Lab 7

MOSFET
(Metal-Oxide-Semiconductor Field -Effect Transistor)

Introduction:

A MOSFET, or Metal-Oxide-Semiconductor Field-Effect Transistor, is a type of transistor that can be used as a switch or amplifier in electronic circuits. It consists of a metal gate, an insulating oxide layer, and a semiconductor channel, and operates by applying a voltage to the gate to control the flow of current through the channel.

1-Device Characterization

The test setups for the NMOS transistor are shown in Figure 1 , which will produce the plots shown in graphs 1 and 2 , using parametric analysis.

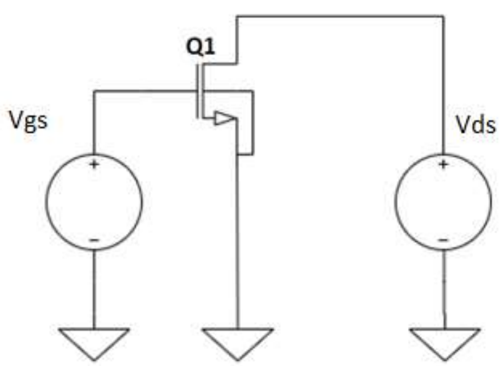
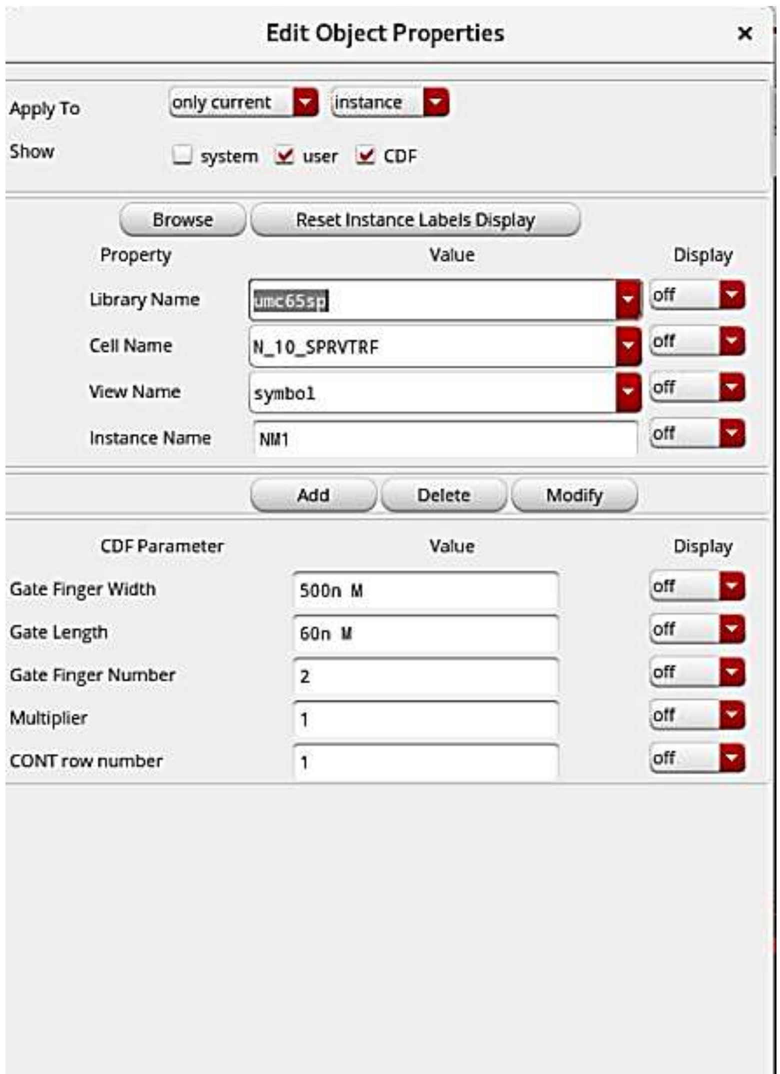


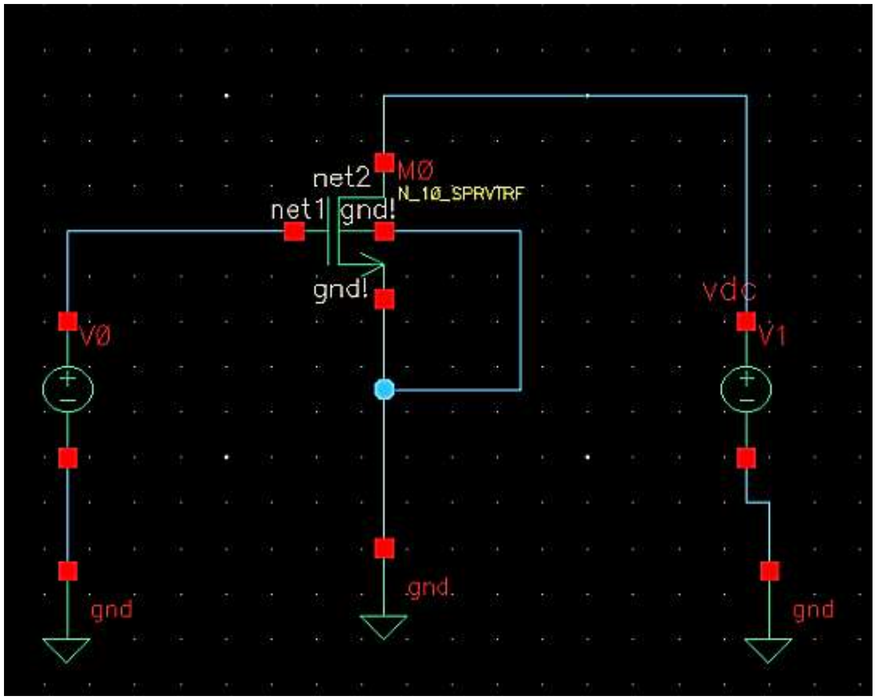
Figure 1 Active Mode circuit

<u>Steps:</u>

-Starting cadence with normal way then :
-Create >> Instance
-Library=> UMC 65

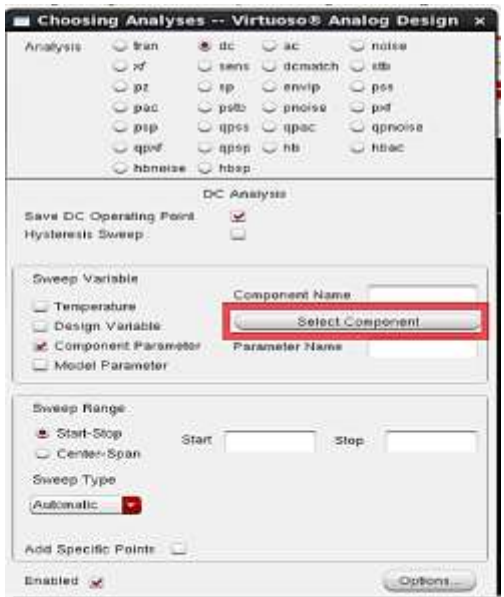


-SCHEMATIC1:

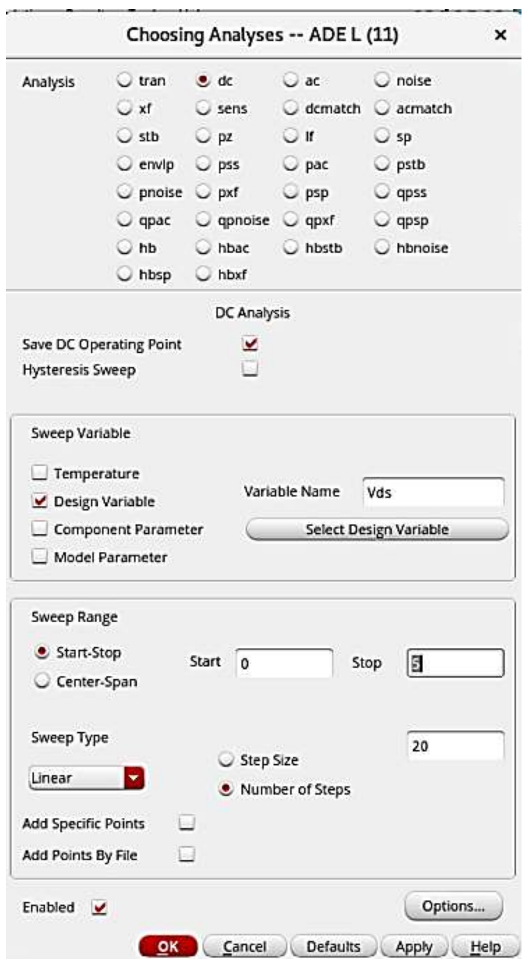


-we need to define DC analysis for getting the response of mosfet's operation
- Launch >> ADE XL window.

-on sweep 2 variables ,need to clarify the input component so we can select it by click on bottom like that:
-Choosing Analysis window =>dc
-click on =>" Save DC Operating point" icon
-Component parameter=>Select component



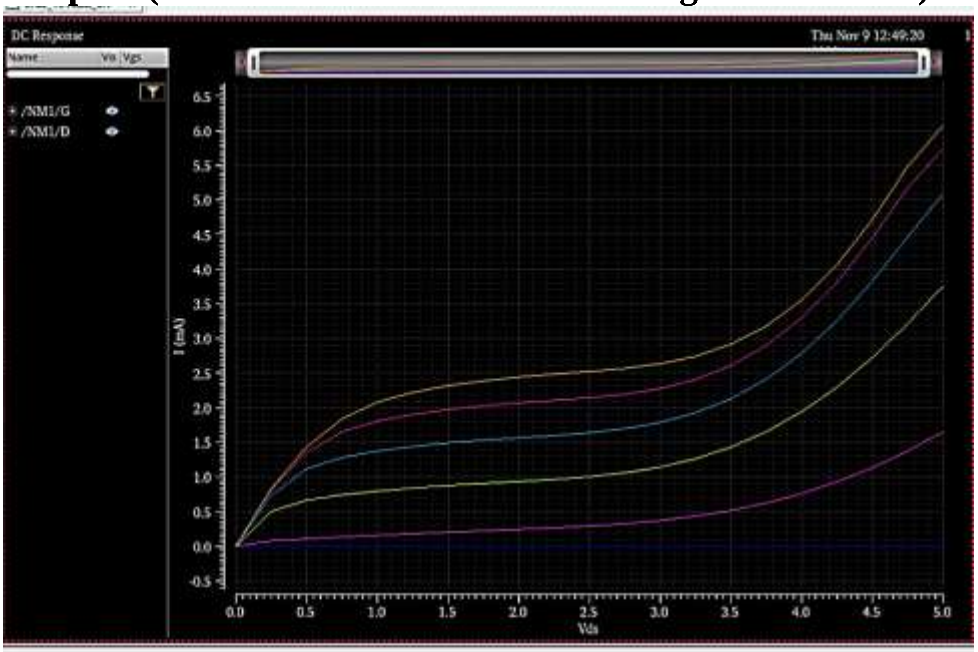
-Schematic Window => vds Source =>OK.



-Run from XL's window

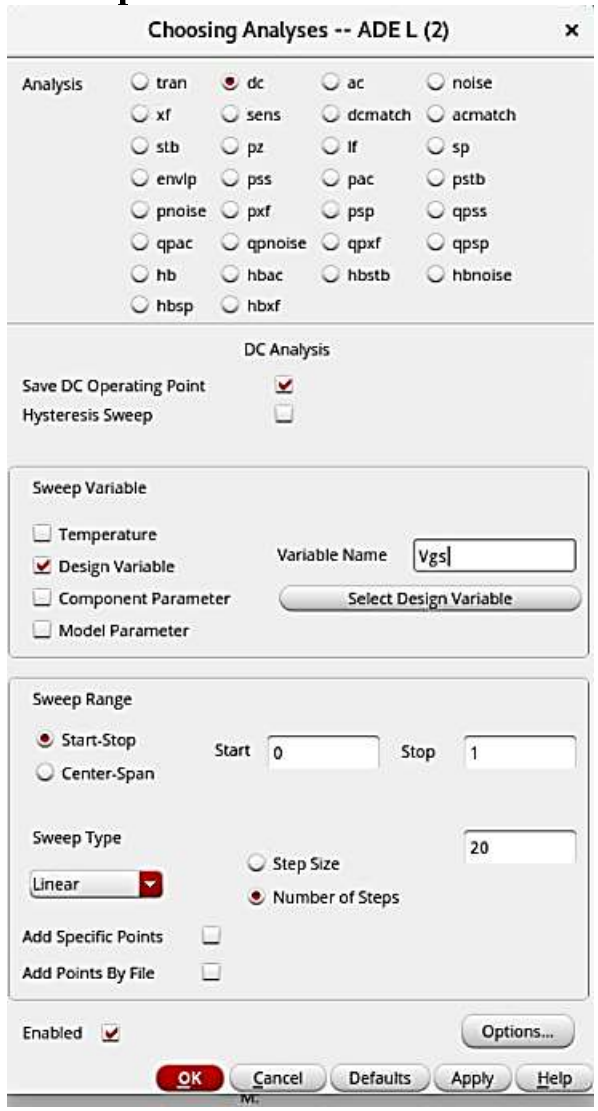
-Final Results

Graph 1 (I/Vds Characteristic for select regions of mosfet)



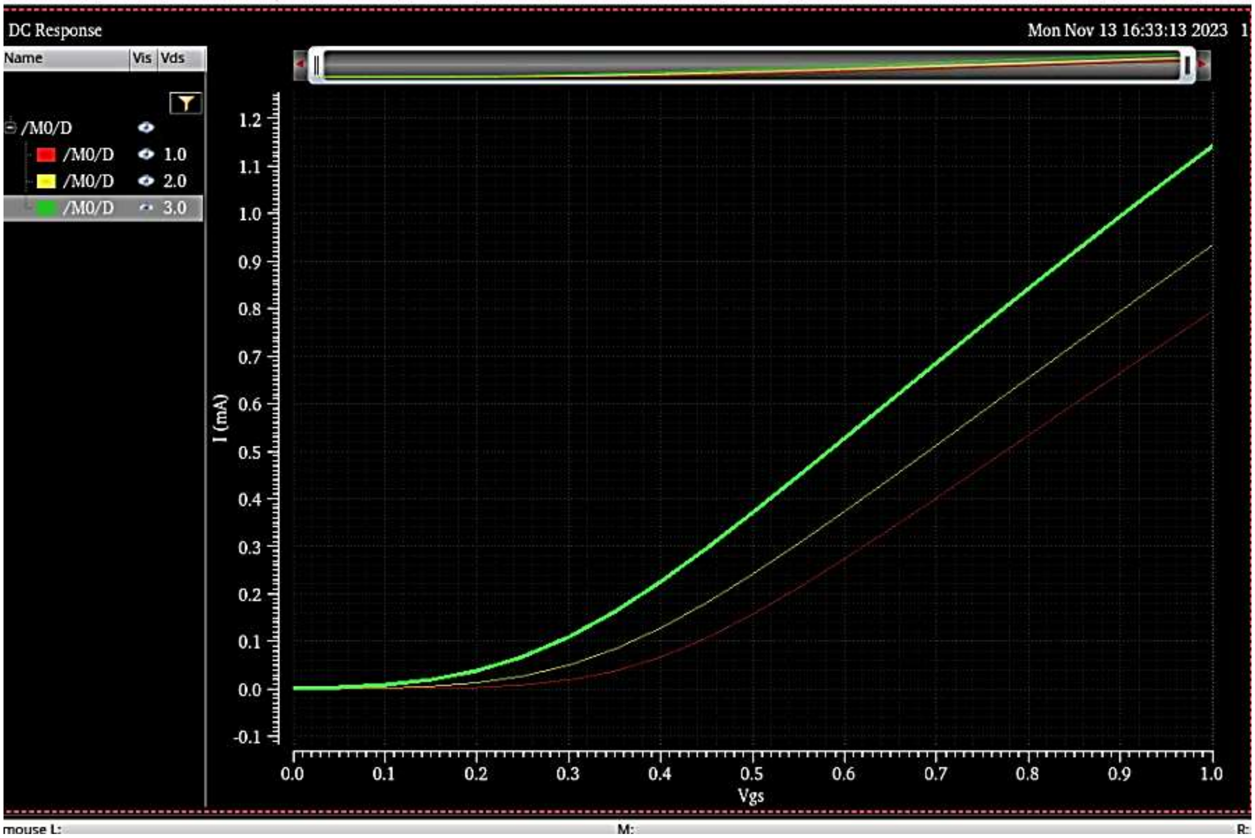
Note that : the output curve will be linear for 2 stages , the second stage due to the library of MOSFET selecting breakdown voltage of MOSFET at almost 4v so after that voltage ,MOSFET will act as resistor

- **Replacing the main sweep variables as shown below**



At Vds=1,2,3volts

Graph 2(I/Vgs for select the operating point of gate voltage)



From the above 2 curves we suggest to work on Vds=3volts and Vgs started from 0.1volts

2-Types of MOSFET Amplifiers

MOSFET amplifiers are available in three types like common source (CS), common gate (CG), and common drain (CD), where each type along with its configuration is discussed below.

2-a Common Source

The common source circuit provides a medium input and output impedance levels. Both current and voltage gain can be described as medium, but the output is the inverse of the input, i.e. 180° phase change. This provides a good overall performance and as such it is often thought of as the most widely used configuration.

The common-source MOSFET amplifier is related to the CE (common-emitter) amplifier of BJT. This is very popular due to high gain and larger signal amplification can be achieved.

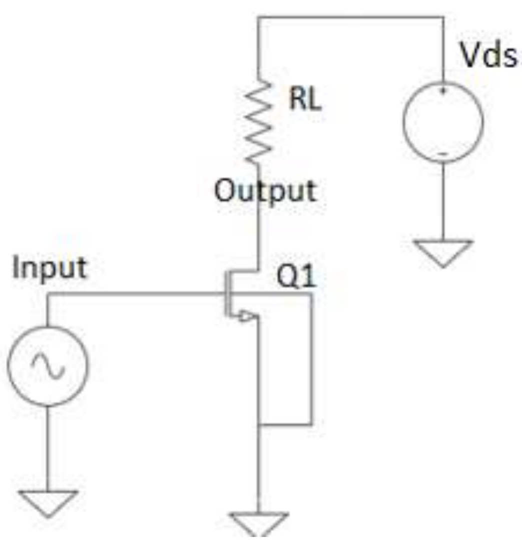
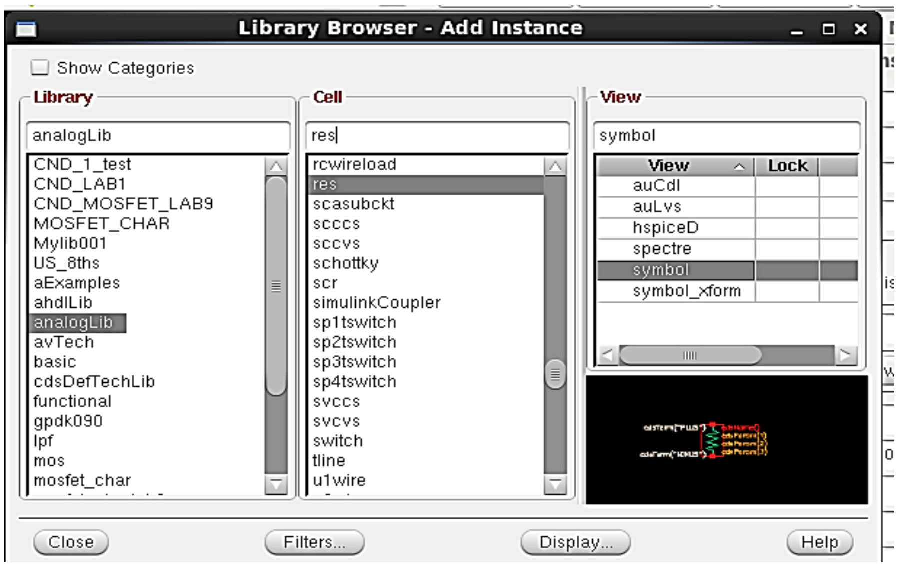


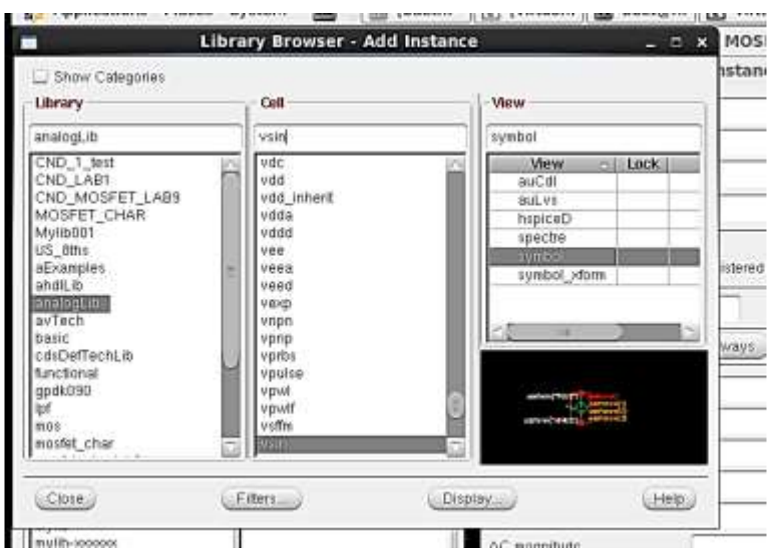
Figure 2 Common Source Circuit

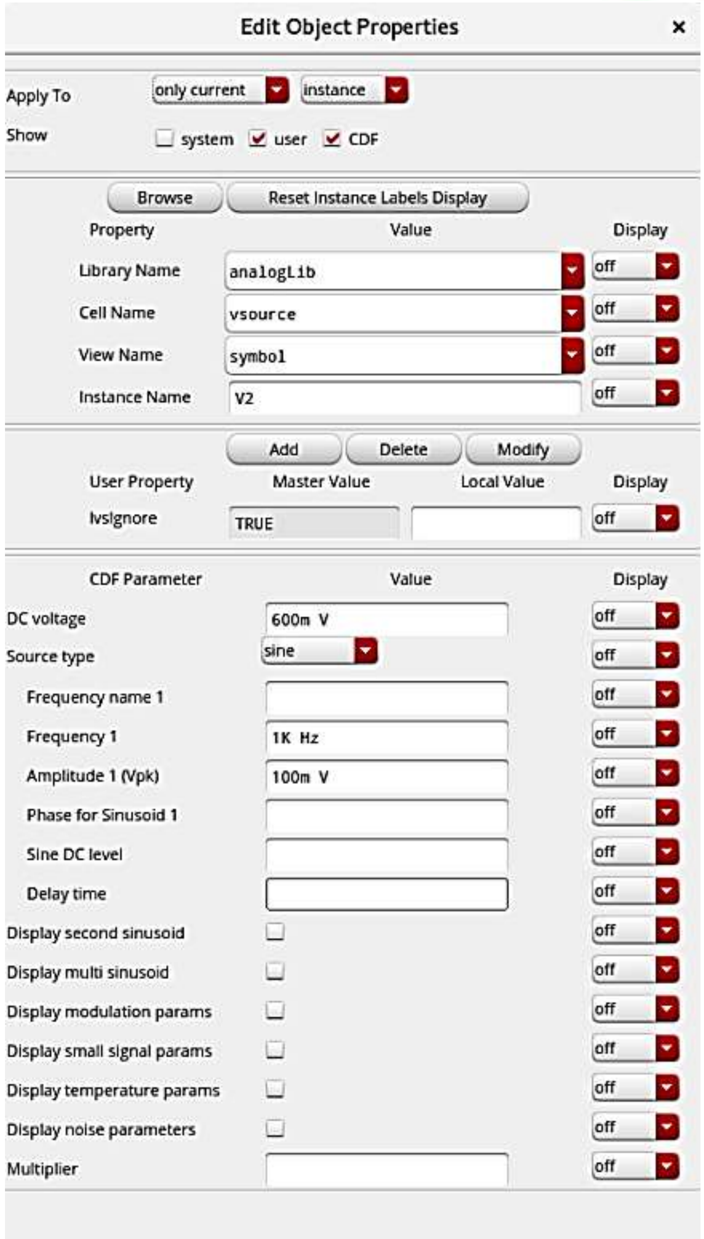
Steps:

-Library=> analogLib
-Cell=>res
-view=> symbol

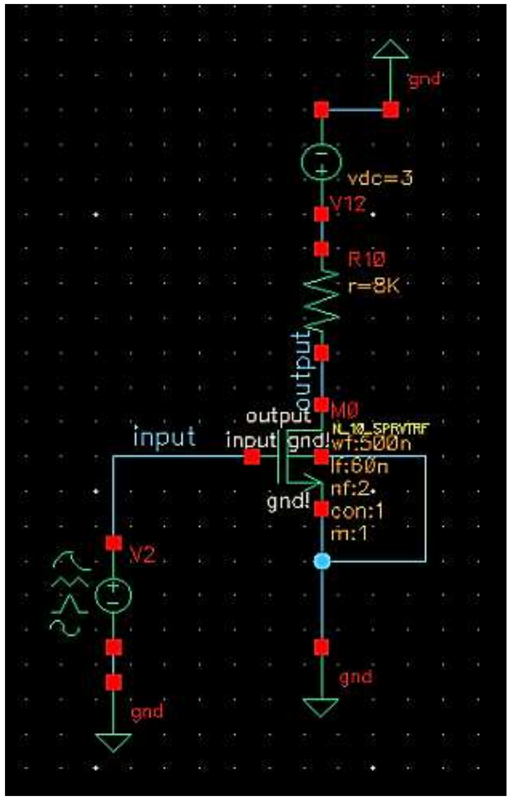


-Library=> analogLib
-Cell=>Vsin
-view=> symbol

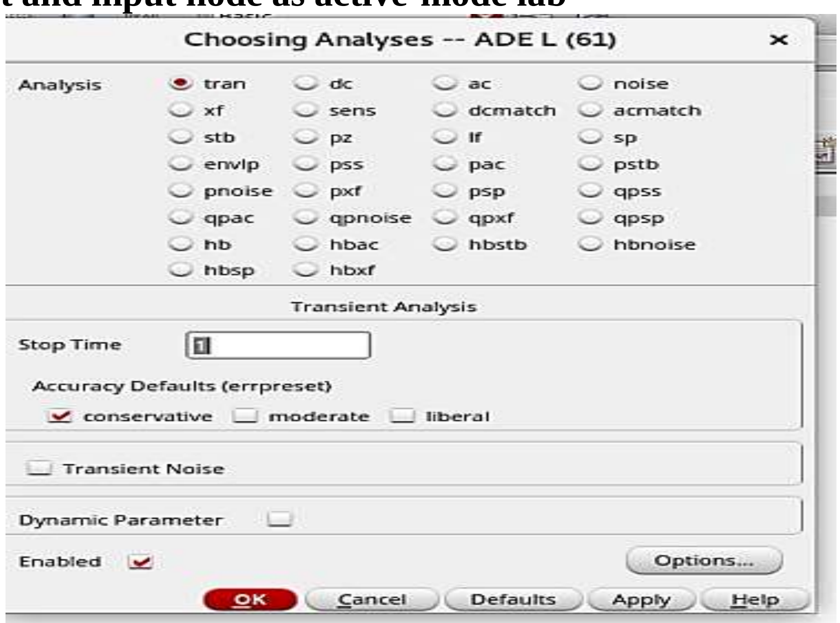



Edit Object Properties
Apply To
only current
instance
Show
system
user
CDF
Browse
Reset Instance Labels Display
Property
Value
Display
Library Name
analogLib
Cell Name
vsource
View Name
symbol
Instance Name
V2
Add
Delete
Modify
User Property
Master Value
Local Value
lvsIgnore
TRUE
CDF Parameter
DC voltage
600m V
Source type
sine
Frequency name 1
Frequency 1
1K Hz
Amplitude 1 (Vpk)
100m V
Phase for Sinusoid 1
Sine DC level
Delay time
Display second sinusoid
Display multi sinusoid
Display modulation params
Display small signal params
Display temperature params
Display noise parameters
Multiplier
off

- SCHEMATIC 2:

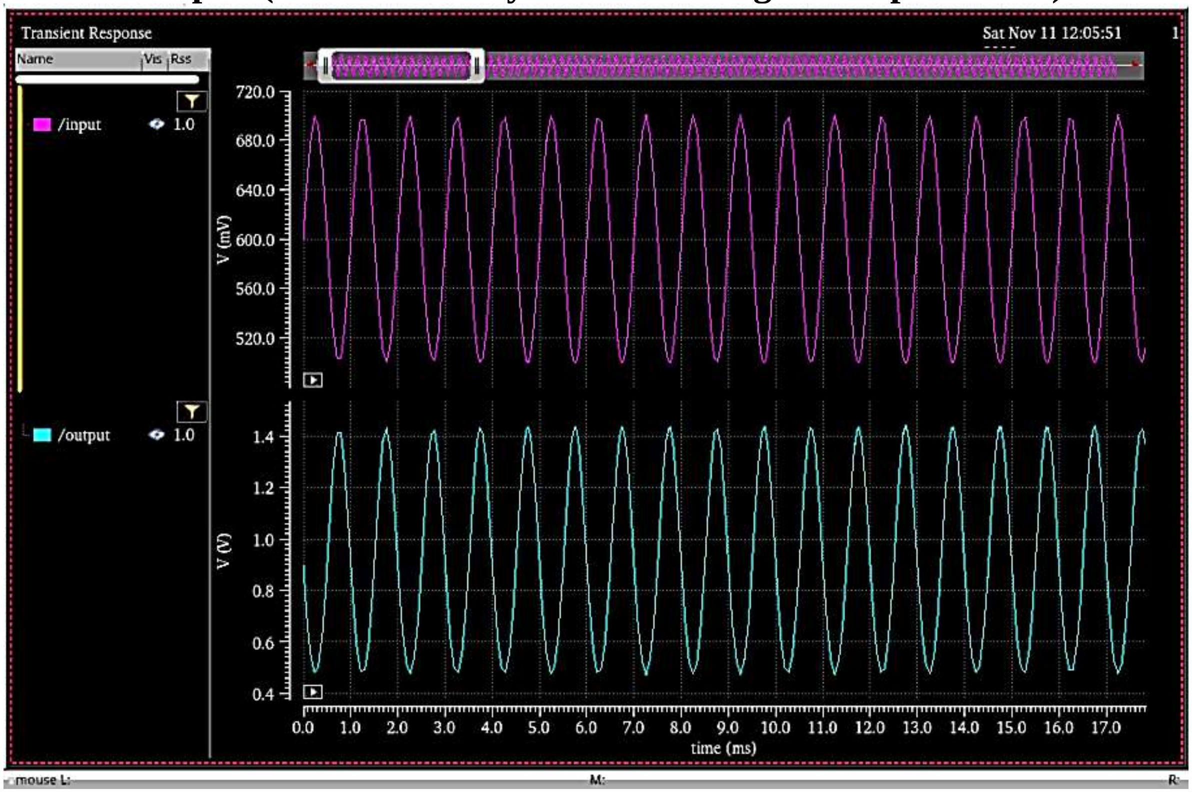


-select output and input node as active-mode lab

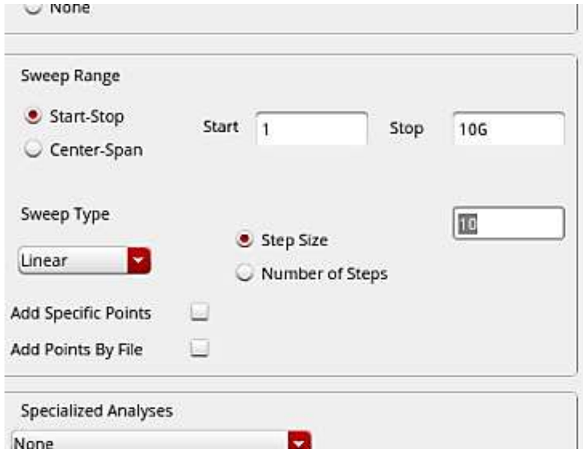


-Final Results:-

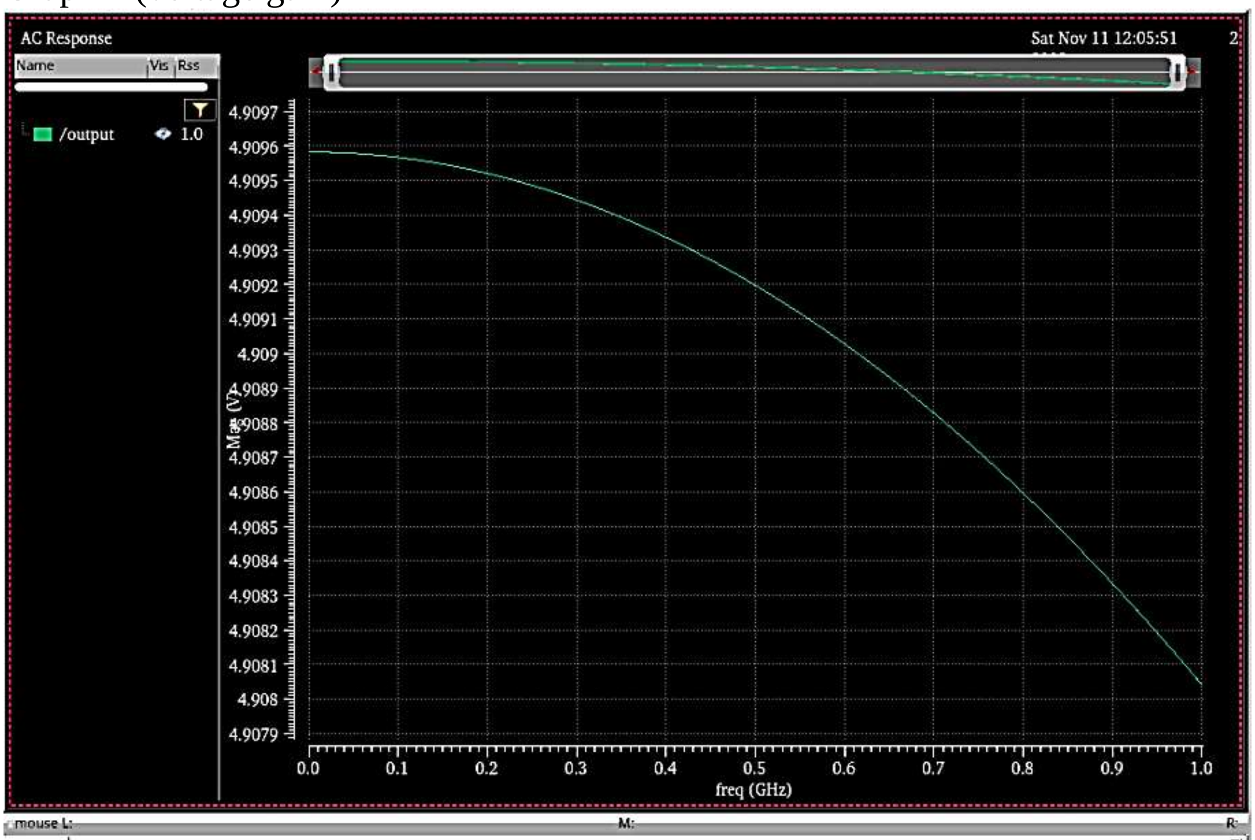
Graph 3(Transient analysis for checking the amplification)



- **Making Ac analysis to check the output voltage gain**



Graph 4 (voltage gain)



2-b Common gate

Common gate FET configuration provides a low input impedance while offering a high output impedance. As the gate is grounded, this acts as a barrier between input and output providing high levels of isolation, preventing feedback, especially at very high frequencies.

Although the voltage gain is high, the current gain is low and the overall power gain is also low when compared to the other FET circuit configurations available.

The other salient feature of this configuration is that the input and output are in phase.

Note that: although gate have to be grounded, we have to make voltage difference between gate and source =1v so MOSFET can work

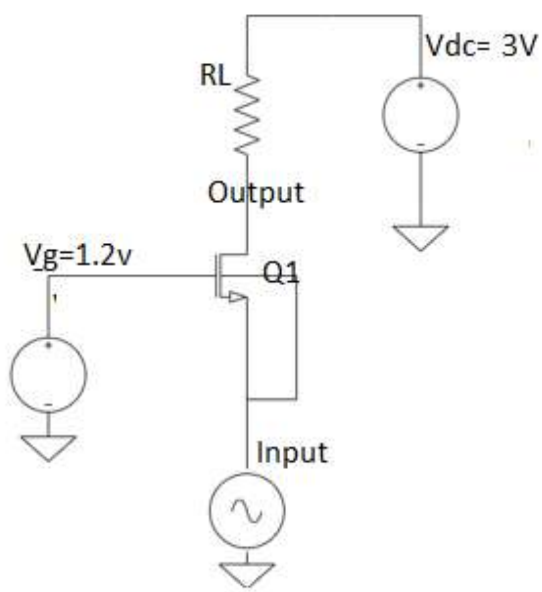


Figure 3 Common Gate Circuit

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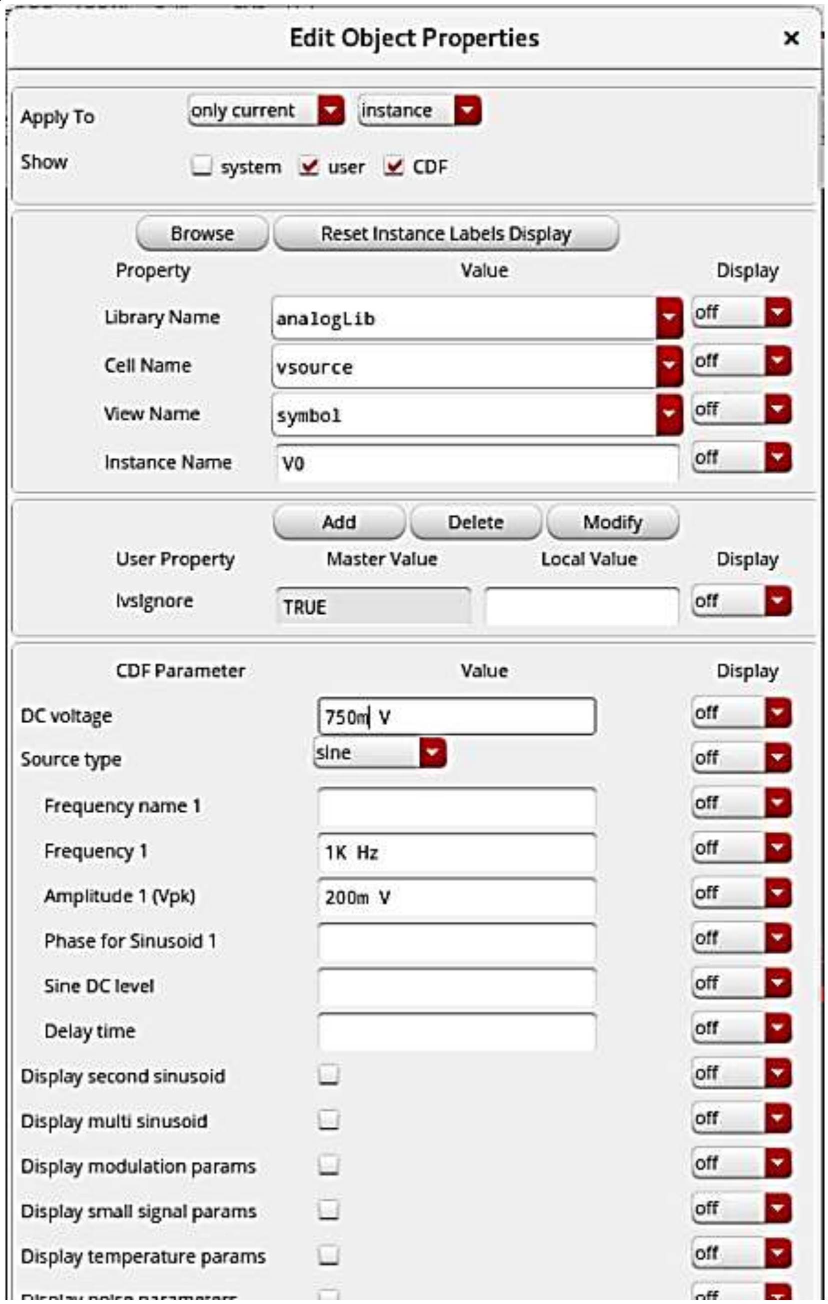
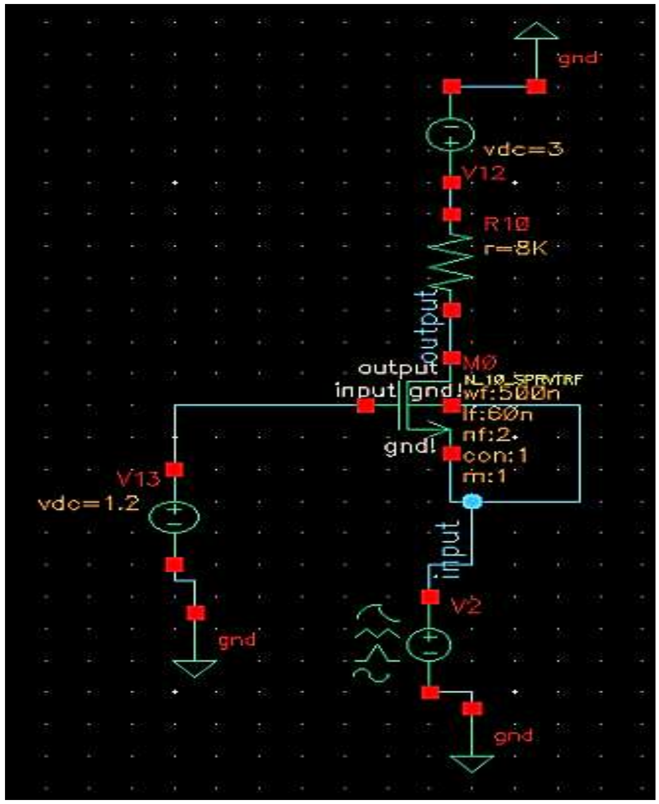
<u>Steps:</u>

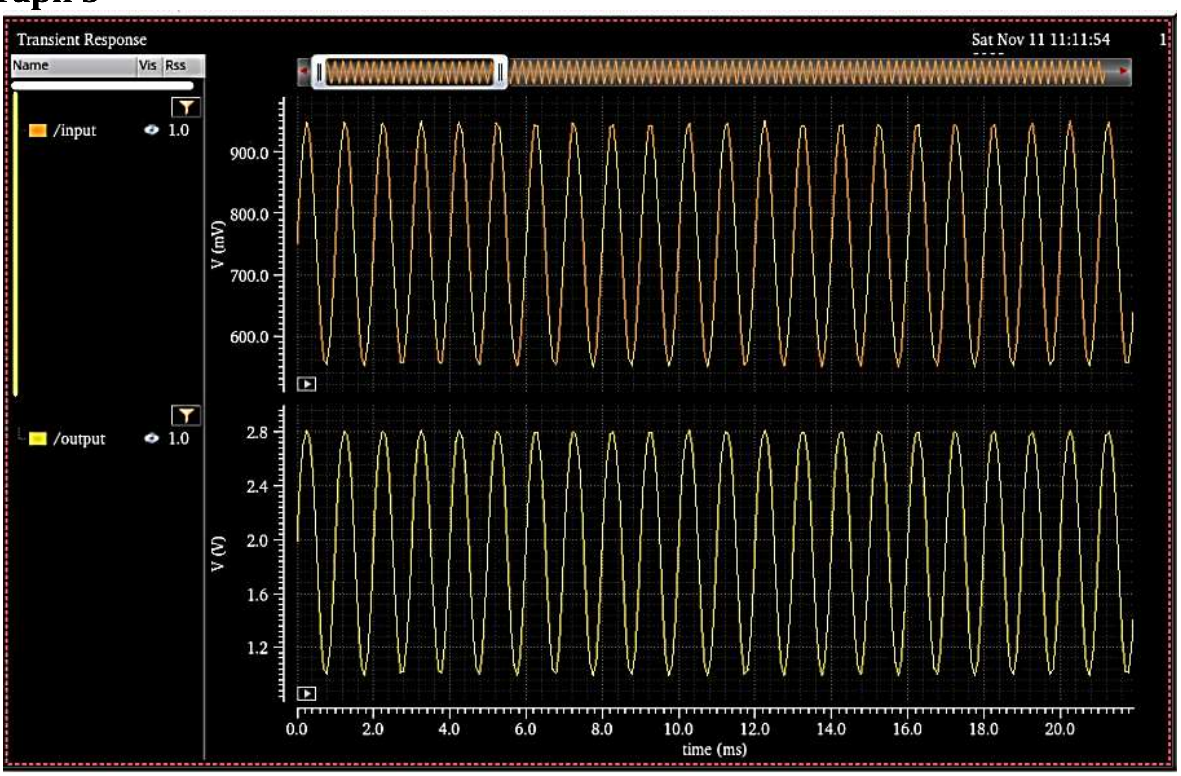
Same properties of component (input sine wave) and setup of analysis(even transient or AC) then:-



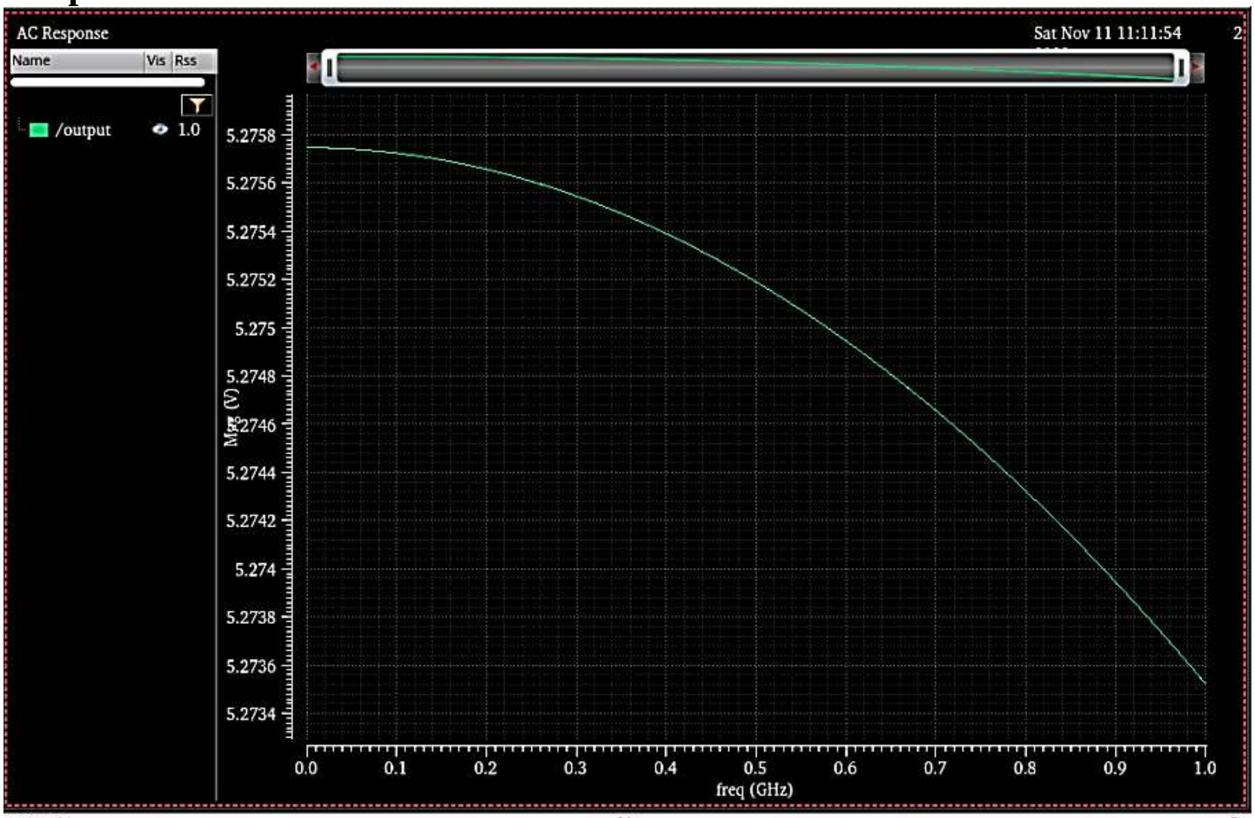
SCHEMATIC 3:



-Final Results
Graph 5



Graph 6


AC Response
Sat Nov 11 11:11:54
Name
Vis
Rss
/output
1.0
5.2758
5.2756
5.2754
5.2752
5.275
5.2748
5.2746
5.2744
5.2742
5.274
5.2738
5.2736
5.2734
Mag (V)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
freq (GHz)

2-c Common drain

The like the transistor emitter follower, the FET source follower configuration itself provides a high level of buffering and a high input impedance. The actual input resistance of the FET itself is very high as it is a field effect device. This means that the source follower circuit is able to provide excellent performance as a buffer.

The voltage gain is unity, although current gain is high. The input and output signals are in phase.

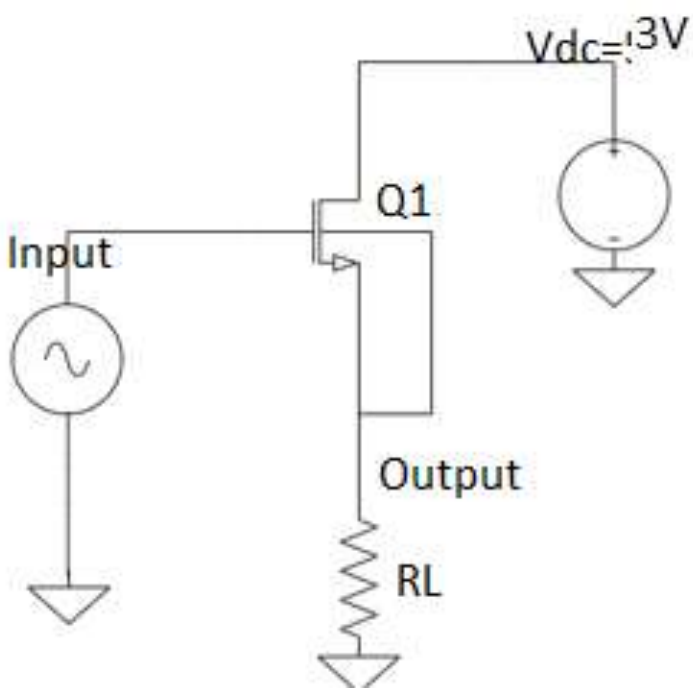
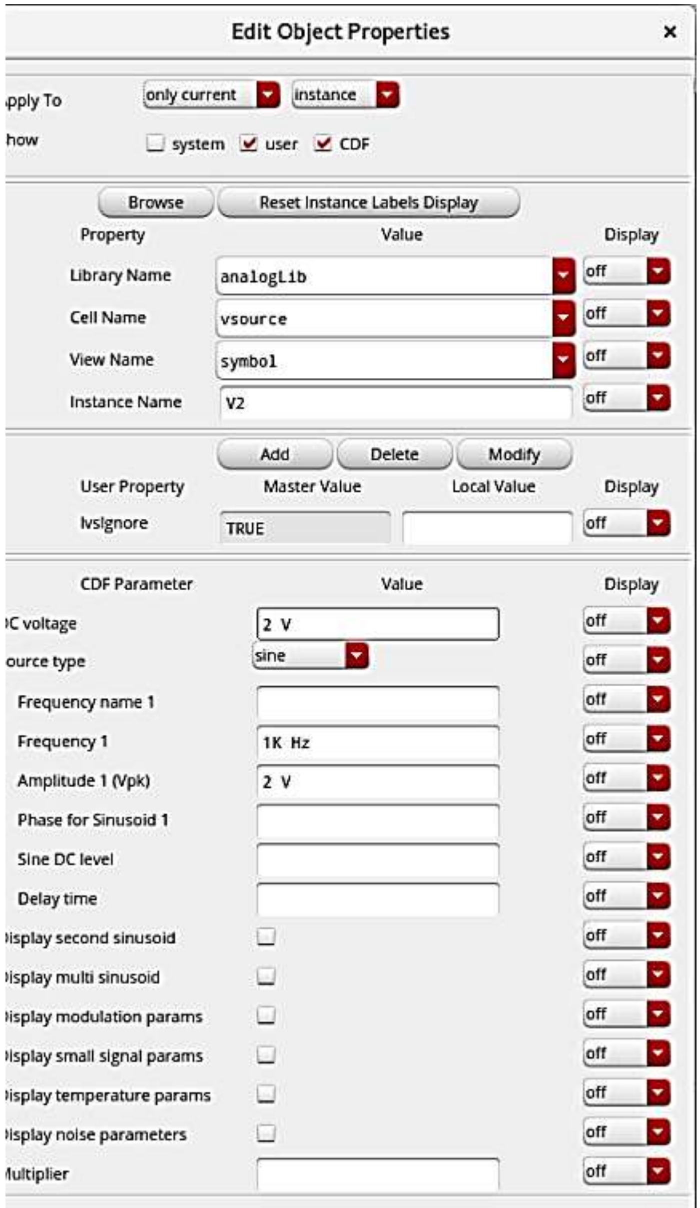
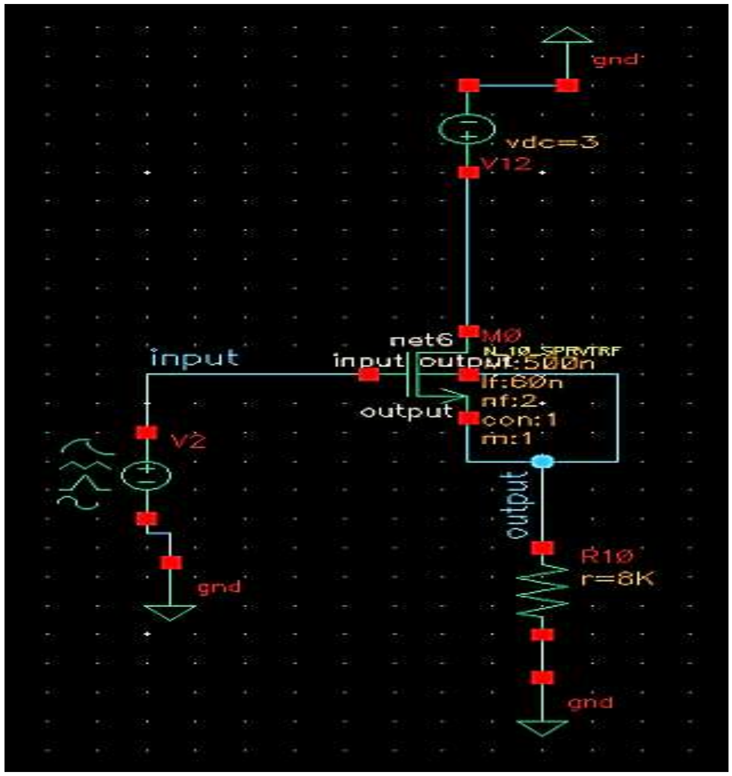


Figure 4 Common Drain Circuit

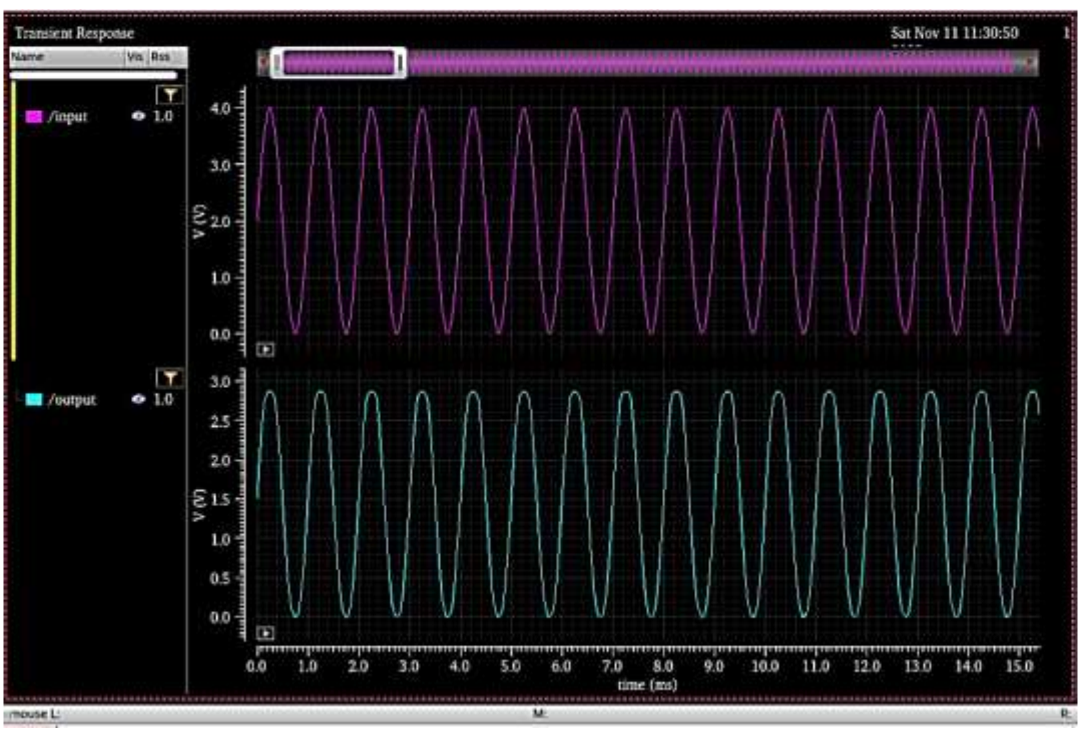
Steps:


Edit Object Properties
pply To
only current
instance
how
system
user
CDF
Browse
Reset Instance Labels Display
Property
Value
Display
Library Name
analogLib
Cell Name
vsource
View Name
symbol
Instance Name
V2
off
Add
Delete
Modify
User Property
Master Value
Local Value
lvsIgnore
TRUE
CDF Parameter
C voltage
2 V
ource type
sine
Frequency name 1
Frequency 1
1K Hz
Amplitude 1 (Vpk)
2 V
Phase for Sinusoid 1
Sine DC level
Delay time
isplay second sinusoid
isplay multi sinusoid
isplay modulation params
isplay small signal params
isplay temperature params
isplay noise parameters
ultiplier

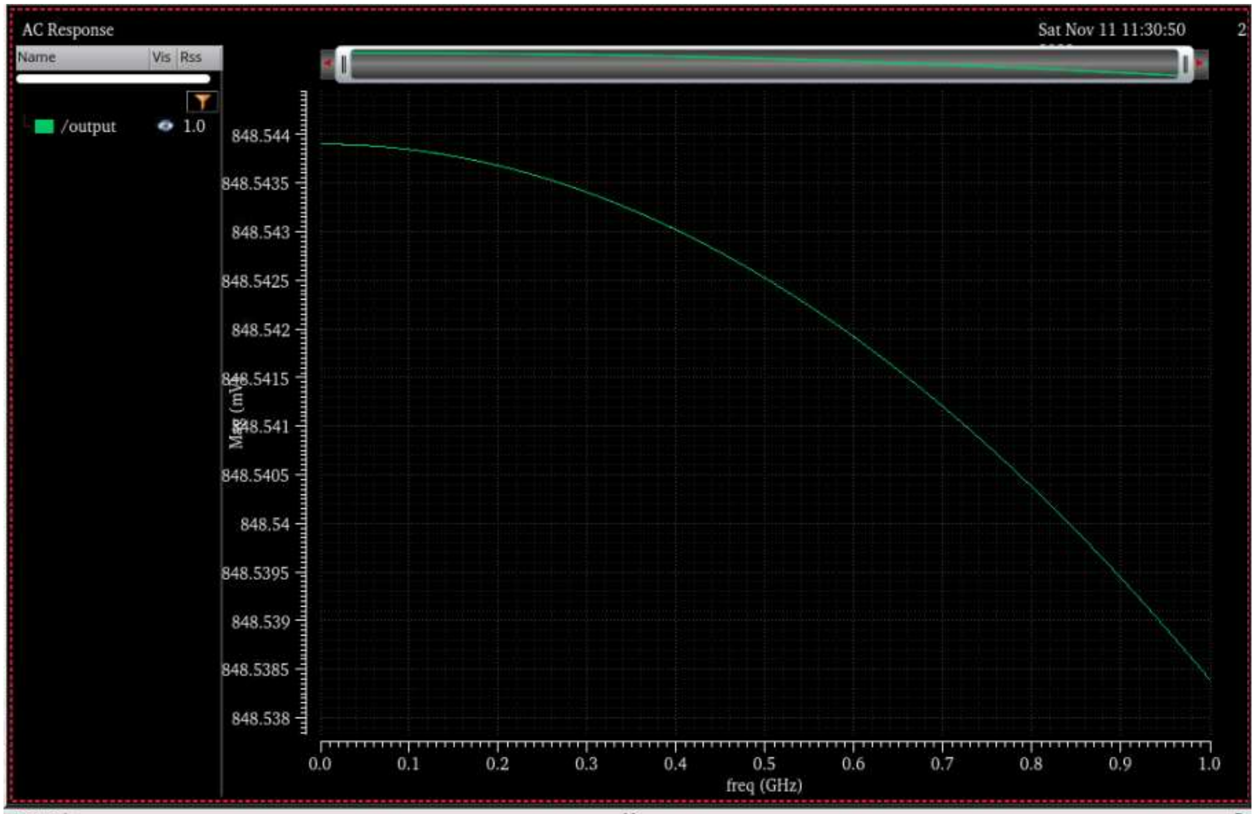
-SCHEMATIC 4:



-Final Results
Graph 7

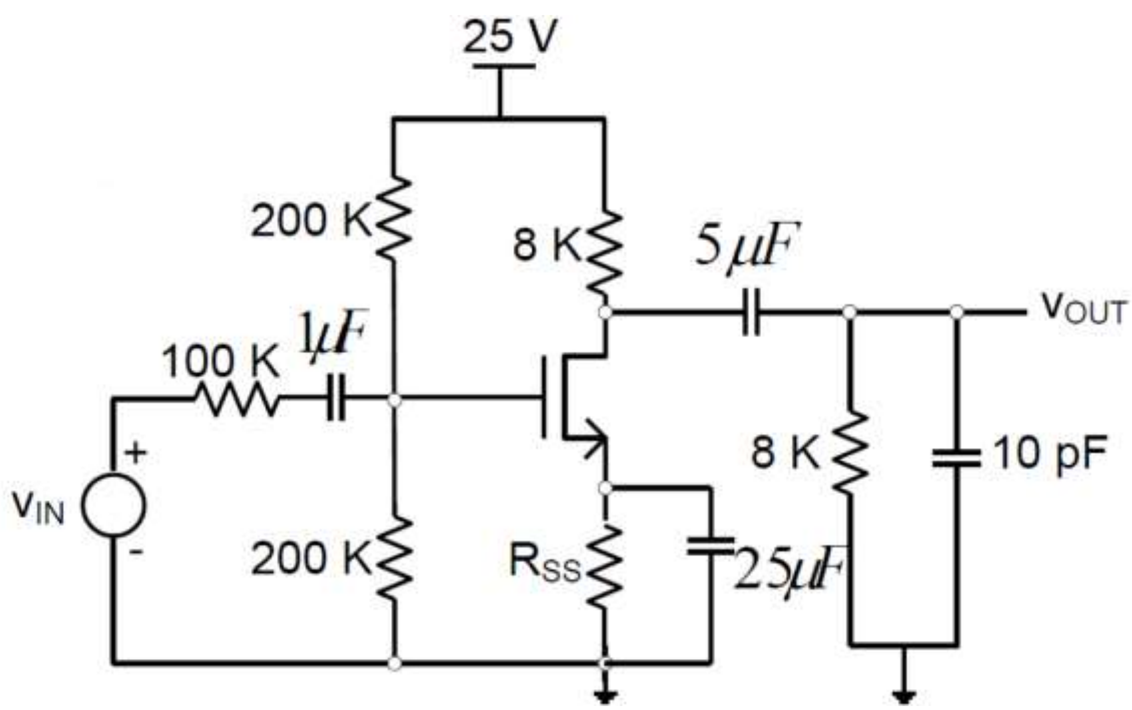


Graph 8


AC Response
Sat Nov 11 11:30:50
Name
Vis
Rss
/output
1.0
848.544
848.5435
848.543
848.5425
848.542
848.5415
848.541
848.5405
848.54
848.5395
848.539
848.5385
848.538
Mag (mV)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
freq (GHz)

Assignment 7

Using cadence simulation build the below circuit and answer the following question using the simulator.



P.S.: Create a .scs file including the following model library at the adexl to save the parameters of the Mosfet and to make it easier to analyze.

```
save*:gm sigtype=dev
save*:gds sigtype=dev
save*:id sigtype=dev
save*:vgs sigtype=dev
save*:vds sigtype=dev
save*:vth sigtype=dev
save*:vdsat sigtype=dev
save*:gmbs sigtype=dev
save*:region sigtype=dev
```

Q1) Using DC sweep find the value of RSS that will make the current ID = 2.75 mA. Report the Graph RSS vs ID

Q2) 2- After setting the Value of RSS Report the DC operating points of the MOSFET ID, Vgs, Vds, gm, region of operation and vth

Q3) Find the input resistance and output resistance of the amplifier mid-band.

Bonus 7

Q4) If it's desired to attach 100 Ω resistance instead of 8K load resistance and maintain the same gain of the amplifier at the same value, then what type of the amplifier stage should be inserted between this one and the load. (Justify your answer using graph simulations)