WEEK 1

INTERNSHIP UNDER DR GS JAVED SIR

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YEAR – SECOND

WEEK 1 INTERNSHIP PLAN

- To be able to perform .dc /.op / .tran Simulations
- To design Common Source and Common Drain Amplifier (Used Gm over Id Method)

SOFTWARE USED : LT Spice , MS Excel

BASIC CIRCUIT SIMULATIONS

.DC , .OP AND .TRAN SIMULATION OF BASIC CIRCUITS USING LT SPICE

DESIGN OF COMMON SOURCE AMPLIFIER (USING GM OVER ID METHOD)

PARAMETER CHARTS

IN ORDER TO DESIGN AN AMPLIFIER USING GM OVER ID METHODOLOGY WE REQUIRE PARAMETER CHARTS :

a) Primary Charts

1) Gm/Gds vs Gm/Id
2) Id/W vs Gm/Id
3) Ft vs Gm/Id

b) Secondary Charts

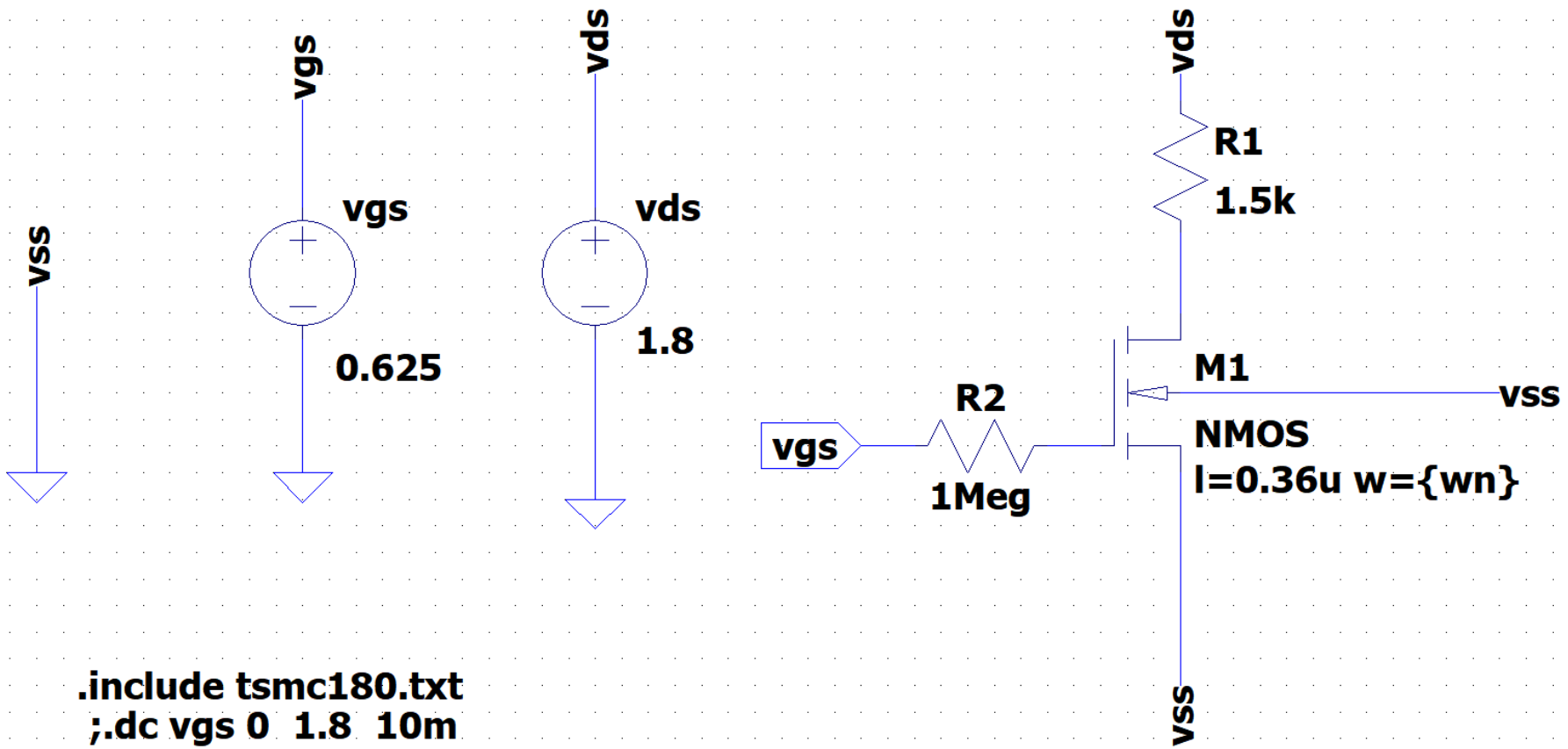
1)Cgd/Cgg vs Gm/Id
2)Cdd/Cgg vs Gm/Id

Plotting Parameter Charts

USING LT SPICE AND MS EXCEL

MODEL FILE : 180n

LT SPICE SETUP TO PLOT CHARTS FOR NMOS



.op

.include tsmc180.txt
;.dc vgs 0 1.8 10m

.step param wn 0.18u 20u 0.18u

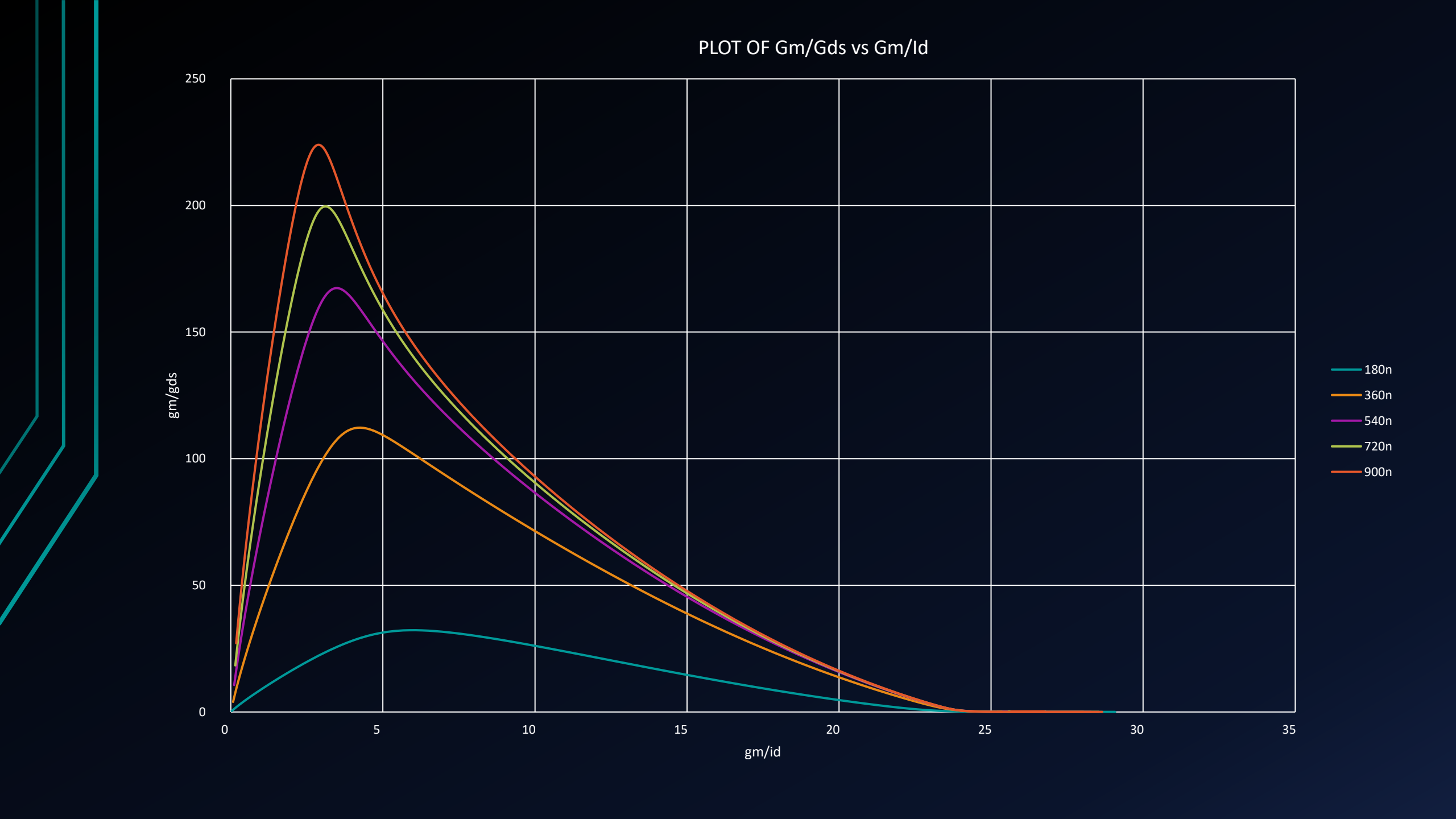
.param wn=0.18u

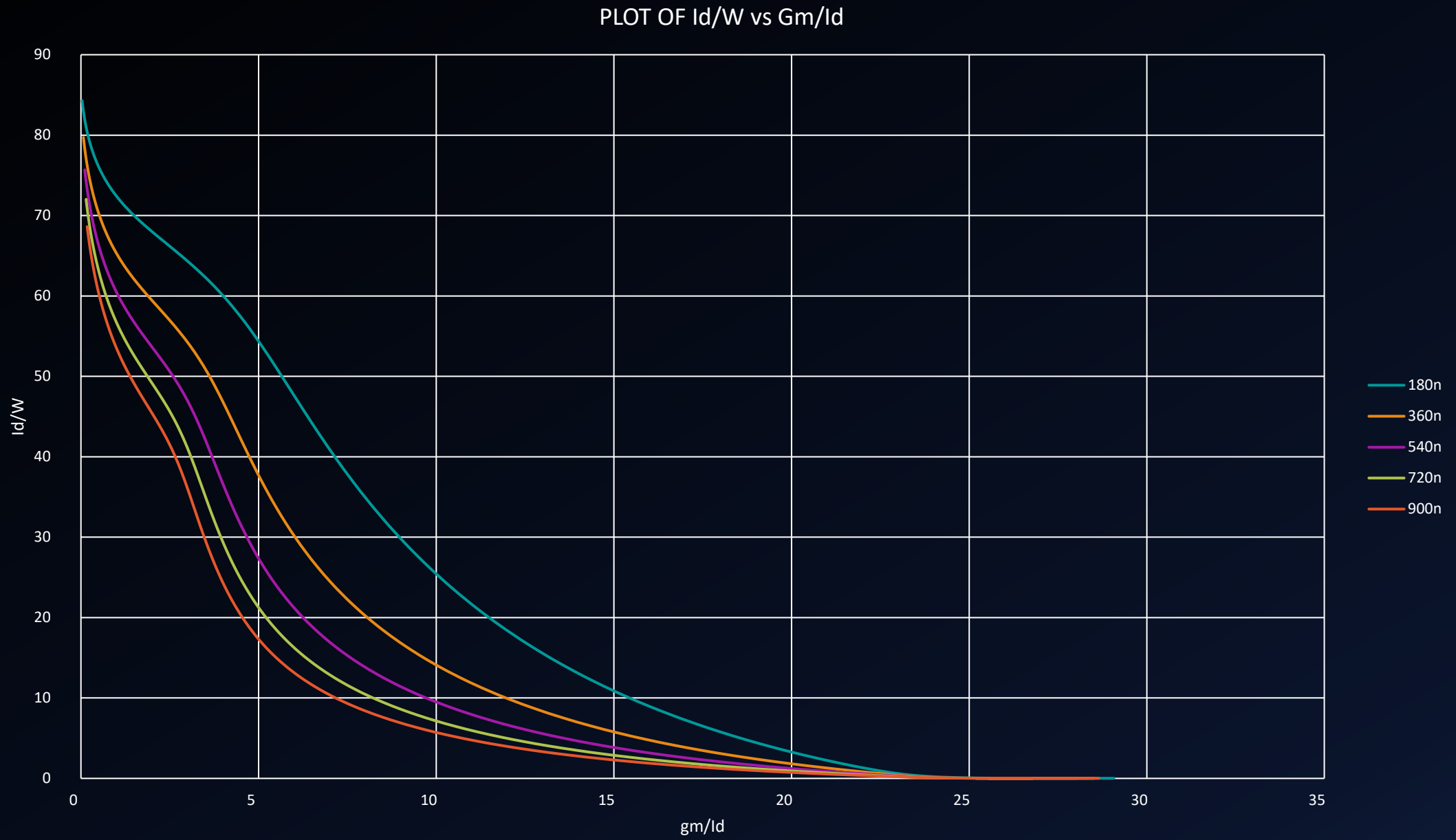
AFTER MAKING THE SETUP IN LT SPICE

Id vs Vgs is plotted by sweeping vgs from 0 to 1.8 V
Gm [d(Id(M1)] vs Vgs is plotted by sweeping vgs from 0 to 1.8 V
Id vs Vds is plotted by sweeping vds from 0 to 1.8 V
Gds [d(Id(M1)] vs Vds is plotted by sweeping vgs from 0 to 1.8 V

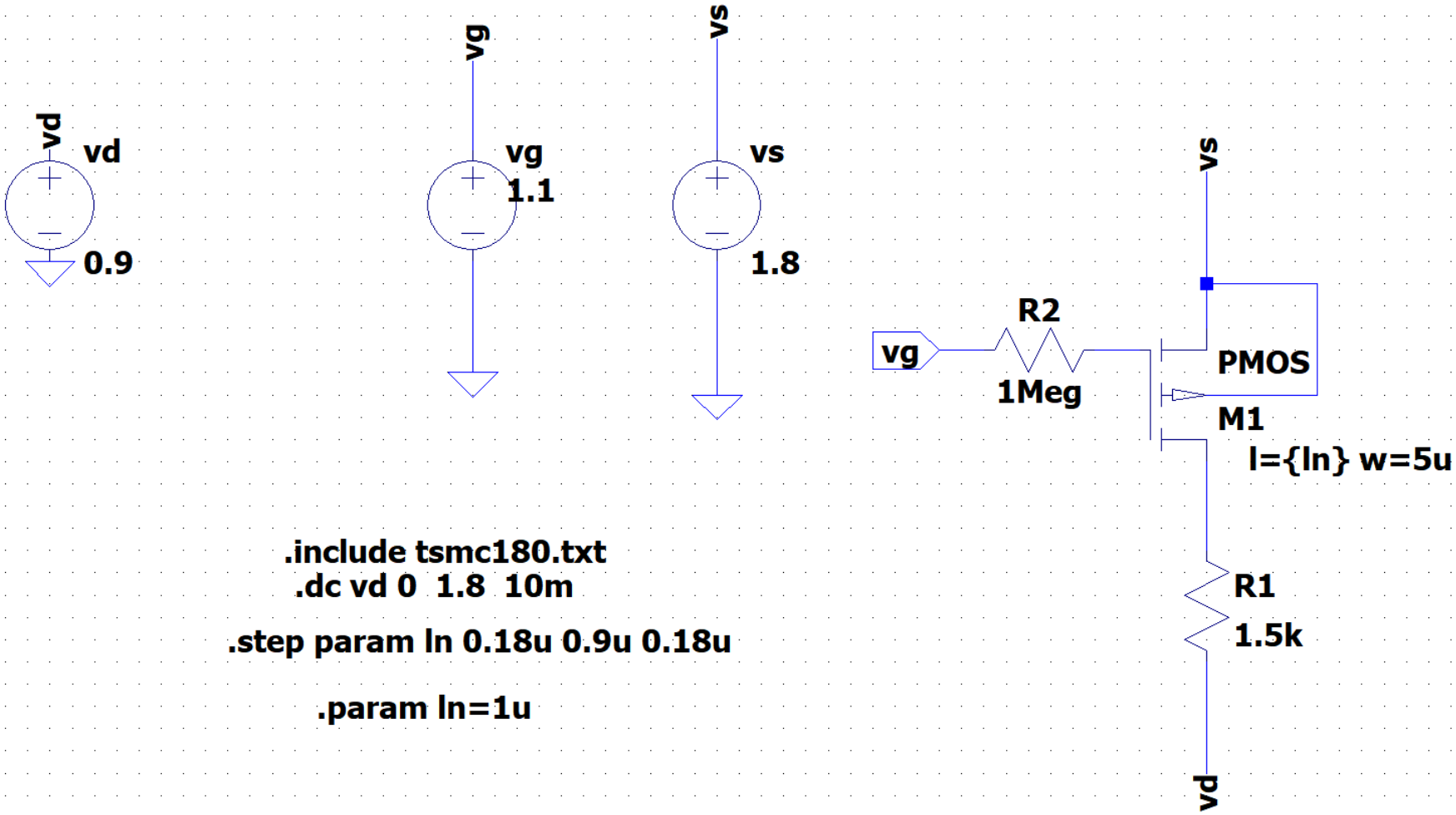
All this data is transferred in MS Excel and then
Gm/Gds vs Gm/Id is plotted
Id/W vs Gm/Id is plotted

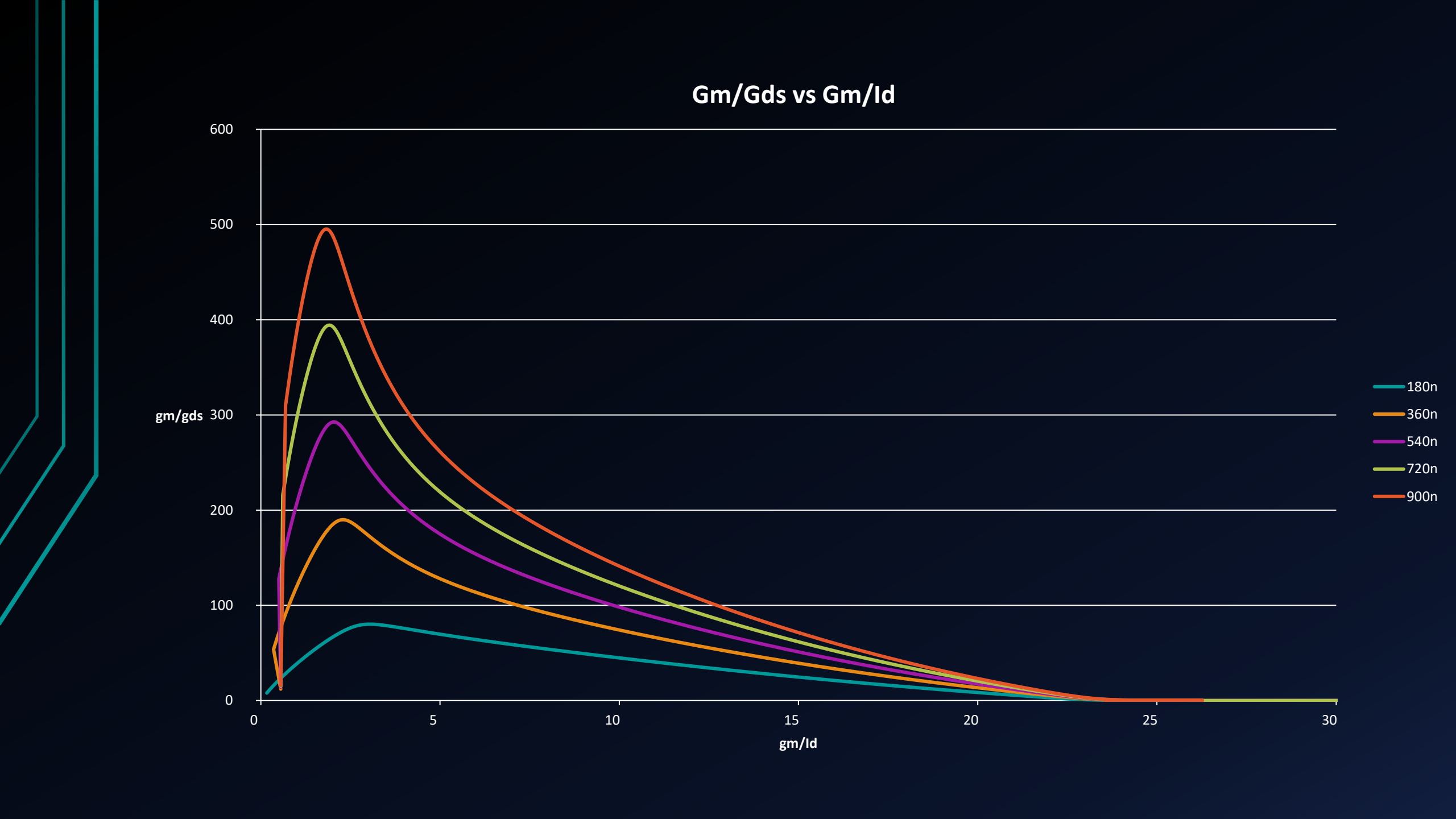
Hence , we got two of the parameter charts that are required to design Common Source Amplifier

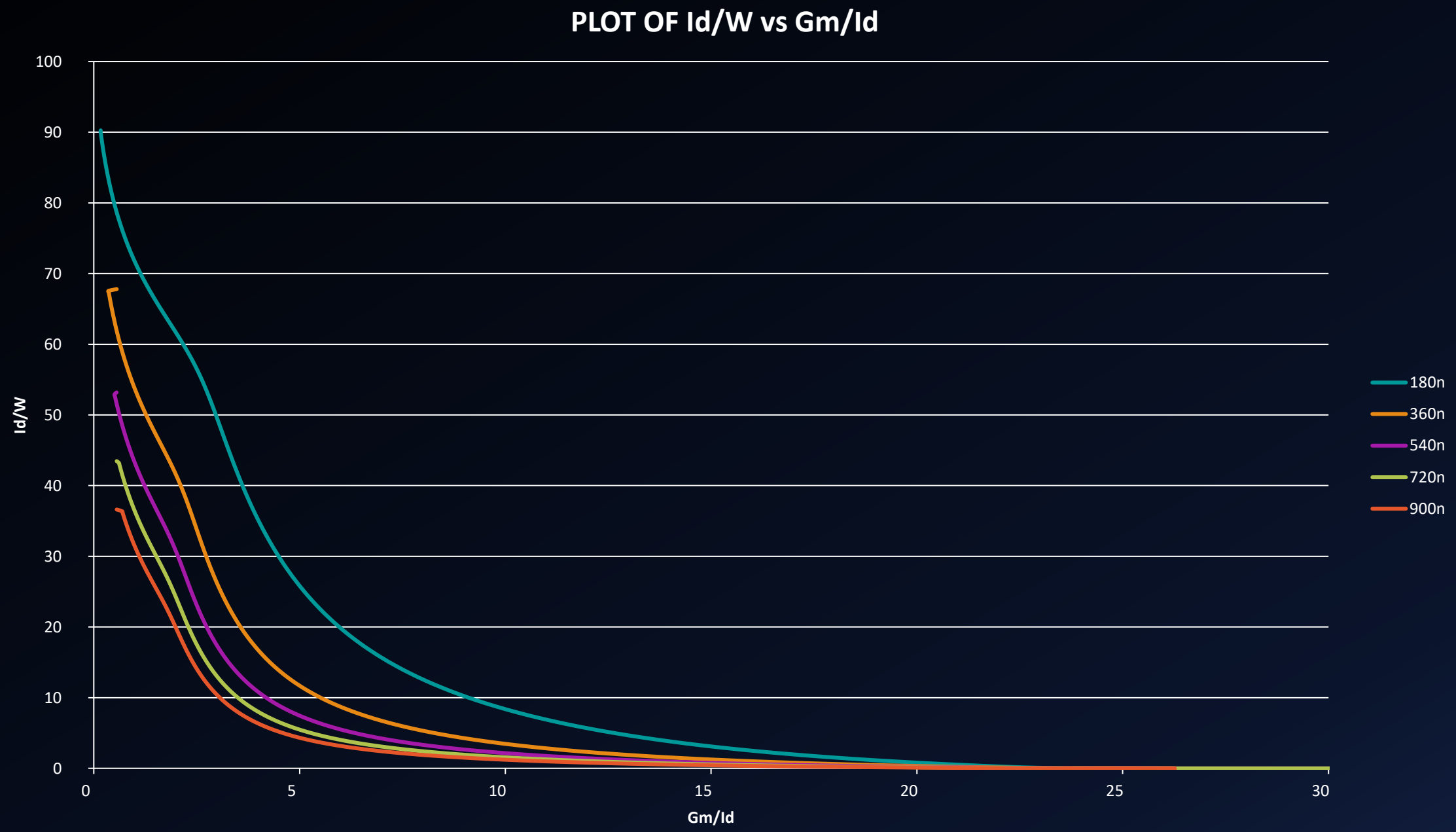

PLOT OF Gm/Gds vs Gm/Id
250
200
150
100
50
0
gm/gds
0
5
10
15
20
25
30
35
gm/id
180n
360n
540n
720n
900n


PLOT OF Id/W vs Gm/Id
Id/W
gm/Id
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35
180n
360n
540n
720n
900n

LT SPICE SETUP TO PLOT CHARTS FOR PMOS




Gm/Gds vs Gm/Id
600
500
400
300
200
100
0
gm/gds
0
5
10
15
20
25
30
gm/Id
180n
360n
540n
720n
900n


PLOT OF Id/W vs Gm/Id
Id/W
Gm/Id
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
180n
360n
540n
720n
900n

COMMON SOURCE AMPLIFIER

USING NMOS AND PASSIVE LOAD

MODEL FILE : 180n

SPECIFICATIONS

GBW=800MHz , VDD=1.8V , L=0.36u

CALCULATIONS

GBW=800MHz , L=0.36u , Vdd=1.8V, Model file = 180n

Let GAIN (A) = 10

f(-3db) = $\frac{GBW}{Gain}$ = 80MHz let C_L=5pF

USING f(-3db) = $\frac{1}{2\pi\ Rout\ C_L}$ Rout = 397.88 ohm

Now , Gain (A) = Gm Rout Gm=25.1 mS

Now , Let Gm/Id = 10.2 Id = 2.46 mA

(From NMOS Parameter Charts)

Gm/Gds = 69.9 Gds=359 uS

AS Ro=1/Gds , Ro=2785 ohm

(From NMOS Parameter Charts)

Id/W= 13.6 W=180u

CALCULATIONS

Now Rout = Ro || R_L

$$R_L = \frac{Ro * Rout}{(Ro - Rout)}$$

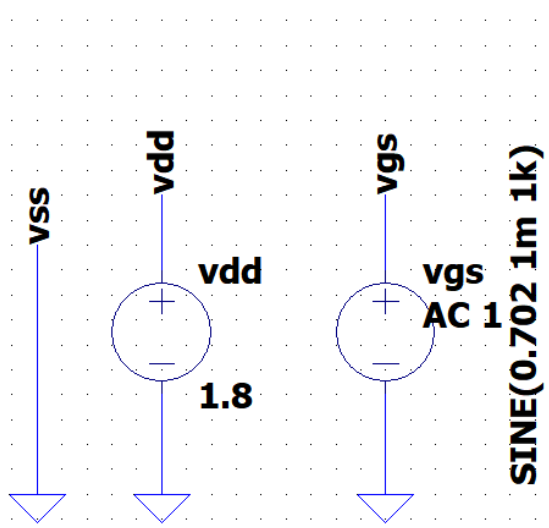
R_L = 464.197 ohms

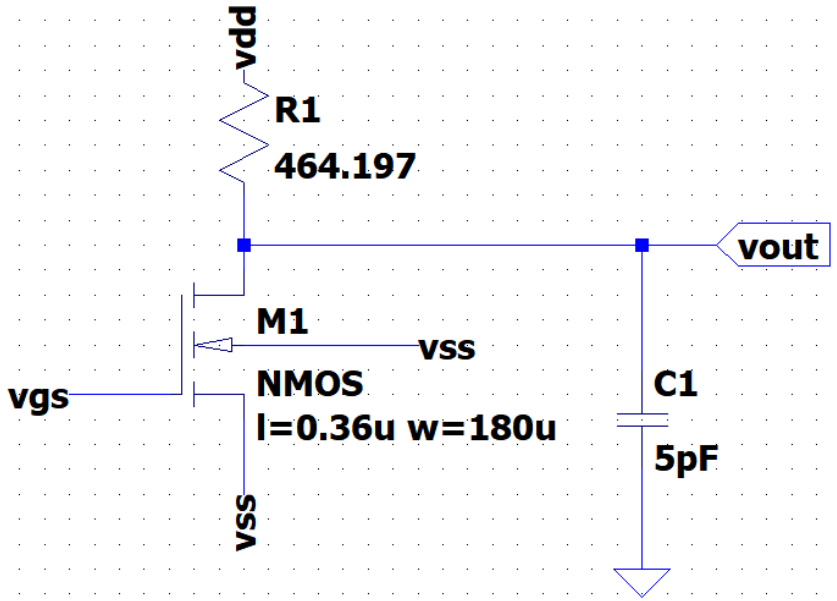
Now, Vgs is calculated from Gm/Id vs Vgs Curve in LT Spice
For , Gm/Id = 10.2
Vgs = 702mV = 0.702V

SCHEMATIC IN LT SPICE

COMMON SOURCE AMPLIFIER DESIGNED USING GM OVER ID METHOD USING NMOS AND RESISTOR for GBW = 800MHz

(SPECIFICATIONS)
GAIN = 10
FREQUENCY (-3DB)=80MHz
load capacitance=5pF
vdd=1.8V





.include tsmc180.txt

.op

;.ac dec 100 1M 100G

;.tf V(vout) vgs

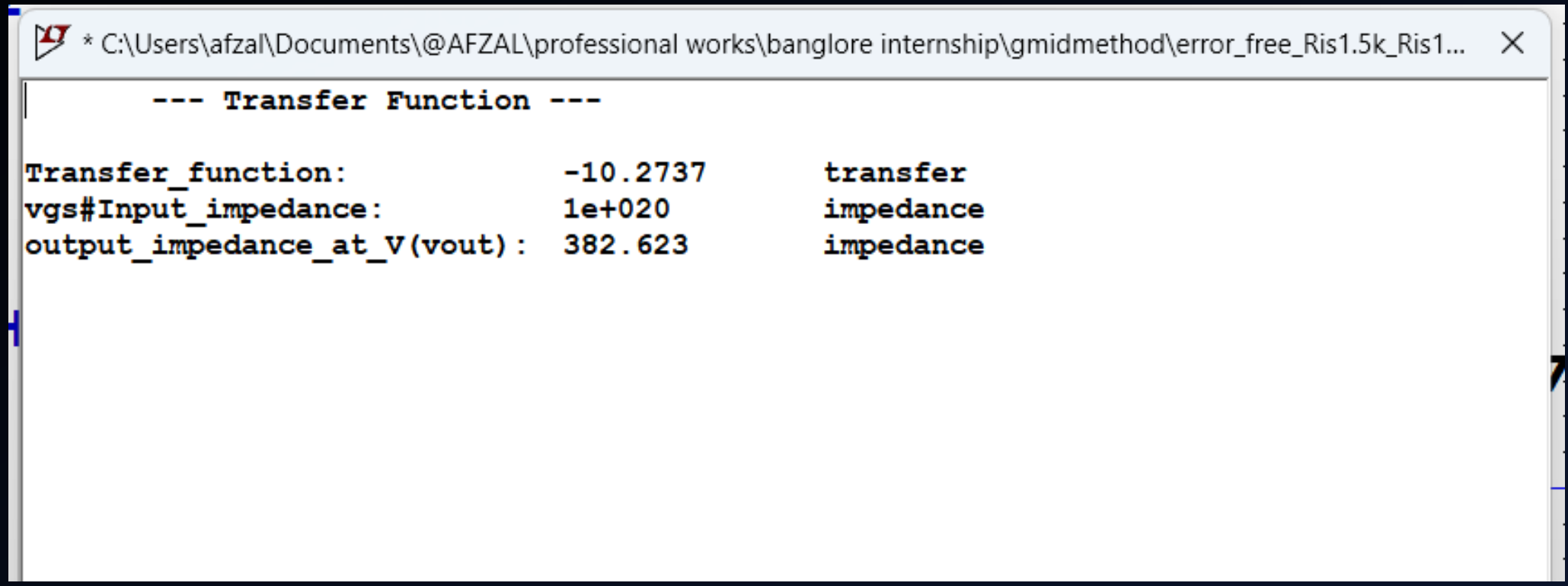
;.tran 5m

;.dc vgs 0 1 1m

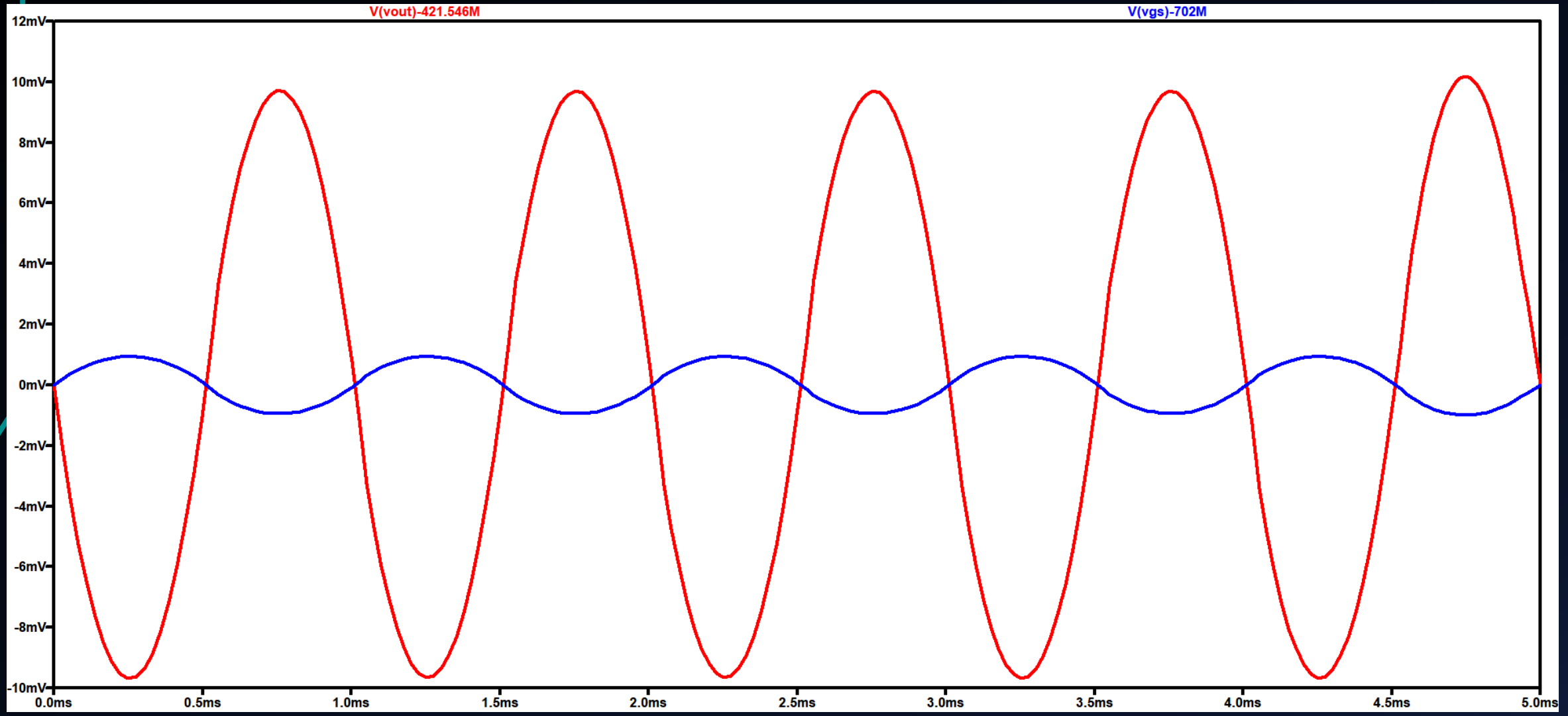
.OP ANALYSIS IN LT SPICE

* C:\Users\afzal\Documents\@AFZAL\professional works\banglore internship\gmidm

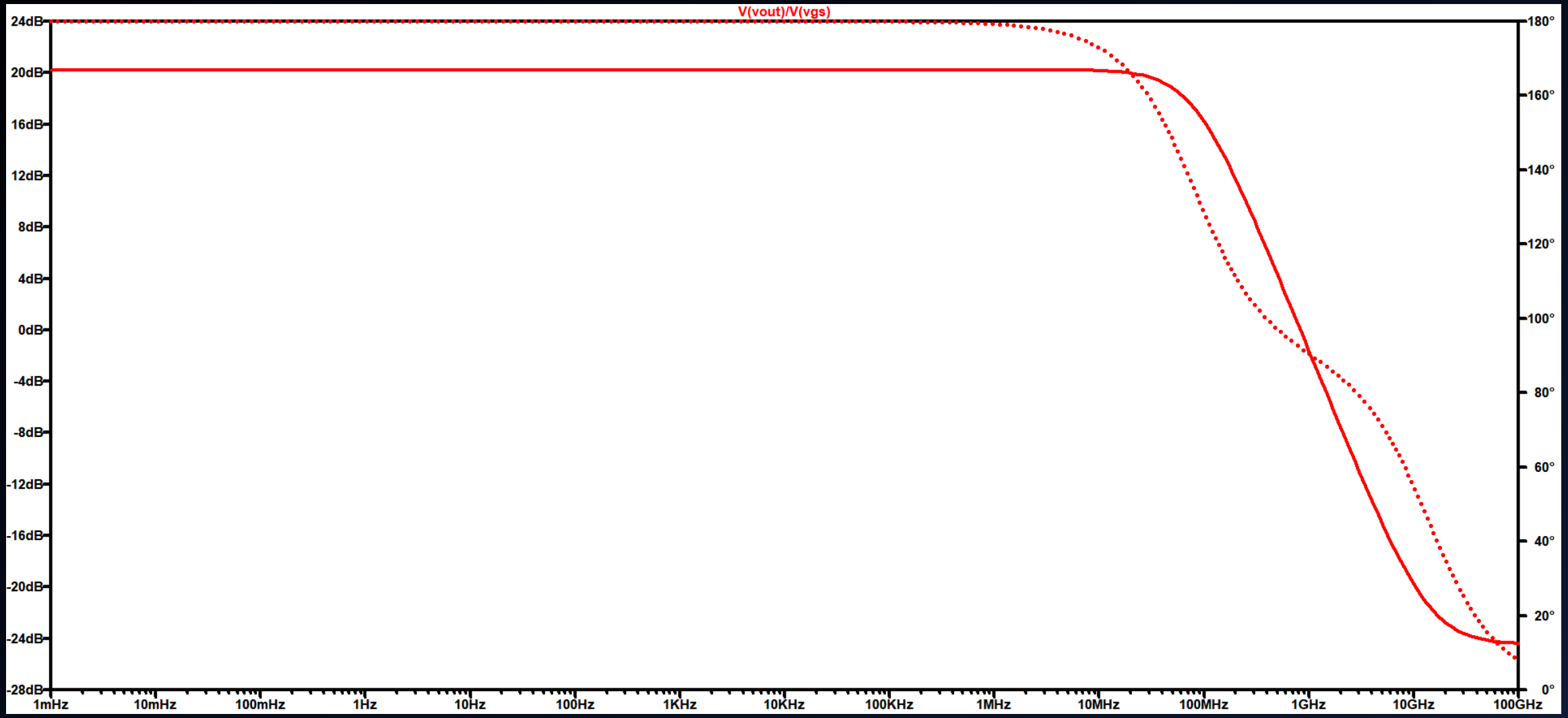
```
    --- Operating Point ---

V(vout):        0.421546        voltage
V(vgs):         0.702           voltage
V(vdd):         1.8             voltage
Id(M1):         0.00296954      device_current
Ig(M1):         0               device_current
Ib(M1):         -4.31546e-013   device_current
Is(M1):         -0.00296954     device_current
I(C1):          2.10773e-024    device_current
I(R1):          0.00296954      device_current
I(Vgs):         0               device_current
I(Vdd):         -0.00296954     device_current
```


* C:\Users\afzal\Documents\@AFZAL\professional works\banglore internship\gmidmethod\error_free_Ris1.5k_Ris1...
--- Transfer Function ---
Transfer_function: -10.2737 transfer
vgs#Input_impedance: 1e+020 impedance
output_impedance_at_V(vout): 382.623 impedance

TRANSIENT ANALYSIS IN LT SPICE



FREQUENCY RESPONSE IN LT SPICE



SIMULATIONS RESULT

Name:	m1
Model:	nmos
Id:	2.97e-03
Vgs:	7.02e-01
Vds:	4.22e-01
Vbs:	0.00e+00
Vth:	4.64e-01
Vdsat:	1.81e-01
Gm:	2.69e-02
Gds:	4.59e-04
Gmb	7.02e-03
Cbd:	0.00e+00
Cbs:	0.00e+00
Cgsov:	1.39e-13

GBW=837MHz

Gain= 10.2737

COMMON SOURCE AMPLIFIER

USING PMOS AND PASSIVE LOAD

MODEL FILE : 180n

SPECIFICATIONS

GBW=800MHz , VDD=1.8V , L=0.36u

CALCULATIONS

GBW=800MHz , L=0.36u , Vs=1.8V, Model file = 180n

Let GAIN (A) = 10

f(-3db) = $\frac{G_{BW}}{Gain}$ = 80MHz let C_L=5pF

USING f(-3db) = $\frac{1}{2\pi\ Rout\ C_L}$ Rout = 397.88 ohm

Now , GAIN (A) = Gm Rout Gm=25.1 mS

Now , Let Gm/Id = 10.2 Id = 2.46 mA

(From NMOS Parameter Charts)

Gm/Gds = 72.2 Gds=347.64 uS

AS Ro=1/Gds , Ro=2876.5 ohm

(From NMOS Parameter Charts)

Id/W= 3.3 W=745u

CALCULATIONS

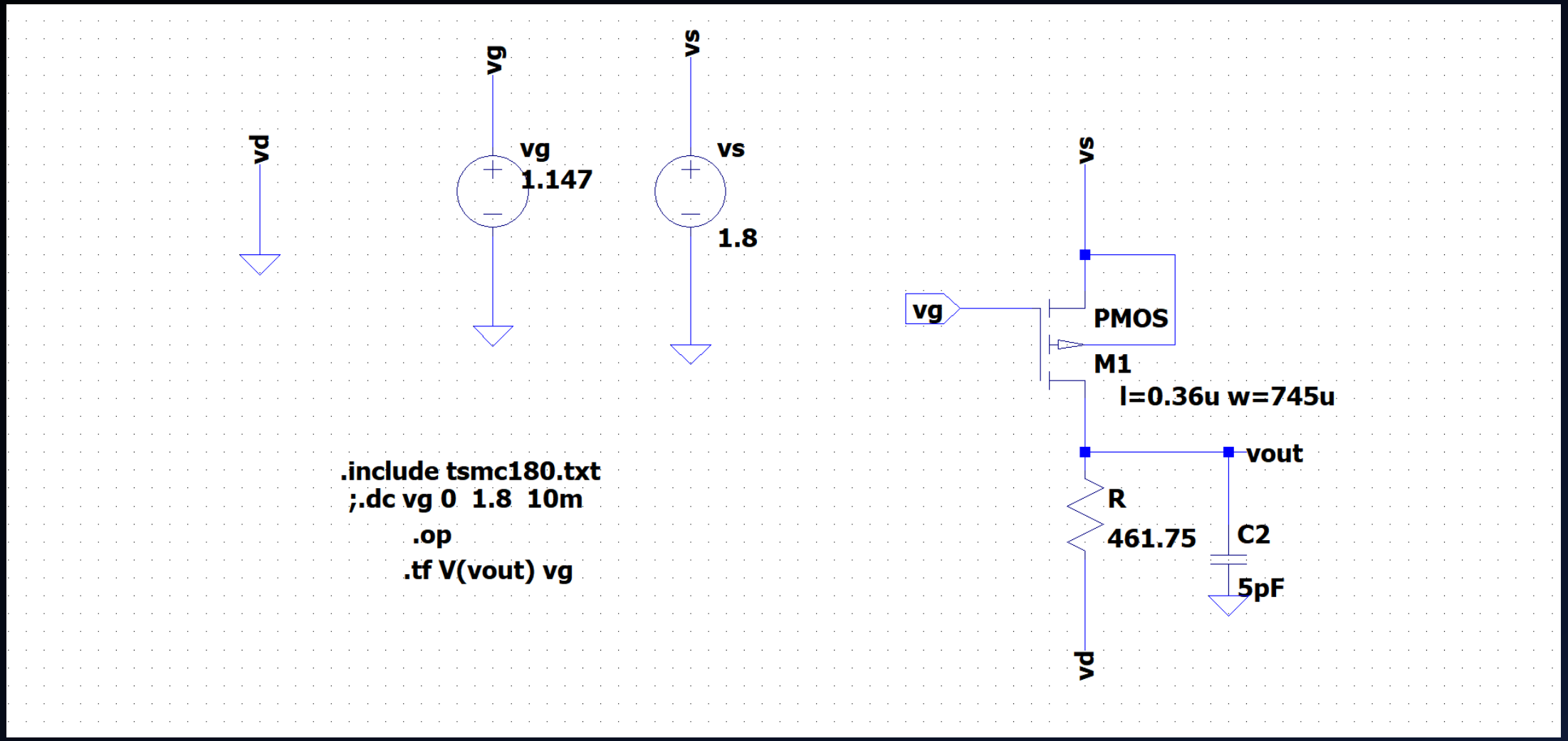
Now Rout = Ro || R_L

$$R_L = \frac{Ro * Rout}{(Ro - Rout)}$$

R_L = 461.75 ohms

Now, Vgs is calculated from Gm/Id vs Vgs Curve in LT Spice
For , Gm/Id = 10.2
Vg = 1.1V

SCHEMATIC IN LT SPICE



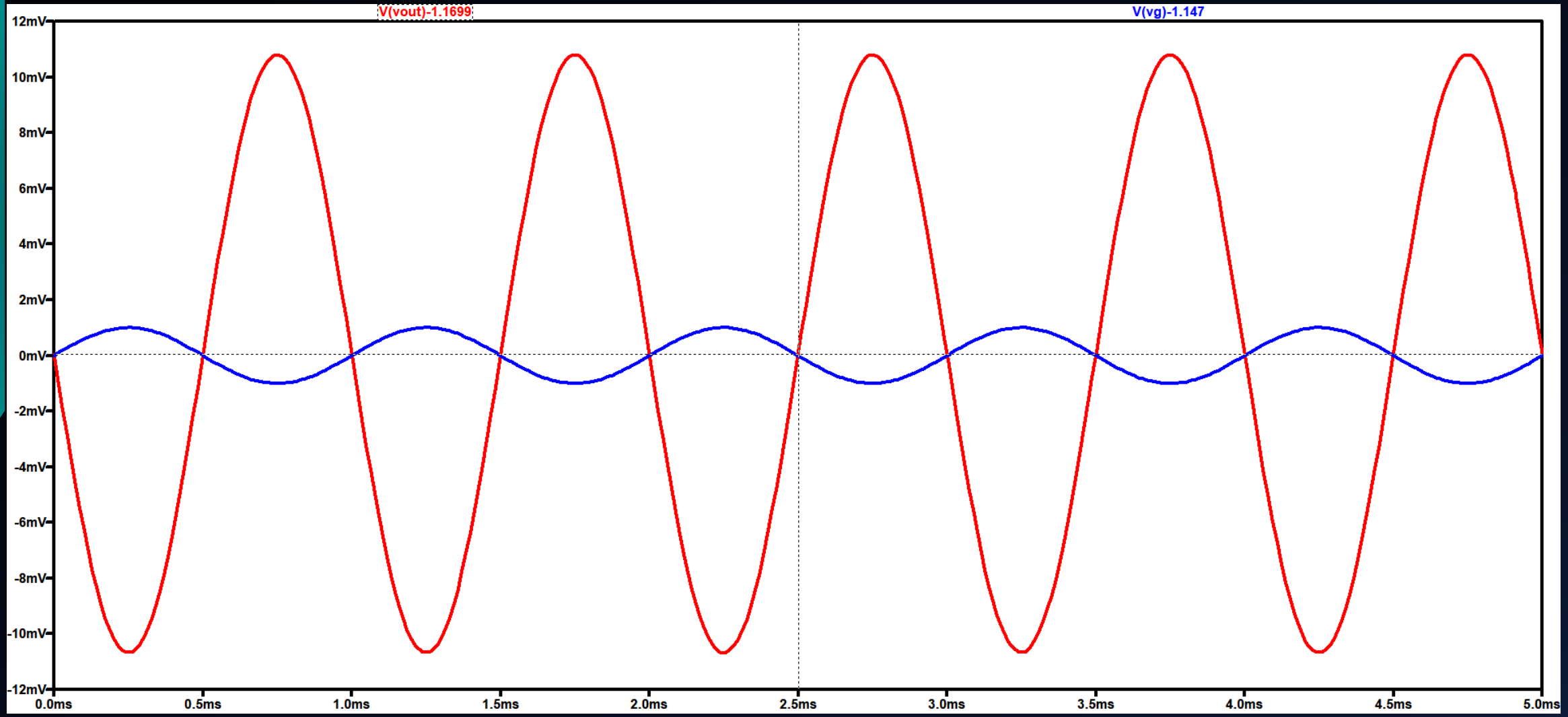
* C:\Users\afzal\Documents\@AFZAL\professional works\banglore internship\gmidmeth

```
        --- Operating Point ---

V(vg):          1.147           voltage
V(vs):          1.8             voltage
V(vout):        1.16995         voltage
Id(M1):         -0.00253372     device_current
Ig(M1):         -0              device_current
Ib(M1):         6.40054e-013    device_current
Is(M1):         0.00253372      device_current
I(C2):          5.84973e-024    device_current
I(R):           0.00253372      device_current
I(Vs):          -0.00253372     device_current
I(Vg):          0               device_current
```

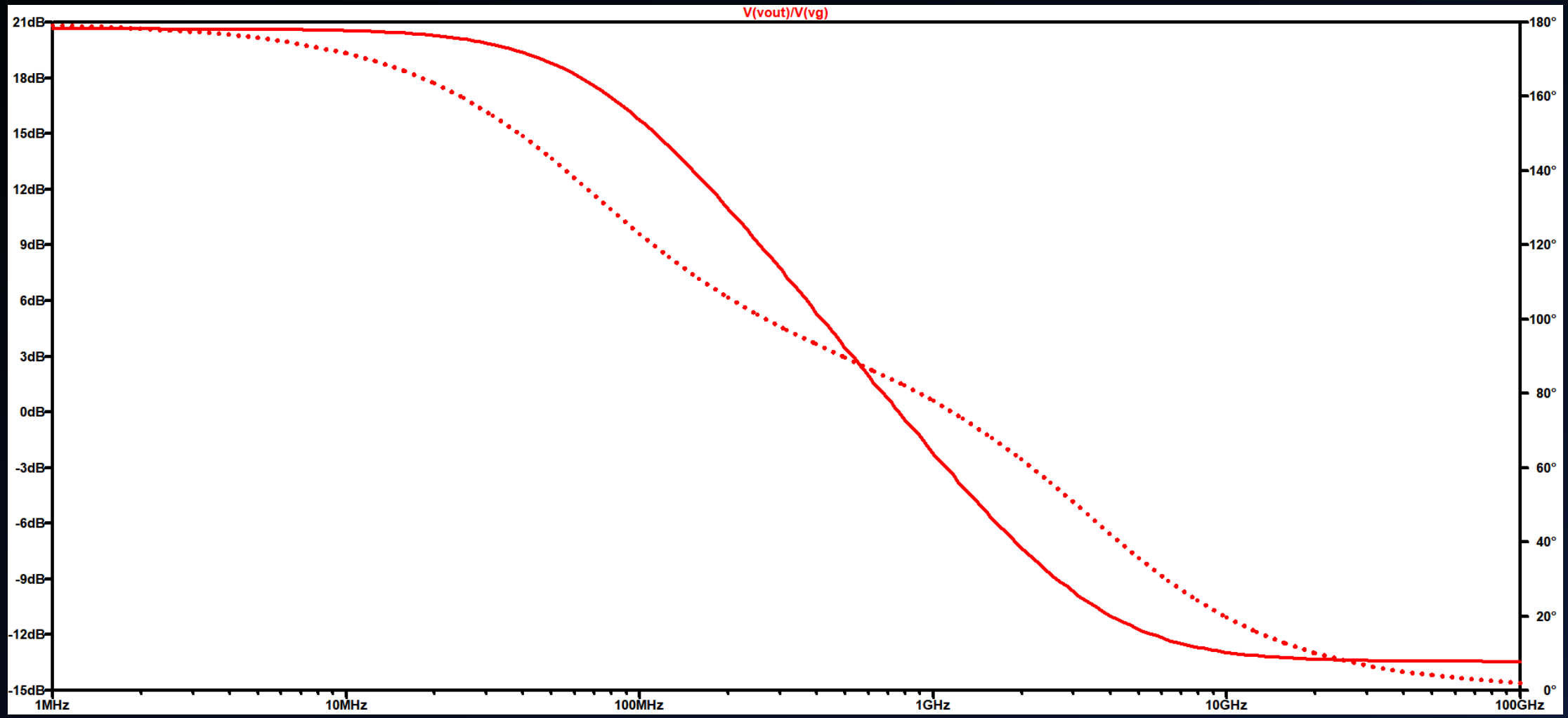
* C:\Users\afzal\Documents\@AFZAL\professional works\banglore internship\gmidmethod\error_free_Ris1.

```
        --- Transfer Function ---

Transfer_function:           -10.7566       transfer
vg#Input_impedance:          1e+020         impedance
output_impedance_at_V(vout): 416.704        impedance
```

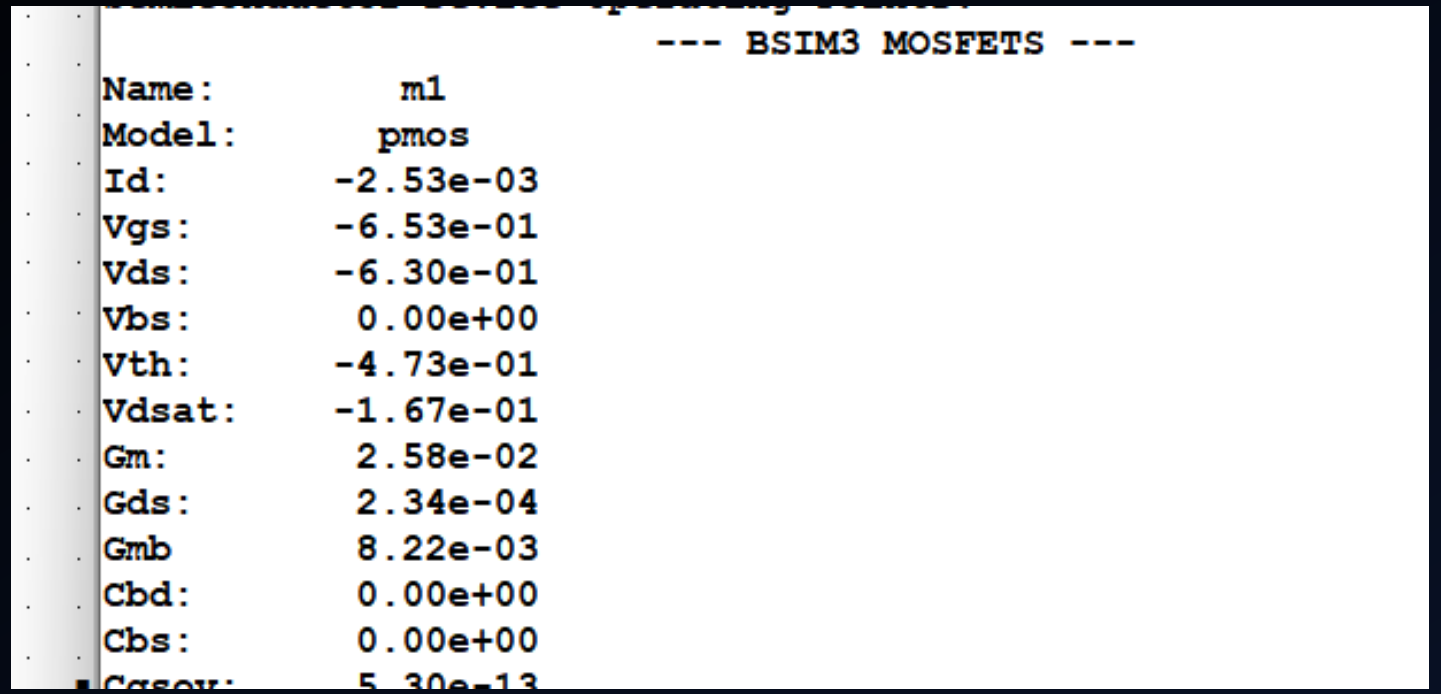
TRANSIENT ANALYSIS IN LT SPICE



FREQUENCY RESPONSE IN LT SPICE



SIMULATIONS RESULT



```
                    --- BSIM3 MOSFETS ---

Name:          m1
Model:       pmos
Id:       -2.53e-03
Vgs:      -6.53e-01
Vds:      -6.30e-01
Vbs:       0.00e+00
Vth:      -4.73e-01
Vdsat:    -1.67e-01
Gm:        2.58e-02
Gds:       2.34e-04
Gmb        8.22e-03
Cbd:       0.00e+00
Cbs:       0.00e+00
Cgsov:     5.30e-13
```

GBW=763MHz

Gain= 10.756

COMMON DRAIN AMPLIFIER (SOURCE FOLLOWER)

USING NMOS AND RESITANCE

MODEL FILE : 180n

SPECIFICATIONS

VDD=1.8V , L=0.36u , GAIN(A)=0.95
Rout=50 ohm, C_L = 5pf

CALCULATIONS

VDD=1.8V , L=0.36u , GAIN(A)=0.95
Rout=50 ohm, C_L = 5pf

Using $B.W = \frac{1}{2\pi\, Rout\, C_L}$ BW= 636.61MHz

Now , $Gain\ (A) = \frac{(Rs||Ro)}{(Rs||Ro)+1/Gm}$ and $Rout = 1/Gm||Ro||Rs$

On solving both the equation , we get
Gm=19mS $(Rs||Ro)$=1000 ohm

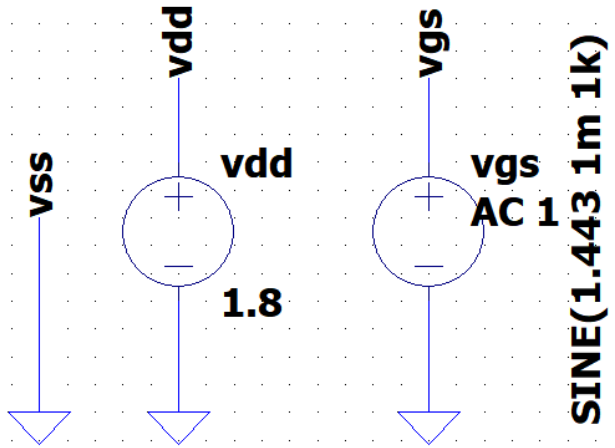
Now , let Gm/Id = 15.1 Id=1.26mA
Gm/Gds = 38.2 Gds=497uS Ro=2.012 K ohm
And hence , Rs=1.988 K ohm (by further inspection taken as 720 ohm)
Vgs = 0.543V Vg = vgs + vs =1.443 V
Id/W=5.65 W=223u

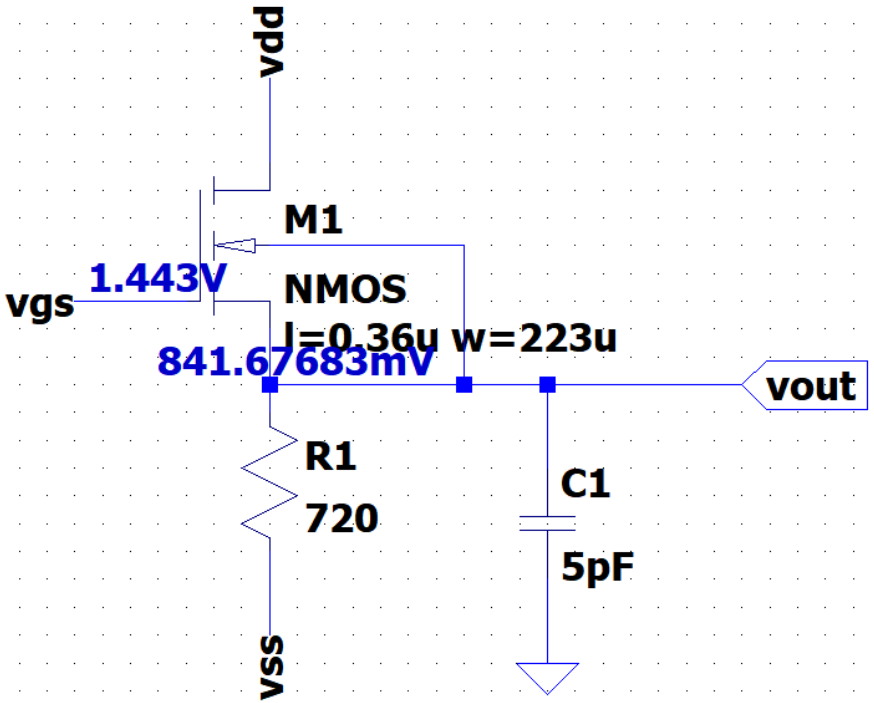
SCHEMATIC IN LT SPICE

COMMON DRAIN AMPLIFIER DESIGNED USING GM OVER ID METHOD USING NMOS AND RESISTOR

(SPECIFICATIONS)
GAIN = 0.95
Output Impedance = 50 ohm
load capacitance=5pF
vdd=1.8V

```
.include tsmc180.txt
.op
.tf V(vout) vgs
;tran 5m
;.dc vgs 0 1 1m
;ac dec 100 1meg 100G
```



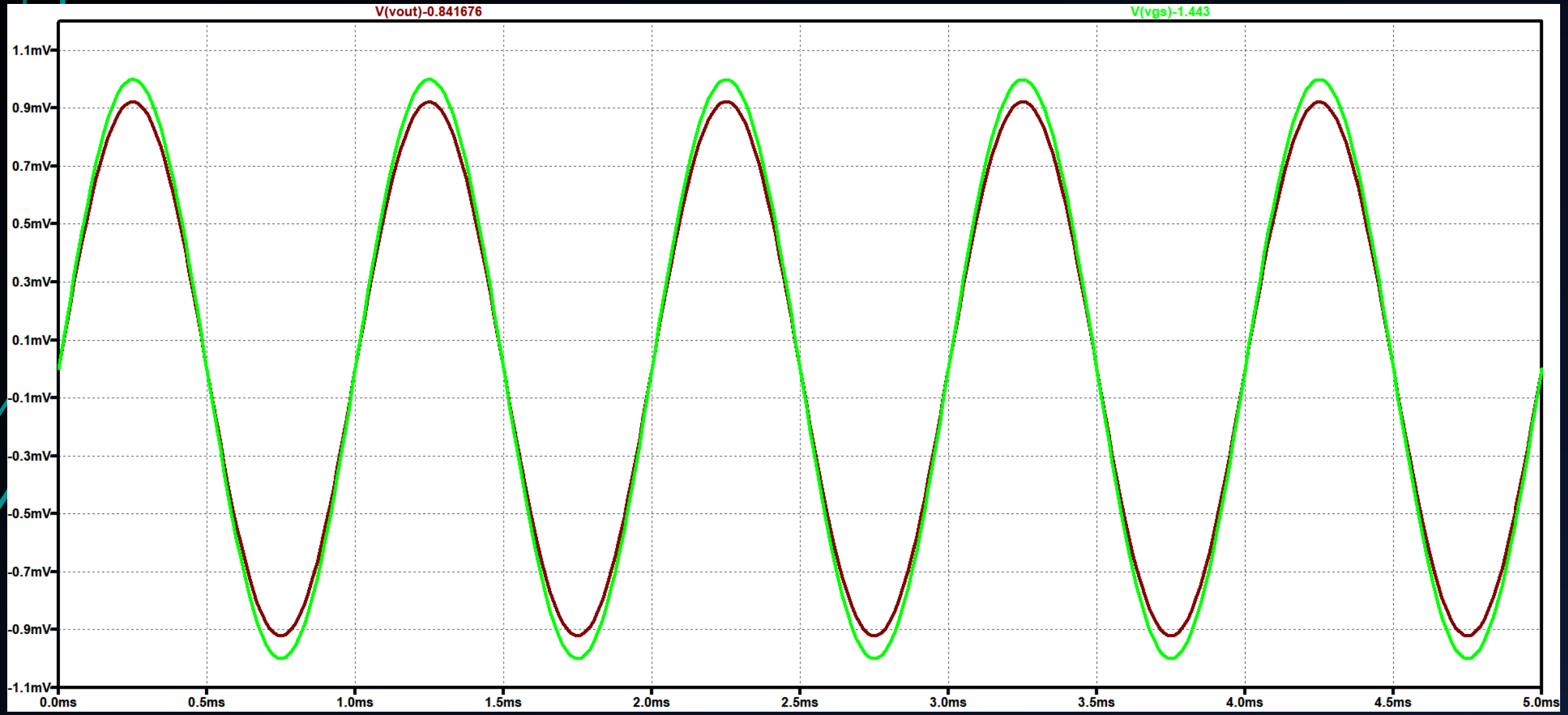


```
        --- Operating Point ---

V(vdd):         1.8             voltage
V(vgs):         1.443           voltage
V(vout):        0.841677        voltage
Id(M1):         0.001169        device_current
Ig(M1):         0               device_current
Ib(M1):         -9.68323e-013   device_current
Is(M1):         -0.001169       device_current
I(C1):          4.20838e-024    device_current
I(R1):          0.001169        device_current
I(Vgs):         0               device_current
I(Vdd):         -0.001169       device_current
```

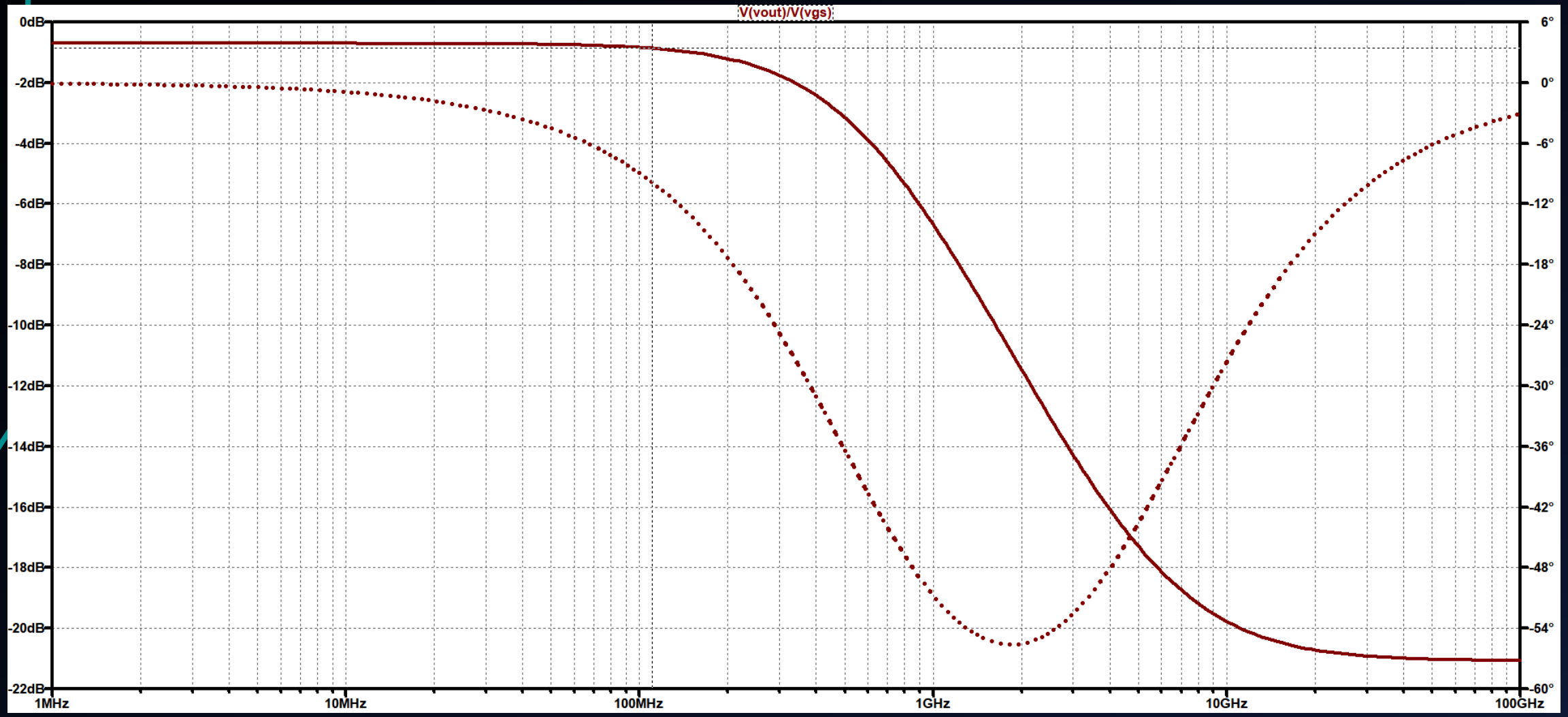
```
Semiconductor Device Operating Points:
                                --- BSIM3 MOSFETS ---
Name:          m1
Model:        nmos
Id:         1.17e-03
Vgs:        6.01e-01
Vds:        9.58e-01
Vbs:        0.00e+00
Vth:        4.63e-01
Vdsat:      1.08e-01
Gm:         1.82e-02
Gds:        1.52e-04
Gmb         4.78e-03
Cbd:        0.00e+00
Cbs:        0.00e+00
Cgsov:      1.72e-13
```

```
        --- Transfer Function ---

Transfer_function:              0.921846        transfer
vgs#Input_impedance:            1e+020          impedance
output_impedance_at_V(vout):    50.716          impedance
```

TRANSIENT ANALYSIS IN LT SPICE



FREQUENCY RESPONSE IN LT SPICE



Feedback I got

Specifications are not exactly matching with simulations , W/L ratio is very high , so now I have to redesign them by making slight modification in design approach

THANK YOU