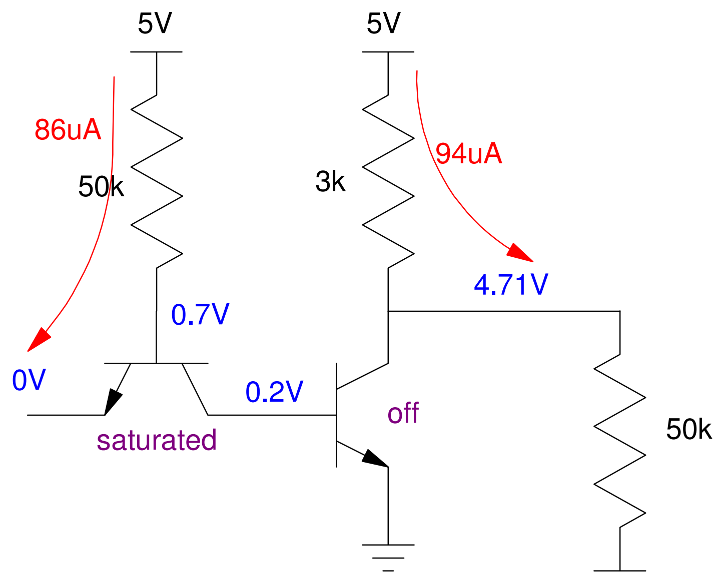
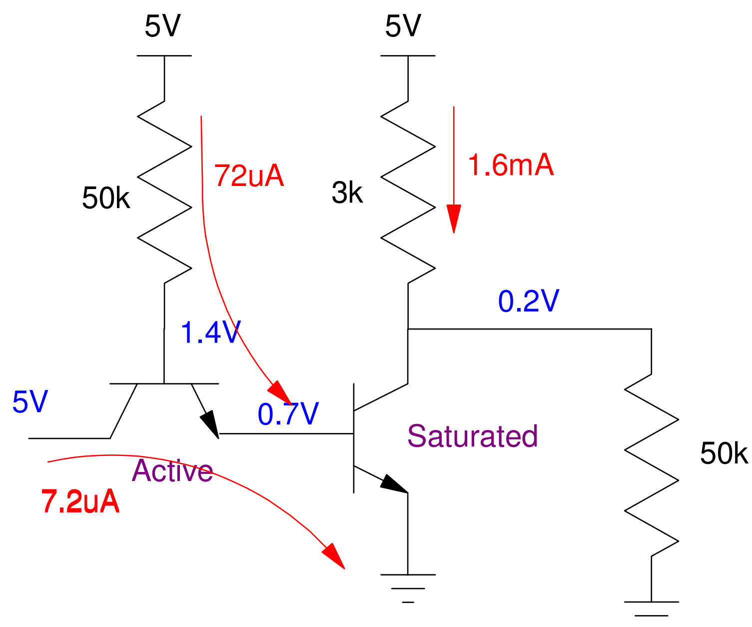
ECE 320 - Homework #9

TTL Logic, MOSFET Theory, MOSFET Switches. Due Monday, March 19th

TTL Logic:

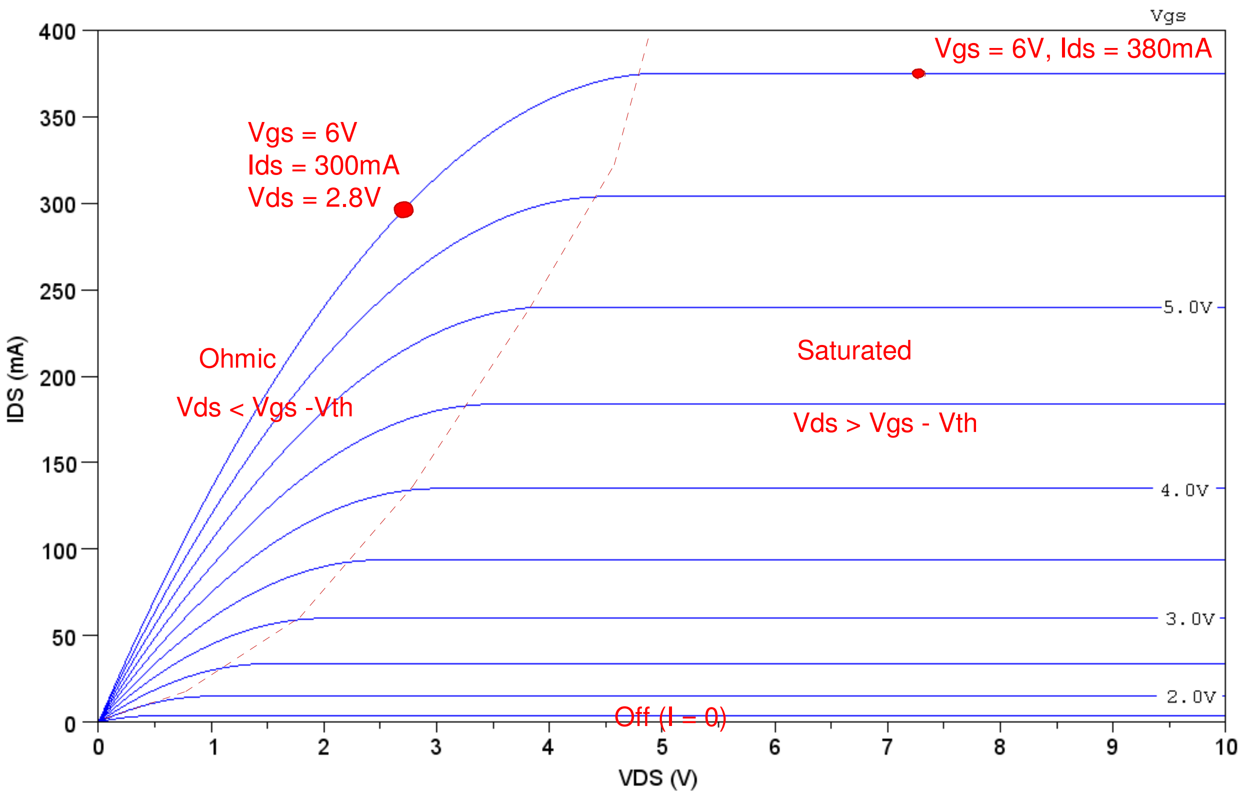
1) Determine the voltages and currents for the following TTL AND gate. Assume ideal silicon diodes and transistors with $\beta = 100$.





MOSFET:

2a) Label the Off / Saturated / Ohmic regions for the following n-channel MOSFET



2b) Determine the transconductange gain, kn ($V_{th} = 1.0V$)

Pick a point in the Ohmic region

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

$$300mA = k_n\left(6V - 1V - \frac{2.8V}{2}\right)2.8V$$

$$k_n = 0.0297\ \frac{A}{V^2}$$

Pick a point in the saturated region

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

$$380mA = \frac{k_n}{2}(6V - 1V)^2$$

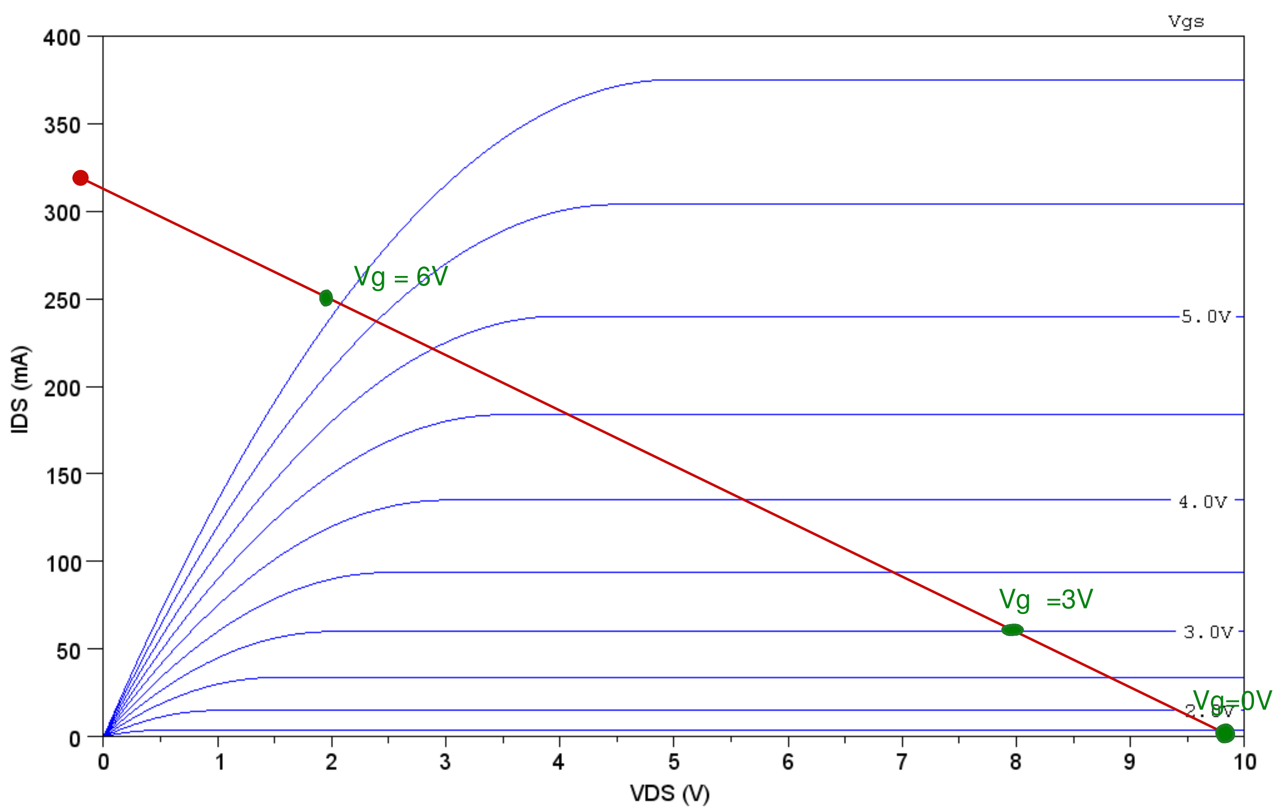
$$k_n = 0.0304\ \frac{A}{V^2}$$

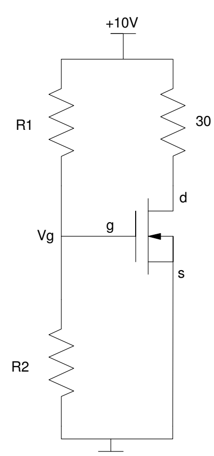
You can use a point in either region to find kn. You just have to use the appropriate equation for that region.

3a) Draw the load line for the following circuit on the previous graph

3b) Determine the Q-point (Vds, Ids) when

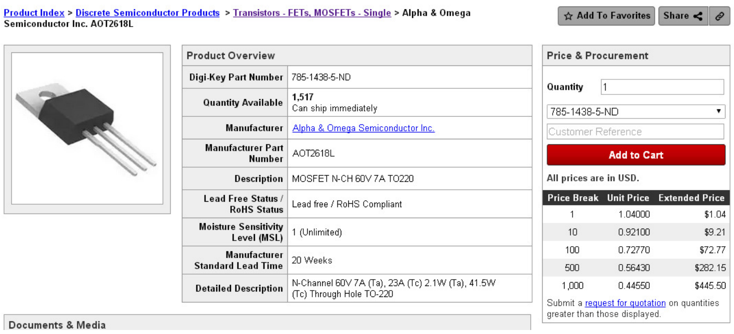
- Vg = 0V Vds = 10V, Ids = 0mA (off)
- Vg = 3V Vds = 8.2V, Ids = 62mA (saturated)
- Vg = 6V Vds = 2V, Ids = 250mA (Ohmic)





Assume a AOT2618L n-channel MOSFET:

- 23A max continuous current Ids
- 70A max pulse current
- 19 mOhm @ 20A @ Vgs = 10V
- Vth = 2.5V (max)
- $0.72 (qty = 100)
- Digikey part number: 785-1438-5-ND



Product Index > Discrete Semiconductor Products > Transistors - FETs, MOSFETs - Single > Alpha & Omega Semiconductor Inc. AOT2618L

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Product Overview

Digi-Key Part Number	785-1438-5-ND
Quantity Available	1,517 Can ship immediately
Manufacturer	Alpha & Omega Semiconductor Inc.
Manufacturer Part Number	AOT2618L
Description	MOSFET N-CH 60V 7A TO220
Lead Free Status / RoHS Status	Lead free / RoHS Compliant
Moisture Sensitivity Level (MSL)	1 (Unlimited)
Manufacturer Standard Lead Time	20 Weeks
Detailed Description	N-Channel 60V 7A (Ta), 23A (Tc) 2.1W (Ta), 41.5W (Tc) Through Hole TO-220

Price & Procurement

Quantity 1

785-1438-5-ND

Customer Reference

Add to Cart

All prices are in USD.

Price Break	Unit Price	Extended Price
1	1.04000	$1.04
10	0.92100	$9.21
100	0.72770	$72.77
500	0.56430	$282.15
1,000	0.44550	$445.50

Submit a request for quotation on quantities greater than those displayed.

Documents & Media

4) Determine the transconductance gain, kn

The spec (19mOhm) refers to the Ohmic region

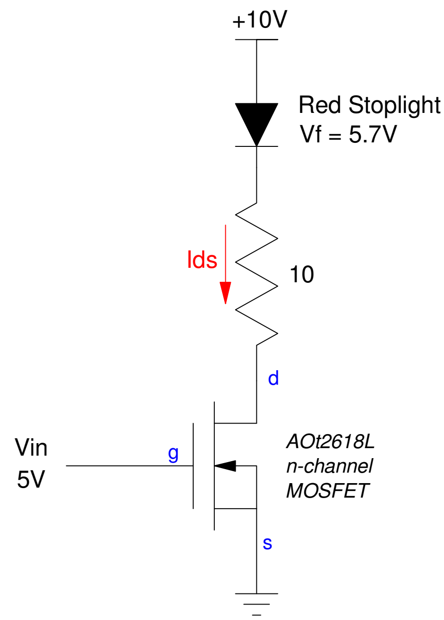
$$V_{ds} = 0.019\Omega \cdot 20A = 0.38V$$

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

$$20A = k_n\left(10V - 2.5V - \tfrac{0.38V}{2}\right)0.38V$$

$$k_n = 7.20\ \tfrac{A}{V^2}$$

5) Determine the voltages for the MOSFET circuit to the right



Assume Ohmic region

(Vds < Vgs - Vth = 2.5V)

To solve for Vds and Ids you need two equations to solve for two unknowns:

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

$$I_{ds} = 7.2\left(5 - 2.5 - \frac{V_{ds}}{2}\right)V_{ds}$$

b) $$V_{ds} + 10I_{ds} + 5.7 = 10$$

Solving gives two solutions:

Vds = 0.02387V Ids = 427.6mA

Vds = 5.004V Ids = -70.39mA

The solution close to Vds = 0 is correct

Answer:

Vds = 0.02387V **Ids = 427.6mA**

Note: The actual resistance is

$$R_{ds} = \frac{V_{ds}}{I_{ds}} = 55.8m\Omega$$

If you assume Rds = 19mΩ, your answer will be slightly off:

Vds = 0.02396V Ids = 427.6mA

6) Modify this circuit so that Ids = 1A when Vin = 5V.

Assume the on resistance is 19m Ohms. For 1A

$$R_{total} = \left(\frac{4.3V}{1A}\right) = 4.3\Omega$$

$$R_{total} = R_{ds} + R_d$$

$$4.3\Omega = 0.019\Omega + R_d$$

$$R_d = 4.281\Omega$$

or roughly 4.3 Ohms

This gives an answer that is slightly off. Solving two equations for two unknowns:

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

$$V_{ds} + 4.3I_{ds} + 5.7 = 10$$

Solving...

Vds = 0.05545 V

Ids = 987.1 mA

meaning that

Rds = 0.056 Ohms

(vs 0.019 Ohms assumed)