



EET 1131 Unit 13

Multivibrators and the 555 Timer

- Read Kleitz, Chapter 14.
- Lab #13 due next week.
- Homework #13 due next week.
- Quiz next week.



Multivibrator

- A **multivibrator** is a circuit whose output changes between two digital levels.
- Three types:
 - Bistable: Two stable states (latches and flip-flops)
 - Monostable (also called "one-shot"): One stable state
 - Astable (also called "oscillator"): No stable state



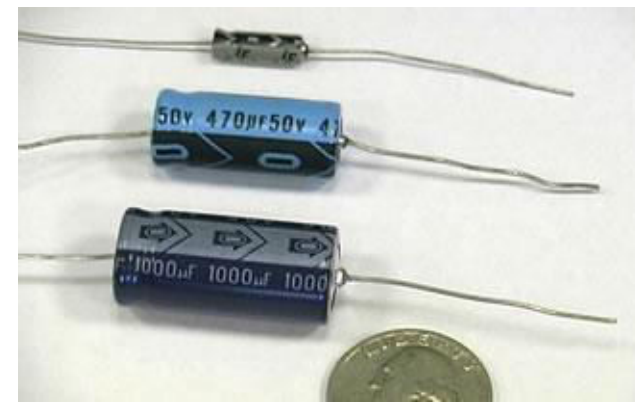
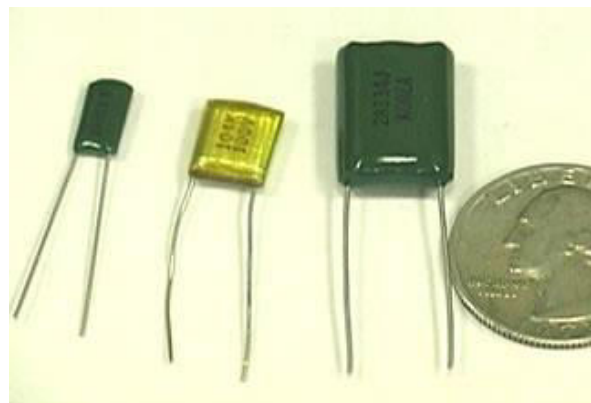
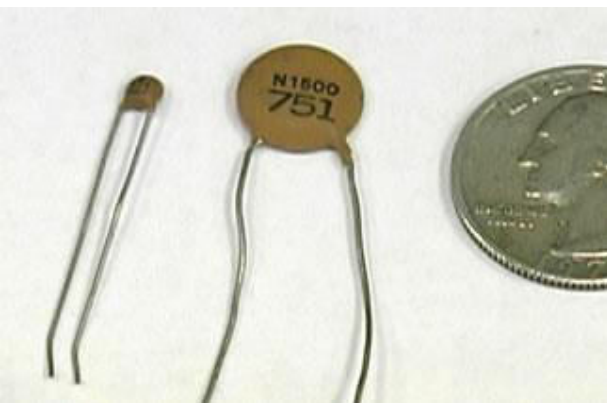
More on the Three Types

- Bistable Multivibrator: When placed in either state, it will stay there indefinitely; won't spontaneously switch to the other state.
- Monostable ("One-shot"): Will stay in its stable state indefinitely, but if forced into the other state it will spontaneously switch back after a certain time.
- Astable ("Oscillator"): From either state it will spontaneously switch to the other state after a certain time.

Resistors and Capacitors




- Resistors and capacitors are often used to control the timing of monostable and astable multivibrators.



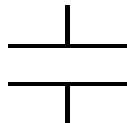
Resistors



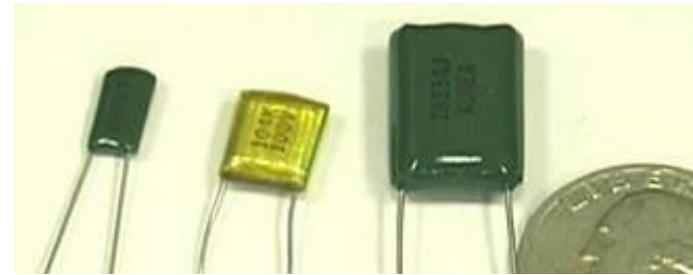
- (From EET 1150, DC Circuits)
- Resistors are measured in ohms (Ω).
- Typical values range from 10Ω to $10 \text{ M}\Omega$.
- Value is coded on the body using a color code. Above, green-blue-red = $5.6 \text{ k}\Omega$.
- Schematic symbol: 

Capacitors



- (From EET 1150, DC Circuits)
- Capacitors are measured in farads (F).
- Typical values range from 10 pF to 1000 μ F.
- Value may be printed directly on the body (as above) or using a numeric code.
- Schematic symbol: 

Polarized Capacitors

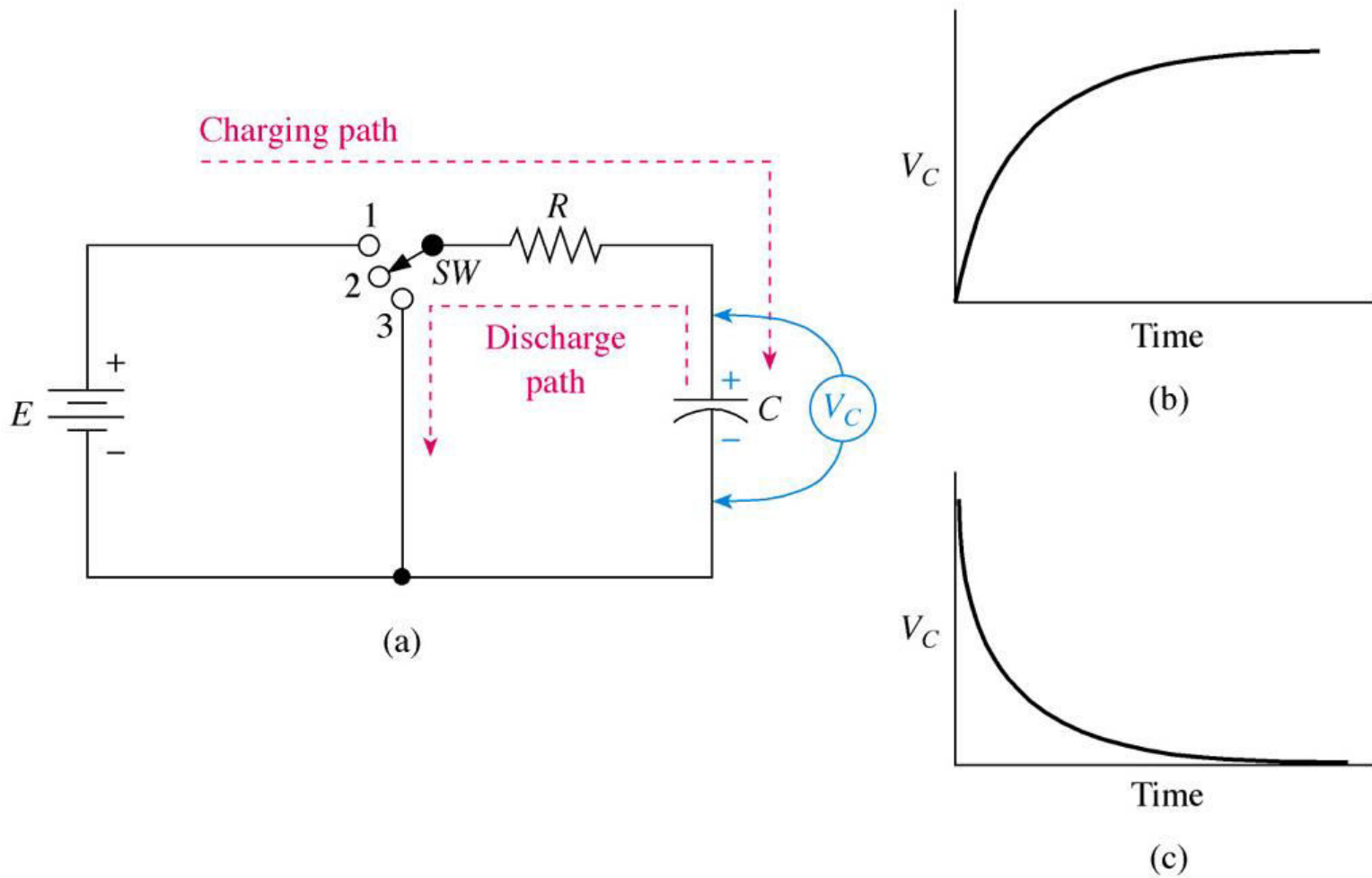


- (From EET 1150, DC Circuits)
- Most capacitors (above) are not polarized: it doesn't matter which way you insert them in a circuit.
- Some capacitors (below) **are** polarized. Body markings show which end is negative.



Capacitor Charge and Discharge

RC circuit charge and discharge



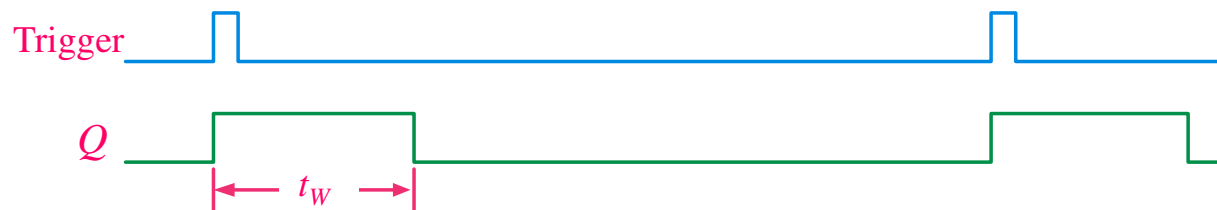
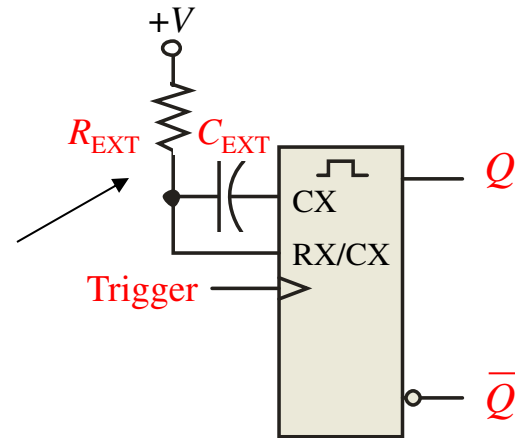
Capacitor Charge and Discharge

- (From EET 1150, DC Circuits)
- For the circuit on the previous slide, the **time constant** is equal to the product of R times C:
$$\text{Time constant} = R \times C$$
- This time constant is a measure of how quickly the capacitor charges.
- Rule of thumb: The capacitor is fully charged after about 5 time constants.

One-Shots

The **one-shot** or **monostable** multivibrator is a device with only one stable state. When triggered, it goes to its unstable state for a predetermined length of time, then returns to its stable state.

For most one-shots, the length of time in the unstable state (t_w) is determined by an external RC circuit.

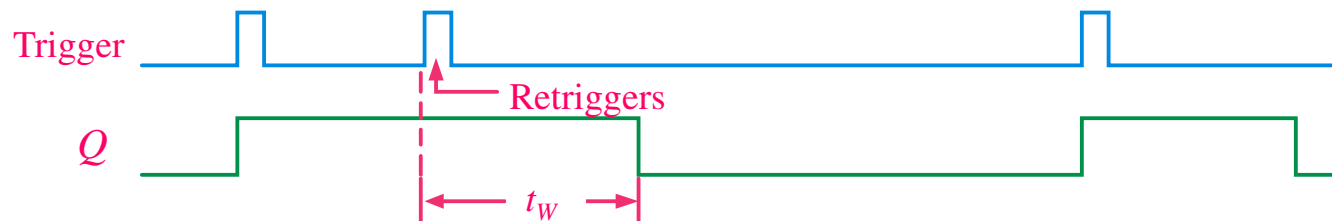


One-Shots

Nonretriggerable one-shots do not respond to any triggers that occur during the unstable state.

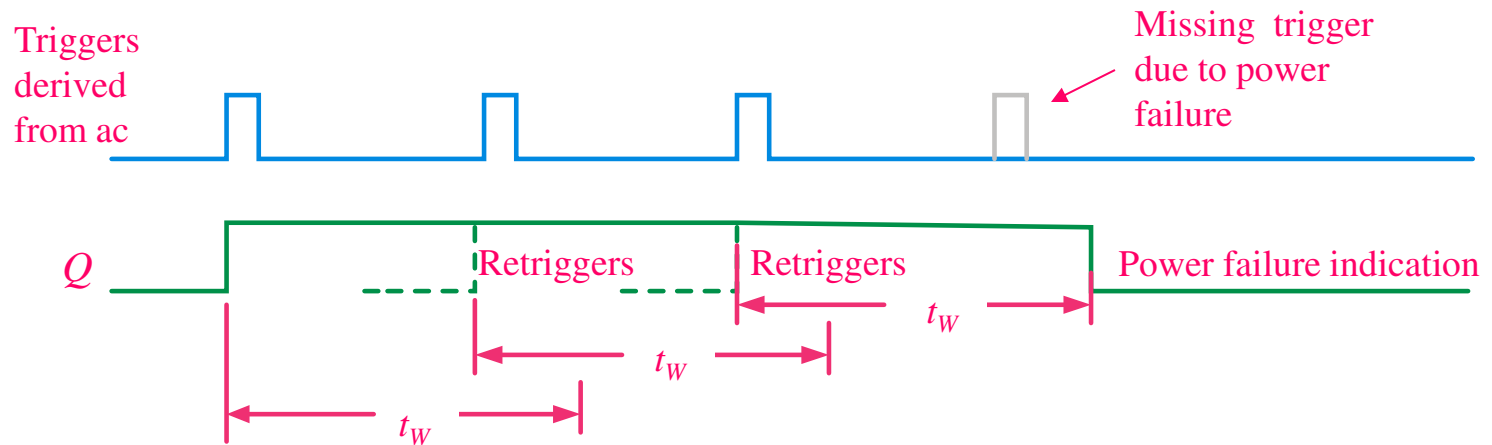
Retriggerable one-shots respond to any trigger, even if it occurs in the unstable state. If it occurs during the unstable state, the state is extended by an amount equal to the pulse width.

Retriggerable one-shot:



One-Shots

An application for a retriggerable one-shot is a power failure detection circuit. Triggers are derived from the AC power source, and continue to retrigger the one-shot. In the event of a power failure, the one-shot is not triggered and an alarm can be initiated.

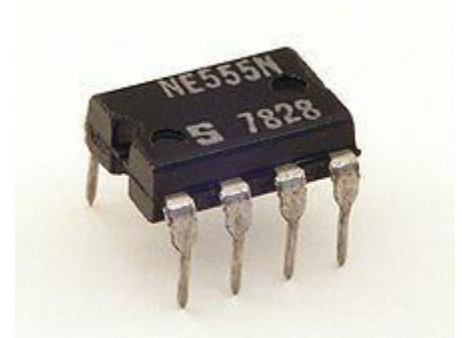


IC Monostable Multivibrators

- 74121
 - Nonretriggerable
- 74122 & 74123
 - Retriggerable

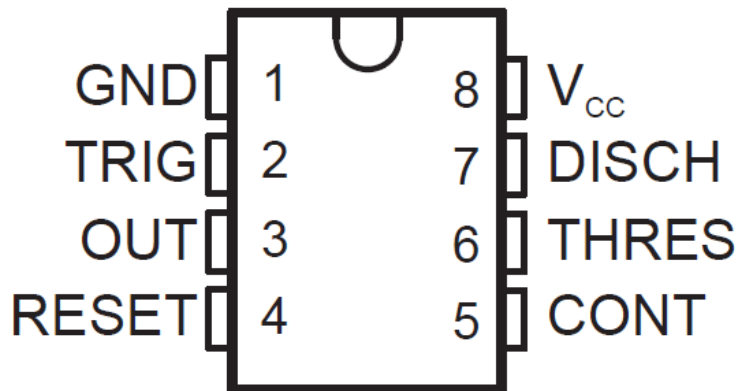
555 Timer

- The 555 is a popular, versatile chip used in many timing applications.
- By itself, it's neither a one-shot nor an astable multivibrator, but it can be hooked up to perform as either of these.
- These applications, and several others, are discussed in its [data sheet](#).

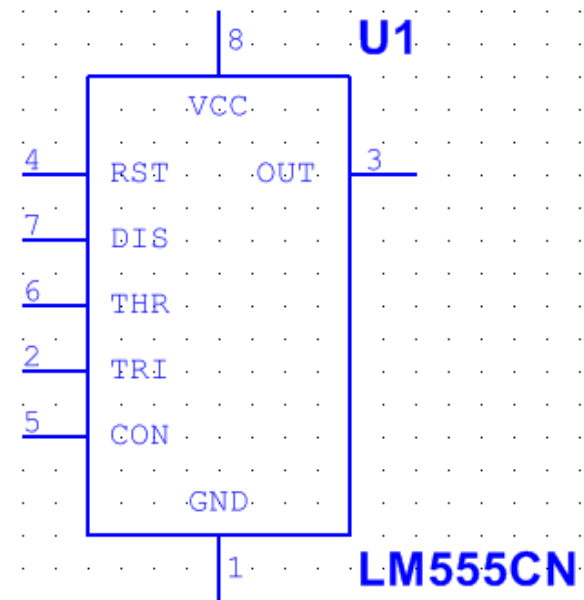


555 Input and Output Pins

- Aside from its power and ground pins, the 555 has five input pins and one output pin.



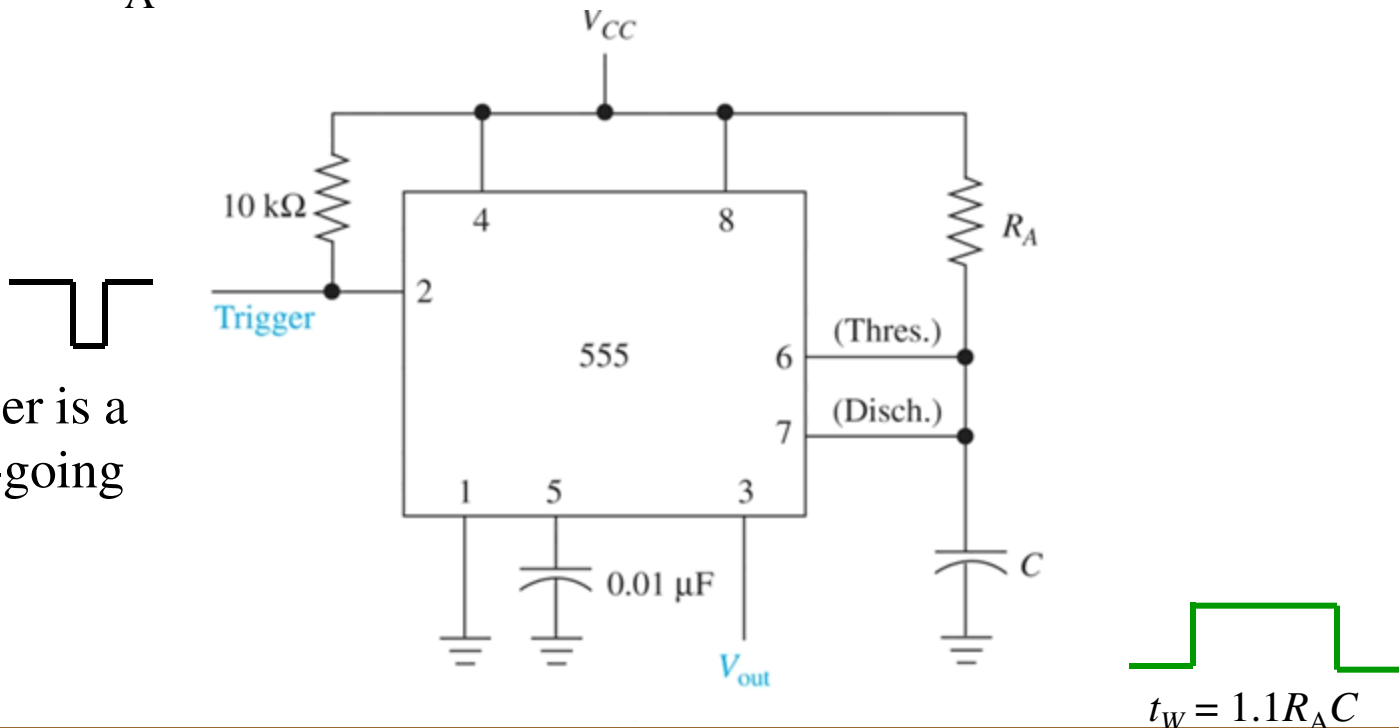
Pin diagram
from datasheet



Logic symbol
from Multisim

The 555 timer as a monostable multivibrator

The 555 timer can be configured in various ways, including as a one-shot. A basic one shot is shown. The pulse width is determined by $R_A C$ and is approximately $t_W = 1.1R_A C$.

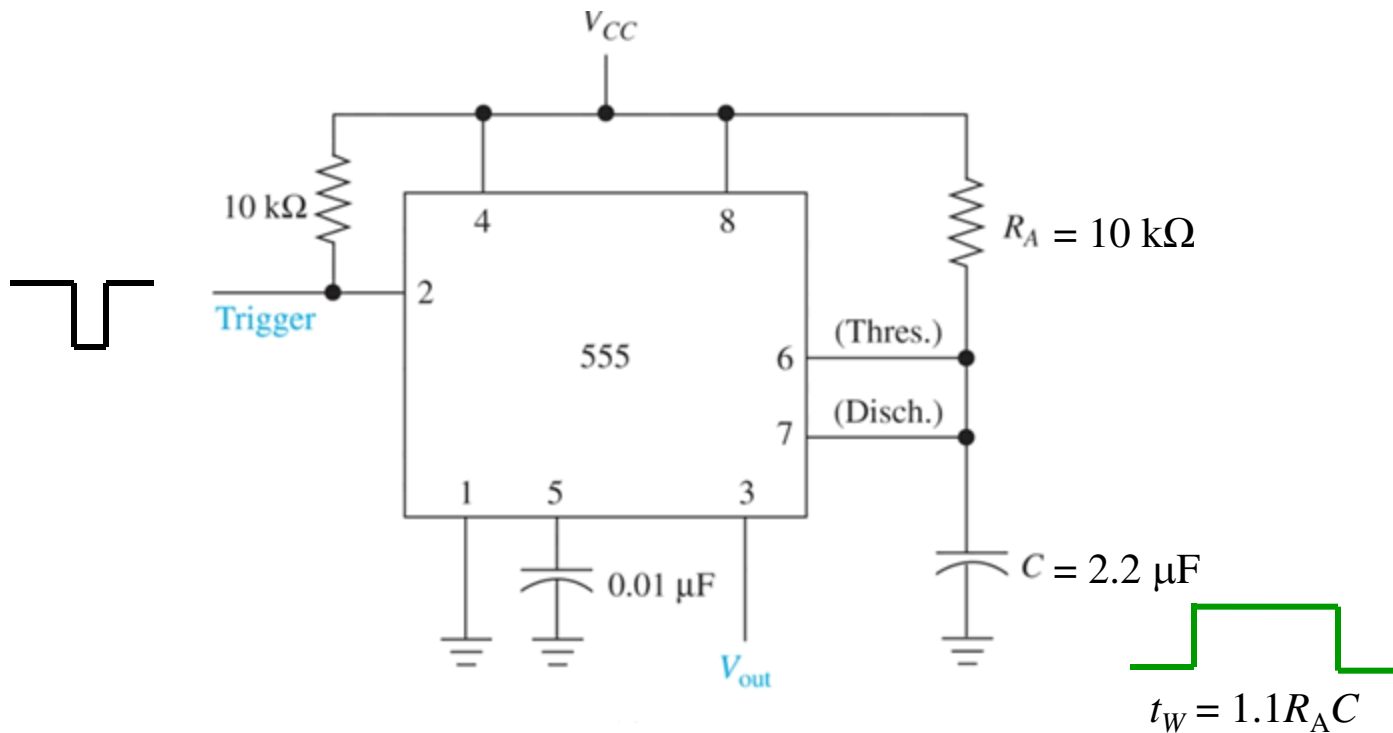


The trigger is a negative-going pulse.

The 555 timer as a monostable multivibrator

Example Determine the pulse width for the circuit shown.

Solution $t_W = 1.1R_1C_1 = 1.1(10 \text{ k}\Omega)(2.2 \text{ }\mu\text{F}) = 24.2 \text{ ms}$



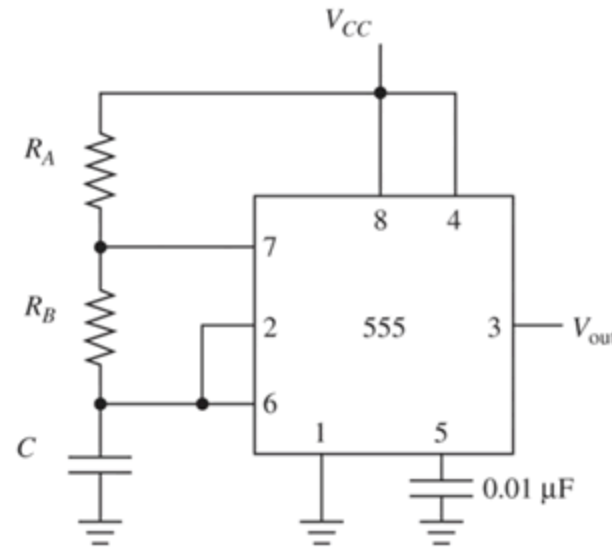
The 555 timer as an astable multivibrator

The 555 can be configured as a basic **astable multivibrator** with the circuit shown. In this circuit C charges through R_A and R_B . It discharges through only R_B . The time high, time low, and frequency are given by:

$$t_{LO} = 0.693R_B C$$

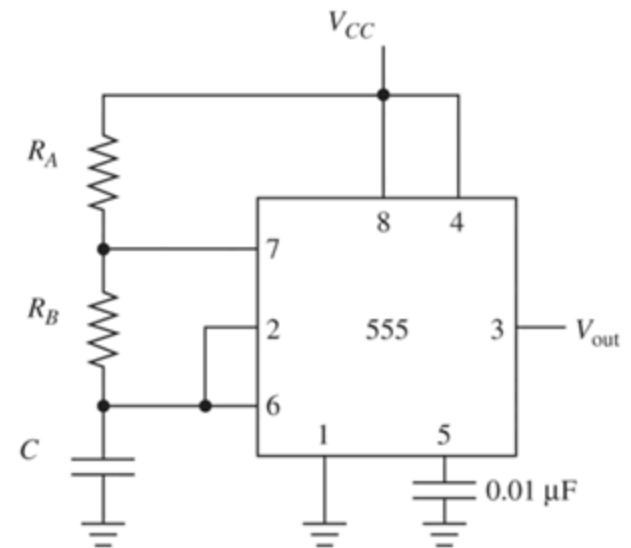
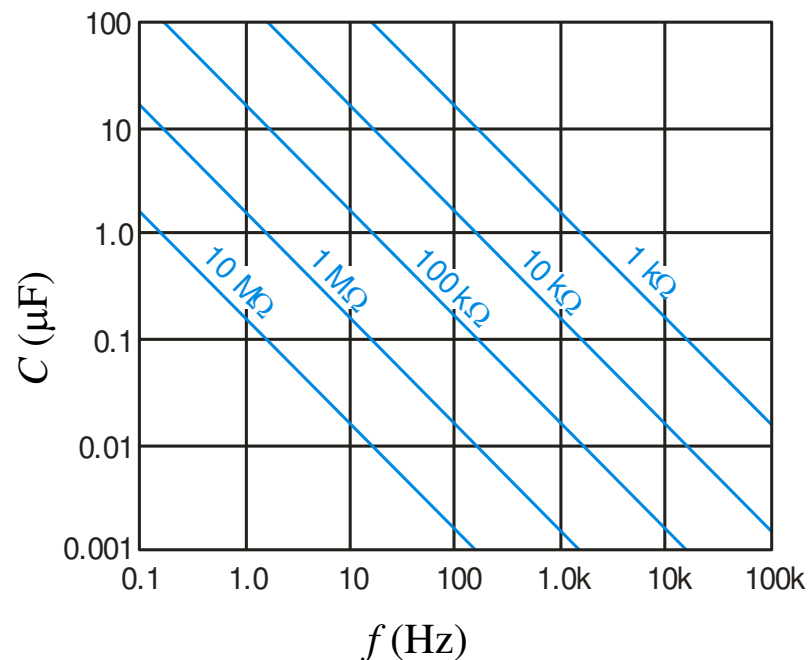
$$t_{HI} = 0.693(R_A + R_B)C$$

$$f = \frac{1}{t_{LO} + t_{HI}}$$

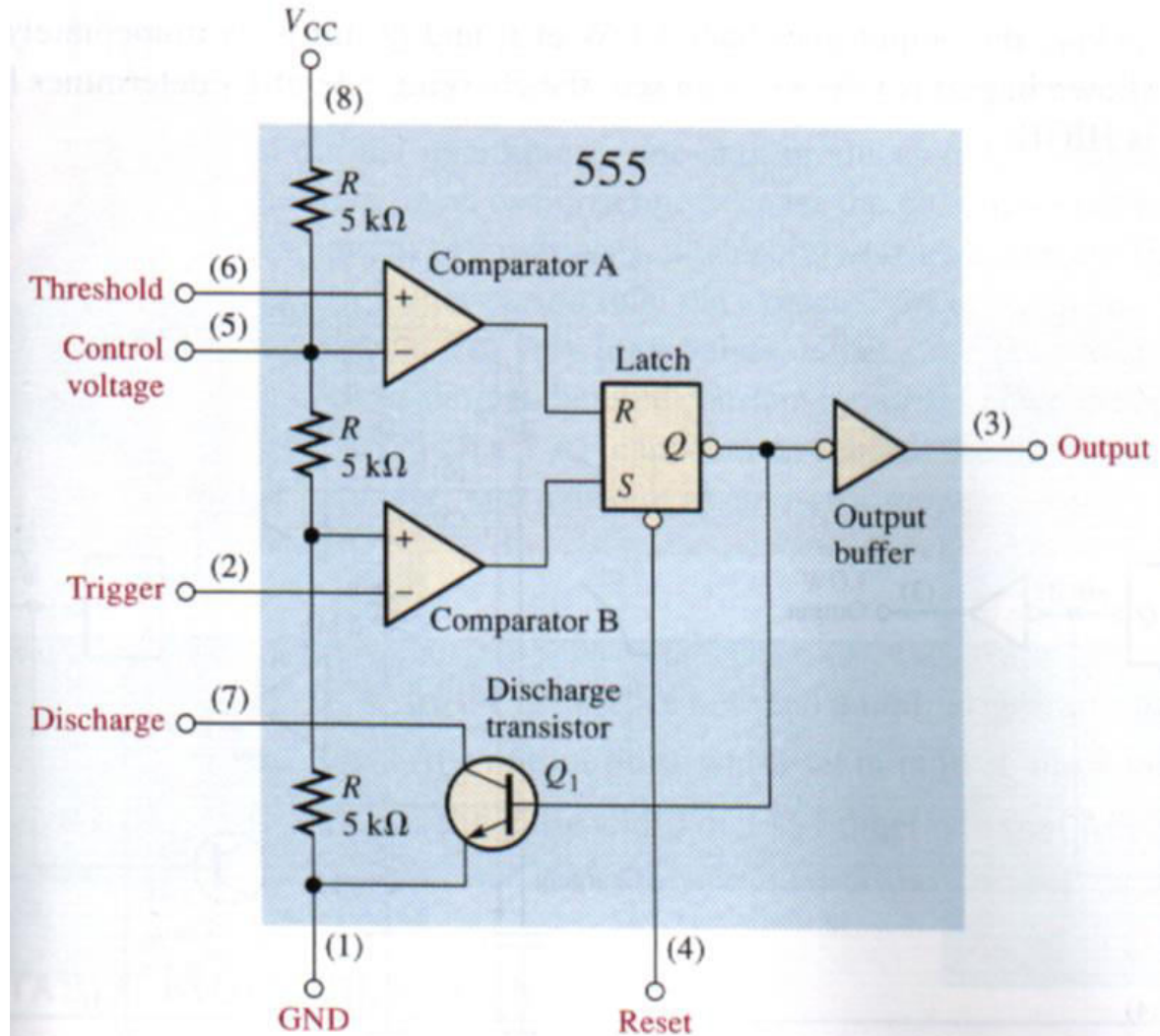


The 555 timer as an astable multivibrator

Given the components, you can read the frequency from the chart. Alternatively, you can use the chart to pick components for a desired frequency.



555 IC Timer Block Diagram



555's internal components

- A three-resistor voltage divider
- Two analog comparators
- An SR latch
- An inverter
- A transistor that acts as a switch

555's Voltage Divider

- From EET 1150 (DC Circuits):
 - The voltage between the top resistor and the middle resistor equals $2/3$ of V_{CC} .
 - The voltage between the middle resistor and the bottom resistor equals $1/3$ of V_{CC} .

555's Analog Comparators

- From EET 2201 (Electronic Devices and Circuits):
 - If the voltage at a comparator's + input is greater than the voltage at its – input, it outputs a HI.
 - If the voltage at a comparator's + input is less than the voltage at its – input, it outputs a LO.

555's SR Latch

S	R		Q	Q'		Comments
----- ----- -----						
0	0		Q_0	Q_0'		No change.
0	1		0	1		RESET
1	0		1	0		SET
1	1		0	0		Invalid state.

Five Rules of 555 Operation

- a) Whenever $V_{\text{pin 2}} < 1/3 V_{\text{CC}}$, the latch is set, and the 555's output (pin 3) is HIGH.
- b) Whenever $V_{\text{pin 6}} > 2/3 V_{\text{CC}}$, the latch is reset, and the 555's output (pin 3) is LOW.
- c) Whenever neither a) nor b) is true, the latch holds its value, and the 555's output (pin 3) is constant.
- d) When the 555's output (pin 3) is LOW, pin 7 is shorted to GROUND, which will discharge an external capacitor connected to pin 7.
- e) When the 555's output (pin 3) is HIGH, pin 7 is internally open, allowing the external capacitor to charge up.

555's Transistor

- From EET 2201 (Electronic Devices & Circuits):
 - This transistor acts as a switch.
 - When the voltage at its base is LOW, the transistor turns OFF, disconnecting its collector from to its emitter.
 - When the voltage at its base is HIGH, the transistor turns ON, connecting its collector to its emitter.



Summary

- Capacitor voltage charging and discharging rates are the most common way to produce predictable time duration for oscillator and timing operations.

Summary

- A monostable multivibrator (“one-shot”) is used to produce an output pulse that starts when the circuit receives an input trigger and lasts for a length of time dictated by the attached RC circuit.
- An astable multivibrator is a free-running oscillator whose output oscillates between two voltage levels at a rate determined by an attached RC circuit.