CENG4480 Embedded System Development and Applications
The Chinese University of Hong Kong

Laboratory 2: Op Amp – 2

Your Name:
Student ID:

2020 Fall

1 Introduction

This lab session introduces some very basic concepts of operational amplifier "op amp" that every engineering student should know about. The op amp used in this lab is LM324. In this lab we use TINA-TI Simulator to construct some typical op amp circuits and simulate their function and study their behavior.

1.1 Objectives

By completing this lab session, you should know:

- how to use op amp circuits to interface between sensors and MCU;
- how to design amplifier circuit using op amp and
- how to design integrator and differentiator circuit using an op amp

1.2 Guidelines for TINA-TI Setup and Basics

Plz follow the report. as described in the previous lab. Find it Here

2 Experiment 1. Differential Amplifier

In this experiment, you will construct and observe the Differential Amplifier. Record the input and output simulation waveforms.

Procedures

1) Similar to previous Experiments, use TINA-TI simulator to construct Differential Amplifier as shown in the Figure 1. Configure **Battery** V1 to 5V and V2 to 1V, input signal VG1 (**Voltage Generator**) as shown in Figure 2. (**DC Level: 250m, Sine wave, Amplitude: 250m, Frequency: 1k**)

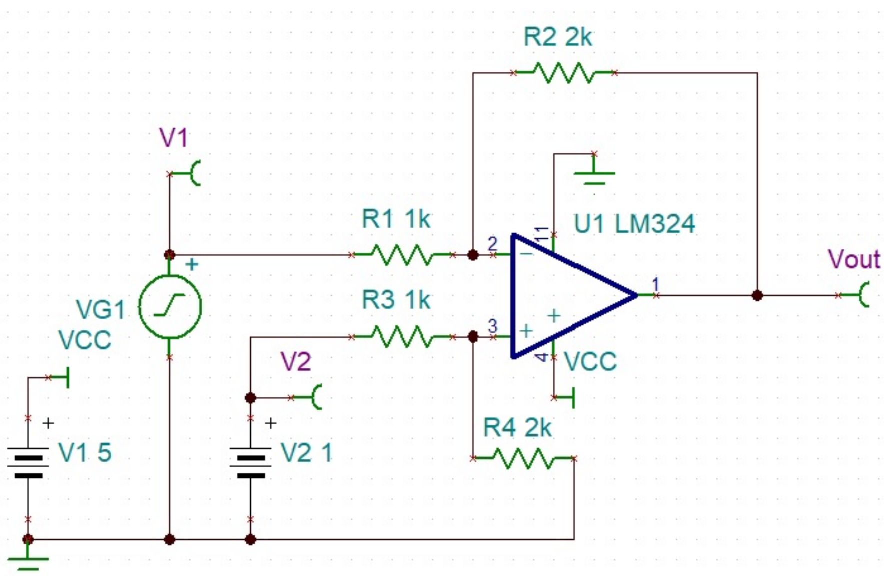
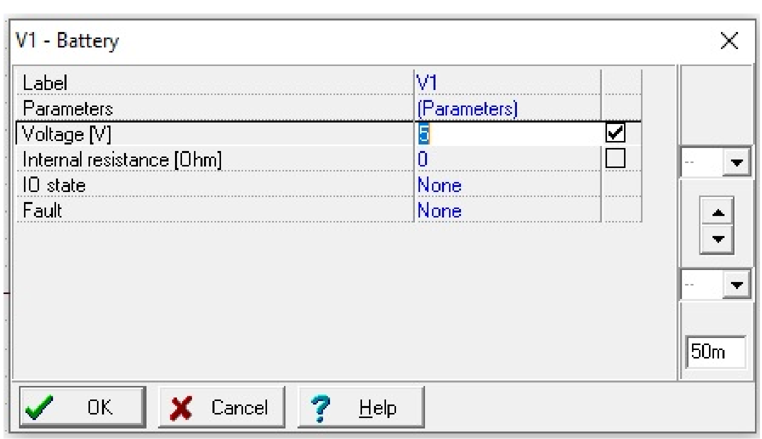


Figure 1: Differential Amplifier

2) [**Task 1**] Capture your oscilloscope screen with V1, V2 and Vout waveforms displayed on the screen. Attached the captured screen and based on the result of the simulation waveforms (use peak to peak Vp-p value of V1, V2 and Vout from the oscilloscope screen) state the voltage gain $V_{out}/V_{in} = V_{out}/(V2\text{-}V1)$ in your lab report.



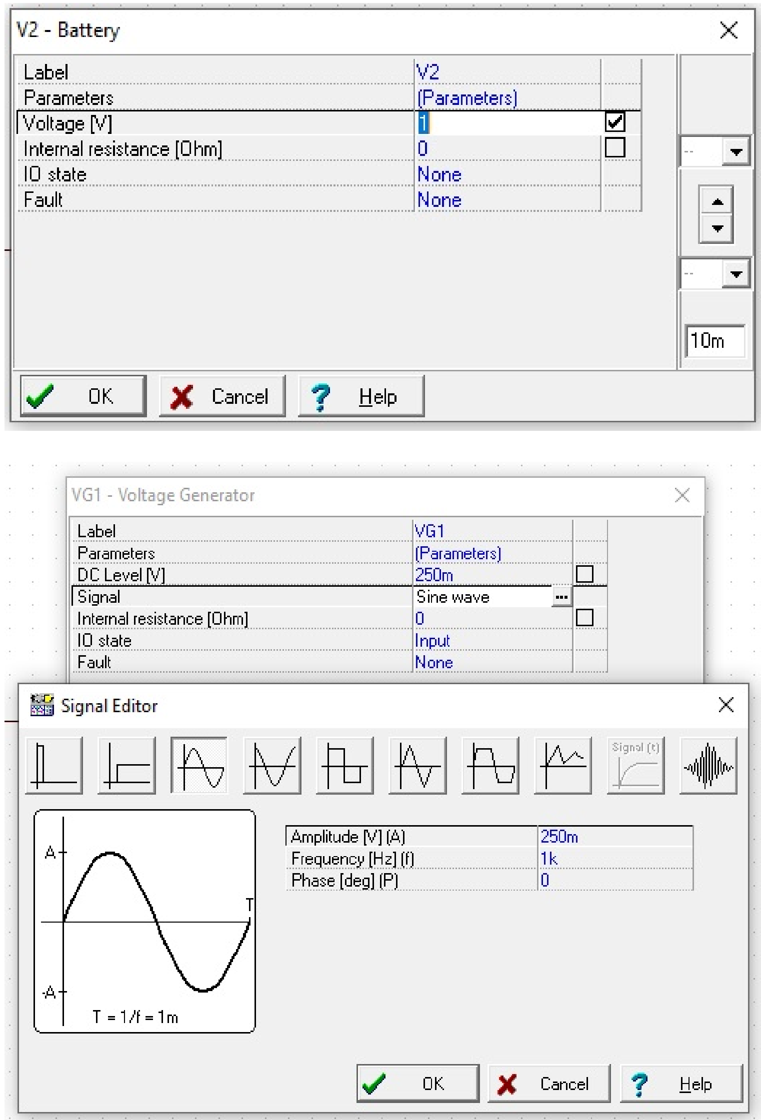


Figure 2: Detailed Configurations for Experiment 1

3) [**Task 2**] In your lab report, give your derivation and compare the calculated with simulation output voltages.

3 Experiment 2. Summing Amplifier

In this experiment, you will construct and observe Summing Amplifier. Record the input and output waveforms.

1) Similar to previous Experiments, use TINA-TI simulator to construct Summing Amplifier as shown in the Figure 1. Configure **Battery** V1 to 5V and V2 to -0.3V, input signal VG1 (**Voltage Generator**) as shown in Figure 1. **(DC Level: -250m, Sine wave, Amplitude: 250m, Frequency: 1k)**

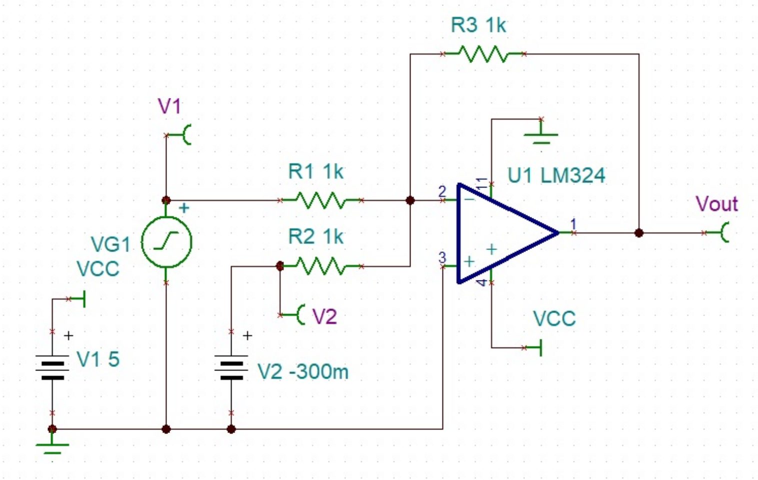


Figure 3: Summing Amplifier

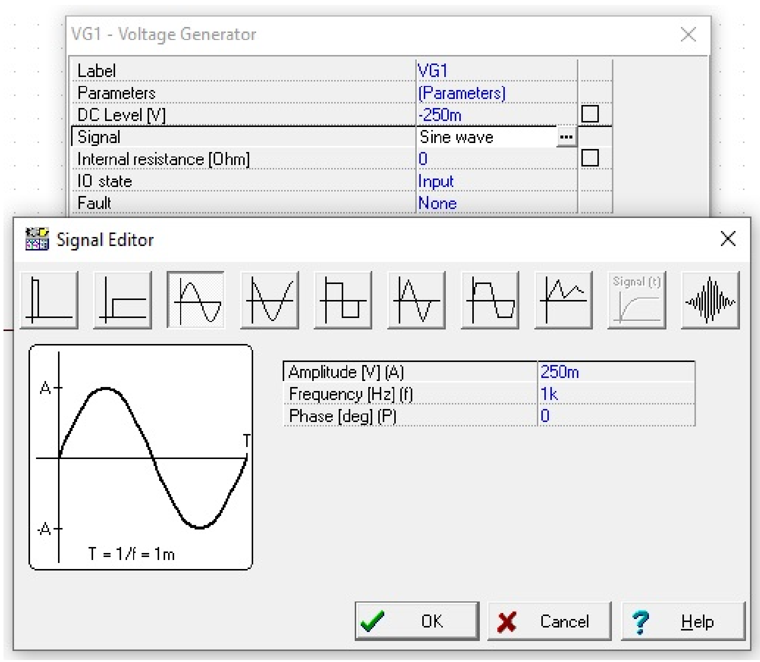


Figure 4: Detailed Configurations for Experiment 2

2) [**Task 3**] Capture your oscilloscope screen with V1, V2 and V_{out} waveforms displayed on the screen. Attached the captured screen and based on the result of the simulation conclude the voltage gain $V_{out}/(V1+V2)$ in your lab report.

4 Experiment 3. Integrator

In this experiment, you will construct and observe Integrator. Record the input and output waveforms.

1) Similar to previous Experiments, use TINA-TI simulator to construct Integrator as shown in the Figure 1. Configure **Battery** V1 to 5V, input signal VG1 (Voltage Generator) as shown in Figure 2. **(DC Level: -250m, Square wave, Amplitude: 250m, Frequency: 1k)**

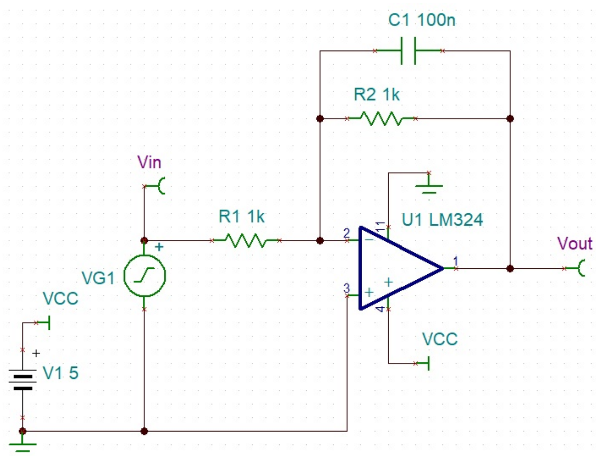


Figure 5: Integrator

2) [**Task 4**] Capture your oscilloscope screen with V_{in} and V_{out} waveforms displayed on the screen. Attached the captured screen in your lab report.

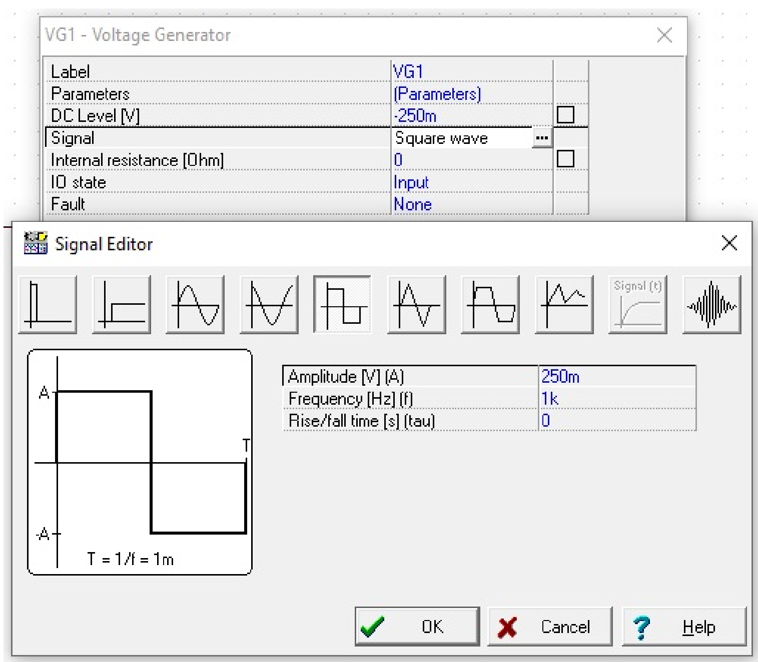


Figure 6: Detailed Configurations for Integrator

5 Differentiator

In this experiment, you will construct and observe Differentiator. Record the input and output waveforms.

1) Similar to previous Experiments, use TINA-TI simulator to construct Differentiator as shown in the Figure 1. Configure **Battery** V1 to 5V, input signal VG1 (**Voltage Generator**) as shown in Figure 2. **(DC Level: -250m, Square wave, Amplitude: 250m, Frequency: 1k)**

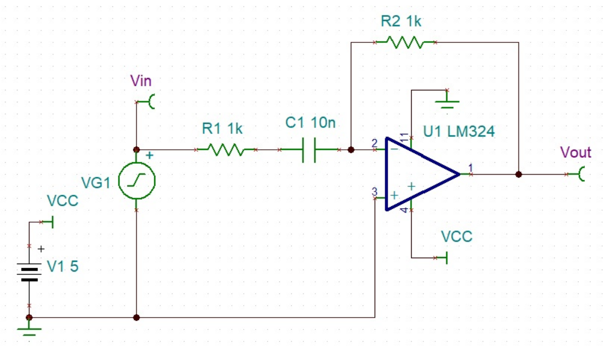


Figure 7: Differentiator

2) [**Task 5**] Capture your oscilloscope screen with V_{in} and V_{out} waveforms displayed on the screen. Attached the captured screen in your lab report.

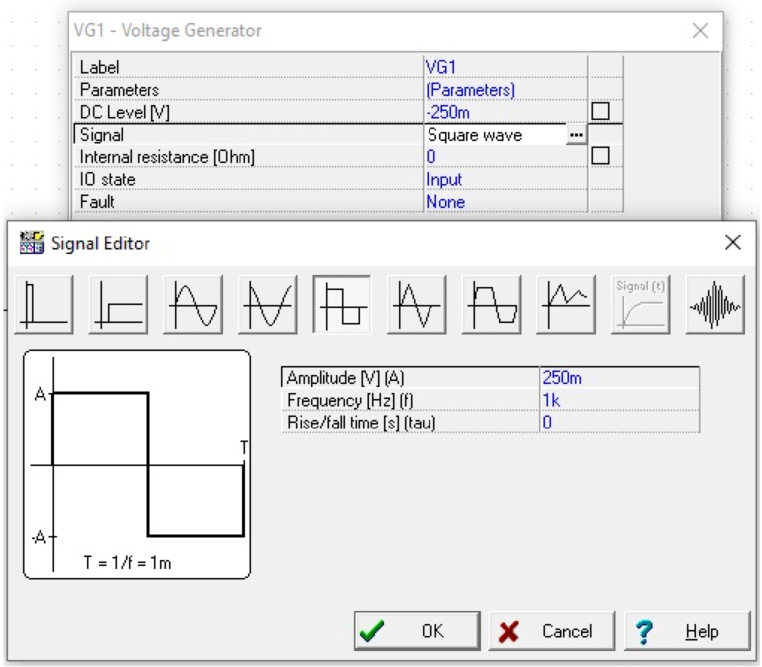


Figure 8: Detailed Configurations for Differentiator

6 Non-inverting Schmitt Trigger

In this experiment, you will construct and observe the Non-inverting Schmitt trigger shown in Figure 9. Measure the Hysteresis (V_{TH} - V_{TL}) with different value of R1.

1) Similar to previous Experiments, use TINA-TI simulator to construct Non-inverting Schmitt trigger as shown in the Figure 1. Configure **Battery** V1 to 5V, input signal VG1 (Voltage Generator) as shown in Figure 1. **(DC Level: 2.5, Triangular wave, Amplitude: 2.5, Frequency: 100)**

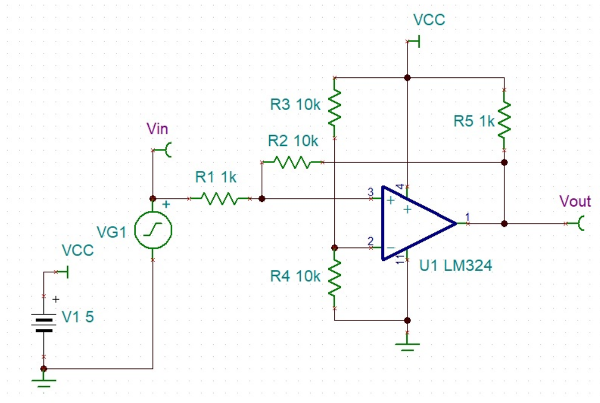


Figure 9: Non-inverting Schmitt Trigger

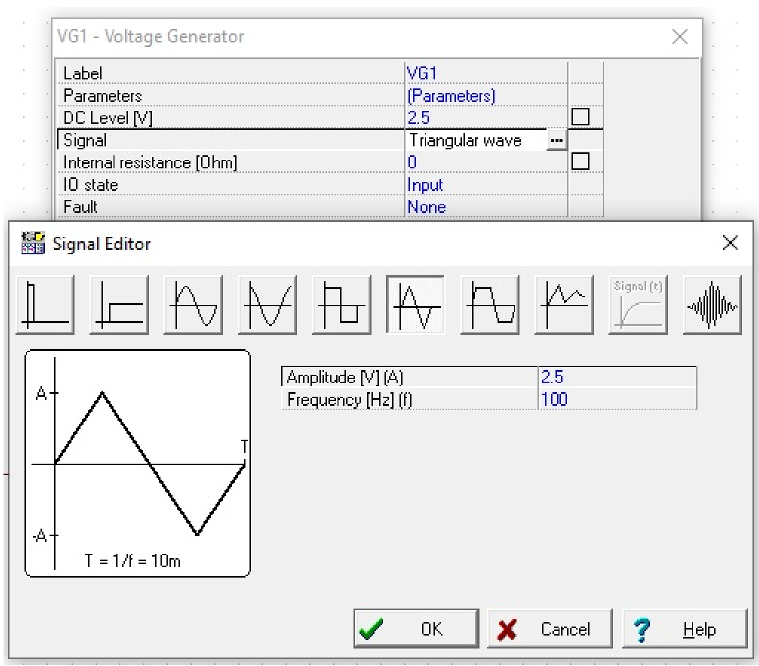
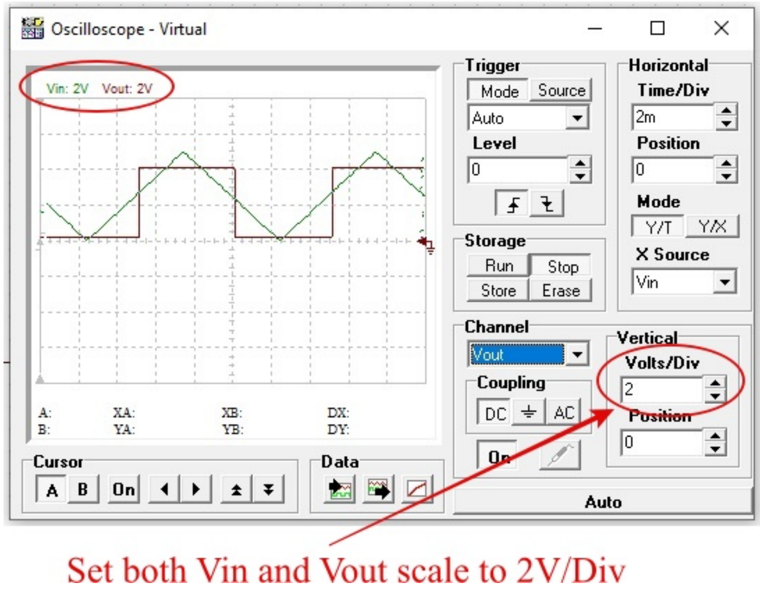
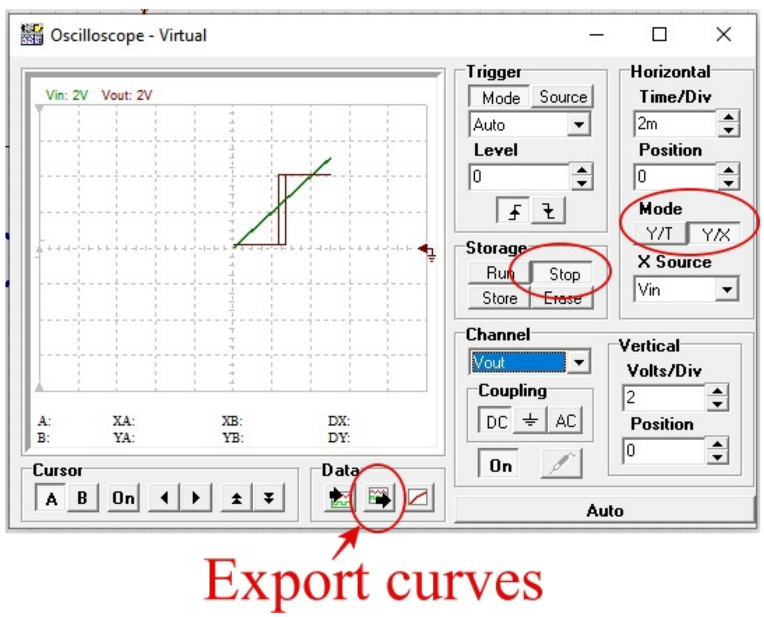


Figure 10: Detailed Configurations I for Non-inverting Schmitt Trigger

2) Add Oscilloscope, add V_{in} and V_{out} Channels, press **Run**, set both V_{in} and V_{out} scale to 2V/Div

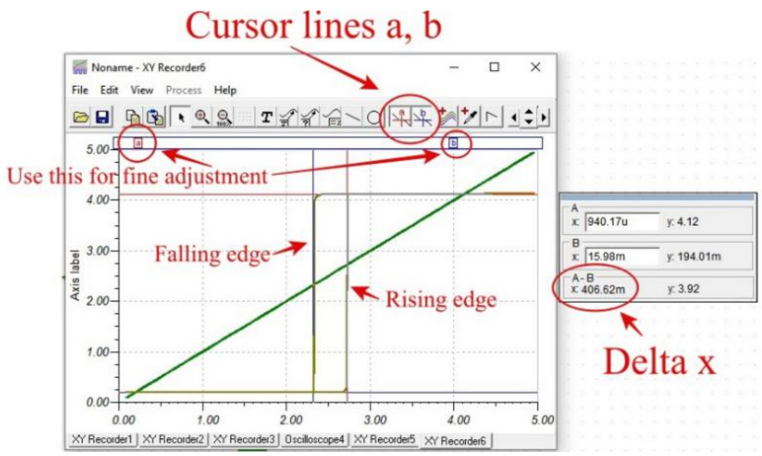


3) Then select **Y/X Mode**, press **Stop**, and press **Export curves**



4) Measure the △X

- On the Exported curve, add a and b cursor lines, adjust the position of the cursor lines to the rising edge (V_{TH}) and falling edge (V_{TL}) of the curve as shown on the picture below.
- Record the △X (406.62mV in here)



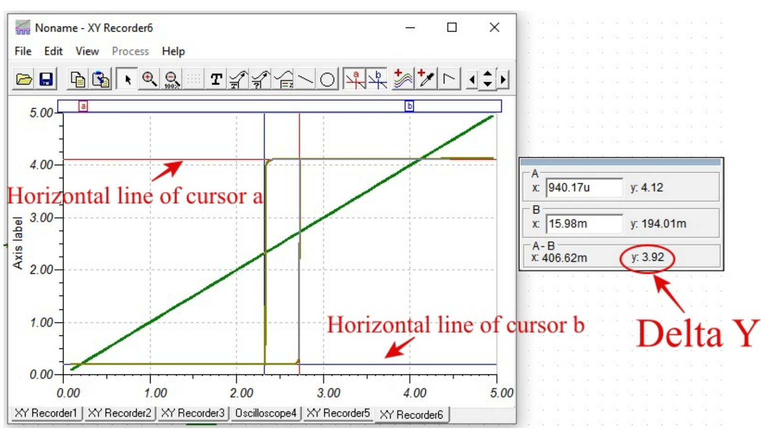
- Hence the Hysteresis of the Schmitt trigger circuit

$$Hysteresis = V_{TH} - V_{TL} = \triangle X = 406.64mV \tag{1}$$

- Another way to measure Hysteresis of the Schmitt trigger circuit is

$$Hysteresis = V_{ohigh} - V_{olow}\frac{R_1}{R_2} = \triangle Y\frac{R_1}{R_2} \tag{2}$$

- To measure △Y, adjust the horizontal line of cursor a to V_{ohigh} of the curve and adjust the horizontal line of the cursor b to V_{olow} of the curve



- Record the $\triangle$Y (3.92V in here)
- Hence the Hysteresis of the Schmitt trigger circuit is

$$Hysteresis = \triangle Y \frac{R_1}{R_2} = 3.92 \times \frac{1k}{10k} = 0.392V \tag{3}$$

5) Repeat steps 2. to 4. with **R1 = 2K, R1 = 3.9K and R1 = 8.2K**

6) [**Task 6**] Fill in the table below

R1	$Hysteresis = \triangle X$	$Hysteresis = \triangle Y \frac{R_1}{R_2}$
1k		
2k		
3.9k		
8.2k		

Table 1: Caption

Send your report to your tutor, with your name and student ID!