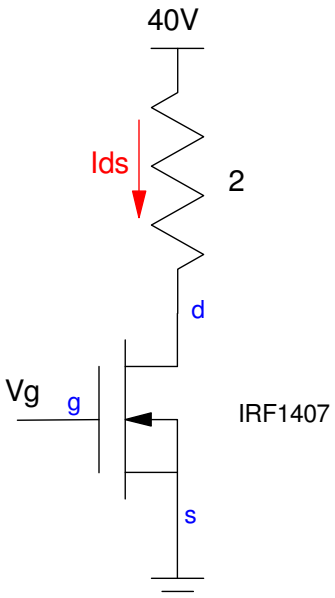
ECE 320 - Homework #9

MOSFET switch, CMOS logic. Due Monday, October 25th

MOSFET Switch

One of the MOSFET's that CircuitLab has is an IRF1047. It's specifications are

- max(Ic) = 100A continuous
- Vgs(th) = 4V (max)
- Rds = 7.8mOhm @ Ids = 78A @ Vgs = 10V
- $0.53 each



1) Determine the transconductance gain, kn, for this MOSFET.

- Assume Vtn = 4.00V

Rds is the Ohmic region

$$V_{ds} = 0.0078\Omega \cdot 78A = 0.608V$$

$$I_{ds} = k_n\left(V_{gs} - V_{th} - \frac{V_{ds}}{2}\right)V_{ds}$$

$$78A = k_n\left(10V - 4V - \frac{0.608V}{2}\right)0.608V$$

$$k_n = 22.508\ \frac{A}{V^2}$$

2) Determine the votlages and currents for the following circuit when Vg = 5V

Assume Ohmic. This gives 2 equations for 2 unknowns

$$I_{ds} = k_n\left(5 - 4 - \frac{V_{ds}}{2}\right)V_{ds}$$

$$V_{ds} + 2I_{ds} = 40$$

There is no solution (it's not ohmic)

Assume saturated

$$I_{ds} = \frac{k_n}{2}(V_{gs} - V_{th})^2$$

$$I_{ds} = \frac{22.508}{2}(5V - 4V)^2 = 11.254A$$

$$V_{ds} = 40 - 2I_{ds} = 17.492V$$

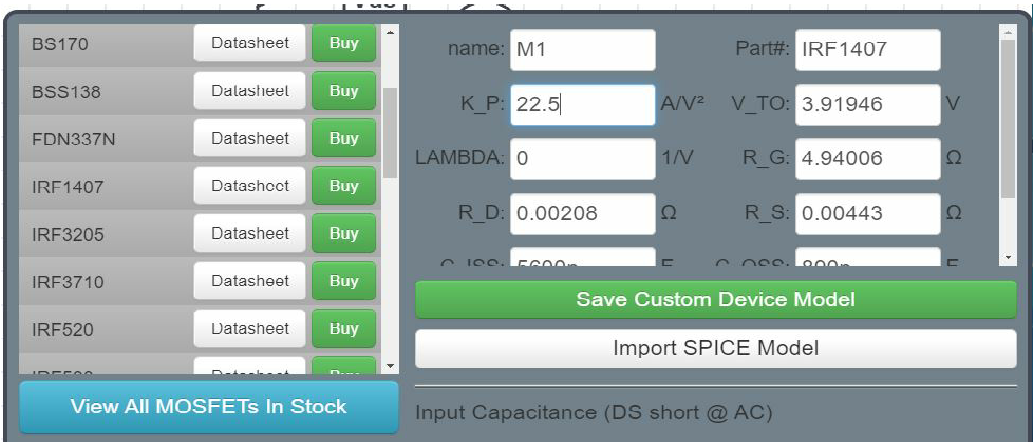
Check: To be in the saturated region

$$V_{ds} > V_{gs} - V_{th}$$

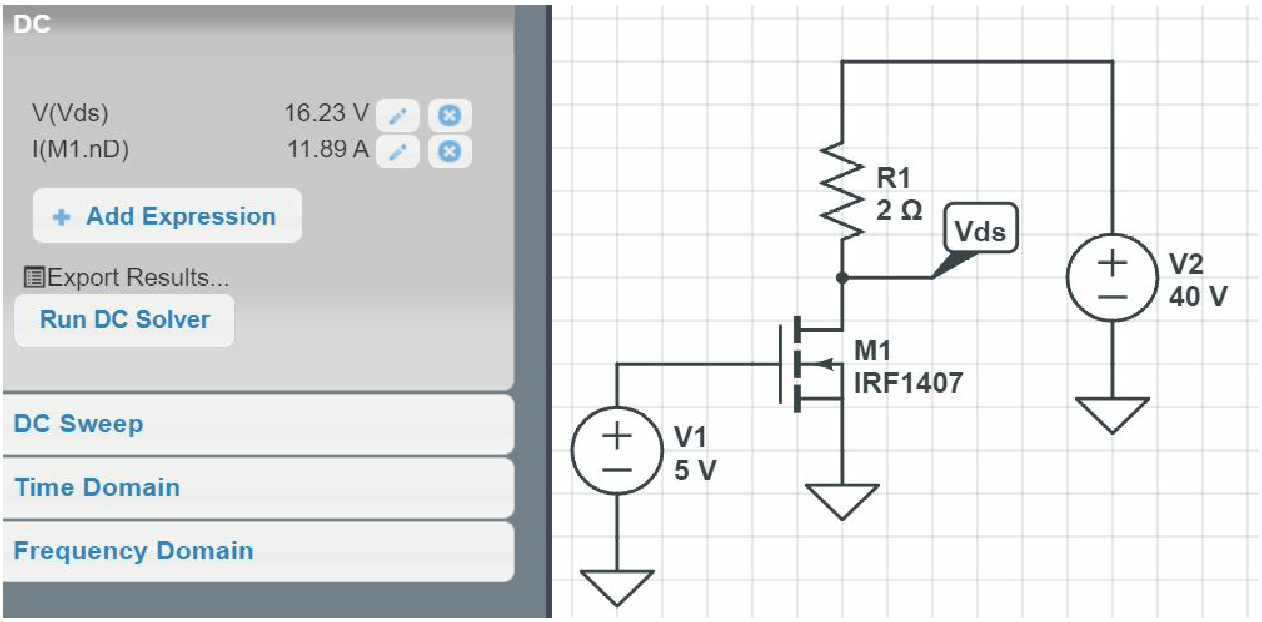
$$17.492V > 5V - 4V$$

Check your result in CircuitLab

- Change the parameters of an IRF1407 to match the data sheets (kn = 22.5 A/V2)



Simulate:



The results are somewhat close (11.89A vs. 11.25A)

3) Determine the votlages and currents for the following circuit when Vg = 10V

Assume ohmic

$$I_{ds} = k_n\left(V_{gs} - V_{th} - \frac{V_{ds}}{2}\right)V_{ds}$$

(1) $$I_{ds} = 22.5\left(10V - 4V - \frac{V_{ds}}{2}\right)V_{ds}$$

(2) $$V_{ds} + 2I_{ds} = 40$$

Solving 2 equations for 2 uknowns

Vds = 0.149V, Ids = 19.926 A ***correct solution***

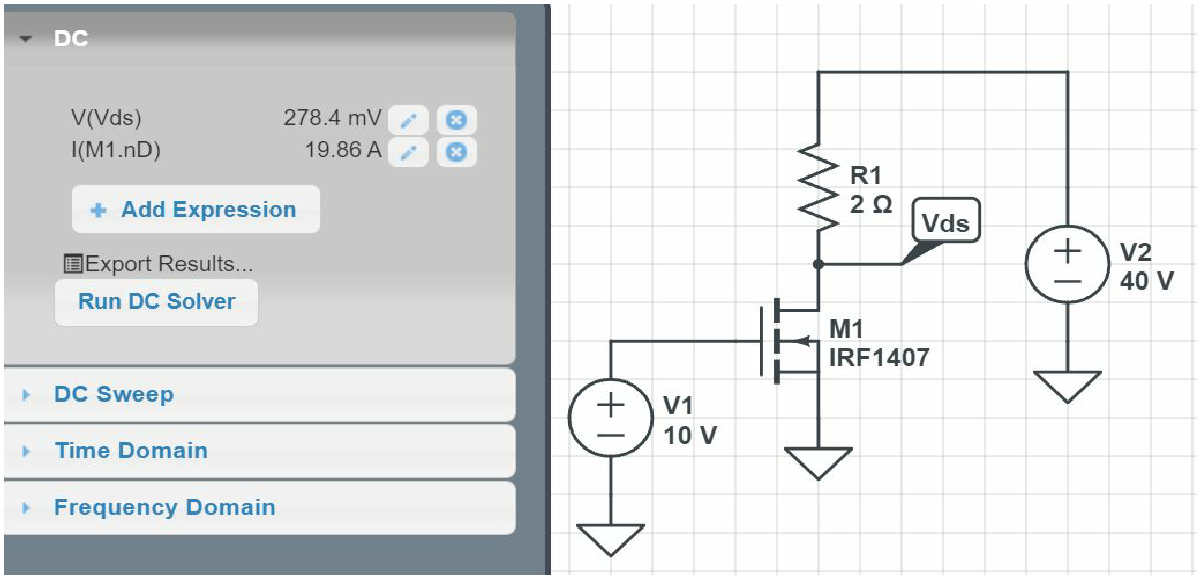
Vds = 11.895V, Ids = 14.053A *stray solution*

Checking that you're in the ohmic region:

$$V_{ds} < V_{gs} - V_{th}$$

$$0.149V < 10V - 4V$$

Check your result in CircuitLab



CMOS Logic

4) Design a CMOS gate to implement the function: f(A, B, C, D)

Y(A,B,C,D)	CD			
AB	00	01	11	10
00	1	0	1	x
01	1	0	0	1
11	1	1	1	0
10	x	1	x	0

Circle the zeros

- This gives the logic for the n-channel MOSFETs.
- You could also circle the ones - giving the logic for the p-channel MOSFETs

$$\overline{Y} = \overline{A}\,\overline{C}D + \overline{A}BD + AC\overline{D}$$

This is the logic for the n-channel MOSFETs

- When turned on, Y is tied to ground
- Series is and
- Parallel is or

The p-channel comes from DeMorgan's law

$$Y = \left(A + C + \overline{D}\right)\left(A + \overline{B} + \overline{D}\right)\left(\overline{A} + \overline{C} + D\right)$$