

CENG4480 Embedded System Development and Applications
The Chinese University of Hong Kong
Laboratory 3: Op Amp — Active Filter

Your Name:

Student ID:

2020 Fall

1 Introduction

This lab session introduces some active filters constructed using op amp. The op amp used in this lab is LM324. In this lab we use TINA-TI Simulator to construct some typical active filters circuits and simulate their function and study their behavior.

1.1 Objectives

By completing this lab session, you should know:

- how to design active filter;
- how to design low pass, high pass, band stop and multivibrator by using op amp

1.2 Procedures

Follow the procedures of each experiment. Submit a lab report sheet with your name and student ID to the tutor after the lab. The lab report sheet should have the measurements or plots of your experiments, and answers of the questions asked in this lab manual. You may prepare using a computer document and use a camera to capture the waveforms and insert them in your report.

1.3 Guidelines for TINA-TI Setup and Basics

Plz follow the report. as described in the previous lab. Find it [Here](#)

2 Experiment 1. One-pole low pass filter

In this experiment, you will construct and observe the one-pole low pass filter by using TINA-TI. Measure the output waveform against different frequencies.

Procedures

- 1) Similar to previous Experiments, use TINA-TI simulator to construct One-pole Low Pass Filter as shown in the Figure 1. Configure **Battery** V1 to 5V, input signal VG1 (**Voltage Generator**) as shown in Figure 1. (**DC Level: -1.5, Sine wave**)

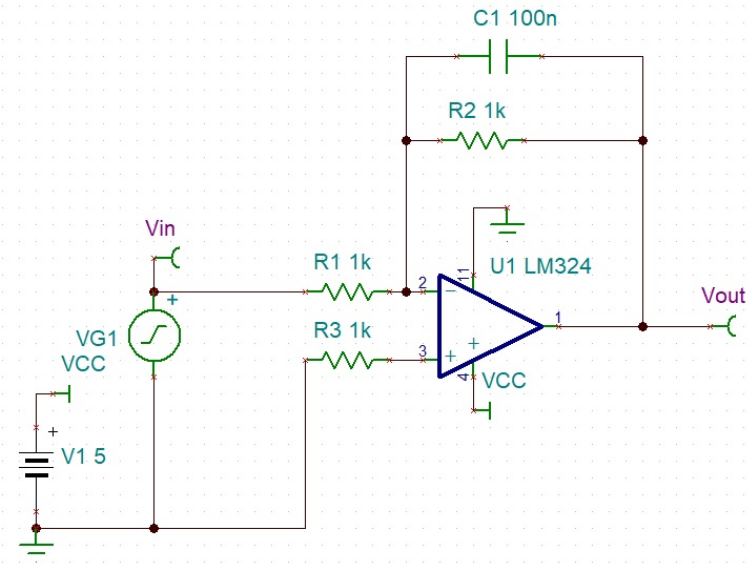


Figure 1: One-pole Low Pass Filter

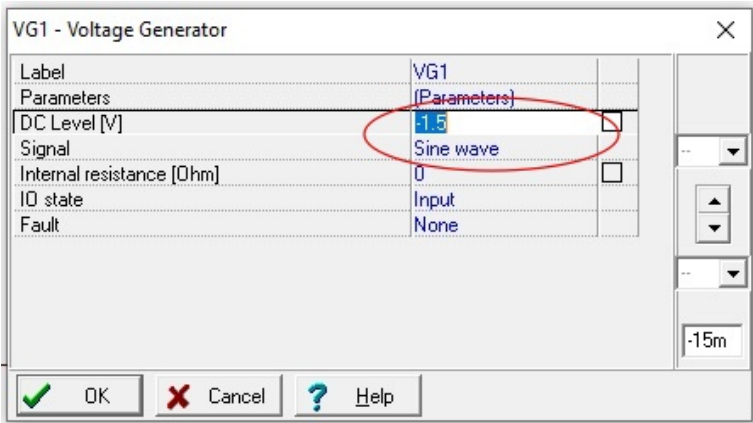


Figure 2: Detailed Configurations for Experiment 1

2) Add **Signal Analyzer**

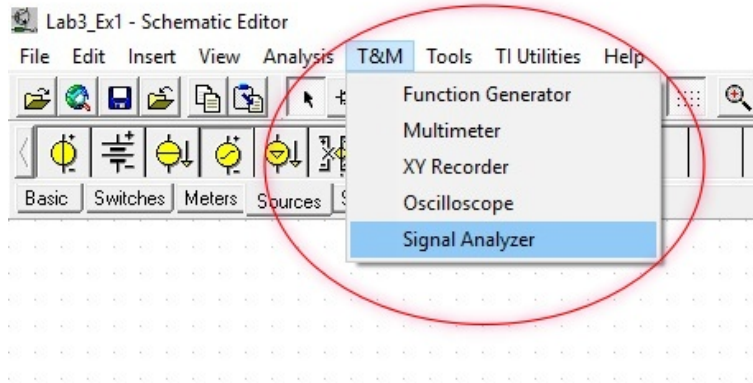
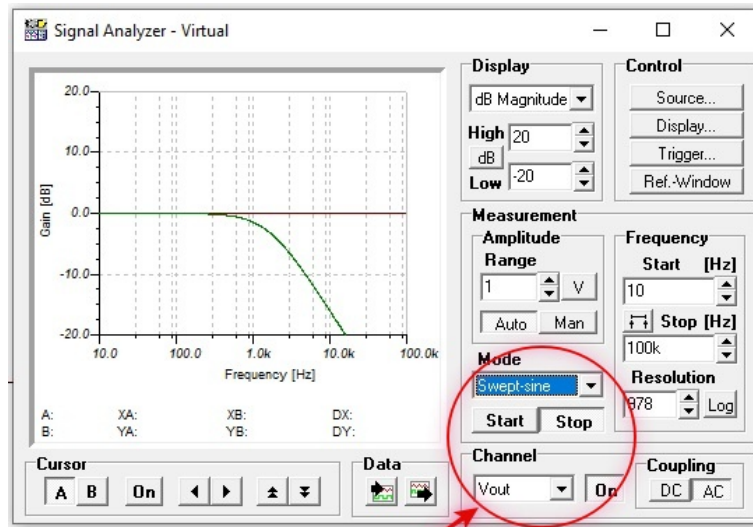


Figure 3: Detailed Operations for Experiment 1

3) Set **Channel** to V_{out} , then press **Start**. The frequency response curve of the circuit will be displayed

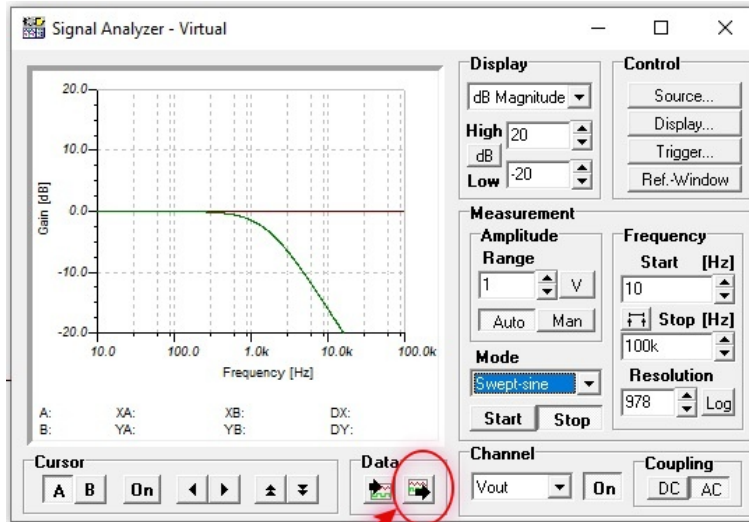


Set Channel to V_{out} , then press Start

Figure 4: Detailed Operations for Experiment 1

- 4) Then press **Export curves**
- 5) On the exported curve add cursor line a, adjust the cursor line position to -3dB point as shown on the below picture. Record the cut off frequency F_c (1.59Khz in here)
- 6) The cut off frequency F_c can also be calculated by following equation:

$$F_c = \frac{1}{2\pi R_2 C_1} = \frac{1}{2\pi \times 1000 \times 0.1 \times 10^{-6}} = 1591.55 Hz (R_2 = 1K, C_1 = 0.1\mu F) \quad (1)$$



Export curves

Figure 5: Detailed Operations for Experiment 1

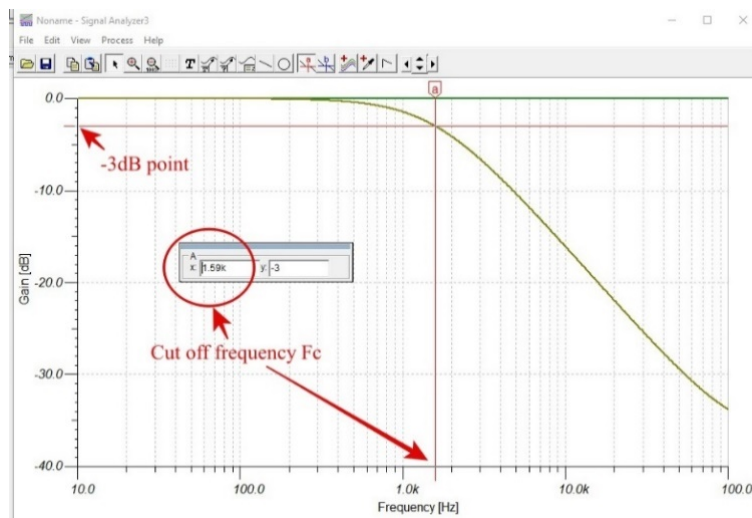


Figure 6: Detailed Operations for Experiment 1

- 7) On the exported curve add another cursor line b, position it on any point of the curve and calculate the slope of the curve

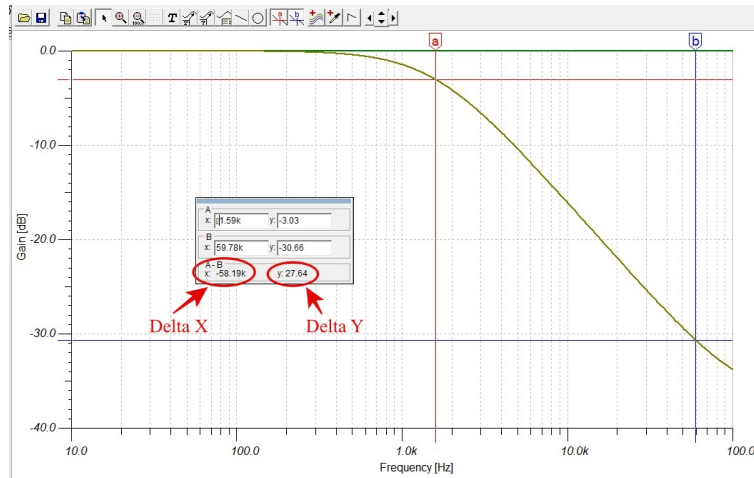


Figure 7: Detailed Operations for Experiment 1

$$Slope = \frac{\delta Y}{\delta X} = \frac{27.64}{-58.19} = -0.47 \quad (2)$$

- 8) **[Task 1]** Repeat steps 2) to 7), for $C_1=0.05\mu\text{F}$, $0.01\mu\text{F}$ and $0.005\mu\text{F}$, then fill in the following table:

C_1	F_c by Measurements	F_c by calculation	Slope
0.1 μF			
0.05 μF			
0.01 μF			
0.005 μF			

3 Experiment 2. Two-pole low pass filter

In this experiment, you will construct and observe two-pole low pass filter by using TINA-TI. Measure the output waveform against different frequencies.

- 1) Similar to previous Experiments, use TINA-TI simulator to construct Two-pole Low Pass Filter as shown in the Figure 1. Configure **Battery** V1 to 5V, input signal VG1 (**Voltage Generator**) as shown in Figure 1. (**DC Level: -1.5, Sine wave**)

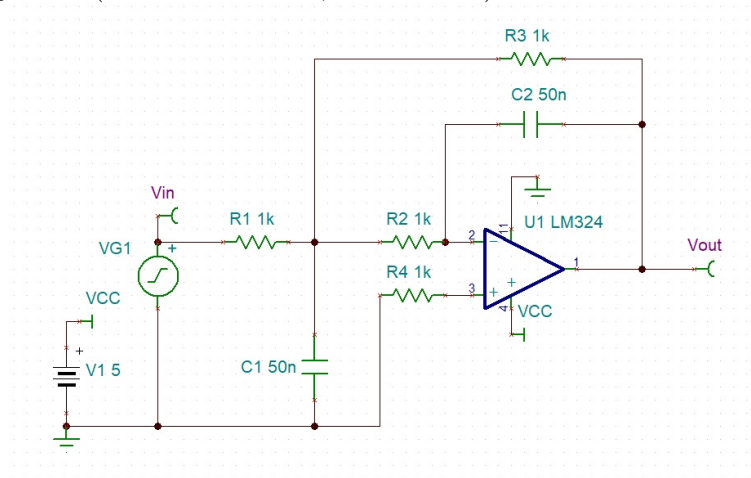


Figure 8: Two-pole Low Pass Filter

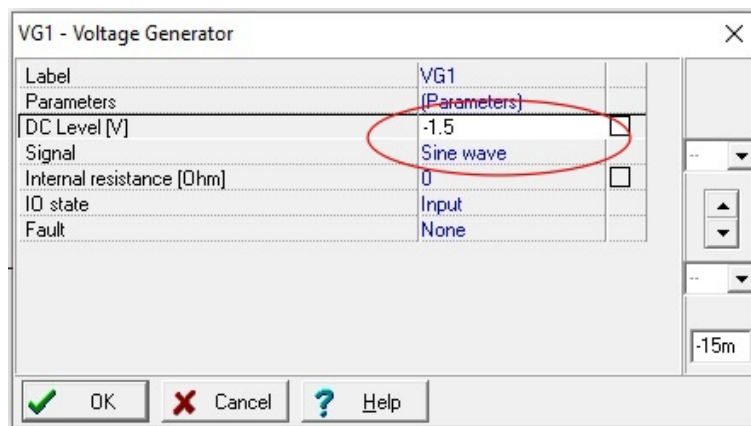


Figure 9: Detailed Configurations for Experiment 2

- 2) **[Task 2]** Similar to the procedures in Ex1, obtain the frequency response curve of Two-pole Low Pass Filter. Find out the cut off frequency F_c of the circuit.

Put your captured frequency response curve on your report and state the F_c of the circuit.

- 3) **[Task 3]** Hence find out the slope of the curve, compare with the slope of One-pole Low Pass Filter.

What can you conclude the different of Two-pole Low Pass Filter from One-pole Low Pass Filter?

Write down your answer on your report.

4 Experiment 3. High pass filter

In this experiment, you will construct and observe High Pass Filter by using TINA-TI. Measure the output waveform against different frequencies.

- 1) Similar to previous Experiments, use TINA-TI simulator to construct High Pass Filter as shown in the Figure 1. Configure **Battery V1** to 5V, input signal **VG1 (Voltage Generator)** as shown in Figure 1. (**DC Level: 1.5, Sine wave**)

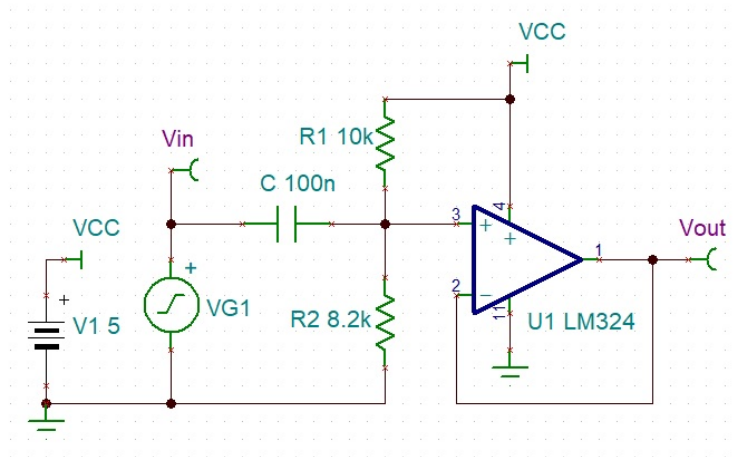


Figure 10: High pass filter

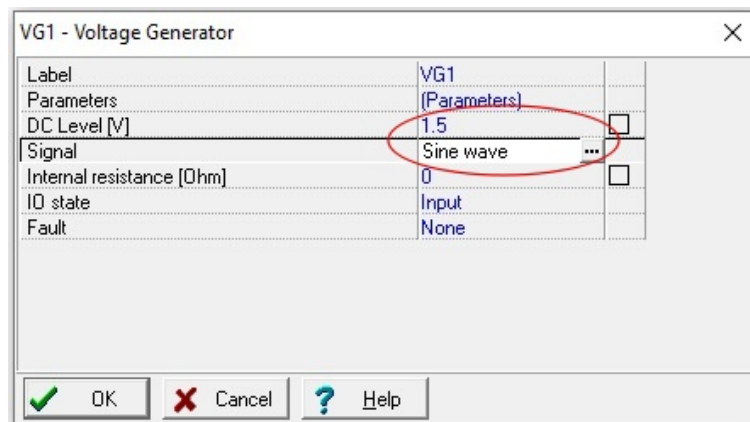


Figure 11: Detailed Configurations for High pass filter

- 2) **[Task 4]** Similar to the procedures in Ex1, obtain the frequency response curve of High Pass Filter. Find out the cut off frequency F_c of the circuit.

Put your captured frequency response curve on your report and state the F_c of the circuit.

5 Band stop (notch) filter

In this experiment, you will construct and observe Band Stop Filter by using TINA-TI. Measure the output waveform against different frequencies.

- 1) Similar to previous Experiments, use TINA-TI simulator to construct Band Stop Filter as shown in the Figure 1. Configure **Battery V1** to 5V, input signal **VG1 (Voltage Generator)** as shown in Figure 1. (**DC Level: 1.5, Sine wave**)

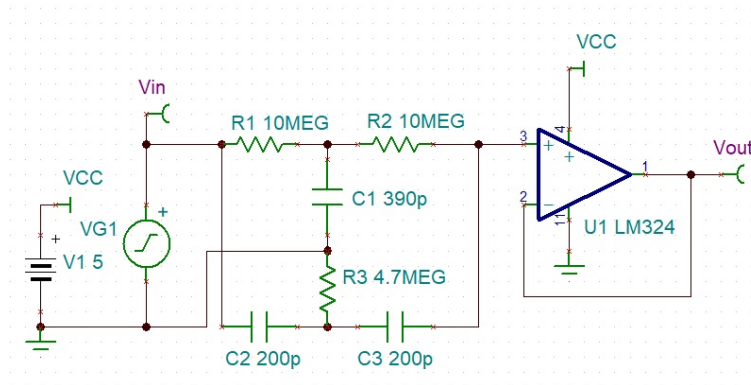


Figure 12: Band stop (notch) filter

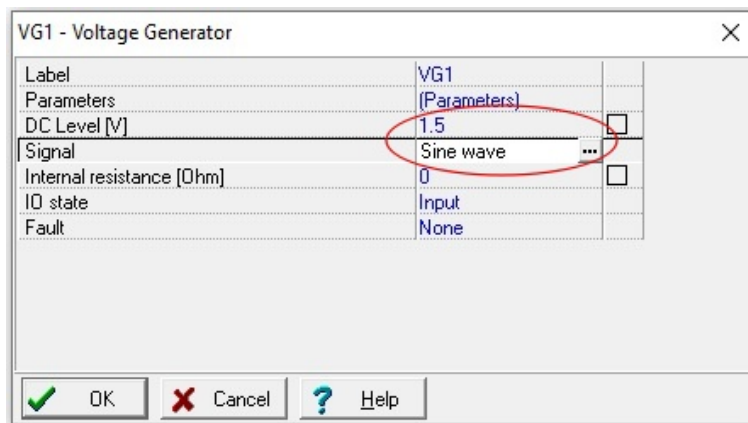


Figure 13: Detailed Configurations for Band stop (notch) filter

- 2) **[Task 5]** Similar to the procedures in Ex1, obtain the frequency response curve of Band Stop Filter. Configure the Signal Analyzer as shown in picture below.

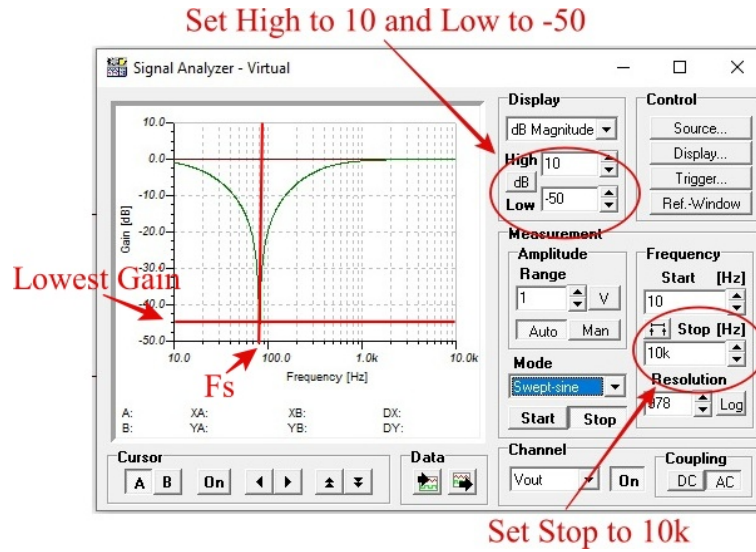


Figure 14: Detailed Configurations for Band stop (notch) filter

- 3) **[Task 6]** Export the curve. Measure the stop frequency F_s and the lowest Gain of the Band Stop Filter. Put your exported curve and write down the answer on your report.

6 Op-amp multivibrator

In this experiment, you will construct and observe an Op-amp multivibrator. Measure the frequency of the square wave generated by multivibrator.

- 1) Similar to previous Experiments, use TINA-TI simulator to construct Op-amp Multivibrator as shown in the Figure 1. Configure **Battery V1** to 5V and V2 to -5V, label V1 as +V and V2 as -V. Add op-amp LM7171A by pressing **Spice Macros** button, then select op-amp as shown in picture below.

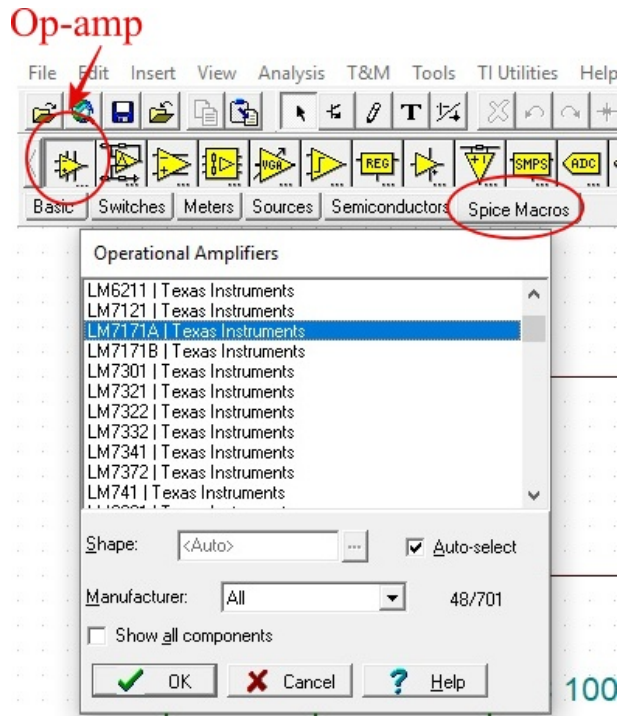


Figure 15: Op-amp multivibrator

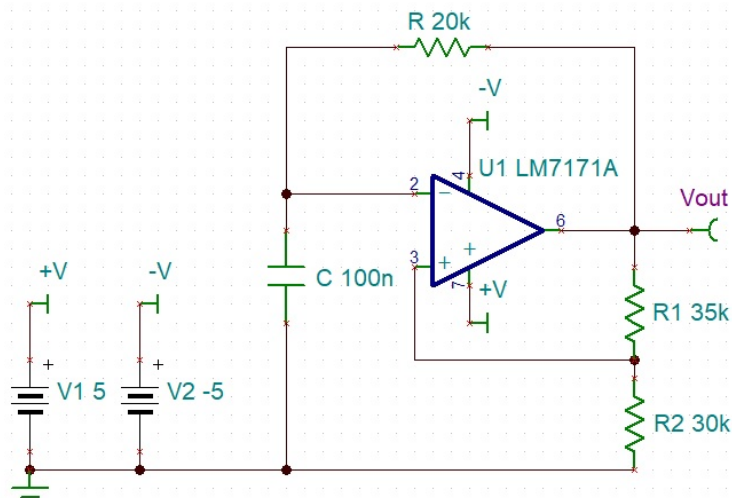


Figure 16: Detailed Configurations for Op-amp multivibrator

- 2) Add Oscilloscope, adjust **Horizontal** scale and **Vertical** scale to appropriate value such that the waveform can be displayed on the screen clearly. Press **Run** and then **Stop**

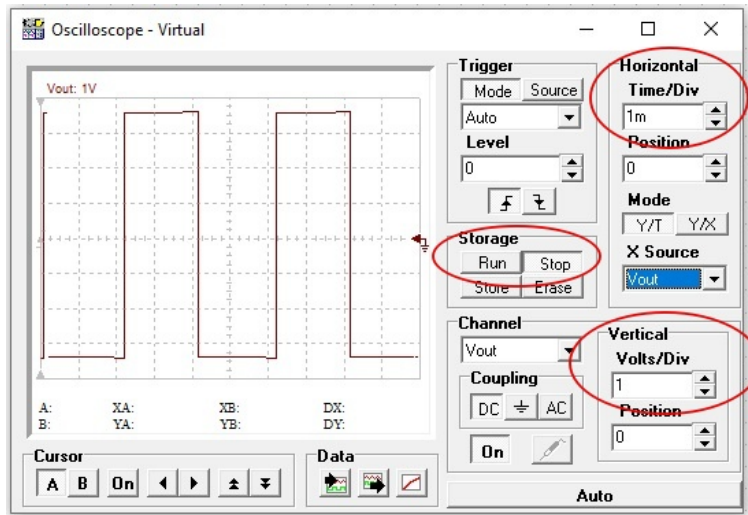
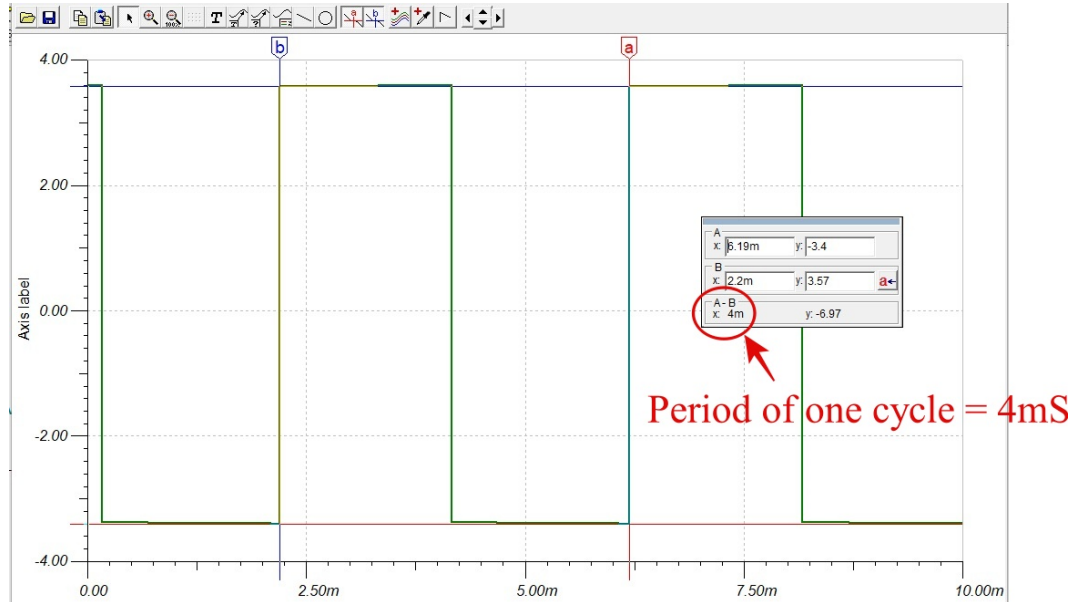


Figure 17: Detailed Configurations for Op-amp multivibrator

- 3) Then press **Export curves**. On the exported curve add cursor line a and cursor line b. Put them in between one cycle of the waveform. Calculate the frequency of the waveform generated by the Multivibrator.



$$Frequency F = \frac{1}{Period T} = \frac{1}{4mS} = 250Hz \quad (3)$$

4) Design an Op-amp Multivibrator which will generate 1KHz square wave similar to above example.

- Calculate the value of R and C by using the Multivibrator equation

$$Frequency F = \frac{1}{2RC} \quad (4)$$

- Then use these values to change the R and C in the example circuit
- Simulate and verify the output waveform whether it is correct 1KHz
- Capture your circuit diagram with correct R and C values on the circuit
- Capture the exported curve with measurement
- Submit your circuit diagram and curve to tutor

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