

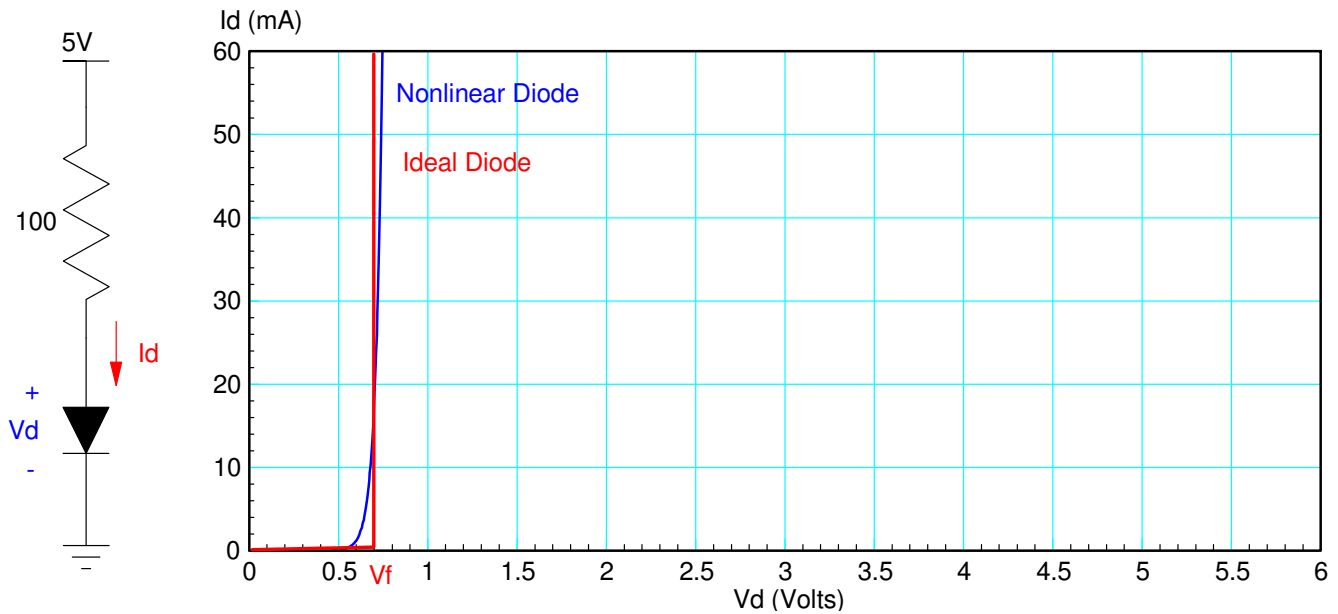
ECE 320 - Homework #3

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 silicon diodes ($V_f = 0.7V$). Determine the voltages and currents for the following circuit



Assume the diode is on:

$$V_d = 0.7V$$

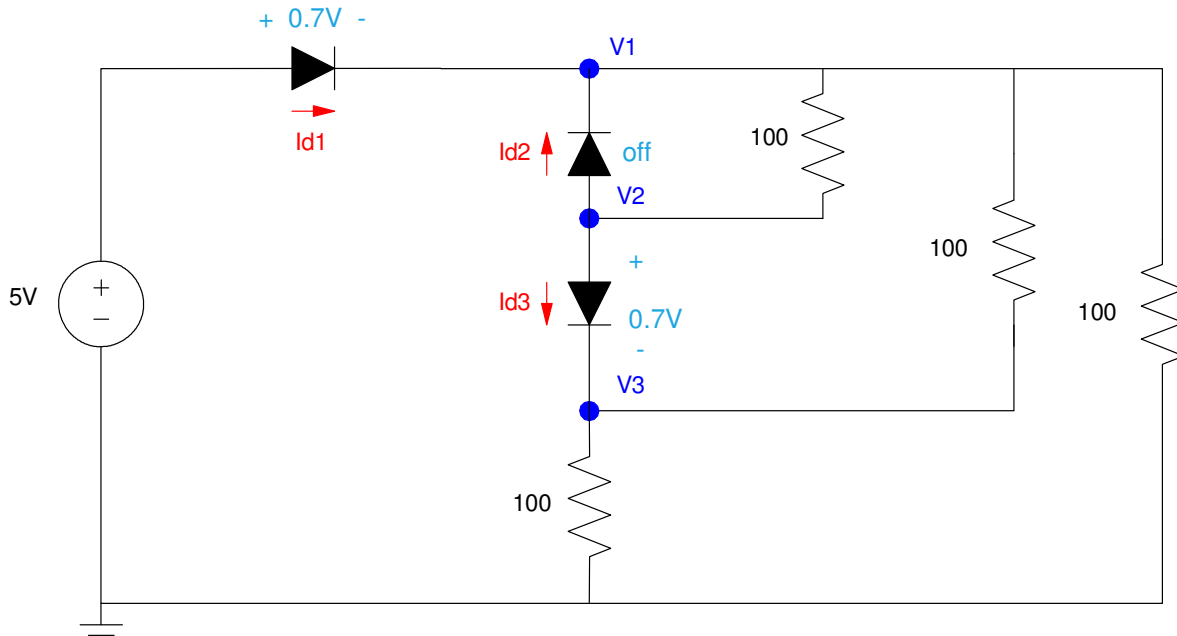
$$I_d = \left(\frac{5V - 0.7V}{100\Omega} \right) = 43.00mA$$

Note:

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

	V_d	I_d
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 V_d)

2) Assume ideal silicon diodes ($V_f = 0.7V$). 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 $\{V_1, V_2, V_3\}$ 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)

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

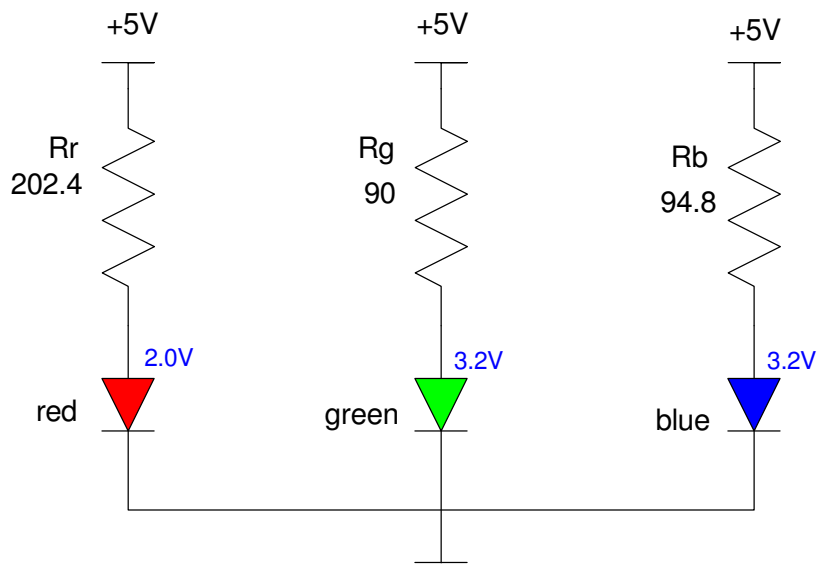
$$R_r = \left(\frac{5 \text{ V} - 2.0 \text{ V}}{14.822 \text{ mA}} \right) = 202.4 \Omega$$

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

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

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

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



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)

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

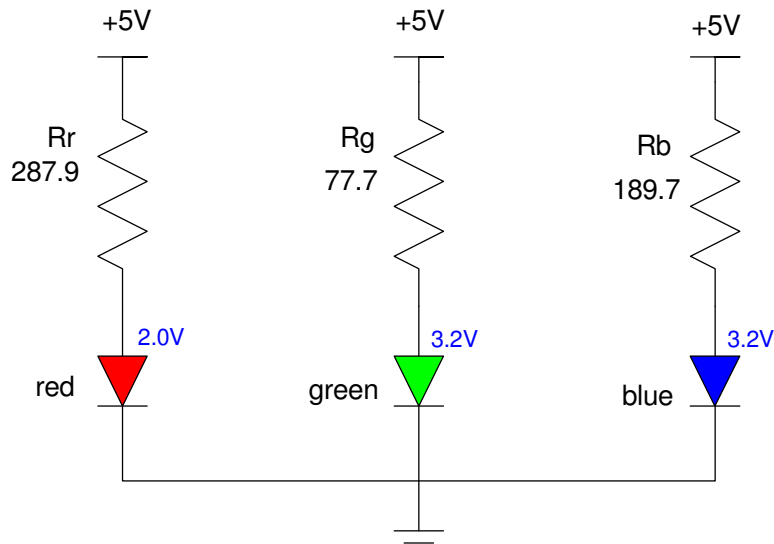
$$R_r = \left(\frac{5 \text{ V} - 2.2 \text{ V}}{9.724 \text{ mA}} \right) = 287.9 \Omega$$

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

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

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

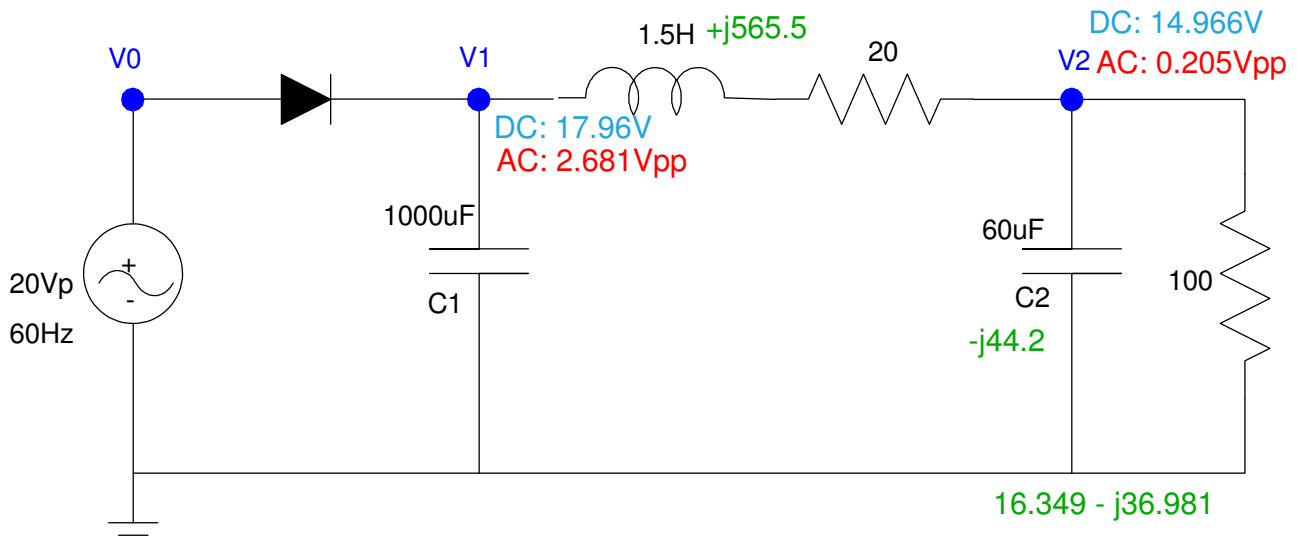
$$R_b = \left(\frac{5 \text{ V} - 3.2 \text{ V}}{9.49 \text{ mA}} \right) = 189.7 \Omega$$



AC to DC Converters

For the circuit below:

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



DC Analysis:

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

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

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

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

$$dV_1 = 2.681V$$

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

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

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

AC Analysis

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

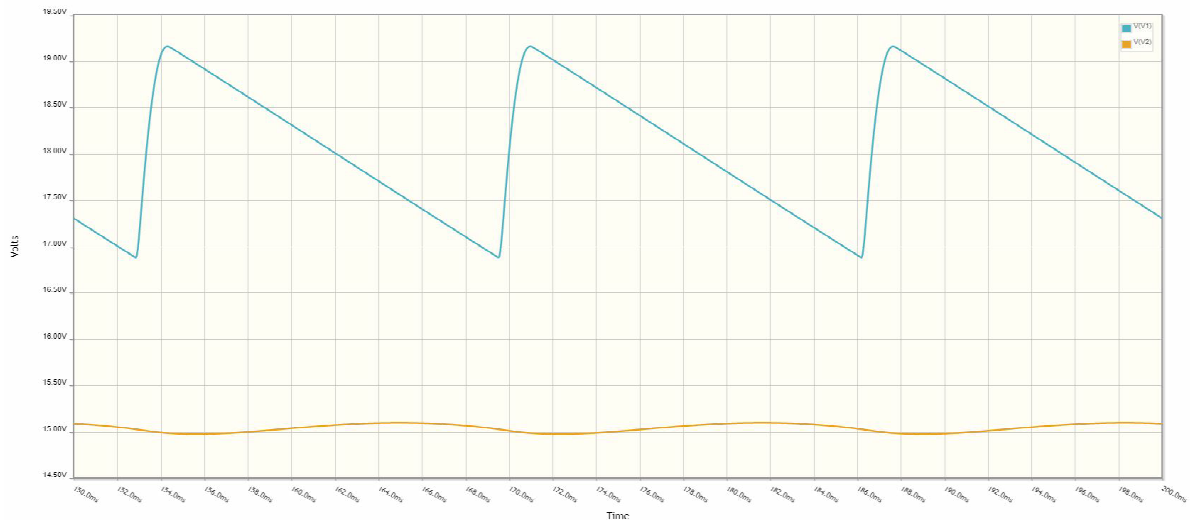
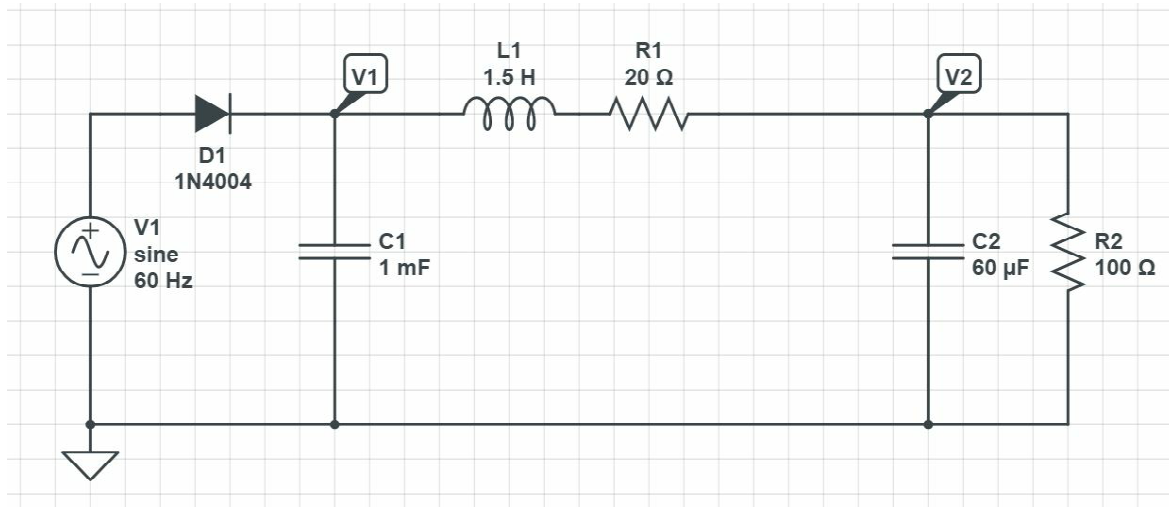
$$C_2 \rightarrow \frac{1}{j\omega C} = \frac{1}{j(377)(60\mu F)} = -j44.21\Omega$$

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

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

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

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



V1 (top curve)

- $\max(V1) = 19.16\text{V}$
- $\min(V1) = 16.88\text{V}$
- $V1(\text{AC}) = \max - \min = 2.28\text{Vpp}$
- $V1(\text{DC}) = (\max + \min)/2 = 18.02\text{V}$

V2 (bottom curve)

- $\max(V2) = 15.09\text{V}$
- $\min(V2) = 14.97\text{V}$
- $V2(\text{AC}) = \max - \min = 120\text{mVpp}$
- $V2(\text{DC}) = (\max + \min)/2 = 15.02\text{V}$

	V1		V2	
	DC	AC	DC	AC
calculated	17.96 V	2.681 Vpp	14.966 V	205 mVpp
simulated	18.02 V	2.28 Vpp	15.02 V	120 mVpp

7) Determine C1 and C2 so that AC voltages are: $V_1 = 2V_{pp}$ and $V_2 = 250mV_{pp}$.

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

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

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

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

$$C_1 = 1271\mu F$$

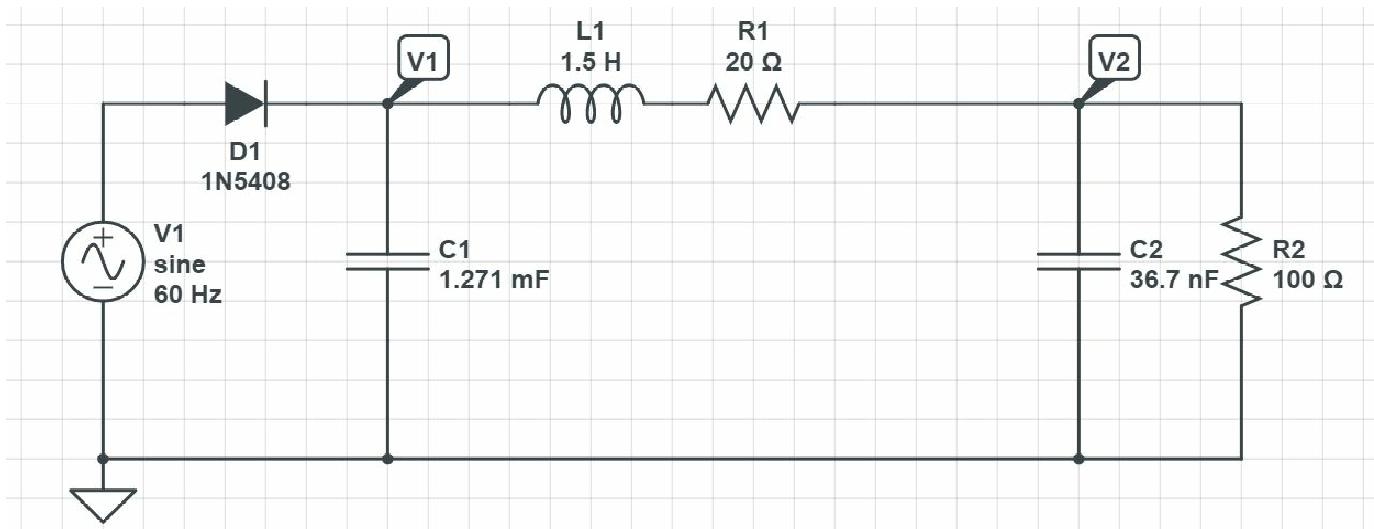
Assume $C_2 = 0$.

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

For the ripple to be 250mVpp

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

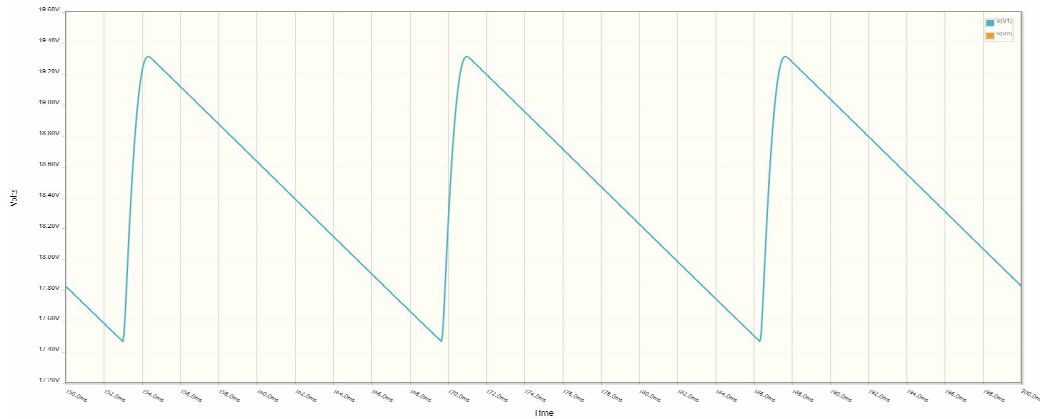
$$C_2 = 36.7nF$$



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

V1

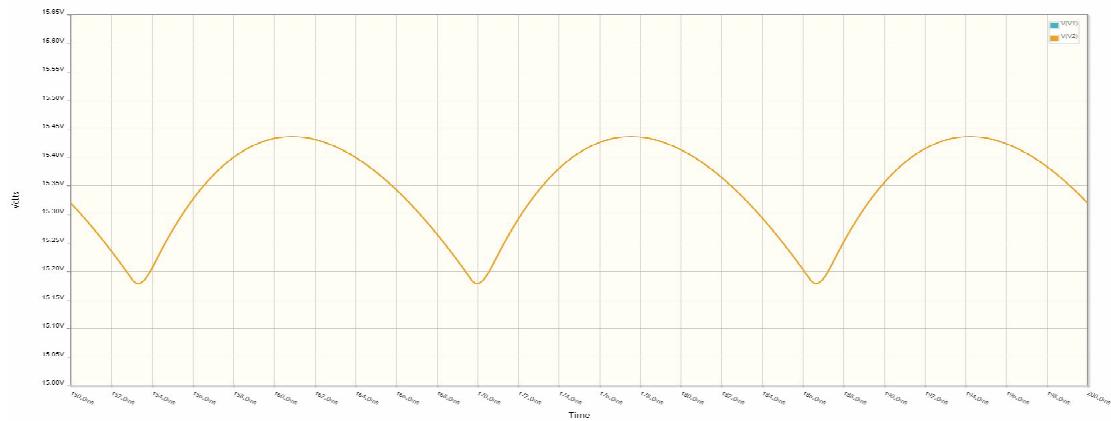
- $\max(V1) = 19.31V$
- $\min(V1) = 17.47V$
- $V1(AC) = \max - \min = 1.840V_{pp}$ (vs. $2.00V_{pp}$ calculated)
- $V1(DC) = (\max + \min)/2 = 18.39V$ (vs. $18.30V$ calculated)



V1(t)

V2

- $\max(V2) = 15.44V$
- $\min(V2) = 15.18V$
- $V2(AC) = \max - \min = 260mV_{pp}$ (vs. $250mV_{pp}$ calculated)
- $V2(DC) = (\max + \min)/2 = 15.31V$



V2(t)