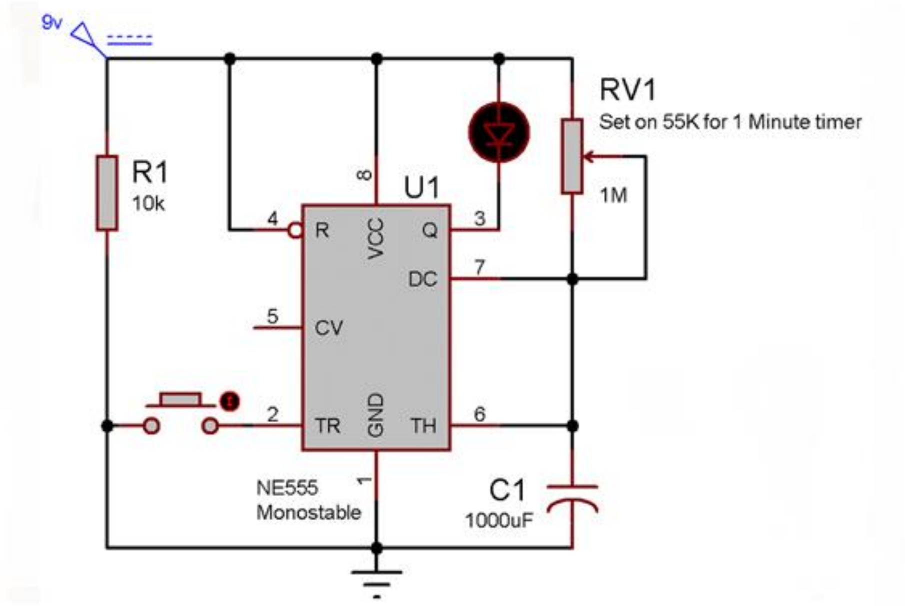
Multivibrators, Timer Circuit and Schmitt Trigger

EEE 203: Electronic Devices and Circuits & Pulse Techniques



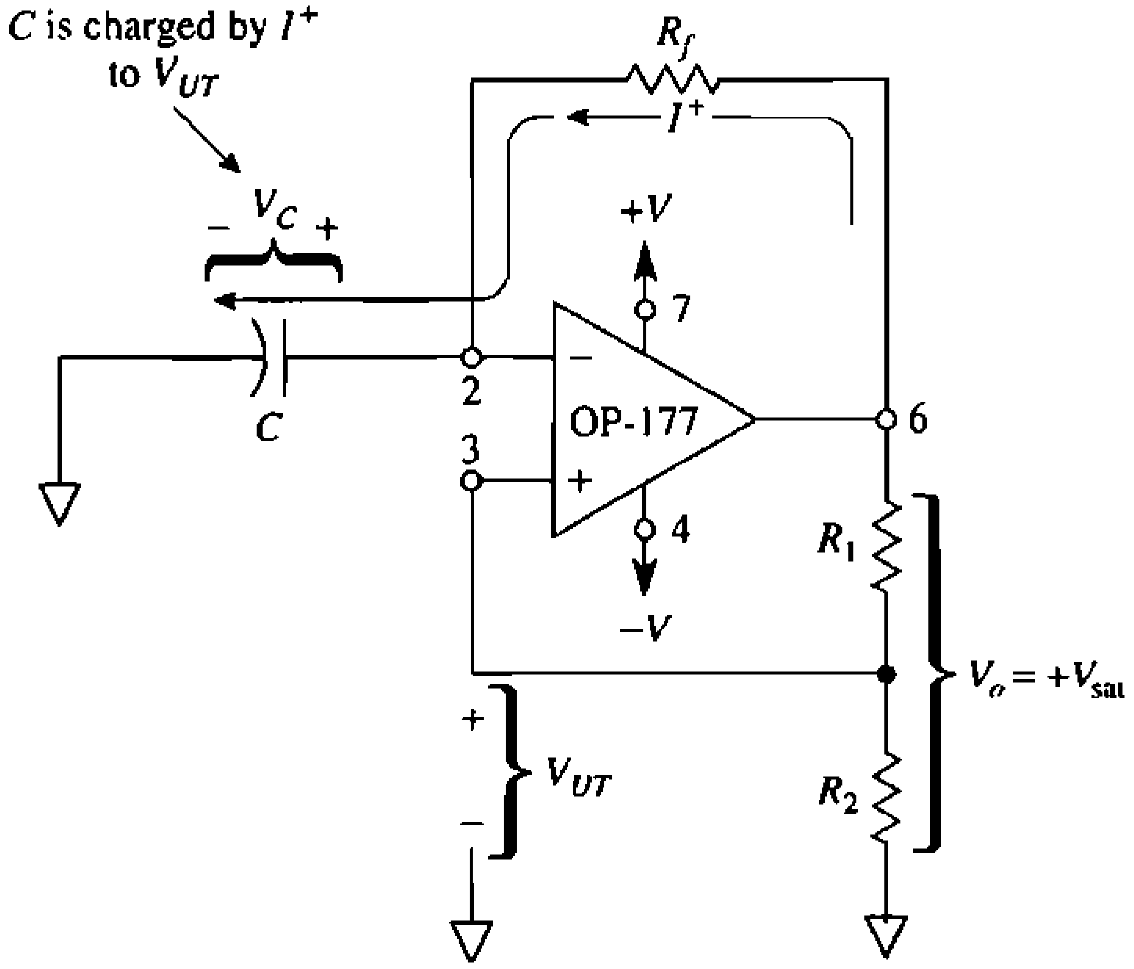
Md. Istiac Ahmed
Lecturer, Dept. of EEE
Green University of Bangladesh

Multivibrators

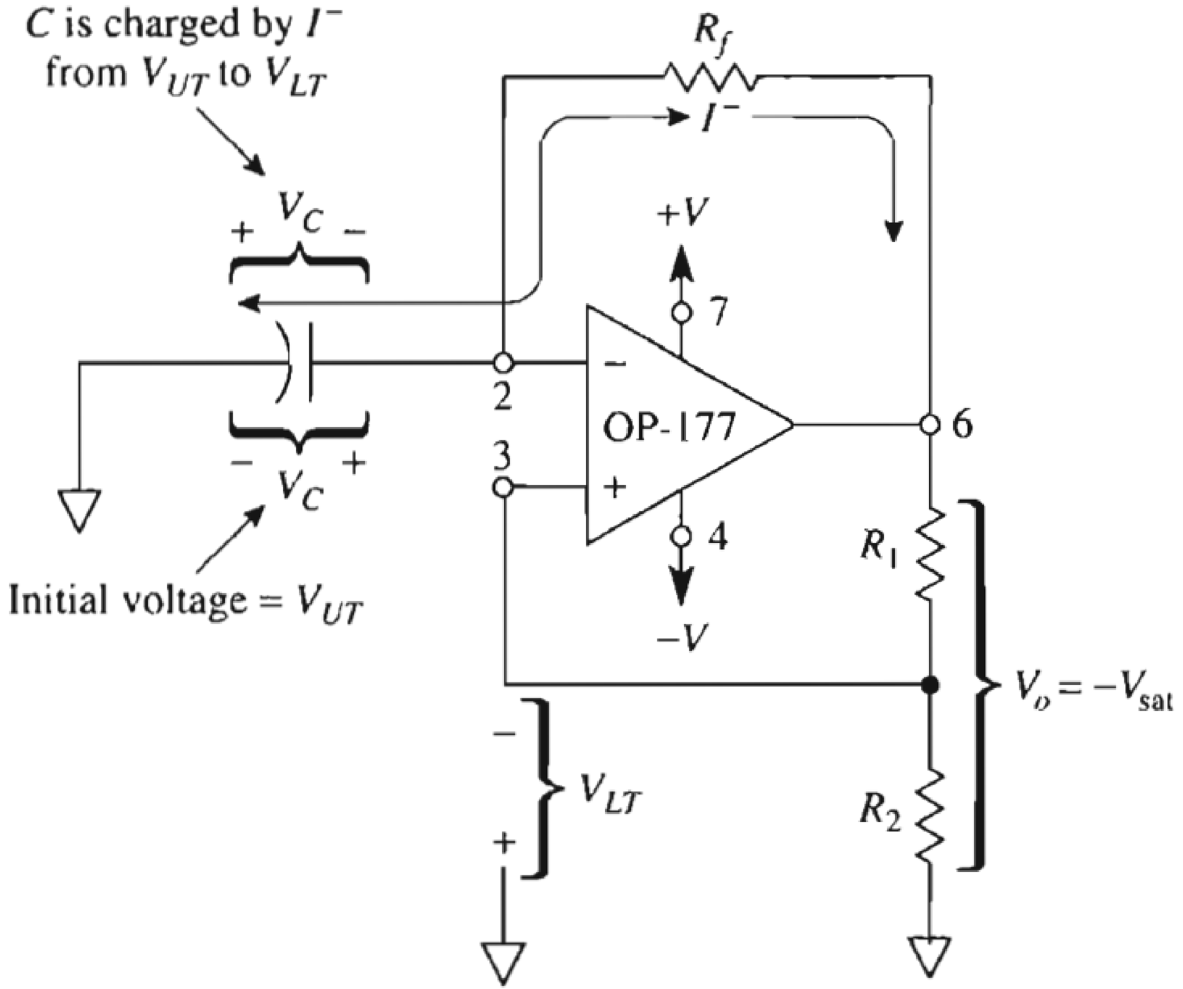
Using Op-Amps

Md. Istiac Ahmed, Lecturer, EEE, GUB

Astable Multivibrator

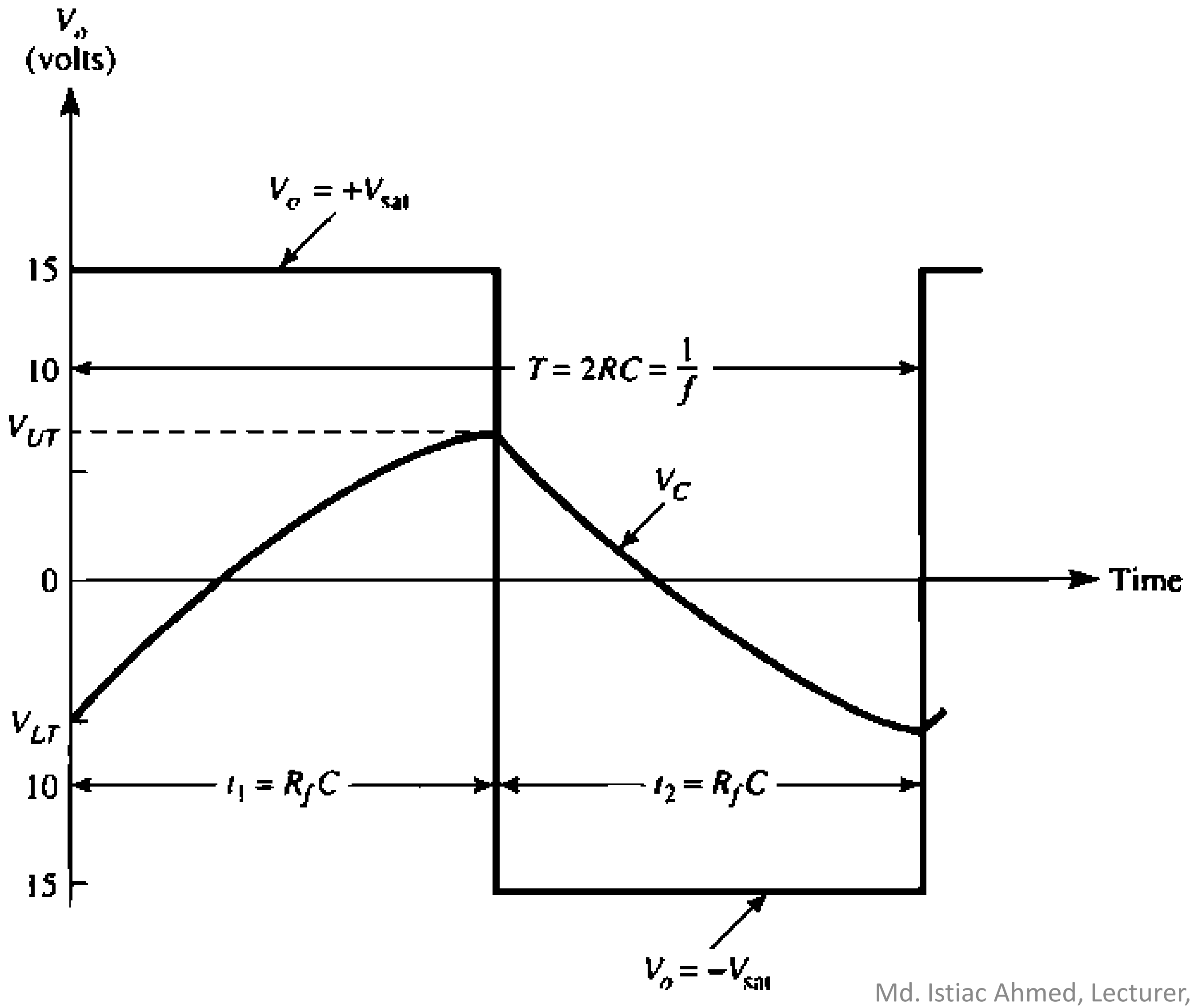


(a) When $V_o = +V_{sat}$, V_C charges toward V_{UT}.



(a) When $V_o = -V_{sat}$, V_C charges toward V_{LT}.

Astable Multivibrator



$$V_{UT} = \frac{R_2}{R_1 + R_2}(+V_{sat})$$

$$V_{LT} = \frac{R_2}{R_1 + R_2}(-V_{sat})$$

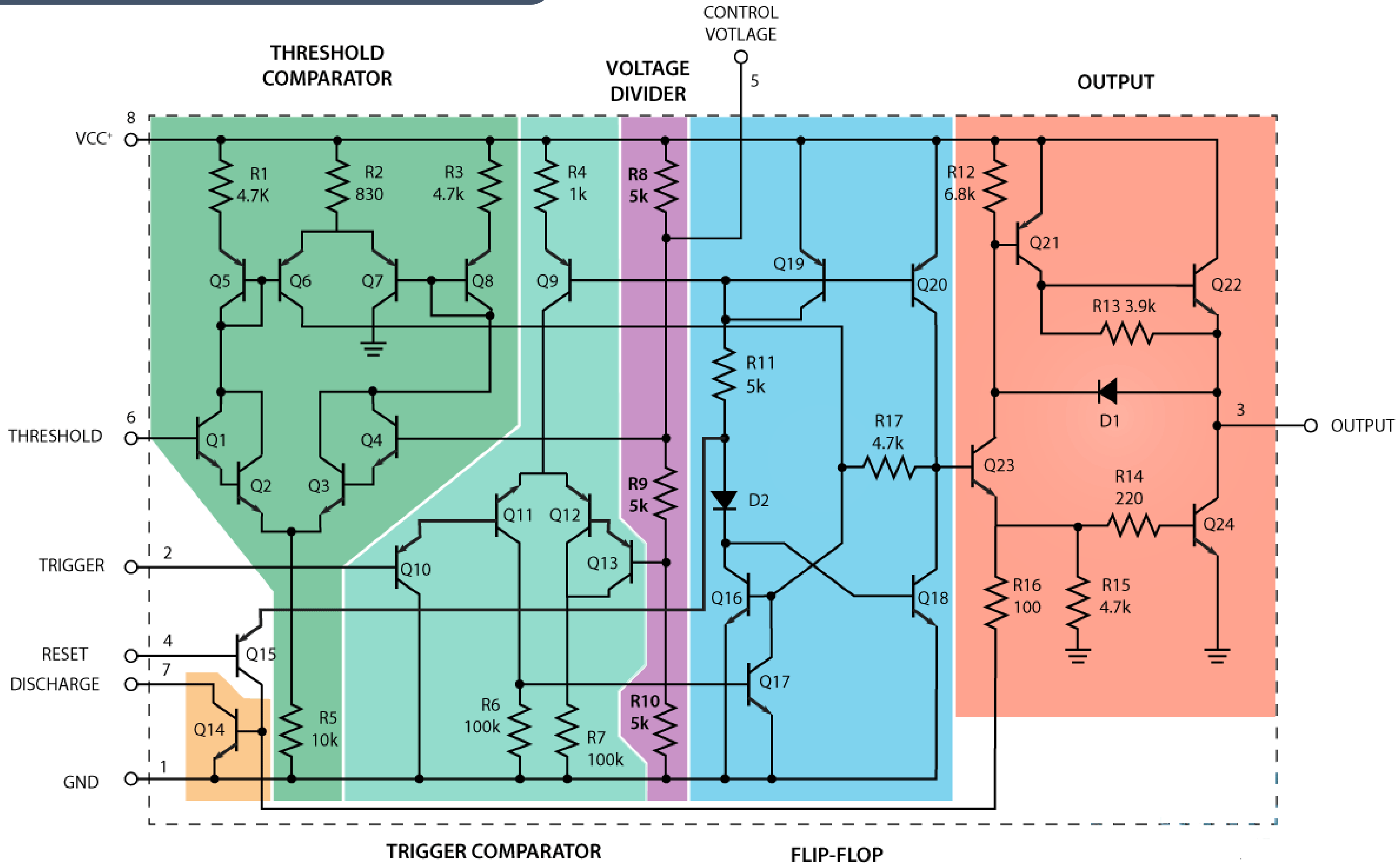
$$T = 2R_f C \ \ln\left(\frac{2R_1 + R_2}{R_2}\right)$$

**Self Study: One-shot (Monostable) Multivibrator from Ref 1.

555 Timer

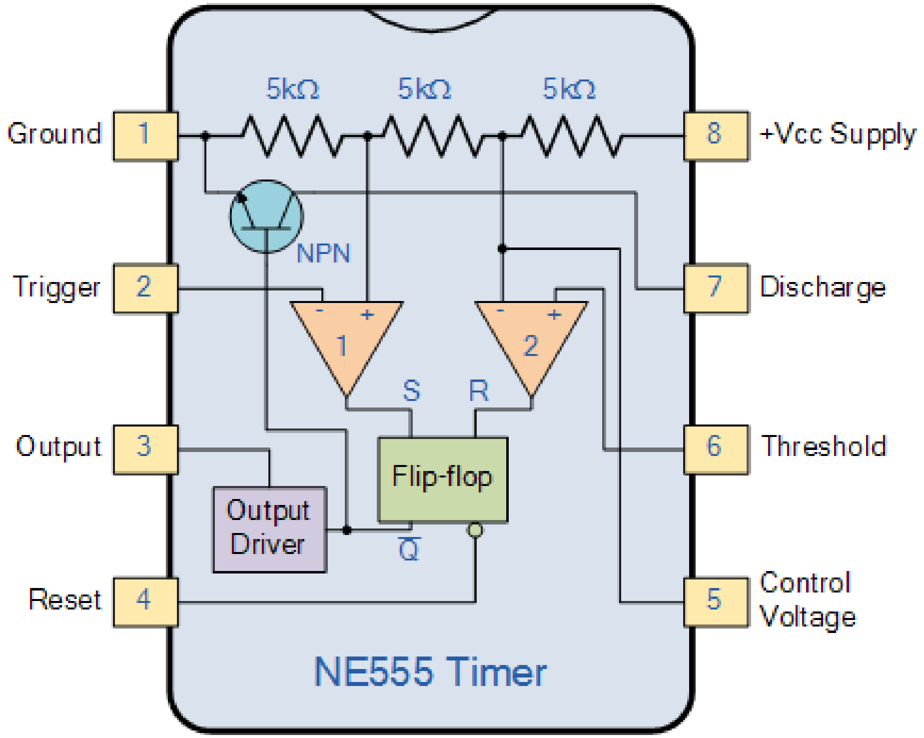
Md. Istiac Ahmed, Lecturer, EEE, GUB

Internal Diagram



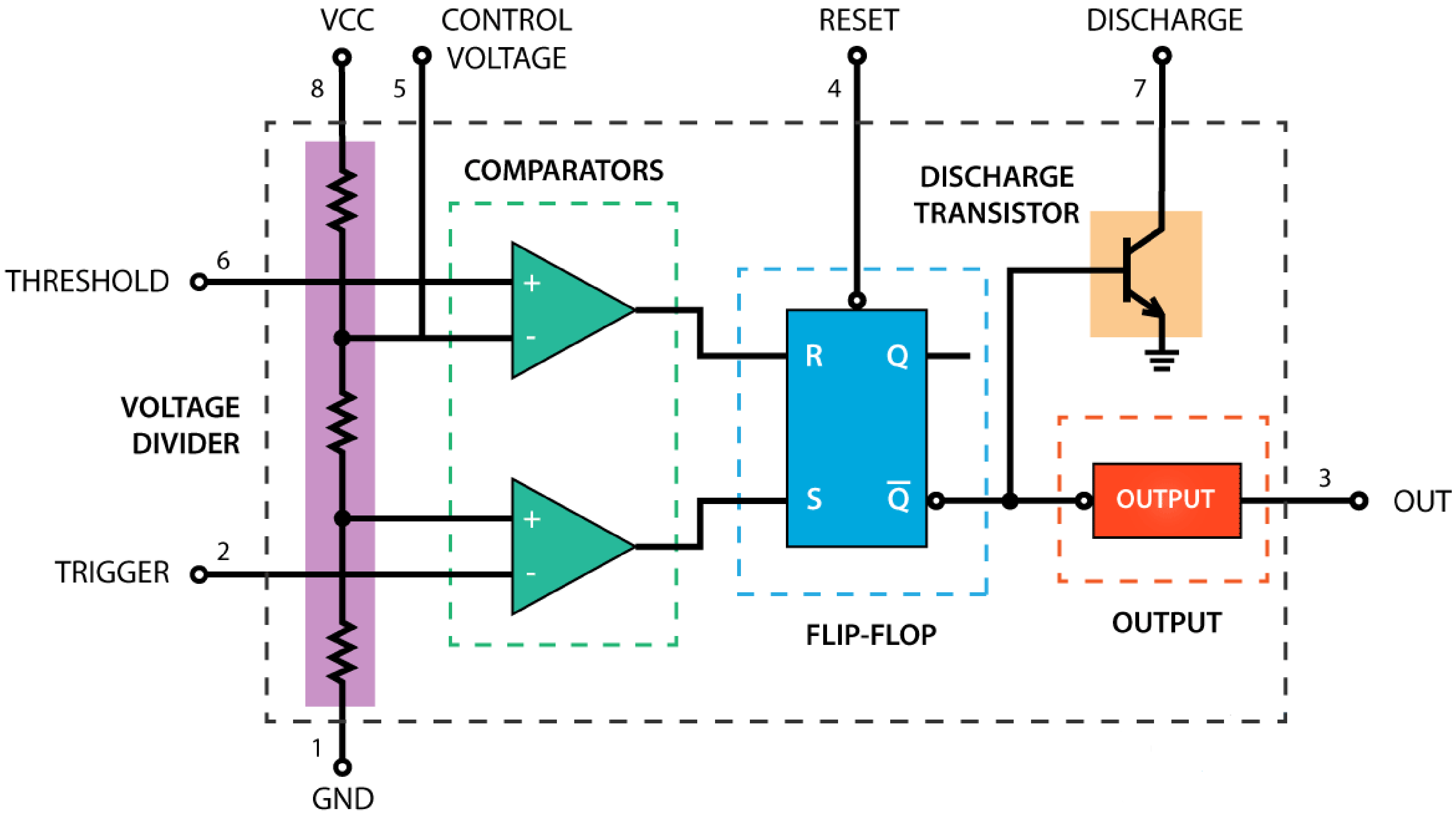
DIP Structure

There is a **voltage divider** circuit consisting of **three 5 *kΩ* resistors**. Again it has adjustable controls over the **timing** of the output signal. For these reasons, this IC is called **555 Timer.**

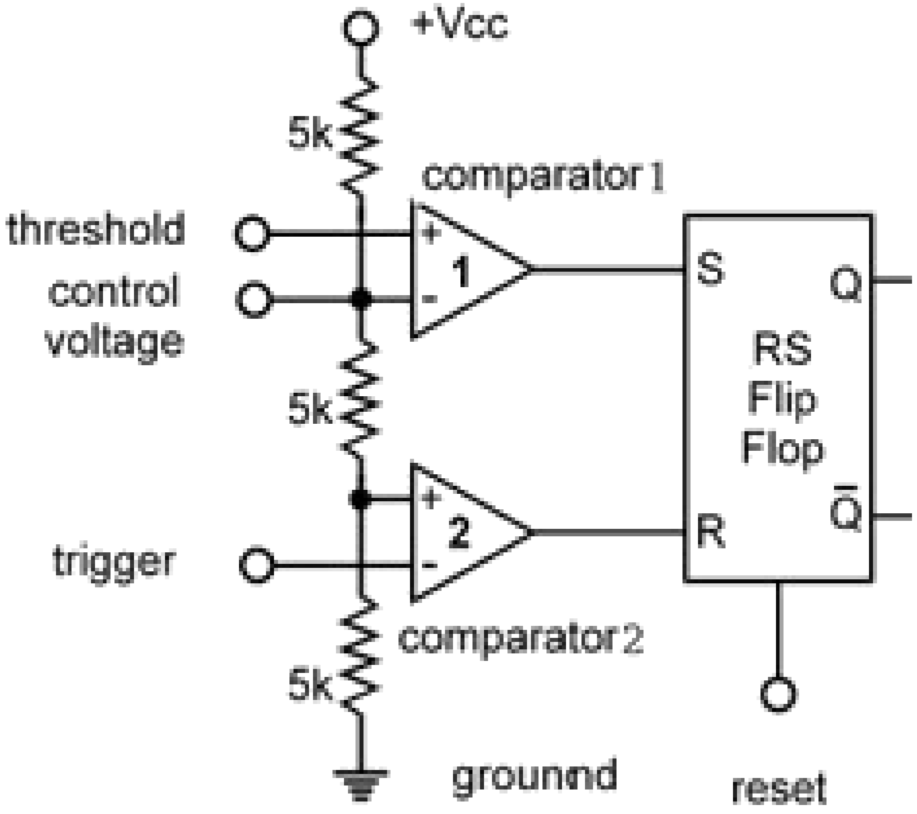


Block Diagram

1. Voltage Divider
2. Comparators
3. Flip-Flop
4. Discharge
5. Output



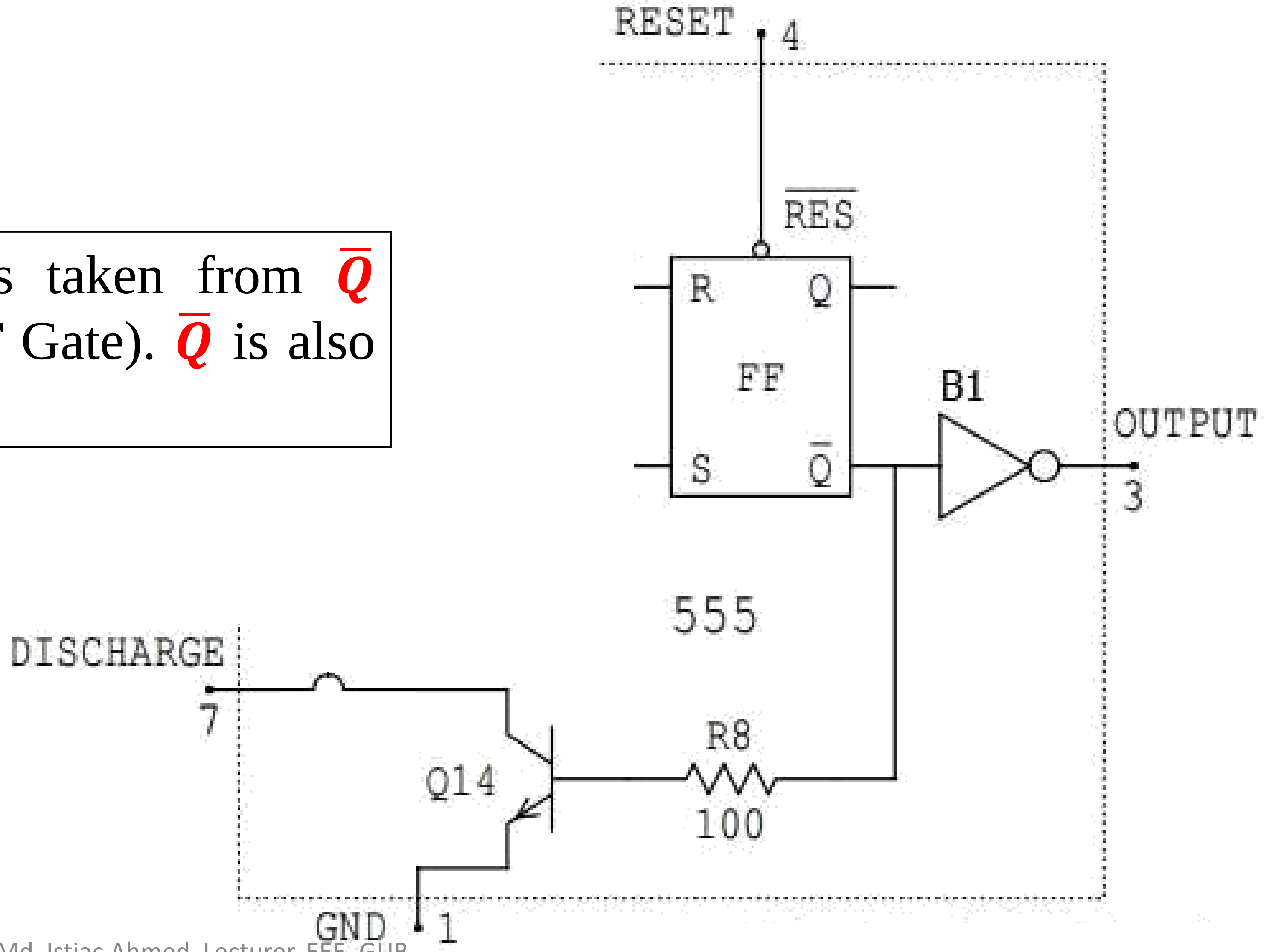
Comparator Unit



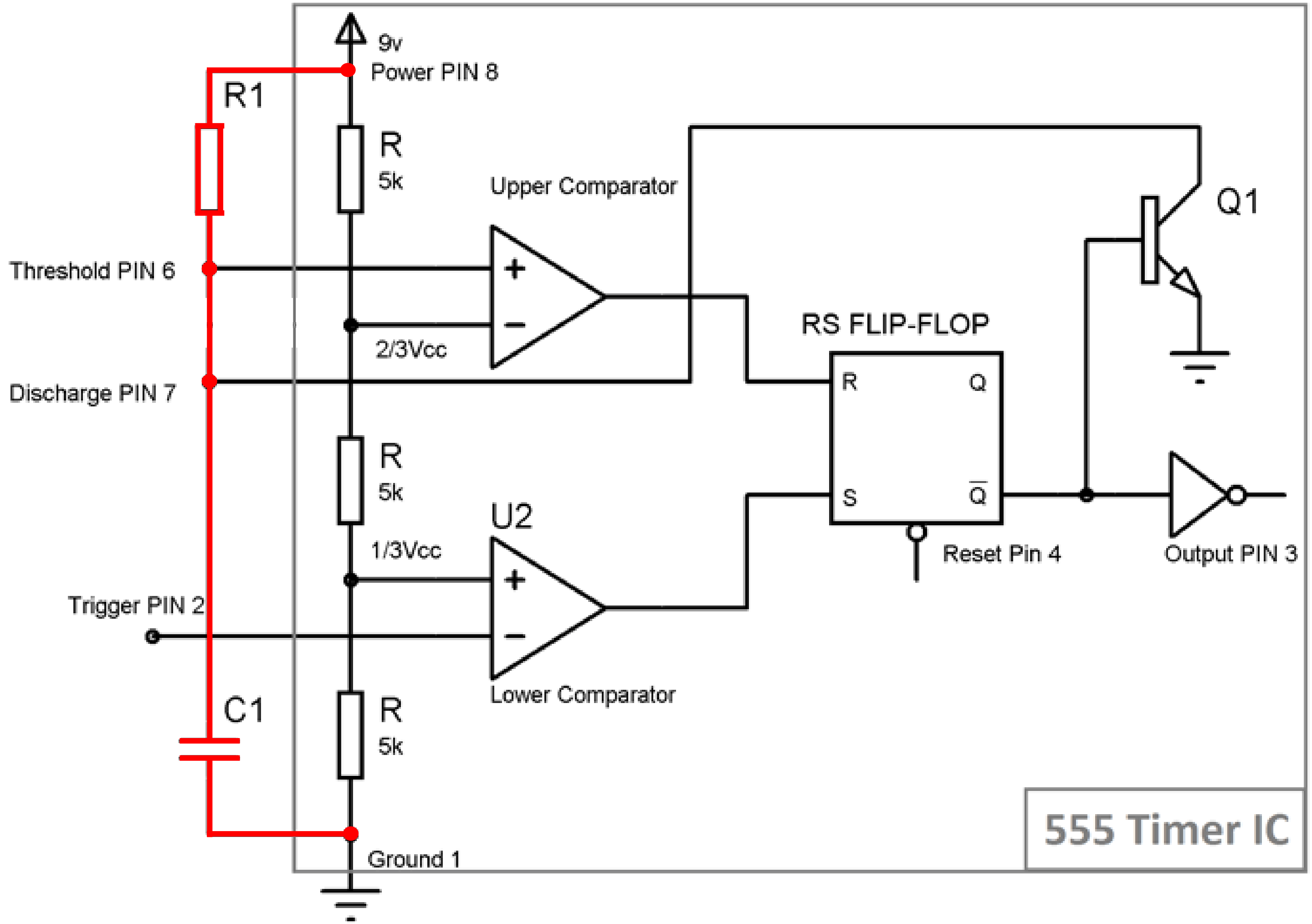
Condition		C1=S	C2=R	Q
$V_{THD} > \frac{2}{3}V_{CC}$	$V_{TRG} > \frac{1}{3}V_{CC}$	1	0	1 [SET]
	$V_{TRG} < \frac{1}{3}V_{CC}$	1	1	[INVALID]
$V_{THD} < \frac{2}{3}V_{CC}$	$V_{TRG} > \frac{1}{3}V_{CC}$	0	0	[NC]
	$V_{TRG} < \frac{1}{3}V_{CC}$	0	1	0 [RESET]

Output Unit

The output of the 555 timer is taken from $\bar{Q}$ through an inverting buffer (NOT Gate). $\bar{Q}$ is also fed to the discharge unit.

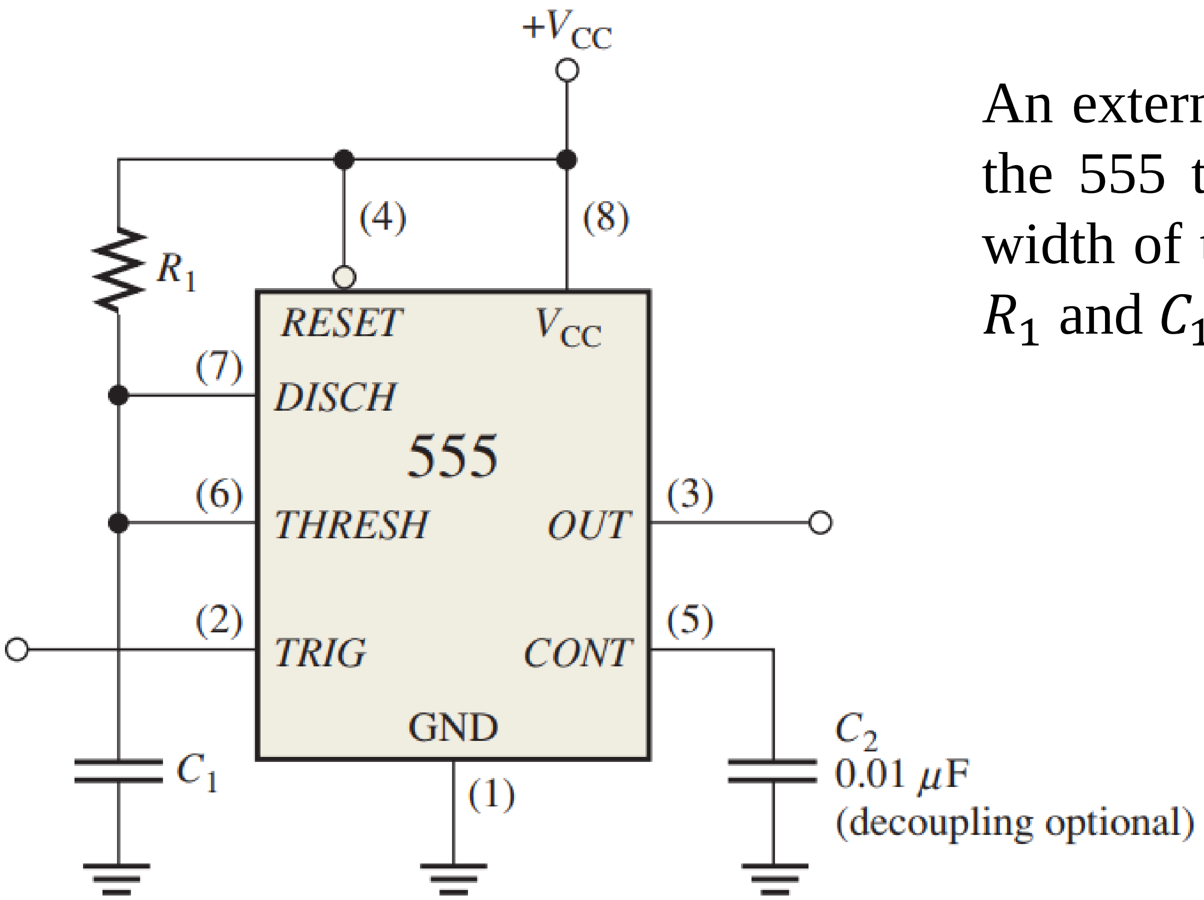


Discharge Unit



$\bar{Q}$	O/P	Q1	Capacitor Status
1	0	ON	Discharging
0	1	OFF	Charging

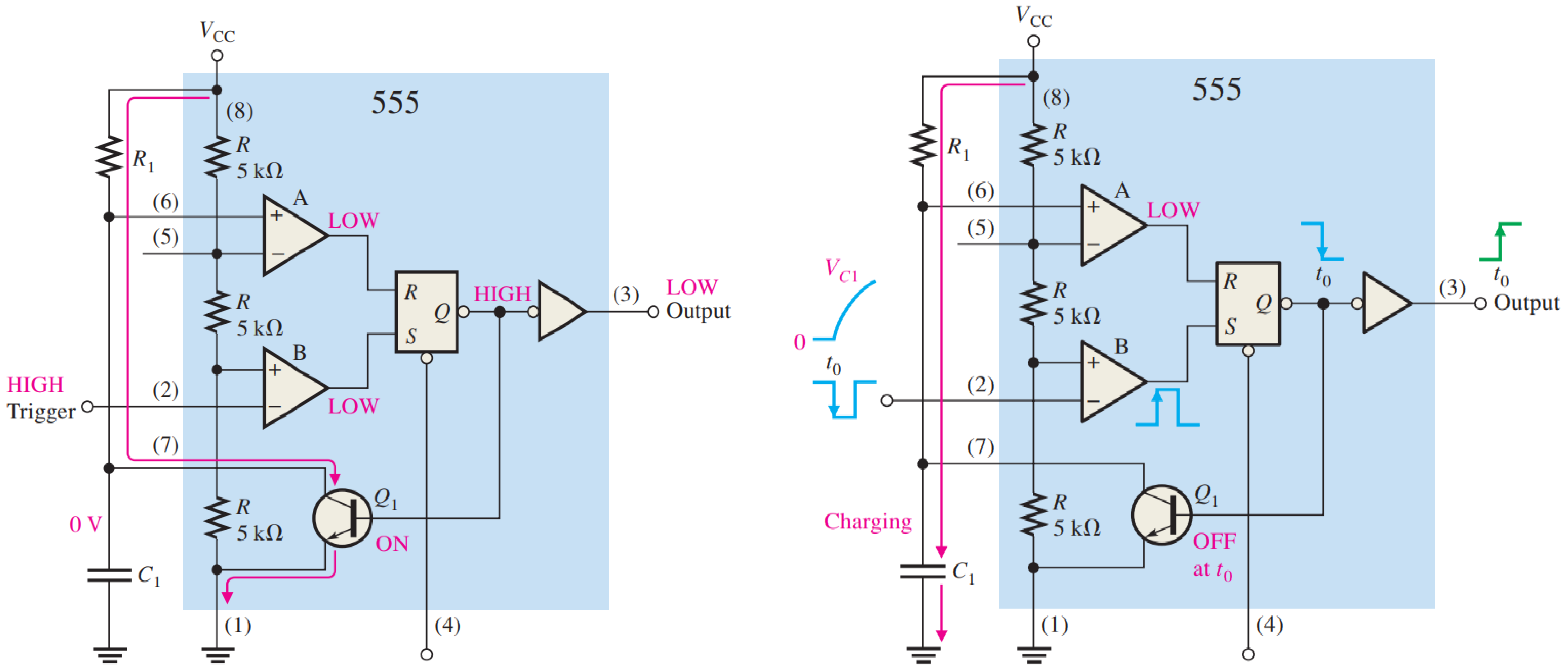
Monostable Multivibrator using 555 Timer IC



An external resistor R_1 and capacitor C_1 is used to set up the 555 timer as a monostable multivibrator. The pulse width of the output is determined by the time constant of R_1 and C_1 according to the following formula;

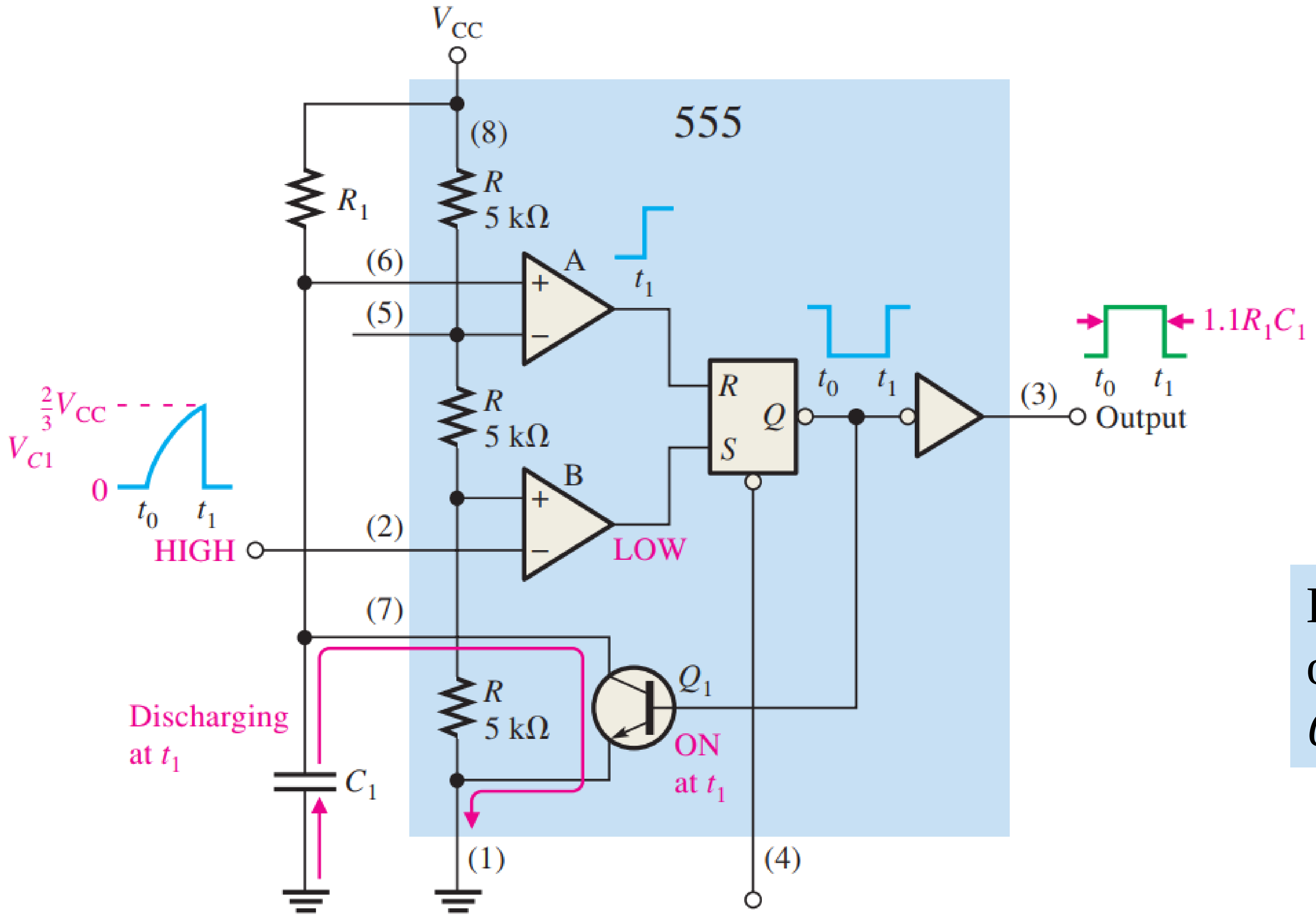
$$\boxed{t_w = 1.1 R_1 C_1}$$

Monostable Multivibrator



(a) Prior to triggering. (The current path is indicated by the red arrow.) (b) When triggered

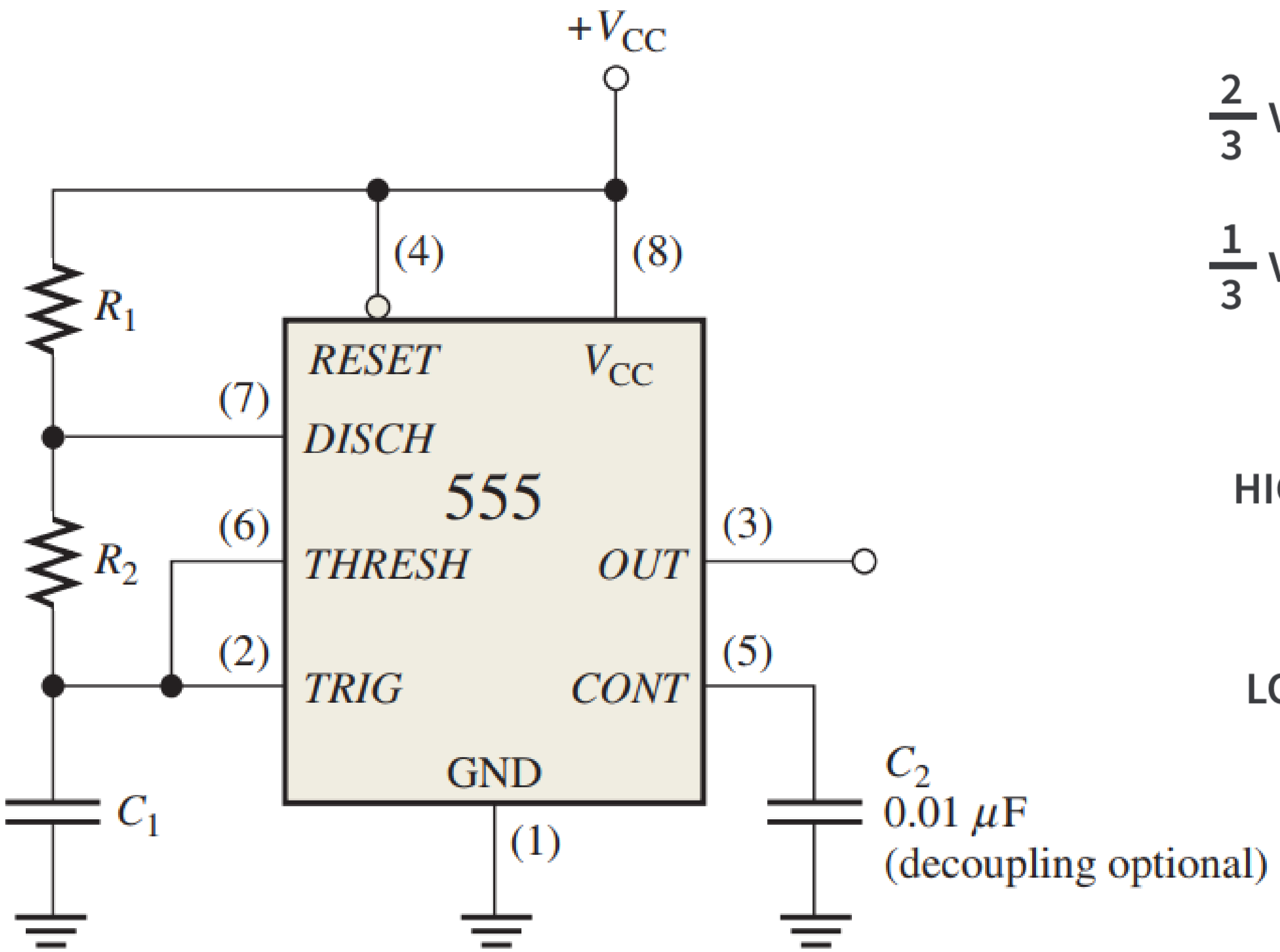
Monostable Multivibrator

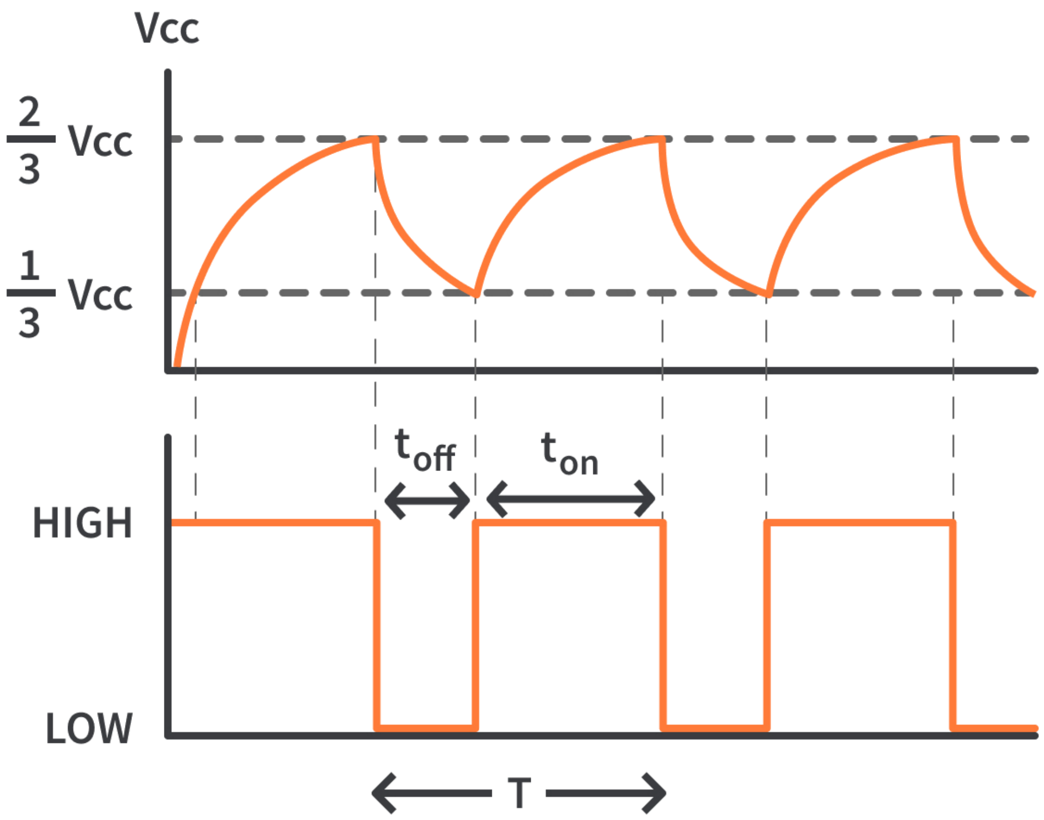


(c) At end of charging interval

Determine the pulse width of a 555 timer one-shot when $C = 1\mu F$ and $R = 10k\Omega$

Astable Multivibrator using 555 Timer IC





Astable Multivibrator

$$\text{Frequency, } \boldsymbol{f} = \frac{\mathbf{1.44}}{(\boldsymbol{R_1+2R_2})\boldsymbol{C_1}}$$

$$\text{Duty Cycle} = \left(\frac{\boldsymbol{R_1+R_2}}{\boldsymbol{R_1+2R_2}}\right) \times \mathbf{100\%}$$

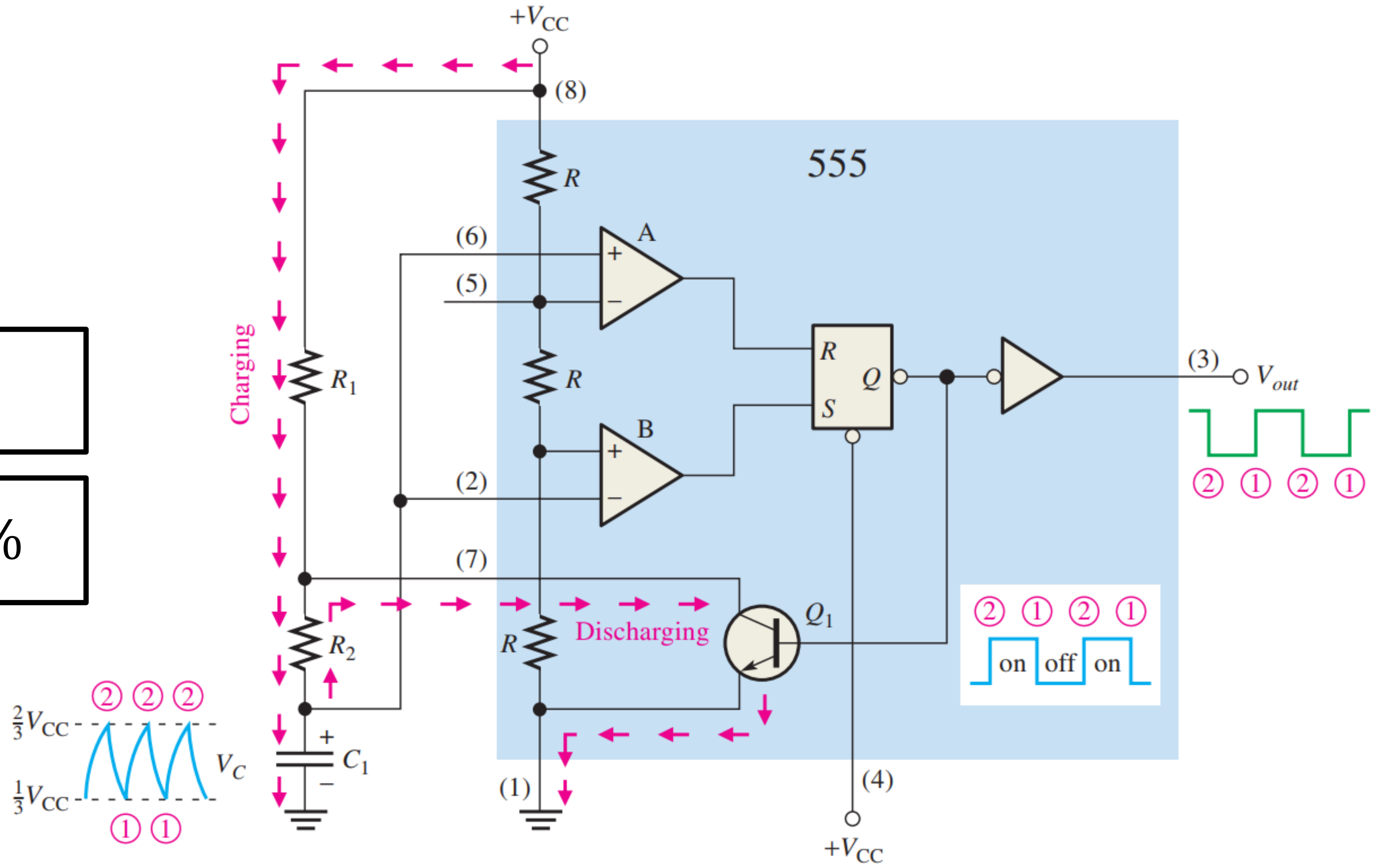


FIGURE 7–57 Operation of the 555 timer in the astable mode.

Astable Multivibrator

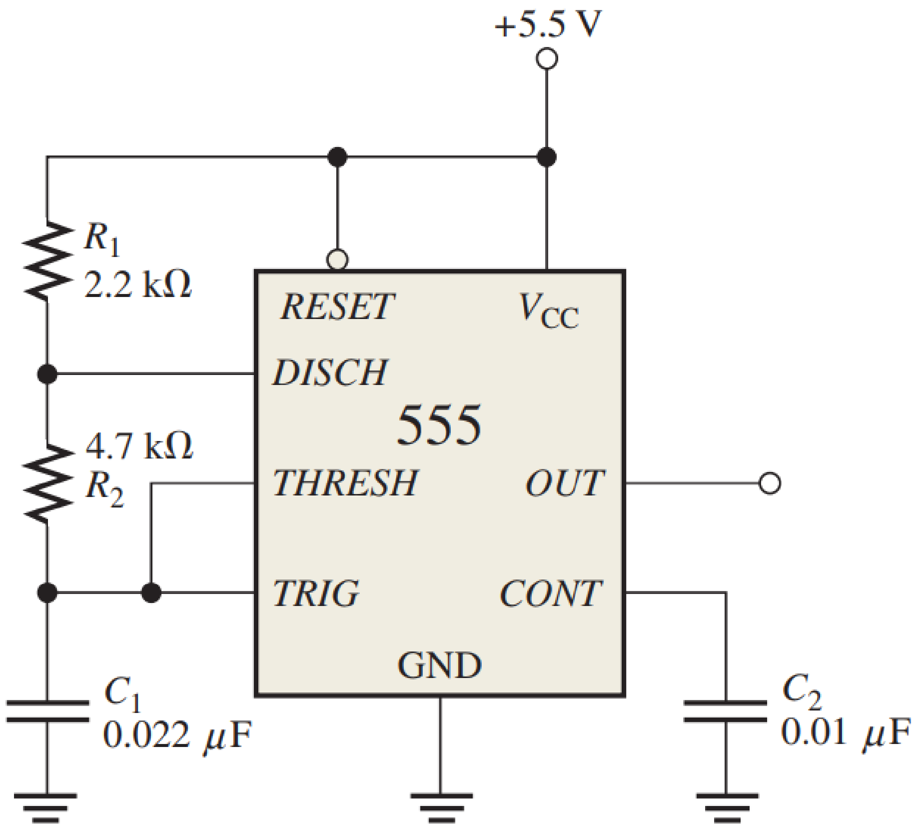
A 555 timer configured to run in the astable mode is shown. Determine the frequency of the output and the duty cycle.

$$f = \frac{1.44}{(R_1 + 2R_2)C_1} = \frac{1.44}{(2.2k\Omega + 9.4k\Omega)0.022\mu F}$$

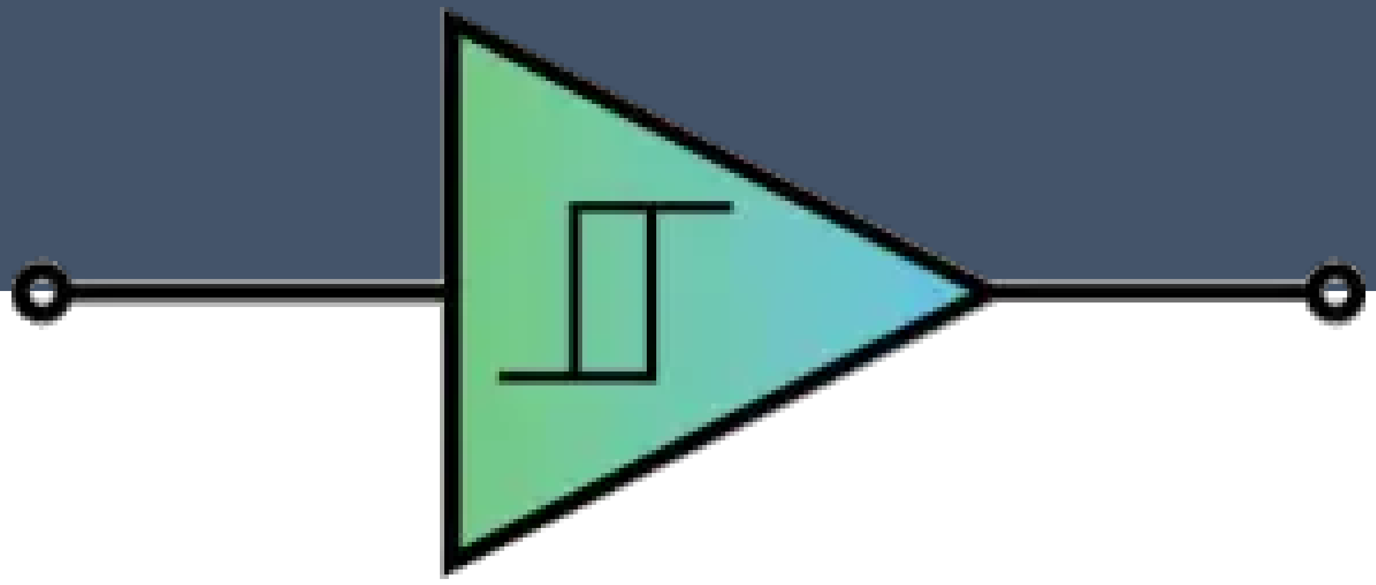
$$f = 5.64\ kHz$$

$$D.C. = \left(\frac{R_1 + R_2}{R_1 + 2R_2}\right)100\% = \left(\frac{2.2k\Omega + 4.7k\Omega}{2.2k\Omega + 9.4k\Omega}\right)100\%$$

$$Duty\ Cycle = 59.5\%$$



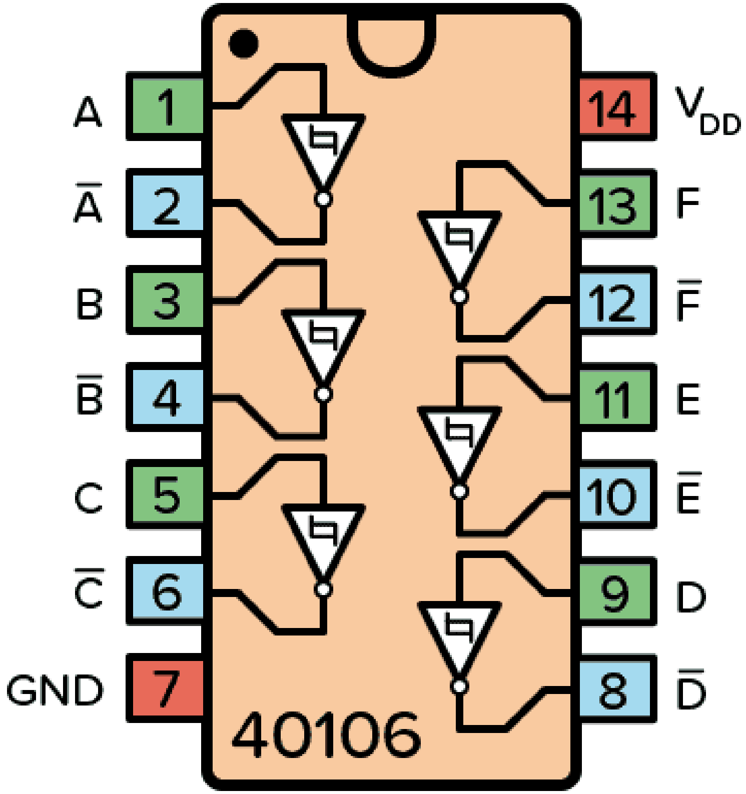
Schmitt Trigger



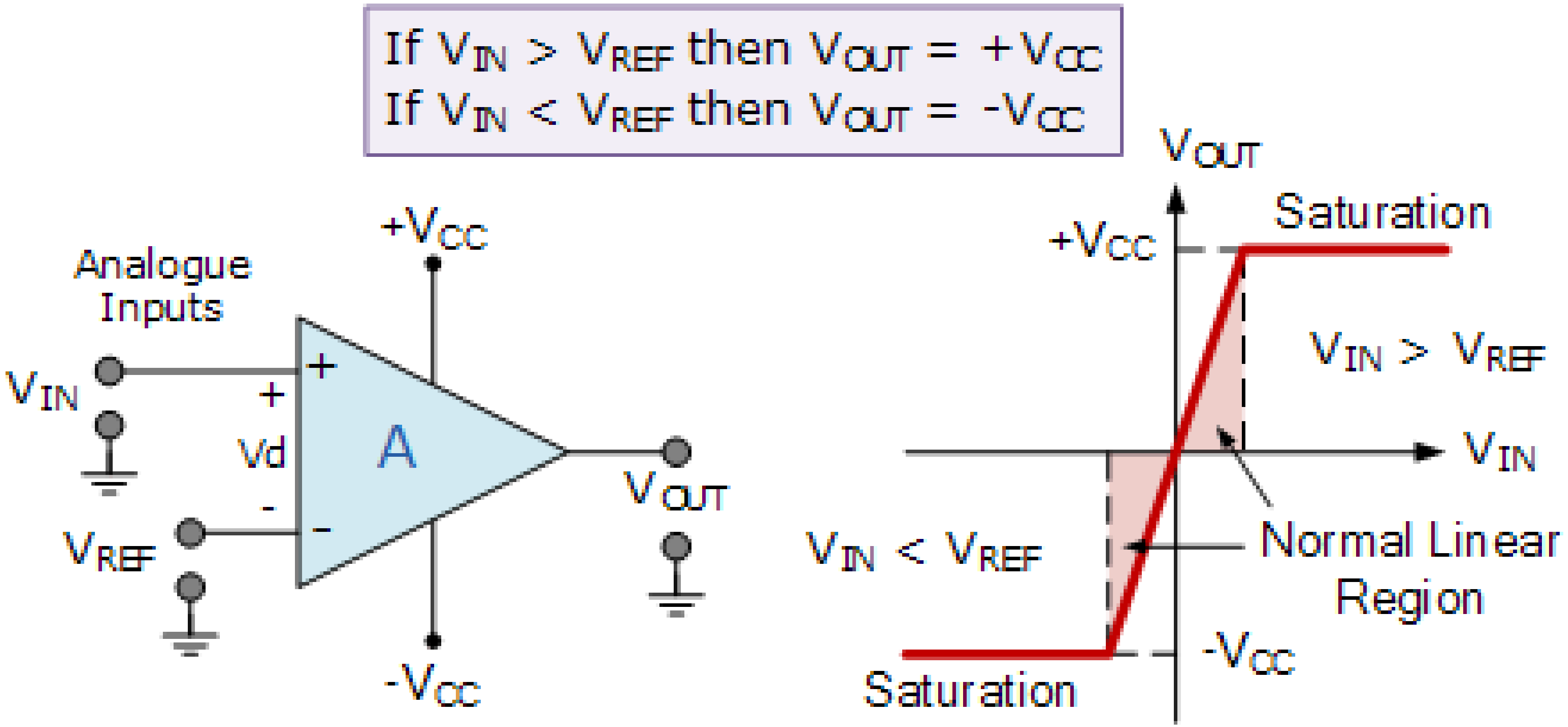
Md. Istiac Ahmed, Lecturer, EEE, GUB

Introduction

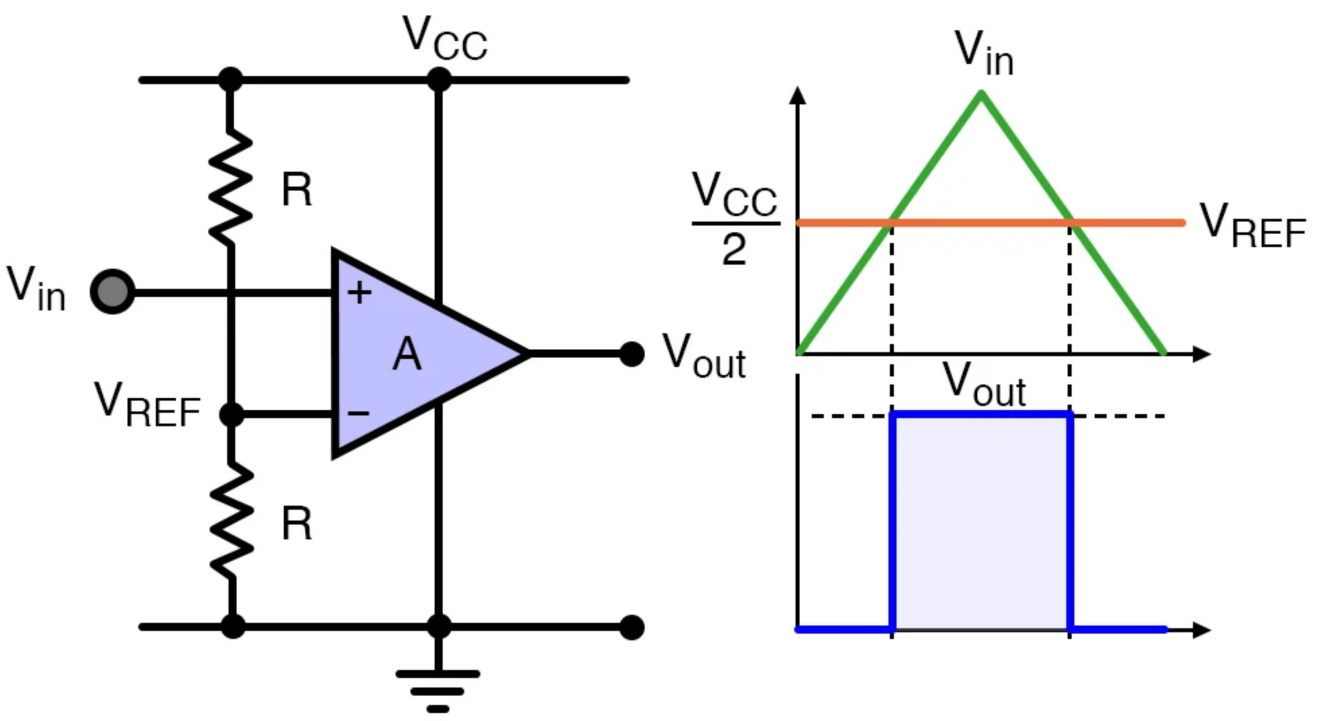
Schmitt trigger is basically a voltage comparator consisting of operational amplifier circuits. Both inverting and non-inverting comparator can be designed. Schmitt trigger eliminates the noise effect.

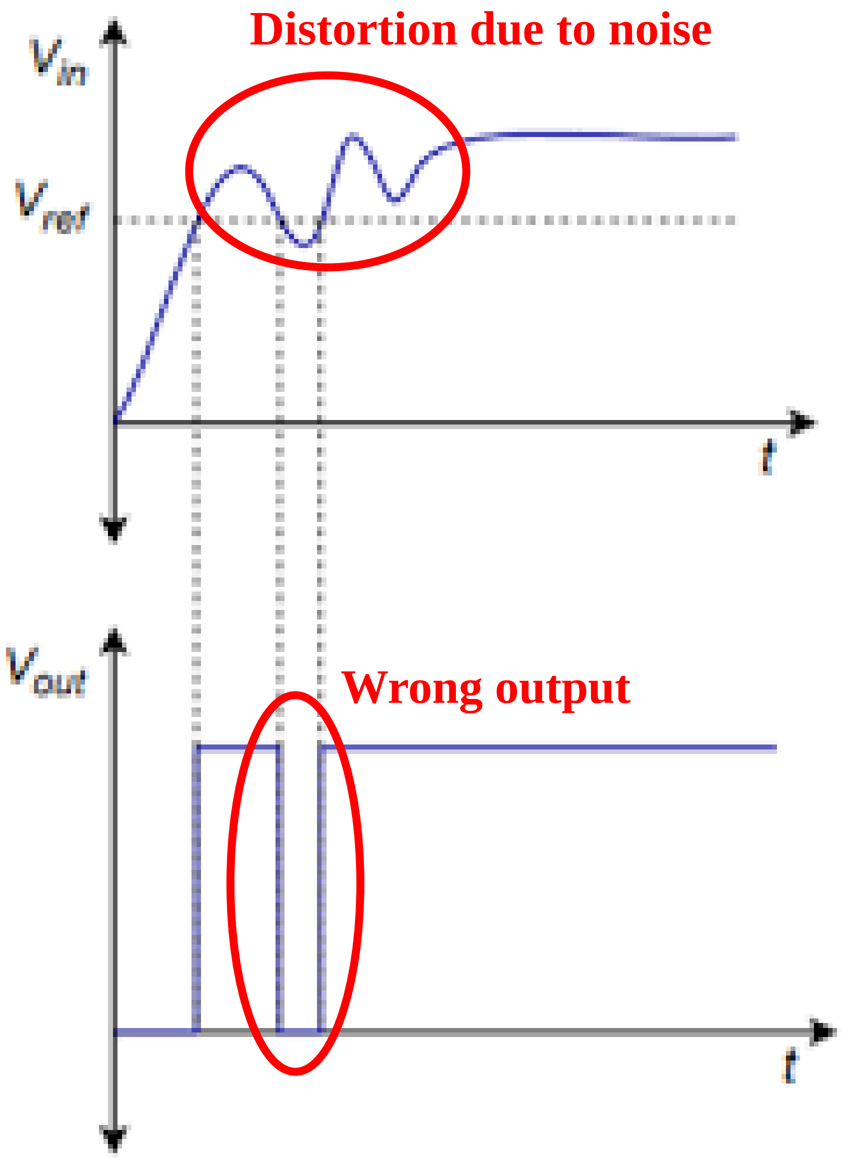


Voltage Comparator



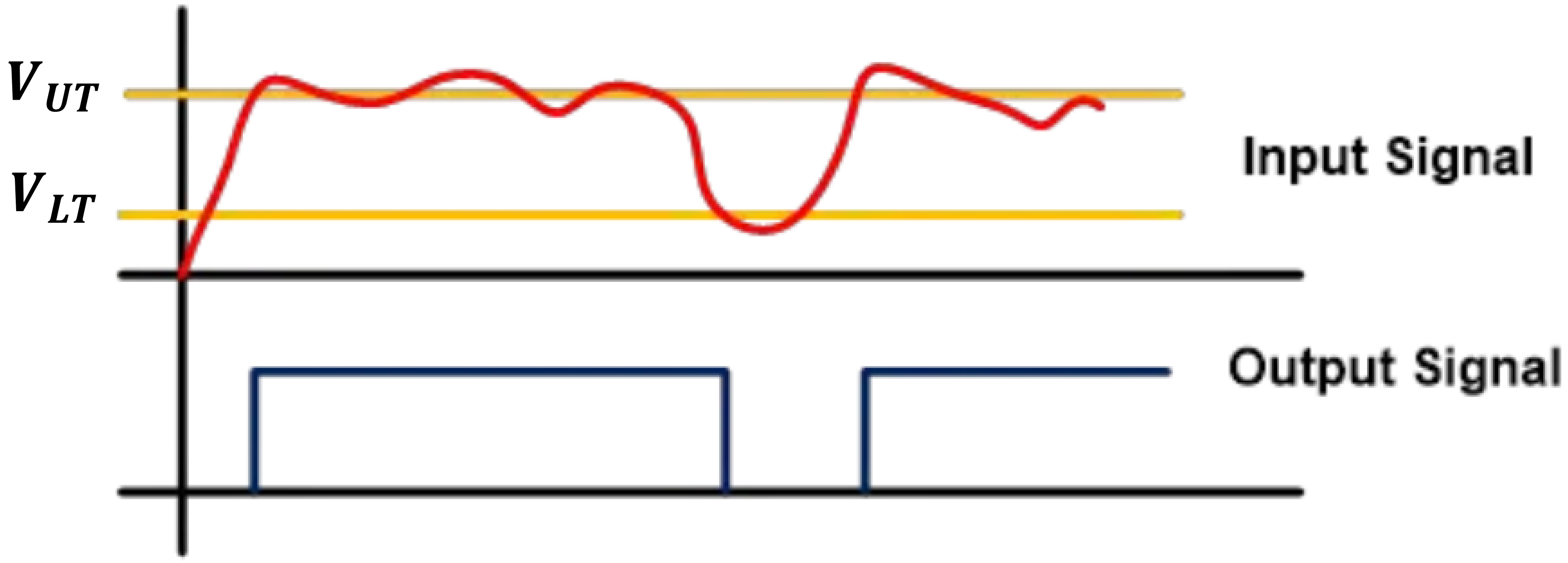
Noise Effect on Comparator





Schmitt Trigger

Unlike typical comparator, Schmitt trigger uses 2 reference voltages; **Upper Threshold Voltage, V_{UT}** and **Lower Threshold Voltage, V_{LT}**, respectively.



Triggering Conditions

1. The output will be LOW until the signal crosses the upper threshold voltage when the comparator is turned on.

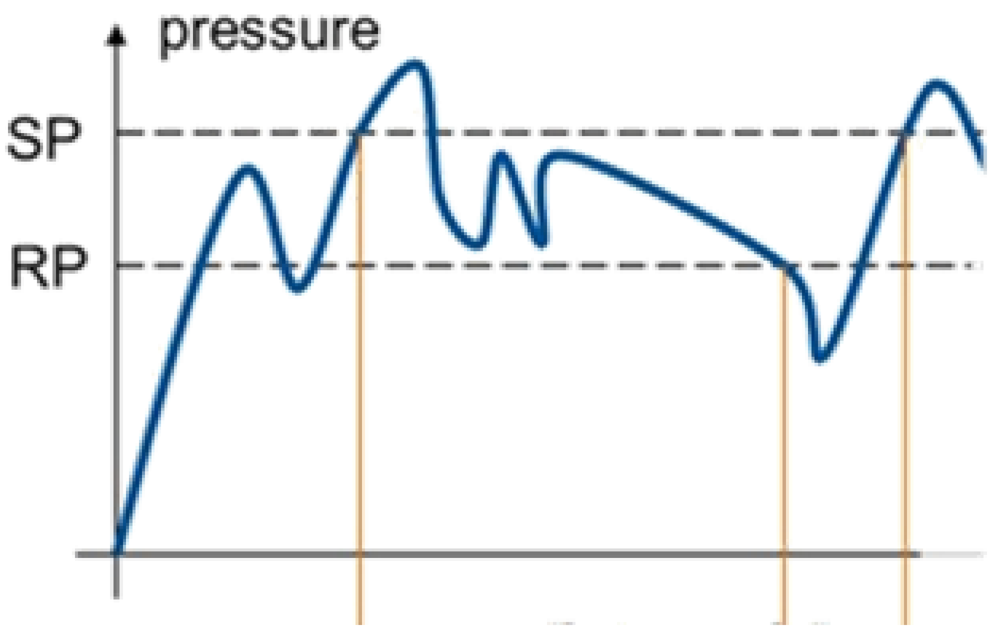
2. If the noise affected input signal is greater that or equal the upper threshold voltage $(V_{in} \geq V_{UT})$, then the comparator output is HIGH.

3. If the noise affected input signal is less than the upper threshold voltage but greater tha the lower threshold voltage $(V_{LT} < V_{in} < V_{UT})$, still the comparator output is HIGH.

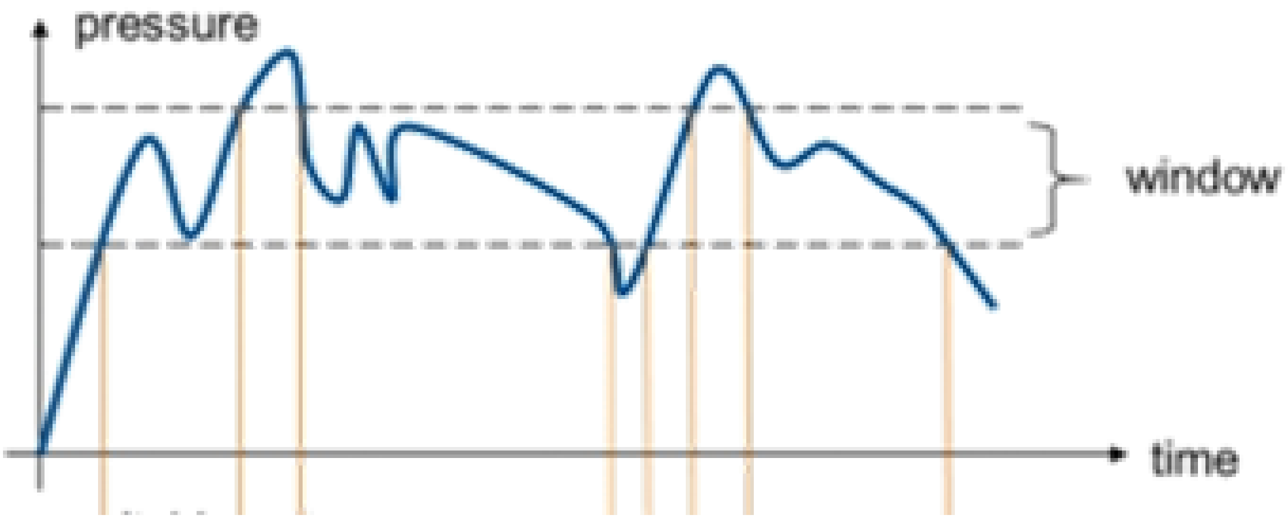
4. If the noise-affected input signal is less than or equal the lower threshold voltage $(V_{in} \leq V_{LT})$, the comparator output is LOW.

Class Works

Draw the output for the given output signals

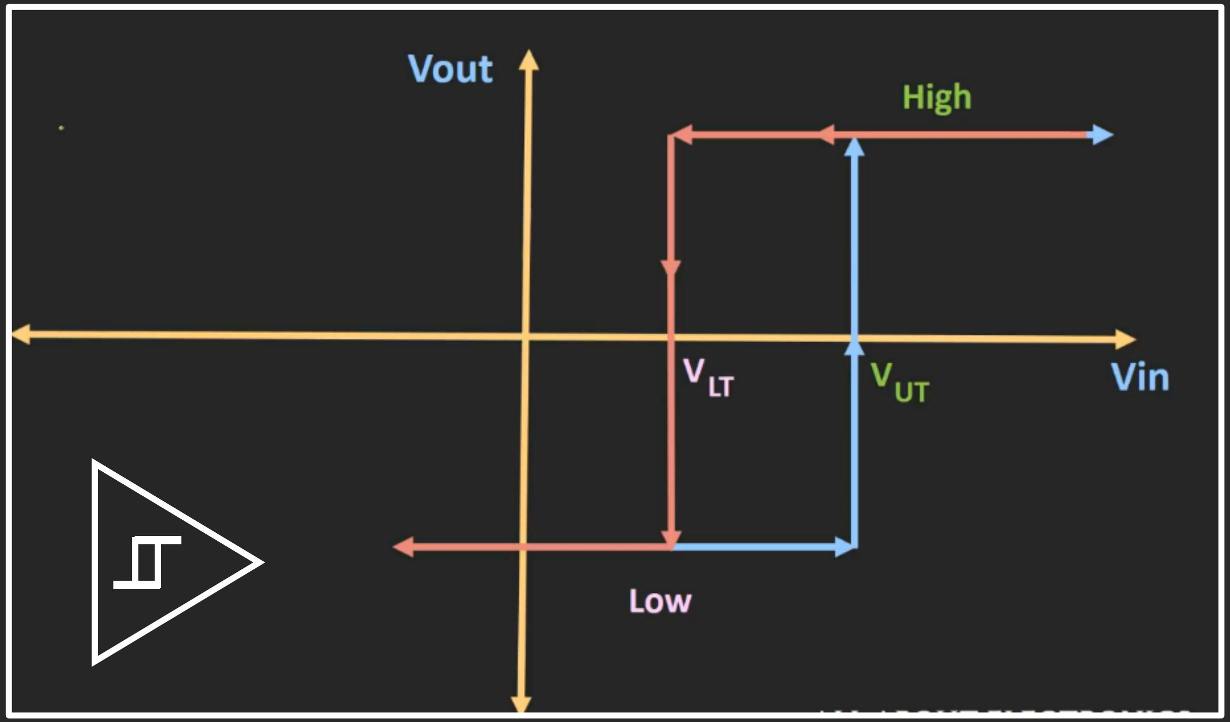


Signal 1

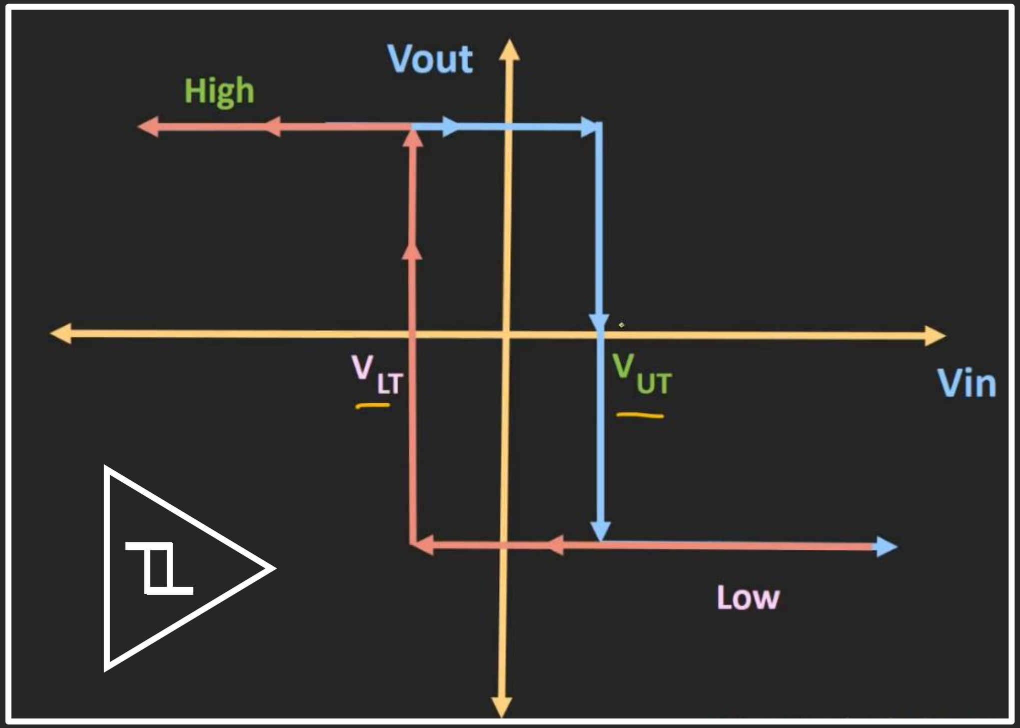


Signal 2

Hysteresis Characteristics

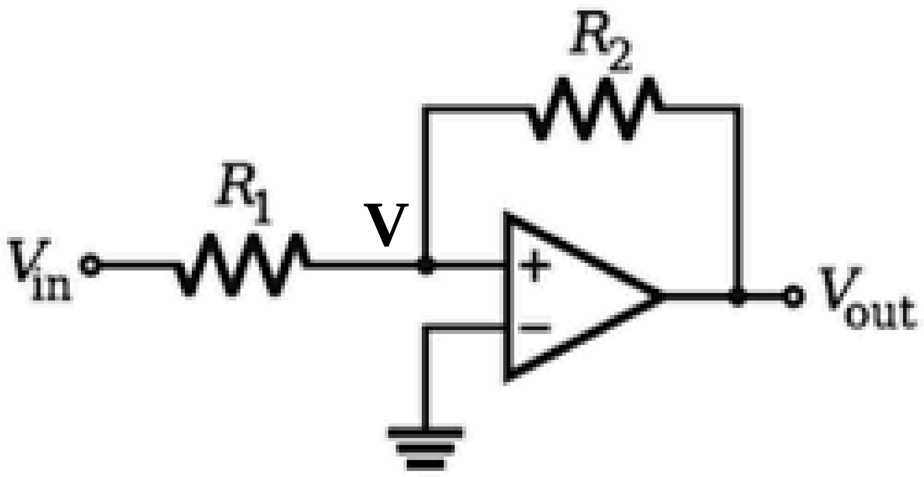


Non-inverting



Inverting

Non-inverting Schmitt Trigger



$$\begin{array}{l} V > 0;\ V_{out} = V_H \\ V < 0;\ V_{out} = V_L \end{array}$$

Applying KCL at V, we get,

$$V = \frac{R_1}{R_1+R_2} V_{out} + \frac{R_2}{R_1+R_2} V_{in}$$

Assuming when $V = V_1, V_{out} = V_H$

Therefore, $V_1 = \frac{R_1}{R_1+R_2} V_L + \frac{R_2}{R_1+R_2} V_{in}$

Now, following the condition, $\frac{R_2}{R_1+R_2} V_{in} \succ -\frac{R_1}{R_1+R_2} V_L$

Finally, $V_{in} \succ -\frac{R_1}{R_2} V_L$ and so

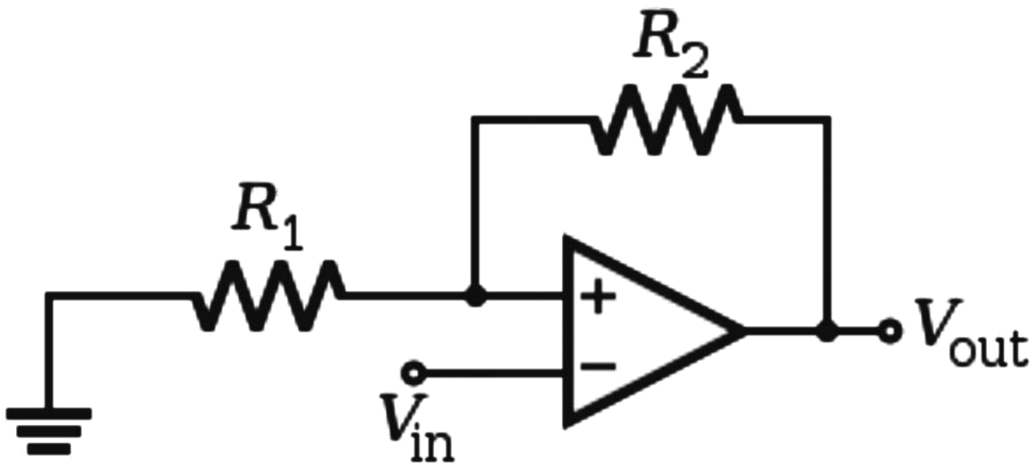
$$\boxed{\boldsymbol{V_{UT} = -\frac{R_1}{R_2} V_L}}$$

Similarly,

$$\boxed{\boldsymbol{V_{LT} = -\frac{R_1}{R_2} V_H}}$$

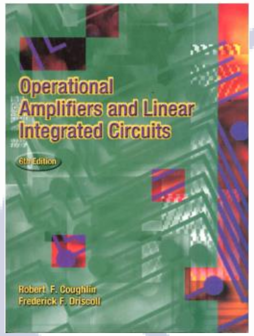
Class Work

Derive the formulations for inverting Schmitt trigger



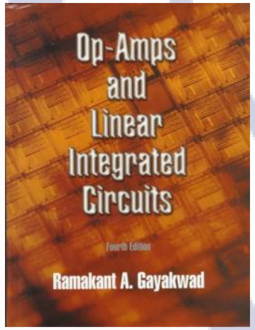
Inverting Schmitt Trigger Circuit

References

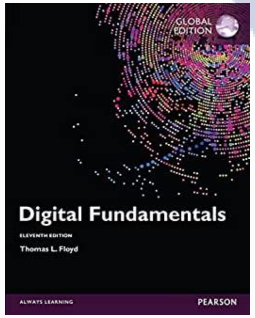


1. Operational Amplifiers and Linear Integrated Circuits, 6th Ed., R.F. Coughlin, F.F. Driscoll

Chapter 06: Section 6.0 – 6.2; All examples, Relevant exercises



2. Op-Amps and Linear Integrated Circuits, 4th Ed., R.A. Gayakwad



3. Digital Fundamentals 11th Ed., T.L. Floyd

Chapter 07


Questions
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Answers
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