1.

CSE251

Electronic Devices and Circuits

Exp-06: Study of Operational Amplifier(op-Amp)

Submitted By:

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Date of Performance: 14/11/22

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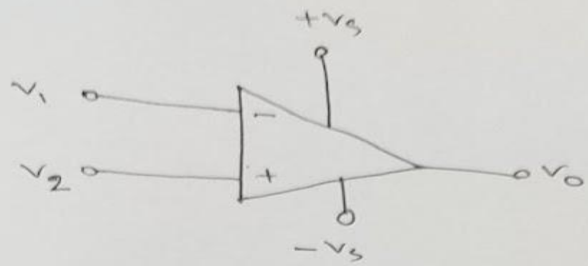
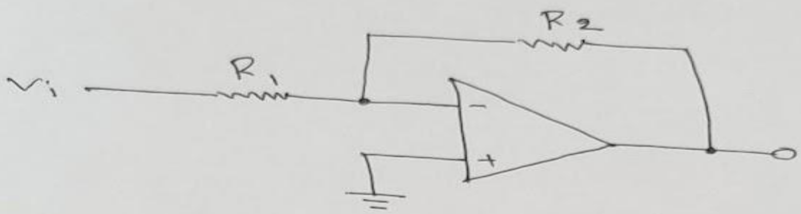
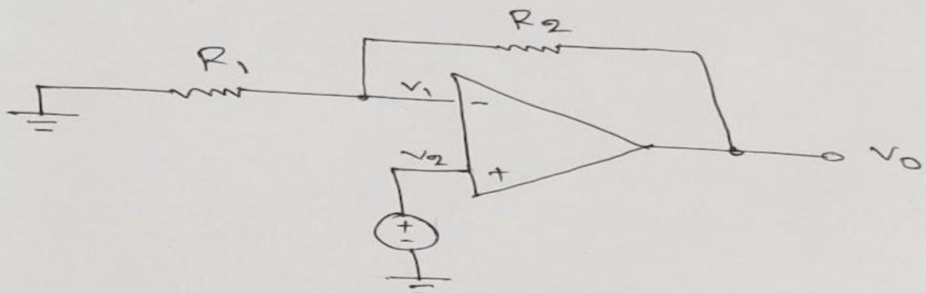
2. Circuit Diagrams:



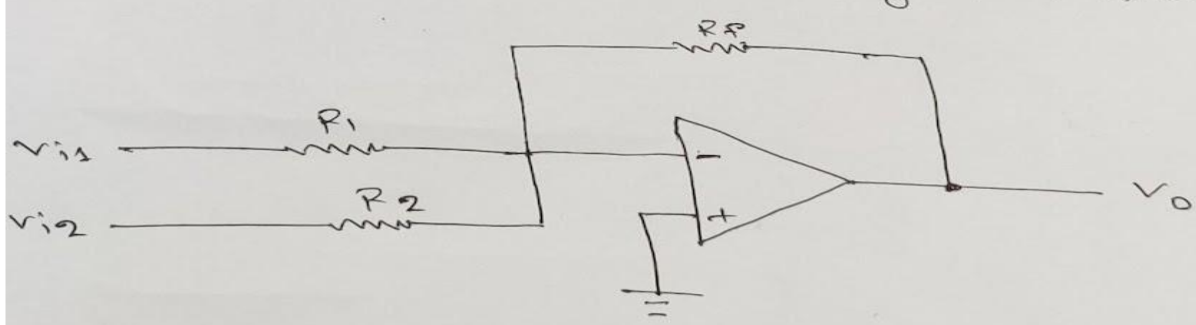
circuit1 : OP-Amp comparator



circuit2 : inverting Amplifier



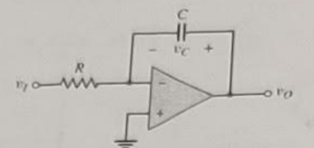
circuit 3 : Non-Inverting Amplifier



circuit 4 : Inverting summing Amplifier.

3. Signed data sheet:

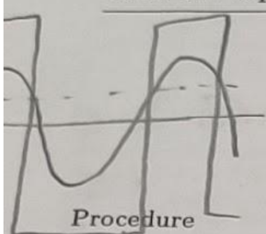
Op-Amp Integrator

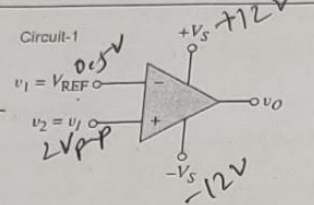


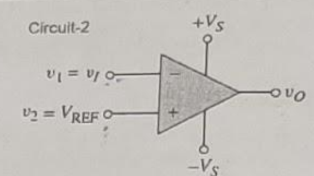
The figure above shows an Op-Amp circuit that can do integration operation on the given input voltage. The figure above shows an Op-Amp circuit that can do integration operation on the given input voltage. The following equation shows the relationship between the input and the output.

$$v_O(t) = -\frac{1}{CR}\int_0^t v_I(t)dt - v_C$$

Task-01: Op-Amp Comparator



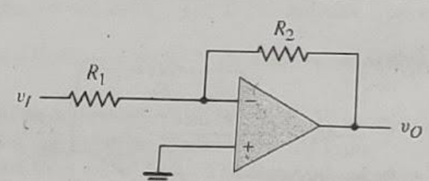




Procedure

1. Construct Circuit-1 with v_I = 2 V (p-p), 1 kHz sine wave and V_{REF} = 0.5 V. The supply voltage $+V_S$ and $-V_S$ should be +15 V and -15 V respectively which can be taken from the trainer board. **Use this supply voltage throughout the experiment.** The input voltage v_I can be taken from the oscilloscope.
2. Connect the Ch1 and Ch2 of the oscilloscope to v_I and v_O respectively. Observe the input and output waveform and capture them using a camera.
3. Now, construct Circuit-2 and repeat the experiment with same values given above. Observe the input and output waveform and capture them using a camera.

Task-02: Inverting Amplifier



$-\frac{2.2}{1} \times 1$
$= -2.22$

Procedure

1. Construct the circuit with v_I = 2 V (p-p), 1 kHz sine wave. Use $R_1 = 1$ kΩ, $R_2 = 2.2$ kΩ.
2. Connect the Ch1 and Ch2 of the oscilloscope to v_I and v_O respectively. Observe the input and output waveform and capture them using a camera.

servation and Calculation

output waveform should be amplified and inverted compared to the input waveform.

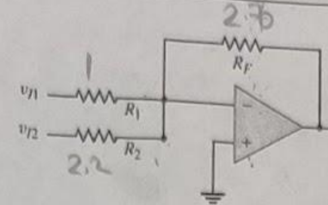
t Amplitude from oscilloscope, v_I = 1V

ut Amplitude from equation, $v_O = -(\frac{R_2}{R_1}) \times v_I$ = $\left(-\frac{2.186}{0.98} \times 1\right) = -2.23$

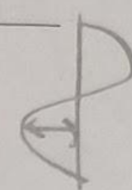
it Amplitude from oscilloscope, v_O = 2.08

2 $2\sin\theta$ 2

Task-03: Inverting Summing Amplifier



$= -2.6V_1 + 1.1V_2$



Procedure

Part-01

$-2.6 \times \cancel{2\sin}\sin\theta + 2.2$

1. Construct the circuit with $v_{I1} = v_{I2} = 2$ V. Use $R_1 = 1$ kΩ, $R_2 = 2.2$ kΩ, $R_F = 2.7$ kΩ.
2. Use the digital multimeter to measure the output voltage.

Part-02

1. Construct the circuit with $v_{I1} = 2$ V (p-p), 1 kHz sine wave and $v_{I2} = 2$ V (from the DC Supply). Use $R_1 = 1$ kΩ, $R_2 = 1$ kΩ, $R_F = 1$ kΩ.
2. Connect the Ch1 and Ch2 of the oscilloscope to v_I and v_O respectively.

Observation and Calculation

For Part-01,
from multimeter, $v_{I1} =$ 2.005
from multimeter, $v_{I2} =$ 2.005
Output Amplitude from equation, $v_O = -(\frac{R_F}{R_1} \times v_{I1} + \frac{R_F}{R_2} \times v_{I2}) =$ $-\left(\frac{2.6}{0.98} \times 2.005 + \frac{2.6}{2.18} \times 2.005\right)$
Output Amplitude from multimeter, $v_O =$ ~~7.77~~

$= -7.71067$

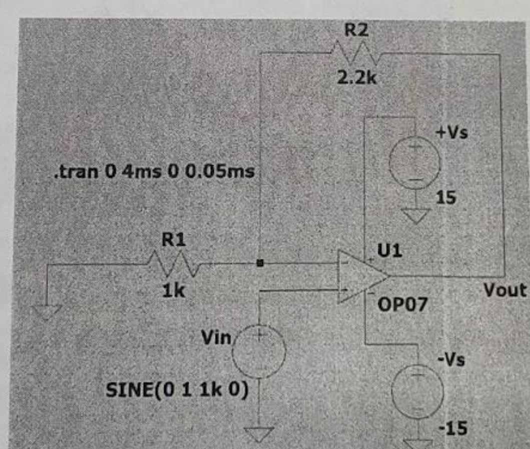
For Part-02,
The output waveform should be amplified and inverted compared to the input waveform. Observe the input and output waveform and capture them using a camera.

Task-04: Simulation (Home Task)

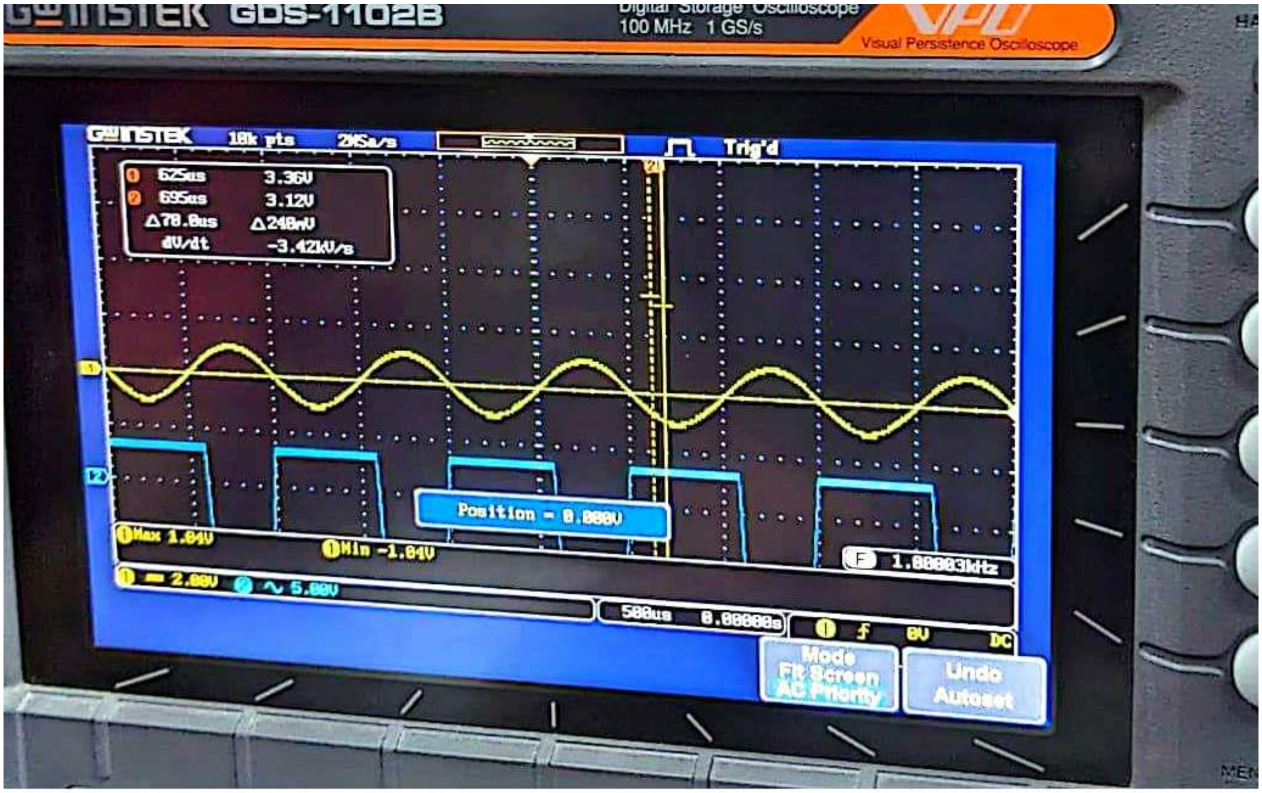
In this part, we will simulate a Non-inverting Amplifier and a 3 input Inverting Summing Amplifier in LTspice.

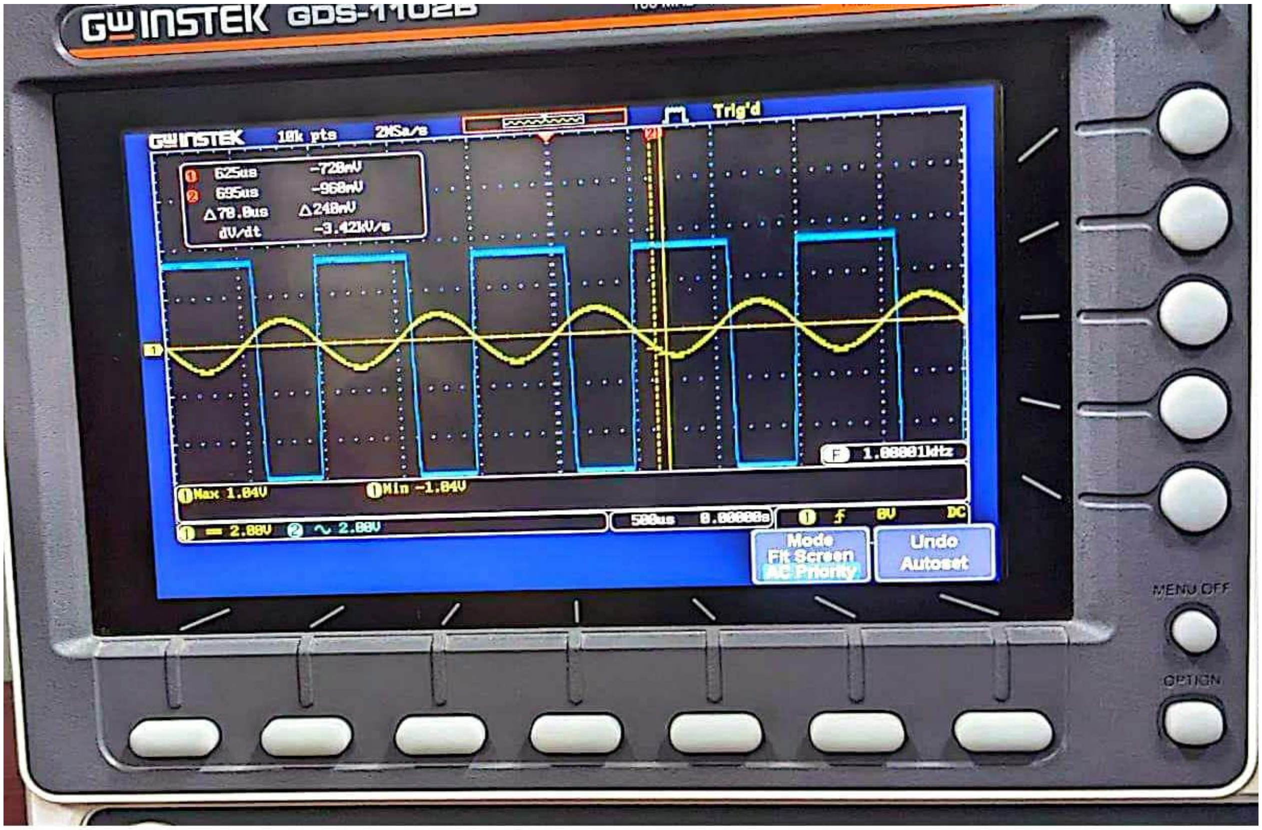
Non-inverting Amplifier

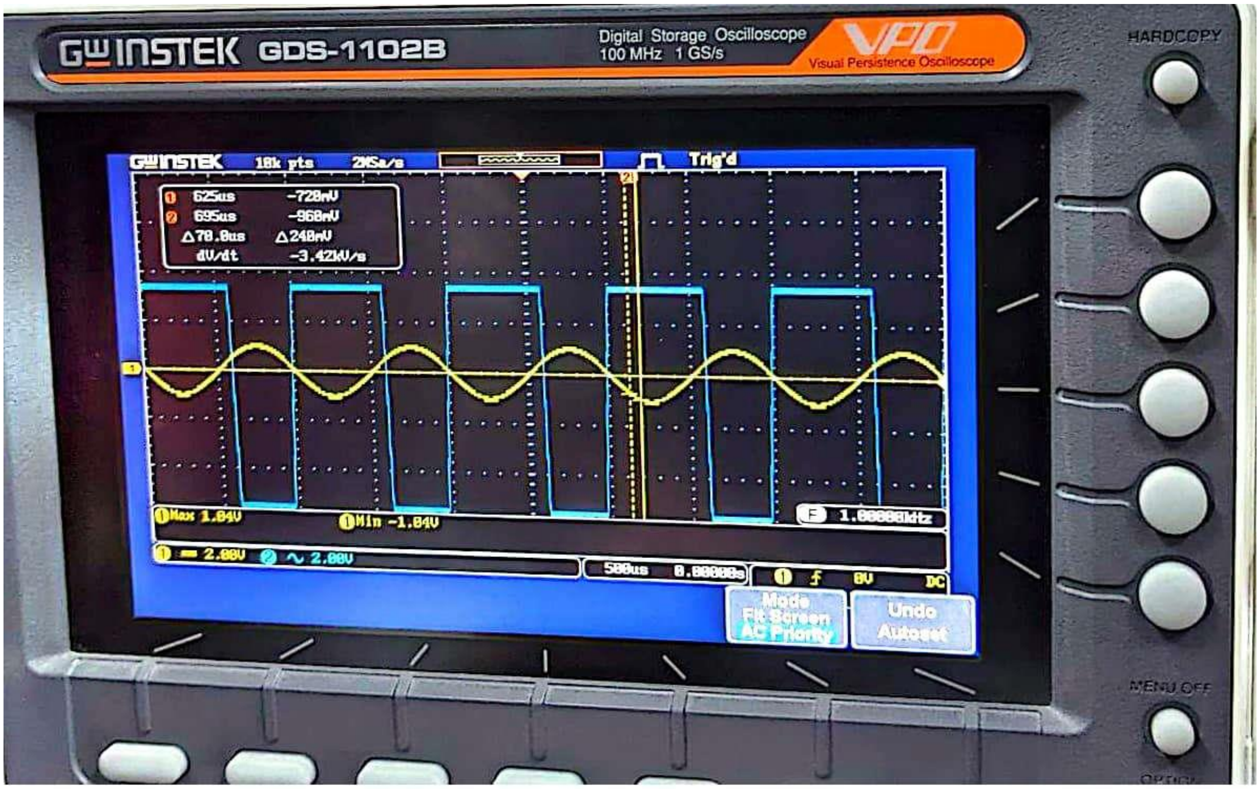
1. Open a new schematic and build the following circuit. To insert an Op-Amp in LTspice, type 'op07' in the Select Component Symbol window and select the Op-Amp from there.

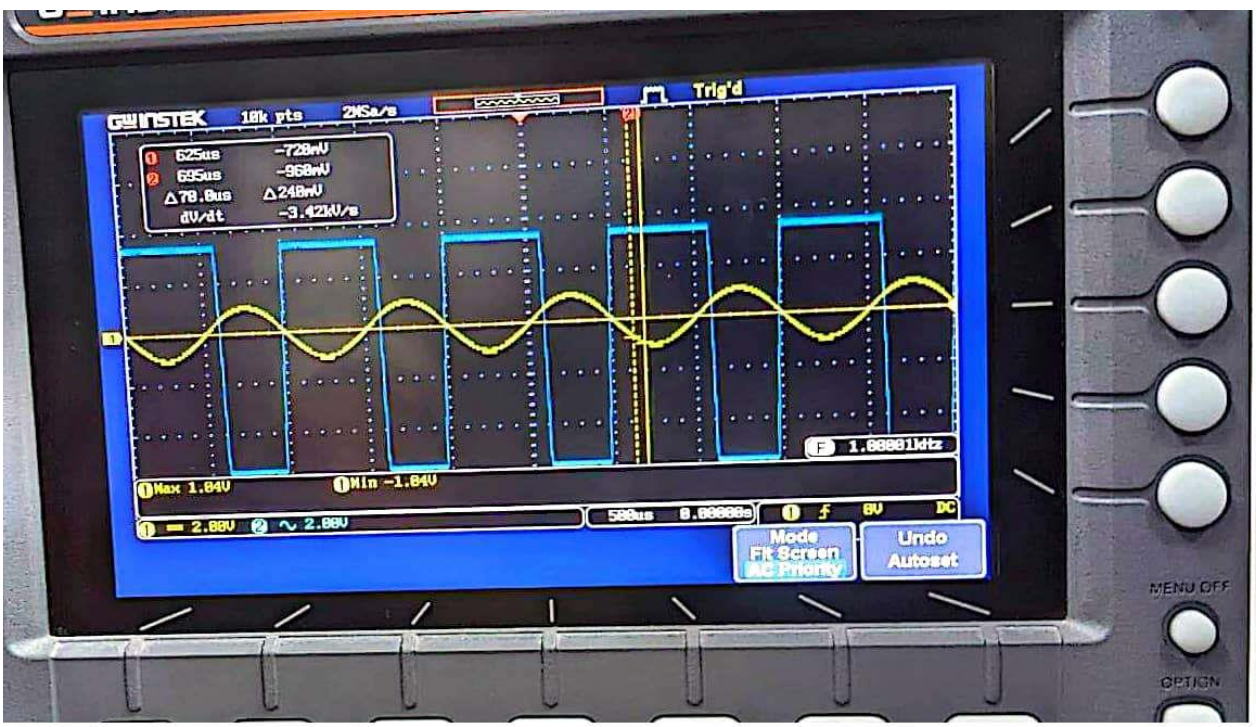


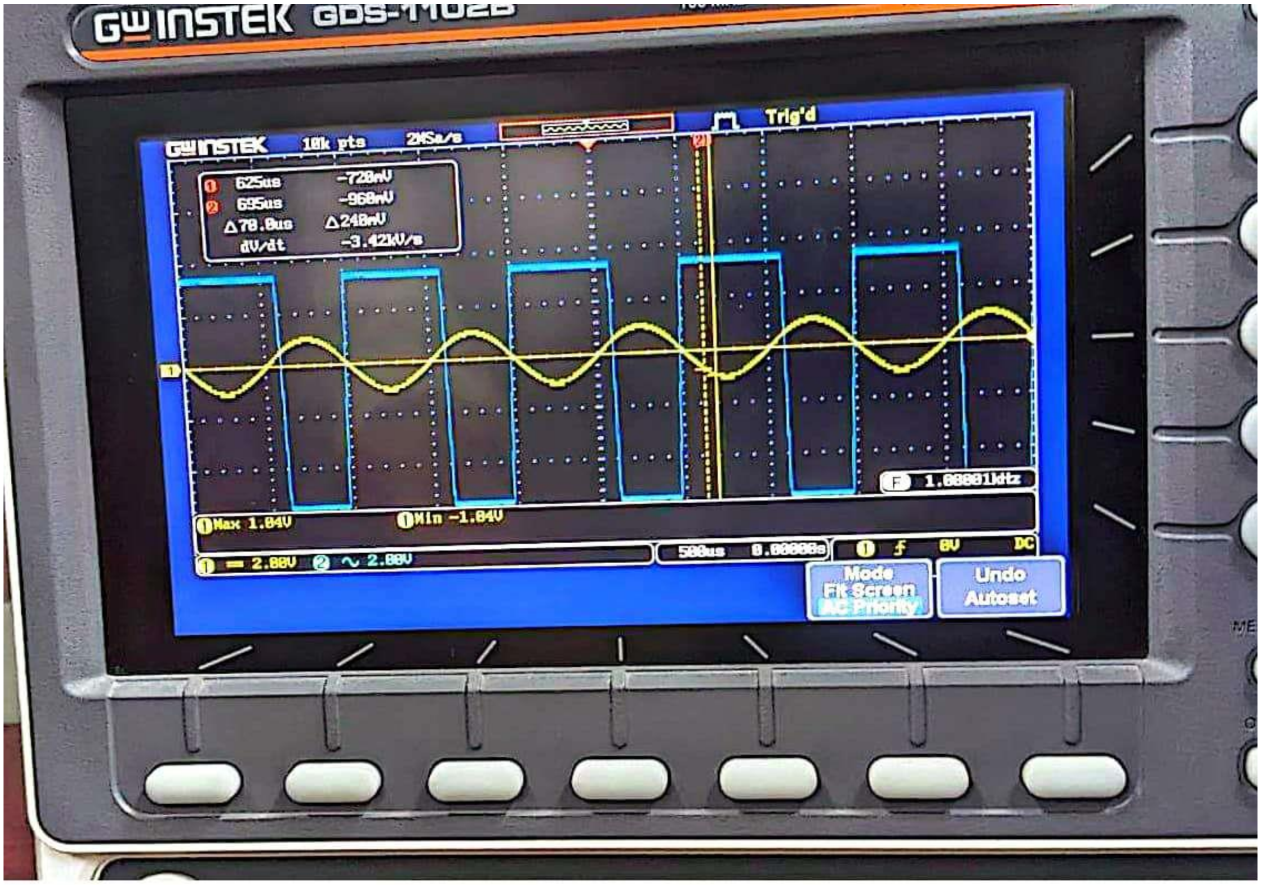
4.captured photos of all the waveforms from the oscilloscope:

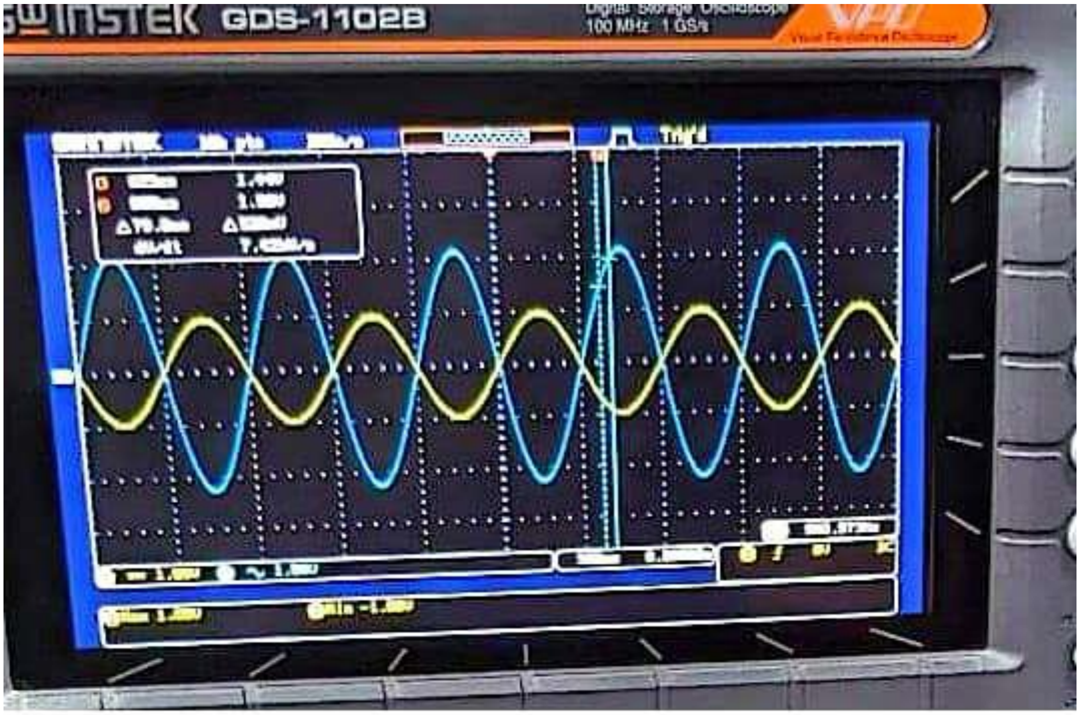

GDS-1102B
100 MHz 1 GS/s
Visual Persistence Oscilloscope
10k pts
2MSa/s
Trig'd
625us 3.36V
695us 3.12V
Δ70.0us Δ240mV
dV/dt -3.42kV/s
Position = 0.000V
Max 1.04V
Min -1.04V
1.00003kHz
2.00V
5.00V
500us 0.00000s
0V
DC
Mode
Fit Screen
AC Priority
Undo
Autoset

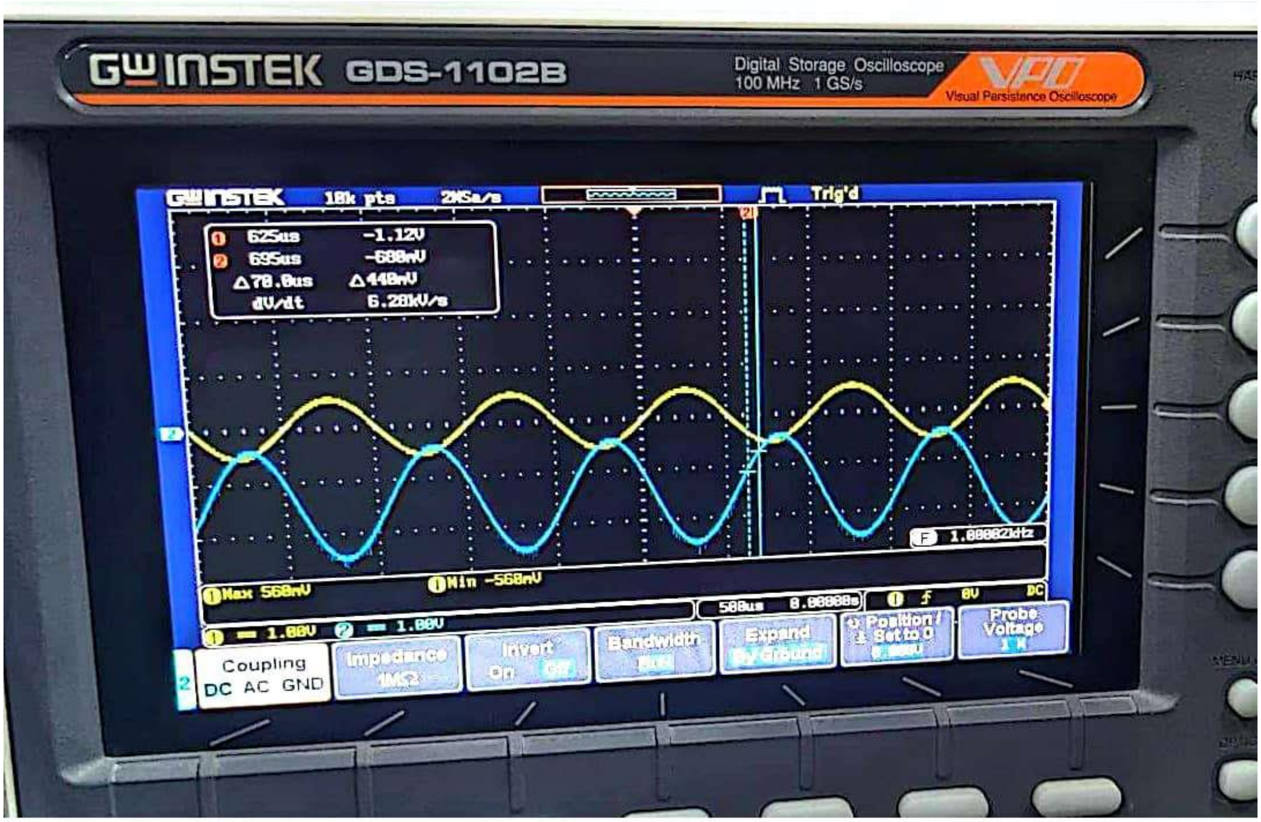

GW INSTEK GDS-1102B
GW INSTEK
10k pts
2MSa/s
Trig'd
625us -728mV
695us -960mV
Δ70.0us Δ240mV
dV/dt -3.42kV/s
1.00001kHz
Max 1.84V
Min -1.84V
2.00V
2.00V
500us 0.00000s
0V
DC
Mode
Fit Screen
AC Priority
Undo
Autoset
MENU OFF
OPTION

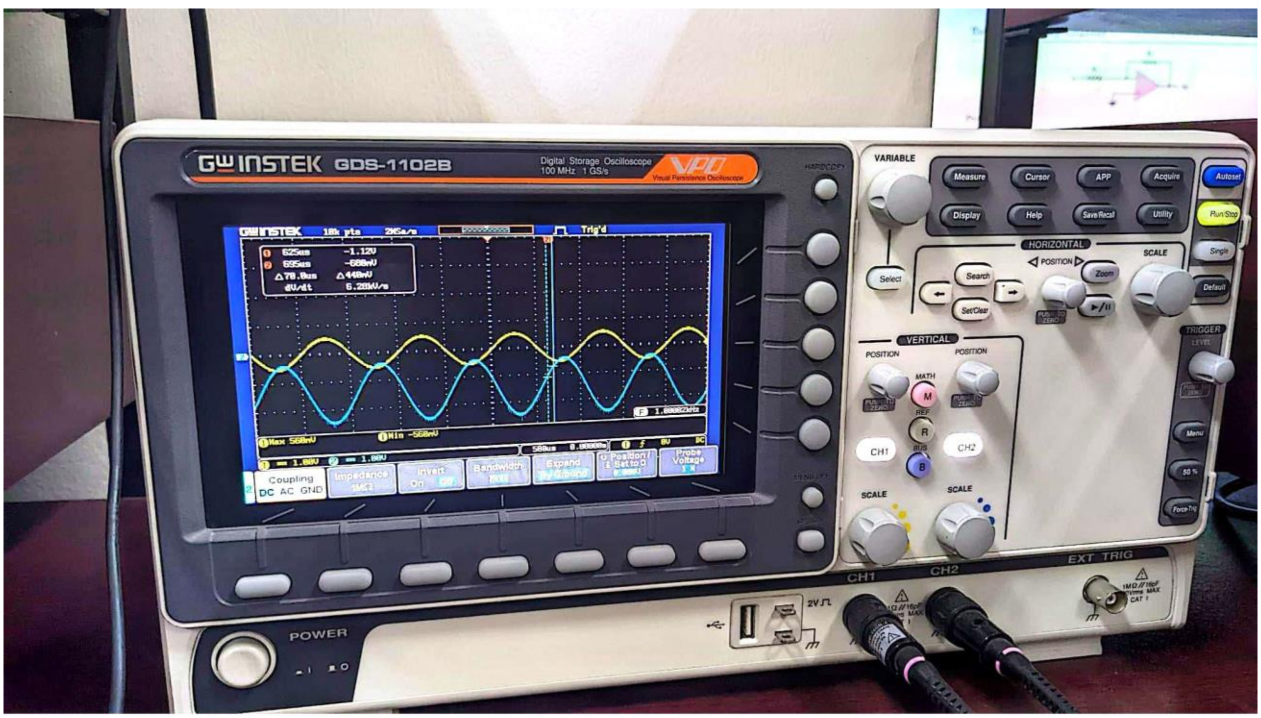

GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
Visual Persistence Oscilloscope
HARDCOPY
10k pts
2MSa/s
Trig'd
625us -720mV
695us -960mV
Δ70.0us Δ240mV
dV/dt -3.42kV/s
Max 1.04V
Min -1.04V
1.00000kHz
2.00V
2.00V
500us 0.00000s
0V DC
Mode Fit Screen AC Priority
Undo Autoset
MENU OFF

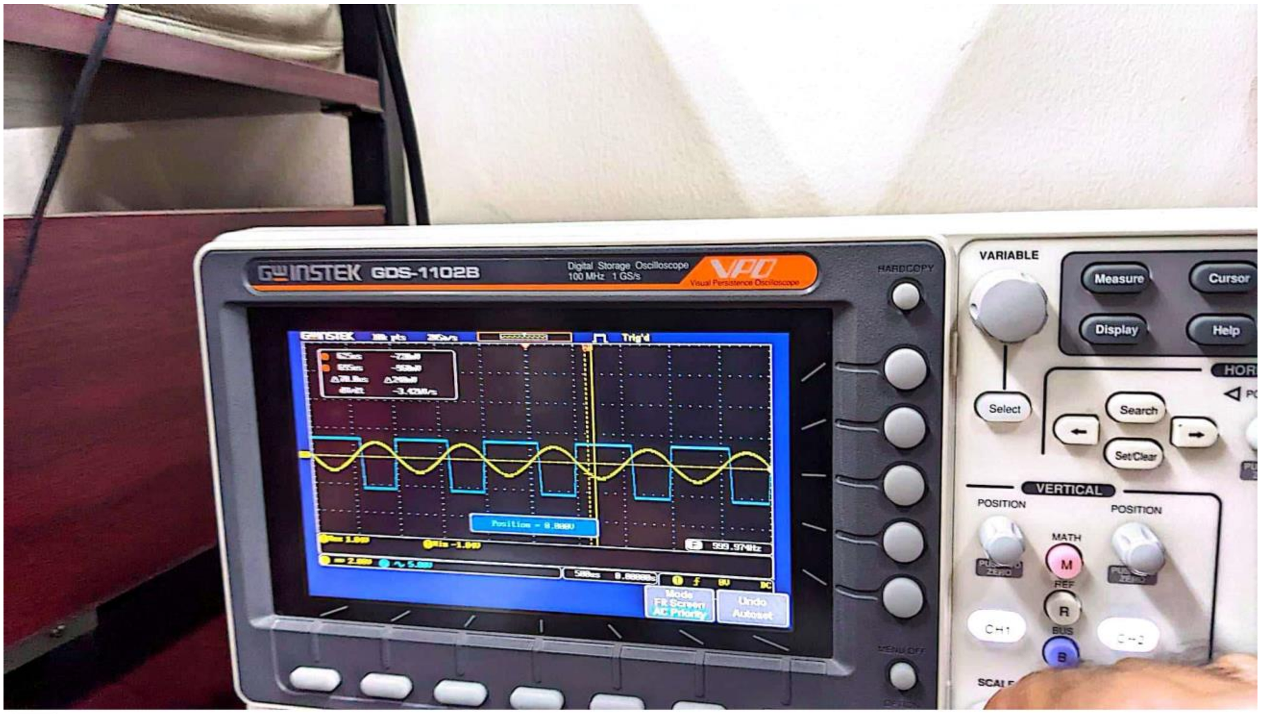

10k pts
2MSa/s
Trig'd
625us -720mV
695us -960mV
Δ70.0us Δ240mV
dV/dt -3.42kV/s
1.00001kHz
Max 1.04V
Min -1.04V
2.00V
2.00V
500us 0.00000s
0V DC
Mode Fit Screen AC Priority
Undo Autoset
MENU OFF
OPTION

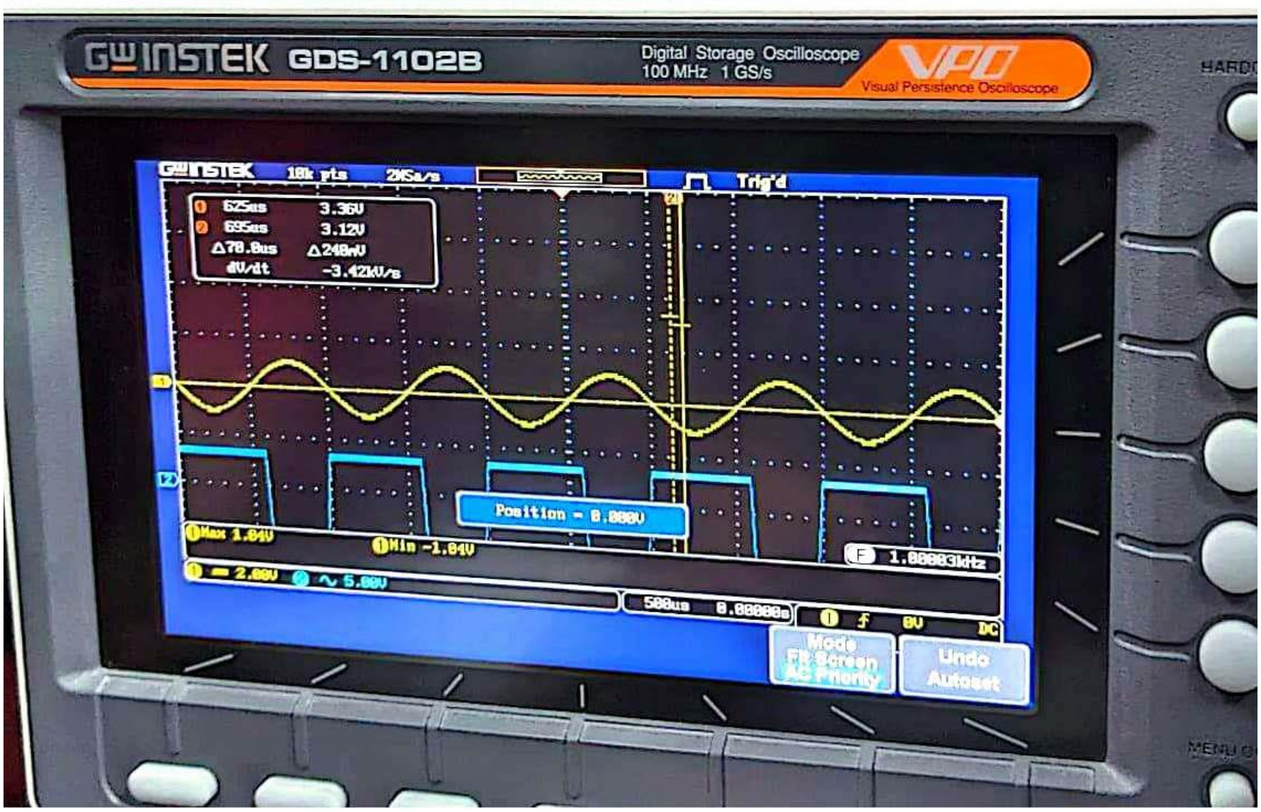

GW INSTEK GDS-1102B
GW INSTEK
10k pts
2MSa/s
Trig'd
625us -720mV
695us -960mV
Δ70.0us Δ240mV
dV/dt -3.42kV/s
F 1.00001kHz
Max 1.04V
Min -1.04V
1 = 2.00V
2 ∿ 2.00V
500us 0.00000s
0V
DC
Mode
Fit Screen
AC Priority
Undo
Autoset


GDS-1102B
100 MHz 1 GS/s

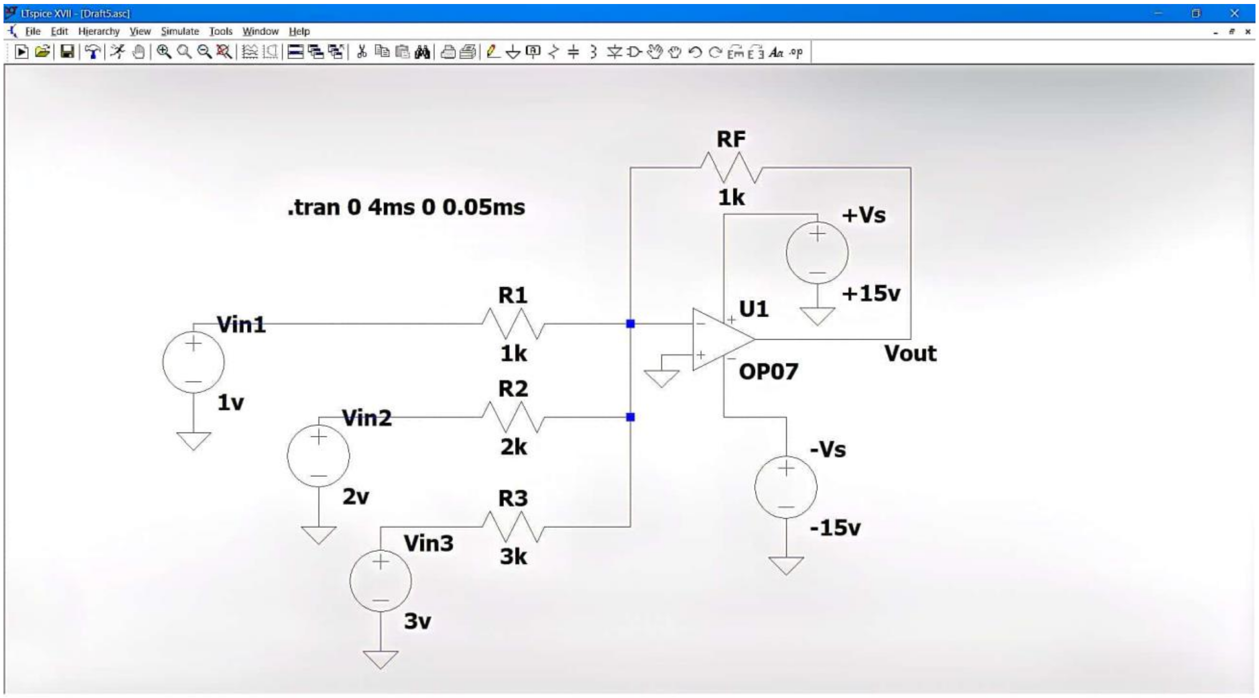

GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
Visual Persistence Oscilloscope
18k pts
2MSa/s
Trig'd
625us -1.12V
695us -680mV
Δ70.0us Δ440mV
dV/dt 6.28kV/s
1.00082kHz
Max 560mV
Min -568mV
500us 0.00000s
0V
DC
1.00V
1.00V
Coupling
DC AC GND
Impedance
1MΩ
Invert
On Off
Bandwidth
Expand
By Ground
Position / Set to 0
Probe
Voltage


GW INSTEK GDS-1102B
VARIABLE
Measure
Cursor
APP
Acquire
Autoset
Display
Help
Save/Recall
Utility
Run/Stop
Single
Default
HORIZONTAL
POSITION
SCALE
Search
Zoom
Set/Clear
Select
VERTICAL
POSITION
MATH
REF
BUS
CH1
CH2
SCALE
TRIGGER
LEVEL
Menu
50 %
Force-Trig
POWER
EXT TRIG

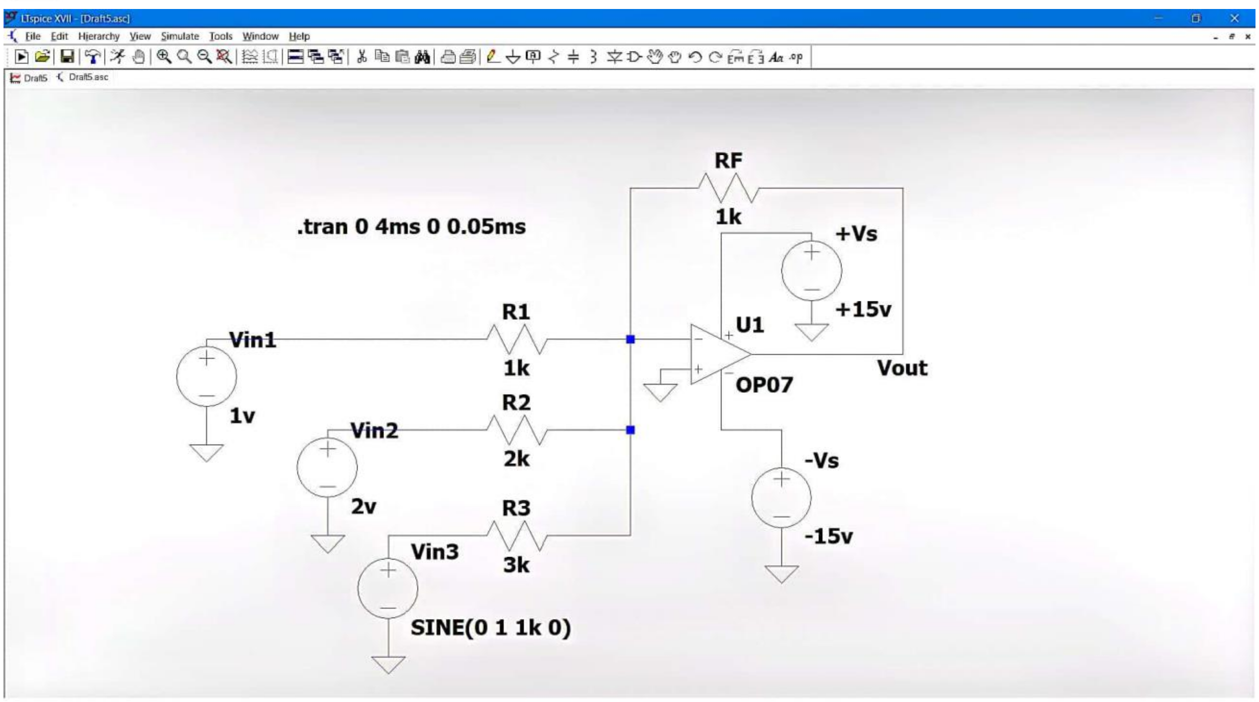

GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
Visual Persistence Oscilloscope
HARDCOPY
VARIABLE
Measure
Cursor
Display
Help
Select
Search
Set/Clear
VERTICAL
POSITION
MATH
M
REF
R
BUS
B
CH1
Position = 0.000V
Mode
FR Screen
AC Priority
Undo
Autoset


GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
Visual Persistence Oscilloscope
10k pts
2MSa/s
Trig'd
625us 3.36V
695us 3.12V
Δ70.0us Δ240mV
dV/dt -3.42kV/s
Position = 0.000V
Max 1.84V
Min -1.84V
1.00003kHz
2.00V
5.00V
500us 0.00000s
0V
DC
Mode
FR Screen
AC Priority
Undo
Autoset

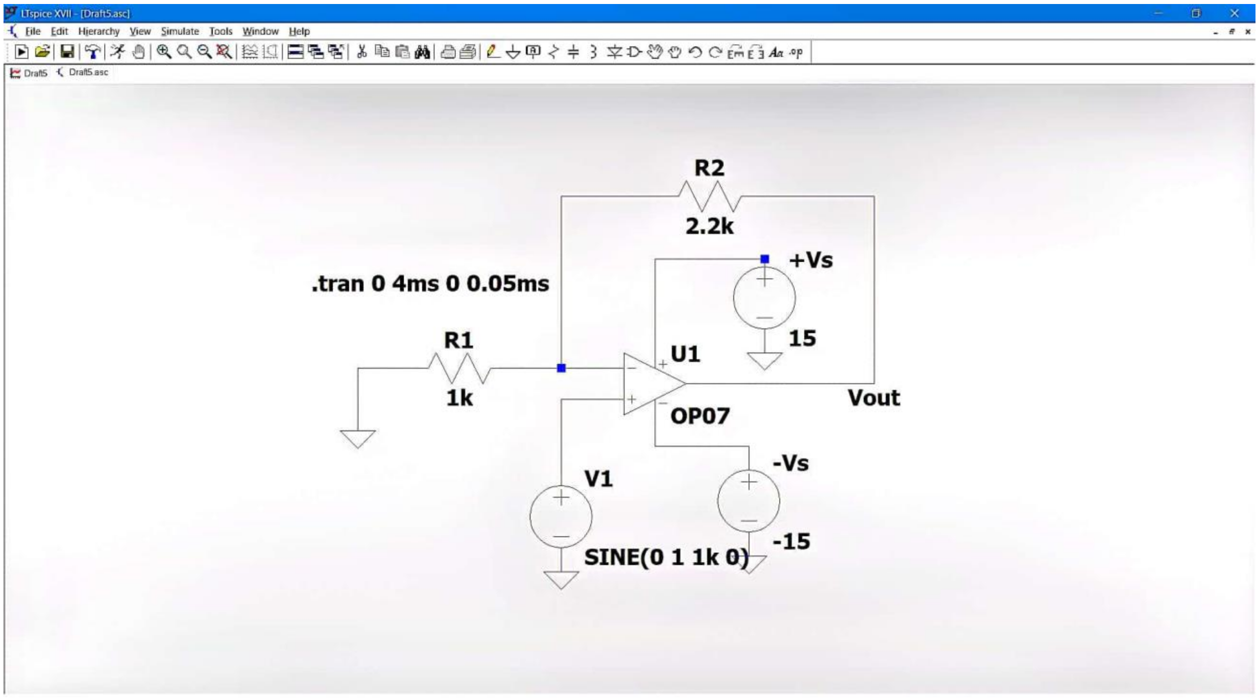
5. screenshots of circuits from simulation part:



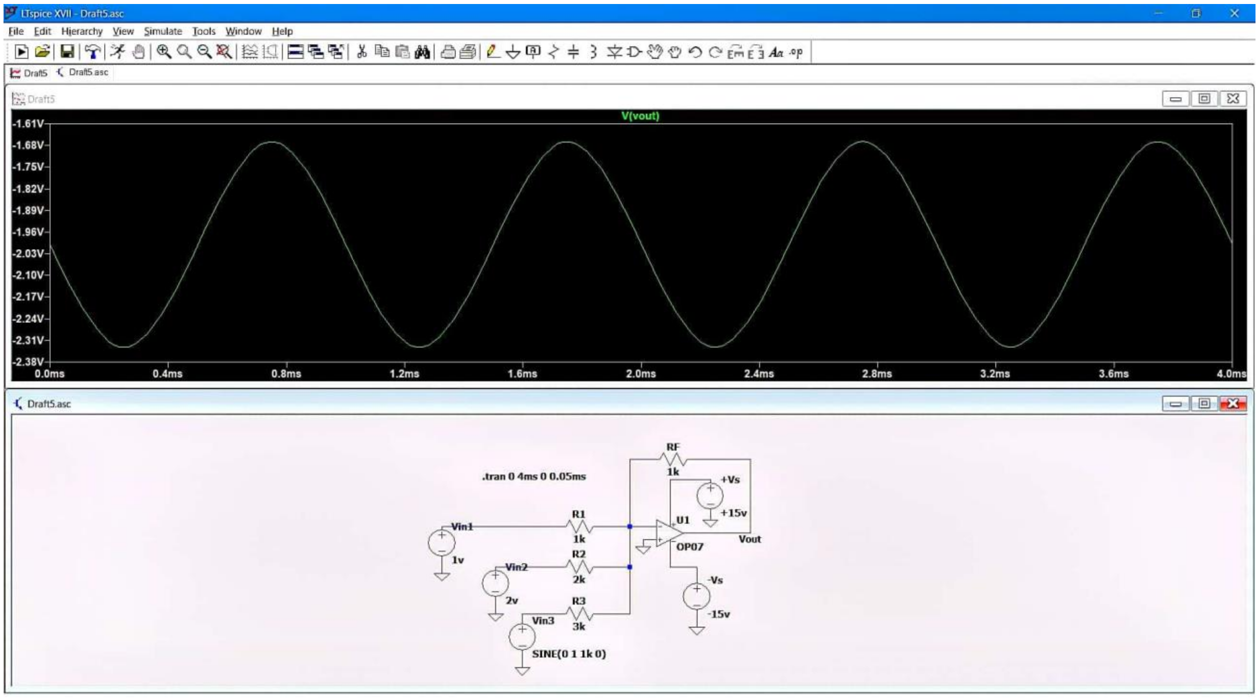
LTspice XVII - [Draft5.asc]
File Edit Hierarchy View Simulate Tools Window Help
.tran 0 4ms 0 0.05ms
RF
1k
+Vs
+15v
R1
1k
U1
OP07
Vout
Vin1
1v
Vin2
R2
2k
2v
R3
3k
Vin3
3v
-Vs
-15v

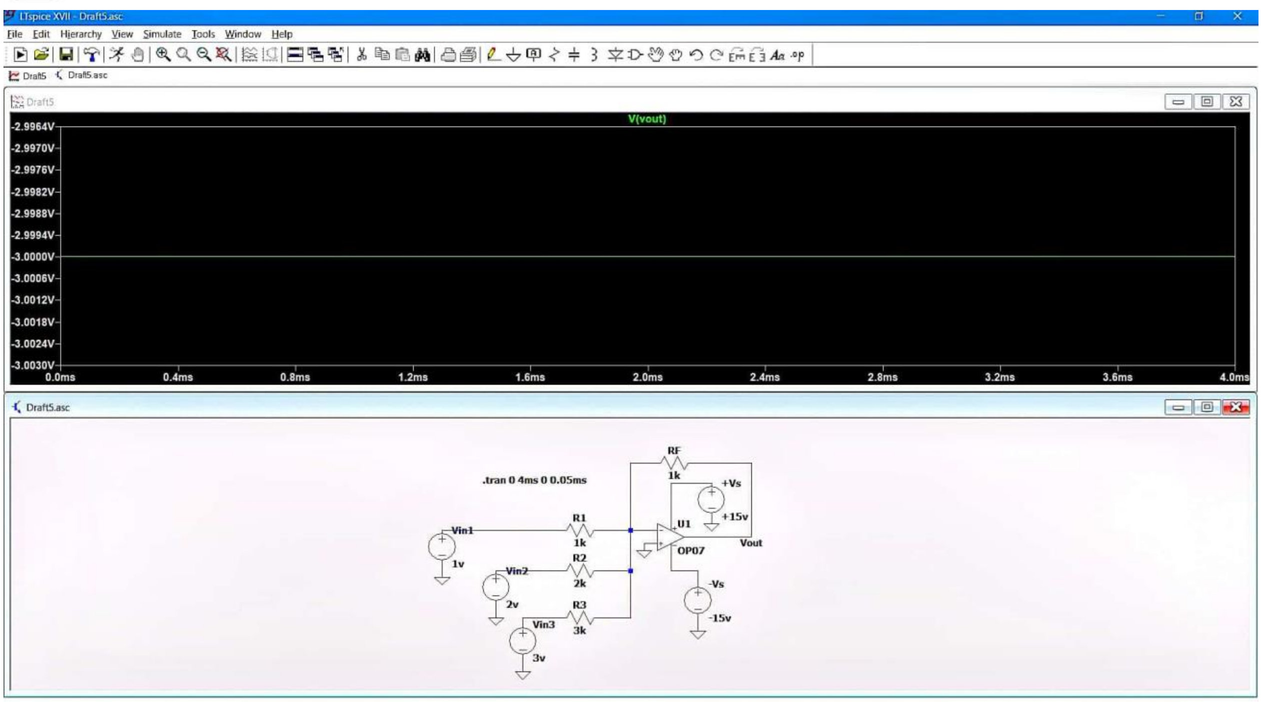


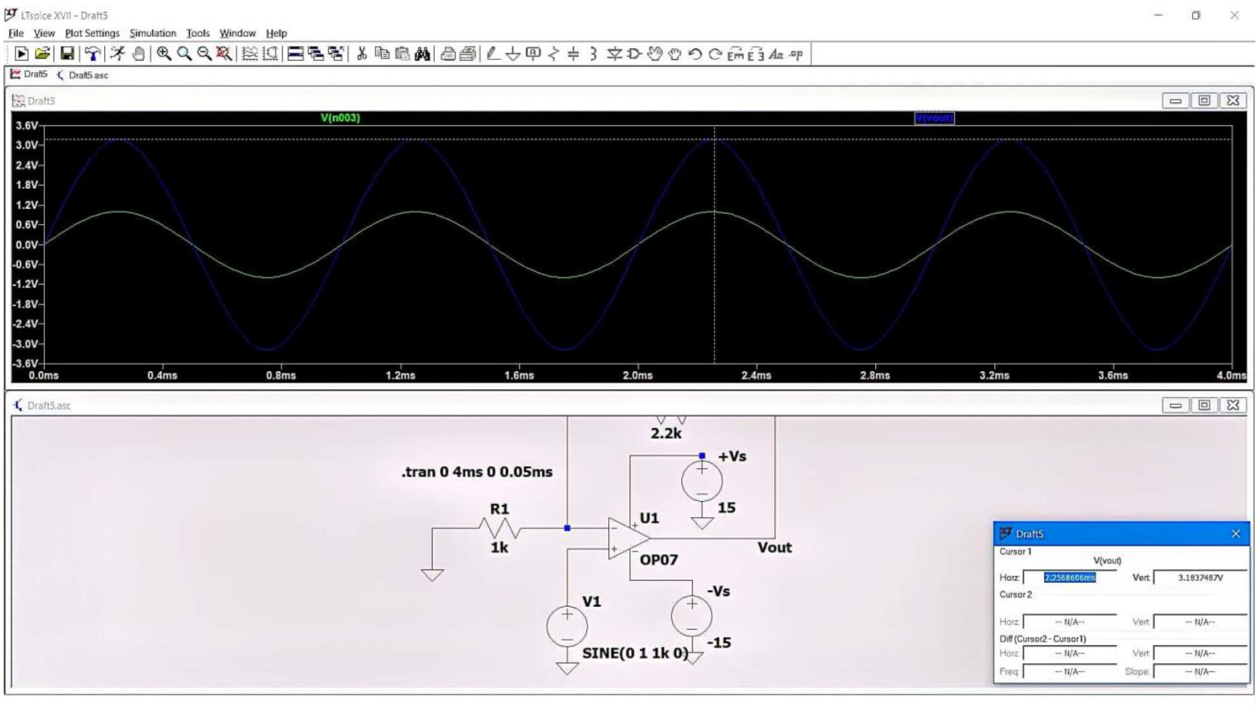
LTspice XVII - [Draft5.asc]
File Edit Hierarchy View Simulate Tools Window Help
Draft5 Draft5.asc
.tran 0 4ms 0 0.05ms
RF
1k
+Vs
+15v
R1
1k
U1
OP07
Vout
Vin1
1v
Vin2
R2
2k
2v
R3
3k
Vin3
SINE(0 1 1k 0)
-Vs
-15v



6. generated graph from simulation part:


LTspice XVII - Draft5.asc
V(vout)
-1.61V
-1.68V
-1.75V
-1.82V
-1.89V
-1.96V
-2.03V
-2.10V
-2.17V
-2.24V
-2.31V
-2.38V
0.0ms
0.4ms
0.8ms
1.2ms
1.6ms
2.0ms
2.4ms
2.8ms
3.2ms
3.6ms
4.0ms
Draft5.asc
.tran 0 4ms 0 0.05ms
RF
1k
+Vs
+15v
U1
OP07
Vout
Vin1
R1
1k
1v
Vin2
R2
2k
2v
Vin3
R3
3k
-Vs
-15v
SINE(0 1 1k 0)


LTspice XVII - Draft5.asc
V(vout)
-2.9964V
-2.9970V
-2.9976V
-2.9982V
-2.9988V
-2.9994V
-3.0000V
-3.0006V
-3.0012V
-3.0018V
-3.0024V
-3.0030V
0.0ms
0.4ms
0.8ms
1.2ms
1.6ms
2.0ms
2.4ms
2.8ms
3.2ms
3.6ms
4.0ms
Draft5.asc
.tran 0 4ms 0 0.05ms
RF
1k
+Vs
+15v
U1
OP07
Vout
Vin1
R1
1k
1v
Vin2
R2
2k
2v
Vin3
R3
3k
3v
-Vs
-15v



7. calculations:

For non inverting amplifier:

Vout=(1+R2/R1)*Vi; where gain=(1+R2/R1)
And from the simulation the peak output voltage,
Voutput_peak= 3.18375 volt which is almost close to gain, (1+2.2/1_=3.2 volt.

8. Discussions:

For inverting amplifier, we can say that it is clear that a feedback signal is provided in the operational amplifier so that the circuit can perform the closed loop operation. It may also be noted that the feedback provided is the negative one, which increases the accuracy of operation of the circuit. inverting amplifiers are used in a number of applications like phase shifter, integration, signal balancing, mixer circuits, etc.

And for non-inverting amplifier, we can say that he input signal is applied at the non-inverting terminal, while the feedback is provided at the inverting terminal. Thus, the non-inverting amplifier has a negative feedback. Non-inverting amplifiers are used in circuits where high input impedance is required. They are used as a voltage follower, isolation of cascaded circuits, to perform mathematical simulations, etc. Morever, the most significant difference is that an inverting amplifier introduces a phase shift of 180° between the input and output signals, whereas a non-inverting amplifier has 0° phase shift (nophase shift) between input and output signals. Both inverting and non-inverting amplifiers use negative feedback which increases the controllability of the gain of the amplifier.