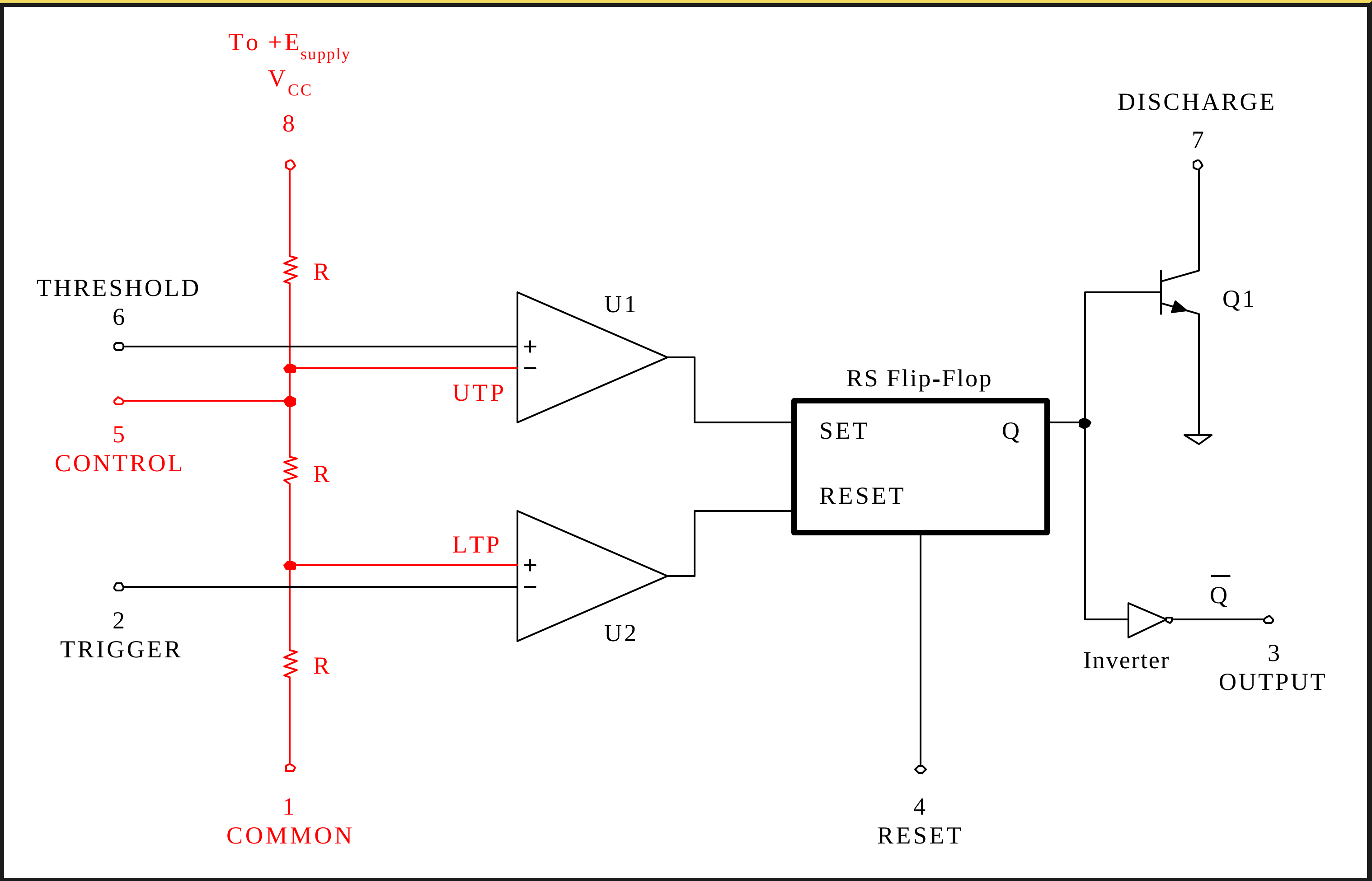


# Bistable Operation

The **bistable multivibrator has two stable states and utilizes one input pulse to take the output high and another input pulse to take the output low.**



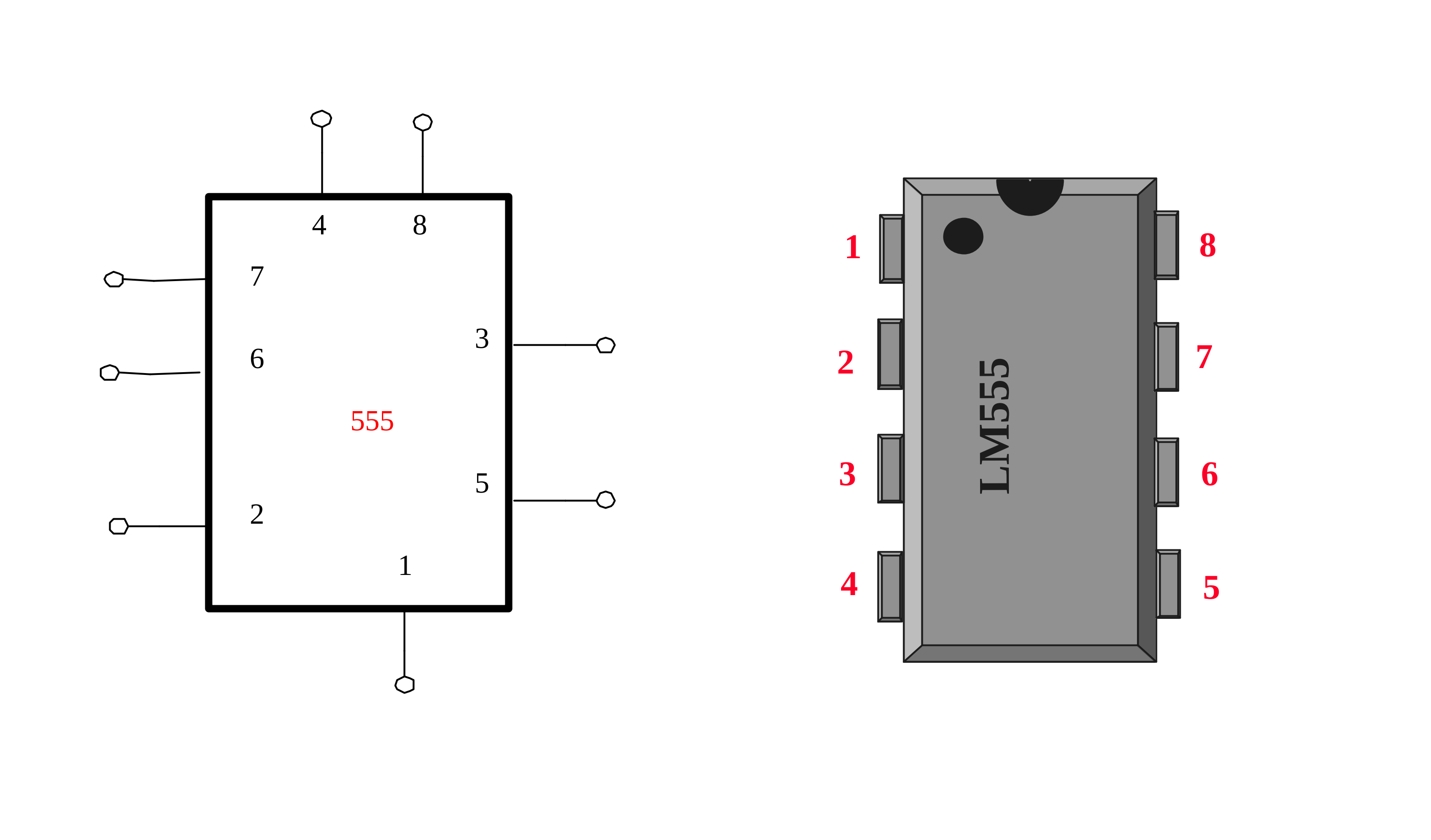
# 555 Timer IC - Schematic



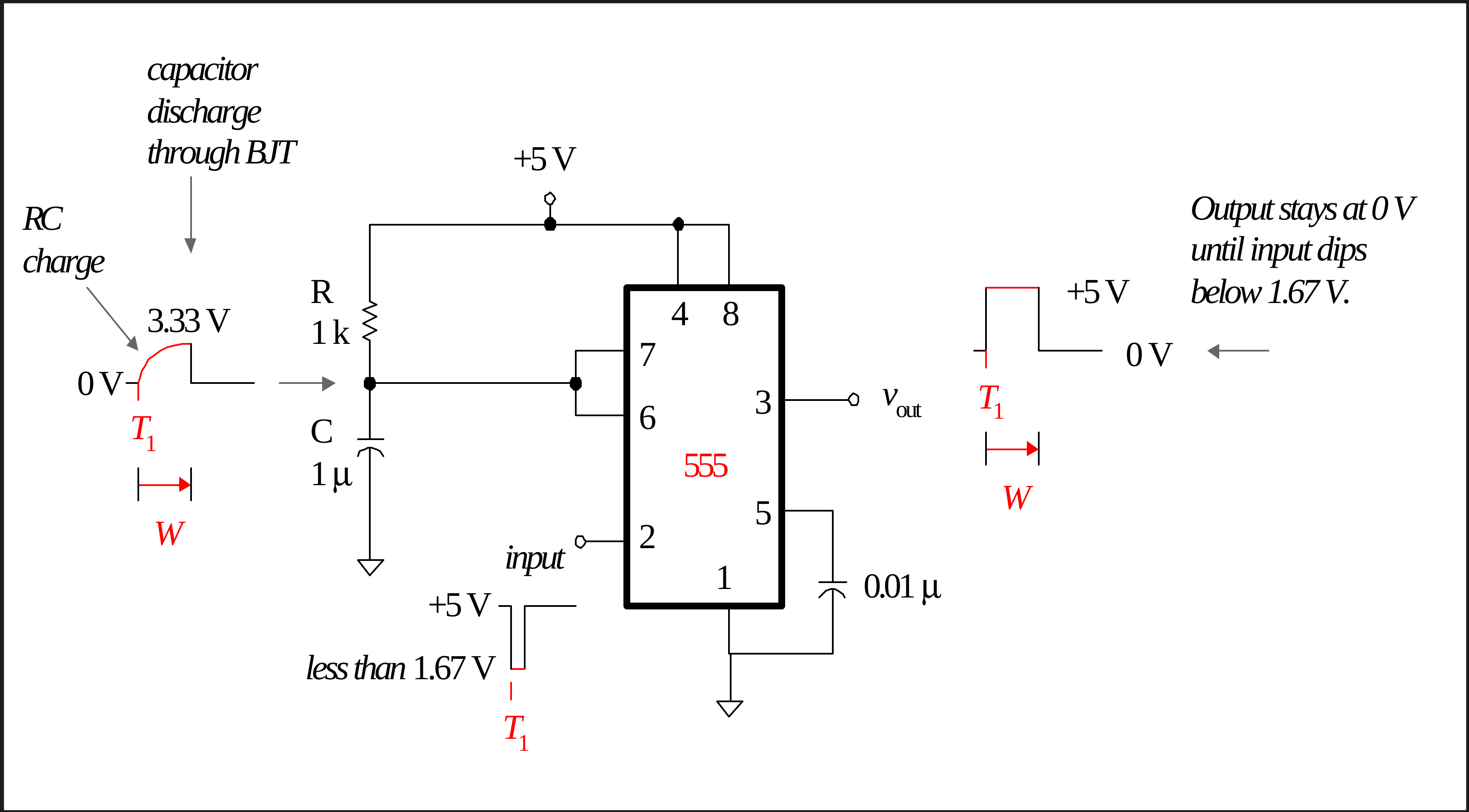
# 555 Timer IC - Features

- Q FF output–high or low output
- $\overline{Q}$ Complement (opposite) of Q–low or high output
- SET FF input–high signal *sets* high and low
- RESET FF input–high signal in *resets* low and high
- U1 Noninverting comparator driving the FF *set input*
- U2 Inverting comparator driving the FF *reset input*
- UTP Upper trip point for U1 set by 2R/3R of $E_{supply}$
- LTP Lower trip point for U2 set by R/3R of $E_{supply}$
- Q1 BJT used to discharge external capacitor when Q high
- Pin 7 Open or tied to common through BJT switched on

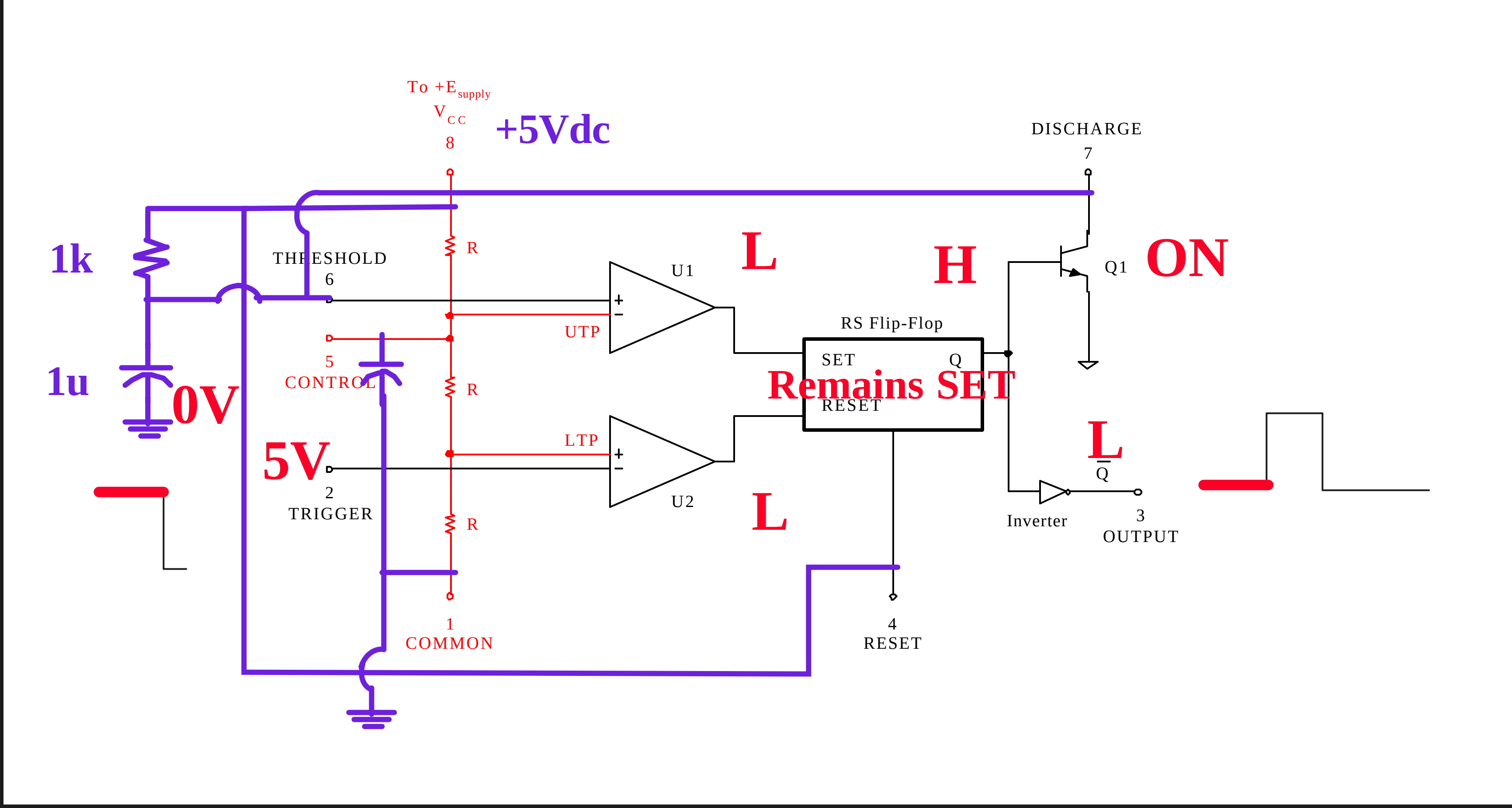
# 555 Timer - Symbol & Chip



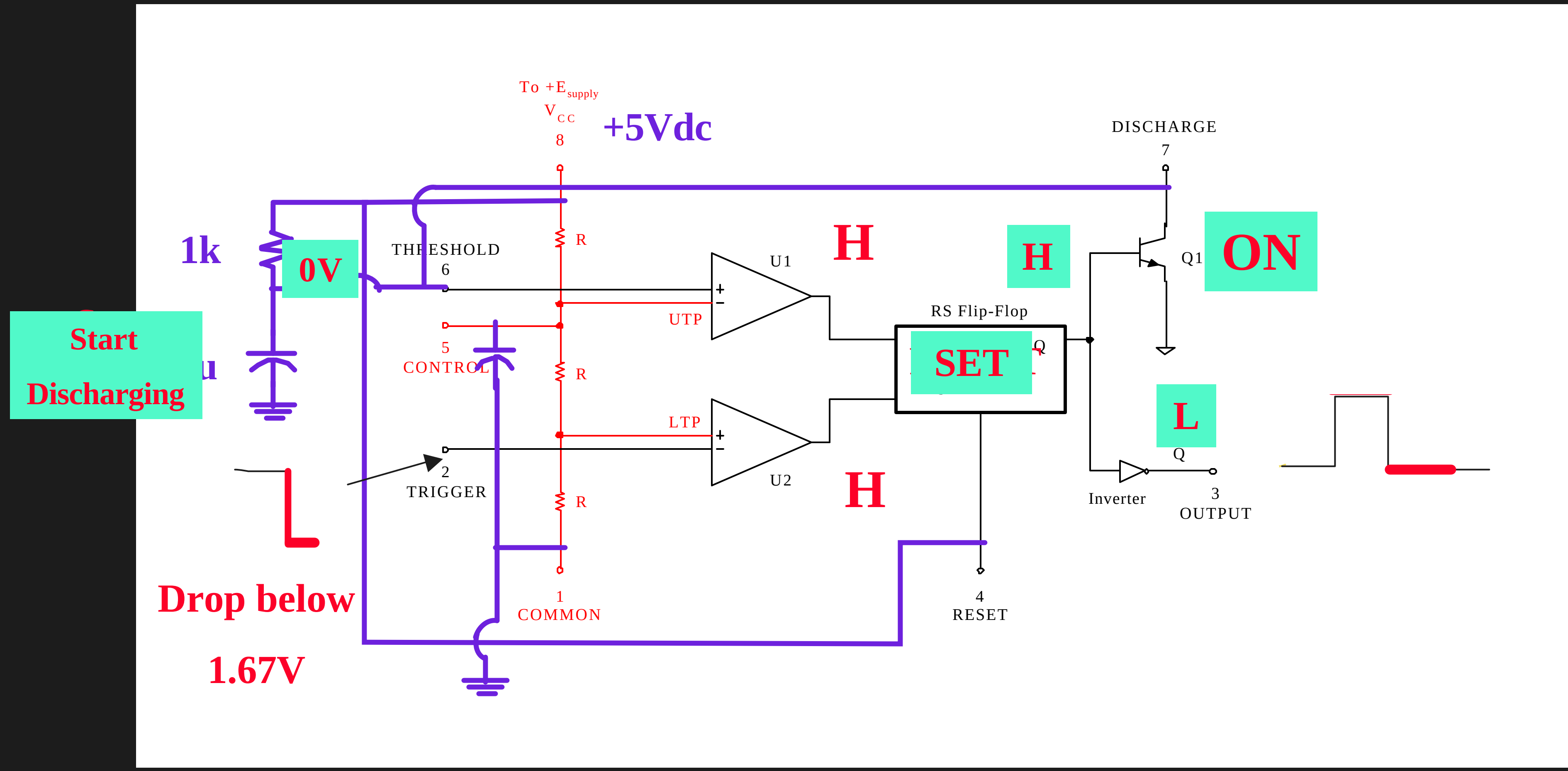
# 555 Timer – Monostable Connection



# 555 Timer – Monostable Operation



# 555 Timer – Monostable Operation



# Monostable Pulse Width Calculation

The pulse width *W* is the time required to charge the capacitor; therefore,

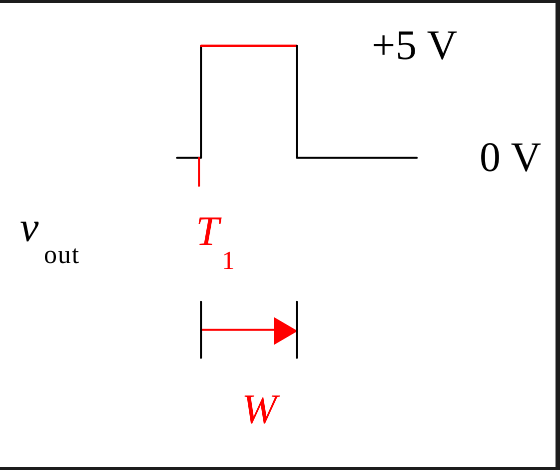
$$\tau = RC = 1\ \text{k}\Omega \times 1\ \mu\text{F} = 1\ \text{ms}$$

$$v_C(t) = 5\ \text{V} + \left(0\ \text{V} - 5\ \text{V}\right)\text{e}^{-t/t}$$

$$v_C(t) = 5\ \text{V} - 5\ \text{V}\ \text{e}^{-t/1\ \text{ms}}$$

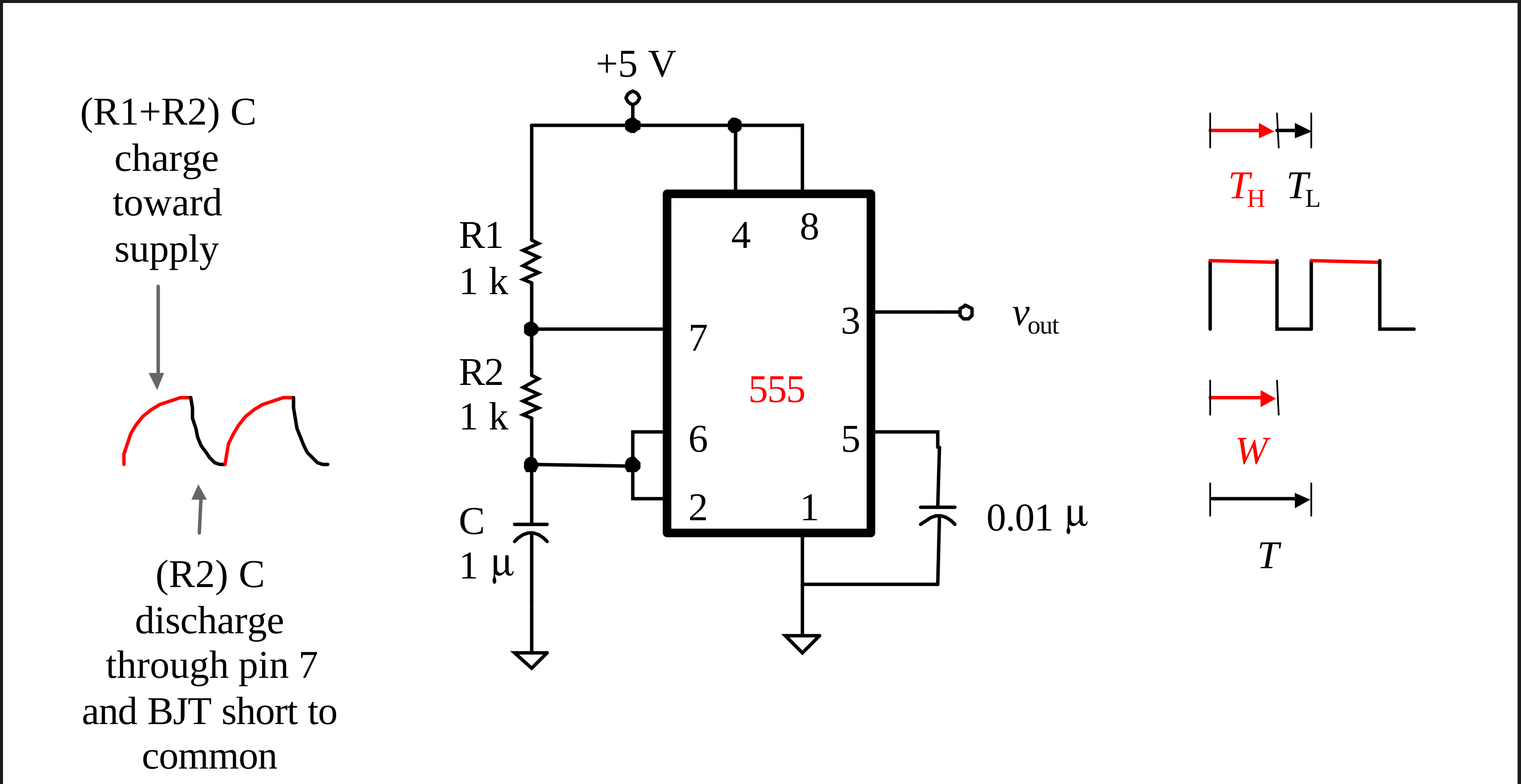
$$3.33\ \text{V} = 5\ \text{V} - 5\ \text{V}\ \text{e}^{-t/1\ \text{ms}}$$

$$t = 1.10\ \text{ms}$$

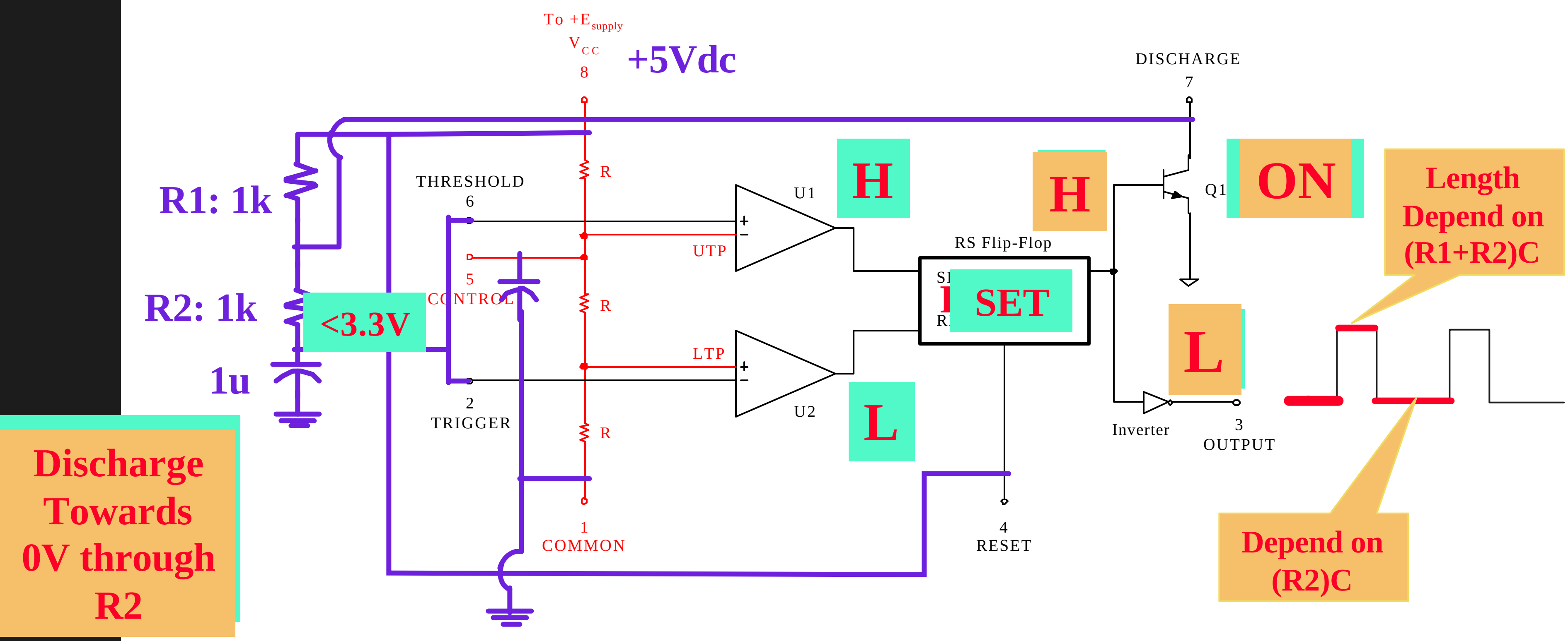



$$W = 1.10\ \text{ms}$$

# 555 Timer – Astable Connection



# 555 Timer – Astable Operation



# Astable Pulse Width Calculation

The pulse width *W* depends upon the (R1 + R2) C time constant $\tau_H$ and the capacitor charging from 1.67 V to 3.33 V while the output is in the high (or 5 V) state. The capacitor must follow the universal dc transient expression

$$v_C(t) = V_{ss} + (V_{init} - V_{ss})\ e^{-t/t}$$

$$t = (R1 + R2)\,C = 2\ k\Omega \times 1\ \mu F = 2\ ms$$

$$v_C(t) = 5\ V + (1.67\ V - 5\ V)\ e^{-t/2\ ms}$$

$$v_C(t) = 5\ V - 3.33\ V\ e^{-t/2\ ms}$$

# Astable Pulse Width Calculation

The capacitor charges to 3.33 V (or 2/3 of $V_{CC}$) when it transitions back to its stable state. Set the capacitor voltage expression equal to 3.33 V and solve the expression inversely for the time *t* required to charge the capacitor to 3.33 V.

$$3.33\ \mathrm{V} = 5\ \mathrm{V} - 3.33\ \mathrm{V}\ e^{-t/2\ \mathrm{ms}}$$

$$t = 1.386\ \mathrm{ms}$$

# Astable Pulse Width Calculation

The pulse width $W$ is the time required to charge the capacitor, so

$$W = 1.386 \text{ ms}$$

# Astable Pulse Space Calculation

- The time $T_L$ of the pulse depends upon the (R2) C time constant $\tau_L$ and discharging the capacitor from 3.33 V to 1.67 V while the output is in the low (0 V) state. The capacitor must follow the universal dc transient expression

# Astable Pulse Space Calculation

$$\tau_L = (R2)C = 1\ \text{k}\Omega \times 1\ \mu\text{F} = 1\ \text{ms}$$

The capacitor starts with a value of 3.33 V (initial value) and attempts to fall to 0 V

$$v_C(t) = 0\ \text{V} + (3.33\ \text{V} - 0\ \text{V})\ \text{e}^{-t/1\ \text{ms}}$$

$$v_C(t) = 3.33\ \text{V}\ \text{e}^{-t/1\ \text{ms}}$$

# Astable Pulse Space Calculation

- The capacitor discharges to 1.67 V (or 1/3 of $V_{CC}$), when it transitions back to its stable state. Set the capacitor voltage expression equal to 1.67 V and solve the expression inversely for the time $t$ required to discharge the capacitor to 1.67 V.

$T_L = 0.693\text{ ms}$

$$1.67\text{ V} = 3.33\text{ V e}^{-t/1\text{ ms}} \;\Rightarrow\; t = 0.693\text{ ms}$$

$$T_L = 0.693\text{ ms}$$

# Astable Pulse Space Calculation

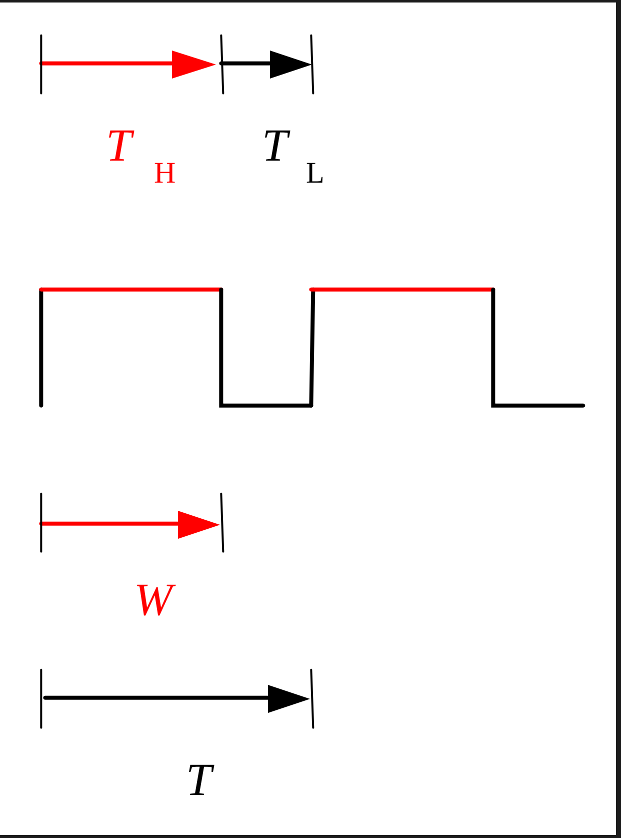
T = TH + TL

T = 1.386ms +0.693 ms

T = 2.079 ms

$f$ = 1/T

$f$ = 481 Hz



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