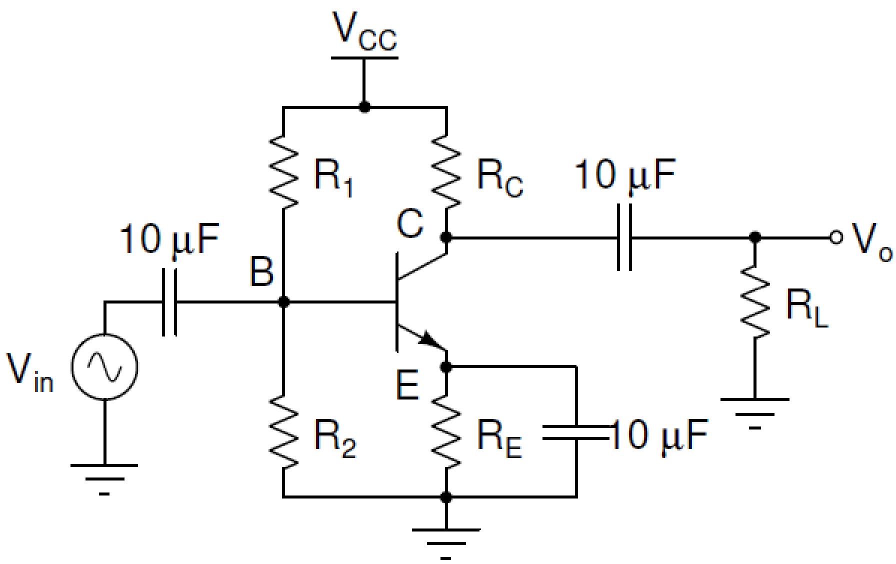
Experiment-5

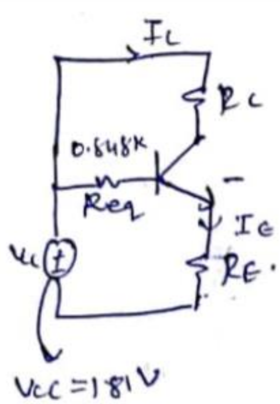
BJT Amplifier

Name: Arya Marda

Roll No: 2021102021

Reference circuit:





$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{eq} = \frac{(1)(5.6)}{1 + 5.6}$$

$$R_{eq} = 0.848\ K.$$

$$V_{cc} \Rightarrow \frac{(12)(1)}{6.6} \Rightarrow 1.81\ V.$$

$$V_{cc} = \frac{(R_2)(V_{cc})}{R_1 + R_2}.$$

$\therefore$ Applying KVL $\Rightarrow$

$$1.81\,V - (I_B)(R_{eq}) - 0.7 - I_E R_E = 0$$

$$\Rightarrow 1.11 - \frac{(I_E)}{\beta} R_{eq} - I_E R_E = 0$$

$$\Rightarrow 1.11 = (I_E)\left(R_E + \frac{R_{eq}}{\beta}\right)$$

Given $\rightarrow I_C = 1.5\,mA$

callculating R_E, we get

$R_E = 727.72\ \Omega$

$\Rightarrow$ callculating R_C.

$$\frac{(1.5\times10^{-3})}{25\times10^{-3}} \times \frac{R_C \cdot 1}{R_C + 1} = 5 \Rightarrow R_C = \frac{1000}{11} = 90.90\ \Omega$$

$R_C = 90.90\ \Omega$

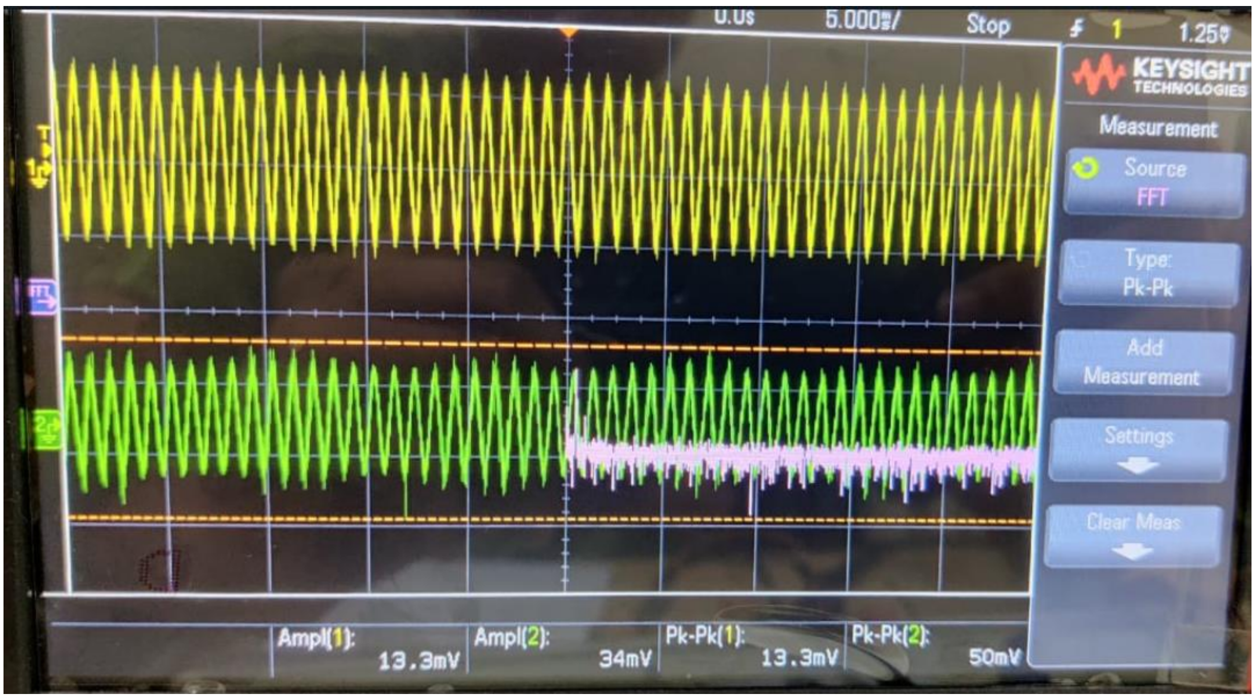
$R_E = 727.72\ \Omega$

2. Transient response and total harmonic distortion (THD)

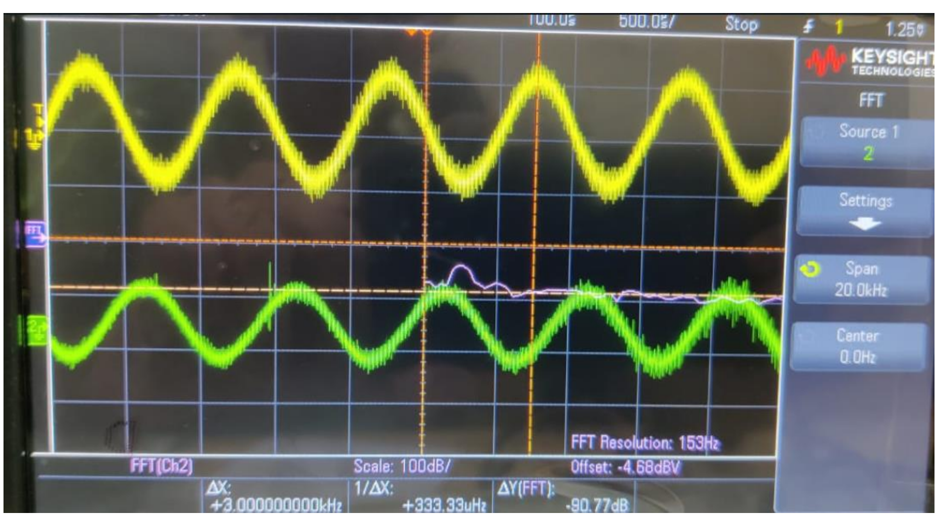
Plots of input signal and output signal with output signals Fourier transformation.

1)Vin: 13.3mV

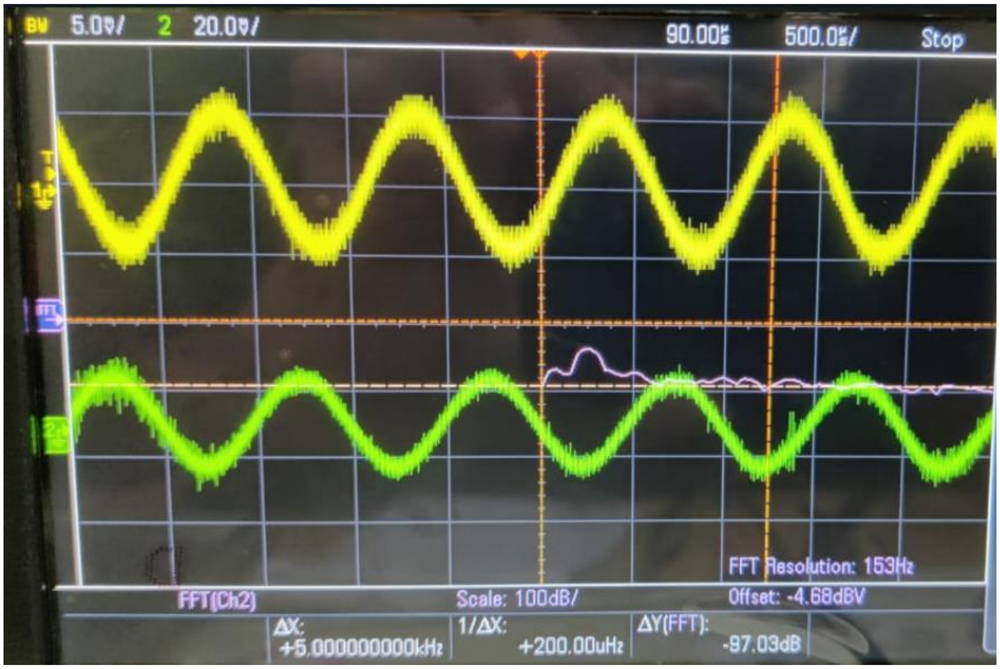
a. Vout:50mV



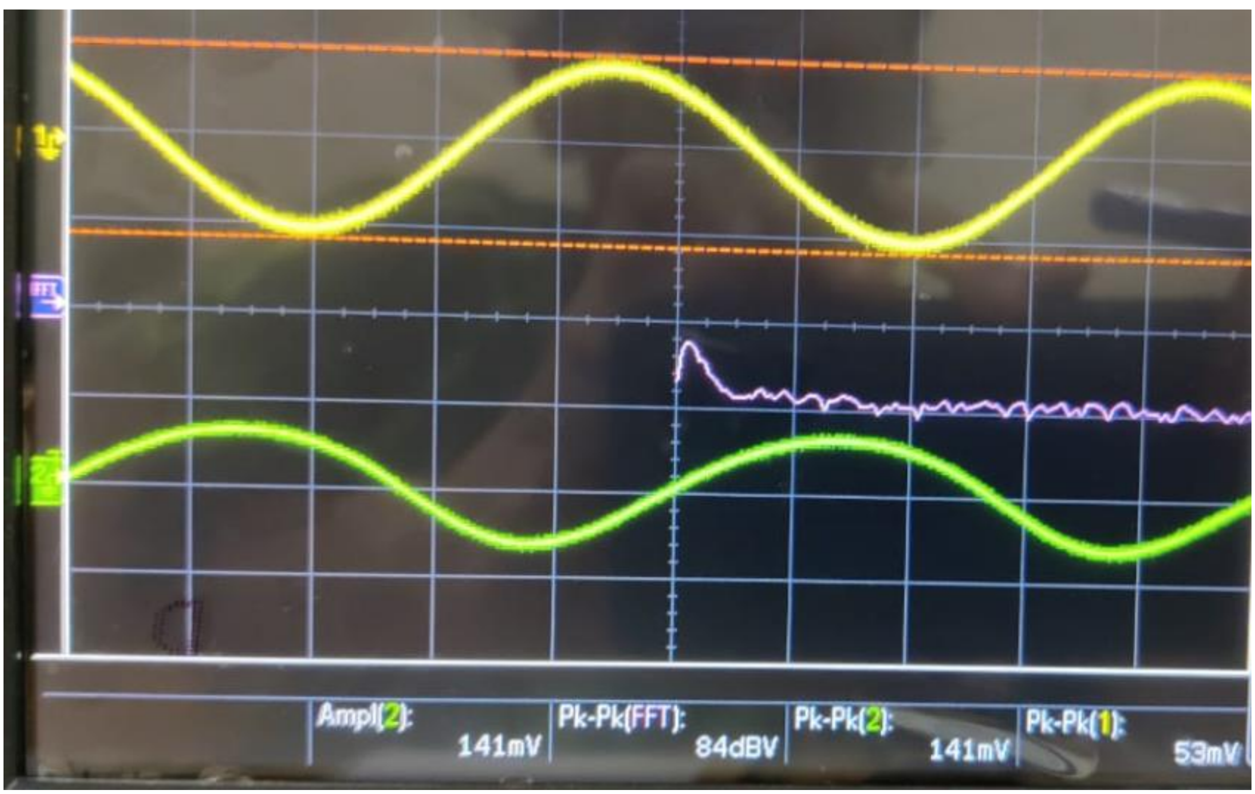
b. Amplitude of Fourier transformation at 3kHz.



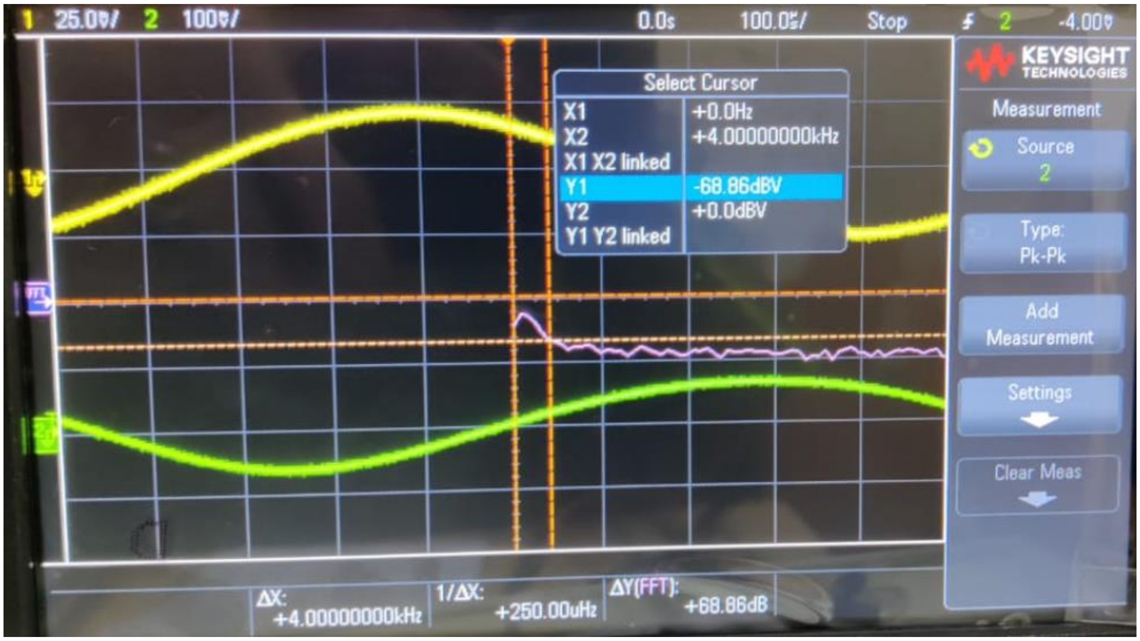
c. Amplitude of Fourier transformation at 5kHz.



2)Vin: 50mV

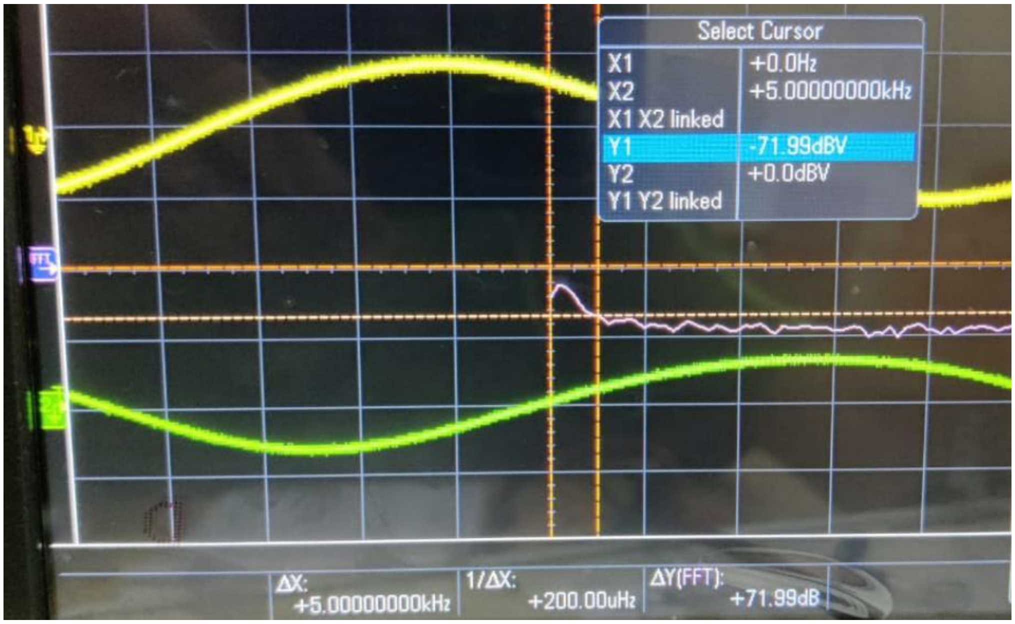


a. Amplitude of Fourier transformation at 4kHz.

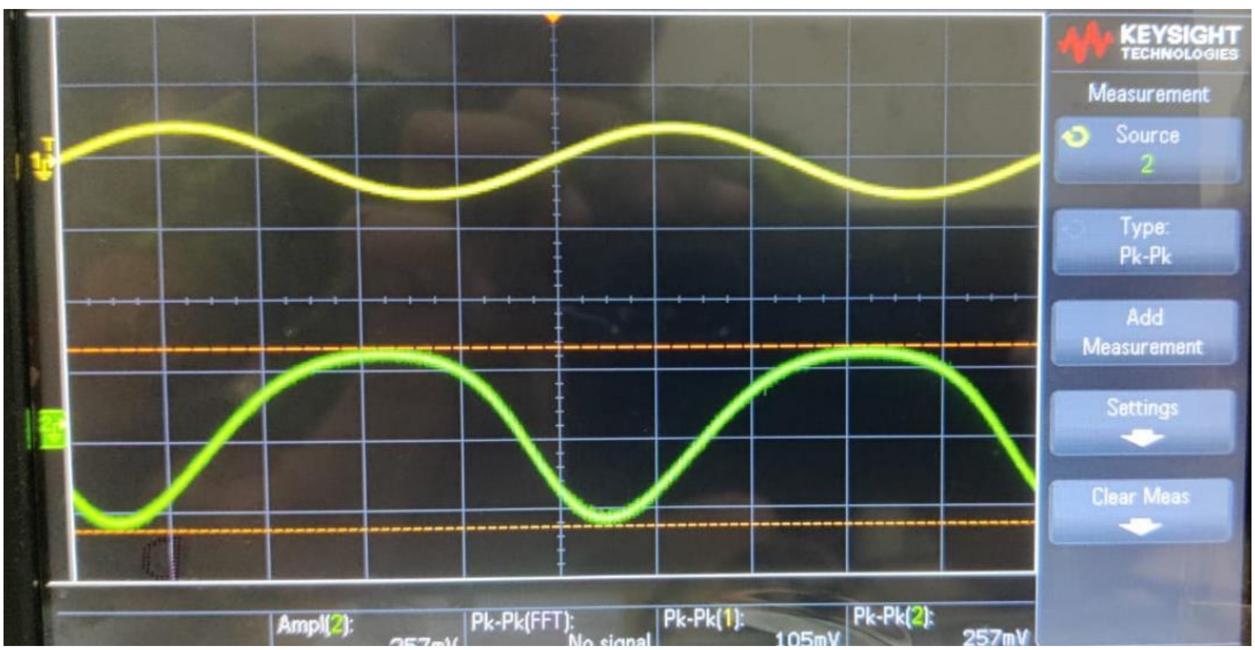


b. Amplitude of Fourier transformation at 3kHz.

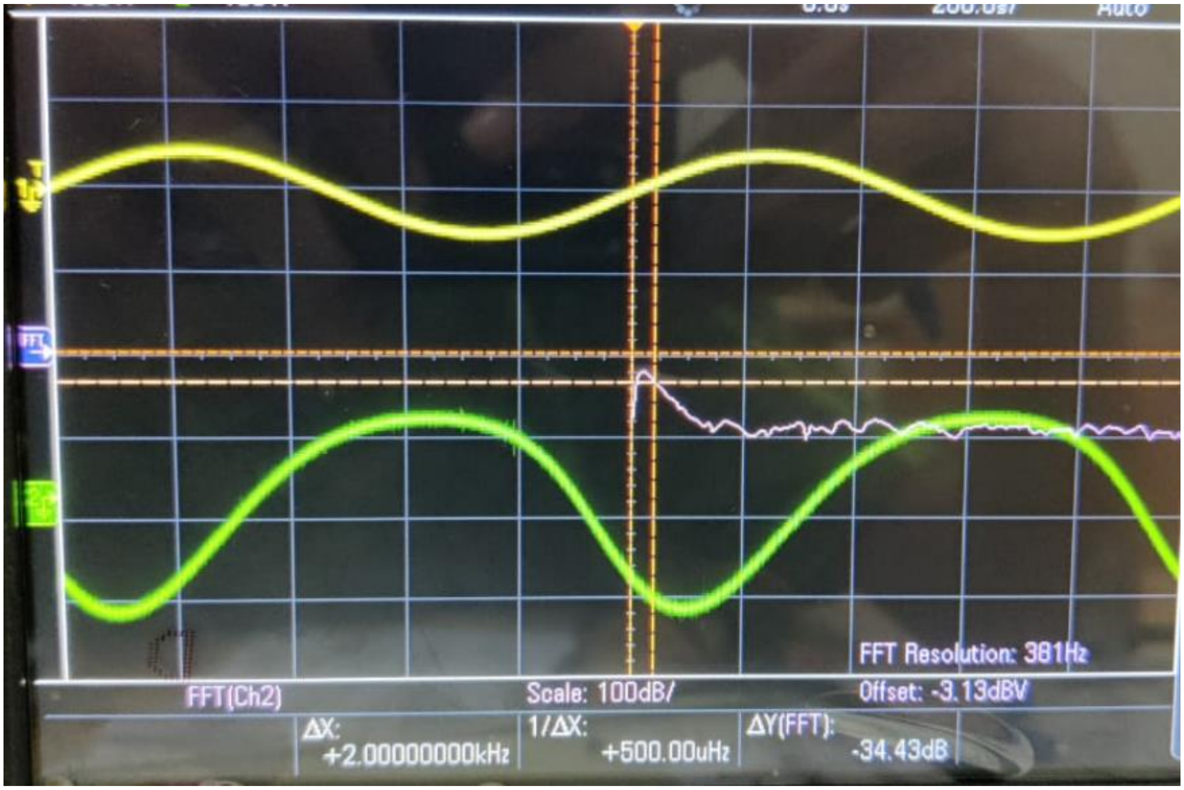
c. Amplitude of Fourier transformation at 3kHz.



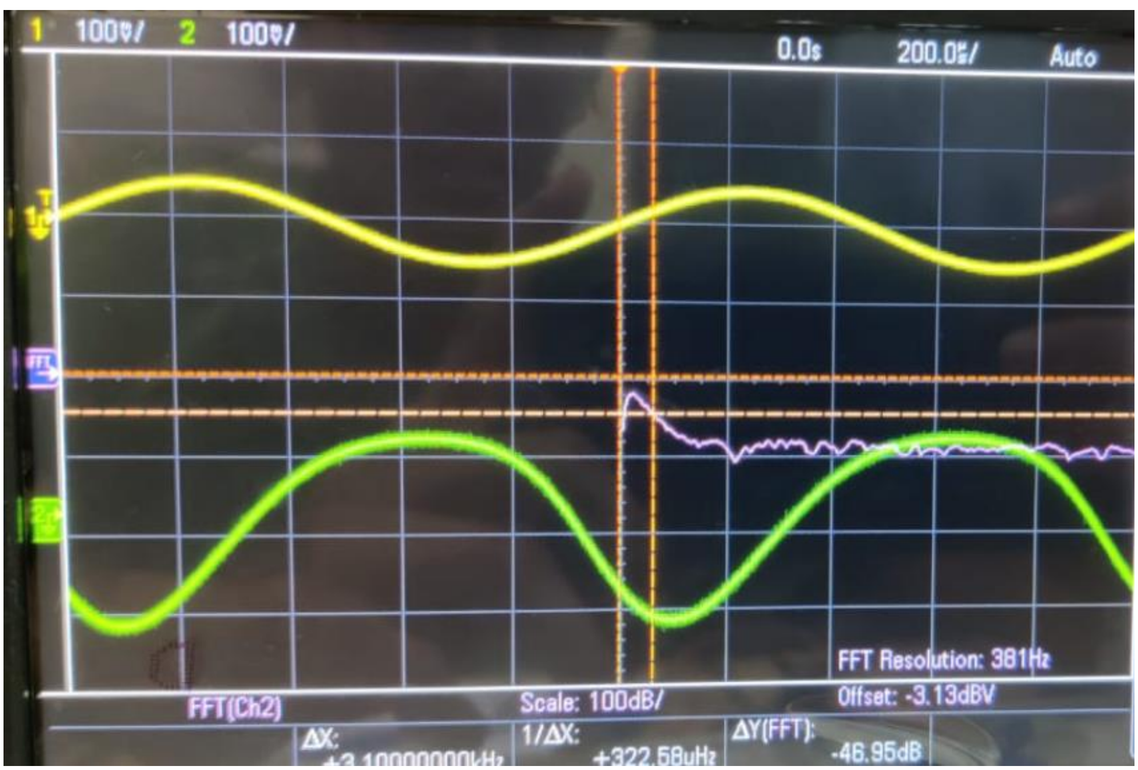
3)Vin: 100mV



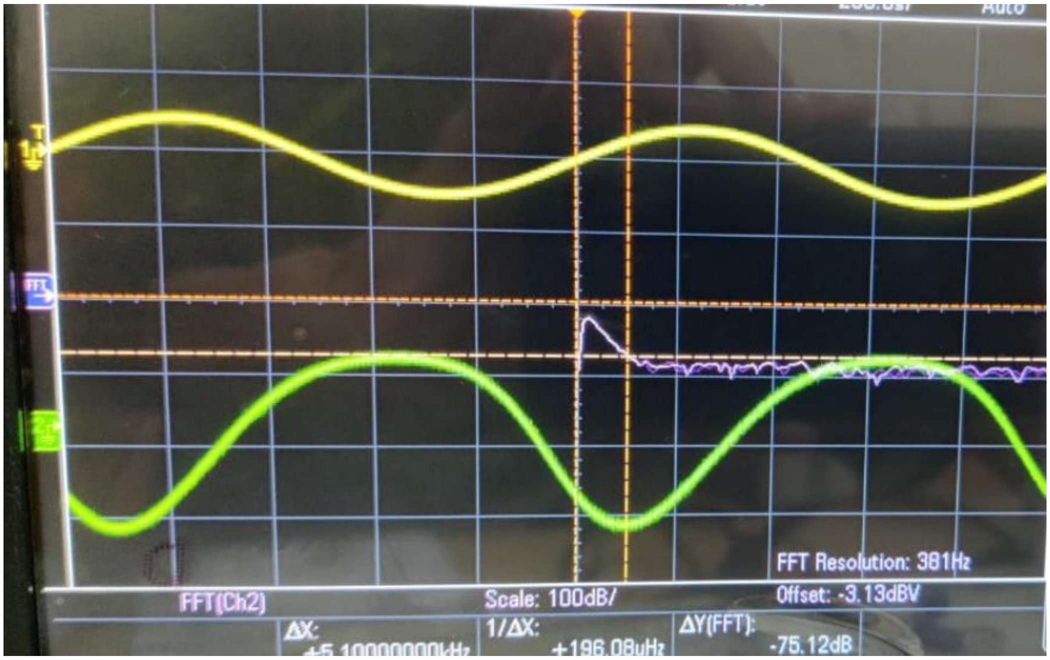
a. Amplitude of Fourier transformation at 2kHz.



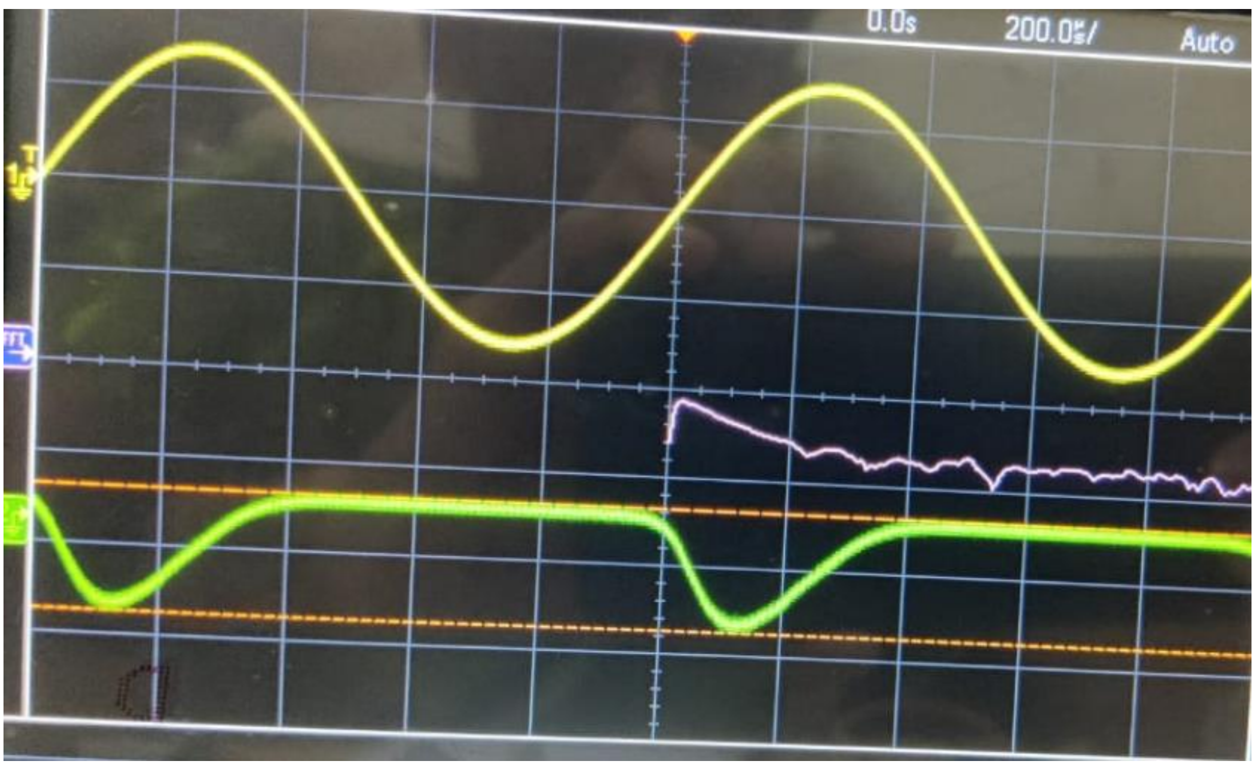
b. Amplitude of Fourier transformation at 3kHz.



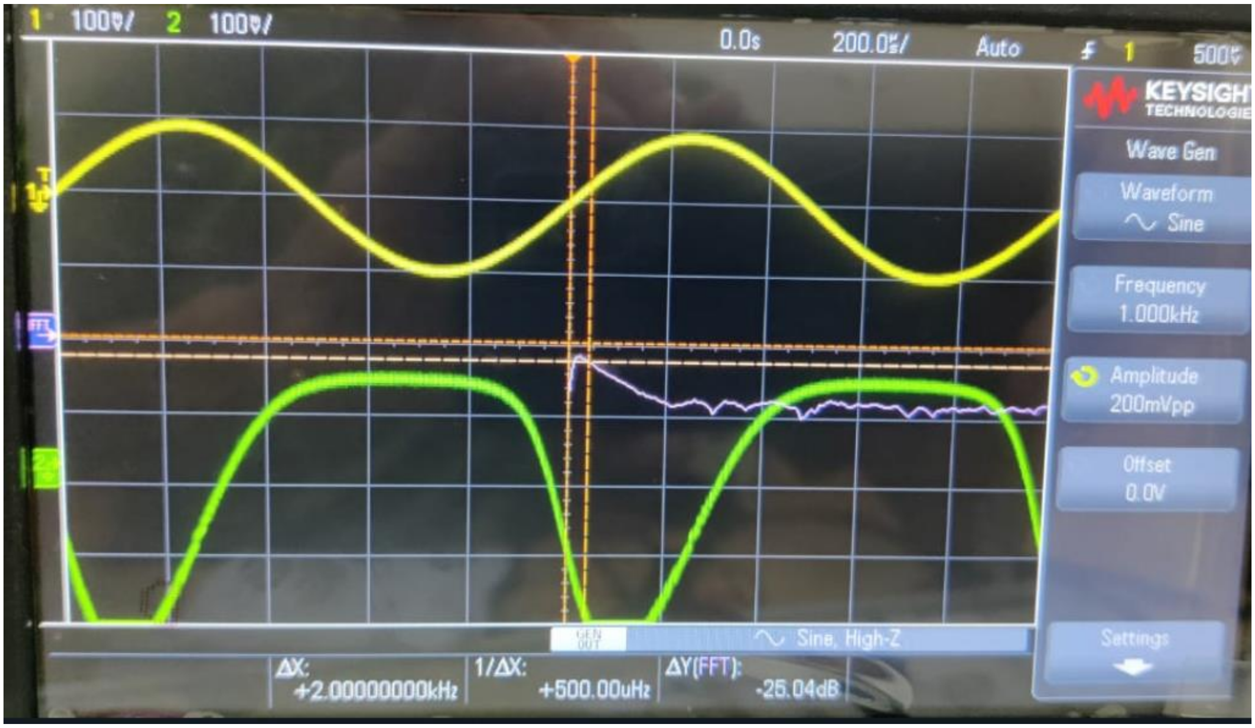
c. Amplitude of Fourier transformation at 5kHz.



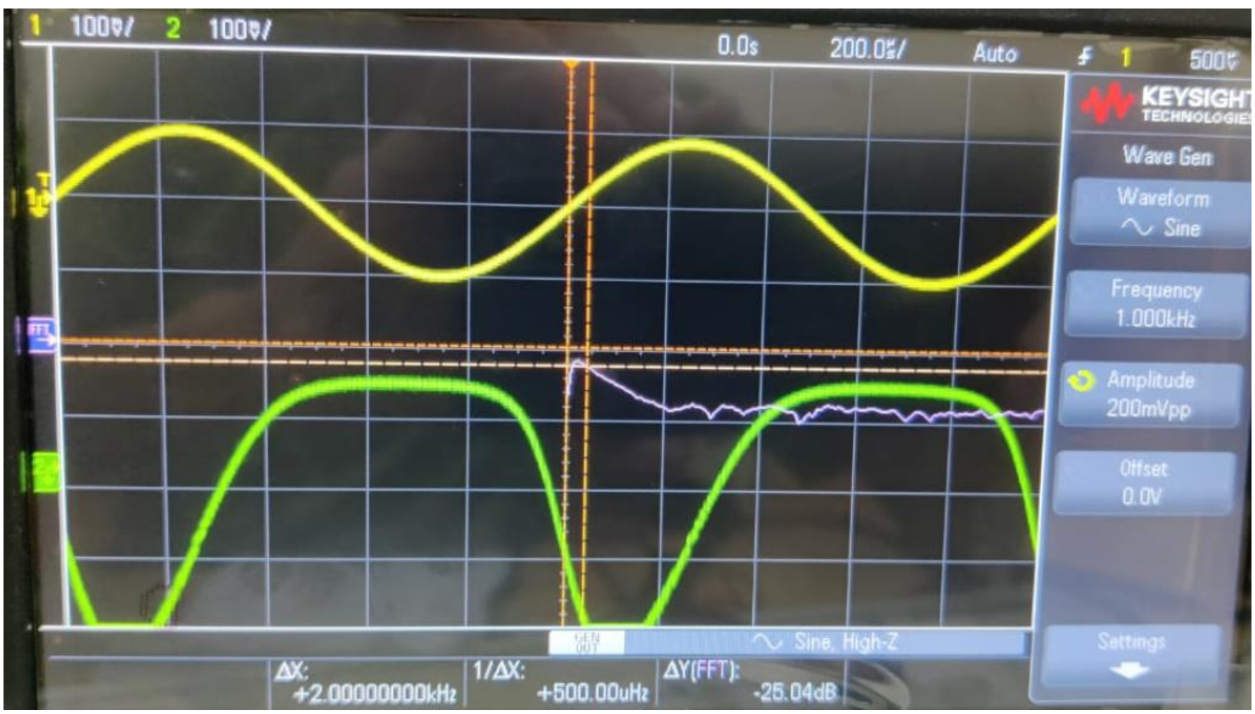
4) Vin: 200mV



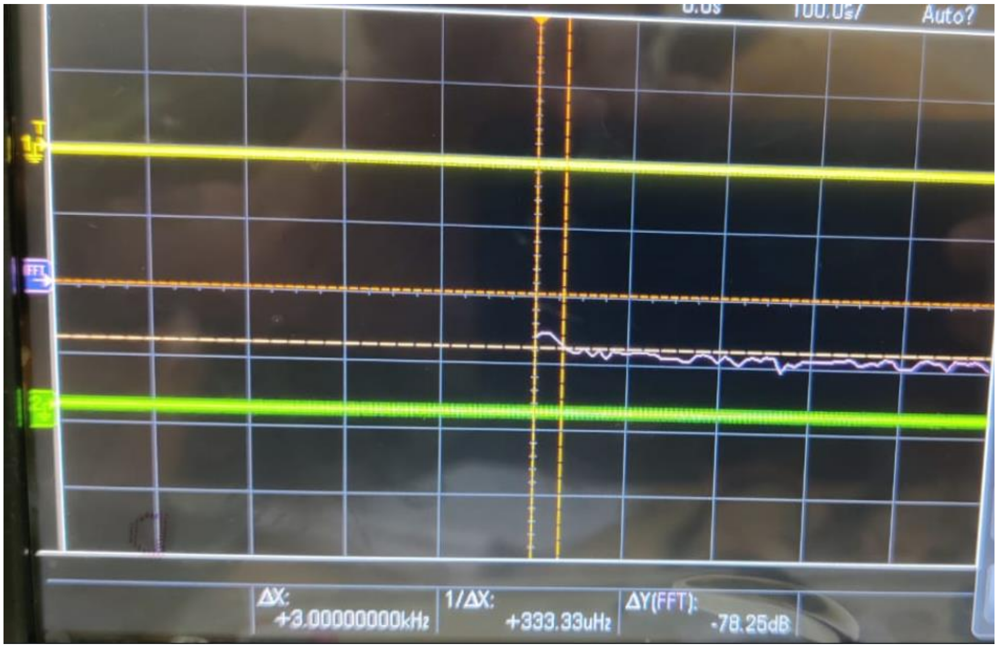
d. Amplitude of Fourier transformation at 2kHz.



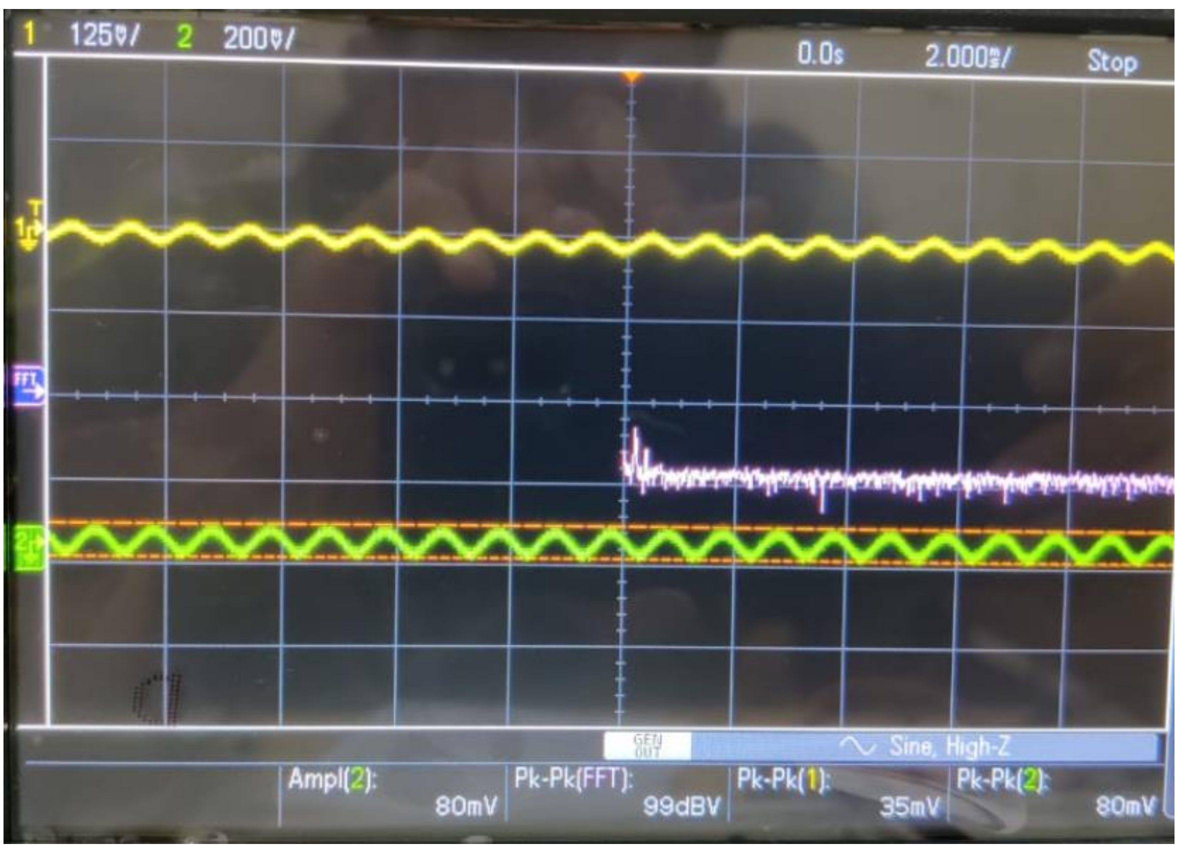
1) Amplitude of Fourier transformation at 2kHz.



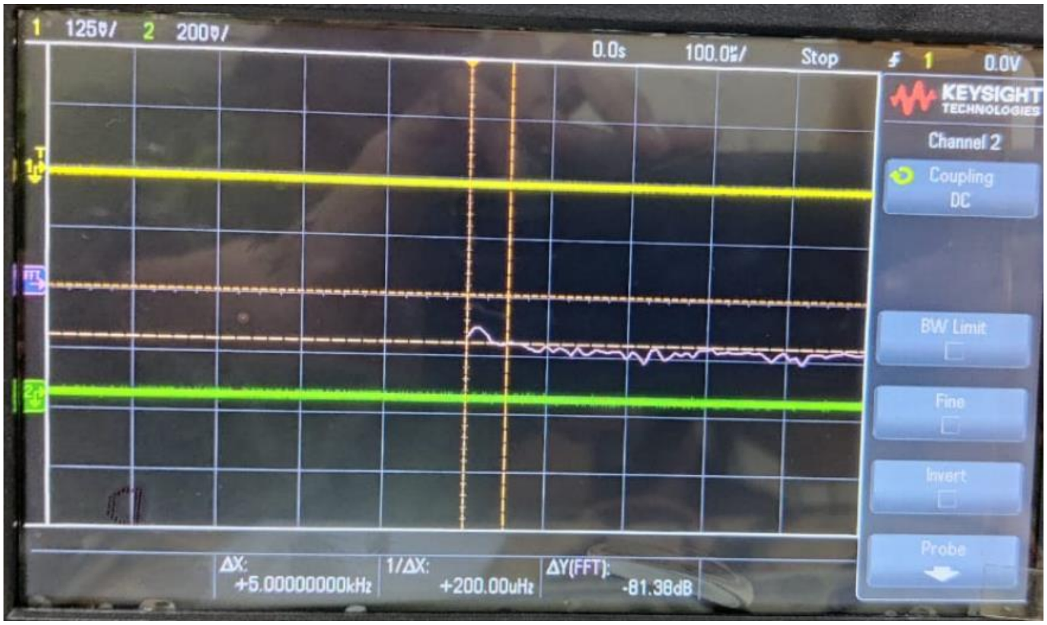
Amplitude of Fourier transformation at 3kHz.



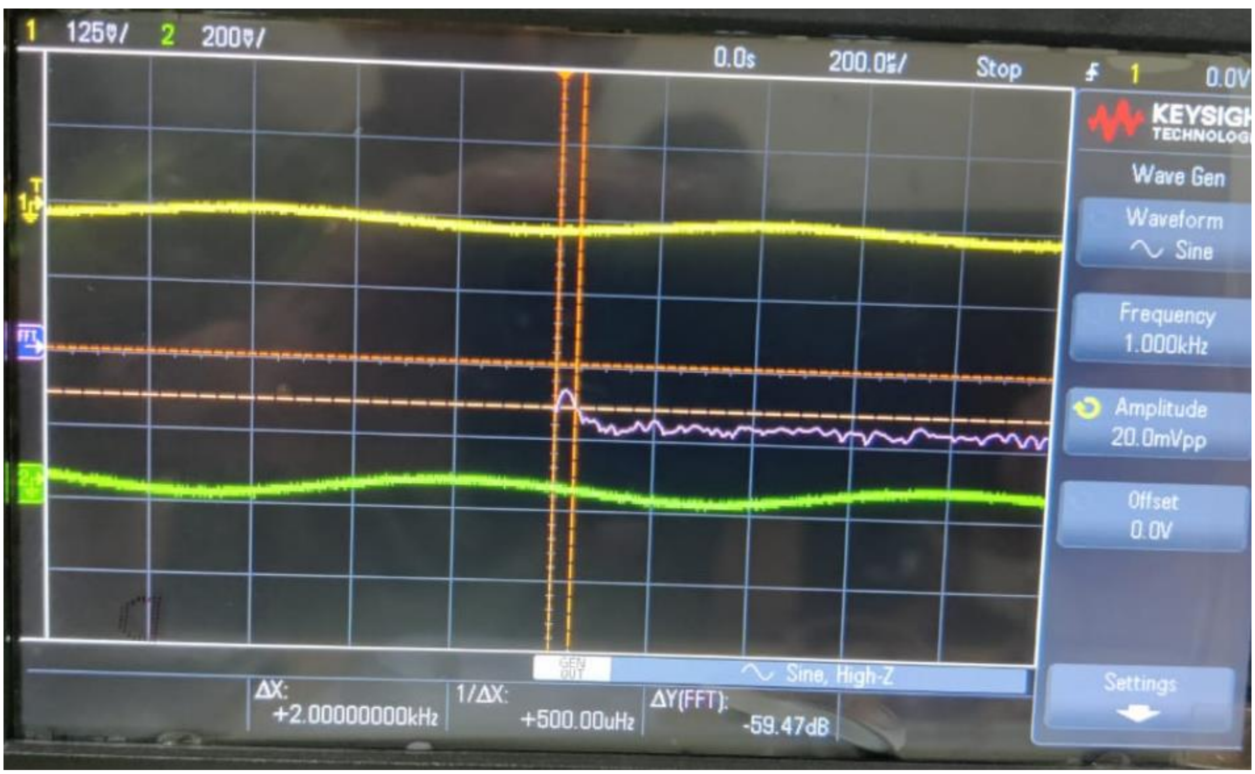
Vin: 20mV



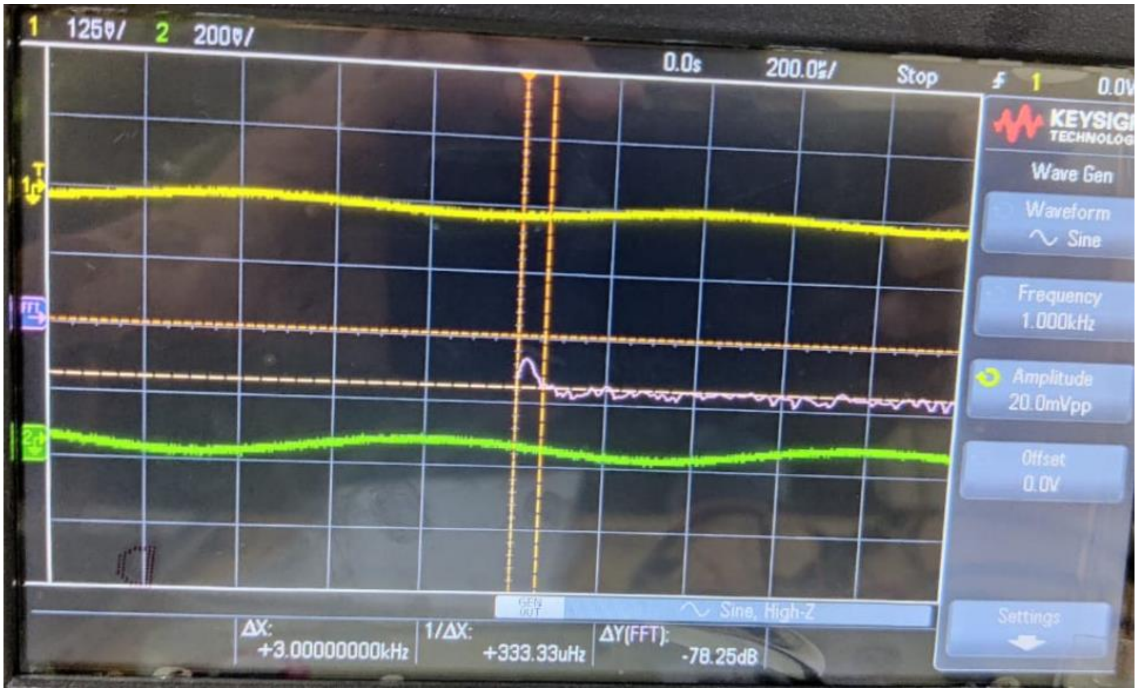
Amplitude of Fourier transformation at 5kHz.



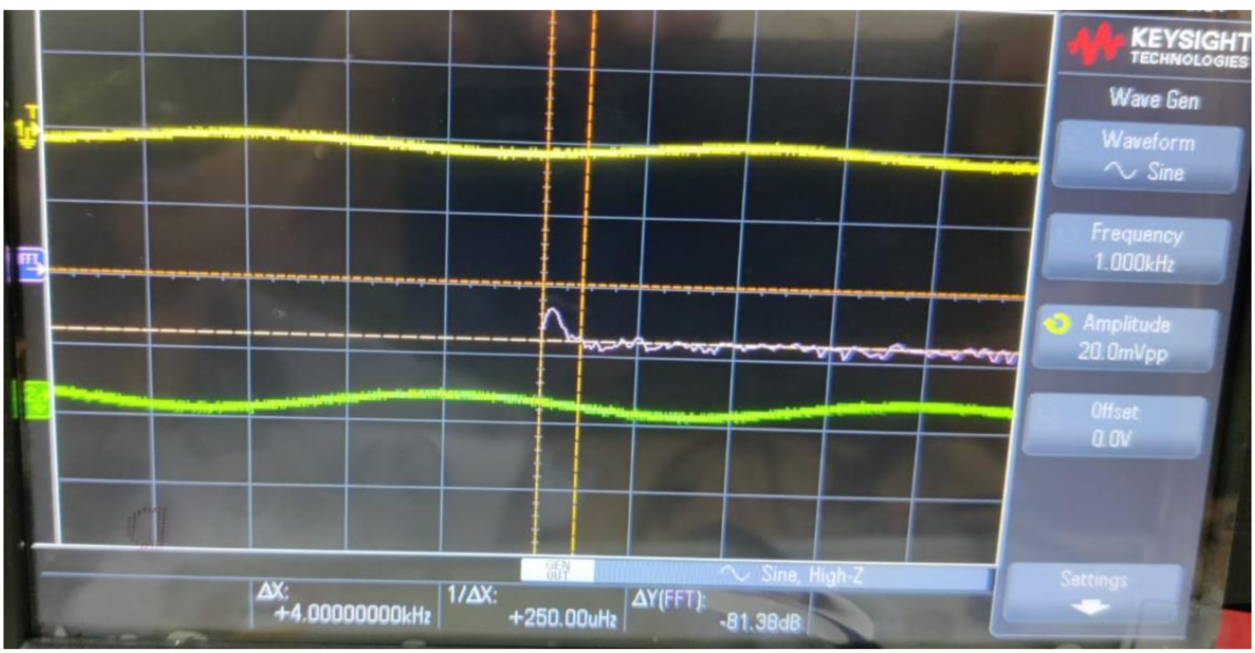
Amplitude of Fourier transformation at 2kHz.



Amplitude of Fourier transformation at 3kHz.

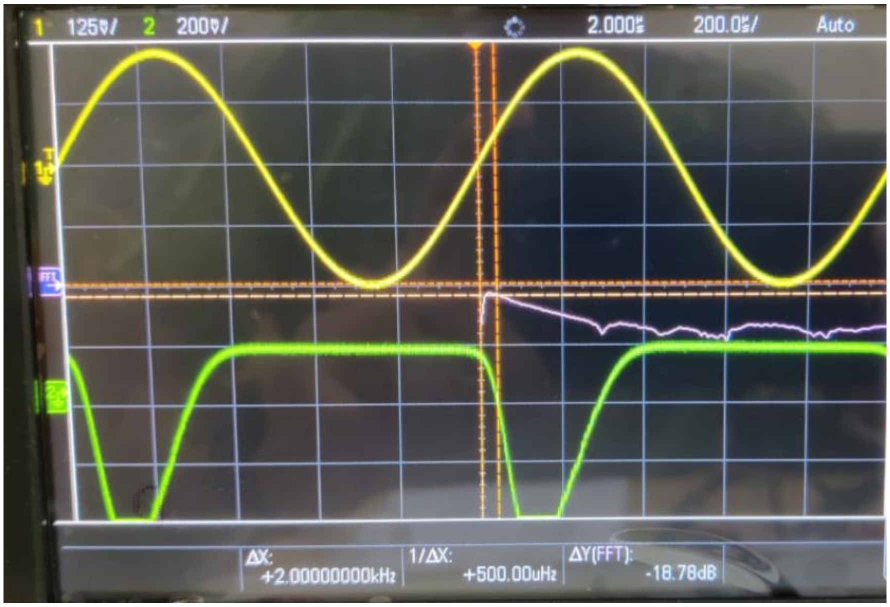


Amplitude of Fourier transformation at 4kHz.



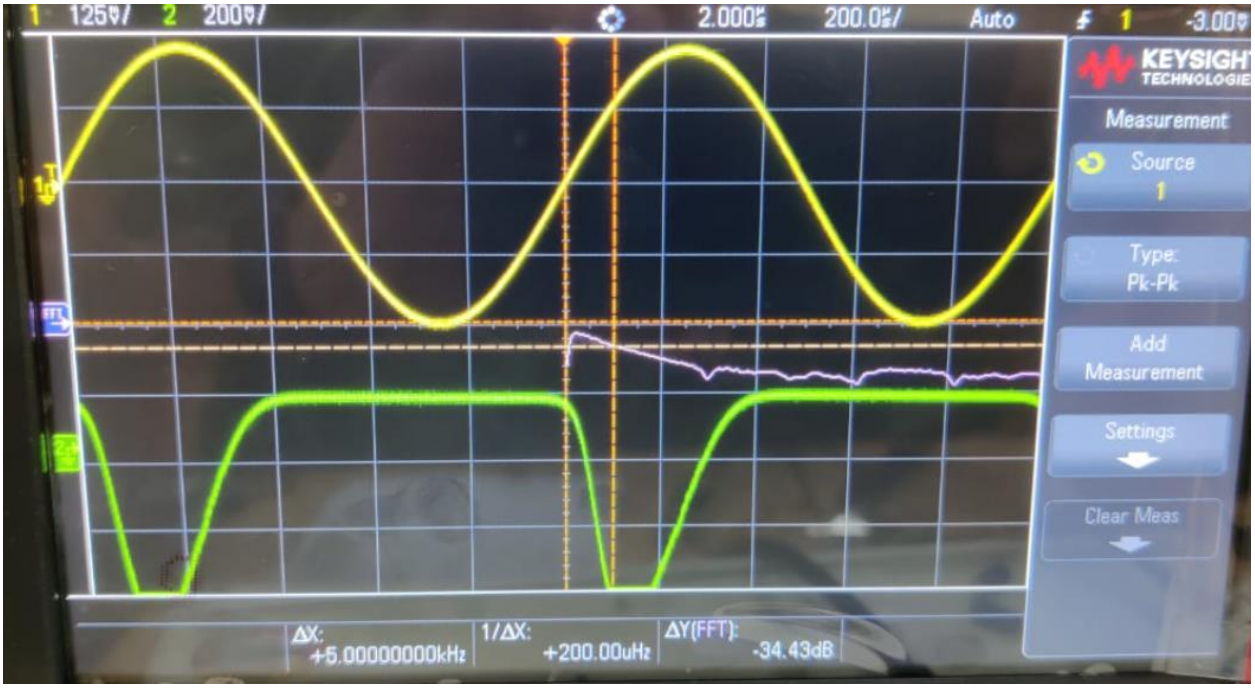
Vm:500mV

Amplitude of Fourier transformation at 2kHz.

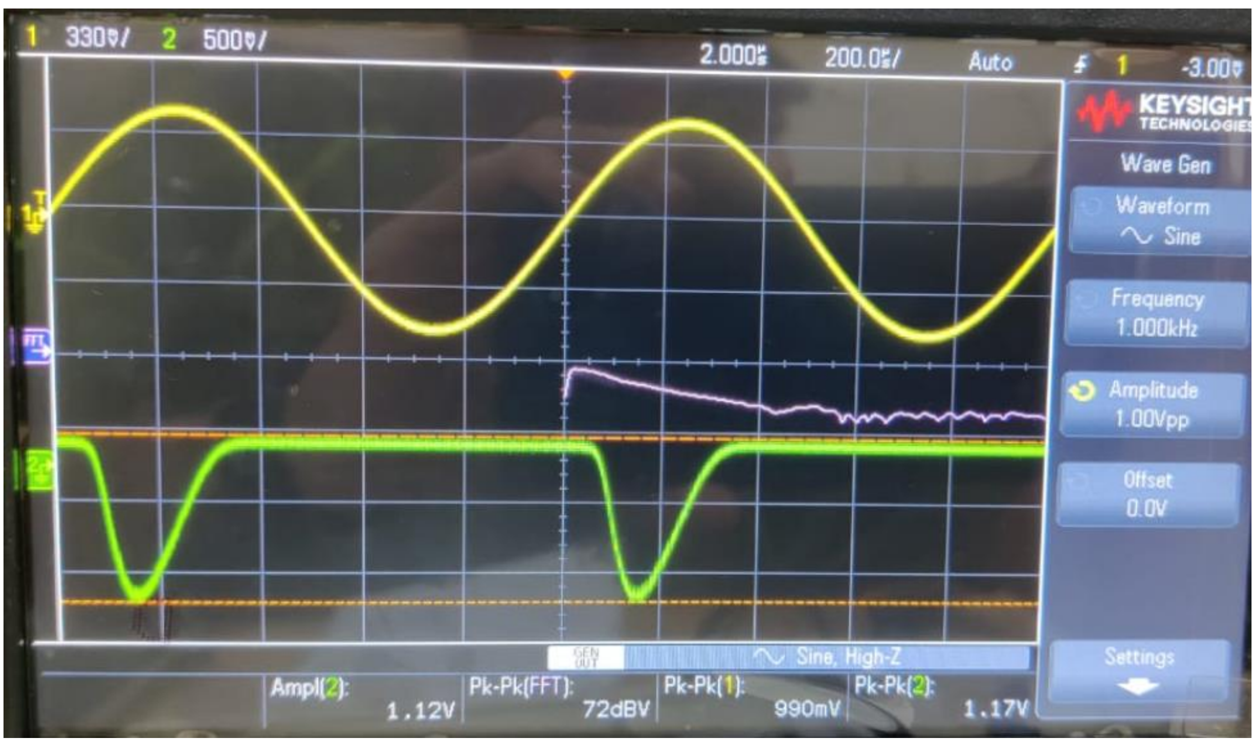


Amplitude of Fourier transformation at 3kHz.

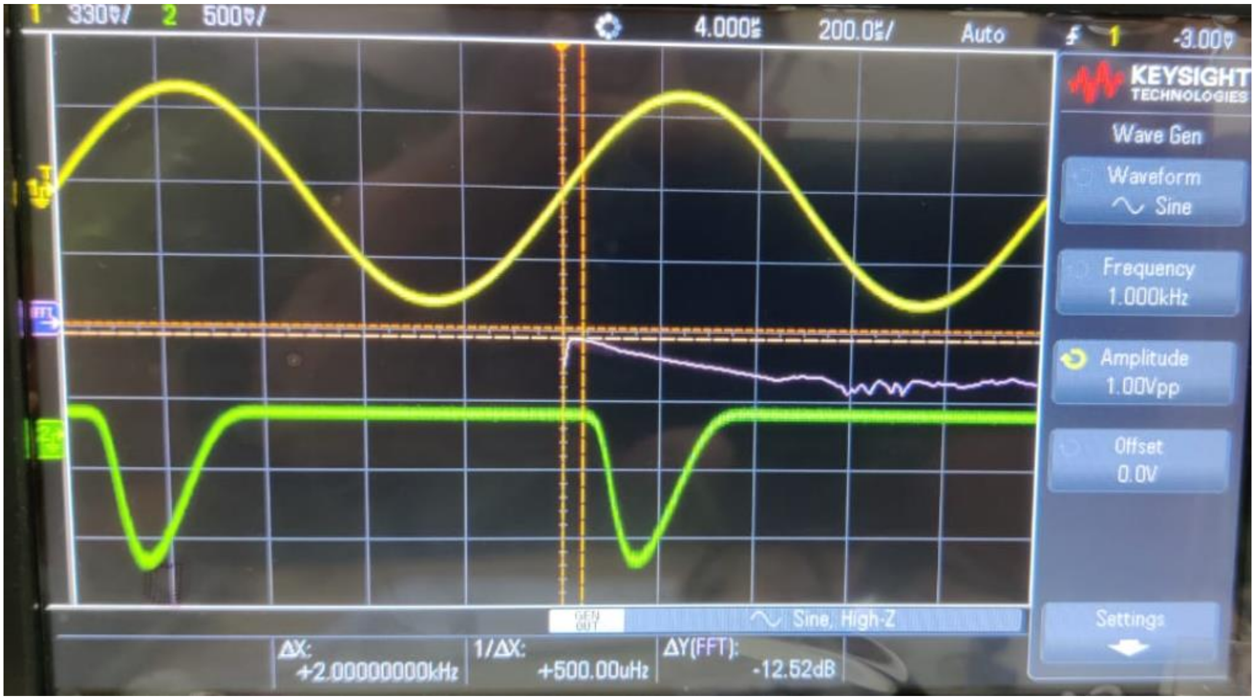
Amplitude of Fourier transformation at 5kHz.



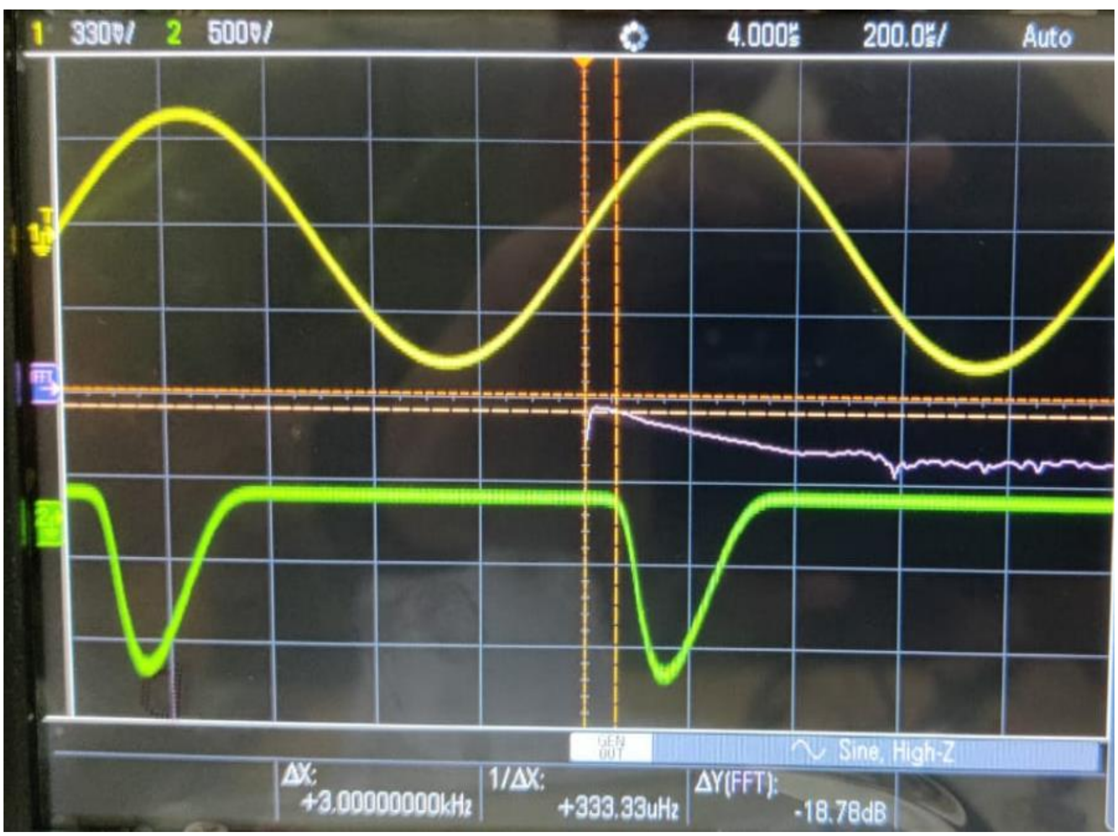
Vm:1V



Amplitude of Fourier transformation at 2kHz.



Amplitude of Fourier transformation at 3kHz



Amplitude of Fourier transformation at 5kHz

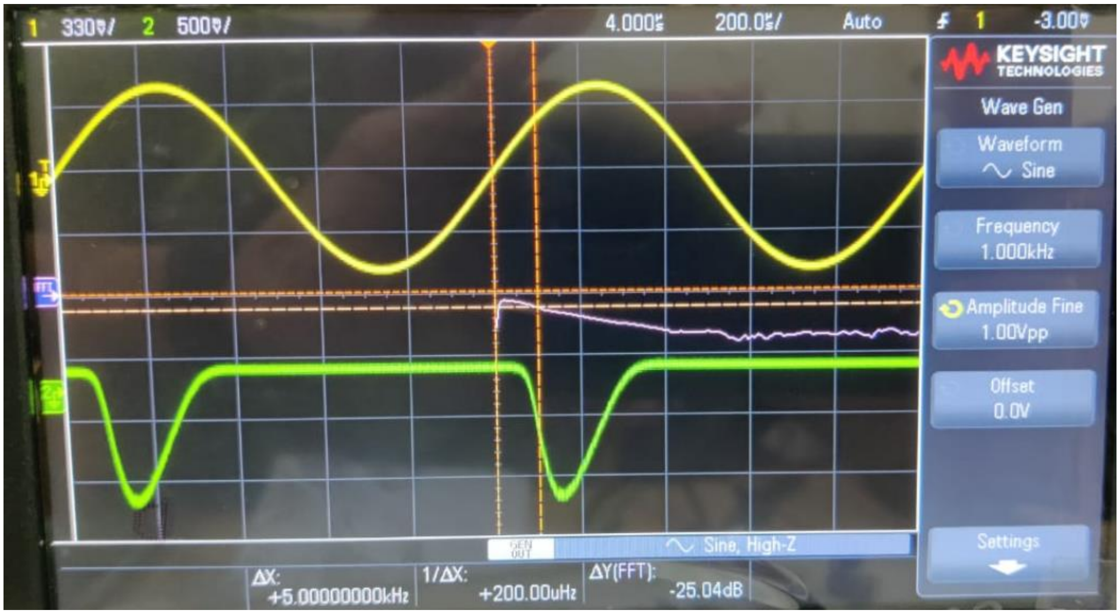


Table of the values needed to calculate THD and Gain:

Vm (mV)	Vo (mV)	1kHz (dB)	2kHz (dB)	3kHz (dB)	4kHz (dB)	5kHz (dB)	TDH (dB)
2	15	-53.21	-62.60	-78.25	-81.38	-81.38	2.86791
10	50	-40.69	-75.12	-90.77	-81.16	-81.39	4.04524
20	80	-28.17	-59.47	-78.25	-81.38	-81.28	5.37063
50	141	-25	-37.5	-53.25	-68.87	-71.99	4.76108
100	257	-21.91	-34.43	-46.95	-62.60	-75.12	5.19419
200	422	-15.65	-25.04	-34.3	-43.80	-53.12	5.1688
500	740	-15.65	-18.78	-25	-31	-34.3	3.56636
1000	1170	-12.5	-12.52	-18.7	-25.04	-25.04	3.5661

Av (Average over all the 8 values noted above) = 8.89

3. Frequency response

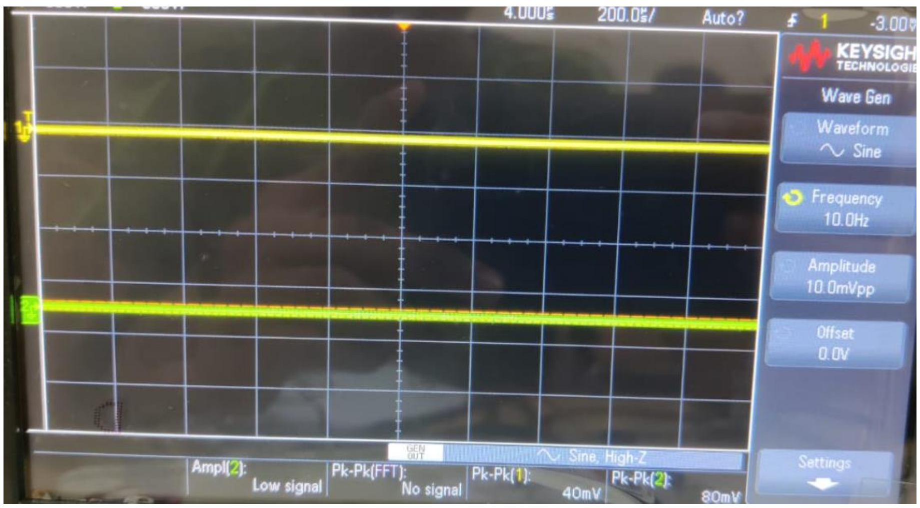
For RL = 1 KΩ and Vm = 10 mV,

We will vary the frequency of input signal fin = {10 Hz, 50 Hz, 100 Hz, 500 Hz, 1 kHz, 10 kHz, 100 kHz,1 MHz, 10 MHz, 20 MHz} and report input Vpp, output Vpp and voltage gain.

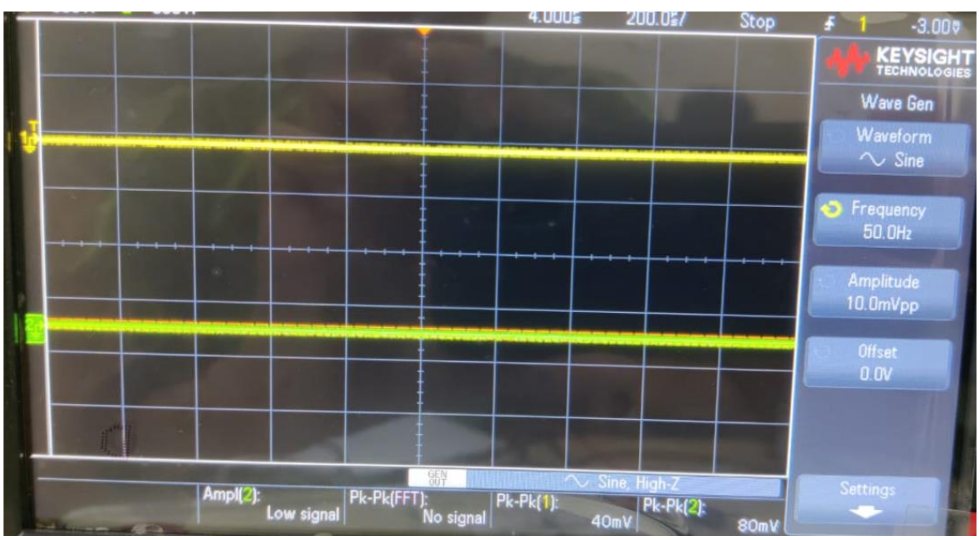
Note: On giving input voltage as 10mV, my OSC is showing amplitude of Vin as 40-50mV. This can be seen in my OSC pictures.

Plots:

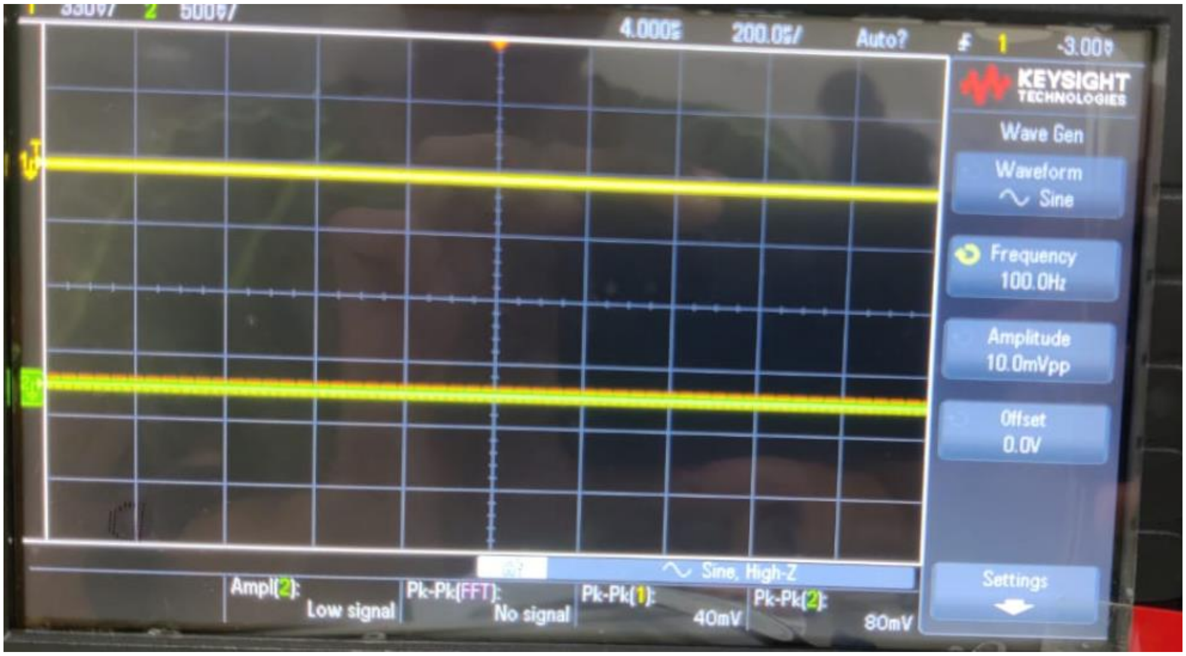
Frequency: 10Hz



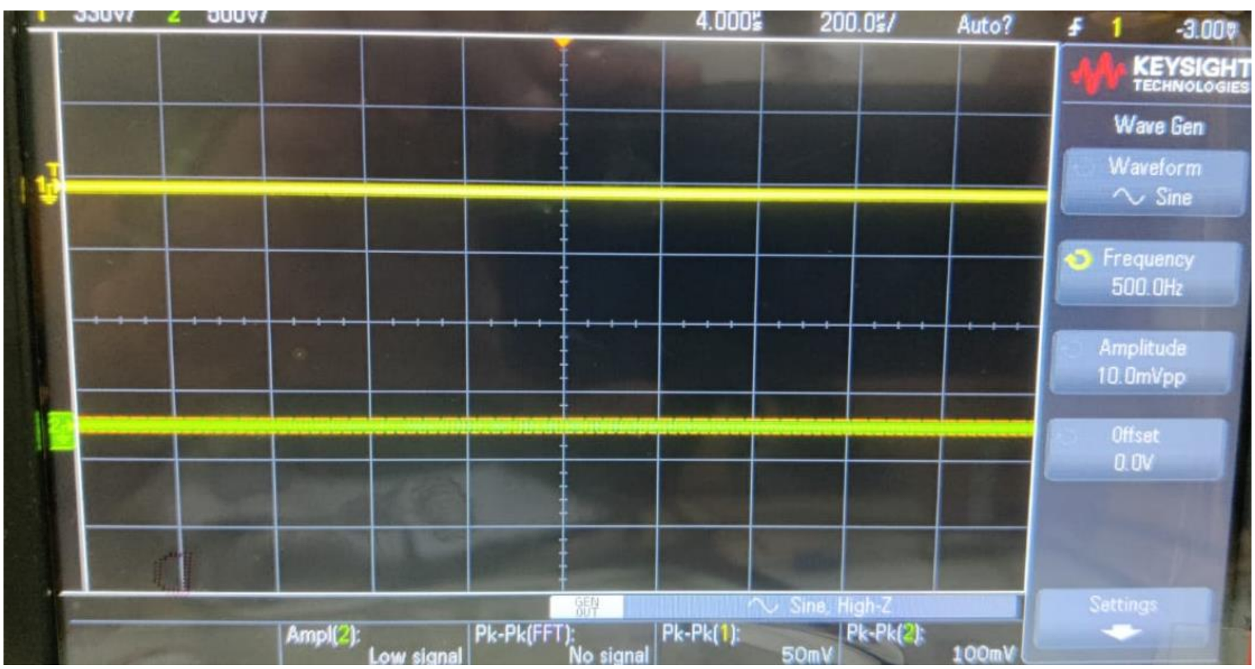
Frequency: 50Hz



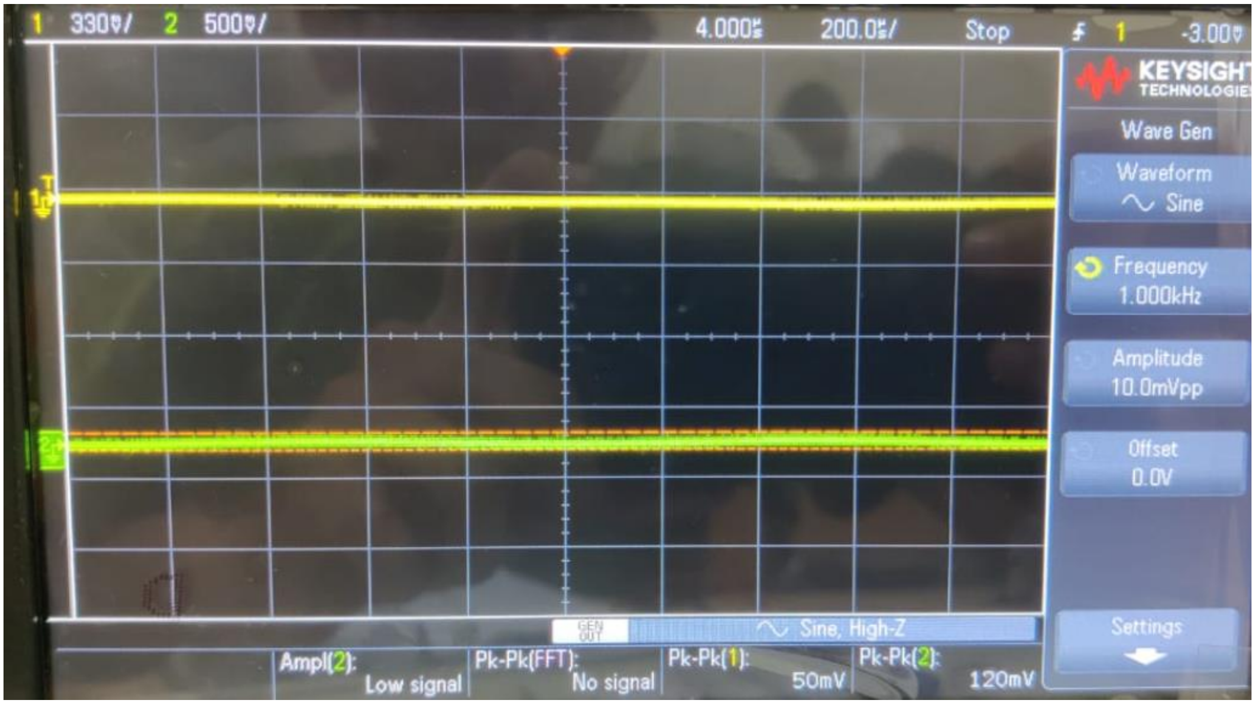
Frequency: 100Hz



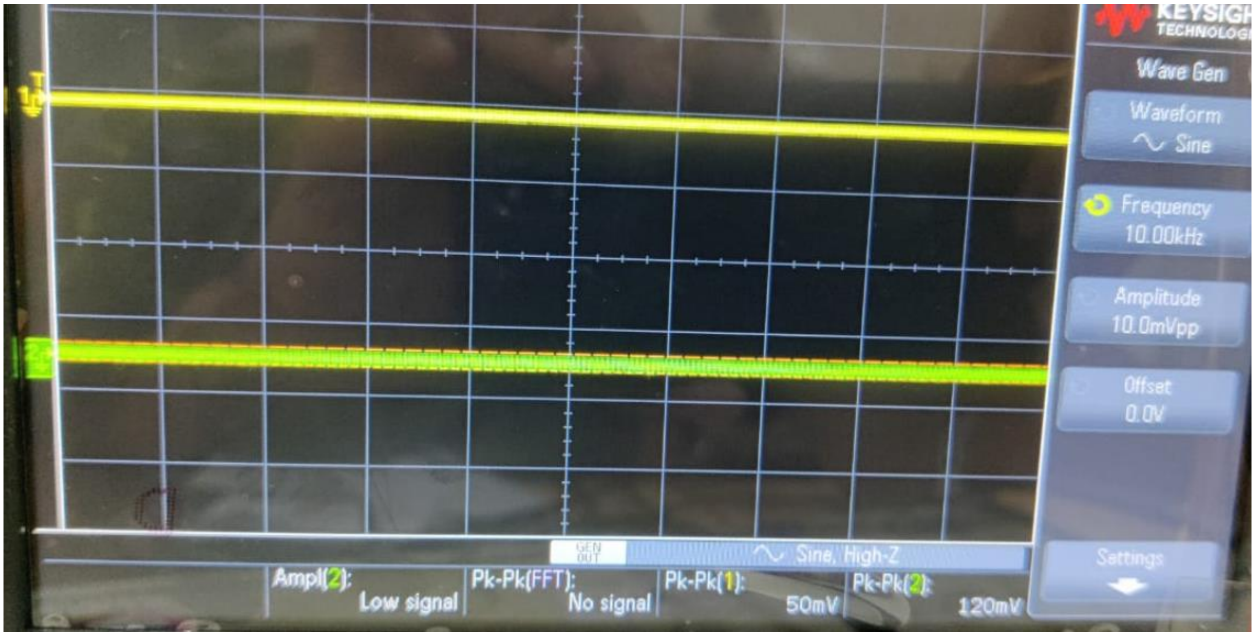
Frequency: 500Hz



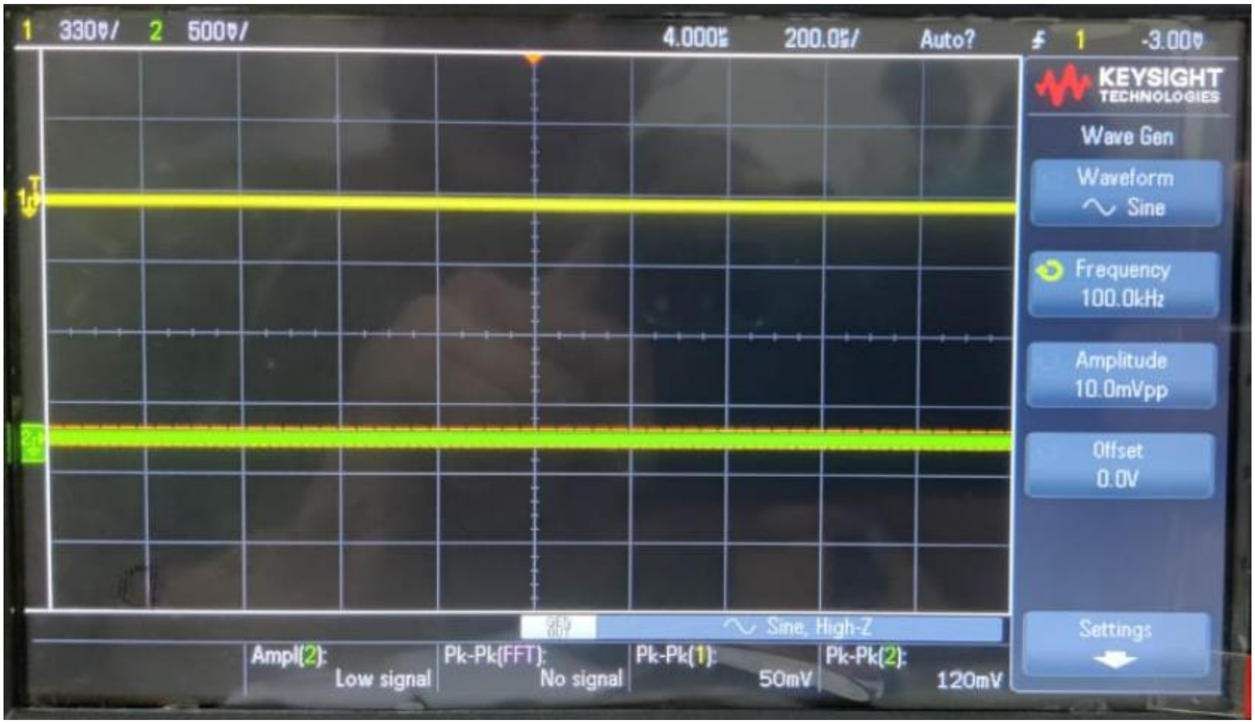
Frequency: 1000Hz



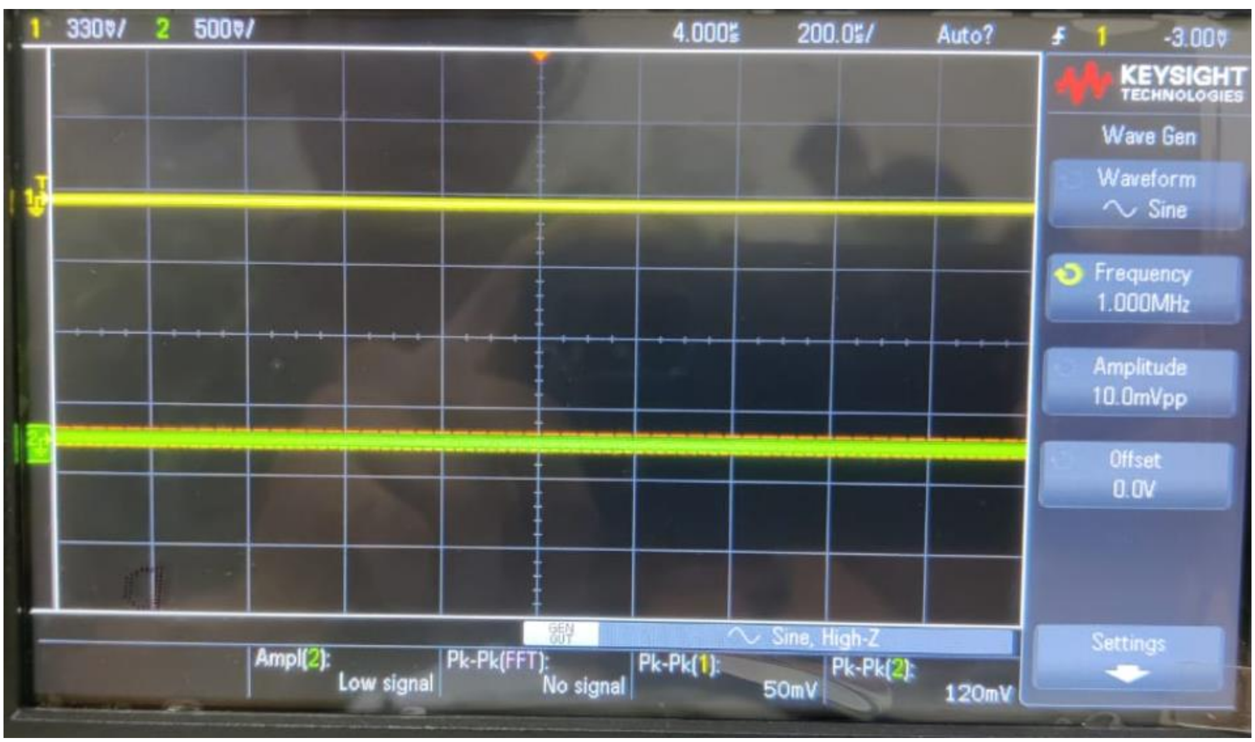
Frequency: 10KHz



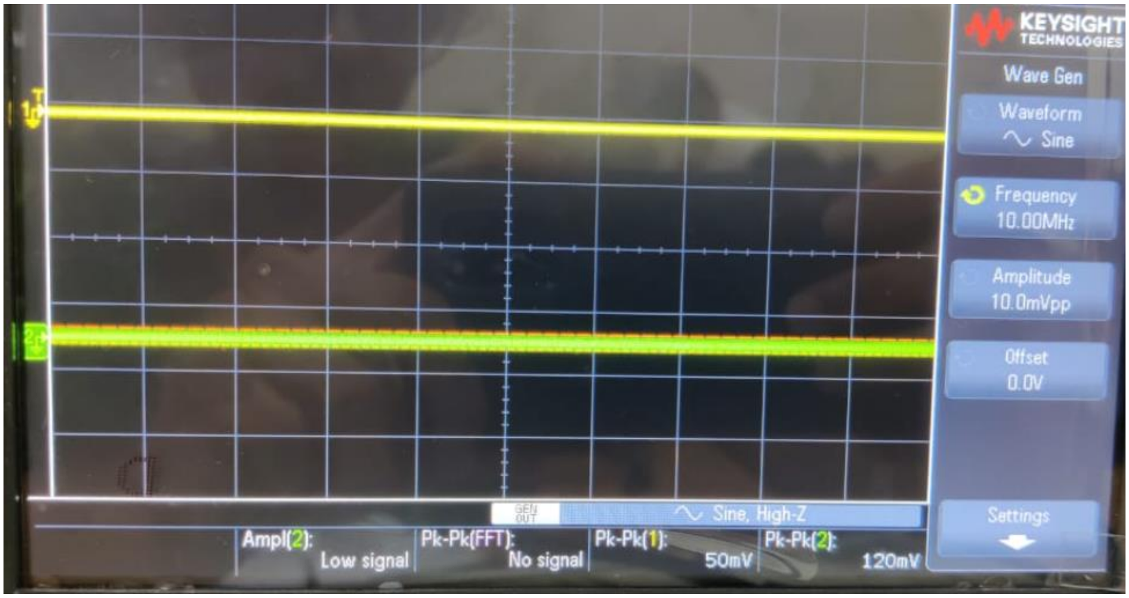
Frequency:100KHz



Frequency:1MHz



Frequency:10MHz



Frequency:20MHz

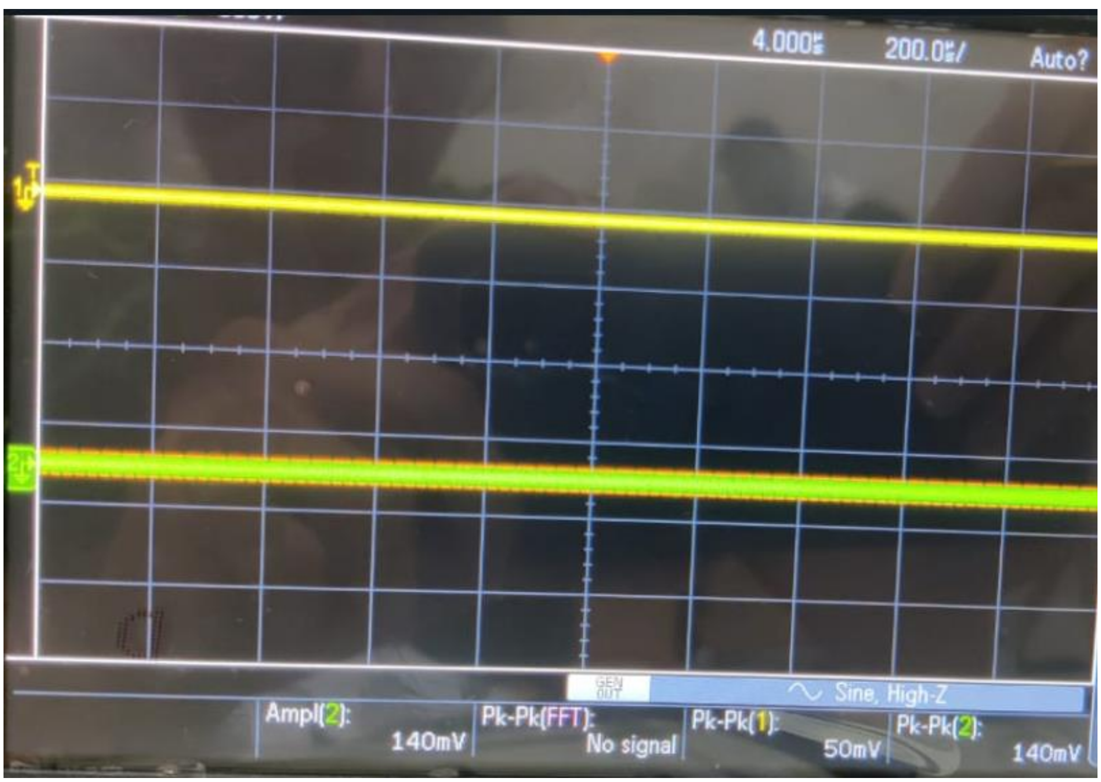


Table:

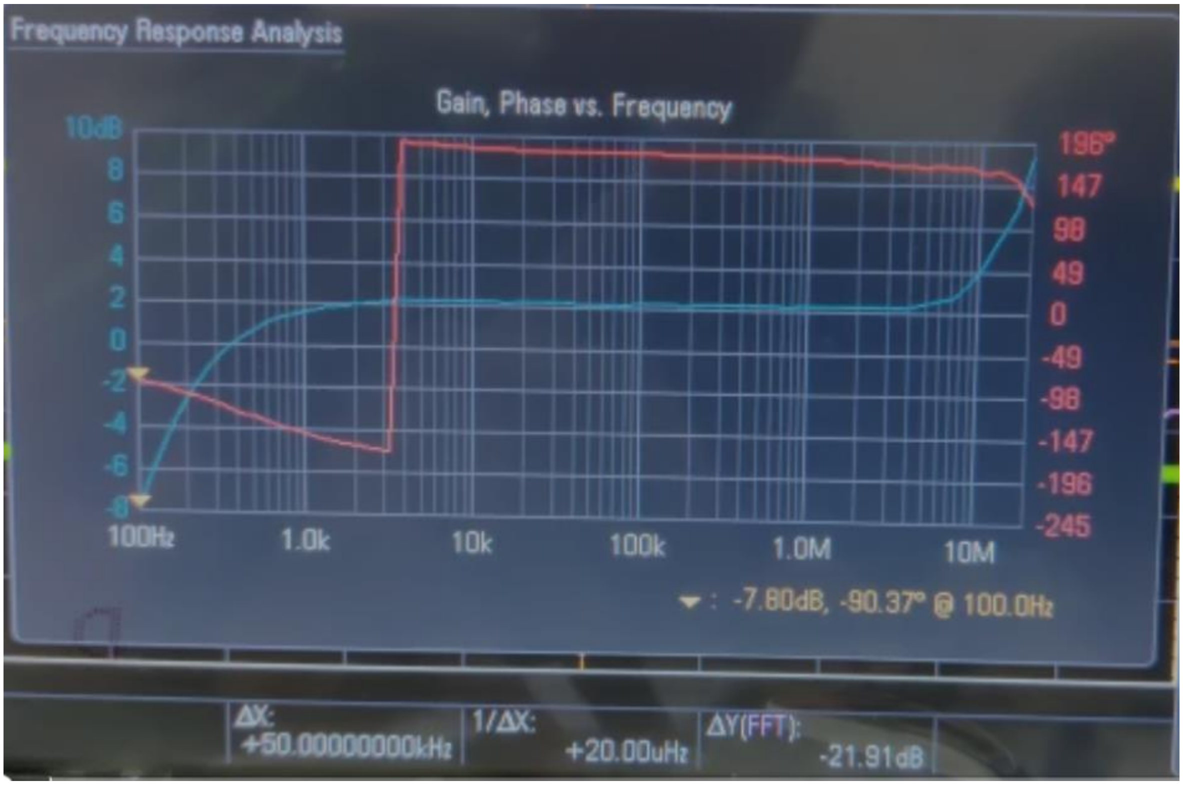
Frequency	Vm(mV)	Vout(mV)	Av	Av(dB)
10Hz	40	80	2	6.02
50Hz	40	80	2	6.02
100 Hz	40	80	2	6.02
500 Hz	50	100	2	6.02
1K Hz	50	120	2.4	7.604
10K Hz	50	120	2.4	7.604
100K Hz	50	120	2.4	7.604
1M Hz	50	120	2.4	7.604
10M Hz	50	120	2.4	7.604
20 Hz	50	140	2.8	8.942

The frequency F_H is nearly equal to 1KHz, we cannot predict the value of F_L because it is too high in this case and that high frequency cannot be obtained from wave generator. As the load now is a resistance there will be higher loss across resistance and hence Vout<<Vs, therefore higher frequency is required to avoid loss across the capacitor and compensate loss across resistance,

(b) Using analysis option in DSO we will plot the frequency response and verify the results (Av, fL and fH) with the previous part.

Plots of Gain and phase vs frequencies at different frequencies for Vin=10mV.

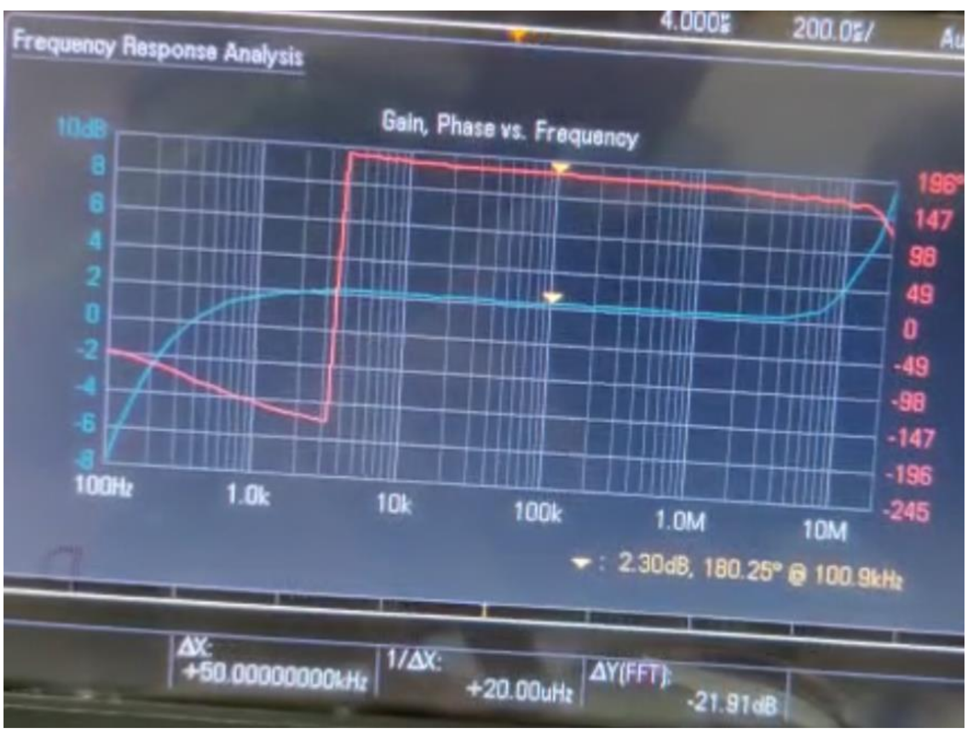
Plot1 (100Hz):



1KHz:

10KHz:

100KHz:



1MHz:

(C) Values of F_L and F_H from above plots:

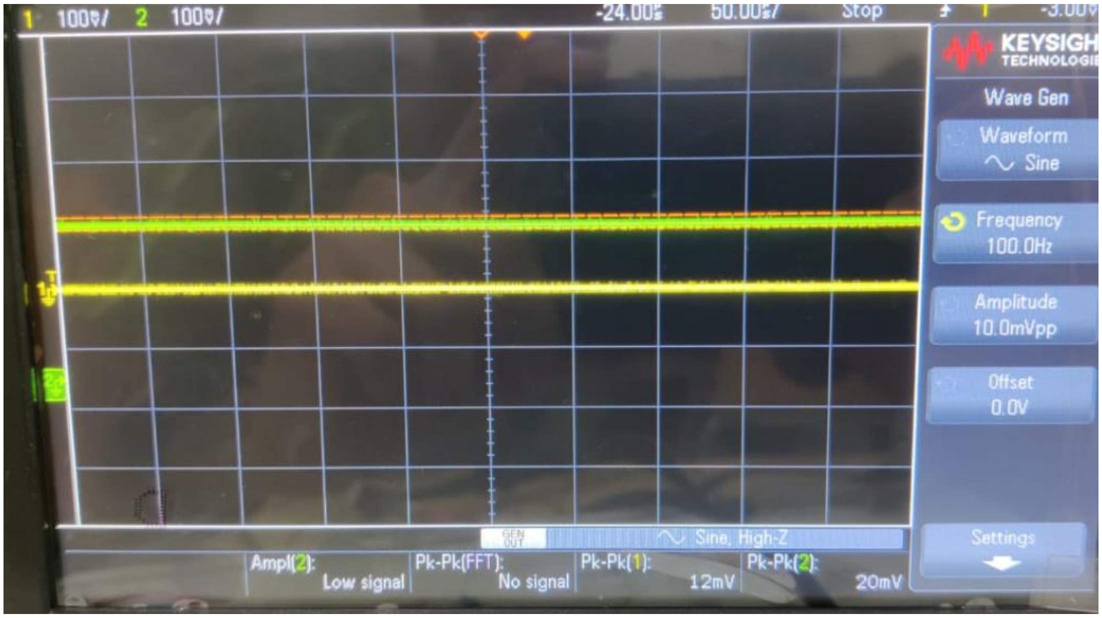
F_L: Nearly equal to 1200Hz.

F_H: Couldn't get any higher frequency than 20MHz, so unable to predict F_H

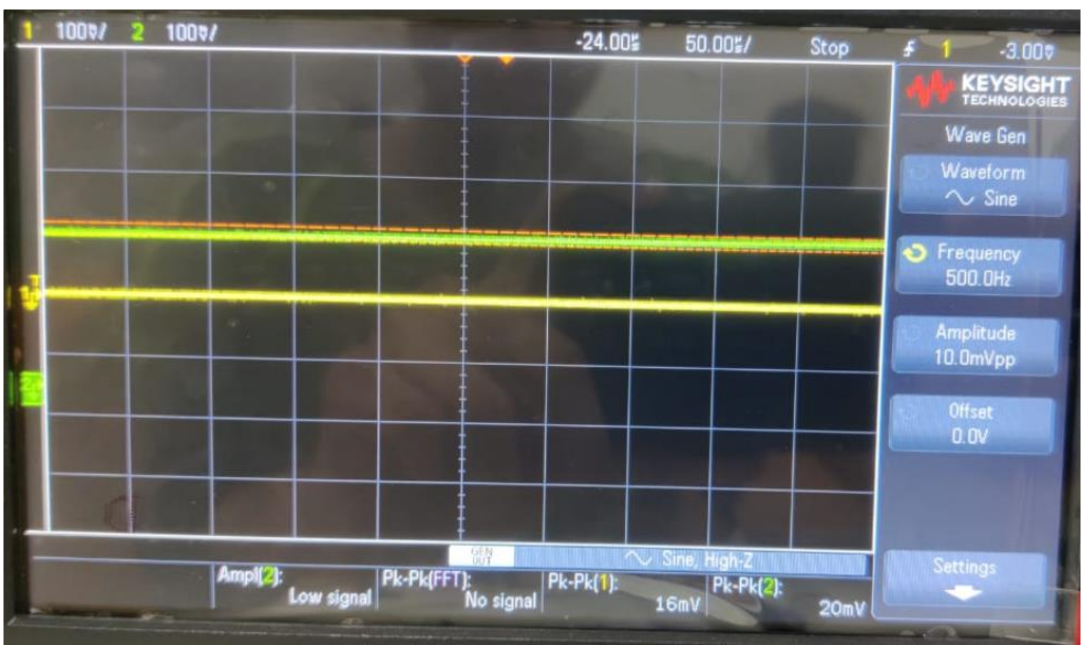
D. Using a capacitor load CL = 440 pF in place of RL and repeat the previous experiment.

Plot:

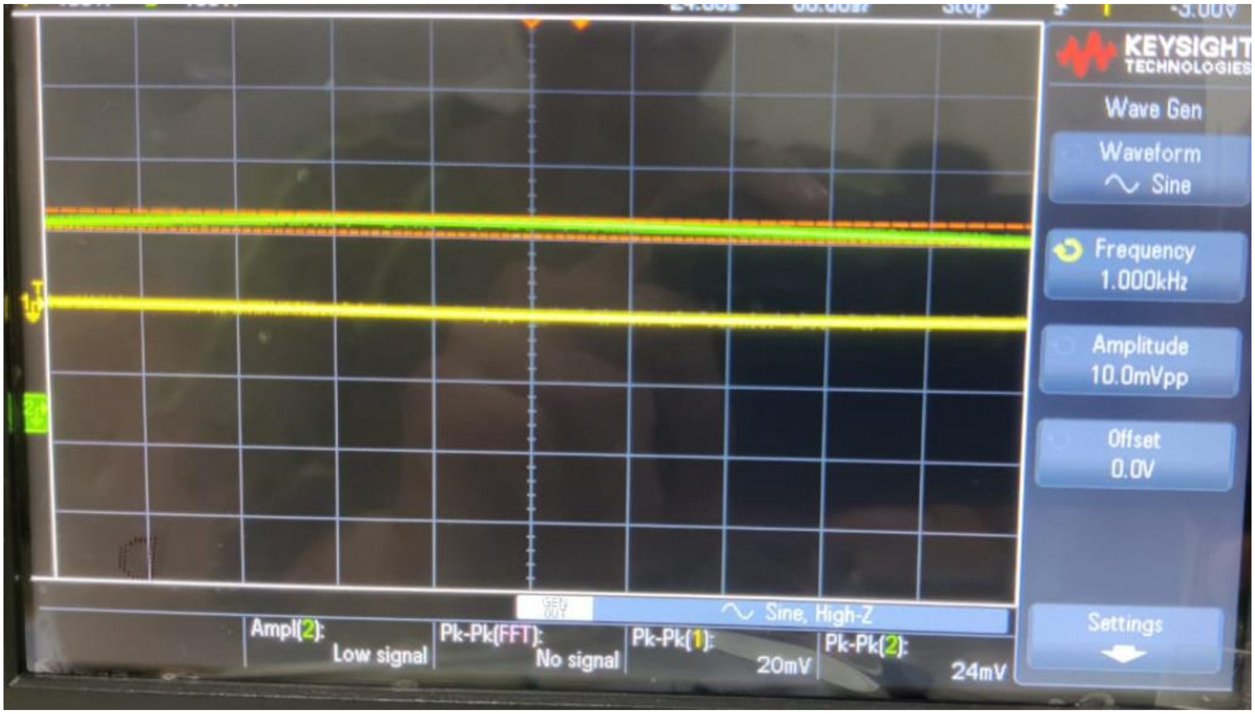
Frequency: 100Hz



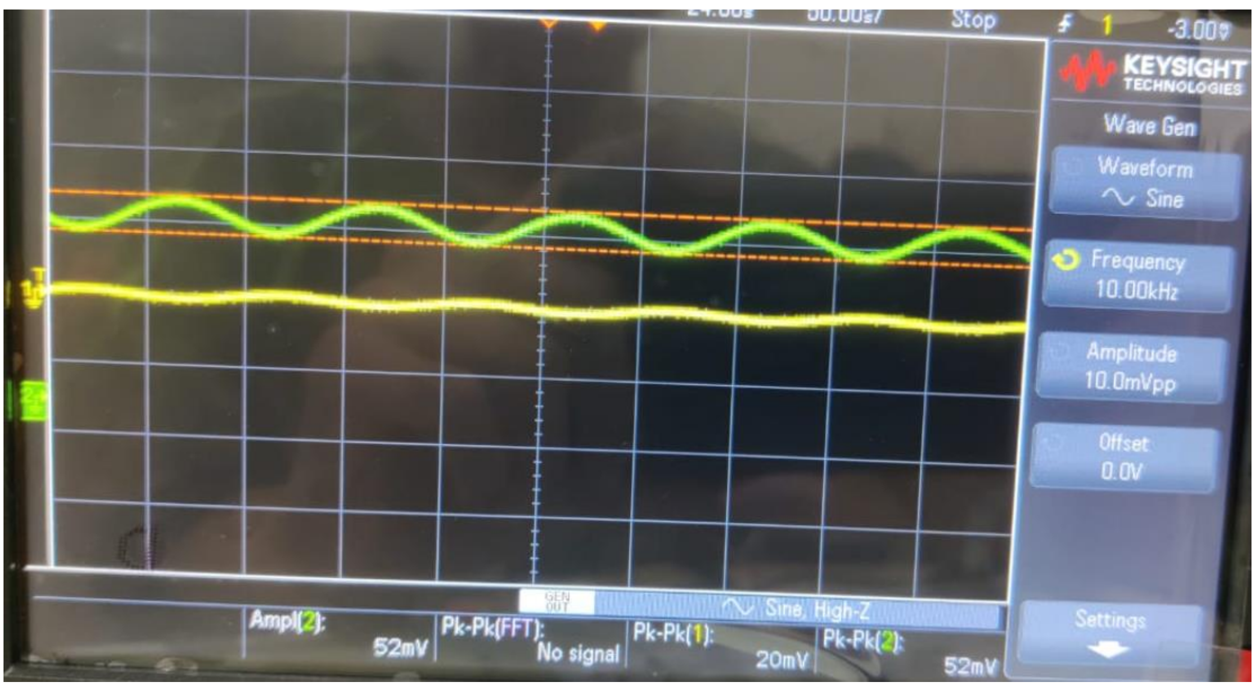
Frequency:500Hz



Frequency:1KHz

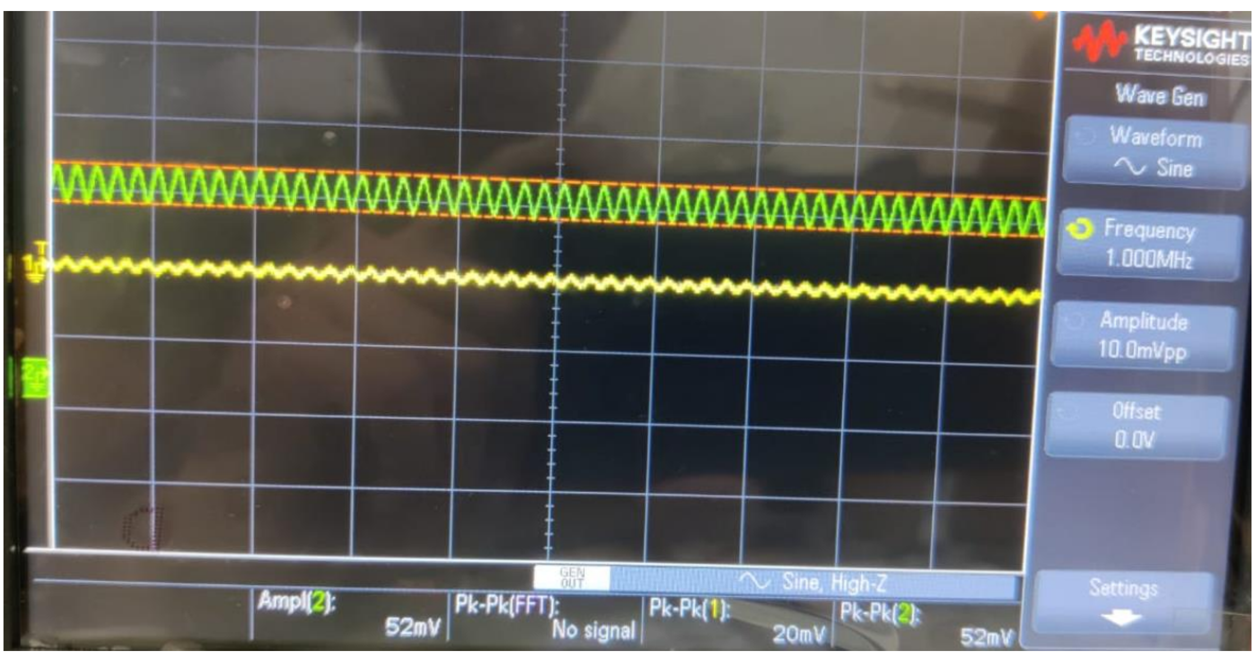


Frerquency:10KHz

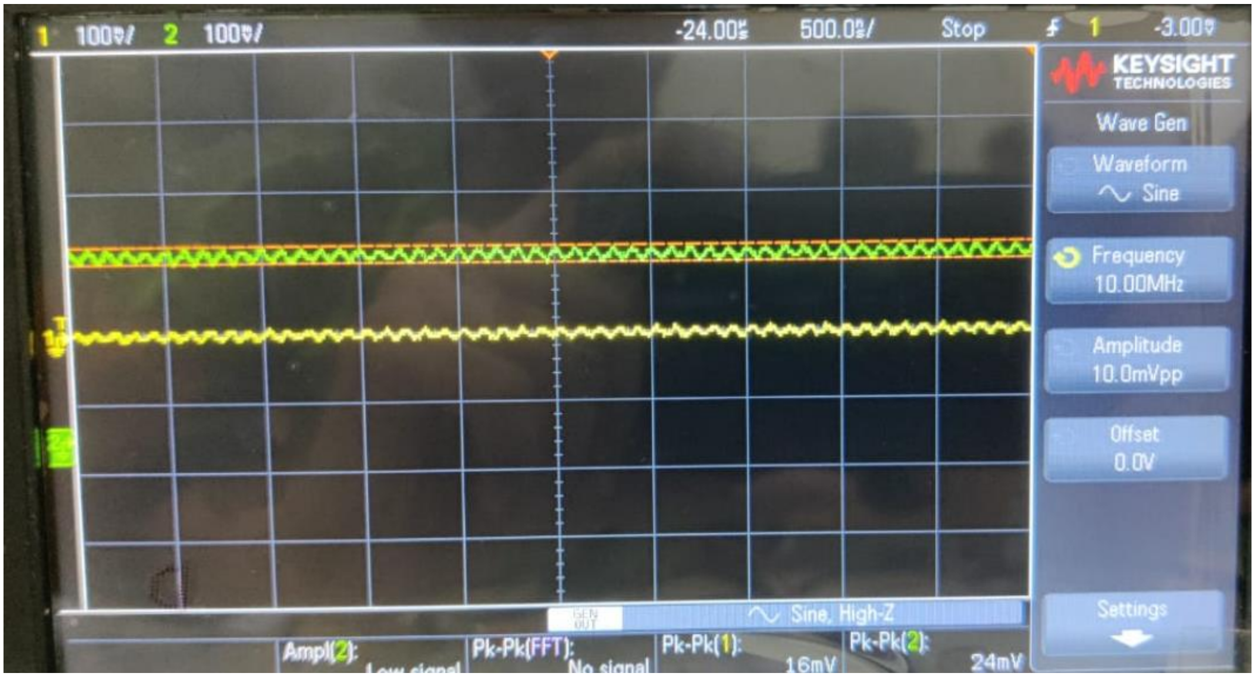


Frequency: 100KHz

Frequency:1MHz



Frequency:10MHz



Frequency:20MHz

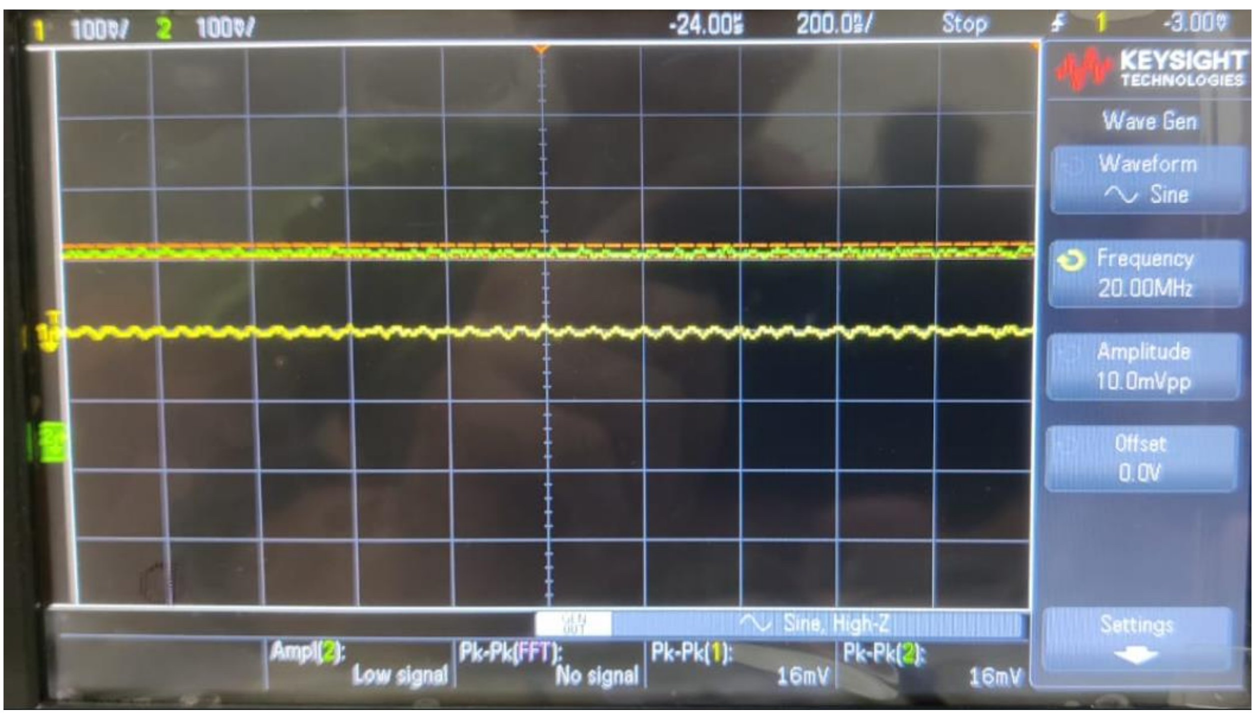


Table:

Frequency	Vm(mV)	Vout	Av	Av(dB)
10	16	24	1.5	3.52
50	12	16	1.33	2.477
100	12	20	1.66	4.402
500	16	24	1.5	3.52
1K	20	24	1.2	1.583
10K	20	52	2.6	8.29
100K	24	56	2.33	7.347
1M	20	52	2.6	8.299
10M	16	24	1.5	3.52
20M	16	16	1	0

Plots of Gain and phase vs frequencies at different frequencies for Vin=10mV.

Plot1 (100Hz):

1K:


Frequency Response Analysis
Gain, Phase vs. Frequency
6dB
3
0
-3
-6
-9
-12
-15
-18
-21
200°
150
100
50
0
-50
-100
-150
-200
-250
100Hz
1.0k
10k
100k
1.0M
10M
2.33dB, -148.67° @ 937.3Hz
ΔX:
+52.00000000kHz
1/ΔX:
+19.23uHz
ΔY(FFT):
-21.91dB

10K:


Frequency Response Analysis
Gain, Phase vs. Frequency
6dB
3
0
-3
-6
-9
-12
-15
-18
-21
200°
150
100
50
0
-50
-100
-150
-200
-250
100Hz
1.0k
10k
100k
1.0M
10M
ΔX:
+52.00000000kHz
1/ΔX:
+19.23uHz
ΔY(FFT):
-21.91dB

100K:


Frequency Response Analysis
Gain, Phase vs. Frequency
6dB
3
0
-3
-6
-9
-12
-15
-18
-21
200°
150
100
50
0
-50
-100
-150
-200
-250
100Hz
1.0k
10k
100k
1.0M
10M
2.94dB, 179.09° @ 100.9kHz
ΔX:
+52.00000000kHz
1/ΔX:
+19.23uHz
ΔY(FFT):
-21.91dB

1MHz


Frequency Response Analysis
Gain, Phase vs. Frequency
6dB
3
0
-3
-6
-9
-12
-15
-18
-21
200°
150
100
50
0
-50
-100
-150
-200
-250
100Hz
1.0k
10k
100k
1.0M
10M
2.88dB, 167.48° @ 945.7kHz
ΔX:
+52.00000000kHz
1/ΔX:
+19.23uHz
ΔY(FFT):
-21.91dB

From the plots:

F_L : 1.15KHz

F_H : 4MHz

Yes we can clearly observe F_H now, this is because we replaced the resistance with a capacitor, this time there is only capacitor and so no loss across resistors and at low frequencies all loss will be across capacitor and Vout will be nearly equal to Vs.