Experiment-7

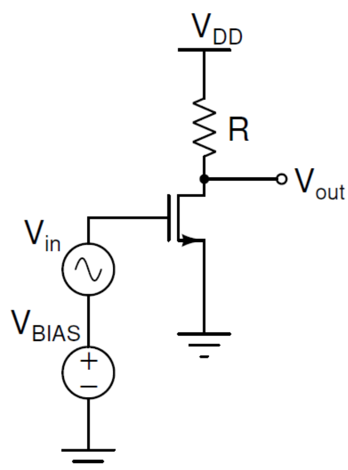
Common Source Amplifier

Name: Arya Marda Roll No: 2021102021

Part1:

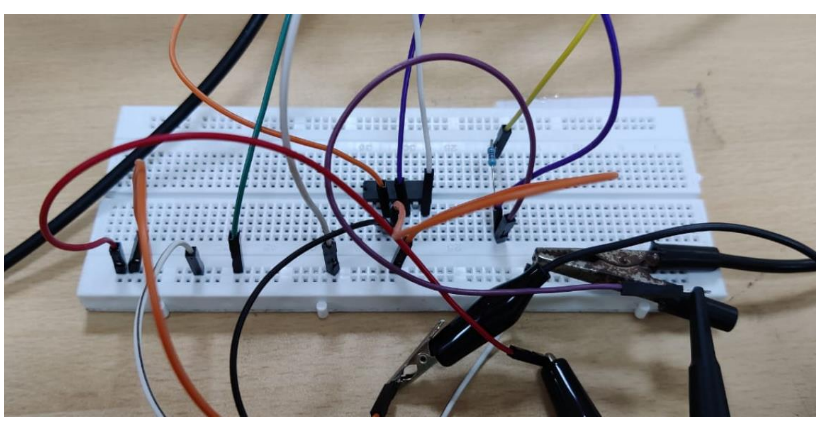
Study of body-effect on gain of CS amplifier.

Schematic view of the circuit:



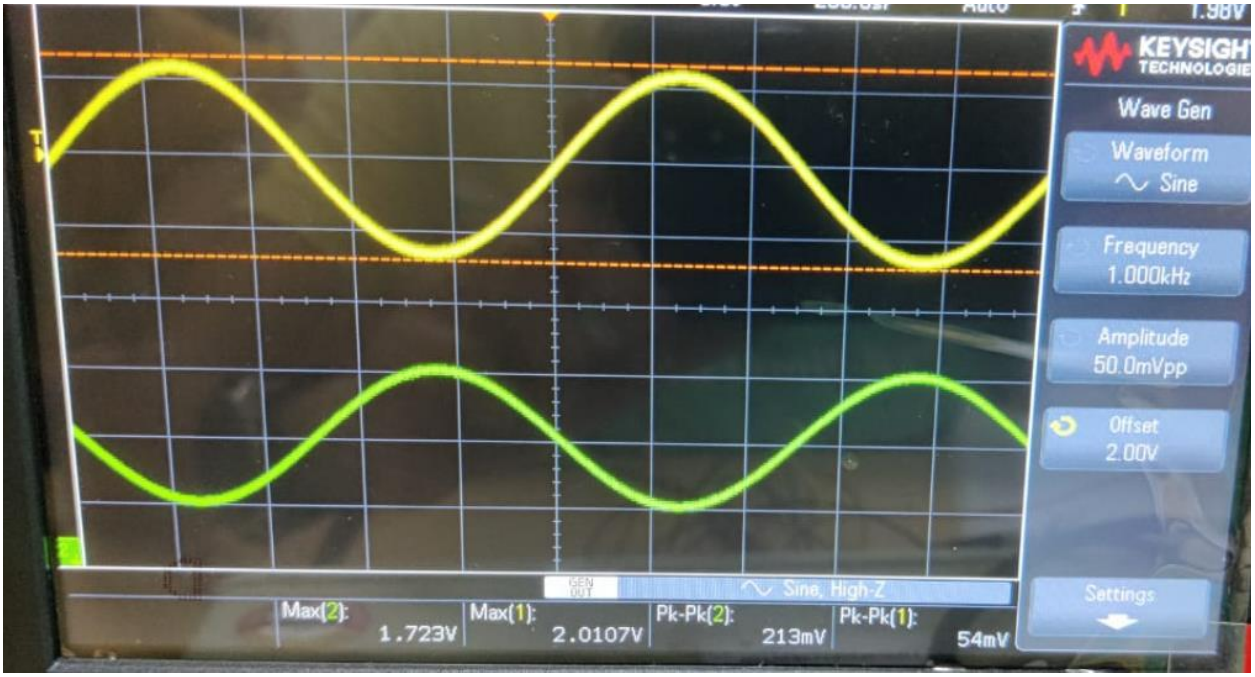
Given: Vdd = 5V, V_{BIAS} = 2 V, V_T = 1.8 V, R_L = 4.7 kΩ.

Circuit:



(a)Initially the Body terminal (pin 7) is grounded.

V_{DD}= 5V, V_{BIAS} = 2V, V_T= 1.8V.



Channel 1 is connected to V_{GS} and output is connected over channel 2, therefore for V_{GS} =2V the V_{DS}=1.723V.

$I_{DS} = V_{DD} - V_{DS}/R_L$.
Therefore I_{DS}= 95.04 uA

And using $I_{DS} = \mu_n C_{ox} W/L\ (V_{GS} - V_T)^2$.

Let: $\mu_n C_{ox} W/L$ = K.

I_{DS} = K $(V_{GS} - V_T)^2$.

I_{DS} = K(0.44)*(0.44).

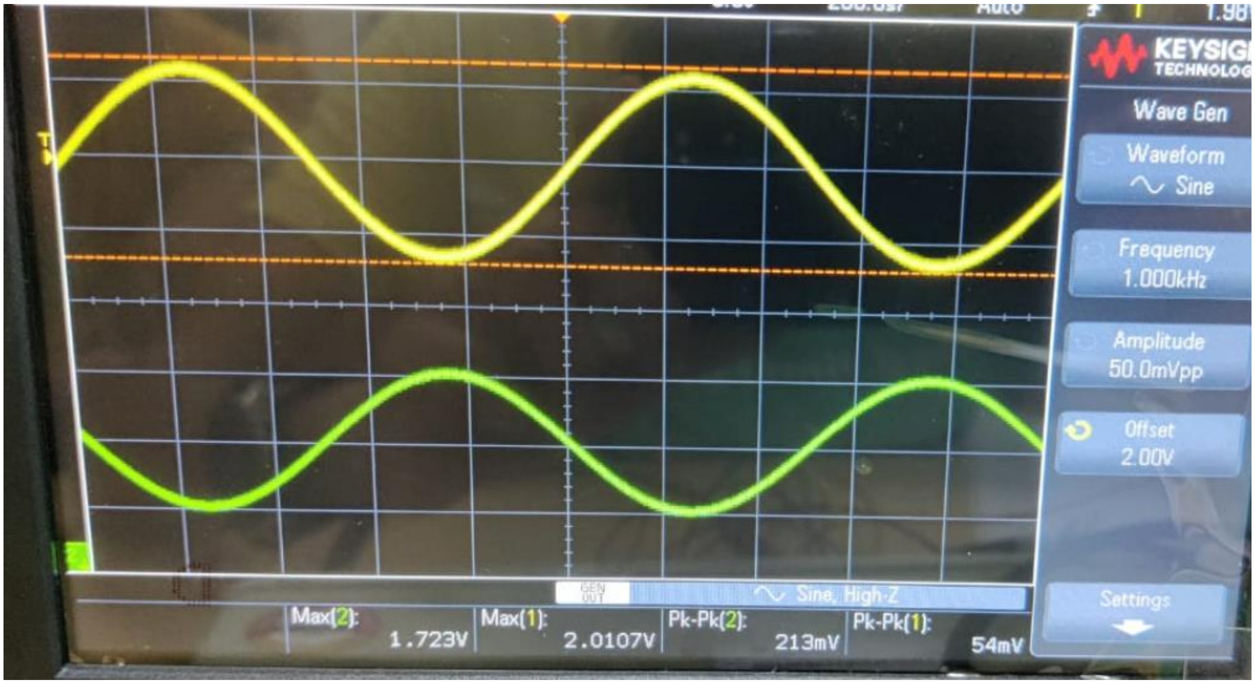
95.04uA / 0.1936 = K

K = 4.909 * 10^{-4} A/V^2.

g_m = K*0.45

g_m = 2.209*10^{-4} A/V

(b)AC signal: 50mVpp

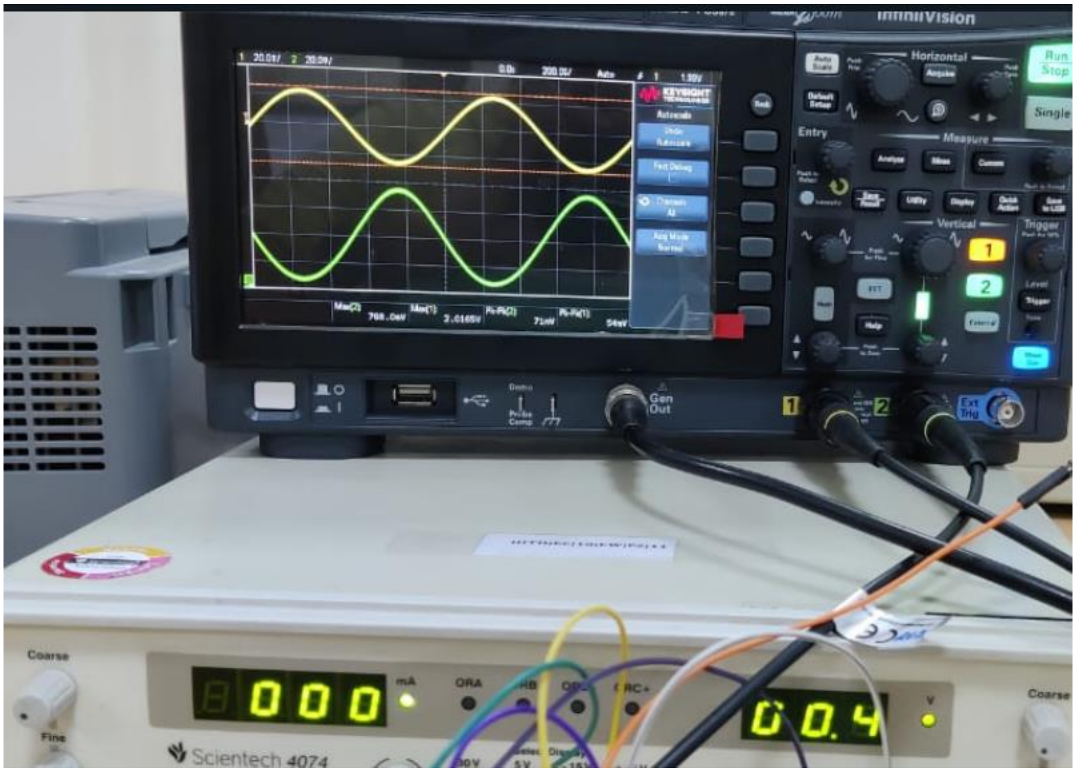


Gain (Practical): 213/54 = 3.944 = $g_m \times R_L$

$0.83*10^{-3} = 8.3 * 10^{-4}$.

(C)In order to see body effect, we connect V_{SS} to DC supply, on increasing V_{SS} value, V_{TH} decrease hence the gain should increase, this is because, as V_{SS} increases, more electrons flow into p-substrate, hence MOS requires low voltage to cause the inversion.

$V_{SS} = 0.4$


InfiniiVision
Horizontal
Run Stop
Single
Entry
Measure
Vertical
Trigger
Gen Out
Coarse
Fine
mA
ORA
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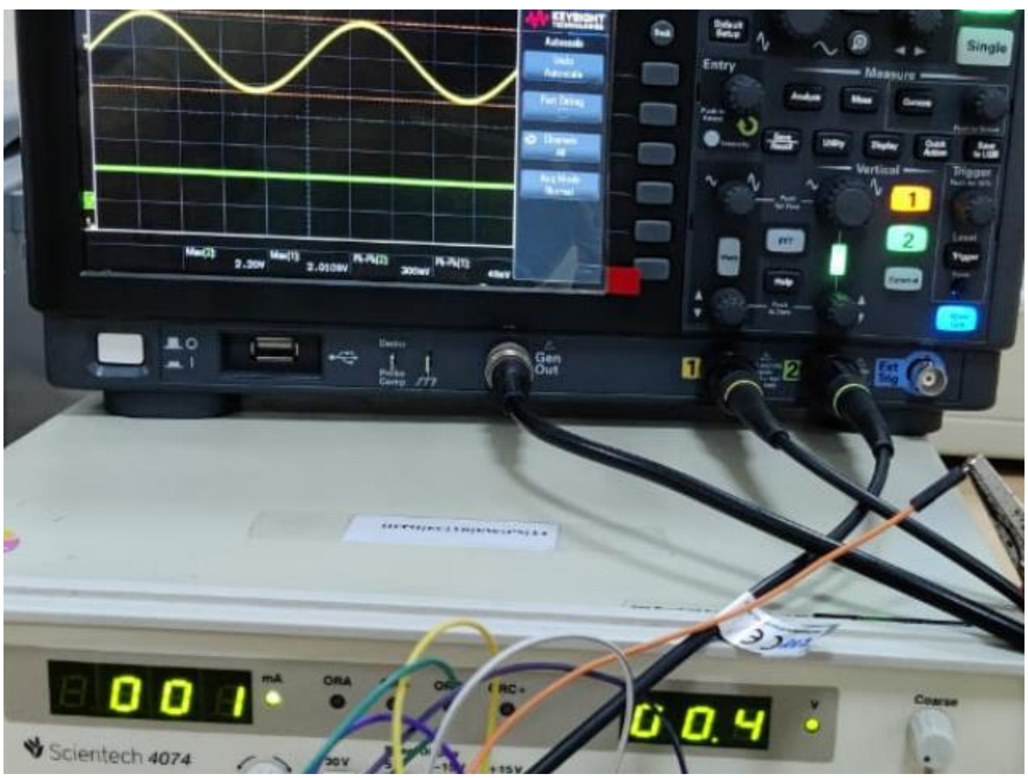
0.4
Scientech 4074

VSS= -0.4


Single
Entry
Measure
Vertical
Trigger
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Scientech 4074

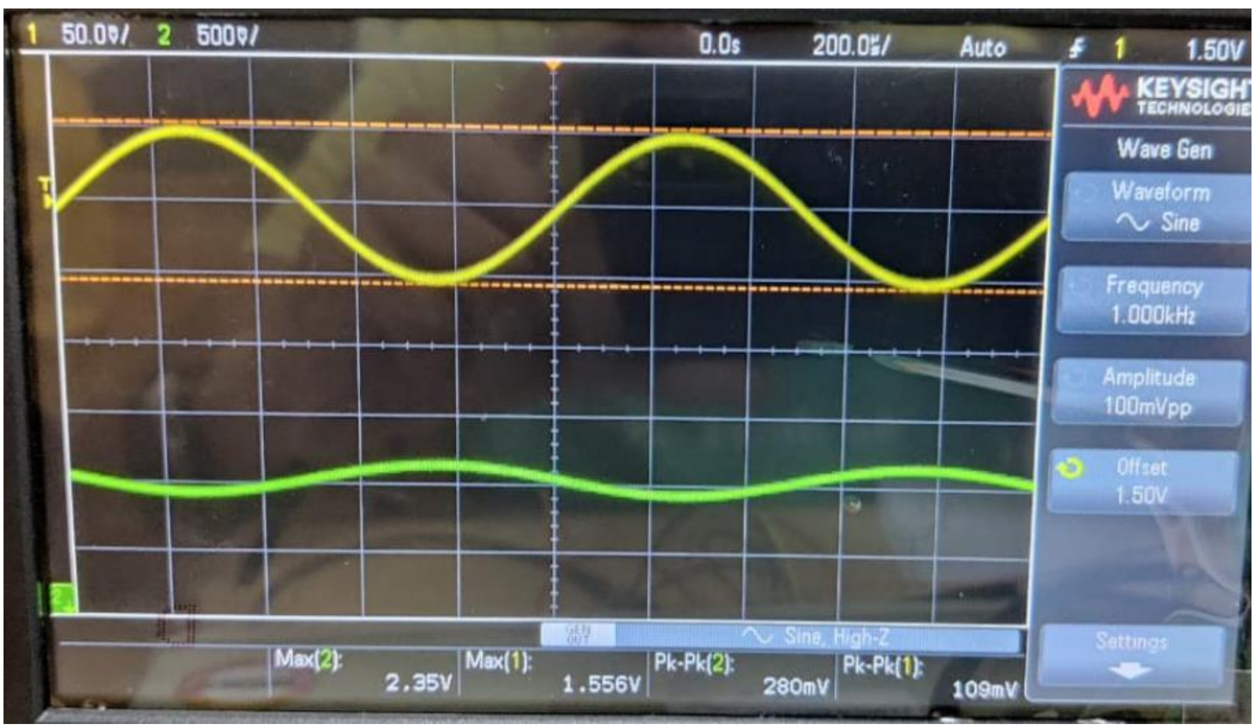
V_{SS}	V_{OUT}	Gain	Gm
0	213mV	4.26	$0.906*10^{-3}$
0.4	400mV	8	$1.7021*10^{-3}$
-0.4	72mV	1.44	$0.0306*10^{-3}$

2. Effect of BIAS points on Gain of common source amplifier

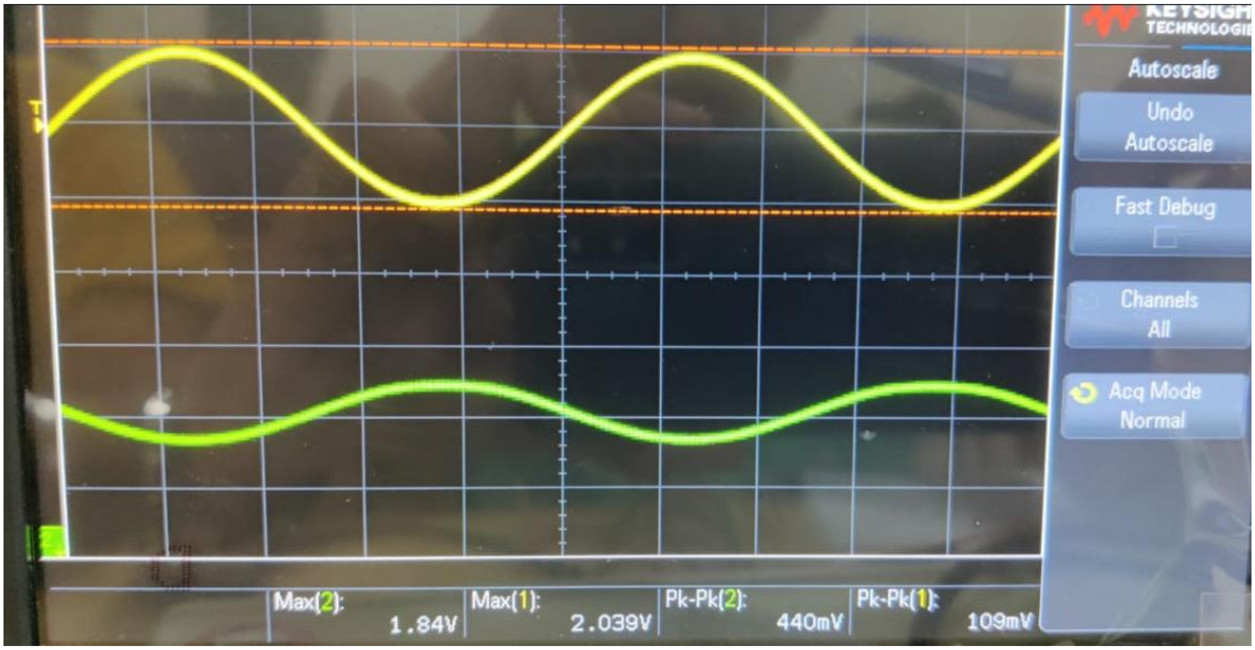
Now we will increase the offset value of V-Bias, with AC amplitude=$100m_{VPP}$

V_{BIAS}	V_{OUT}(AC)	Gain	$Gm*10^3$
1.5	280mV	2.8	0.5957
2	440mV	4.4	0.9361

V_{BIAS} = 1.5V

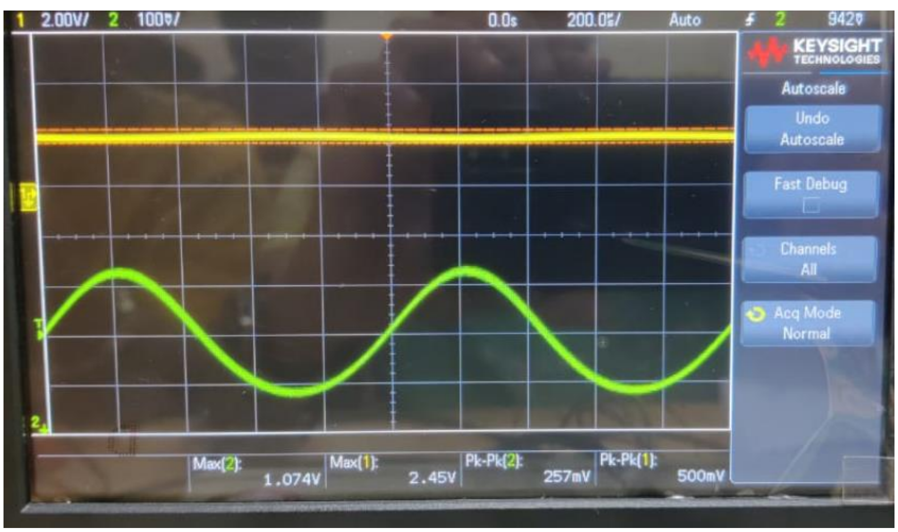


$V_{BIAS} = 2V$



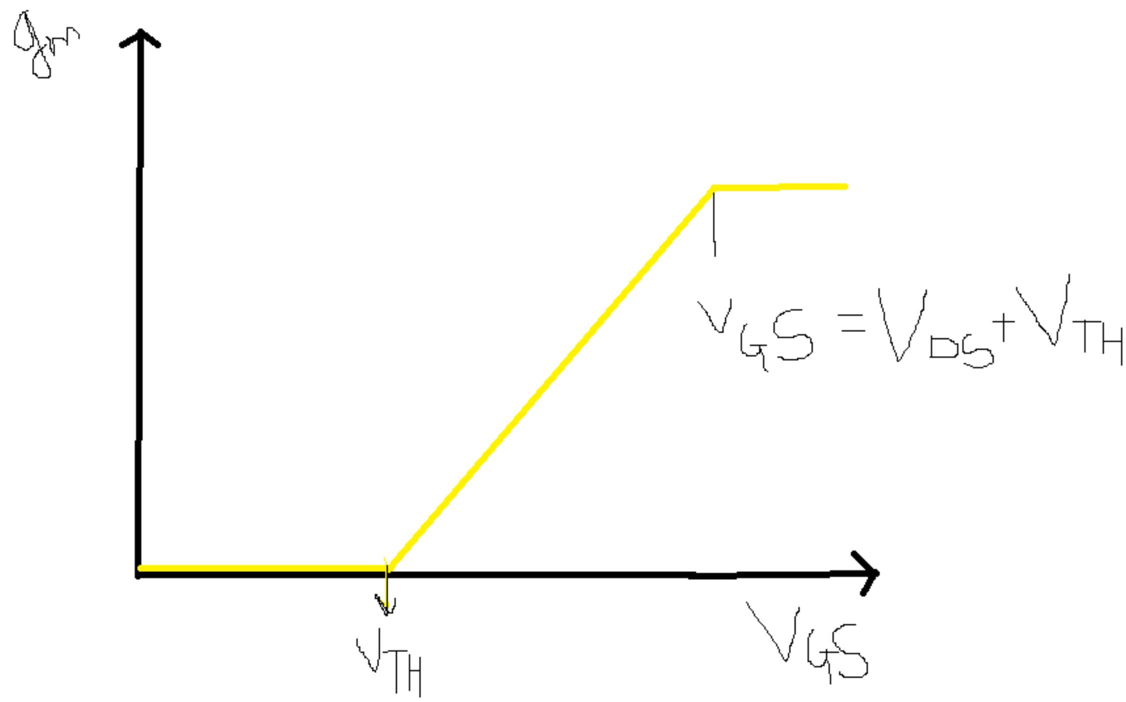
We are not able to increase V_{BIAS} any more due to probe restriction, as we increase it more, the V_{BIAS} shoot's up to 500mVpp.

The abnormality is shown below:



Explanation for above g_m trend is, when V_{GS} is less than V_{TH} there is nearly 0 gain as current is negligible, as the circuit enters saturation mode, the gm increases linearly with V_{GS}, this is because gm = $k(V_{GS}-V_{TH})$ in saturation region. Then in linear region it is constant with V_{GS} and linearly increases with $V_{DS.}$

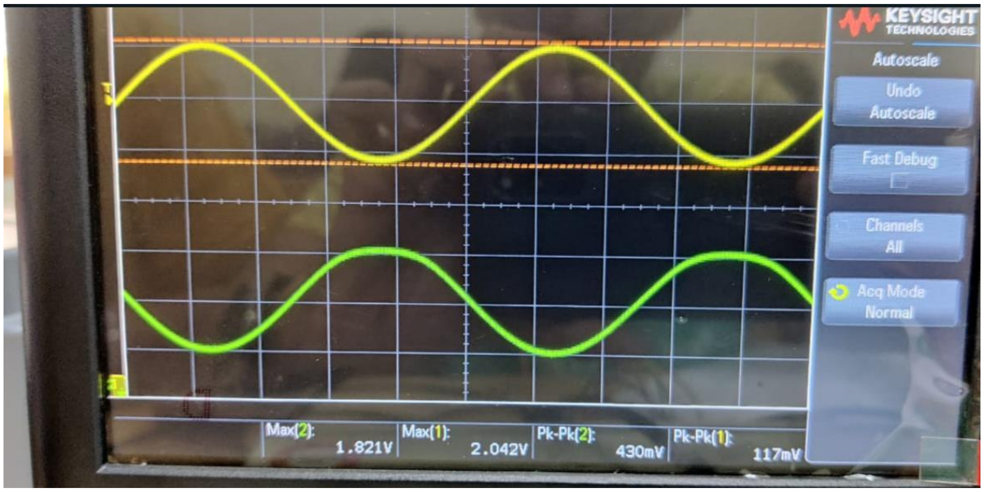
Graph:



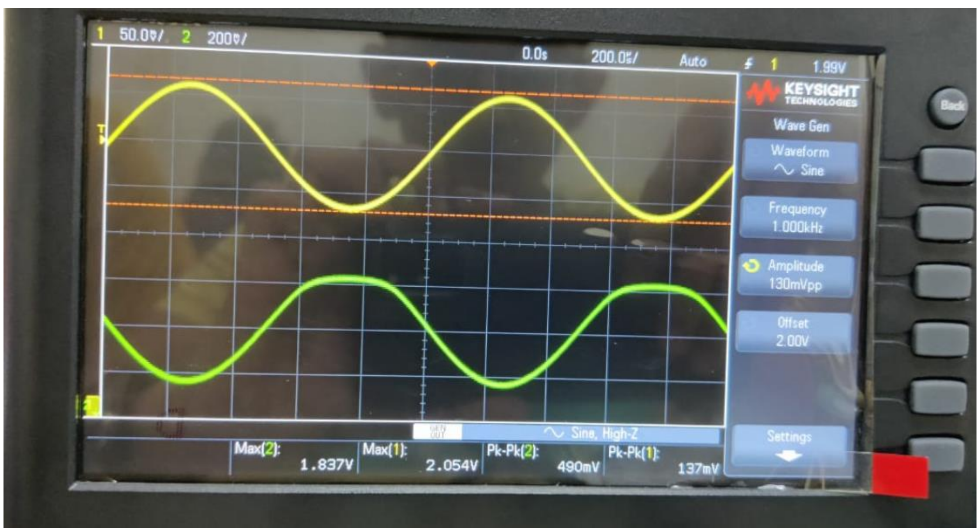
3. Effect of small signal input swing on gain of common source amplifier

For low values of (V_{BIAS}) AC the output comes out to be a perfect sine wave, but as we increase the input, the wave starts getting clipped, this is because due to higher AC voltage the saturation condition $V_{GS} – V_{TH} <= V_{DS}$ is violated at amplitude= $V_{DS}+V_{TH}$, and so the circuit, enters the linear mode.

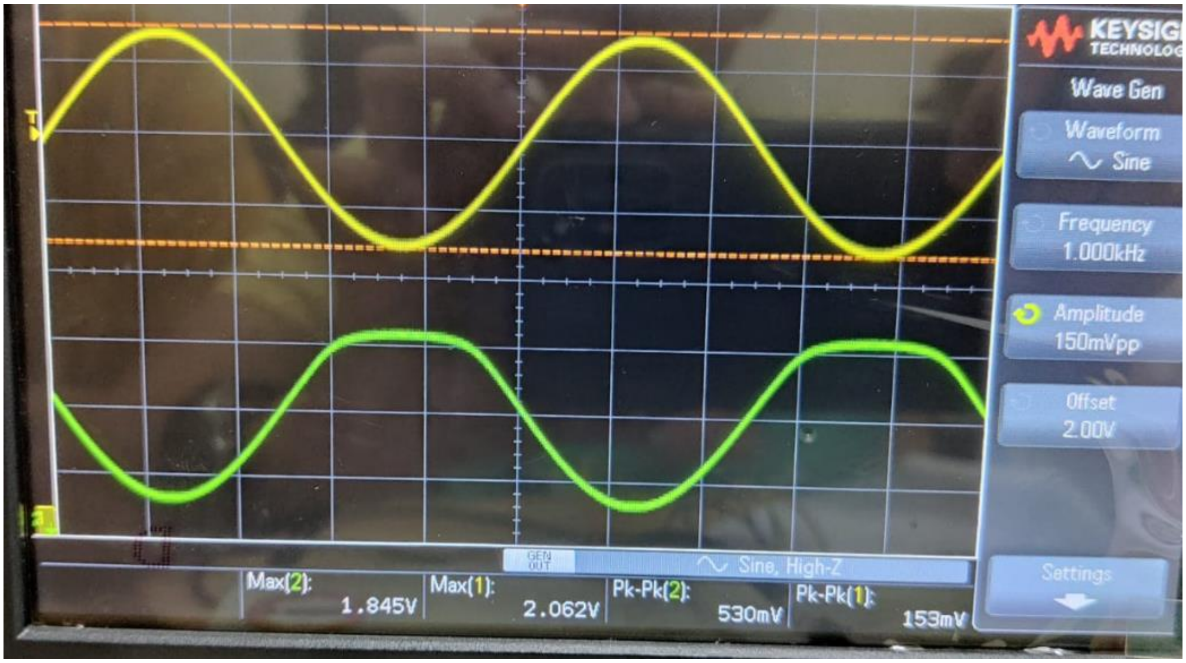
(V_{BIAS}) AC = 110mVpp



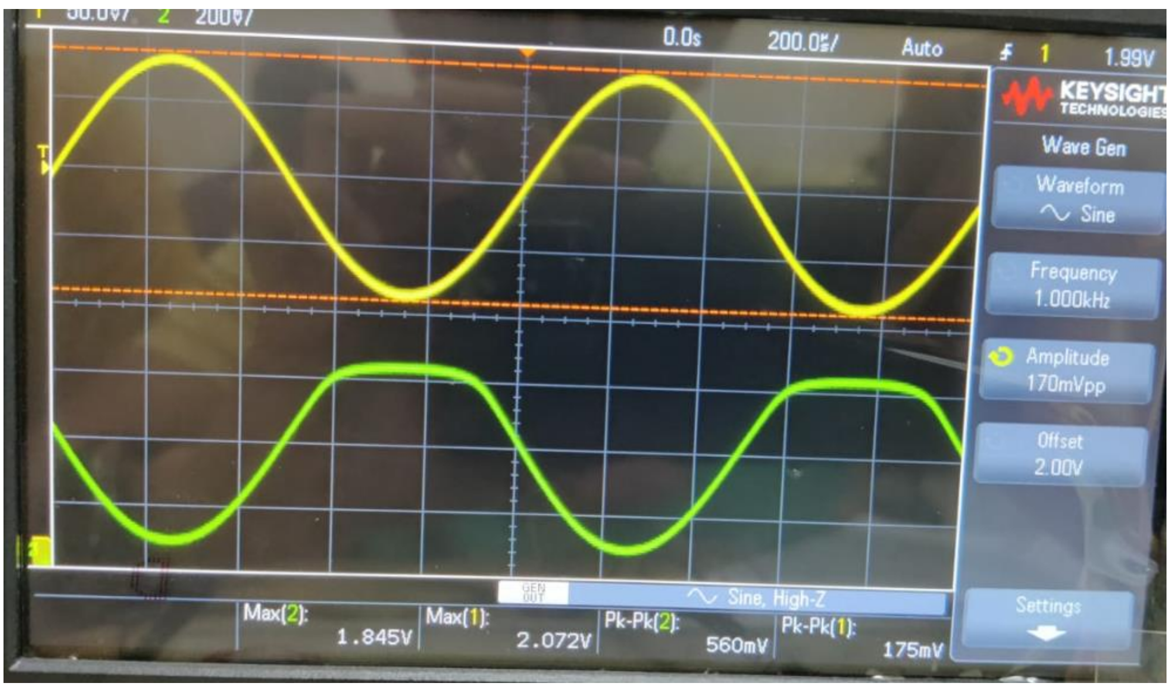
(V_{BIAS}) AC = 130mVpp



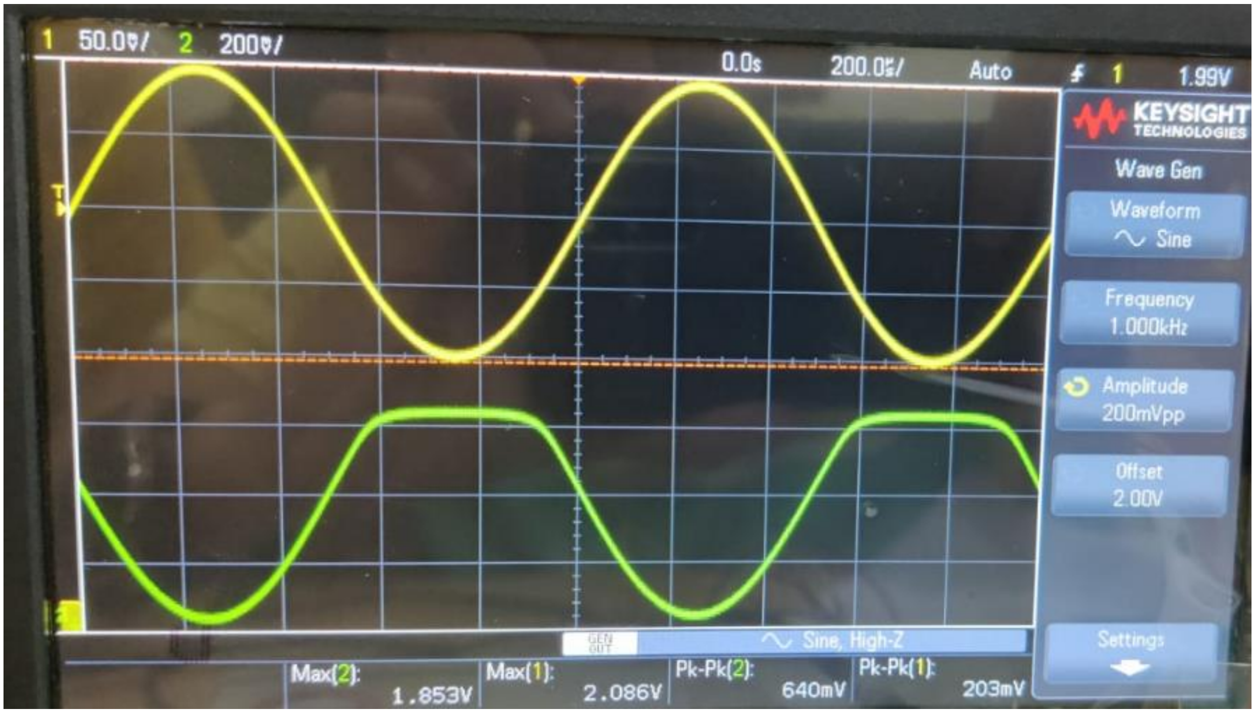
(V_{BIAS}) AC = 150mVpp



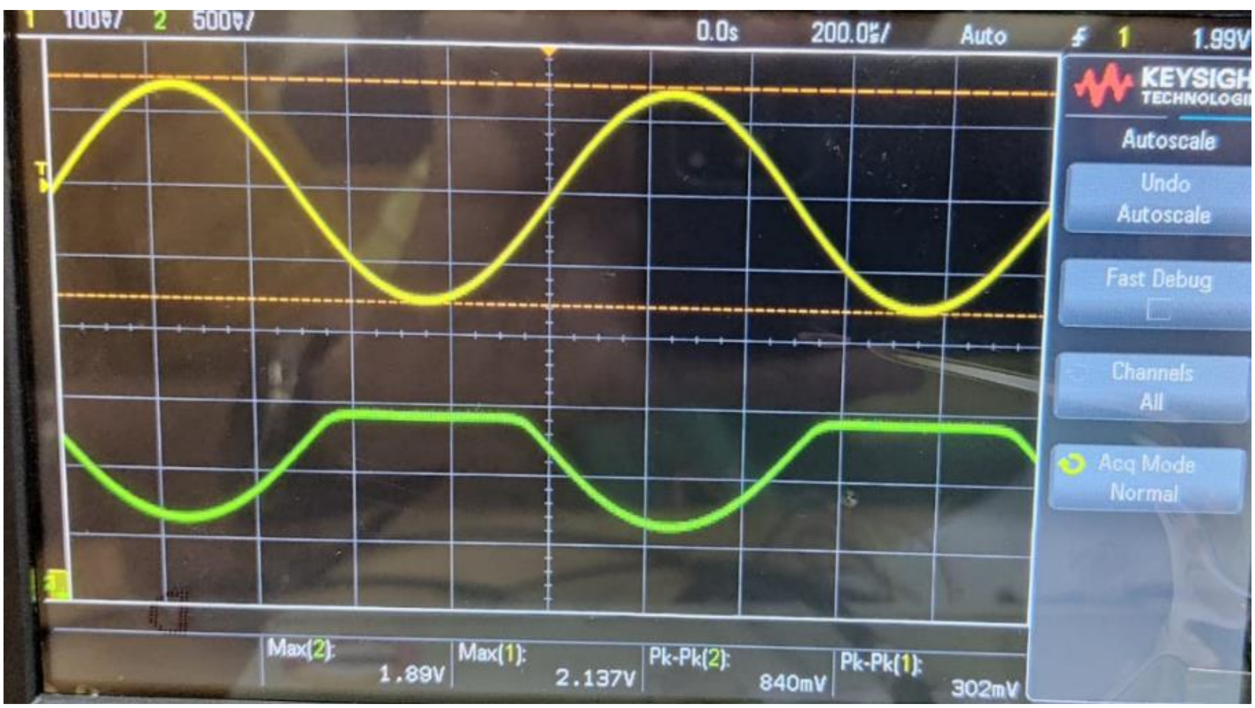
(V_{BIAS}) AC = 175mVpp



(V_{BIAS}) AC = 200mVpp



(V_{BIAS}) AC = 300mVpp

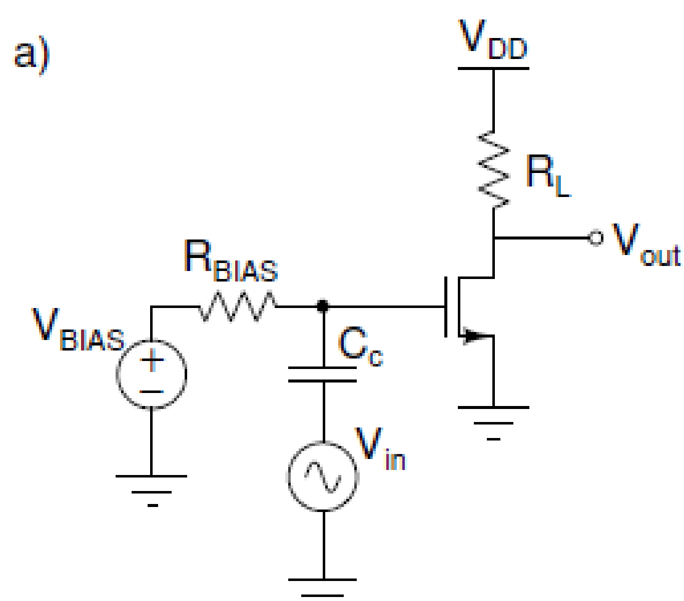


$V_{INPUPT\ AC}$	$V_{OUTPUT\ AC}$	Gain	$g_m * 10^3$
110Mv	440mV	4	0.85
135mV	430mV	3.185	0.677
150mV	530mV	3.53	0.75710
175mV	560mV	3.2	0.6808
200mV	640mV	3.2	0.6808
300mV	840mV	2.8	0.5957

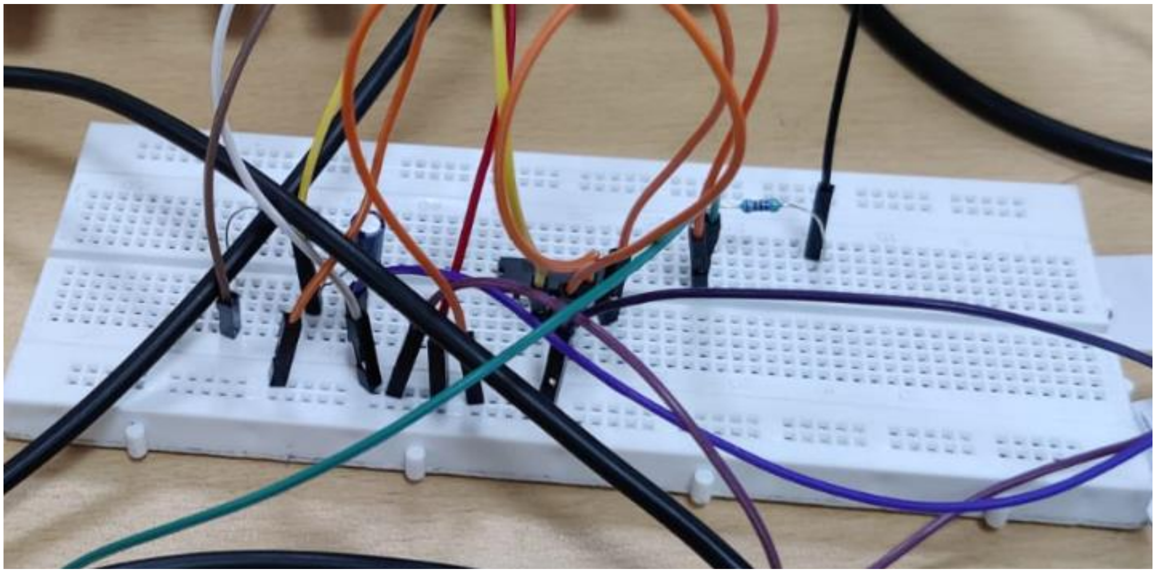
As the $V_{INPUPT\ AC}$ the gain increases till the point there is no clipping, as the clipping starts the gain decreases due to decrease in output voltage.

4. CS amplifier with external coupling

Schematic view of the circuit:



Circuit:



The difference in gain is observable at high frequencies when due to capacitances there comes a frequency factor into play, below is the graph showing gain vs frequency.

It is evident that as the frequency increases the gain of the circuit decreases.

Vin = 107mV

Vout = 302mV

Gain: 2.8224

Gm = $0.6 * 10^{-3}$.

The value of gain and gm decreased this is because of frequency term in the denominator of the gain.

$-gm*R_L / (1 + C_C*R_{BIAS}*\omega)$.

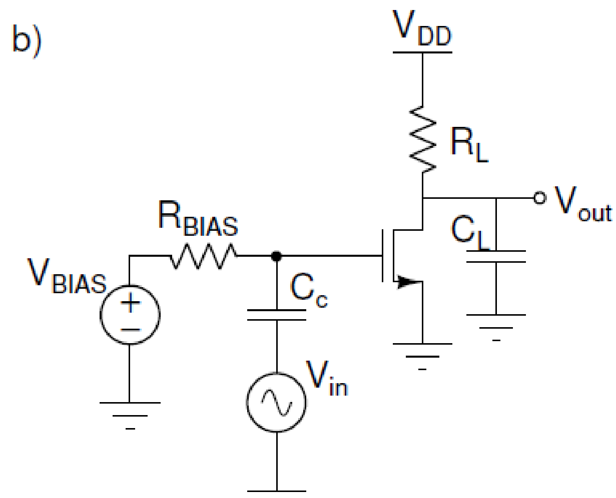
$V_{DS} = 1.5V$.

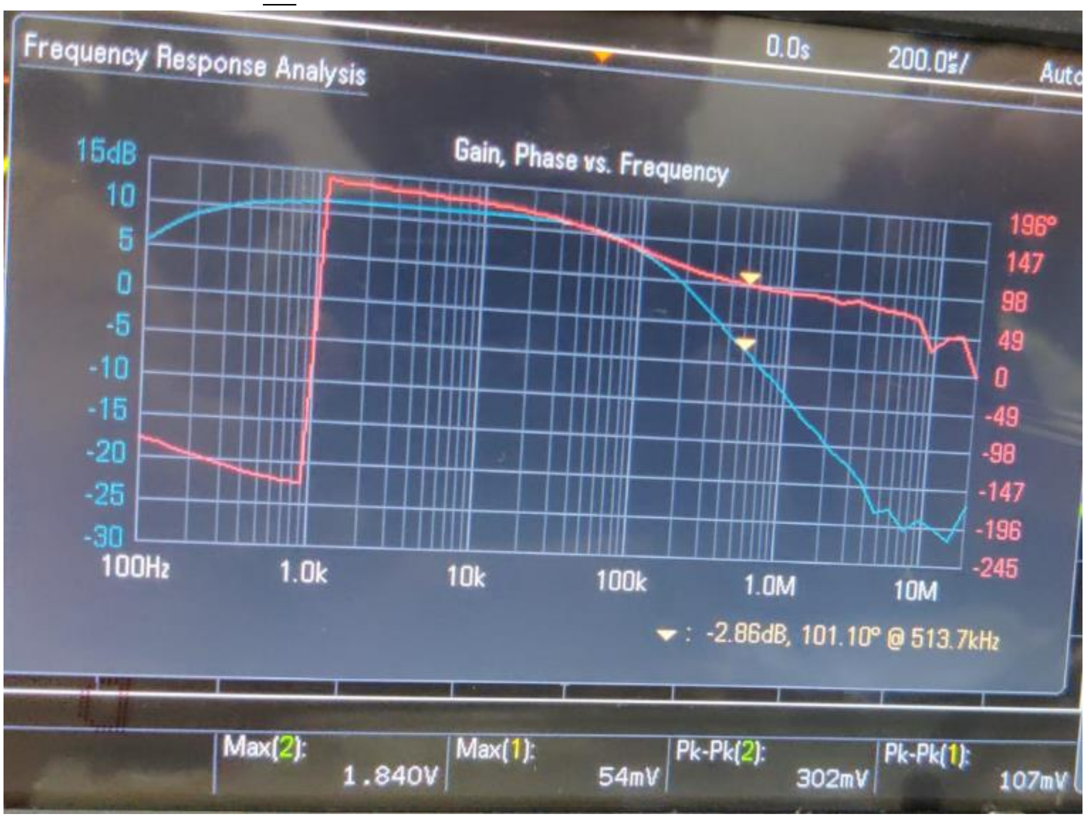
$I_{DS} = (V_{DD} - V_{DS}) / R_L$

$I_{DS} = 1.06 * 10^{-2}$.

$\mu C_{ox}\frac{W}{L}$ $= I_{DS}/(V_{DS}-V_{TH})^2 = 5.47*10^{-2}$.

(d) Schematic view of circuit:





-3dB bandwidth: 513KHz.

Transfer function: $-gm*R_L / (1+ \omega R_{BIAS}*C_C)(1+\omega R_L*C_L)$

Poles: $1/R_{BIAS}*C_C*2\pi$ and $1/R_L*C_L*2\pi$

Pole1: 0.15KHz

Pole2: 0.07KHz