

## **EXPERIMENT 7. SCHMITT TRIGGER AND MULTIVIBRATOR CIRCUITS**

### **I. Introduction**

#### **I.I Objectives**

The purpose of this experiment is to get familiar with different types of Schmitt trigger and multivibrator circuits and their implementations.

#### **I.II. Prerequisites**

You are expected to get familiar with the basics of the Schmitt trigger and multivibrator circuits. You can start reading your lecture notes and the section titled “CMOS Schmitt Trigger Circuits,” from your text book by Thomas A. Demassa and Zack Ciccone (pages 437-439). These pages are the introduction parts, and they explain what basically hysteresis is, and why it may be needed. However, that chapter explains digital Schmitt trigger circuits. What we construct in the laboratory are analog ones. Detailed information on these analog Schmitt trigger circuits and multivibrator circuits can be found in “Microelectronics Circuits” by Adel S. Sedra, Kenneth C. Smith. Reading these two references and completing the preliminary work will help you to understand the topic prior to your actual lab session and also it will help you in interpreting your experiment results.

## II. Preliminary Work

- 1) Draw the internal block diagram of 555 timer IC. Explain the aim of the components inside 555 timer.
- 2) Consider the monostable multivibrator circuit given in Fig. 1. What kind of input signal should be applied to the circuit for proper operation? Explain operation principle of this circuit in detail drawing required graphs. Moreover design a circuit doing the same operation using NAND gates, an inductor and a resistor. Calculate the value of the inductance which is needed to be used to observe same output characteristics with Fig. 1 in terms of resistor and capacitor values used in Fig. 1.

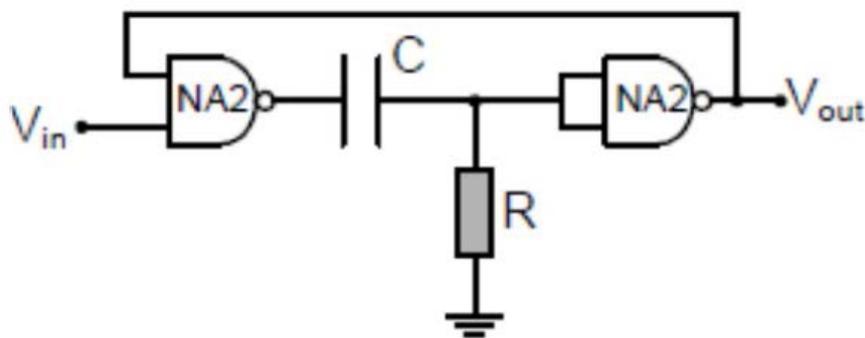


Fig. 1: The monostable multivibrator

- 3) Design a triangular wave generator using 555 Timer and 741 OPAMP whose frequency is 1 kHz, and verify your design using LTSPICE. Show your design procedure in detail and bring snapshot of the simulation results.  
(**Hint:** Design a bistable multivibrator with 555 Timer and an integrator with 741 OPAMP and then combine them with a proper feedback loop.)  
(**Note:** SPICE model of 555 timer can be reached under [Misc] directory with NE 555 name as shown in Fig. 2.)

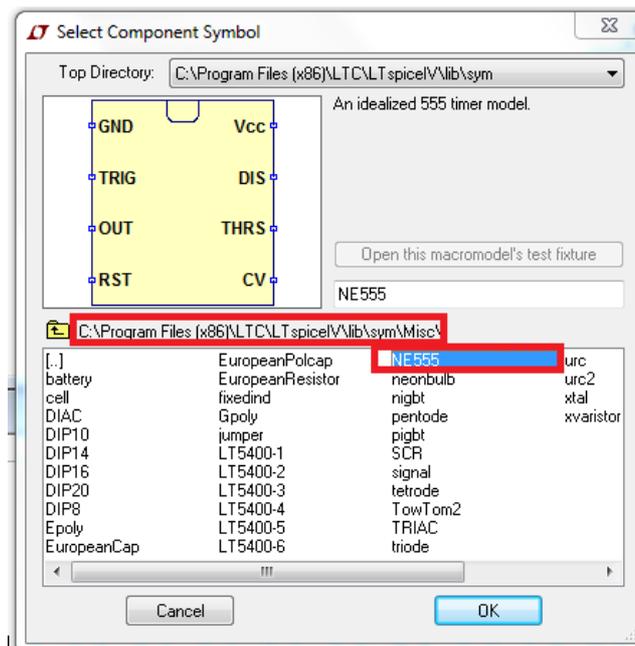


Fig. 2: Choosing 555 Timer from the component list

**4) Design of a smart lighting system using multivibrators:** Assume that you are a system engineer and you are asked to design a smart lighting system which detects movement and becomes active when light intensity drops below a certain level. The designed system should have following specifications:

- The movement sensor has an active low **enable pin** and it is enabled 100 times in a second when light intensity drops.
- The output of the light sensor is noisy. Therefore to prevent effect of the noise on the lighting system, a comparator with 250 mV hysteresis is needed to be used.
- When light intensity is below a certain level, a LED should be light on for 10 seconds.
- You can use 555 Timer, LM741 opamp, any type of resistor or capacitor and the light sensor and movement sensor whose specifications are given below.

- a) Draw the block diagram of the system you designed.
- b) Design the comparator you use in your system with LM741 opamp, and verify your design using LTSPICE. Show your design procedure in detail and bring snapshot of the simulation results. (Hint: You are supposed to design a non-inverting comparator)
- c) Design an astable multivibrator circuit you use in your system with 555 timer and verify your design using LTSPICE. Show your design procedure in detail and bring snapshot of the simulation results.
- d) Design the monostable multivibrator circuit you use in your system with 555 timer and verify your design using LTSPICE. Show your design procedure in detail and bring snapshot of the simulation results.

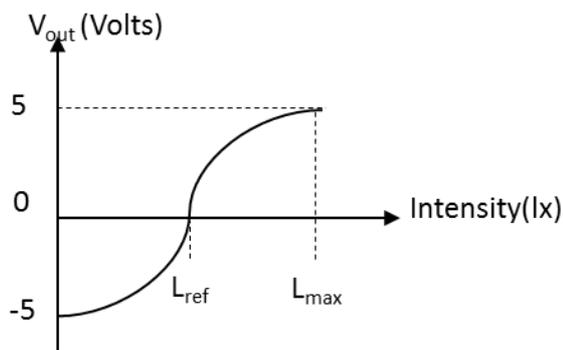


Fig. 3: Output vs Light Intensity graph of the light sensor

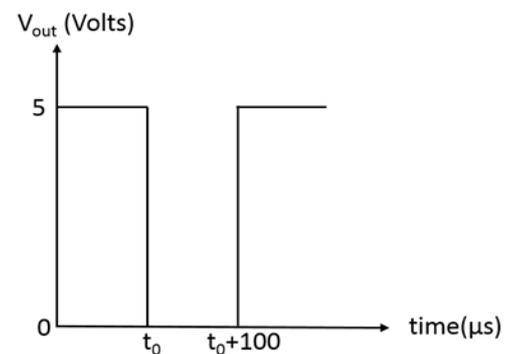


Fig. 4: Movement is detected at  $t_0$  by the movement detector while it is enabled

### III. Experimental Work

#### a) Basic Schmitt Trigger

- 1) Construct the comparator circuit you designed in Preliminary Work. ( $V_{DD}=5V$ ,  $V_{SS}=-5V$ ). Connect signal generator to input of the circuit you constructed and apply a sinusoidal wave whose amplitude is  $8 V_{pp}$  and frequency is 1 KHz. Observe the input and output signals. Are the results similar to what you are expecting? Obtain VTC of the circuit you designed using oscilloscope. (Hint: Use the oscilloscope in XY mode)
- 2) What would you do to increase hysteresis to 500 mV. Propose a method and try it.

#### b) Monostable Multivibrator

- 1) Construct the circuit given in Figure 3. Use  $R=1\text{ k}\Omega$  and  $C=1\text{ }\mu\text{F}$ . Connect signal generator to input of the circuit you constructed and apply a square wave with  $5 V_{pp}$  magnitude, 2.5 V offset and 100 Hz frequency. Observe  $V_{out}$  and  $V_{in}$  indicating all the voltage levels and time intervals. Measure the pulse width of output signal. Moreover observe the voltage waveform on the resistor and comment on it.
- 2) Increase frequency of the waveform you applied to 200 Hz and repeat the same procedure with part b 1.
- 3) Use  $R=10\text{ k}\Omega$  and  $C=1\text{ }\mu\text{F}$  and repeat same procedure with part b 1.
- 4) Construct the monostable multivibrator you designed in your preliminary work. Connect a push button to input of the circuit which is connected to VDD by default and connected to GND when pushed. The switch circuit is shown in Fig. 4. Note that, the aim of connecting capacitor parallel to switch is to prevent unwanted pushes at one time.

(**Note:** When you push the switch once, unwanted and short pulses occurs. Connecting capacitor we are filtering these unwanted pulses.)

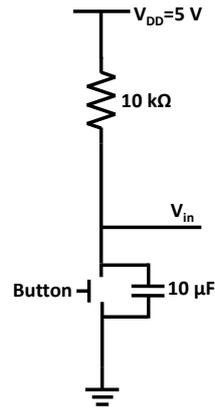


Fig. 4: Switch Circuit

**c) Astable Multivibrator Circuit**

- 1) Construct the astable multivibrator circuit you designed in your preliminary work. Observe output signal. How can you increase the frequency of the circuit to 200 Hz? Propose at least two methods, and try the methods you proposed.

**d) Triangular Wave Generator**

- 1) Construct the triangular wave generator you designed in your preliminary work. Observe output signal. How can you increase the frequency of the circuit to 2 KHz? Propose a method, and try the method you proposed.

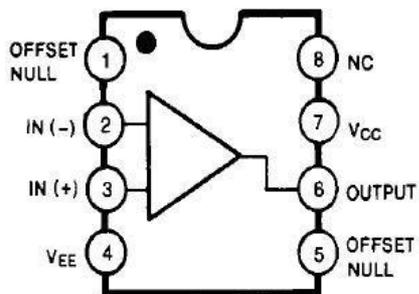
## IC LIST FOR EXPERIMENT 7

741 IC Operational Amplifier-OPAMP

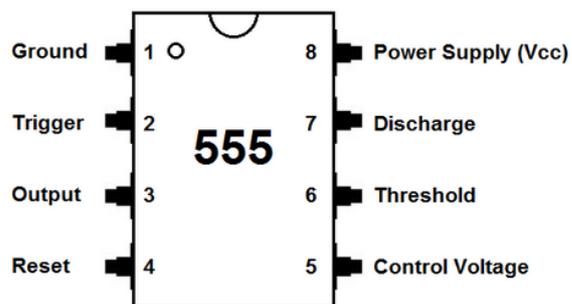
555 IC Timer IC

74HC00 2-input Quad NAND gate

### Pin Diagram of 741 OPAMP



### Pin Diagram of 555 Timer



### Pin Diagram 74HC00

