

ECE 2274
Pre-Lab for Experiment 6
555 Timer Chip

Introduction to the 555 Timer

The 555 IC is a popular chip for acting as multivibrators. Go to the web to obtain a data sheet to be turn-in with the pre-lab. A simpler layout of the chip is shown below.

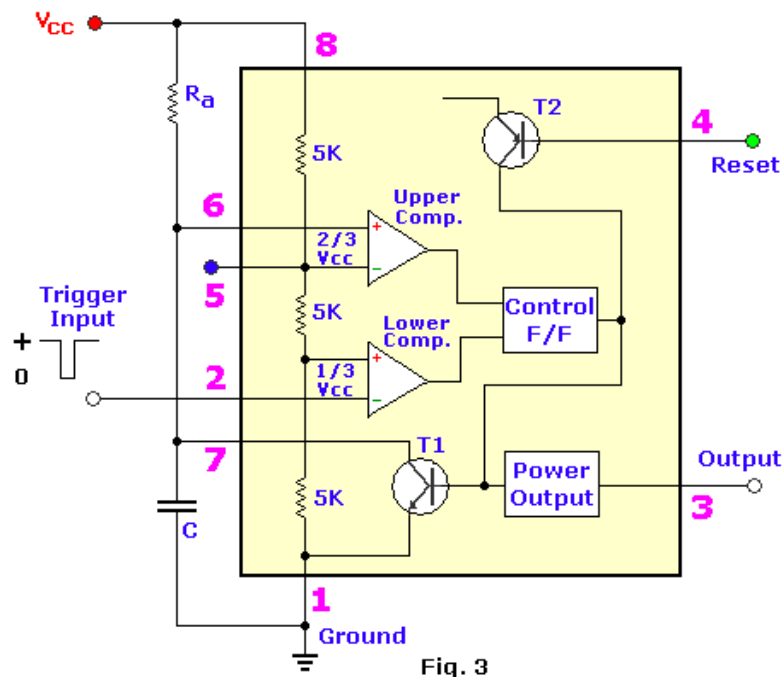


Fig. 3

555 Timer

The comparators:

The first note about the 555 timer is the comparator segments. A comparator circuit is an opamp circuit that is designed to compare an input with a fixed threshold voltage. The output will be high if the input voltage is higher, or lower depending on the comparator's design, than the threshold voltage. In the 555 IC, if the threshold pin input (pin 6) is higher than $2/3V_{cc}$, the output of CP1 (upper comparator) goes high. When the trigger pin input is lower than $1/3V_{cc}$, then the output of CP2 (lower comparator) is high.

The RS Flip-Flop(Control F/F):

The second segment of the 555 IC to analyze is the RS flip-flop. When the output of CP2 is high, and thus the output of CP1 is low, then the flip-flop has inputs, $R=0$ and $S=1$. This causes the output of the RS flip-flop to be high, or logic 1. Thus, the inverted output of the flip-flop will be logic 0, or low. When the output of CP1 is high, and thus the output of CP2 is low, then the flip-

flop has the inputs, $R=1$ and $S=0$. This causes the output of the RS flip-flop to be logic 0 and the inverted output of the flip-flop to be logic 1. The last input pin is Cl (pin 4), or reset. The reset feature of the RS flip-flop is active low. Thus, when the input to the reset pin is low, the flip-flop's output will be logic 0 and the inverted output will be logic 1. To disable the reset feature, the Cl input of the flip-flop, and thus the reset pin of the 555 IC, should be tied high.

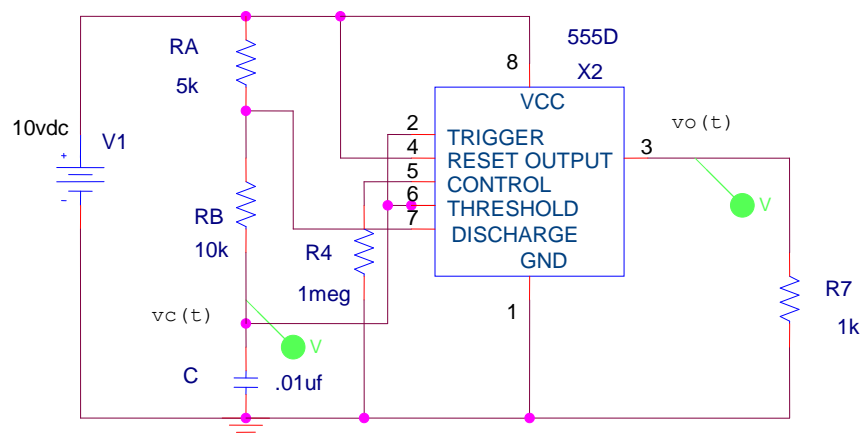
The Discharge Transistor(T1):

The last aspect of the 555 IC to be analyzed is the discharge transistor. When the output of the flip-flop is high, and thus the inverted output is low, the transistor is off. Since, the transistor is connected to the inverted output of the flip-flop, when the inverted output is low the transistor is off because there is no current flowing in to the base of the transistor. When the output of the flip-flop is low, and thus the inverted output of the flip-flop is high, the discharge transistor turns on and thus current flows in through the discharge pin (pin 7) and to ground through the discharge transistor.

Prelab:

The 555 Astable Multivibrator

By adding two timing resistors R_A , R_B and a capacitor to the 555 IC forms an astable multivibrator. An astable multivibrator is an oscillator that generates a square wave output. Build the Astable Multivibrator show below in PSpice:



Astable Multivibrator

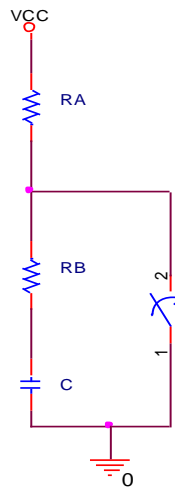
1. Graph the output $vo(t)$ and $vc(t)$ using PSpice. The graph is to be turned in with the pre-lab.

PSpice Hint: Simulation Settings \Rightarrow Time Domain(transient) \Rightarrow Run to time 700us \Rightarrow Start saving data after 0 sec \Rightarrow \checkmark Skip initial(SKIPBP)

2. Using the results of the graph of output versus the capacitor, and the description of how the 555 IC works above, **derive** the two expressions for the period and duty cycle of the output voltage in terms of R_A , R_B , and C .

T_{on} : When the supply V_{cc} is connected, the timing capacitor C charges toward $2/3 V_{cc}$ through R_A and R_B . When the capacitor voltage reaches $2/3 V_{cc}$, the upper comparator triggers the flip-flop.

T_{off} : The capacitor starts to discharge towards ground through R_B . When the discharge reaches $1/3 V_{cc}$, the lower comparator is triggered and a new cycle is started.



The 555 IC can be visualized as a switch in this situation. The switch is simulating when the discharge transistor is on and when it is off. The capacitor charges through R_A and R_B during T_{on} . The capacitor only discharges through R_B during T_{off} .

Charging a capacitor:

$$V_{initial} = V_{final} \left(1 - e^{\frac{-T_{on}}{R_{equivalent}C}} \right)$$

Discharging a capacitor:

$$V_{final} = V_{initial} \left(e^{\frac{-T_{off}}{R_{equivalent}C}} \right)$$

Period:

$$T_{total} = T_{on} + T_{off}$$

Duty cycle:

$$Duty\ cycle\ (\%) = \frac{T_{on}}{T_{total}}$$

Note: $V_{initial}$, V_{final} , and $R_{equivalent}$ are different for charging and discharging the capacitor. The

conditions are different when the switch is open and when the switch is close.

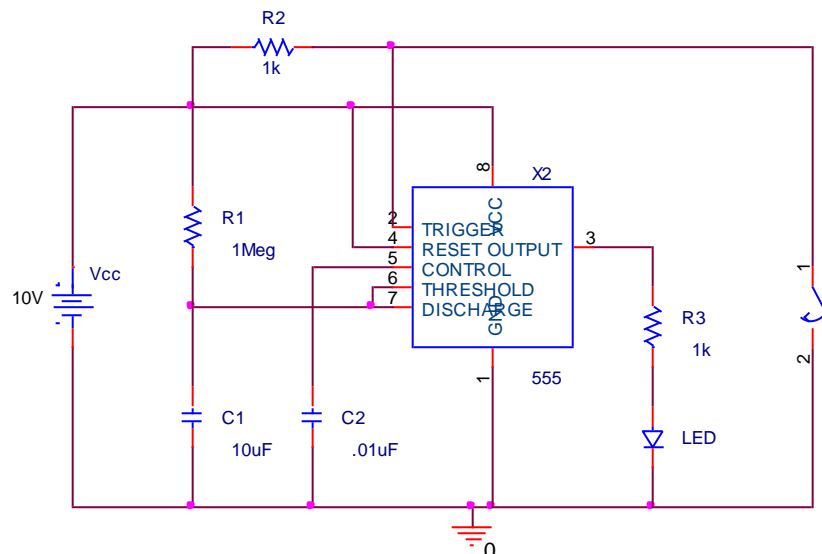
Work area for derivation of T_{total} and *Duty cycle* (%) in terms of R_A , R_B , and C :

3. From the equations you derived determine R_A and R_B ($C=0.022\mu f$) for an output of 1kHz with a 70% duty cycle. Calculate values for R_A , and R_B .
Graph the output $v_o(t)$ and $v_c(t)$ using PSpice. The graph is to be turned in with the pre- lab.

Required Graphs: Transient analyst of output voltage and the capacitor voltage.

Laboratory Exercise:

1. Build the Astable Multivibrator you used in the pre-lab part 3. From the equations you derived determine R_A and R_B ($C=0.022\mu\text{f}$) for an output of 1kHz with a 70% duty cycle.
2. Measure your output on channel 1 and verify that you have obtained an output of 1kHz and 70% duty cycle. Does your output exactly meet the specifications, explain why. Do component tolerances affect your design?
3. On channel 2 of the oscilloscope, measure the voltage across the capacitor, C . Capture and save the two output waveforms from channel 1 and 2. Overlay the captured waveforms so that both the capacitor's voltage and the output voltage are shown on the same graph. Print out only your combined graph.
4. Determine the threshold voltage of the capacitor (channel 2) at which the output goes low (logic 0). Then determine the trigger voltage of the capacitor at which the output goes high (logic 1).
5. Does the threshold voltage correspond reasonably well to $2/3 V_{cc}$? Does the trigger voltage correspond reasonably well to $1/3 V_{cc}$?
6. Build the One-Shot shown below and demonstrate how the circuit functions to your lab instructor. To implement the switch, attach a wire to the R2, Trigger node; then touch and release the wire to ground. The LED should turn on and then expire after 11 seconds. The capacitor C_2 may be as low as $7\mu\text{F}$ because of tolerances, so the time may vary because of this.



One-Shot

ECE 2274
DATA SHEET
Experiment 6
The 555 Timer Chip

1. Astable Multivibrator

Values used: RA _____ RB _____ C _____

2. Frequency _____ Duty Cycle _____

On Channel 1.

Does your output exactly meet the specifications, explain why. Do component tolerances affect your design? Why or why not?

3. Submit graph channel 1 and 2

4. Threshold: V_C _____ (logic 0) V_C _____ (logic 1)
Channel 2

5. Calculate: $2/3 V_{CC}$ _____ $1/3 V_{CC}$ _____

Does the threshold voltage correspond reasonably well to $2/3 V_{CC}$? Does the trigger voltage correspond reasonably well to $1/3 V_{CC}$?

6. Demonstrate the One-Shot to TA _____

Required Graph:
Scope capture of output and capacitor voltage.