California State University Sacramento
Electrical and Computer Science Department

EEE 108L Lab - Section 05
Laboratory Experiment Number 6: Lab Report

MOS Device Characteristics

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Abstract

For this laboratory experiment we will be exploring the characteristics of a MOS transistor. In this lab we are using the CD4007 MOS transistor.

Part 1: Preliminary Calculations

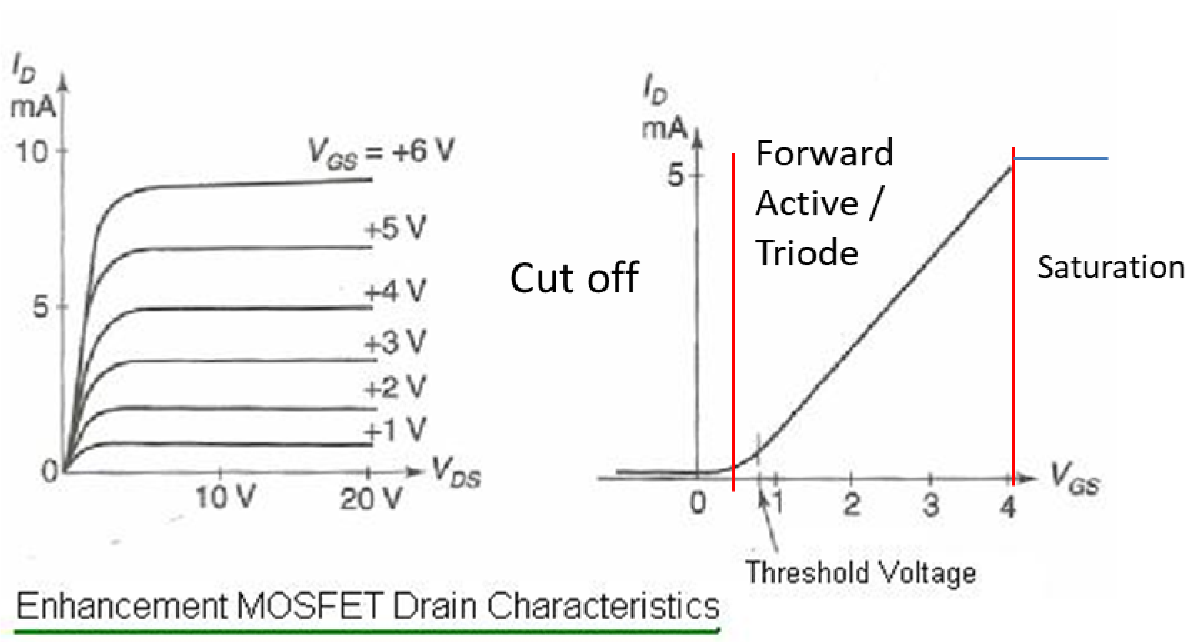
STEP 1:

Vds > (Vgs - Vth)

Vds = (Vgs +Vgd) > (Vgs – Vth)

Vgd > -Vth

Vgs > Vth, happens when the FET transistor is in the forward active region



STEP 2:

Vds = Vdd – Id Rd = Vdd – R (k (Vgs – Vth)^2)

Vdd = 5V and R = 4.7kΩ

From Appendix A12.1 in Moodle

Vth = 1.6 V, k = $8.2x10^{-4}$

Id= $8.2x10^{-4}$ $(Vgs-1.6v)^2$

Vds = 5 – 4700 ($8.2x10^{-4}$ $(Vgs-1.6v)^2$)

When VGS = 1,

Id = (8.2x10^-4)(1-1.6)^2 = 2.95x10^-4

Vds = (5-4700)(2.95x10^-4) = -1.362

When VGS = 2,

Id = (8.2x10^-4)(2-1.6)^2 = 1.3x10^-4

Vds = (5-4700)(1.3x10^-4) = -0.610

When VGS = 4,

Id = (8.2x10^-4)(4-1.6)^2 = 4.72x10^-3

Vds = (5-4700)(4.72x10^-3) =-22.160

VGS	Id	Vds	Region
1	2.95x10^-4	-1.362	Cut Off
2	1.3x10^-4	-0.610	Triode
4	4.72x10^-3	-22.160	Saturation

STEP 3:

Solve for Vth and the transconductance parameter

k = (μCox W)/ 2L

Id = k $(\text{Vgs-Vth})^2$

To find k and Vth, solve for 2 equations with 2 unknowns

35 uA = k $(1.46 - \text{Vth})^2$

430 uA = k $(2.18 - \text{Vth})^2$

Finding Vth,

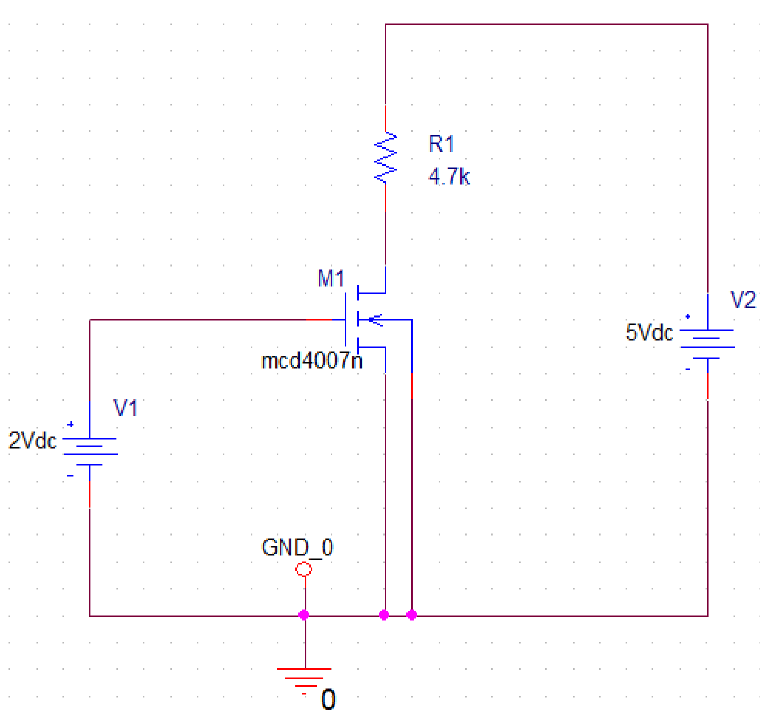
Sqrt(35/430) = (1.46 - Vth)/(2.18 - Vth)

Vth = (1.46- 0.2853(2.18))/(1-0.2853)

Vth = 1.173V

Part 2: Spice Calculations

STEP 4: Construct circuit in figure 1 into Pspice.



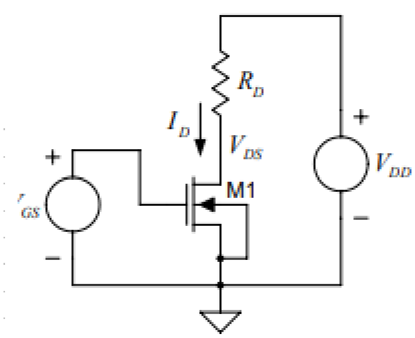
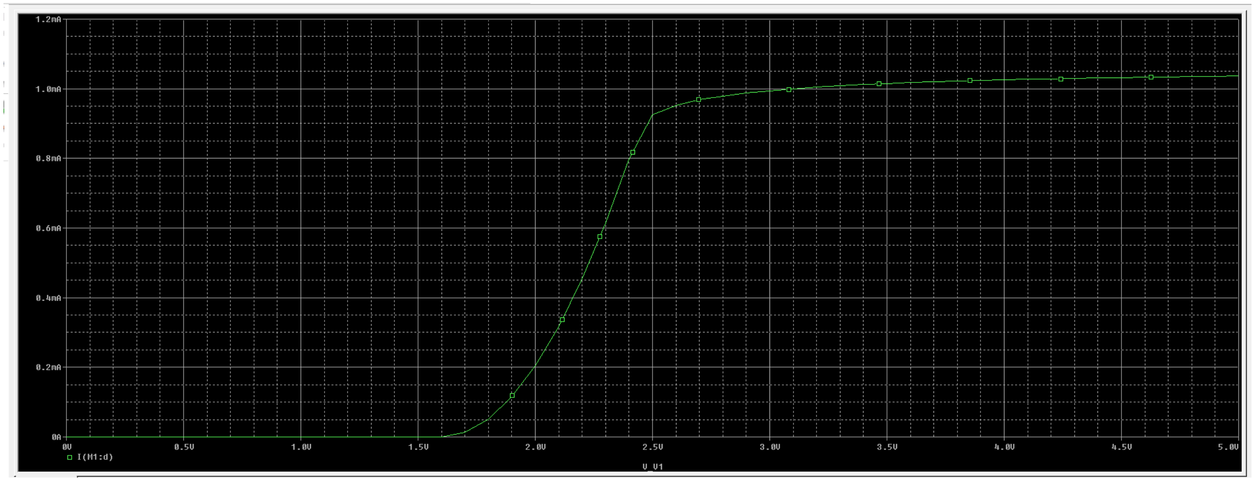
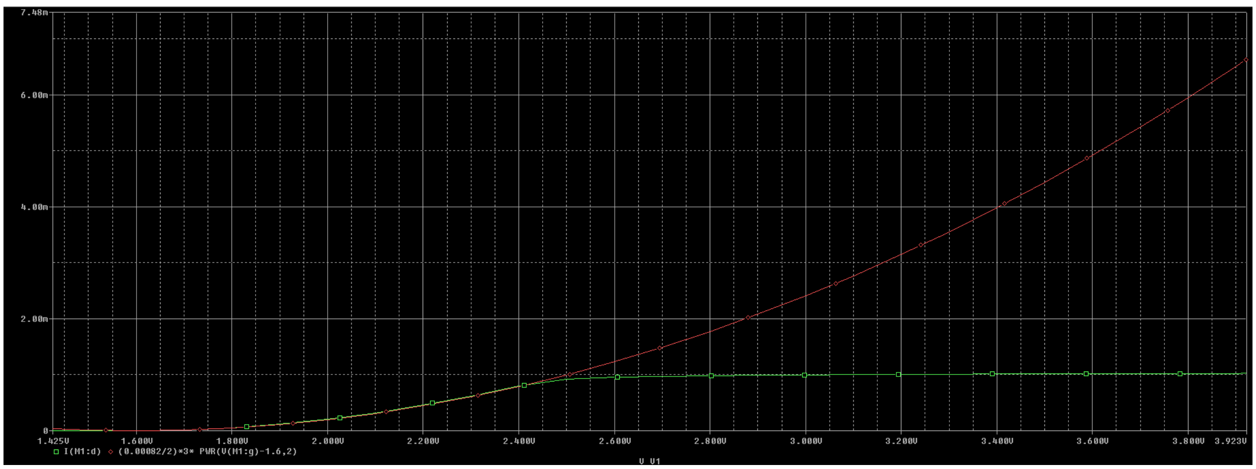


Figure 1

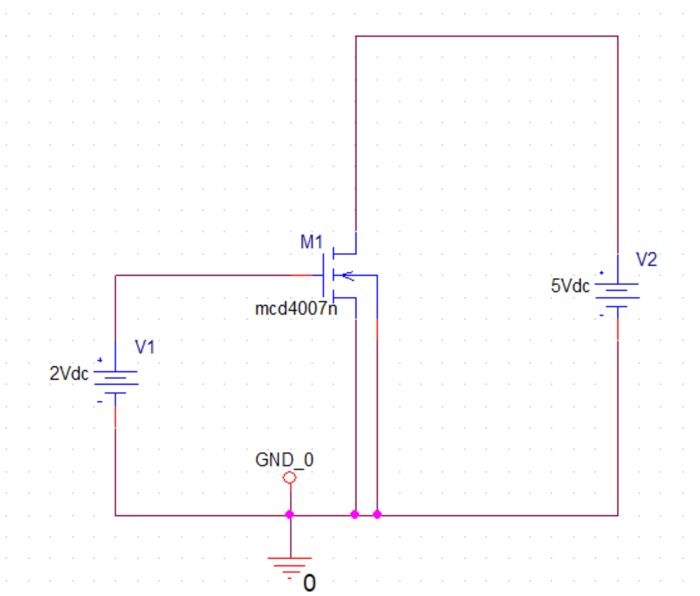
DC Sweep of Id



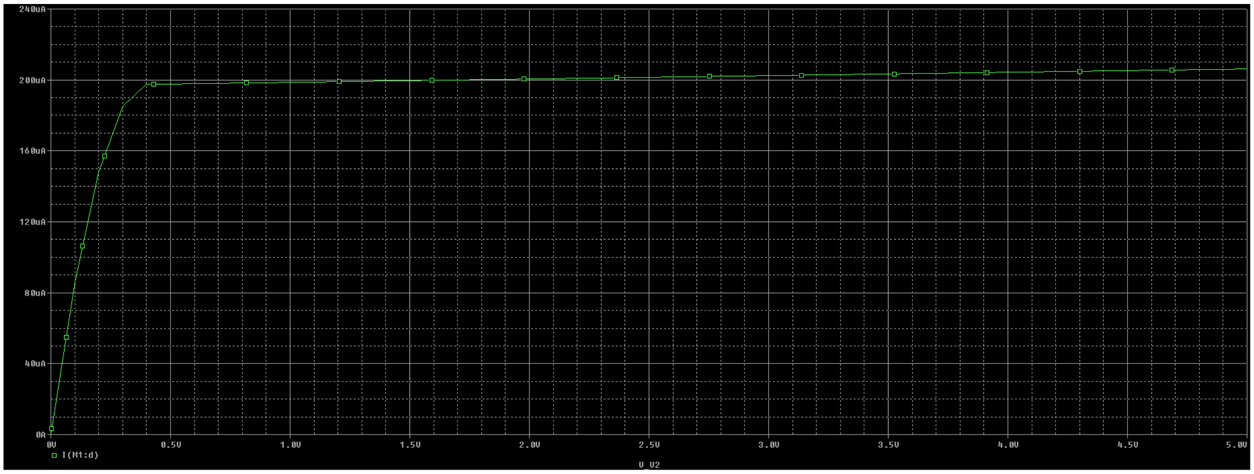
Current + Cox



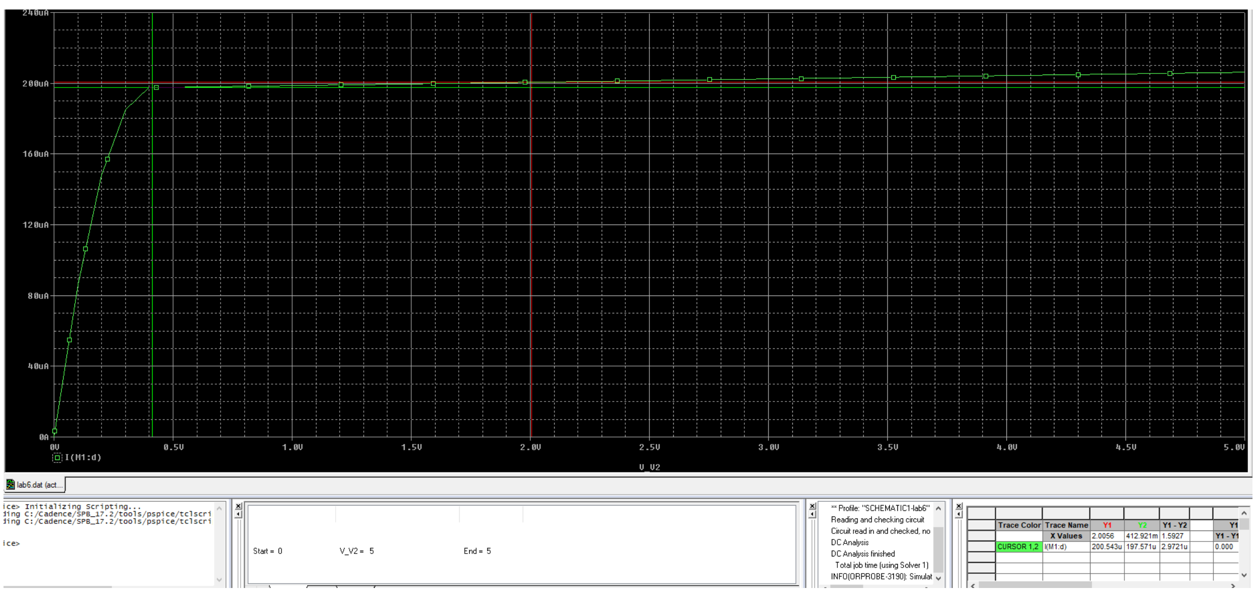
STEP 5: Remove the R



DC Sweep of Id

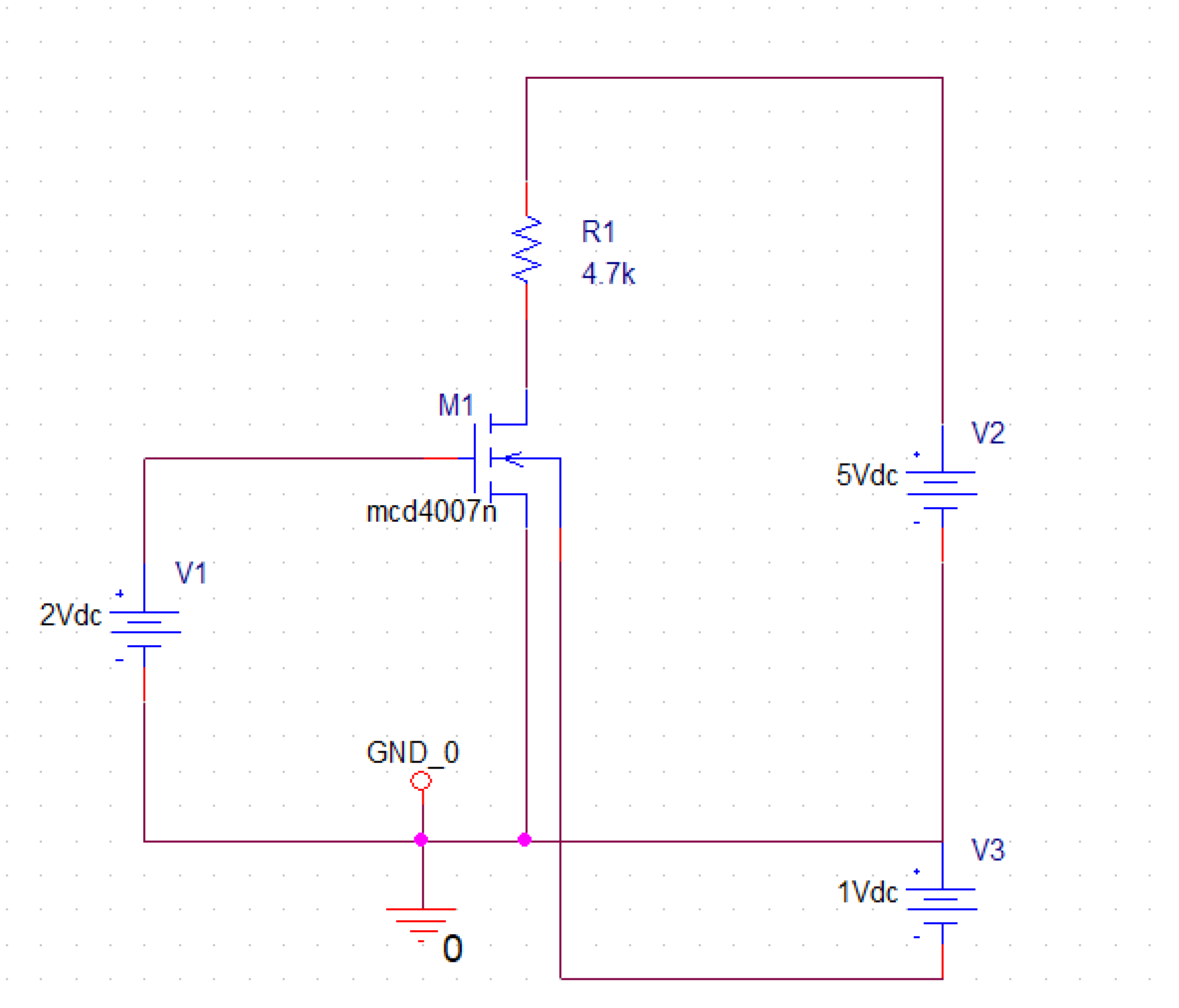


Forward Active Region (a little before the green cursor) and Saturation Region(red cursor)

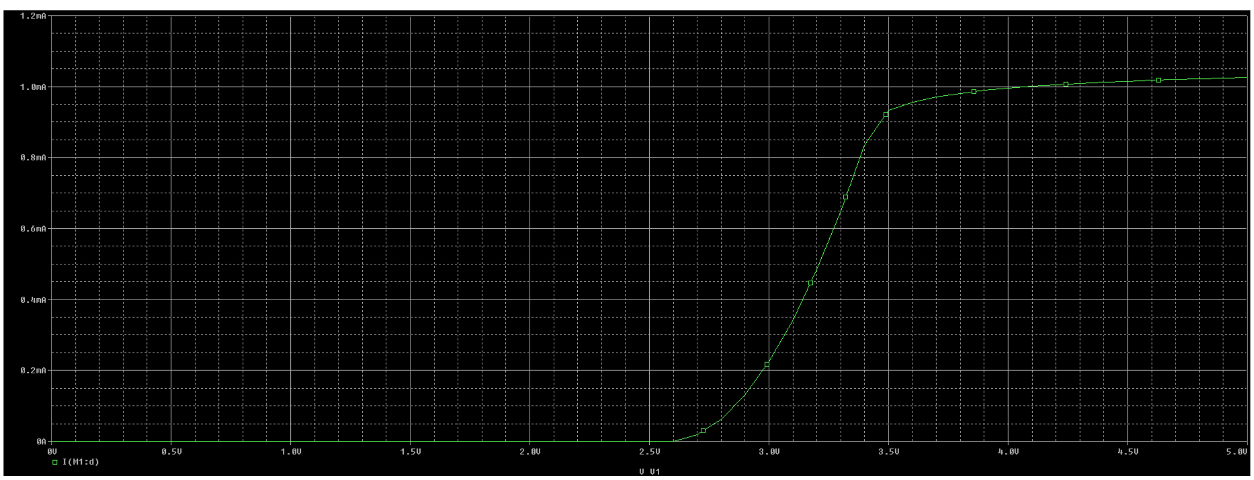


	Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1
		X Values	2.0056	412.921m	1.5927		Y1 - Y1
	CURSOR 1,2	I(M1:d)	200.543u	197.571u	2.9721u		0.000

STEP 7: Construct Circuit



DC Sweep of VTH



Part 3: Laboratory Calculations

STEP 8: Construct Figure 1 Circuit

Vgs	Vds	Id	
0	4.96V	8.51x10^-6	
1	4.96V	8.51x10^-6	
1.5	4.96V	8.51x10^-6	
1.6	4.95V	1.06x10^-5	<-expected cut off
1.8	4.92V	1.70x10^-5	
2	4.81V	4.04x10^-5	
2.2	4.56V	9.36x10^-5	
2.4	4.21V	1.68x10^-4	
2.6	3.77V	2.62x10^-4	
2.8	3.23V	3.77x10^-4	
3	2.61V	5.09x10^-4	
3.2	1.93V	6.53x10^-4	
3.4	1.24V	8.00x10^-4	
3.6	840mV = 0.84V	8.85x10^-4	
3.8	695mV = 0.695V	9.16x10^-4	
4	617mV = 0.617V	9.34x10^-4	
5	443mV = 0.443V	9.70x10^-4	

STEP 9: Determine the value for Vth and K

Id = 1.06x10^-5
Vgs = 1.6
Id = 4.04x10^-5
Vgs = 2

(1.6 - Vth)/(2 - Vth) = sqrt(1.06x10^-5/4.04x10^-5)
(1.6 -Vth) = 0.512(2 - Vth)
0.512-1 = 1.6 + (0.512)(2)
Vth = 2.624/0.488
Vth = 5.377

K = (1.06x10^-5)/(1.6- 5.377)^2
K = 7.43x10^-7

Data from steps 10 and 11 were given from fellow team members and classmates.
STEP 10:

Step 10			
Vdd	Vds		Ids
0	0.03		0.00097451
1	0.152		0.000950588
2	0.316		0.000918431
3	0.54		0.00087451
4	1.08		0.000768627
5	2.01		0.000586275
6	2.99		0.000394118
7	3.94		0.000207843

STEP 11:

		Step 11			
Vdd=5		Vgs	Vds		Ids
		0	4.96		7.84314E-06
		1	4.96		7.84314E-06
		1.5	4.96		7.84314E-06
		1.6	4.96		7.84314E-06
		1.8	4.96		7.84314E-06
		2	4.96		7.84314E-06
		2.2	4.96		7.84314E-06
		2.4	4.96		7.84314E-06
		2.6	4.92		1.56863E-05
		2.8	4.73		5.29412E-05
		3	4.4		0.000117647
		3.2	3.93		0.000209804
		3.4	3.32		0.000329412
		3.6	2.59		0.000472549
		3.8	1.76		0.000635294
		4	1		0.000784314
		5	0.48		0.000886275

CONCLUSION:

ITEM 1: There is no difference between the values measured. The low = below 1.6 and the high = above 2.

ITEM 2: For the K values they were significantly different.

ITEM 3: For Id values I see that they are fairly similar but with some differences in values. I think that is due to our circuit on the live board giving us strange values.

ITEM 4: For the values of Vds/Id in step 5 I found that it

ITEM 5: The value does change when comparing Vsb = 0V to Vsb = -1V, as the value of the Vth increases slightly.