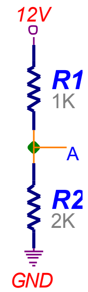
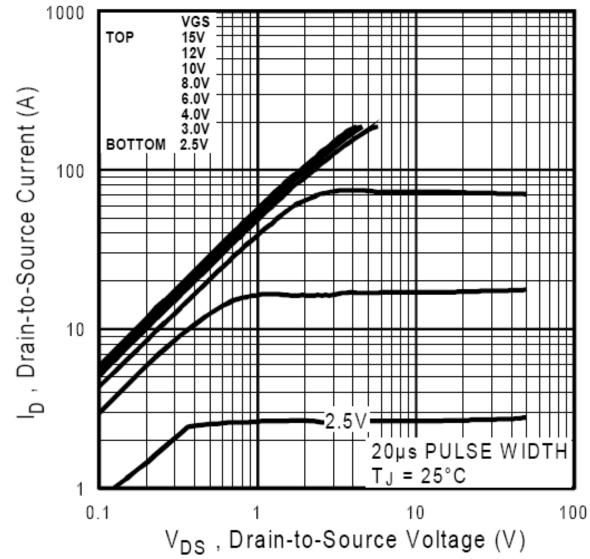
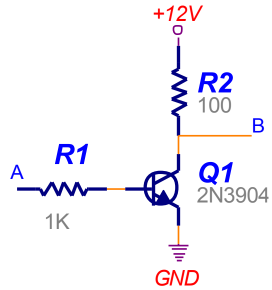
Review the Basics

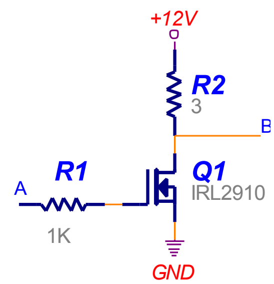


V = IR:
What is the current in R1 & R2 and the voltage at point A?
$I = 12V/3K\Omega = 4mA$
$V_A = 4mA*2K\Omega = 8V$

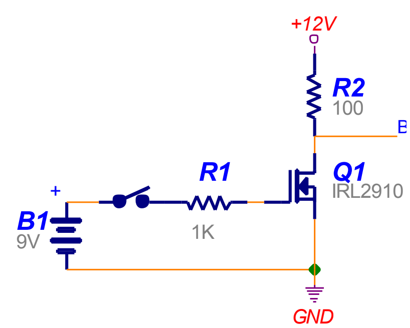




Transistors/FETs:
If A = 5V what's the current in R1?
$I_{R1} = (5V-0.7V)/1K\Omega = 4.3mA$
If $h_{fe} = 50$ what's the current in R2 and the voltage at B?
$h_{fe}*Ib = 50*4.3mA = 215mA$. If Q1 is fully on (i.e. V_B~0.2V) then $I_{R2} = 12V/100\Omega = 120mA$. With the given voltage and resistance it's impossible to put more than 120mA through R2 so $I_{R2} = 120mA$ and $V_B = 0.2V$ (note: It's OK to assume $V_B = 0$ for the current calculation).
If $h_{fe} = 10$ what's the current in R2 and the voltage at B?
$h_{fe}*Ib = 10*4.3mA = 43mA$. $43mA*100\Omega = 4.3V$. $V_B = 12V-4.3V = 7.7V$



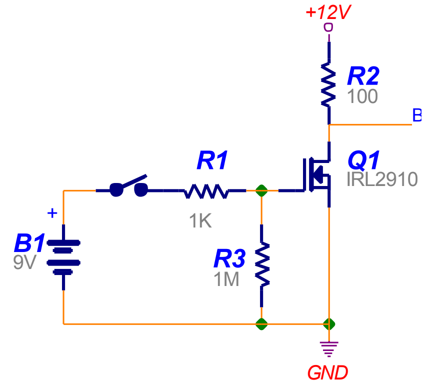
(Use the I_D VS V_{DS} graph for the FET questions)
If A = 2.5V what's the current in R2 and the voltage at B?
From graph I_{Dmax} with V_{GS}=2.5 is about 2.7A. I_{R2} = 2.7A.
$2.7A*3\Omega = 8.1V$. $V_B = 12 - 8.1V = 3.9V$.
If A = 15V what's the current in R2 and the voltage at B (Note: $R_{DS(ON)} = 0.026\Omega$)?
With V_{GS}=15V the graph shows an increasing I_D with V_{DS} (i.e. the max current is limited by the switch on resistance which at V_{GS}=15V is 0.026Ω).
Since $R_{DS} << 3\Omega$, I_D~4A, V_B=4*0.026=0.104V
This makes sense because the graph shows that when I_D=4A V_{DS}<0.1V).
Another words, the FET is fully on and the full 12V is across the 3Ω resistor.
Would the current in R2 or the voltage at B change if R1 was 100K (explain)?
NO. R1 controls how fast the gate capacitance charges and discharges. Doesn't affect steady state.



The switch is initially closed (short circuit) and the circuit is allowed to come to steady state (i.e. wait a few seconds). The switch is then opened (open circuit). What is the current in R2 and the voltage at B about one second after the switch is opened?
The gate will stay charged to 9V for quite a while so the FET will remain on. The max current when V_{GS}=9V is well above the 120mA max ($12V/100\Omega$) so $V_B = 0$, I_D = 120mA.

(Same circuit but with R3 added). The switch is initially closed and the circuit is allowed to come to steady state. The switch is then opened. What is the current in R2 and the voltage at B about one second after the switch is opened?

R3 will bleed off the gate charge quickly once the switch is opened. The input capacitance is about 3.7nF. T=RC=1MΩ*3.7nF=3.7ms. So after a few time constants the cap will be discharged (15-20ms). So after a few seconds the FET will be off and V_B=12V, I_D = 0.



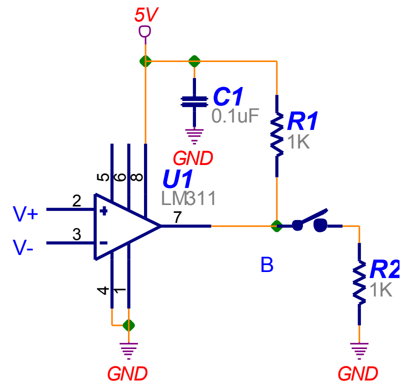
Comparators:

(switch open)

What's the voltage at B when V+ > V-? 5V

What's the voltage at B when V- > V+? 0V

(Recall that the LM311 has an open collector output).



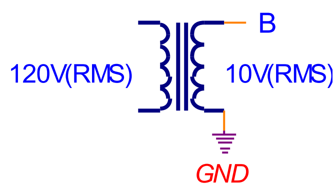
(switch closed)

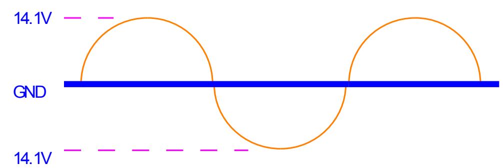
What's the voltage at B when V+ > V-? 2.5V

What's the voltage at B when V- > V+? 0V

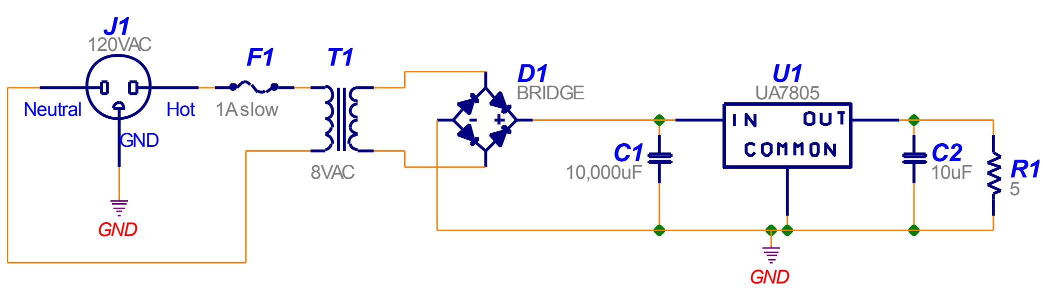
Voltage Regulators & Power Supplies:

This transformer has an input of 120Vrms @ 60Hz and an output of 10Vrms. Sketch the output waveform and label the peak voltage levels.





What is the approximate ripple voltage on C1 (and the max & min voltage on C1)?



8Vrms = 8*1.41=11.3V peak across the bridge input. The bridge will drop about 1.5V (current flows through two diodes at a time, about 0.75V drop per diode). The max voltage on C1 would be 11.3V-1.5V = 9.2V. Assuming the regulator is working, 5V across 5Ω is a 1A load current. Ripple voltage = I*dT/C = 1A*8.33ms/10,000uF = 0.833V. So minimum voltage on C1 is 9.2V-0.83V = 8.37V. Since 8.37V > 7V the output should be a regulated 5V.

Relays:

Why can't you use a SSR designed for an AC load with a DC load?

A SSR designed for an AC load probably uses an SCR to switch the load. An SCR turns off when the current stops (i.e. crosses zero 120 times a second). With a DC load the current will never cross zero and the SCR won't turn off (even if the trigger signal is removed).

What's a flyback diode and where do you put it?

See explanation at: http://www.physics.unlv.edu/~bill/PHYS483/relay.pdf