EXPERIMENT # 8

555 TIMER

OBJECTIVES: To study the monostable and astable modes of the 555 Timer.

EQUIPMENT:

Oscilloscope
Function Generator
555 Timer
Capacitors
Resistors

BACKGROUND:

The 555 is a versatile integrated circuit timer that it can be used in a variety of applications. It's open architecture allows to be connected as a monostable or an astable multivibrator. In the monostable mode the circuit generates pulses of fixed duration in response to a triggering signal. In the astable mode the circuit is actually a square wave generator. The output amplifier is capable of sourcing or sinking up to 150 mA and it can directly drive small loads (lamps, relays, LEDs etc.). However, because of this rather mighty output stage, the 555 generates a lot of switching noise, especially on the power supply line. For this purpose, it is advisable to bypass the power supply pin of the 555 to the ground with a capacitor. Because of it's versatility quite often the 555 is used in digital circuits. In these cases, it is better to use a CMOS version of the 555 which does not generate as much noise as the standard version of the chip. The internal architecture of the 555 is displayed on Figure 1. Referring to Figure 1, the basic monostable and astable modes are discussed next.

A) MONOSTABLE OPERATION:

The basic monostable configuration is shown in Figure 2. Refer to Figure 1 as well. Under normal conditions the flip-flop (latch) is reset, the output is low and the discharge transistor bypasses the capacitor preventing it from charging. To maintain this state the voltage at the trigger input should be kept above $\frac{1}{3}V_{cc}$. If the voltage at the trigger terminal briefly drops below $\frac{1}{3}V_{cc}$ then the flip-flop become set, the output goes high, the discharge transistor switches off allowing the capacitor to begin charging. When the capacitor voltage reaches $\frac{2}{3}V_{cc}$, the flip-flop becomes reset and the transistor quickly discharges the capacitor. Thus the duration of the output pulse will be the time required for the capacitor to charge from 0V up to $\frac{2}{3}V_{cc}$. It can be easily shown that this time duration is given by:

$$T_p = RCln(3) \tag{1}$$

It has to be emphasized that T_p has to be longer than the time which the trigger is held low, otherwise it is possible to get stray oscillations at the output. To prevent this, it is possible to convert the input from level triggered to edge triggered by adding an RC differentiator. This modification is shown in Figure 2. For this modification to be effective, it must be $RC \ll T_p$.

B) ASTABLE OPERATION:

In the astable mode self triggering is used. This is accomplished by connecting the trigger input to the threshold input as depicted in Figure 3. For a more symmetric output waveform an additional resistor is inserted between the capacitor and the discharge terminal. Referring to Figures 1 and 3, the capacitor charges from $\frac{1}{3}V_{cc}$ to $\frac{2}{3}V_{cc}$ through R_A+R_B, and discharges from $\frac{2}{3}V_{cc}$ down to $\frac{1}{3}V_{cc}$ through R_B. The time duration which the output remains high and low are easily found to be given by:

$$T_H = (R_A + R_B)Cln(2) \qquad T_L = R_B C \ln(2) \tag{2}$$

The period, the frequency and the duty-cycle (DC) of the oscillations are given by:

$$F = \frac{1}{T}, \quad \text{and} \quad DC = \frac{T_L}{T} x 100\% \tag{3}$$

From eq. (2) it is noticed that it is impossible to have $T_H = T_L$ (why?), thus we cannot exactly have a 50% duty cycle with this circuit. However, by simply using an extra diode, it is possible to modify the circuit so that a 50% duty cycle can be obtained. (How?)

PREPARATION:

a) For the monostable circuit of Figure 2 select values of the timing components for an output pulse width of 0.1 ms (approx.).

b) For the astable circuit of Figure 3 select values of the timing components for 10 KHz frequency and 1/3 Duty Cycle.

EXPERIMENT:

The purpose of the experiment is to experimentally study the operation of the 555 timer in both the monostable and astable modes. Use a power supply voltage of 12V.

A) MONOSTABLE OPERATION

a) Connect the 555 timer in the basic monostable circuit of Figure 2 using the timing component values you computed in the preparation part (a). Connect pin 4 (Reset) to pin to the power supply. Connect the trigger input to a square-wave alternating from 0V to 6V.

b) Set the input frequency to 6 KHz. Observe on the scope both the trigger and the output voltage. Mark the triggering points.

c) Change the input waveform into triangular (0 to 6V) and determine precisely the input voltage level where triggering occurs.

d) Change the input waveform back to square-wave. From the oscillograms or by using the frequency counter, compare the input and output frequencies when the input frequency is 6 KHz, 18 KHz and 27 KHz. Make comments.

e) Decrease the input frequency to 1 KHz. Observe carefully the output voltage and the voltage across the timing capacitor. Explain what you see.

f) Modify the trigger circuit for edge triggering. You can use the modification suggested in Figure 2. Repeat part (e) and notice any differences. Observe also the trigger (at pin 2) and the output voltages.

B) ASTABLE OPERATION

a) Connect the astable circuit of Figure 3 using the timing component values you computed in the preparation part (b). Observe on the scope the voltages at the output pin and across the timing capacitor. Measure the extreme values of the capacitor voltage.

b) Set the oscilloscope AC coupled and observe the voltage at pin 8 (power supply). Increase the oscilloscope gain. What do you see? Connect now a 10μF capacitor between pins 8 and ground. Did anything change?

c) Connect a diode between pins 6 and 7 with the anode at pin 7. Observe any changes in the output waveform. Explain.

d) Connect the function generator between pin 5 (control voltage) and ground (If you had a capacitor between pin 5 and ground, remove it). Set the generator at 200 Hz. Observe both the outputs of the generator and the 555. Vary the amplitude of the generator output and observe the results. Try with various waveforms.

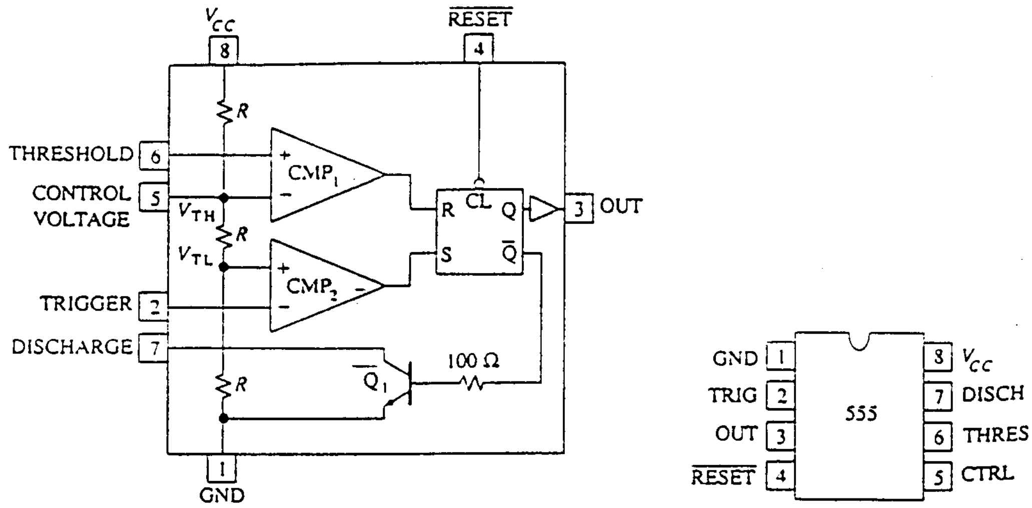
REPORT:

In your report present experimental results and compare them with the expected results. Discuss any discrepancies, make comments and write conclusions.

REFERENCES:

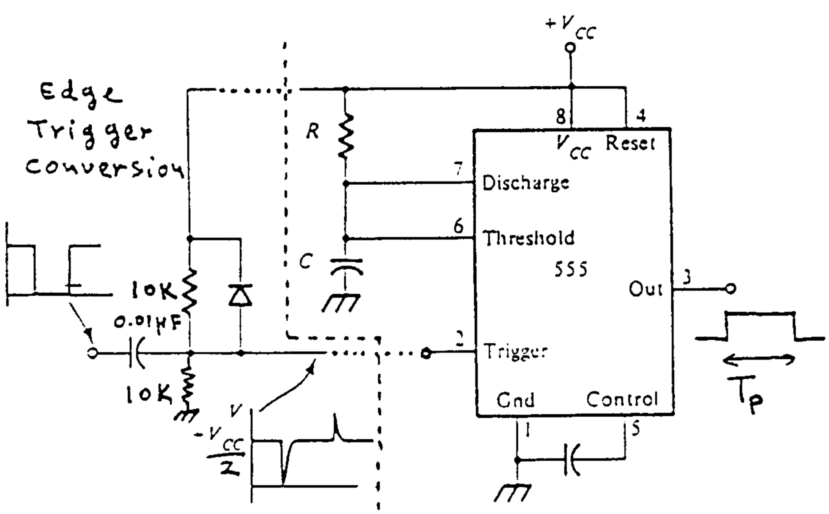
1) "Microelectronic Circuits," Sedra/Smith, Third Edition.

2) Current textbook for EEL 4309.



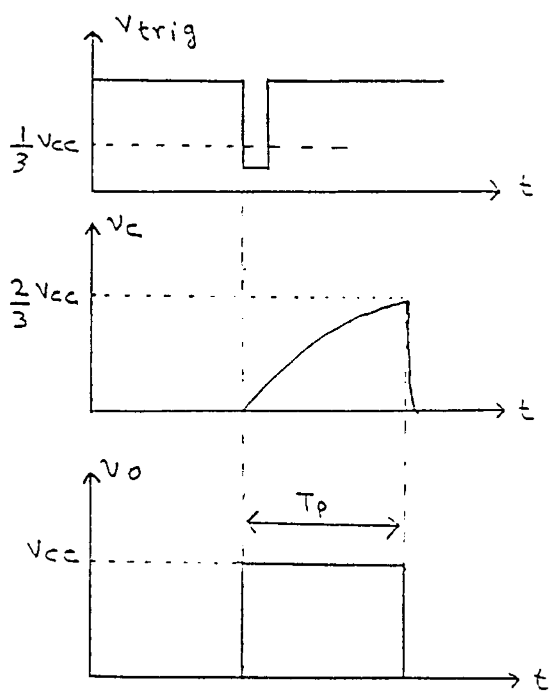
(a) (b)

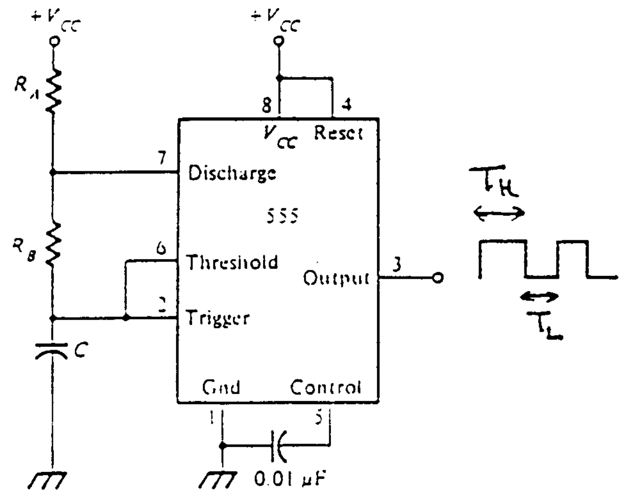
Figure 1

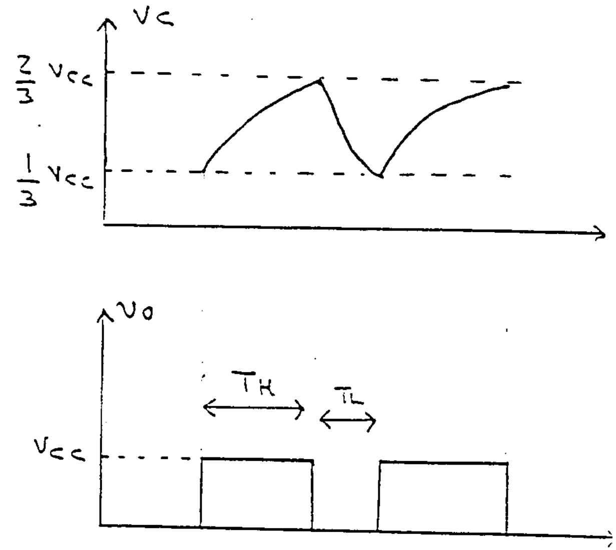


$T_p = RC\ln(3)$

Basic Monostable Circuit







$T_H = (R_A + R_B)C\ln(2)$ $T_L = R_BC\ln(2)$

Basic Astable Circuit

NOTES