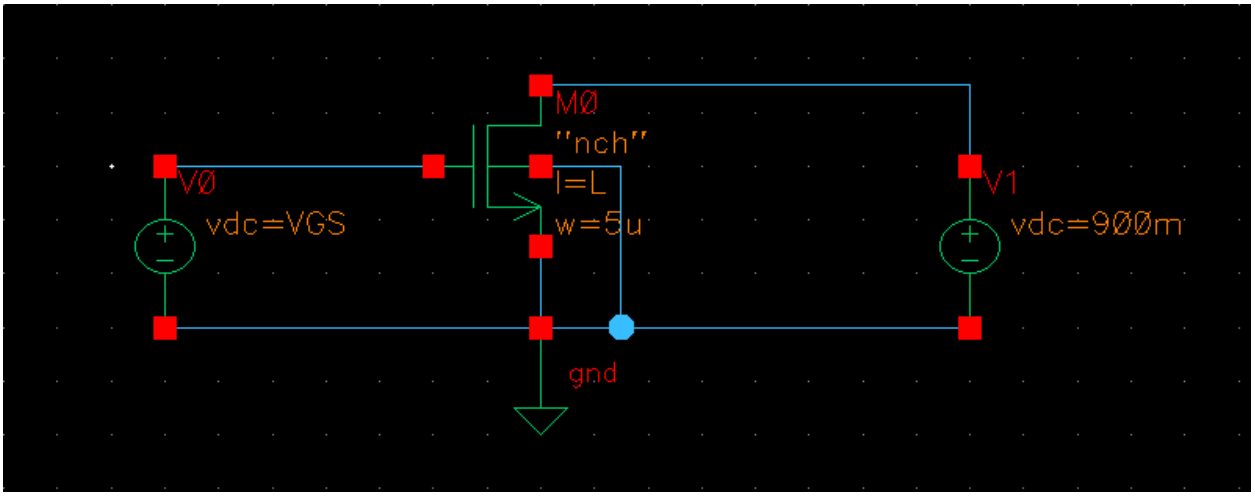


Figure 1: NMOS schematic

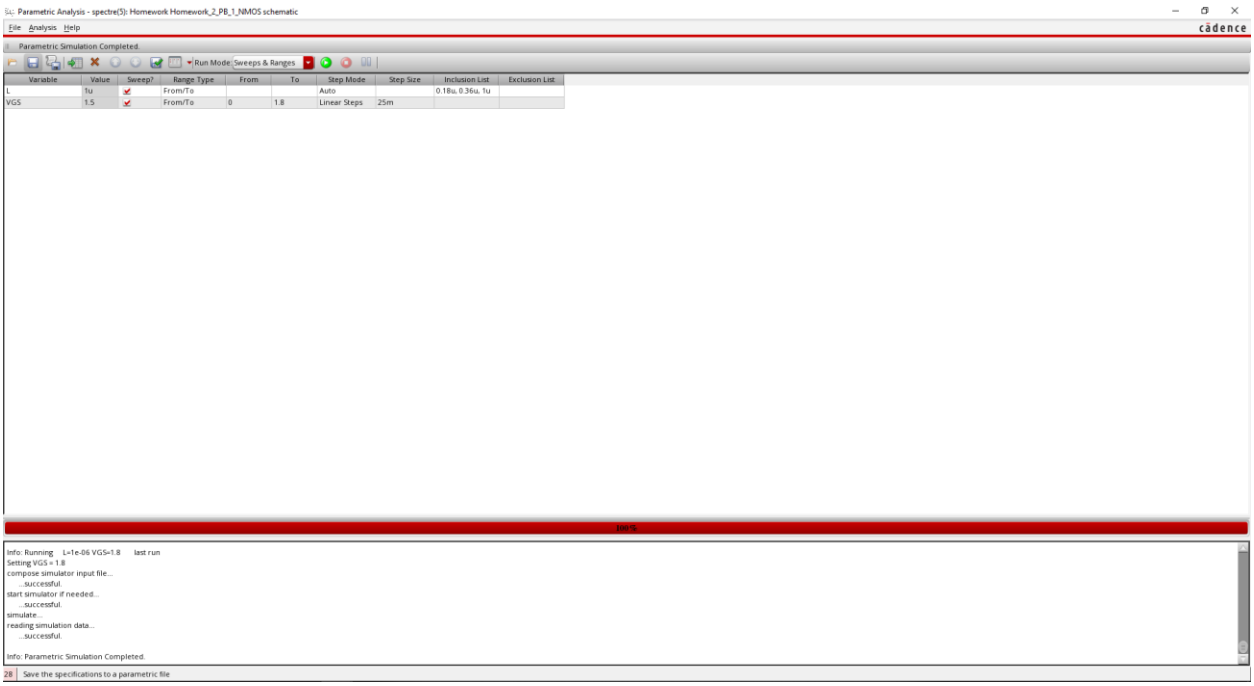


Figure 2: NMOS simulation window

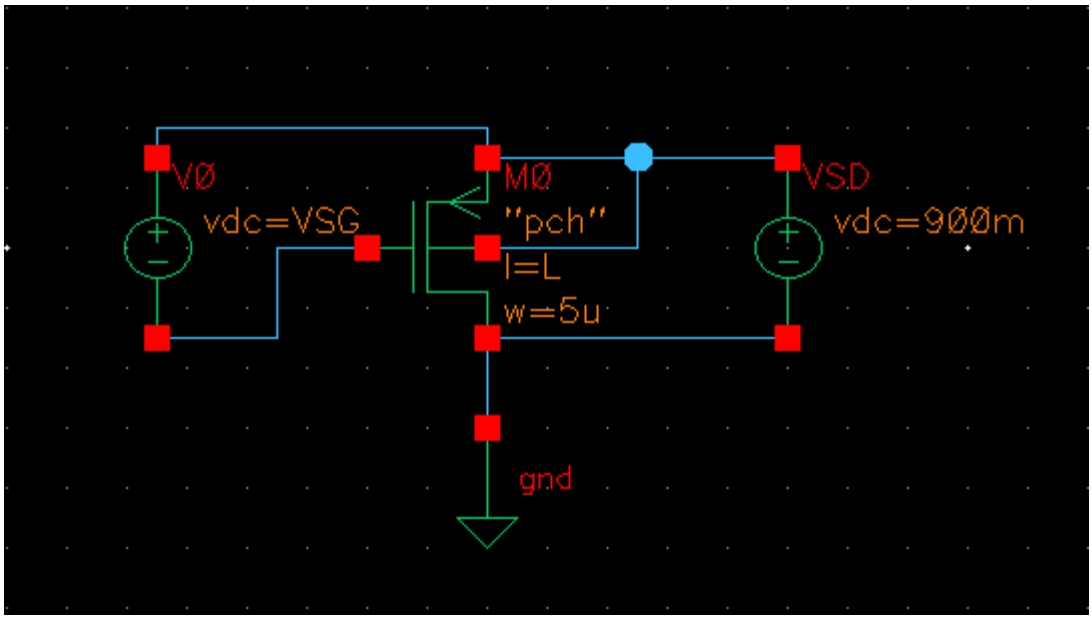


Figure 3: PMOS schematic

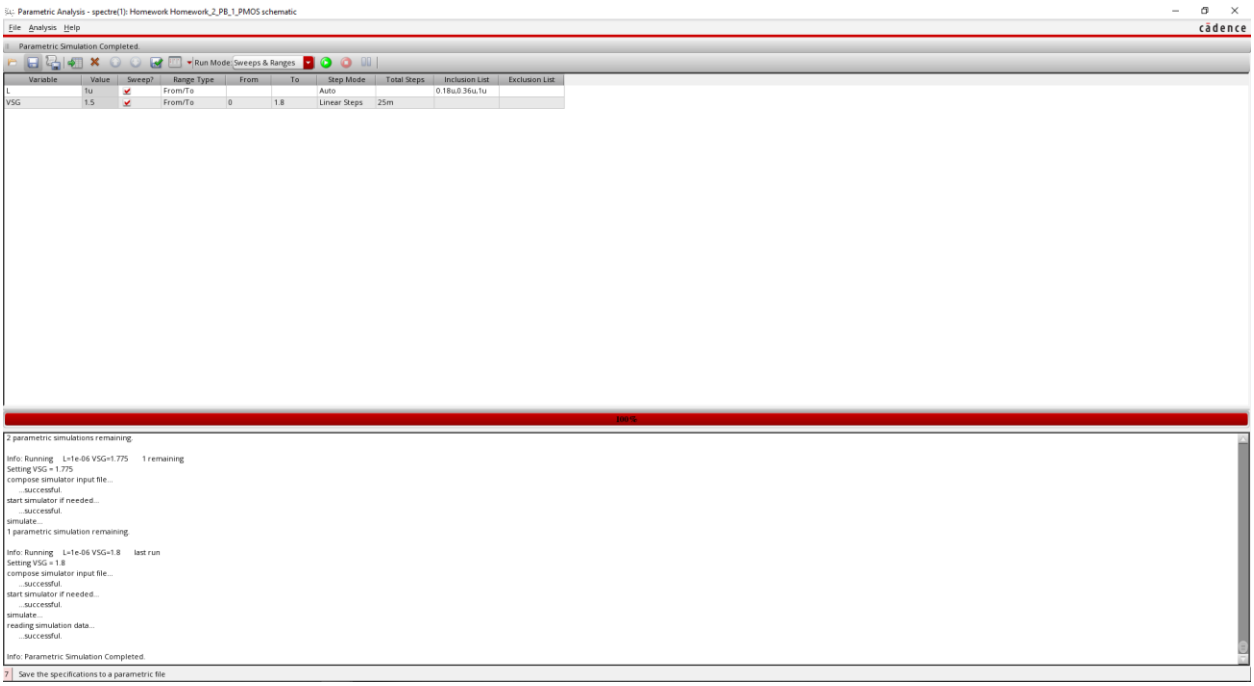
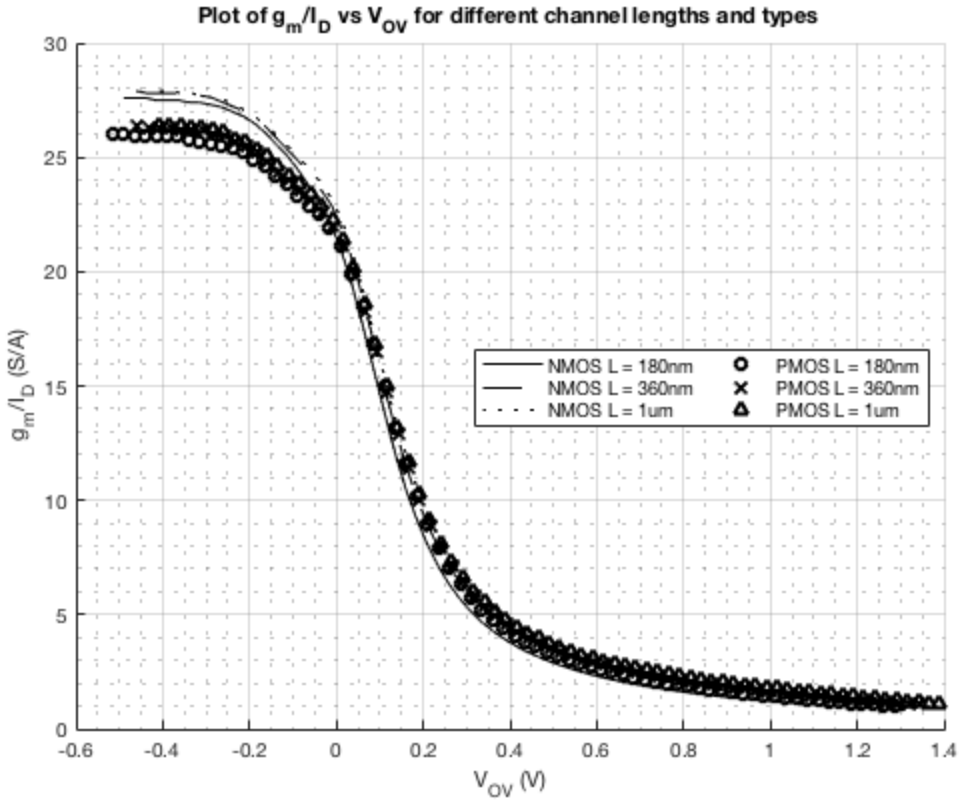


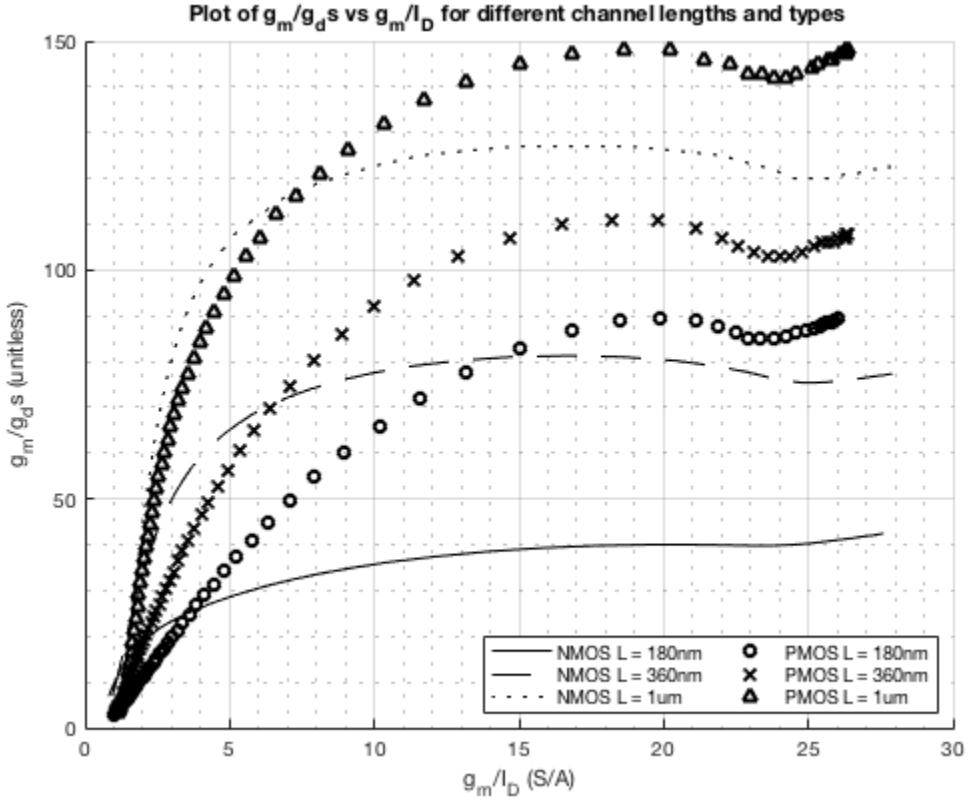
Figure 4: PMOS simulation window

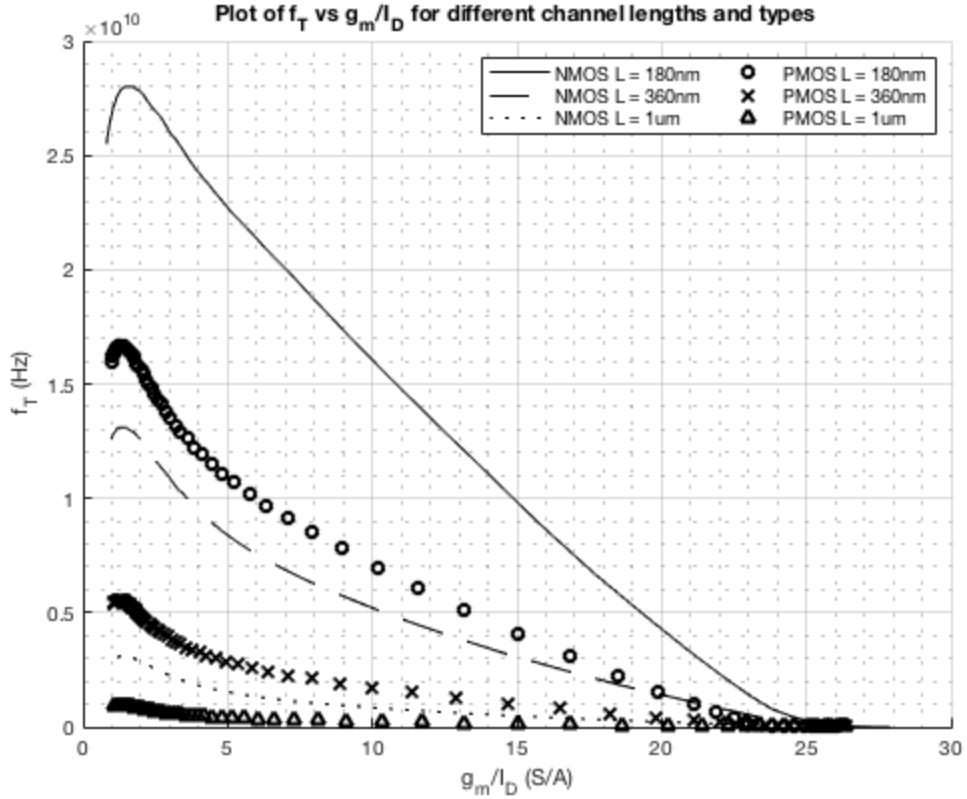
```
%This script reads and plots data from a .CSV file.

clear all;
clc;


%Open data file
fid = fopen('PB1_ALLDATA.csv');

%Read data in from .CSV file
readData = textscan(fid, '%f %f %f %f %f %f %f %f %f %f
 %f %f %f %f %f %f %f %f %f %f %f %f %f %f %f %f %f
 %f', 'Headerlines',2,'Delimiter',',');
%If more columns (yData), add a %f

%NMOS data
Vov_18N = readData{1,1}(:,1);
Vov_36N = readData{1,2}(:,1);
Vov_1N = readData{1,3}(:,1);

gm_over_Id_18N = readData{1,4}(:,1);
gm_over_Id_36N = readData{1,5}(:,1);
gm_over_Id_1N = readData{1,6}(:,1);

gm_over_gds_18N = readData{1,7}(:,1);
gm_over_gds_36N = readData{1,8}(:,1);
gm_over_gds_1N = readData{1,9}(:,1);

ft_18N = readData{1,10}(:,1);
ft_36N = readData{1,11}(:,1);
ft_1N = readData{1,12}(:,1);

Id_over_W_18N = readData{1,13}(:,1);
Id_over_W_36N = readData{1,14}(:,1);
Id_over_W_1N = readData{1,15}(:,1);

%PMOS Data
Vov_18P = readData{1,16}(:,1);
Vov_36P = readData{1,17}(:,1);
Vov_1P = readData{1,18}(:,1);

gm_over_Id_18P = readData{1,19}(:,1);
gm_over_Id_36P = readData{1,20}(:,1);
gm_over_Id_1P = readData{1,21}(:,1);

gm_over_gds_18P = readData{1,22}(:,1);
gm_over_gds_36P = readData{1,23}(:,1);
gm_over_gds_1P = readData{1,24}(:,1);

ft_18P = readData{1,25}(:,1);
ft_36P = readData{1,26}(:,1);
ft_1P = readData{1,27}(:,1);
```

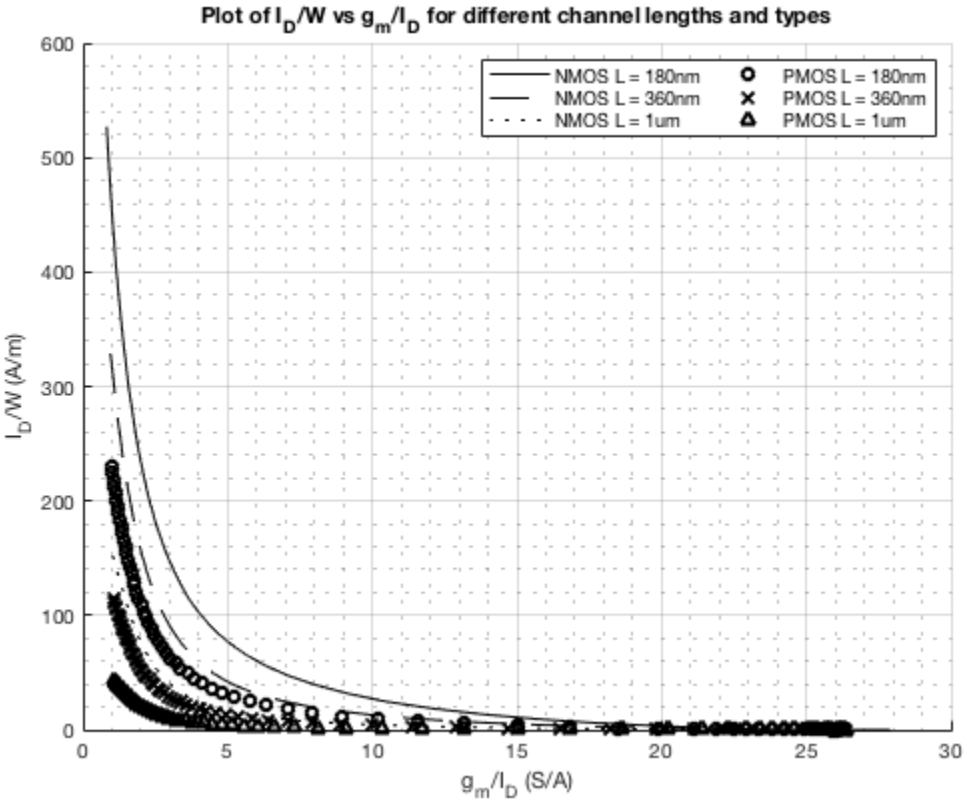
```
Id_over_W_18P = readData{1,28}(:,1);
Id_over_W_36P = readData{1,29}(:,1);
Id_over_W_1P = readData{1,30}(:,1);

%Plot Data
%gm/Id vs Vov
figure(1)
hold on;
plot(Vov_18N, gm_over_Id_18N, 'k-');
plot(Vov_36N, gm_over_Id_36N, 'k--');
plot(Vov_1N, gm_over_Id_1N, 'k:');
plot(Vov_18P, gm_over_Id_18P, 'ko');
plot(Vov_36P, gm_over_Id_36P, 'kx');
plot(Vov_1P, gm_over_Id_1P, 'k^');
legend('NMOS L = 180nm','NMOS L = 360nm','NMOS L =
 1um','PMOS L = 180nm','PMOS L = 360nm','PMOS L =
 1um', 'Location','east','NumColumns',2);
title('Plot of g_m/I_D vs V_O_V for different channel lengths and
 types');
xlabel('V_O_V (V)');
ylabel('g_m/I_D (S/A)');
grid on;
grid minor;

%gm/gds vs gm/Id
figure(2)
hold on;
plot(gm_over_Id_18N, gm_over_gds_18N, 'k-');
plot(gm_over_Id_36N, gm_over_gds_36N, 'k--');
plot(gm_over_Id_1N, gm_over_gds_1N, 'k:');
plot(gm_over_Id_18P, gm_over_gds_18P, 'ko');
plot(gm_over_Id_36P, gm_over_gds_36P, 'kx');
plot(gm_over_Id_1P, gm_over_gds_1P, 'k^');
legend('NMOS L = 180nm','NMOS L = 360nm','NMOS L =
 1um','PMOS L = 180nm','PMOS L = 360nm','PMOS L =
 1um', 'Location','southeast','NumColumns',2);
title('Plot of g_m/g_ds vs g_m/I_D for different channel lengths and
 types');
xlabel('g_m/I_D (S/A)');
ylabel('g_m/g_ds (unitless)');
grid on;
grid minor;

%ft vs gm/Id
figure(3)
hold on;
plot(gm_over_Id_18N, ft_18N, 'k-');
plot(gm_over_Id_36N, ft_36N, 'k--');
plot(gm_over_Id_1N, ft_1N, 'k:');
plot(gm_over_Id_18P, ft_18P, 'ko');
plot(gm_over_Id_36P, ft_36P, 'kx');
plot(gm_over_Id_1P, ft_1P, 'k^');
```

```
legend('NMOS L = 180nm','NMOS L = 360nm','NMOS L =
 1um','PMOS L = 180nm','PMOS L = 360nm','PMOS L =
 1um', 'Location','northeast','NumColumns',2);
title('Plot of f_T vs g_m/I_D for different channel lengths and
 types');
xlabel('g_m/I_D (S/A)');
ylabel('f_T (Hz)');
grid on;
grid minor;

%Id/W vs gm/Id
figure(4)
hold on;
plot(gm_over_Id_18N, Id_over_W_18N, 'k-');
plot(gm_over_Id_36N, Id_over_W_36N, 'k--');
plot(gm_over_Id_1N, Id_over_W_1N, 'k:');
plot(gm_over_Id_18P, Id_over_W_18P, 'ko');
plot(gm_over_Id_36P, Id_over_W_36P, 'kx');
plot(gm_over_Id_1P, Id_over_W_1P, 'k^');
legend('NMOS L = 180nm','NMOS L = 360nm','NMOS L =
 1um','PMOS L = 180nm','PMOS L = 360nm','PMOS L =
 1um', 'Location','northeast','NumColumns',2);
title('Plot of I_D/W vs g_m/I_D for different channel lengths and
 types');
xlabel('g_m/I_D (S/A)');
ylabel('I_D/W (A/m)');
grid on;
grid minor;
```


Plot of g_m/I_D vs V_{OV} for different channel lengths and types
g_m/I_D (S/A)
V_{OV} (V)
NMOS L = 180nm
NMOS L = 360nm
NMOS L = 1um
PMOS L = 180nm
PMOS L = 360nm
PMOS L = 1um


Plot of g_m/g_ds vs g_m/I_D for different channel lengths and types
g_m/g_ds (unitless)
g_m/I_D (S/A)
NMOS L = 180nm
NMOS L = 360nm
NMOS L = 1um
PMOS L = 180nm
PMOS L = 360nm
PMOS L = 1um


Plot of f_T vs g_m/I_D for different channel lengths and types
$\times 10^{10}$
3
2.5
2
1.5
1
0.5
0
f_T (Hz)
0
5
10
15
20
25
30
g_m/I_D (S/A)
NMOS L = 180nm
NMOS L = 360nm
NMOS L = 1um
PMOS L = 180nm
PMOS L = 360nm
PMOS L = 1um


Plot of I_D/W vs g_m/I_D for different channel lengths and types
600
500
400
300
200
100
0
I_D/W (A/m)
0
5
10
15
20
25
30
g_m/I_D (S/A)
NMOS L = 180nm
NMOS L = 360nm
NMOS L = 1um
PMOS L = 180nm
PMOS L = 360nm
PMOS L = 1um

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	Simulated gm/Id	Long Channel Estimate	% error
NMOS, L=0.18um, Vov=50mV	18.4079	40	-54%
NMOS, L=0.36um, Vov=50mV	19.5968	40	-51%
NMOS, L=0.36um, Vov=250mV	7.4286	8	-7%
NMOS, L=1um, Vov=250mV	7.8576	8	-2%
PMOS, L=0.18um, Vov=50mV	19.052	40	-52%
PMOS, L=0.36um, Vov=50mV	19.3004	40	-52%
PMOS, L=0.36um, Vov=250mV	7.6539	8	-4%
PMOS, L=1um, Vov=250mV	7.8037	8	-2%

As you can see, the long channel estimate is only appropriate for higher overdrive voltages (Vov).