University of British Columbia
Electrical and Computer Engineering
ELEC 302
Electronic Circuits for Electromechanical Design
Instructor: Dr. Kenichi Takahata

Laboratory 2 – Bistable and Monostable Multivibrators

Introduction

This laboratory explores various simple, but useful bistable and monostable multivibrator circuits based on operational amplifiers. These circuits are characteristic of the type of circuitry commonly found in commercially available equipment such as oscillators and alarms.

Before you start, make sure to read **Lab Instructions.pdf** posted on the course website. This laboratory also assumes that you have read **Oscilloscope operation & Part identification.pdf**.

Components Required for the Laboratory

- Two-channel oscilloscope
- Function generator
- Dual DC power supply
- LM741 operational amplifiers
- 1N4005 diode
- Potentiometer (100Ω-1kΩ)
- Resistors
- Capacitors

Pre-laboratory Assignments

1) Review the lecture notes and Sections 13.4 and 13.6 of the text for the multivibrators.
2) Have the data sheets for the op amp and the diode listed above.
3) Read the description of Tasks in these sheets.
4) Find an expression for the theoretical pulse duration at the output of the monostable multivibrator circuit shown in Fig. 2.3(b) in terms of resistors, capacitors, and voltages involved in the circuit. (Hint: can be done with R_2, C_2, L_+, L_-, and V_{ref})

References

A.S. Sedra, K.C. Smith, "Microelectronic Circuits 5th edition," Oxford University Press

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Task 1: Bistable Multivibrator (Schmitt Trigger)

A comparator circuit is one in which the output switches between two voltages as the input crosses a voltage threshold (Figs. 2.1(a) and (b)). On the other hand, Schmitt Triggers are comparator circuits with hysteresis, i.e., the input voltage switching thresholds are different depending on whether the input is increasing or decreasing. Typical characteristics of two different Schmitt triggers are shown in Figs. 2.1(c) and (d). The switching thresholds are often referred to as trigger points (V_{t1} and V_{t2} in the figures).

Schmitt triggers are also referred to as bistable circuits because the output has two stable states (here, stable means that the output maintains its state unless an event (crossing one of the trigger points) happens at the input). Schmitt trigger circuits have applications in oscillators and timing circuits. They are also used as comparator for their noise rejection property as noted in the lecture and the text. You can use the concept of Schmitt trigger circuits and hysteresis to design and analyze the circuits required for the next experiment. Figures 2.2(a) and (b) show two of many possible implementations of Schmitt trigger circuits using an operational amplifier.

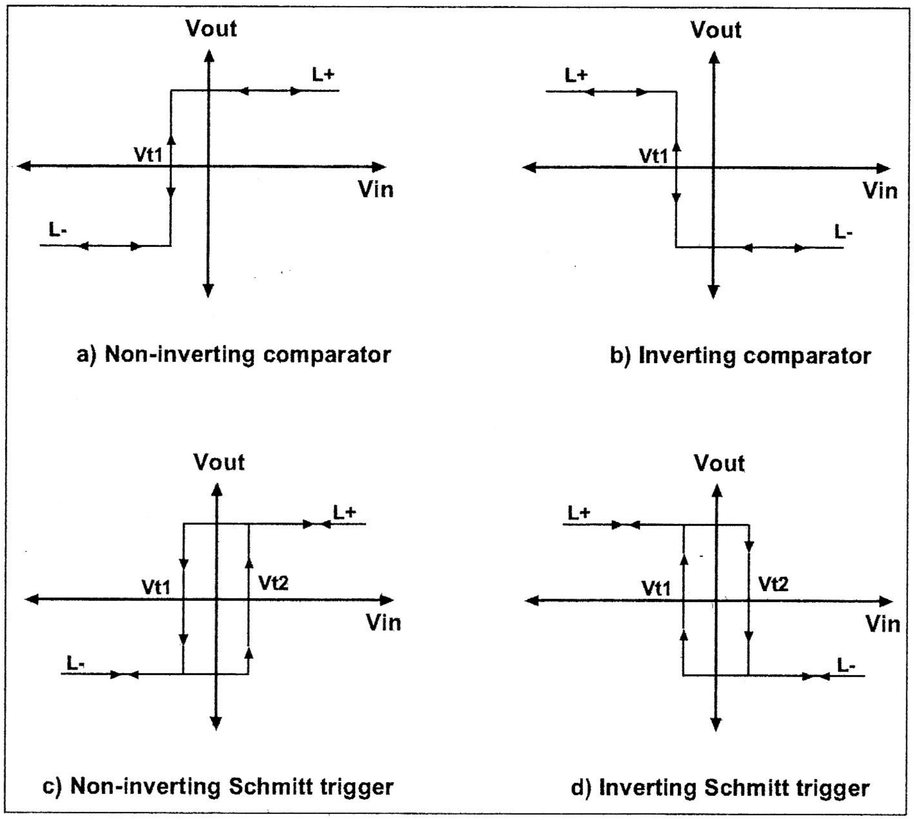

Figure 2.1: Comparator and Schmitt trigger characteristic curves

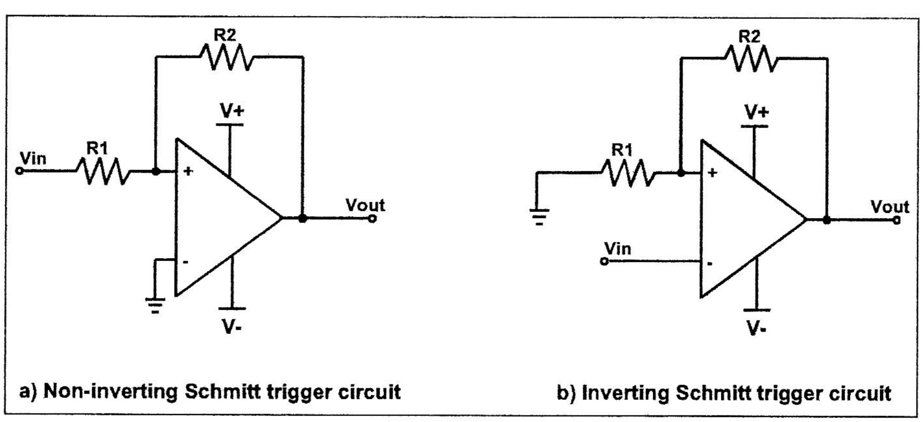

Figure 2.2: Schmitt Trigger circuits

Use the circuit in Fig. 2.2(a) and perform the following steps:

1) For the circuit, find expressions of the typical hysteresis trigger points (V_{t1} and V_{t2}) in terms of R_1, R_2, and the positive and negative op-amp saturation voltages (L_+ and L_-).
2) Choose R_1 and R_2 to obtain $V_{t2}=|V_{t1}|=3$ V. Note that, due to voltage drops within its internal transistors, the saturation voltages at the output of the 741 op amp are approximately ±14 V with supply voltages of ±15 V.
3) Set up the circuit as shown in Fig. 2.2(a). Set the signal generator to supply a triangular waveform of 100-Hz frequency and peak-to-peak amplitude of 16 V. (A low frequency triangular waveform is often used to view the DC characteristic of a circuit.)
4) Connect the CH 1 probe to V_{in} and the CH 2 probe to V_{out}. Change the display mode of the oscilloscope to XY mode and set CH 1 and CH 2 voltage settings to appropriate values. What is the minimum peak-to-peak value of V_{in} in order to observe the trigger points of the hysteresis loop?
5) Plot DC transfer characteristic of the Schmitt trigger. Measure L_+, L_-, V_{t1}, and V_{t2}. Compare your measurements with the theoretical values. Comment on any discrepancies and possible factors that may have caused them.

Task 2: Monostable Multivibrator

Monostable circuits are switching circuits with one stable state at the output. In these circuits, the output switches to another state (unstable state) as the input crosses a threshold voltage, and returns to a stable state after a specific period of time (refer to Fig. 2.3(a)). Monostable circuits have applications in timing circuits, e.g., when in a system a certain operation has to be performed for a specific duration of time after a trigger signal is generated. One realization of monostable circuits is shown in Fig. 2.3(b) (<u>note that the configuration is different from the one reviewed in the lecture</u>).

In this section, you will examine the operation of the monostable circuit in Fig. 2.3(b). Perform the following steps:

1) Choose $-V_{ref}$, R_1, C_1, R_2, and C_2 to obtain a pulse width of 1 msec. You can generate $-V_{ref}$ by using a potentiometer as a voltage divider between V_+ and V_-. Obtain the required components and assemble the circuit.
2) Connect the signal generator output to V_{in} and select a square wave of 200-Hz frequency and 10 V_{pp} amplitude. Observe and plot the voltage waveforms at nodes V_{in}, A, B, and V_{out}, indicating key voltage levels and time relationships. Measure the width of the output pulse. (Note that this is the negative portion of the output waveform.)
3) Compare your observation with the predicted pulse width and comment on any discrepancies.
4) Slowly increase the frequency to 1 kHz and observe the output. What is the pulse width at the frequency 1 kHz? Based on your observation and your knowledge of circuit operation, explain why the pulse width is different from that measured in step 2. You can look at the voltage waveforms at other nodes of the circuit for more clues. Increasing the input frequency might also help you to find the answer.

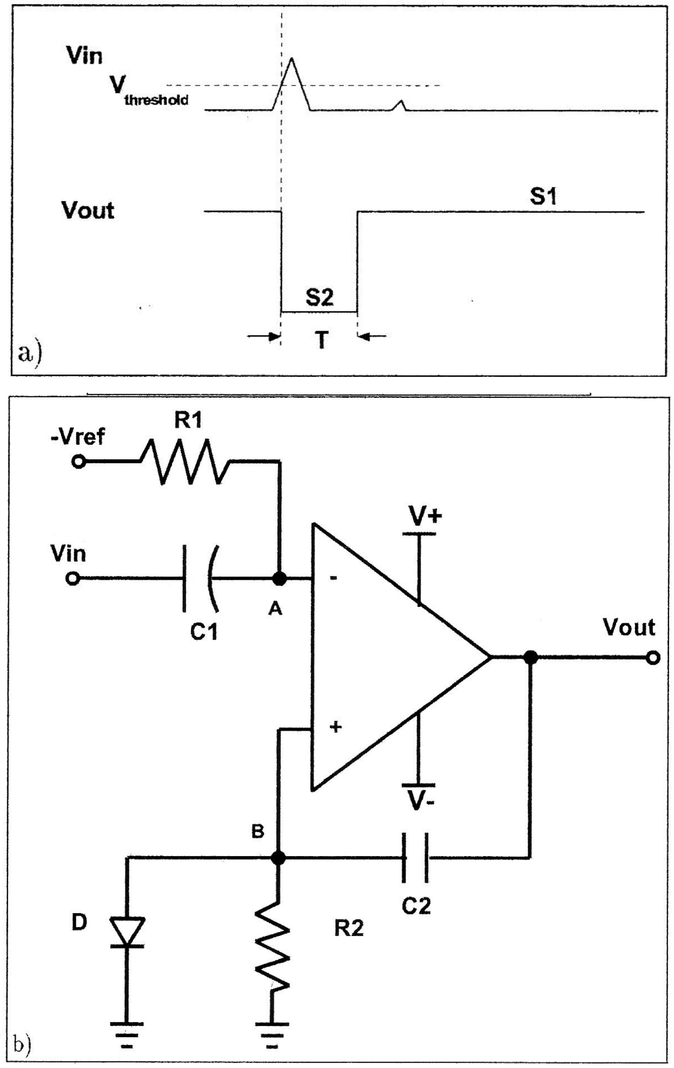

Figure 2.3: (a) Triggering in a monostable circuit, (b) a monostable multivibrator circuit

Report (due date & time – see "Laboratory" page on the course website)

An individual report is required for this experiment. Refer to "Lab instructions.pdf" and follow the report format and other instructions described. Please ensure to present all your data clearly (using diagrams, tables, and graphs as required) and include the following:

- Explanation of the tests that were undertaken and diagrams of their set-ups.
- Descriptions of the measurements you performed in the laboratory.
- Table(s) of measurements obtained where applicable.
- The pre-lab work at the beginning of your report.