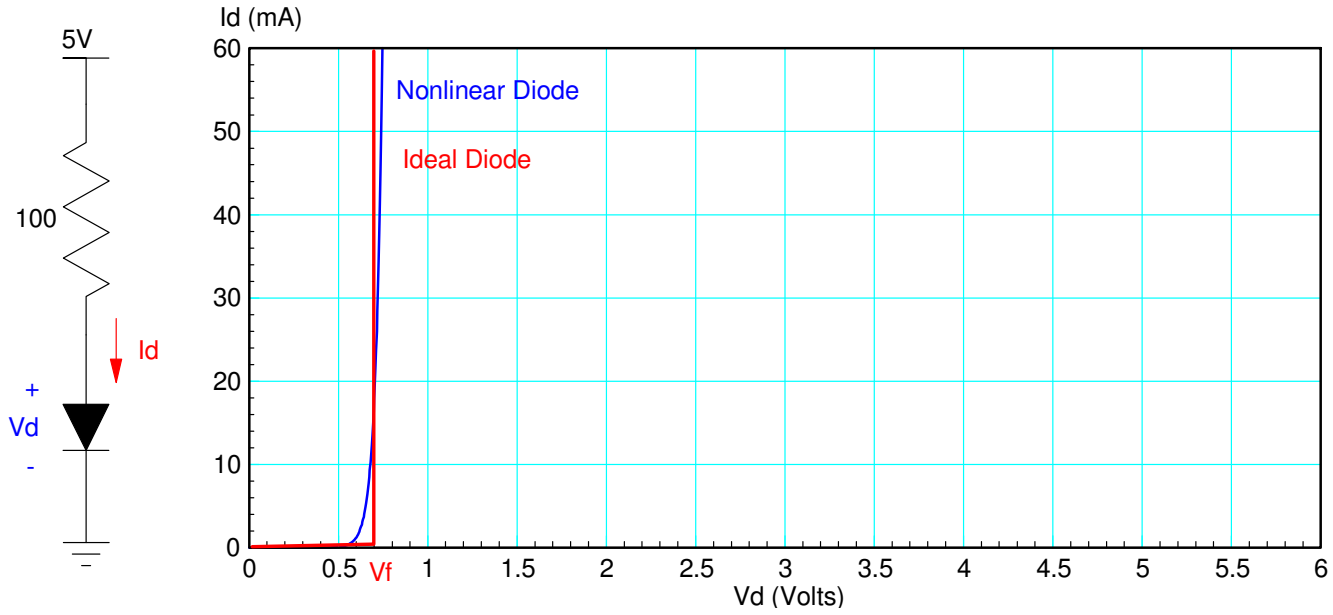
ECE 320 - Homework #3

Ideal Diodes, LEDs, AC to DC Converters. Due Monday, January 31st

Please make the subject "ECE 320 HW#3" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

Ideal Diodes:

1) Assume ideal sililcon diodes (Vf = 0.7V). Determine the voltages and currents for the following circuit



Assume the diode is on:

$$Vd = 0.7V$$

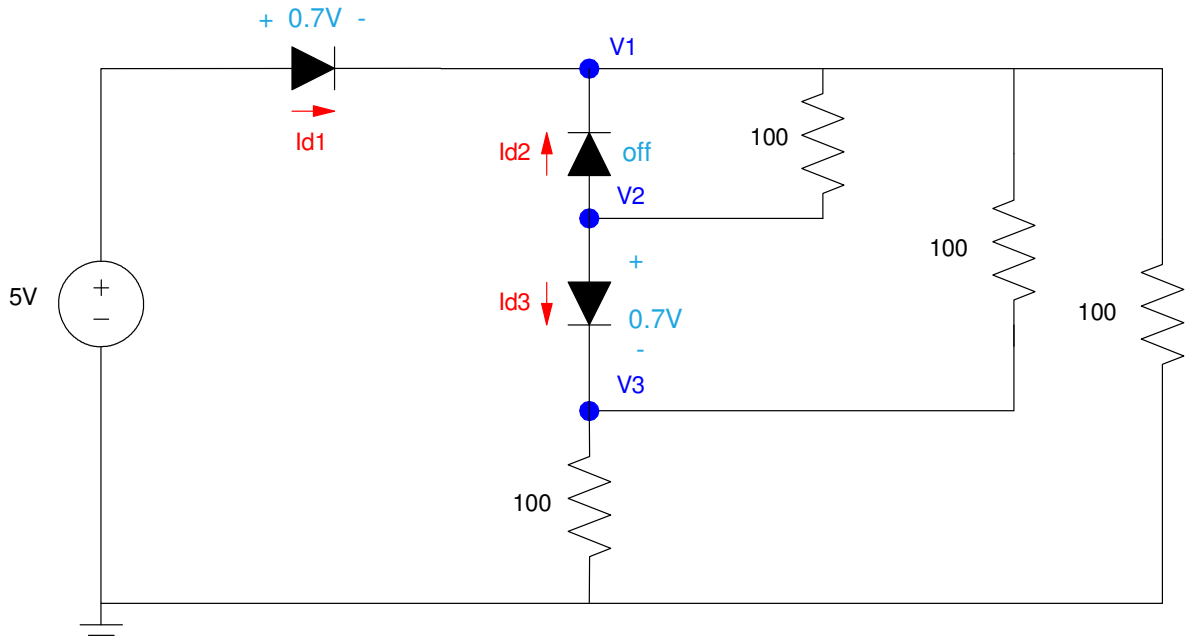
$$I_d = \left(\frac{5V - 0.7V}{100\Omega}\right) = 43.00mA$$

Note:

- The ideal diode model is easy to use
- It's a little off

	Vd	Id
Ideal Diode	0.7V	42mA
Numeric Solution (homework #2)	0.7588V	42.4117mA
Simulation (CircuitLab)	0.7517V	42.483mA
Lab (experimental)	0.768V	42.32mA (calculated from Vd)

2) Assume ideal silicon diodes (Vf = 0.7V). Determine the voltages and currents for the following circuit



Assume

- Diode 1 is on
- Diode 2 is off
- Diode 3 is on

Write the voltage node equations. With 3 unknowns {V1, V2, V3} we need 3 equations for 3 unknowns

$$V_1 = 5 - 0.7 = 4.3V$$

$$V_2 = V_3 + 0.7$$

$$\left(\frac{V_2 - V_1}{100}\right) + \left(\frac{V_3 - V_1}{100}\right) + \left(\frac{V_3}{100}\right) = 0$$

Solving

$$\left(\frac{(V_3+0.7) - 4.3}{100}\right) + \left(\frac{V_3 - 4.3}{100}\right) + \left(\frac{V_3}{100}\right) = 0$$

$$V_3 = 2.633V$$

$$V_2 = 3.333V$$

	V1	V2	V3
Ideal Diode	4.300 V	3.333 V	2.633 V
Numeric Solution (HW #2)	4.1861 V	3.2829 V	2.5447 V
Simulation (CircuitLab) (HW #2)	4.230 V	3.283 V	2.588 V
Lab (experimental) (HW #2)	4.17 V	3.25 V	2.55 V

LEDs

The specifications for a Piranah RGB LED are

Color	Vf @ 20mA	mcd @ 20mA
red	2.0V	10,000
green	3.2V	10,000
blue	3.2V	10,000

1) Design a circuit to drive these LEDs with a 5V source to produce Sky Blue:

- Red = 7411 mcd (189/255)
- Green = 10,000 mcd (255/255)
- Blue = 9490 mcd (242/255)

$$I_r = \left(\frac{7411mcd}{10{,}000mcd}\right)20mA = 14.822mA$$

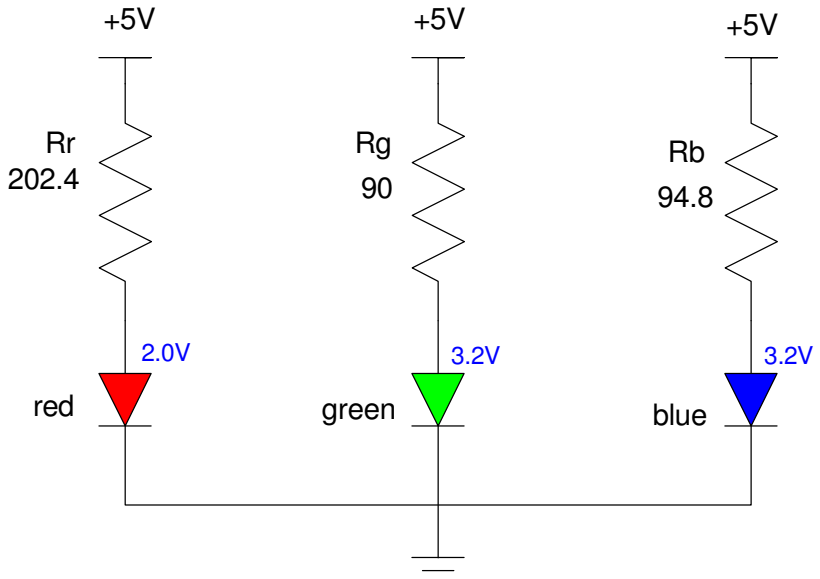
$$R_r = \left(\frac{5V-2.0V}{14.822mA}\right) = 202.4\Omega$$

$$I_g = \left(\frac{10{,}000mcd}{10{,}000mcd}\right)20mA = 20mA$$

$$R_g = \left(\frac{5V-3.2V}{20mA}\right) = 90.0\Omega$$

$$I_b = \left(\frac{9490mcd}{10{,}000mcd}\right)20mA = 18.98mA$$

$$R_b = \left(\frac{5V-3.2V}{18.98mA}\right) = 94.8\Omega$$



2) Design a circuit to drive these LEDs with a 5V source producing Olive Green:

- Red = 4862 mcd (124/255)
- Green = 6431 mcd (164/255)
- Blue = 4745 mcd (121/255)

$$I_r = \left(\frac{4862mcd}{10{,}000mcd}\right)20mA = 9.724mA$$

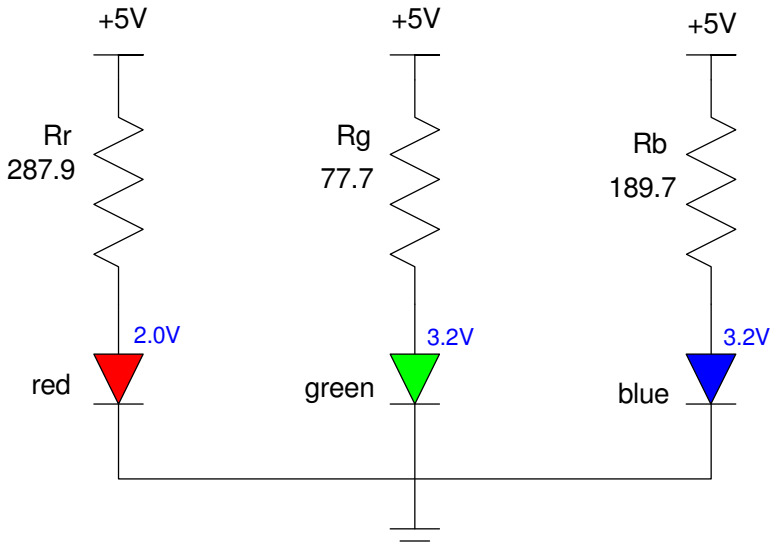
$$R_r = \left(\frac{5V-2.2V}{9.724mA}\right) = 287.9\Omega$$

$$I_g = \left(\frac{6431mcd}{10{,}000mcd}\right)20mA = 12.86mA$$

$$R_g = \left(\frac{5V-3.2V}{12.86mA}\right) = 77.7\Omega$$

$$I_b = \left(\frac{4745mcd}{10{,}000mcd}\right)20mA = 9.49mA$$

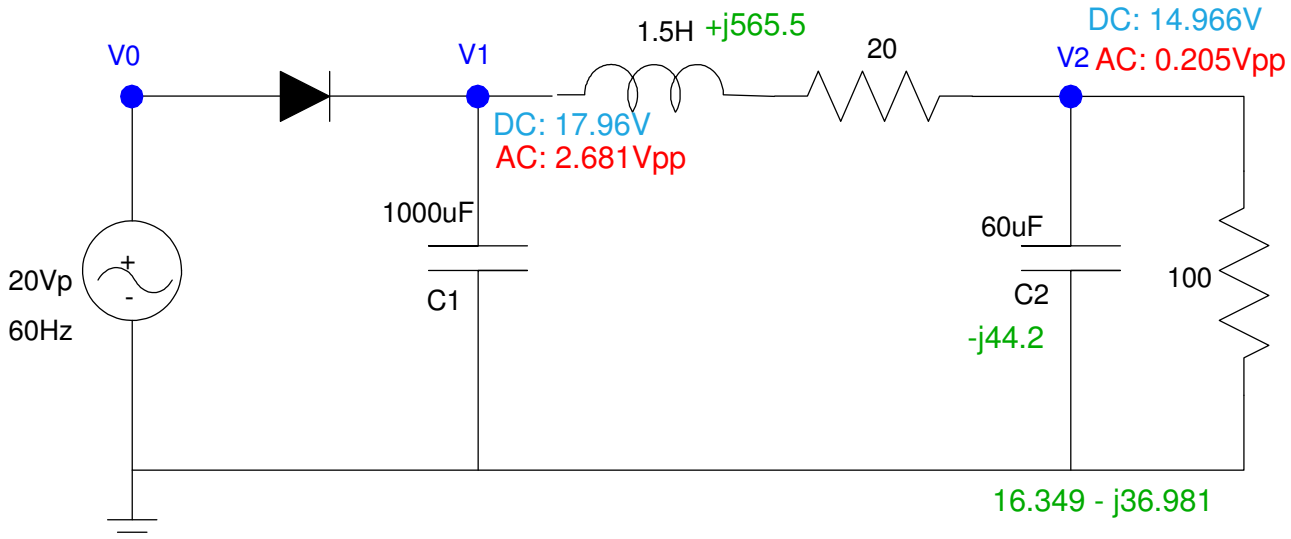
$$R_b = \left(\frac{5V-3.2V}{9.49mA}\right) = 189.7\Omega$$



AC to DC Converters

For the circuit below:

5) Determine the votlages at V1 and V2 (DC and AC)



DC Analysis:

$$\max(V_1) = 30V - 0.7V = 19.3V$$

$$I \approx \left(\frac{19.3V}{100\Omega+20\Omega}\right) = 160.8mA \qquad \textit{worst case}$$

$$I = C_1 \cdot \frac{dV_1}{dt}$$

$$160.8mA = 1000\mu F \cdot \frac{dV_1}{1/60s}$$

$$dV_1 = 2.681V$$

$$V_1(AC) = 2.681V_{pp}$$

$$V_1(DC) = \max(V_1) - \tfrac{1}{2}V_{1pp} = 19.3V - \tfrac{1}{2}(2.681V_{pp}) = 17.96V$$

$$V_2(DC) = \left(\frac{100\Omega}{100\Omega+20\Omega}\right)17.96V = 14.966V$$

AC Analysis

$$V_1(AC) = 2.681V_{pp}$$

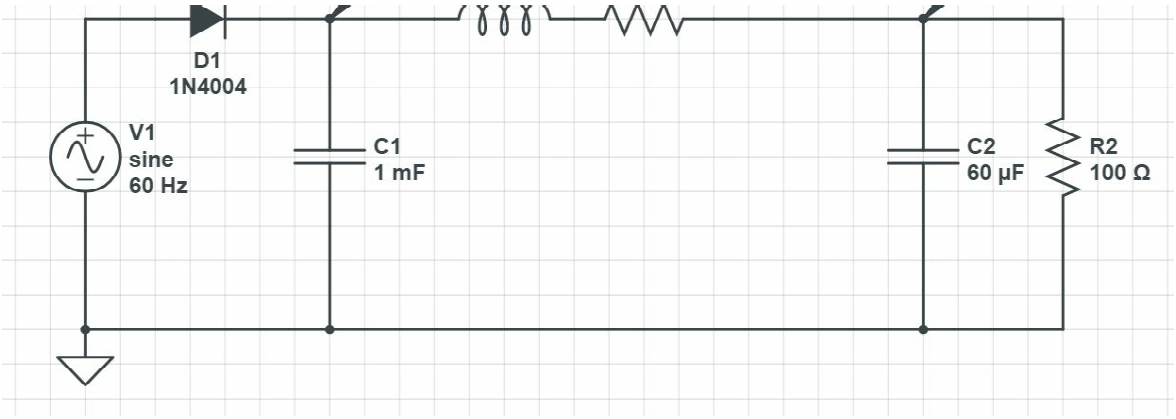
$$C_2 \rightarrow \frac{1}{j\omega C} = \frac{1}{j(377)(60uF)} = -j44.21\Omega$$

$$(-j44.21\Omega)||(100\Omega) = (16.349 - j36.981)\Omega$$

$$V_2(AC) = \left(\frac{(16.349-j36.981)}{(16/349-j39.981)+(20+j565.5)}\right)(2.681V_{pp})$$

$$|V_2(AC)| = 0.205V_{pp}$$

6) Build the circuit in CircuitLab (or similar program) and verify your calculations for problem #5



7) Determine C1 and C2 so that AC voltages are: V1 = 2Vpp and V2 = 250mVpp.

$$V_1(DC) = 19.3V - \tfrac{1}{2}(2V_{pp}) = 18.3V$$

$$I = \left(\frac{18.3V}{120\Omega}\right) = 152.5mA$$

$$I = C_1 \cdot \frac{dV}{dt}$$

$$152.5mA = C_1 \frac{2V_{pp}}{1/60s}$$

$$C_1 = 1271\mu F$$

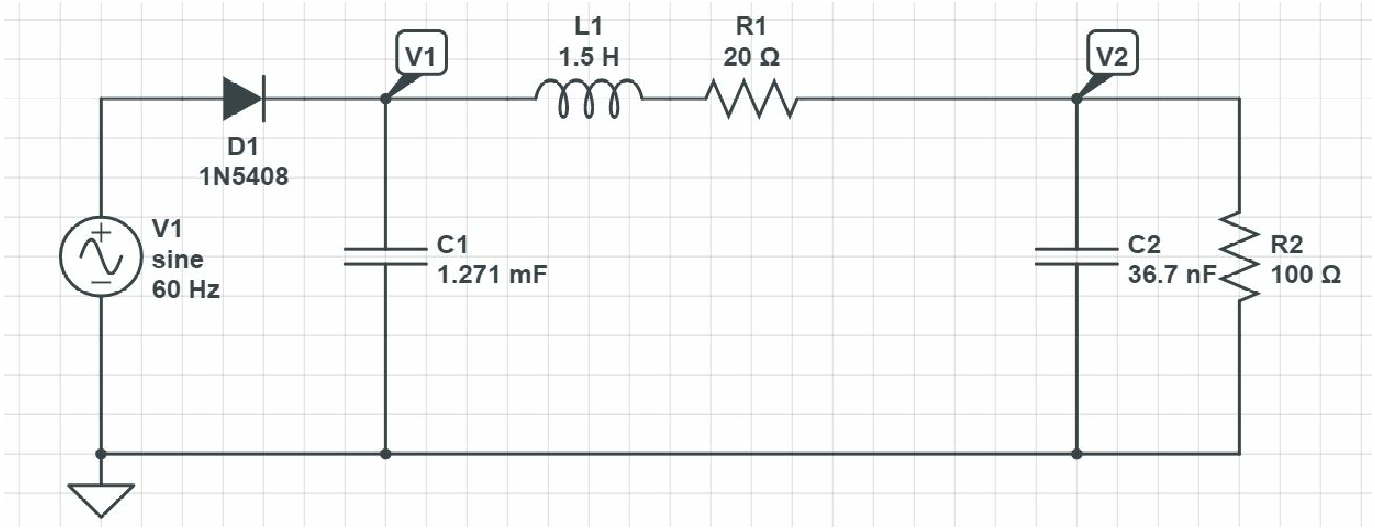
Assume C2 = 0.

$$V_2 = \left(\frac{100}{100+(20+j565.6)}\right) 2V_{pp} = 346mV_{pp}$$

For the ripple to be 250mVpp

$$\left|\frac{1}{j\omega C_2}\right| = \left(\frac{250mV_{pp}}{346mV_{pp}}\right) 100\Omega = 72.26\Omega$$

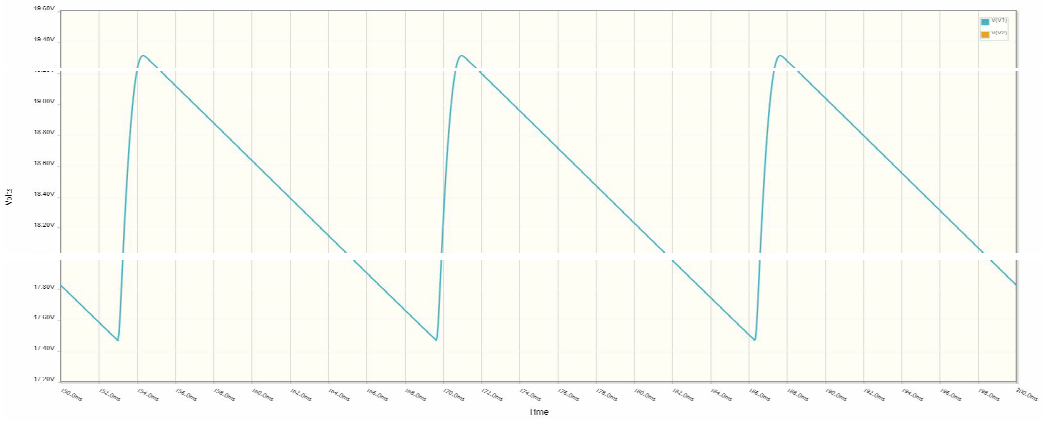
$$C_2 = 36.7nF$$



8) Build this circuit in CircuitLab (or similar program) and verify your calculations for problem #7

V1

- max(V1) = 19.31V
- min(V1) = 17.47V
- V1(AC) = max - min = 1.840Vpp (vs. 2.00Vpp calculated)
- V1(DC) = (max + min)/2 = 18.39V (vs. 18.30V calculated)



V1(t)

V2

- max(V2) = 15.44V
- min(V2) = 15.18V
- V2(AC) = max - min =260mVpp (vs. 250mVpp calculated)
- V2(DC) = (max + min)/2 = 15.31V

V2(t)