Design Procedure

Here the design was done with some improvement. We used emitter degeneration and cascade configuration where the common emitter is followed by a common base stage.

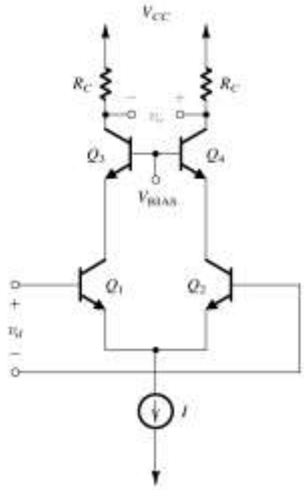

Figure 3: Basic differential amplifier

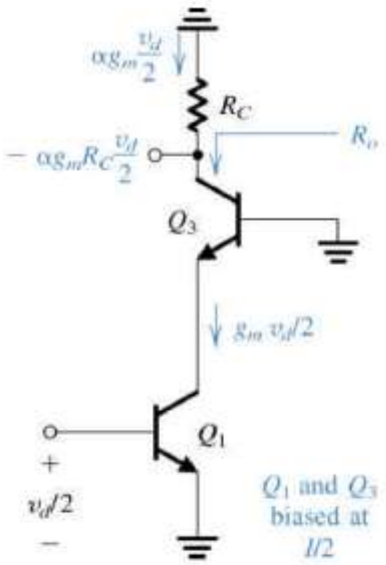

Figure 4: Differential Half Circuit

As shown in the above figure 3, Q1 and Q2 form a basic differential amplifier. Q3 and Q4 form a basic differential common-base stage. The differential half circuit is shown in the Figure 4. The load resistance seen by CE transistor Q1 is no longer Rc, but it the much lower input resistance of the CB transistor, namely r_e. Therefore, the reduction of the effective load resistance of Q1 will lead to a tremendous improvement in the Amplifier frequency response.

SIMULATION REUSLTS

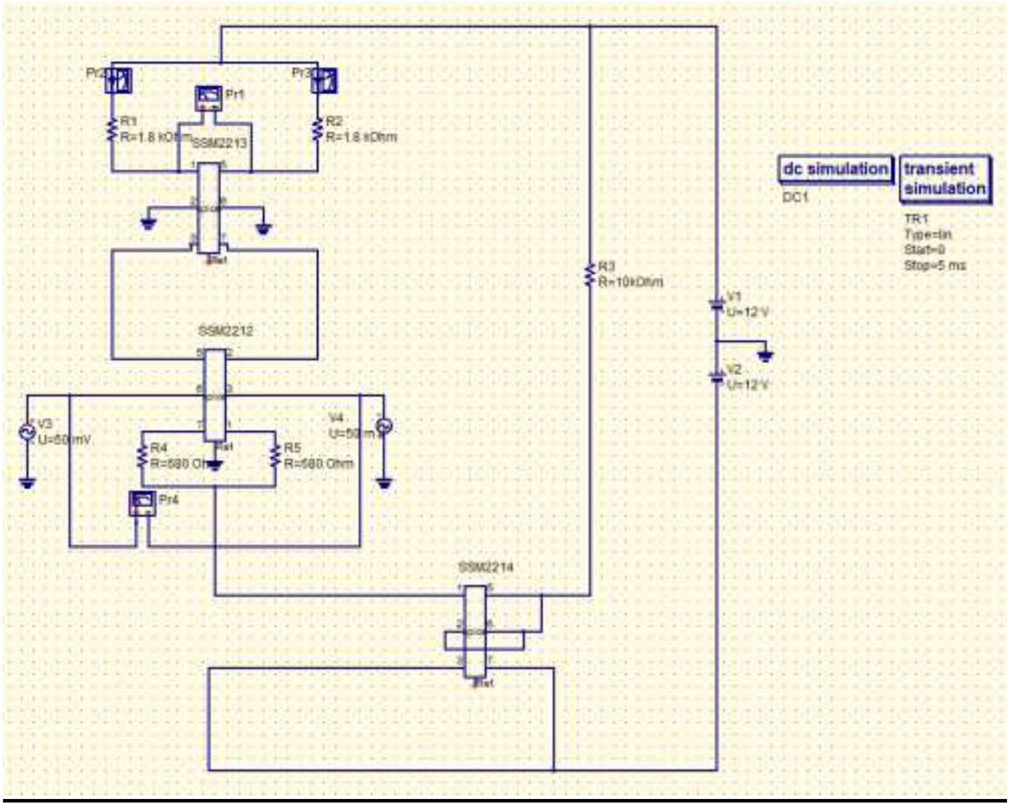

Figure 5: Schematic Diagram

a. Maximum undistorted output swing

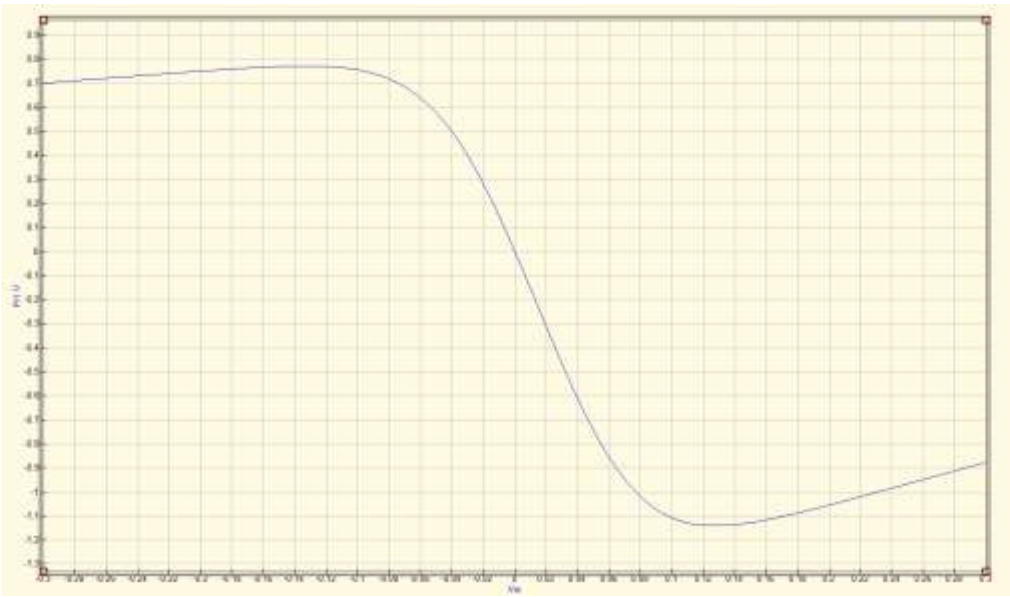

Figure 6: Vin vs Vout variation

Maximum undistorted output swing $= 2 \propto I_{Tail}\, R_C$

$$= 2\ X\ 0.7\ V = 1.4\ V$$

b. DC voltage gain

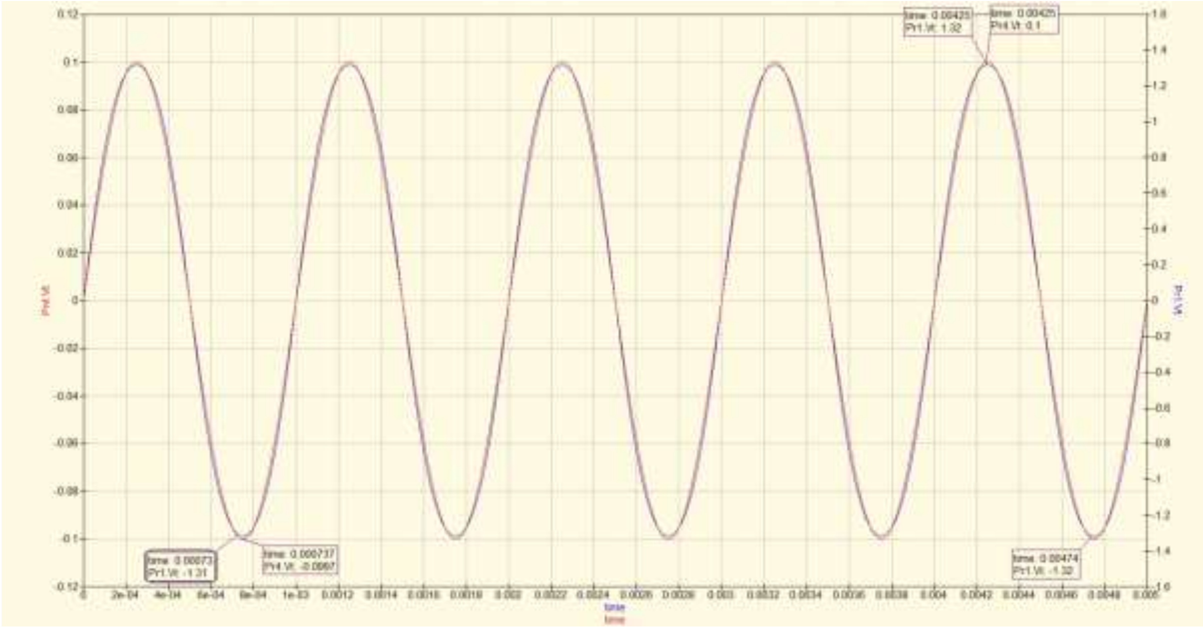

Figure 7: Input output voltage waveforms

DC voltage gain = $\frac{1.32\ V}{0.1v}$ = 13.2

c. Input and output waveforms for 200Hz

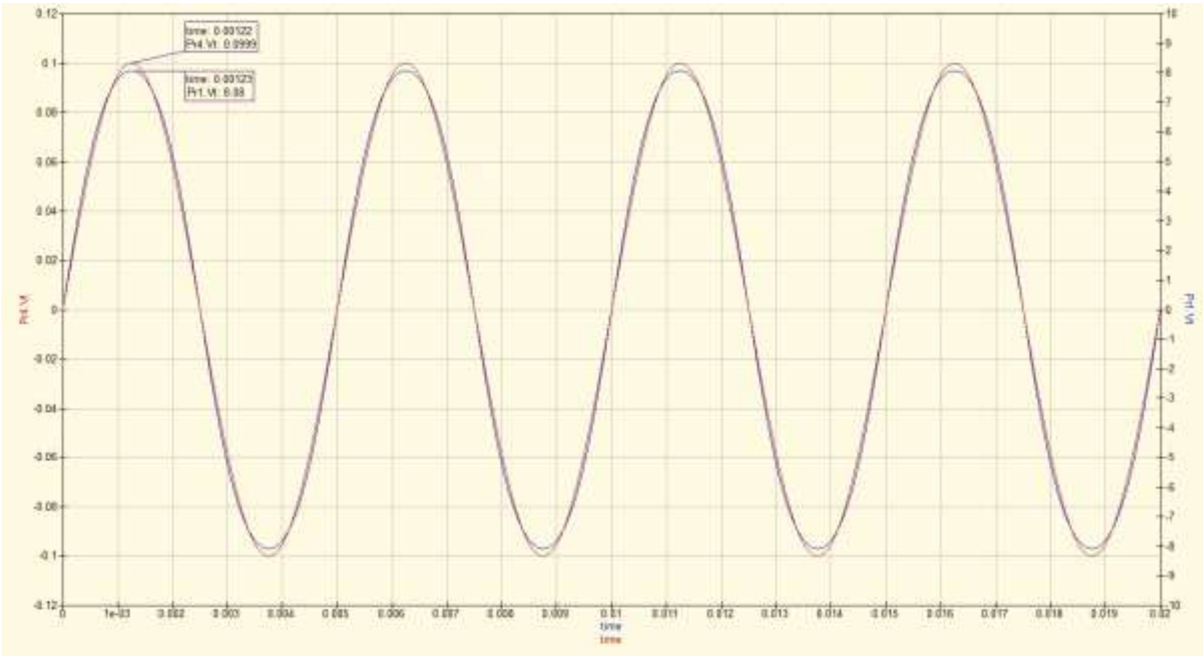

Figure 8: Input output voltage waveforms for 200Hz

d. Differential gain for 0 to 100MHz

Figure 9: Differential Gain for 0 to 100MHz

e. 3dB bandwidth

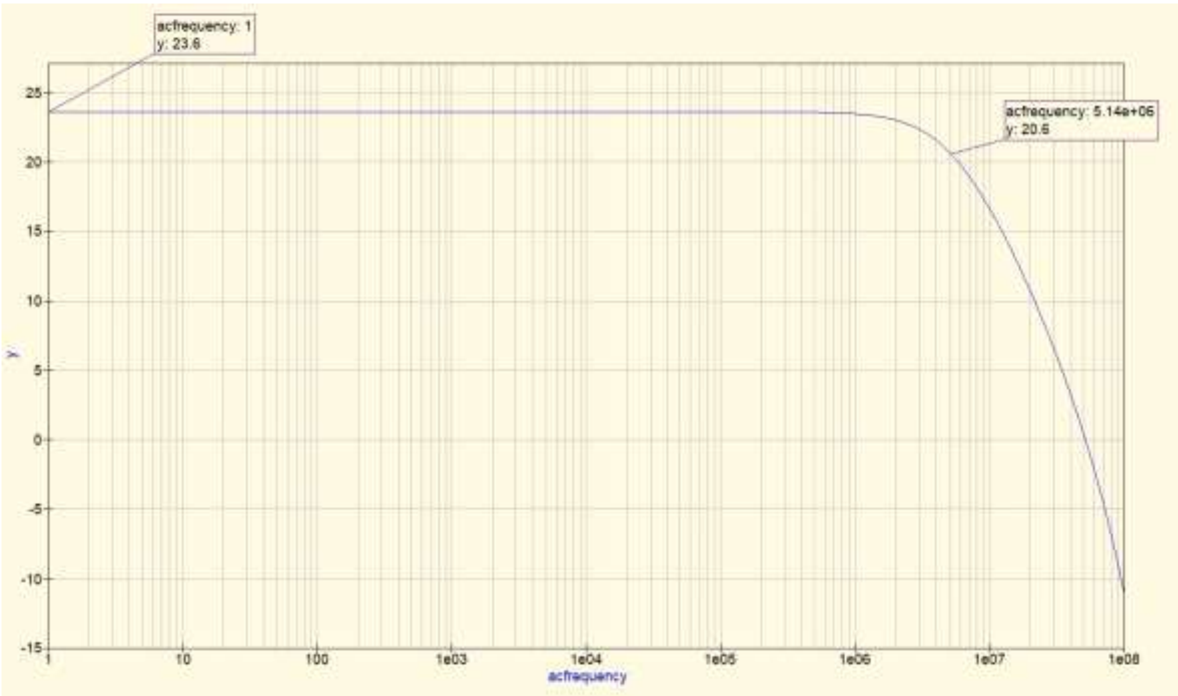

Figure 10: Differential Gain for 0 to 100MHz

3dB bandwidth = 5.14MHz

PCB Design

PCB was designed in the Altium Designer. PCB schematic diagram and the PCB 3D view is shown below.

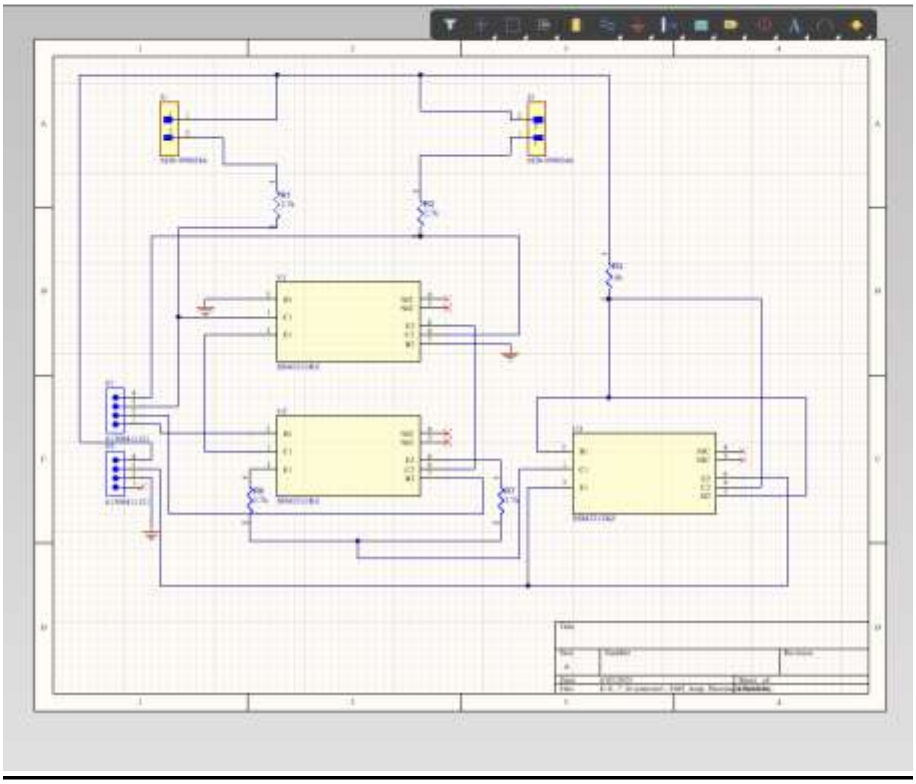

Figure 11: Schematic Diagram for the PCB design

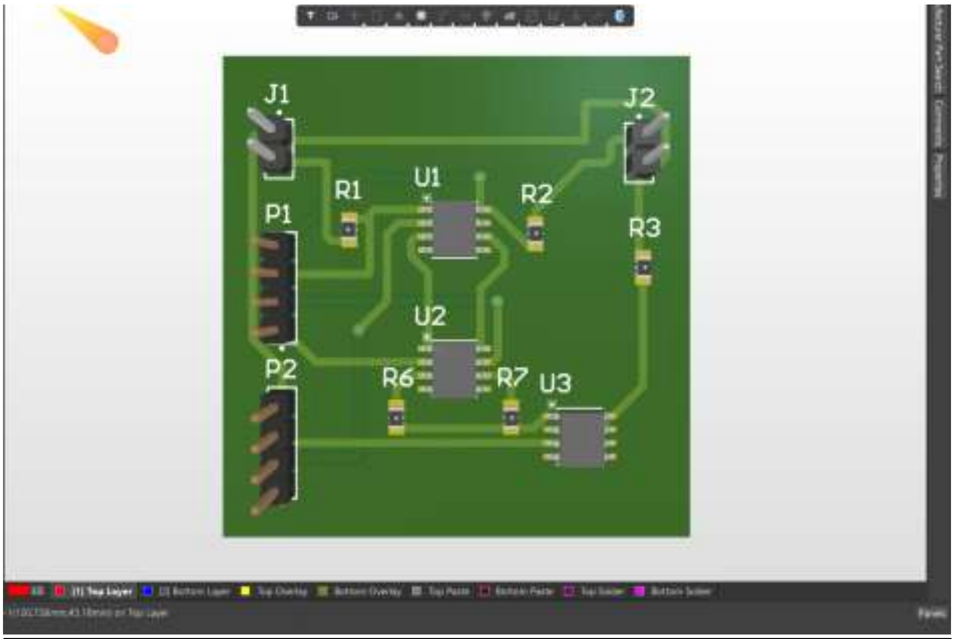

Figure 12: 3D view of the PCB design

OBSERVATIONS

a. Observe output differential voltage by applying $-200\ mV$ to $200\ mv$ input differential DC voltage in the steps of $10\ mV$ and plot input differential voltage vs. output differential voltage in order to observe maximum undistorted output voltage swing.

Table 1: Variation of Output differential voltage for input differential voltage

V_{id} / mV	V_{od} / mV	V_{id} / mV	V_{od} / mV	V_{id} / mV	V_{od} / mV
-250	-1750	-80	-565	90	640
-240	-1680	-70	-500	100	705
-230	-1620	-60	-430	110	770
-220	-1550	-50	-356	120	840
-210	-1480	-40	-290	130	910
-200	-1400	-30	-220	140	990
-190	-1340	-20	-150	150	1055
-180	-1270	-10	-90	160	1130
-170	-1195	0	0	170	1195
-160	-1130	10	90	180	1270
-150	-1055	20	150	190	1340
-140	-990	30	220	200	1400
-130	-910	40	290	210	1480
-120	-840	50	356	220	1550
-110	-770	60	430	230	1620
-100	-705	70	500	240	1680
-90	-640	80	565	250	1750

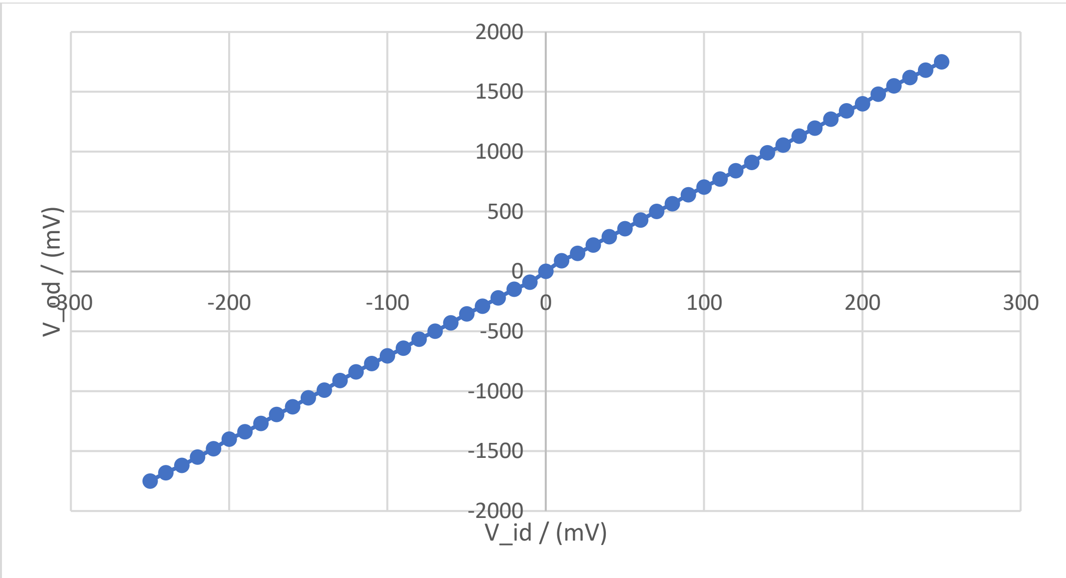

Figure 13: Variation of Output differential voltage for input differential voltage

b. From the above graph identify DC voltage gain.

DC voltage gain = Slope of the curve

$$= \frac{1055}{150} = 7.033$$

c. Apply 10 mV differential DC input voltage and observe the amplification.

DC voltage gain for 10mv $= \frac{90}{10} = 9$

d. Apply 200 Hz 10 mV sinusoidal differential input and observe the output differential waveform.

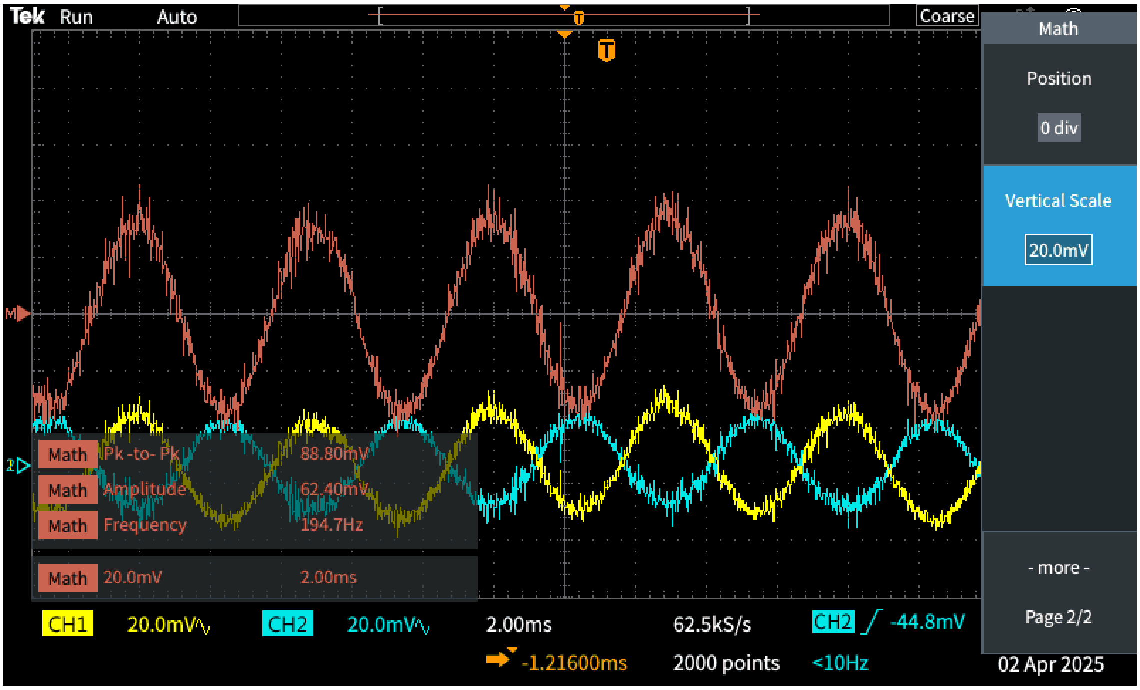

Figure 14: Output Differential waveform for 200Hz, 10mV sinusoidal differential input

e. For differential mode change the frequency of the input differential sinusoidal and observe output waveform for 0, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz, and 100 MHz and plot frequency (dB) vs. Differential mode gain plot.

Table 02: Variation of Differential mode gain with Frequency

Frequency / Hz	Vid / mV	Vod / mV	Gain / dB
2	40	95	7.51
10	40	230	15.19
100	40	288	17.15
1000	40	290	17.21
10000	40	290	17.21
100000	40	240	15.56
500000	40	75	5.46
1000000	40	40	0.00

10000000	40	4	-20.00

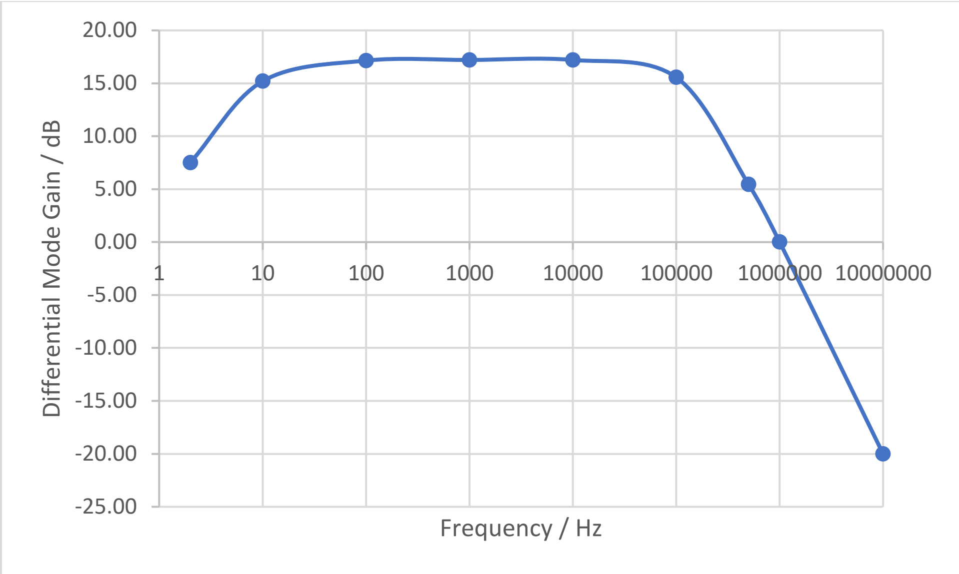

Figure 15: Frequency vs Differential mode gain plot

f. For common mode change the frequency and observe output waveform for 0, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz, and 100 MHz and plot frequency (dB) vs. Common mode gain plot.

Table 03: Variation of common mode gain with Frequency

Frequency / Hz	Vic / mV	Voc / mV	Gain / dB
2	40	70	4.86
10	40	168	12.46
100	40	195	13.76
1000	40	190	13.53
10000	40	200	13.98
100000	40	290	17.21
500000	40	200	13.98
1000000	40	130	10.24
10000000	40	40	0.00

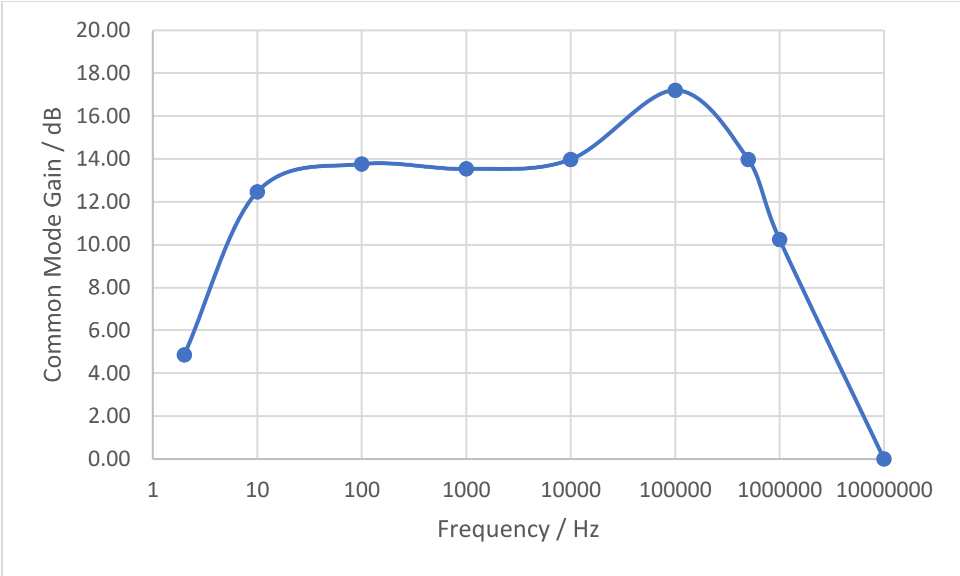

Figure 16: Frequency vs Common mode gain plot

g. Using above values obtain the frequency (dB) vs. CMRR plot.

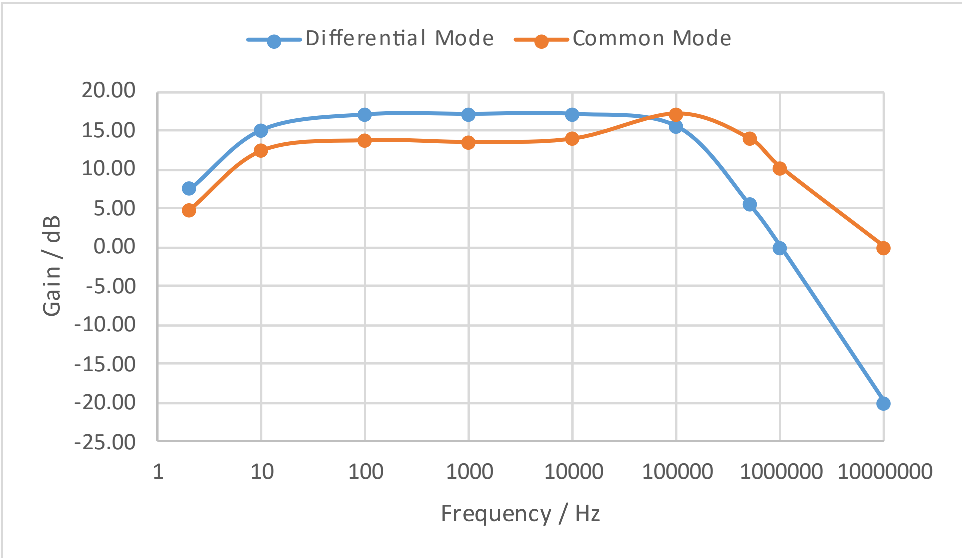

Figure 17: Variation of Differential Mode gain and Common mode gain with Frequency

Table 04: Variation of CMRR with Frequency

Frequency / Hz	Differential Mode Gain	Common Mode Gain	CMRR
2	2.38	1.75	1.357
10	5.75	4.20	1.369
100	7.20	4.88	1.477
1000	7.25	4.75	1.526
10000	7.25	5.00	1.450
100000	6.00	7.25	0.828
500000	1.88	5.00	0.375
1000000	1.00	3.25	0.308

10000000	0.10	1.00	0.100

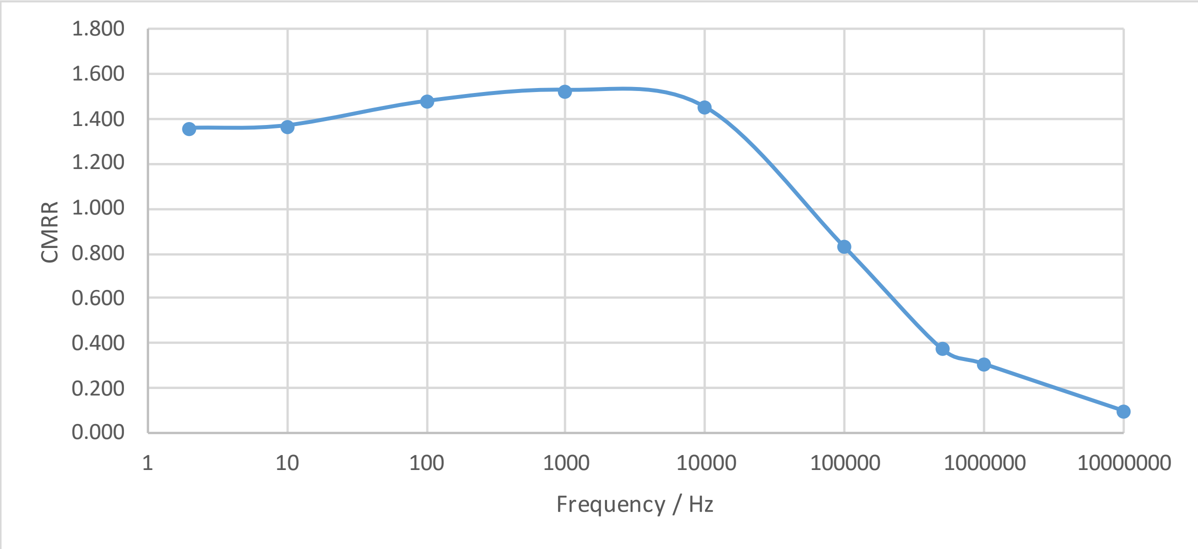

Figure 18: Frequency vs CMRR plot

h. Using the results obtain the 3 dB bandwidth of the differential amplifier.

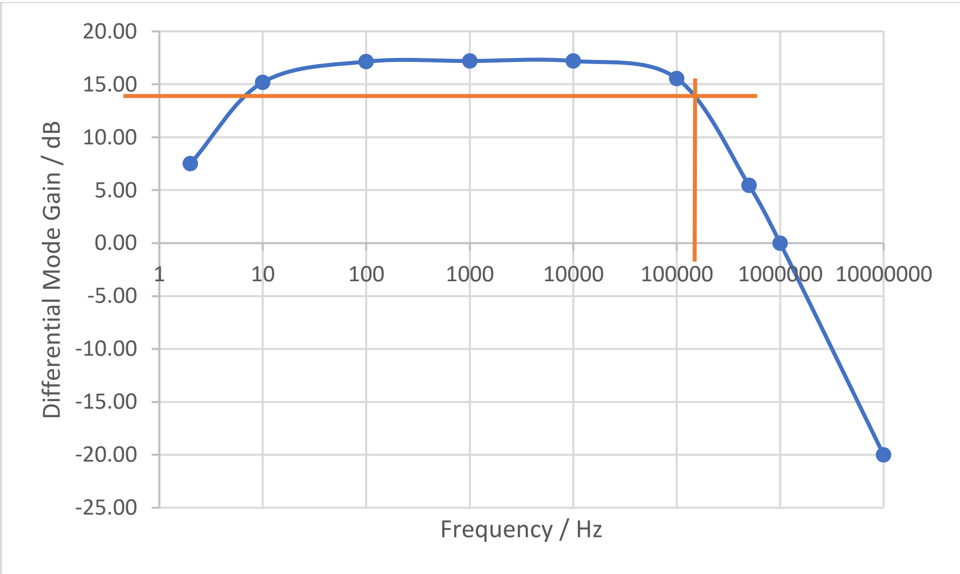

Figure 19: Frequency vs Differential Mode gain plot

3dB bandwidth = 150 kHz