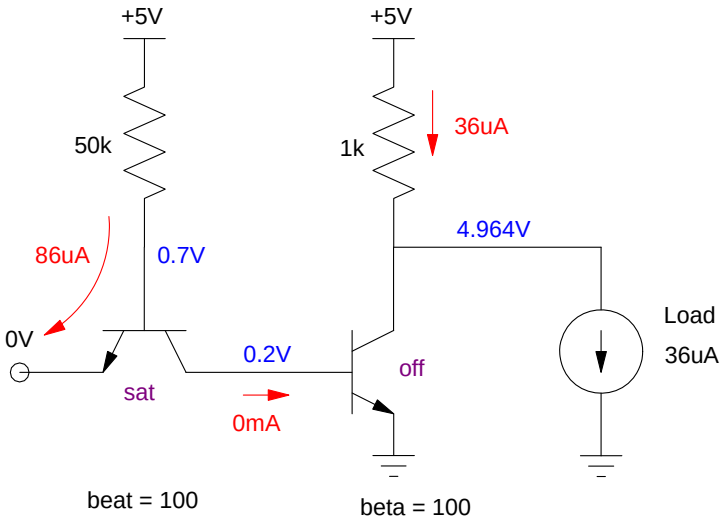
ECE 320 - Homework #9

TTL Logic, MOSFET Theory, MOSFET Switch. Due Monday, October 23rd, 2017

TTL Logic

1) For the following TTL inverter

1a) Determine the voltages and currents



1b) Determine how many 36uA loads you can connect to Y and keep the voltage at Y > 4V (the fan-out high)

For the voltage to drop 1V, you need 1mA through the 1k resistor. The number of loads is then

$$n = \frac{1mA}{36\mu A} = 27.78$$

You can drive 27 loads (fan-out high = 27)

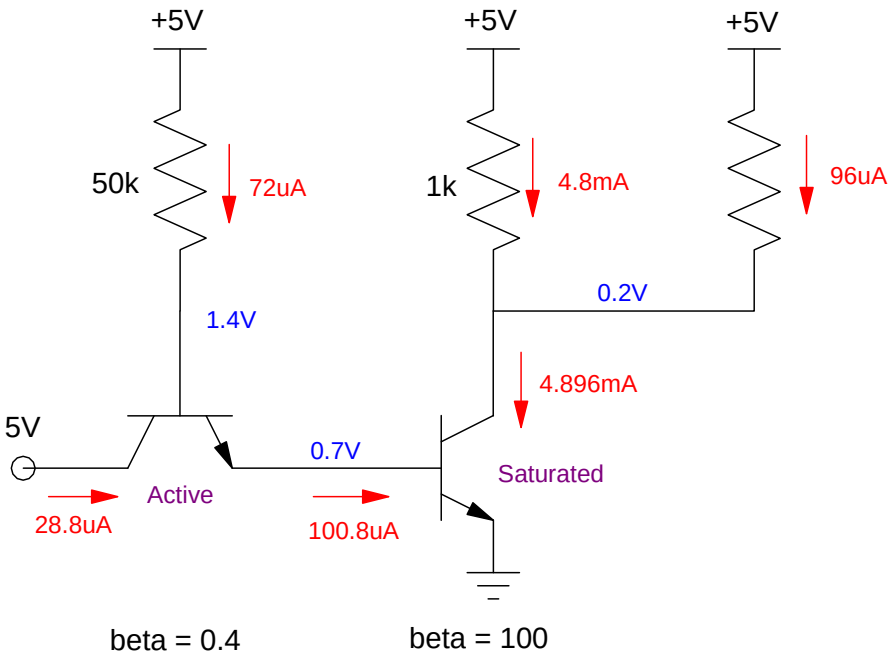
note: From problem #2, it should have been 28.8uA. This results in a fanout of

$$n = \frac{1mA}{28.8\mu A} = 34.72$$

You can actually drive 34 loads (fan-out high = 34)

2) For the following TTL inverter

2a) Determine the voltages and currents



2b) Determine how many 50k loads you can attach to the load and keep the trnansistor saturated (the fanout low)

For the second transistor to be saturated:

$$\beta I_b > I_c$$

$$10.08mA > I_c$$

Each load adds 96uA

$$4.8mA + n \cdot 96\mu A = 10.8mA = I_c$$

$$n = 62.5$$

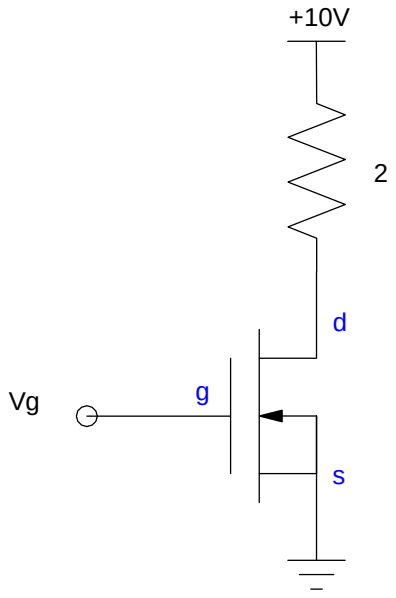
This circuit can sink current from 62 loads while keeping the second transistor saturated.

The fan-out low is 62.

MOSFET Theory

3) For the MOSFET graph given on the back of this page,

- Determine the transconductance gain, kn,
- Mark the off / saturated / ohmic regions



Pick a point in the saturated region

- Vgs = 10V
- Vth = 2V
- Vds = 10V
- Ids = 7.5A

Plug this into the transisor equation

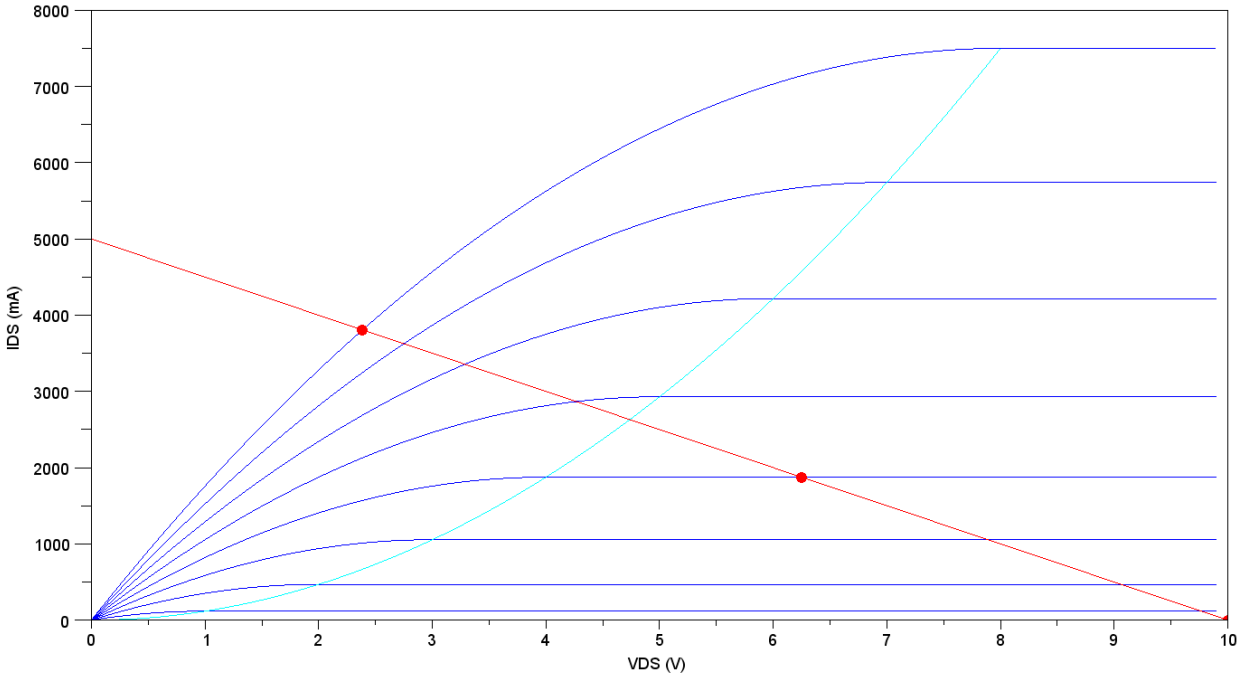
$$I_{ds} = \frac{K_n}{2}(V_{gs} - V_{th})^2$$

$$7.5A = \frac{K_n}{2}(10 - 2)^2$$

$$K_n = 0.2344\frac{A}{V^2}$$

4) On this graph, draw the load-line for the following circuit. Also mark the operating point when

Vg = 0V	Off	Vds = 10V	Ids = 0
Vg = 5V	Saturated	Vds = 6.25V	Ids = 1875mA
Vg = 10V	Ohmic	Vds = 2.38V	Ids = 3810mA



5) A MOSFET has the following characteristics

- Rds = 0.65 Ohms @ 4A when Vgs = 10V.
- Vth = 2.0V

Design a switch which allows this MOSFET to turn on and off an 8 Ohm speaker at 10V using a 0V / 10V souce.

When Vg = 0V

Vgs = 0V < Vth

MOSFET is off

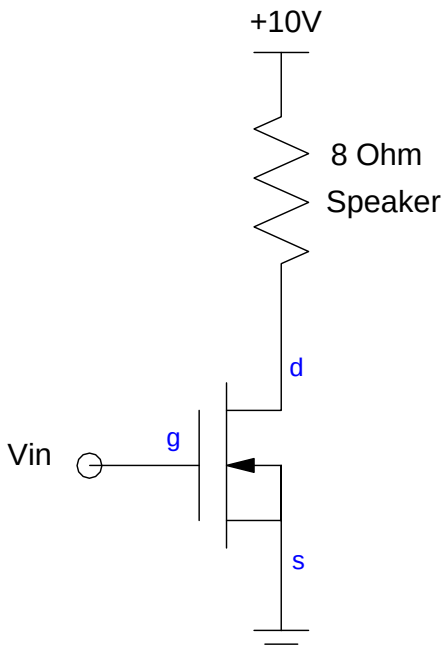
Id = 0

When Vg = 10V

Rds = 0.65 Ohms (approx)

$$I_{ds} = \frac{10V}{0.65\Omega+8\Omega} = 1.156A$$

$$V_{ds} = 0.65\Omega \cdot 1.156A = 0.75V$$



Lab: Term Project (part 2)

Design one part of your term project. Some suggestions are:

- Use a Schmitt Trigger (part 1) and an AC to DC converter (part 2) to drive a 12V DC motor when the temperature is below 5C.
- Use a DTL NAND gate (part 1) and an H-bridge (part 2) to drive a 10V DC motor forward when switch when $\overline{AB}$ is true, reverse when false
- Use an AC to DC converter (part 1) to convert 20Vp 60Hz AC to 20VDC, capable of 100mA (part 1), which then drives a DC to DC converter (part 2) which drives a DC motor from 0V to 20V.
- Other

6) Requirements: Specify the
   - Inputs
   - Outputs
   - How they relate

7) Analysis: Calculate the values of the components in your circuit to meet the requirements.

8) Simulation: Check your analysis using a circuit simulator, such as PartSim

9) Validation: Build your circuit and verify it meets the requirements