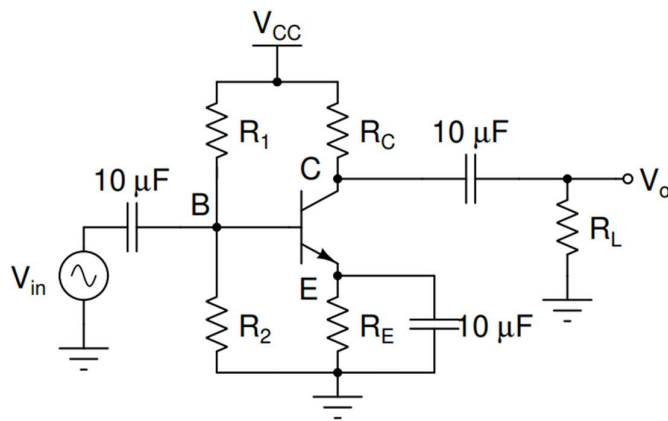


Analog Electronic Circuits – Lab 5

Sricharan Vinoth Kumar

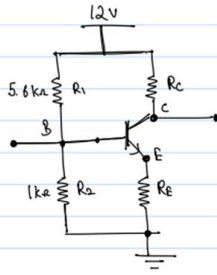
Roll No: 2024112022

Circuit Diagram:



Part 1: DC Analysis

- Hand Calculated Values:
 - $R_C = 95.056\ \Omega$
 - $R_E = 735.099\ \Omega$
- LTSpice Observed Values:
 - $R_C = 135\ \Omega$
 - $R_E = 780\ \Omega$
- Experimentally Applied Values:
 - $R_C = 135\ \Omega$
 - $R_E = 770\ \Omega$



$$V_B = \frac{R_2}{R_1 + R_2} V_{CC} = \frac{1 \text{ k}\Omega}{(1 + 5.6) \text{ k}\Omega} 12 \text{ V}$$

$$= \frac{12}{6.6} \text{ V} = 1.81 \text{ V}$$

$$V_E = V_B - V_{BE} = 1.81 - 0.7$$

$$= 1.11 \text{ V}$$

$$i_E = \frac{V_E}{R_E} = \frac{1.11}{R_E}$$

$$i_C = \left(\frac{\beta}{\beta + 1}\right) i_E$$

$$i_E = \frac{\beta + 1}{\beta} i_C$$

$$\frac{1.11}{R_E} = \frac{151}{150} \left(\frac{10^3 \times 10^{-3}}{10} \right) = \frac{151}{10^5}$$

$$R_E = \frac{1.11 \times 10^5}{151} \approx 735.099 \, \Omega$$

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1.5 \times 10^{-3}}{25 \times 10^{-3}}$$

$$= 0.0576 \, \Omega^{-1}$$

$$\text{gain} = g_m R_o$$

$$R_o = \frac{\text{gain}}{g_m} = \frac{5}{0.0576} = 86.805 \, \Omega$$

From Thevenin Eq. circuit we get

$$R_o = R_L \parallel R_C$$

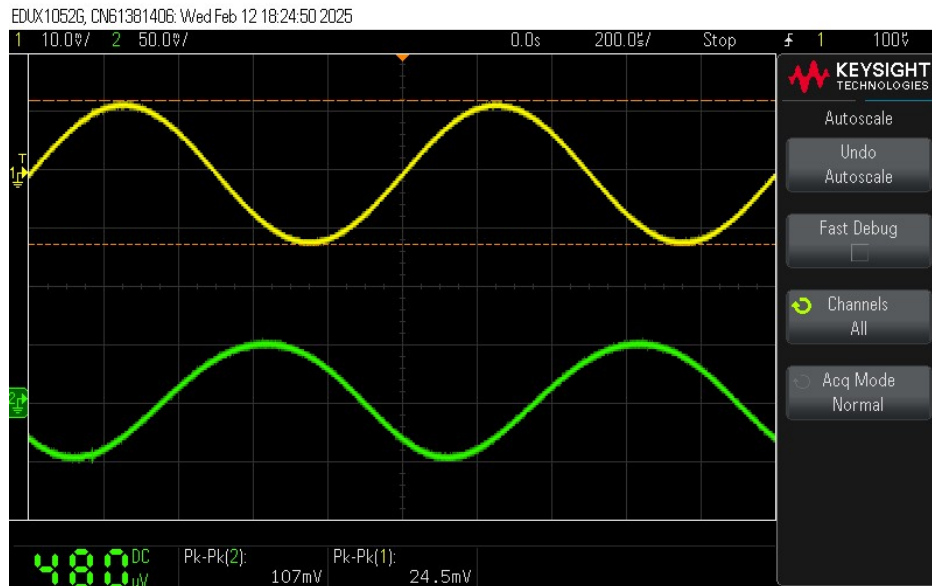
$$= \frac{R_C R_L}{R_C + R_L}$$

$$\Rightarrow R_C = \frac{R_o R_L}{R_L - R_o}$$

$$= \frac{(10^3)(86.805)}{10^3 - 86.805} = \underline{\underline{95.056 \, \Omega}}$$

Calculations for R_E and R_C

Experimental Verification:



Amplitude of Input: 24.5 mV

Amplitude of Output: 107 mV

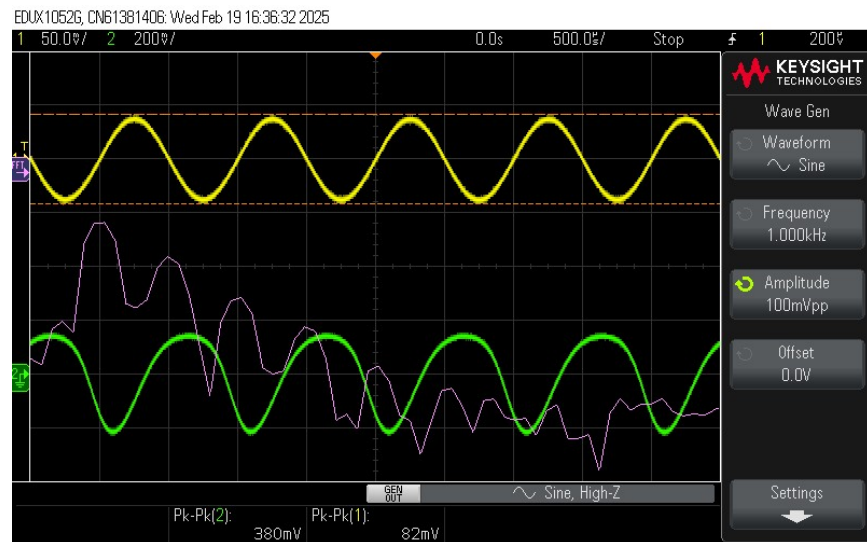
Gain = $107/25 = 4.28$

Part 2: Transient Analysis and THD

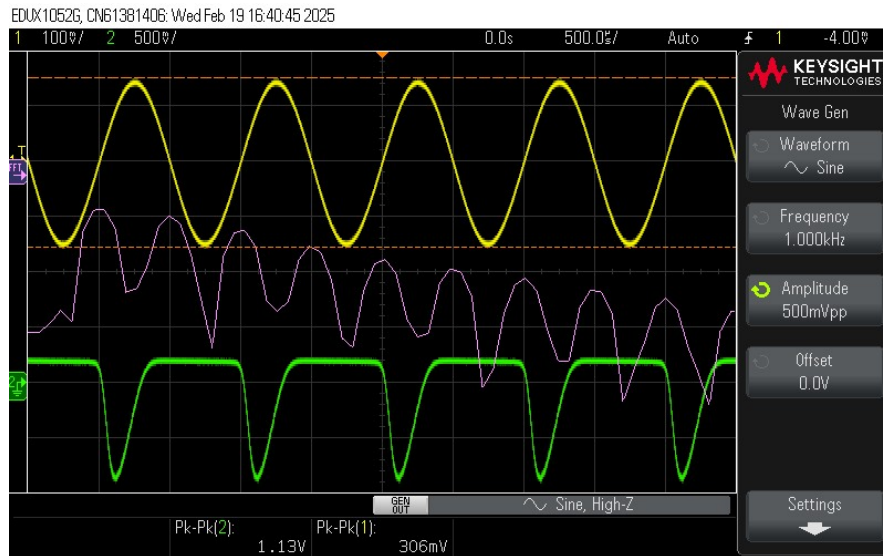
Frequency of Sinusoid = 1kHz

V_{in}	V_1 (dB)	V_2 (dB)	V_3 (dB)	V_4 (dB)	V_5 (dB)	THD (dB)
25mV	-30	-53.75	-88.75	-84.375	-94.375	-5.45603
2mV	-51.875	-80	-93.75	-105.625	-93.75	-3.61335
10mV	-38.125	-71.25	-95.625	-92.5	-103.75	-4.80373
50mV	-23.625	-43.15	-62.375	-76.75	-93.625	-6.04695
100mV	-18.12	-31.875	-46.875	-58.125	-72.5	-6.0071
500mV	-12.5	-15.625	-20	-26.25	-31.25	-3.8448
1 V	-10.625	-12.5	-15	-18.75	-23.125	-3.35088

Obtained FFTs:



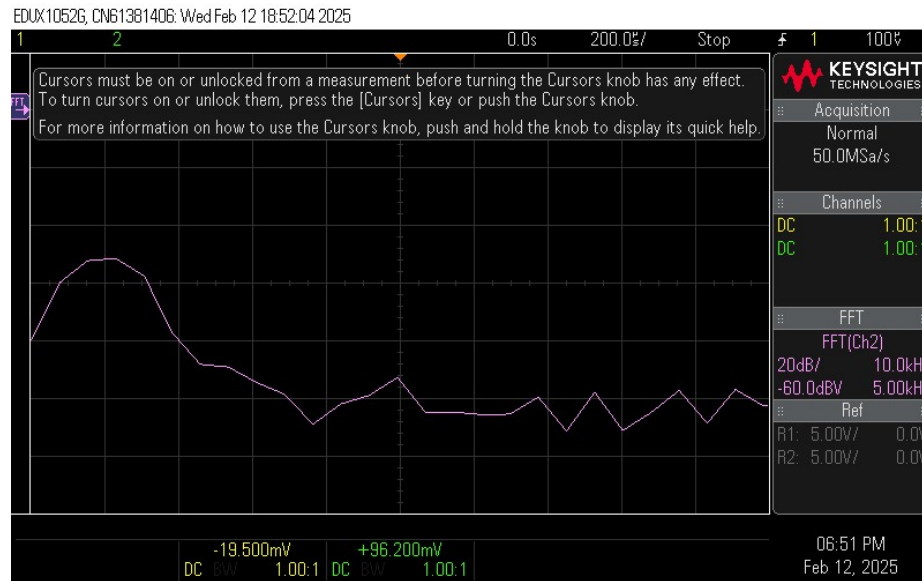
Amplitude = 100mV



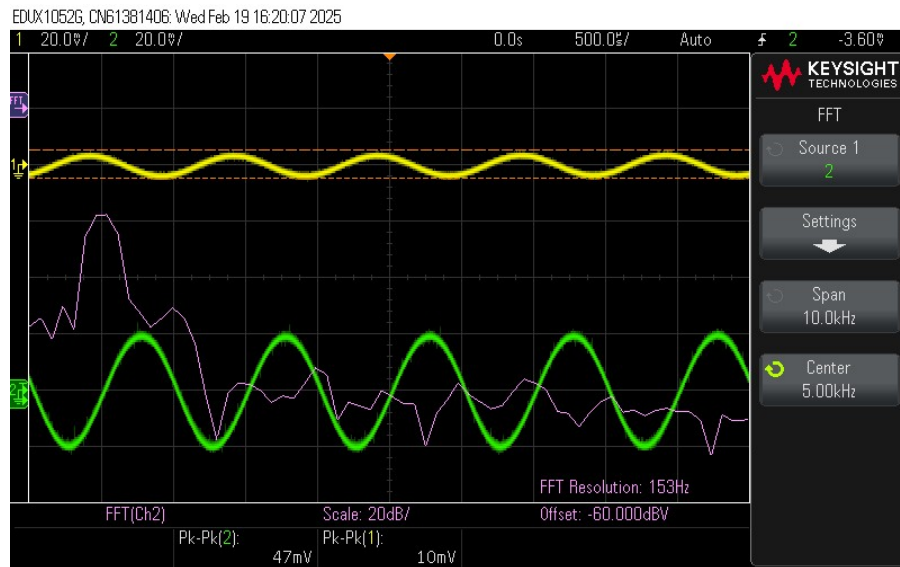
Amplitude = 500mV



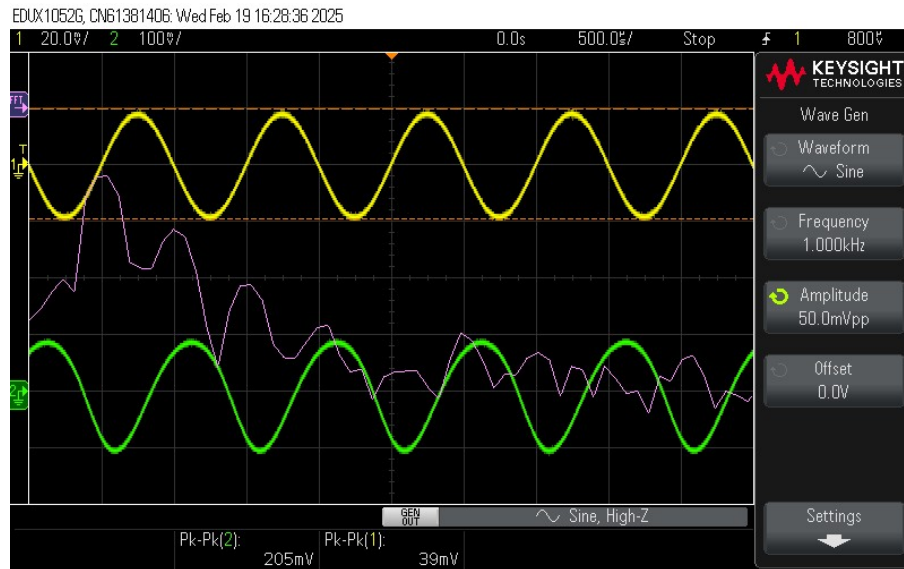
Amplitude = 25mV



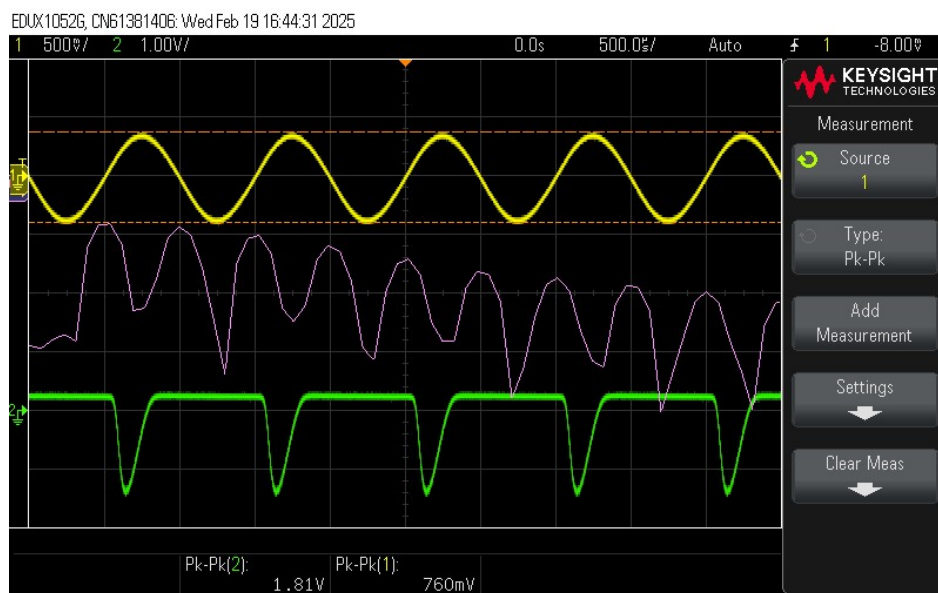
Amplitude = 2mV



Amplitude = 10mV



Amplitude = 50mV



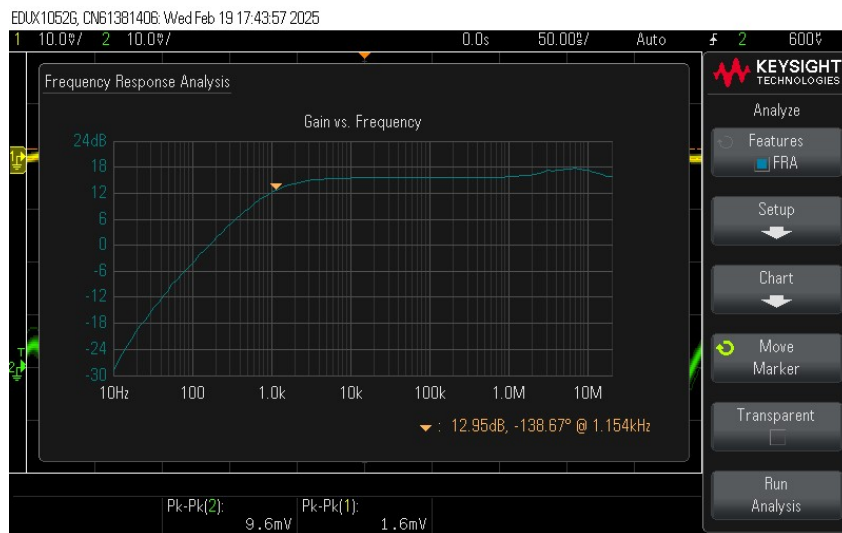
Amplitude = 1 V

From $V_{in} = 100\text{mV}$ onwards we observe some attenuation in the output of the amplifier.

Part 3: AC Analysis

1. Resistor Load:

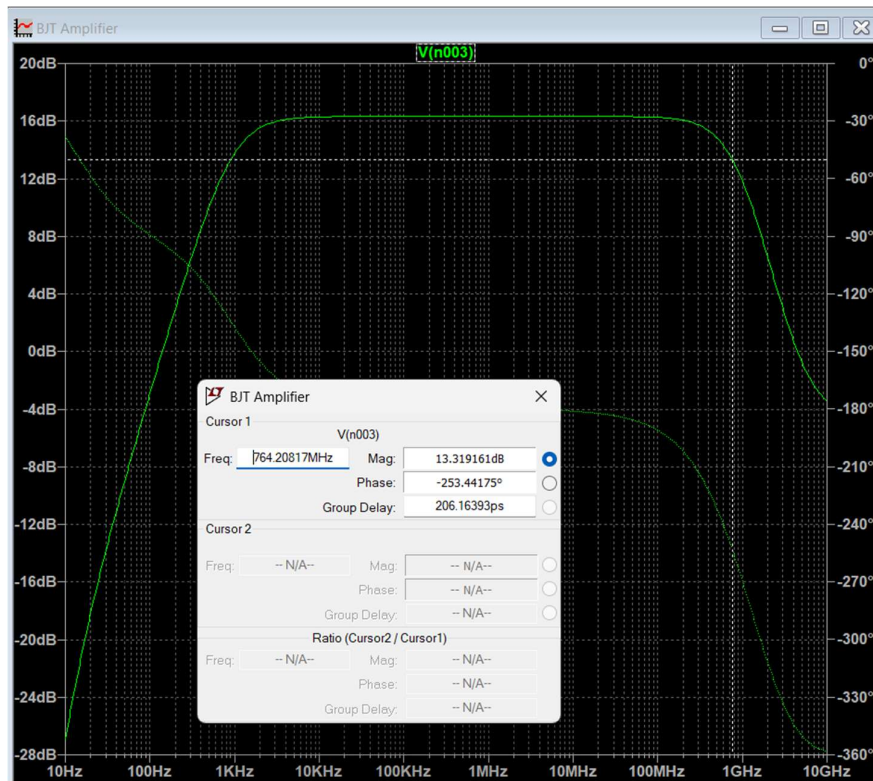
f in	V in (mV)	V o (mV)	A v	A v (db)
10Hz	10	9	0.9	-0.91515
50Hz	10	11.7	1.17	1.363717
100Hz	10	13.7	1.37	2.734411
500Hz	10	32.6	3.26	10.26435
1 kHz	10	45	4.5	13.06425
10 kHz	10	60	6	15.56303
100 kHz	10	60	6	15.56303
1 MHz	10	59	5.9	15.41704
10 MHz	10	20	2	6.0206
20 MHz	10	9.2	0.92	-0.72424



Obtained FRA

Value of $f_L = 12.95$ 1.154 kHz

Since the DSO can only go up to 20MHz and f_H is theorized to be much higher, using LTSpice we can estimate the value of f_H

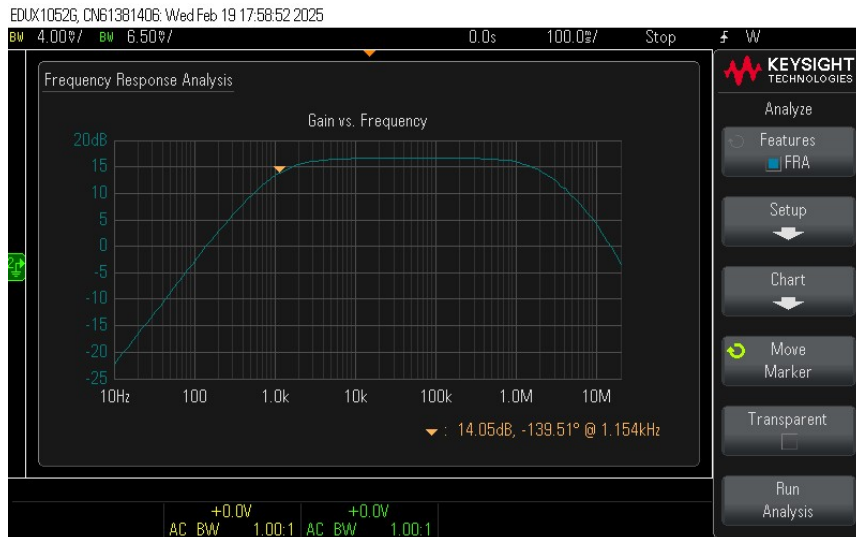
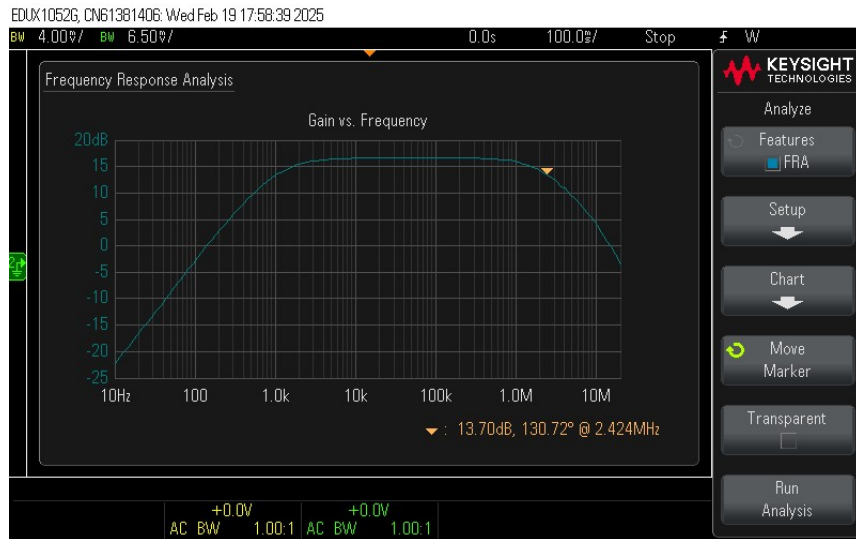


LTSpice FRA

Value of $f_H = 764.208 \text{ MHz}$

2. Capacitor Load:

f_{in}	$V_{in} \text{ (mV)}$	$V_o \text{ (mV)}$	A_v	$A_v \text{ (db)}$
10Hz	10	9	0.9	-0.91515
50Hz	10	10	1	0
100Hz	10	6	0.6	-4.43697
500Hz	10	22	2.2	6.848454
1 kHz	10	30	3	9.542425
10 kHz	10	76	7.6	17.61627
100 kHz	10	72	7.2	17.14665
1 MHz	10	62	6.2	15.84783
10 MHz	10	8	0.8	-1.9382
20 MHz	10	4	0.4	-7.9588



Obtained FRA's

Value of $f_L = 1.154 \text{ kHz}$

Value of $f_H = 2.424 \text{ kHz}$

The obtained value of f_H is much smaller than the one obtained during resistor load since capacitor acts as conductors at higher frequencies, ie, they become “transparent”. Therefore voltage at that node decreases.