EE-111 LINEAR CIRCUIT ANALYSIS

B.S. ELECTRICAL ENGINEERING FINAL LAB PROJECT

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ANALOG COMPUTER

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1. <u>DECLARATION:</u>

This report has been prepared based on my work. Where other published and unpublished source materials has been used, these have been acknowledged.

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2. <u>ABSTRACT:</u>

Analog computer, any of a class of devices in which continuously variable physical quantities, such as electrical potential, fluid pressure, or mechanical motion, are represented in a way analogous to the corresponding quantities in the problem to be solved. We achieved this by using a combination of components i.e. an **OP-AMP (LM741)**, **Resistors** and **Capacitors**.

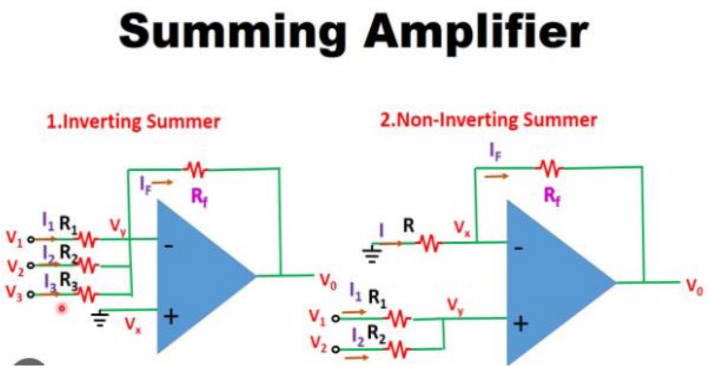
3. <u>OBJECTIVE:</u>

To build an Analog Computer and through use of differential equation model the behavior of these systems.

4. INTRODUCTION:

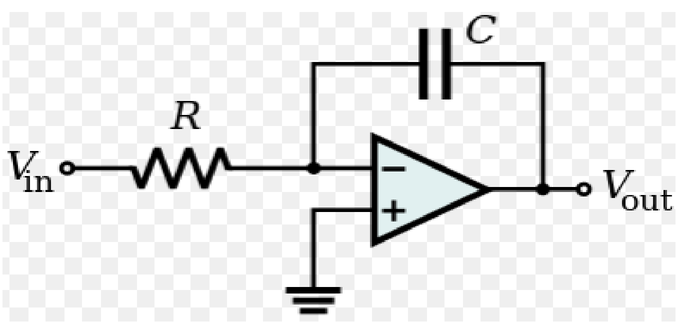
A. OP-AMP SUMMER:

A summer circuit is one that sums or adds multiple analog voltage signals together. There are 2 basic type of op-amp summer circuits: Inverting and Non-Inverting.



B. INTEGRATORS:

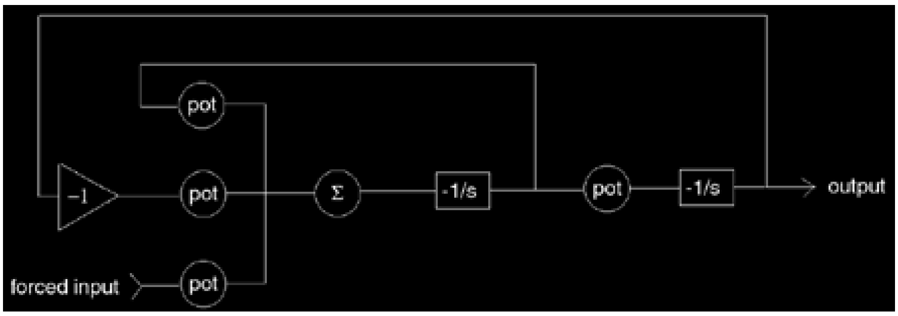
An integrator in measurement and control applications is **an element whose output signal is the time integral of it's input signal**. It accumulates the input quality over a defined time to produce a representative output. Integration is an important part of many engineering and scientific applications.



C. <u>ANALOG COMPUTER:</u> An Analog Computer is built up from **Integrators, Summers, Differentiators, OP-AMPS, etc**. Here is an example of an analog computer.

5. <u>DESIGN PARAMETERS:</u>

Instead of using separate Summers, Amplifiers, and Integrators, we used Summer-Integrators. This allowed us to greatly cut down on the number of components needed. Here is the block diagram for the circuit that I built.



6. DIFFERENTIAL EQUATION TO BE UTILIZED:

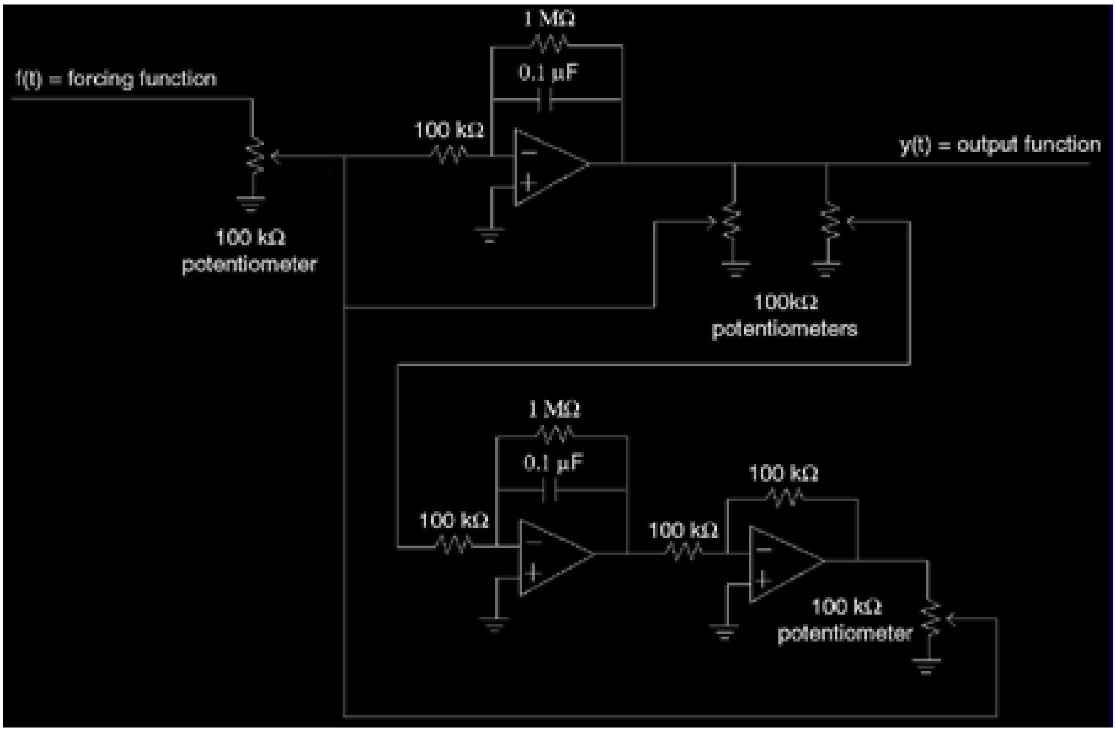
$$M\frac{d^2x(t)}{dt^2}+K_d\frac{dx(t)}{dt}+K_sx(t)=F(t)$$

$$x(0)=0 \qquad \frac{dx(0)}{dt}=0$$

7. APPARATUS:

- RESISTORS
- DC SUPPLY
- CAPACITORS
- BREADBOARD
- JUMPER WIRES
- OP AMP LM-741
- FUNCTION GENERATOR

8. PROCEDURE:



- Determine the component values and construct the circuit bread board as shown in the figure above.
- Apply DC voltage of +10V to (+Vcc) and -10V to (-Vcc).
- Apply the input voltage from function generator.
- Alter frequency and the input waves and measure the corresponding graphs of input and output waves.
- Obtain the Input and Output Curves on different frequencies.
- Perform Error Analysis.

9. CALCULATIONS:

I. THEORETICAL CALCULATIONS:

$$M\frac{d^2x(t)}{dt^2} + K_d\frac{dx(t)}{dt} + K_s x(t) = F(t)$$

$$x(0) = 0 \qquad \frac{dx(0)}{dt} = 0$$

$$x(t) = e^{-\frac{K_d}{2M} \pm \sqrt{\frac{K_d^2}{4M^2} - \frac{K_s}{M}}}$$

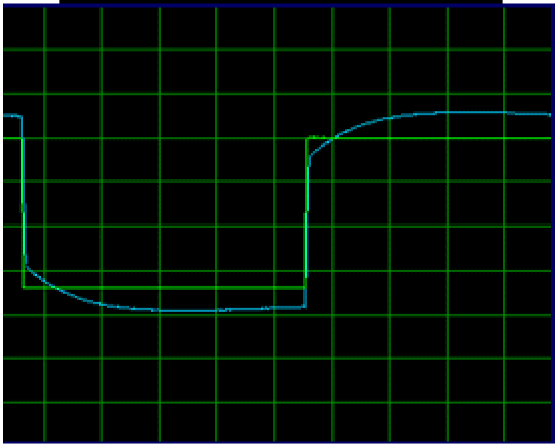
$$x_L(s) = \frac{f_L(s)}{Ms^2 + K_d s + K_s}$$

$$x(t) = L^{-1}\{x_L(s)\}$$
$$= \int_0^t \left[\left(\left(\frac{2K_s}{M}\right)\left(\frac{1}{2K_s + K_d}\right)e^{-\sqrt{\frac{K_s}{M}}t} - \left(\frac{K_d}{M}\right)\left(\frac{1}{2K_s - K_d}\right)e^{-\sqrt{\frac{K_d^2}{4MK_s}}t}\right)\left(F(t-u)\right)\right]du$$

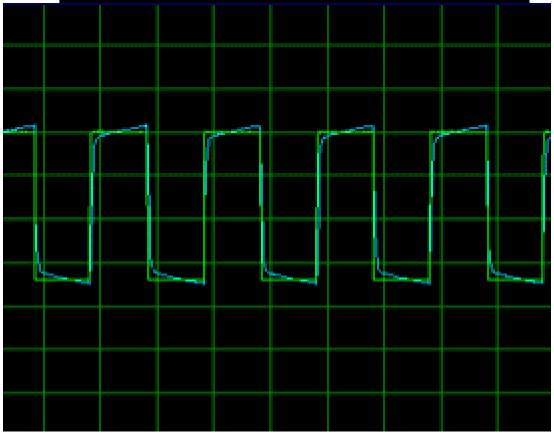
II. SIMULATED CALCULATIONS:

- In the following the input wave is in green, while output wave is plotted in blue.

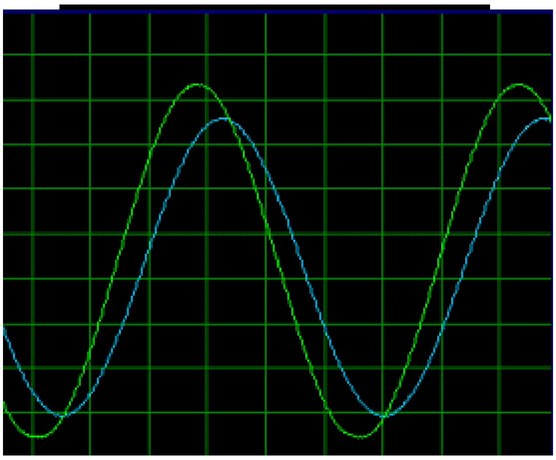
- **1 Hz Square Wave:**



- **10 Hz Square Wave:**



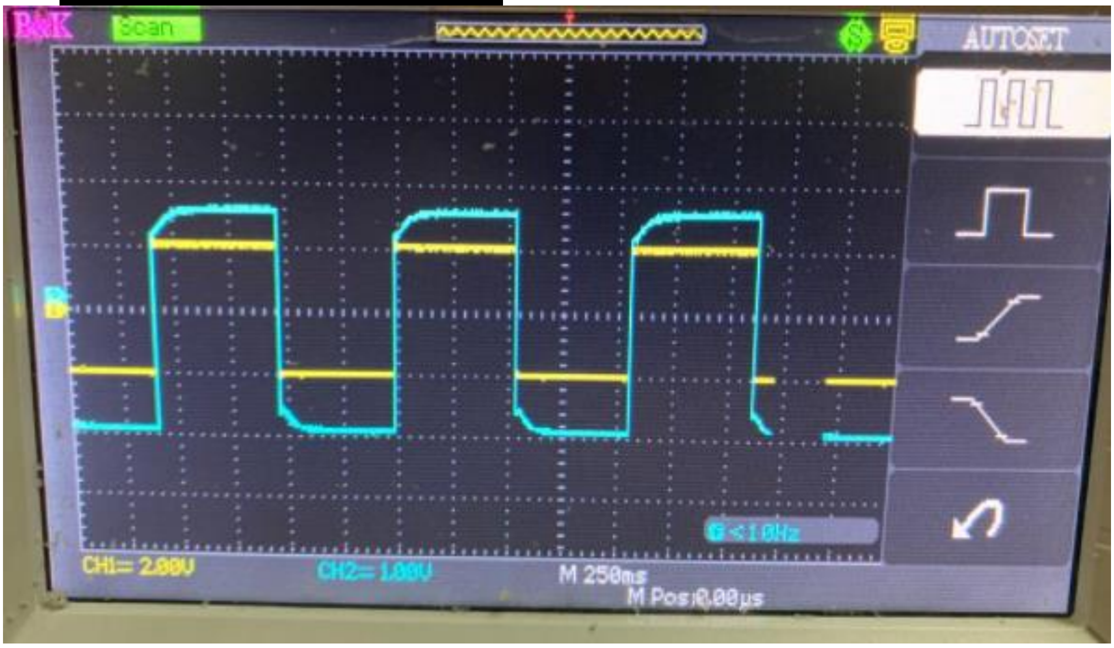
- **100 Hz Sine Wave:**



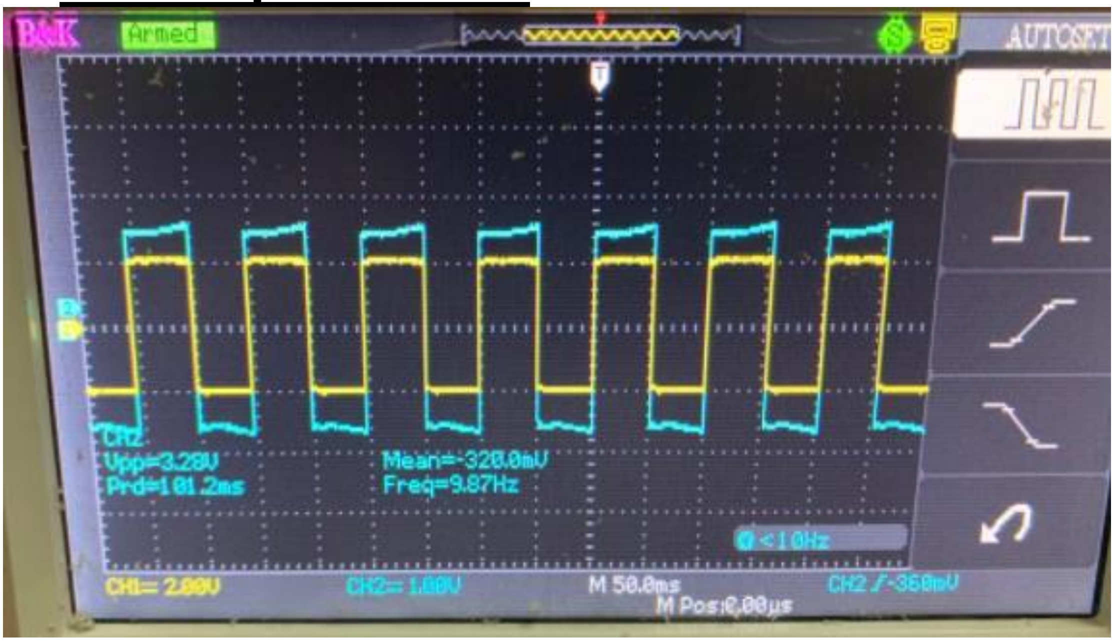
III. MEASURED CALCULATIONS:

- In the following the input wave is in yellow, while output wave is plotted in blue.

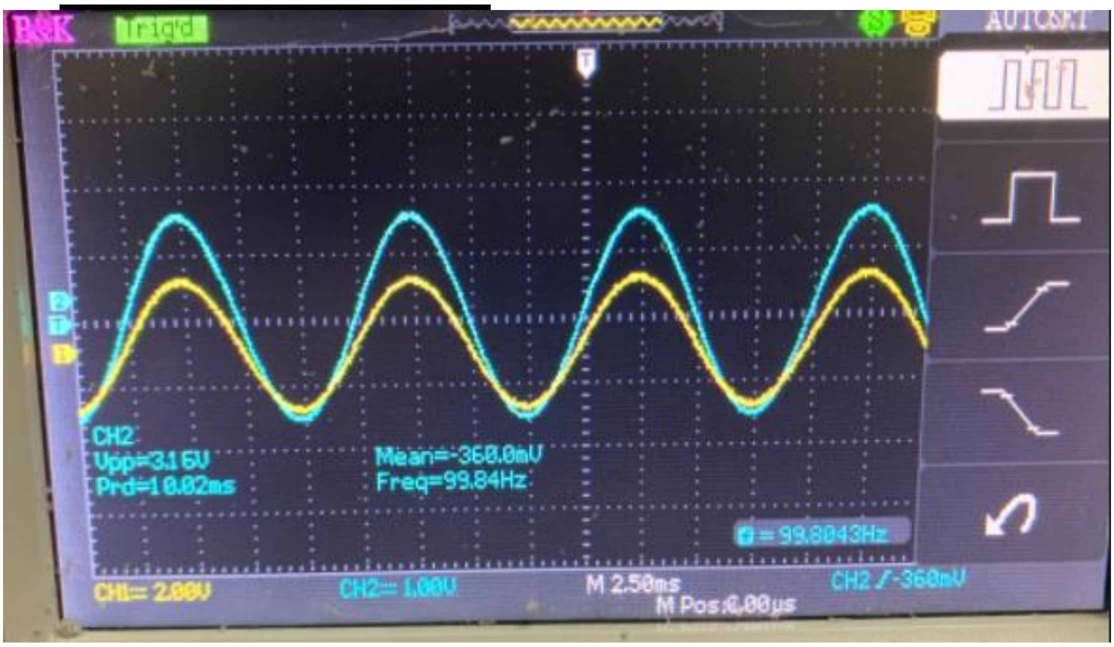
- **1 Hz Square Wave:**



- **10 Hz Square Wave:**



- **<u>100 Hz Sine Wave:</u>**



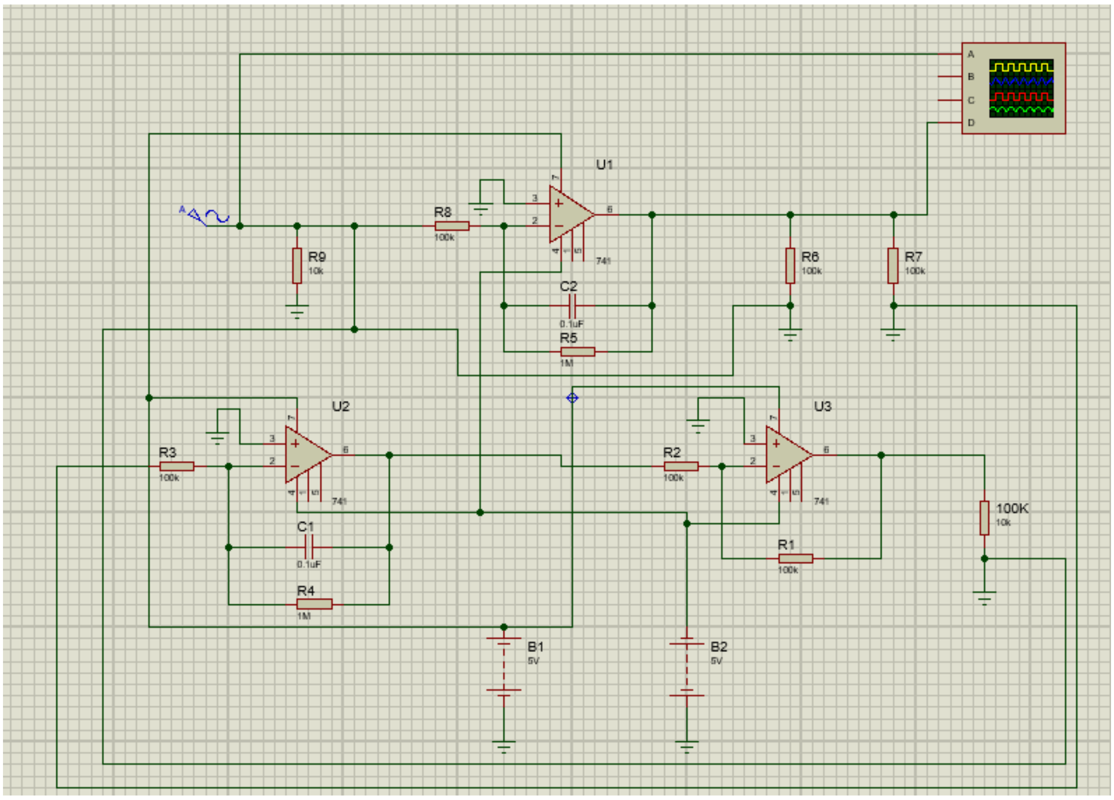
Notice how the output waveform attempts to take the shape of the input in each case. Also, notice the phase shift in the case of sine wave inputs.

IV. <u>Error Analysis:</u>

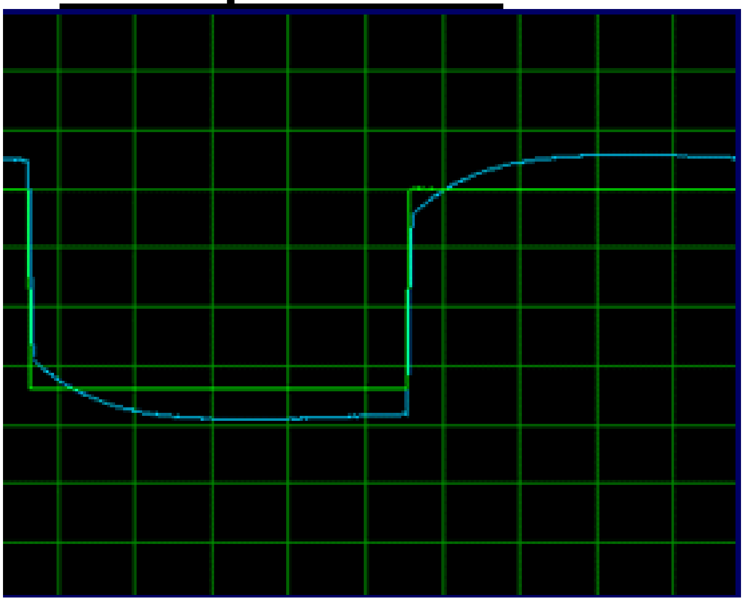
There is a certain variation in the graphs of simulation and the experimental graphs and there are some side factors such as not solid fixing of components on the breadboard, IC LM741, etc. There is a bit of noise effect but it can be certainly reduced by some means.

10. SIMULATION IN “PROTEUS”:

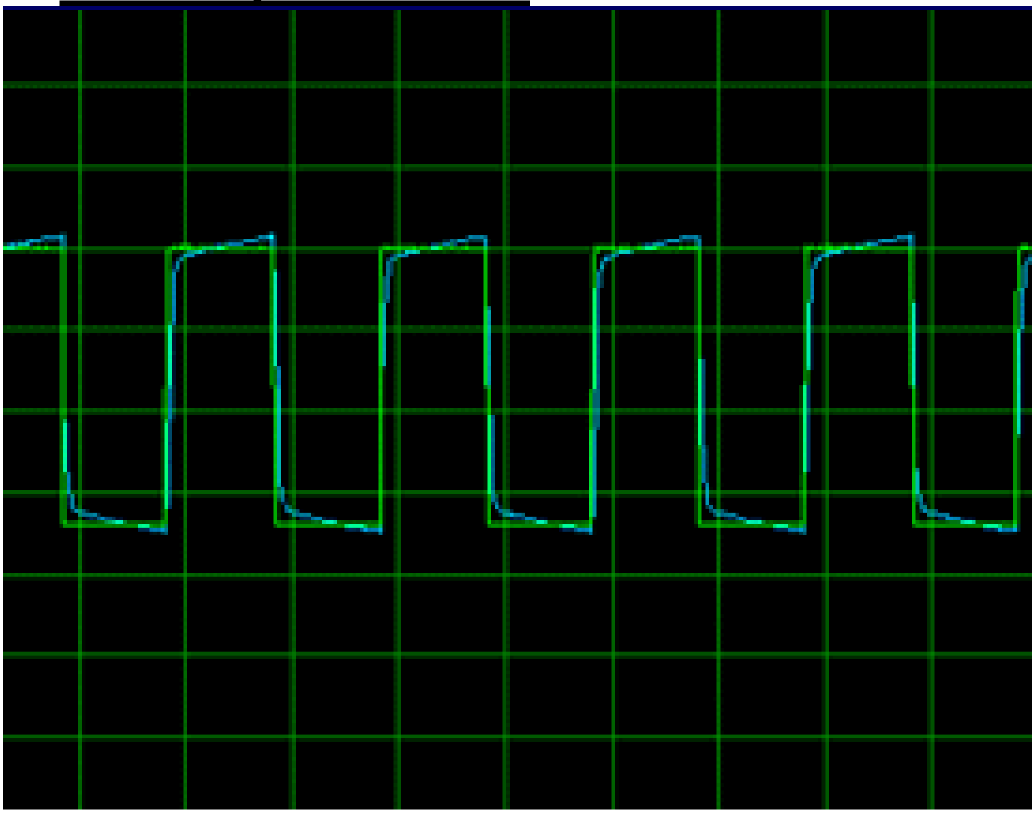
➢ CIRCUIT DIAGRAM:



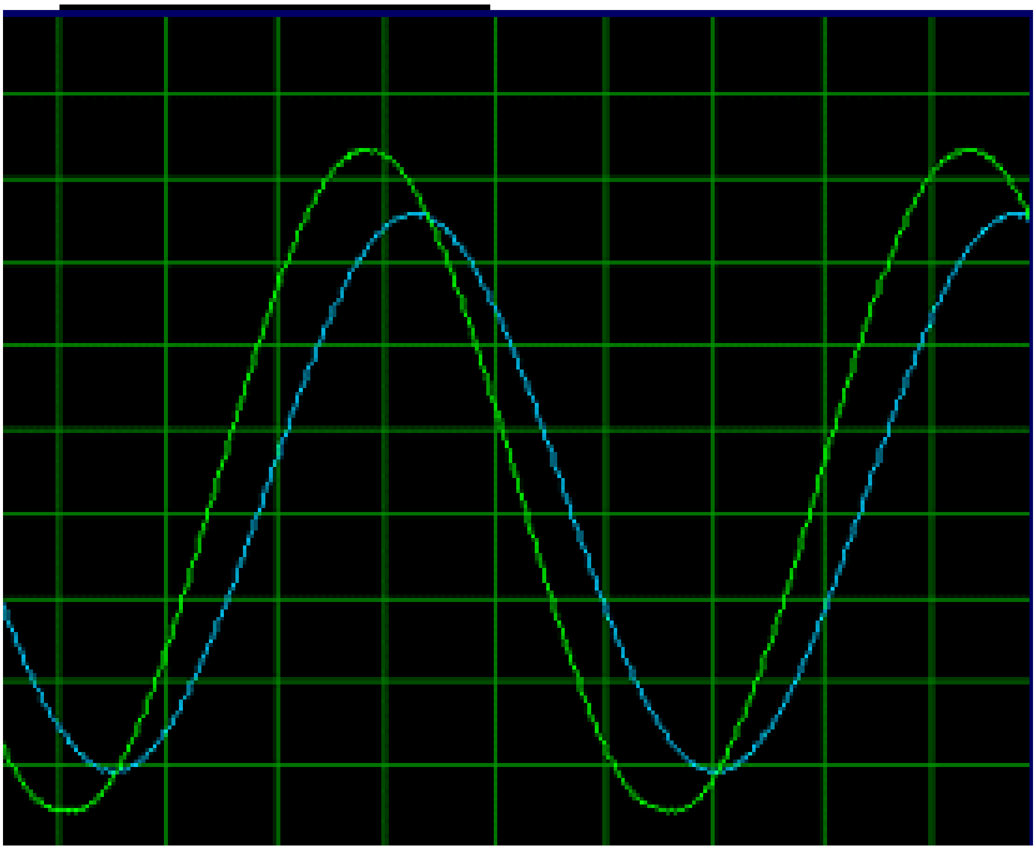
➢ 1 Hz Square Wave:



- **10 Hz Square Wave:**

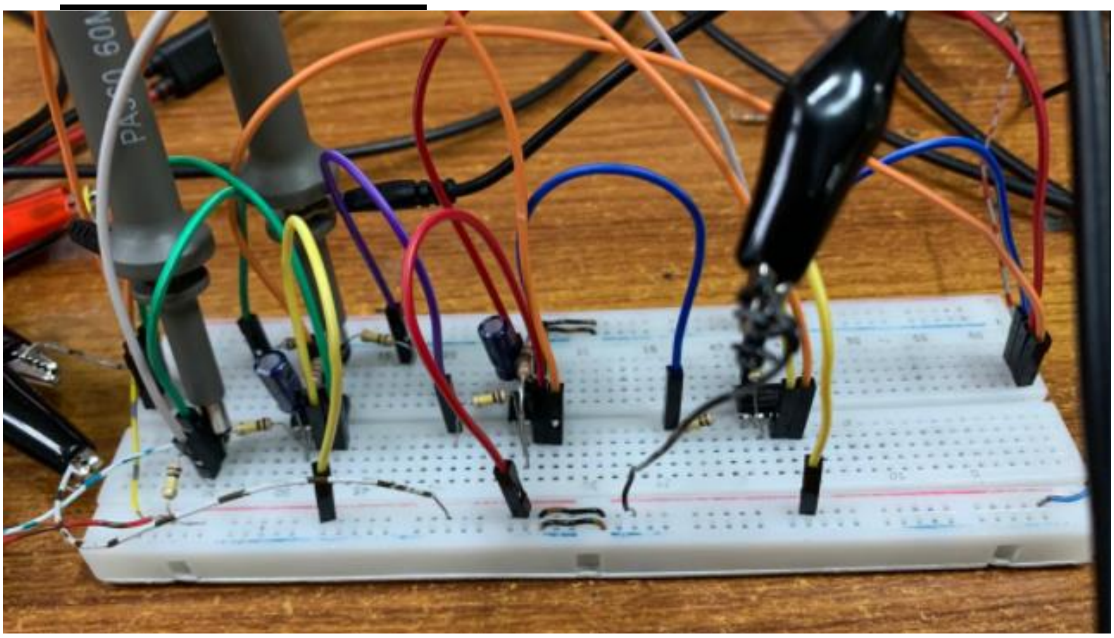


- **100 Hz Sine Wave:**

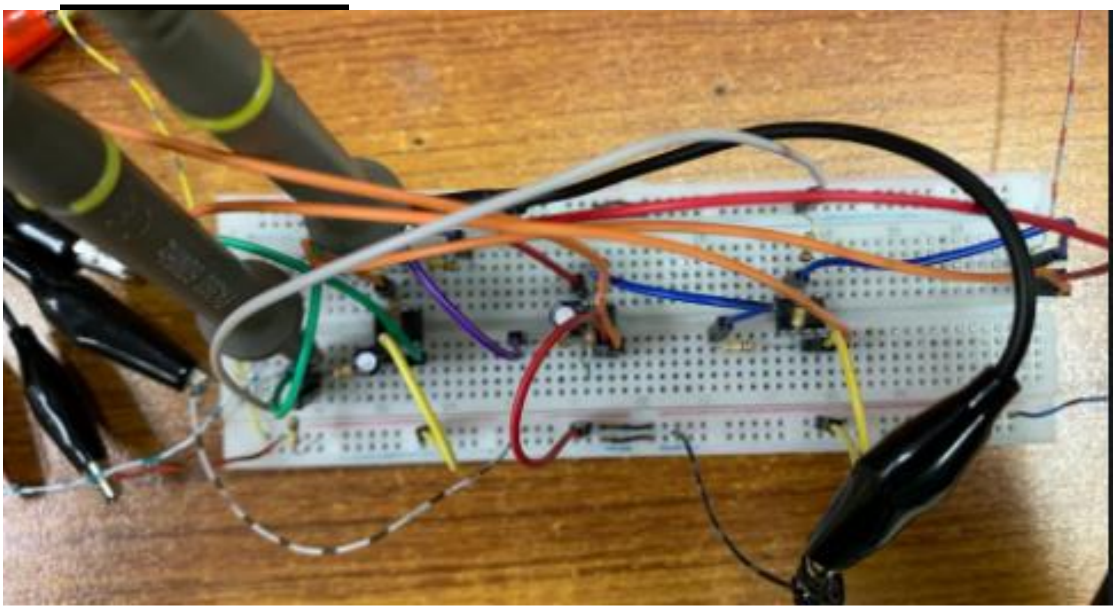


11. HARDWARE:

I. FRONT VIEW:



II. TOP VIEW:



III. SIDE VIEW: