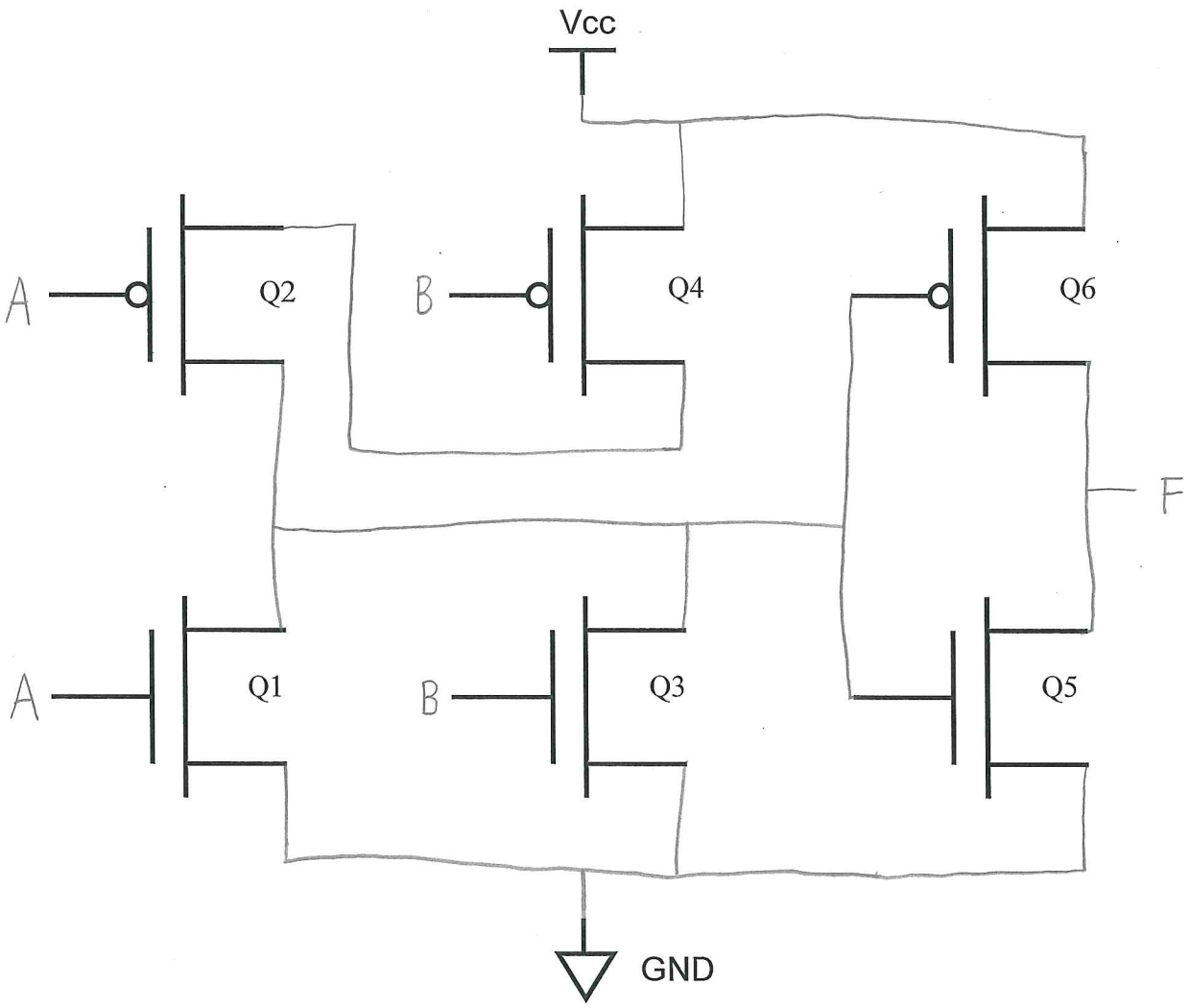
Huddle Board Exercise for Module 1 – No. 1
Wednesday, January 22, 2014

Draw a MOSFET-level circuit for a **2-input OR gate**. Label the inputs, A and B, and the output, F. The transistors, Q1, Q2, Q3, Q4, Q5, and Q6 are labeled. Be sure to include power (Vcc) and ground (GND) connections. In the truth table below, given the input values for A and B, determine if the transistor is "off" or "on" and the corresponding output.

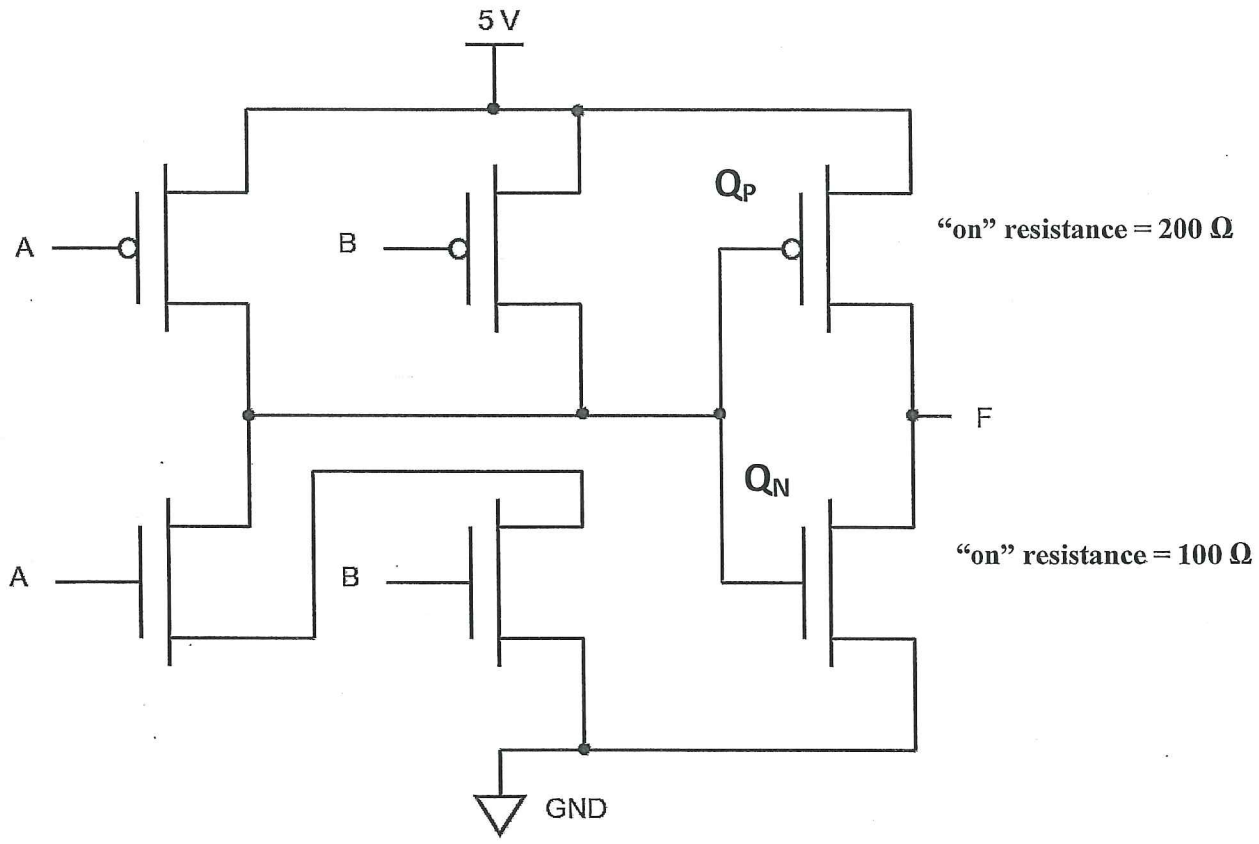


Two-input OR gate Truth Table

A	B	Q1	Q2	Q3	Q4	Q5	Q6	F
0	0	off	on	off	on	on	off	0
0	1	off	on	on	off	off	on	1
1	0	on	off	off	on	off	on	1
1	1	on	off	on	off	off	on	1

Huddle Board Exercise for Module 1 – No. 2
Monday, January 27, 2014

Use the following circuit to answer the questions below:



The circuit above represents this **type of gate:** AND gate

If the "on" resistance of the MOSFET labeled "Q_P" is **200Ω** and the "on" resistance of the MOSFET labeled "Q_N" is **100Ω**, then if **10mA** of current is **sourced** in the high state, V_{OH} will be:

$$R_p = \frac{V_{cc} - V_{OH}}{I_{OH}}$$

$$R_p I_{OH} = V_{cc} - V_{OH}$$

$$R_p I_{OH} - V_{cc} = -V_{OH}$$

$$V_{cc} - R_p I_{OH} = V_{OH}$$

$$5V - 200\Omega\,(10mA) = V_{OH}$$

$$5V - 2V = V_{OH}$$

$$3V = V_{OH}$$

If the "on" resistance of the MOSFET labeled "Q_P" is **200Ω** and the "on" resistance of the MOSFET labeled "Q_N" is **100Ω**, then if **10mA** of current is **sunk** in the low state, V_{OL} will be:

$$R_n = \frac{V_{OL} - V_{GND}}{I_{OL}}$$

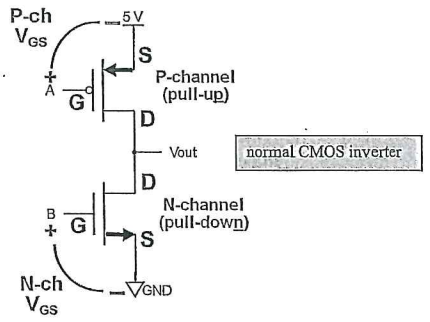
$$R_n I_{OL} = V_{OL} - V_{GND}$$

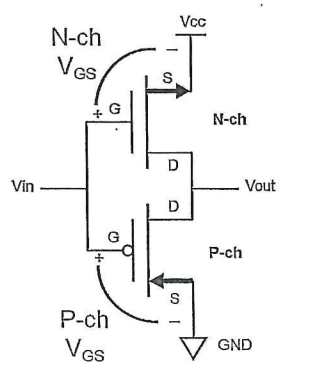
$$R_n I_{OL} + V_{GND} = V_{OL}$$

$$100\,\Omega\,(10\,mA) + 0V = V_{OL}$$

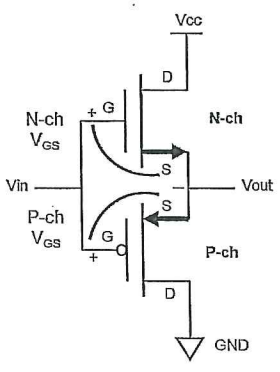
$$1V = V_{OL}$$

A common question students have relates to why the P-channel device has to serve as a "pull-up" while the N-channel device has to serve as a "pull-down" (i.e., why can't it be the "other way around"?). To convince yourself of this reality, try drawing a CMOS inverter "upside down" (with an N-channel device used as a pull-up and a P-channel device used as a pull-down) and analyze the circuit you have created (i.e., determine its Vi-Vo characteristics). Describe your conclusion.





"flipped" upside-down → current unable to flow (cannot pull output high or low)



each transistor "flipped" in "upside-down" circuit → unable to establish V_{GS} potential to turn either transistor ON