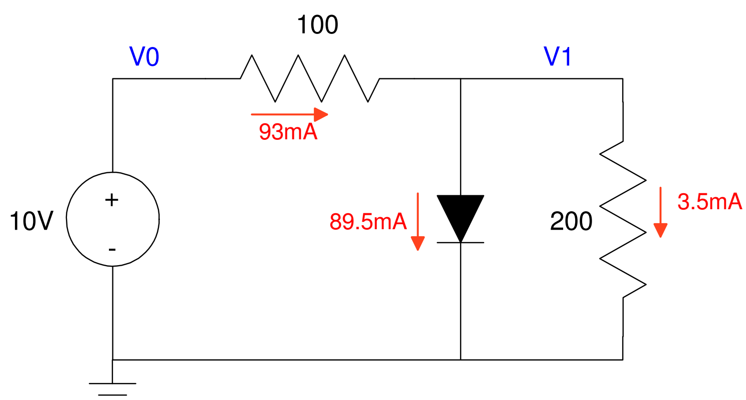
ECE 320 - Homework #3

Ideal Diodes, LEDs, AC to DC Converters. Due Monday, January 28th, 2019

Ideal Diodes

1) Assume an ideal silicon diode (Vf = 0.7V). Determine the voltages and currents



Assume the diode is on

$$V_1 = 0.7V$$

The currents are then

$$I_{100} = \left(\frac{10V-0.7V}{100\Omega}\right) = 93mA$$

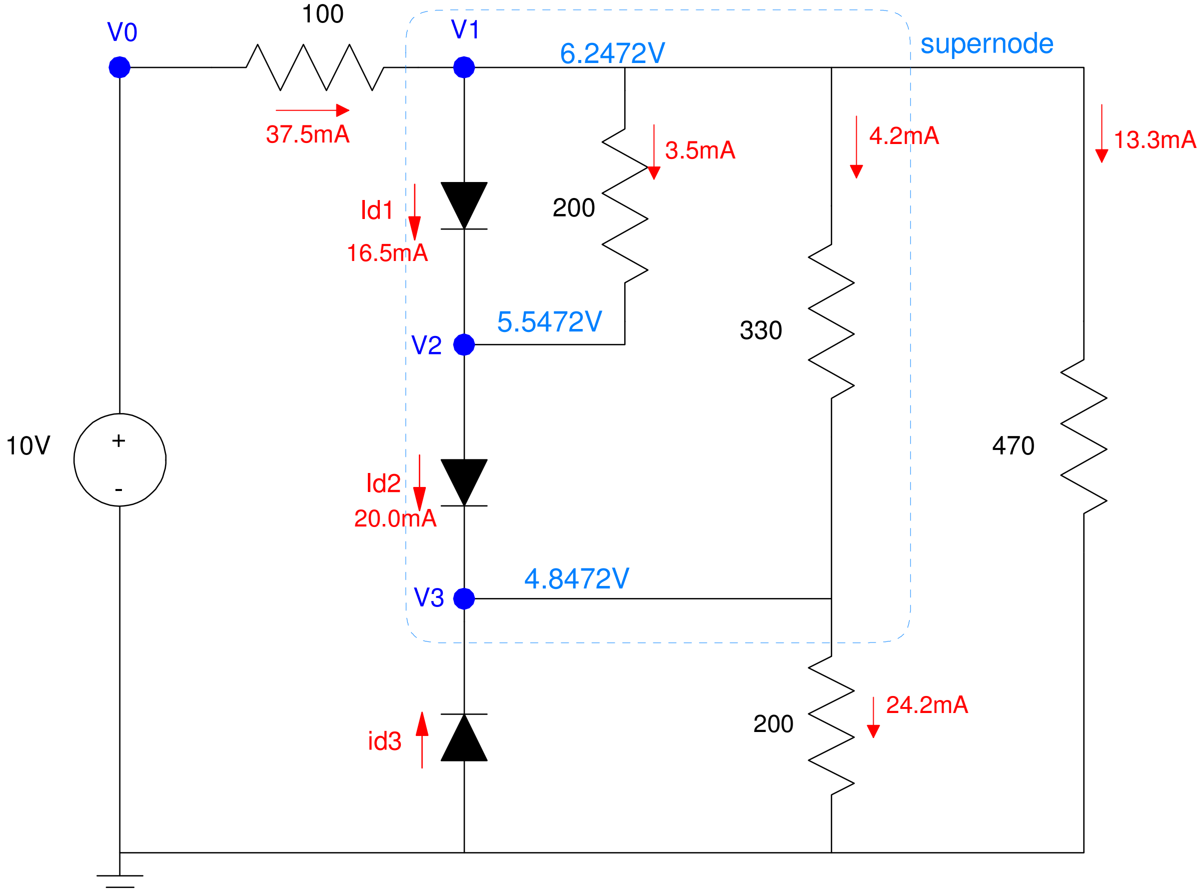
$$I_{200} = \left(\frac{0.7V}{200\Omega}\right) = 3.5mA$$

The current through the diode is then

$$I_d = I_{100} - I_{200}$$

$$I_d = 89.5mA$$

2) Assume an ideal silicon diode (Vf = 0.7V). Determine the voltages and currents



$$V_2 = V_1 - 0.7$$

$$V_3 = V_1 - 1.4$$

$$\left(\frac{V_1-10}{100}\right) + \left(\frac{V_1-1.4}{200}\right) + \left(\frac{V_1}{470}\right) = 0 \quad \text{Super Node}$$

Solving

$$V_1 = 6.2472V$$

$$V_2 = 5.5472V$$

$$V_3 = 4.8472V$$

The resulting currents are shown in the above figure. Note that the currents through the diodes which are "on" are positive.

LED's

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

3) Design a circuit to drive these LEDs with a 10V source to produce lavender:

- Red = 9647 mcd (246/255)
- Green = 8117 mcd (207/255)
- Blue = 9882 mcd (252/255)

Assums a 10V DC source

Red LED

$$I_r = \left(\frac{9647mcd}{10{,}000mcd}\right)20mA = 19.29mA$$

$$R_r = \left(\frac{10V-2.0V}{19.29mA}\right) = 415\Omega$$

Green LED

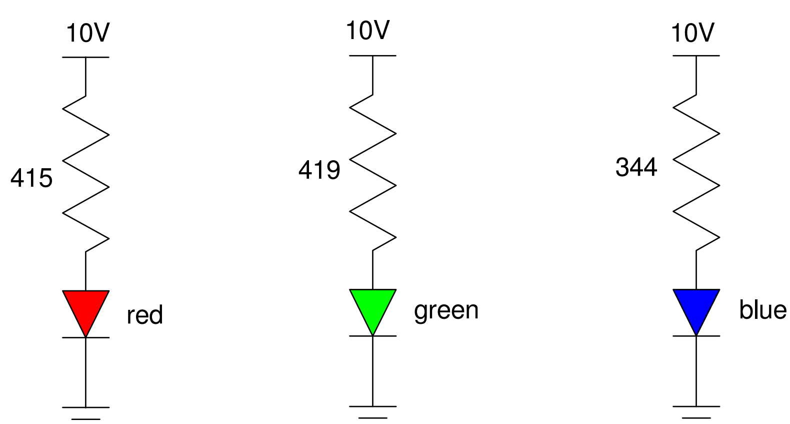
$$I_g = \left(\frac{8117mcd}{10{,}000mcd}\right)20mA = 16.23mA$$

$$R_g = \left(\frac{10V-3.2V}{16.23mA}\right) = 419\Omega$$

Blue LED

$$I_b = \left(\frac{9882mcd}{10{,}000mcd}\right)20mA = 19.76mA$$

$$R_b = \left(\frac{10V-3.2V}{19.76mA}\right) = 344\Omega$$



4) Design a circuit to drive these LEDs with a 10V source producing steel blue:

- Red = 4745 mcd (121/255)
- Green = 6078 mcd (155/255)
- Blue = 8235 mcd (210/255)

Red LED

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

$$R_r = \left(\frac{10V - 2.0V}{9.49mA}\right) = 843\Omega$$

Green LED

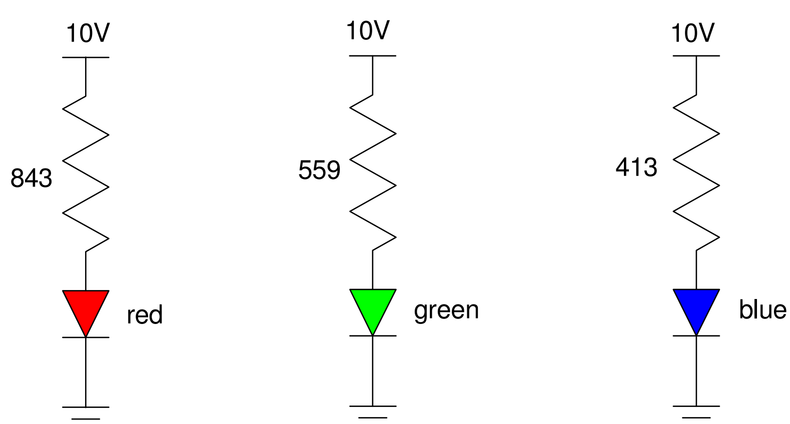
$$I_g = \left(\frac{6078mcd}{10{,}000mcd}\right)20mA = 12.15mA$$

$$R_g = \left(\frac{10V - 3.2V}{12.15mA}\right) = 559\Omega$$

Blue LED

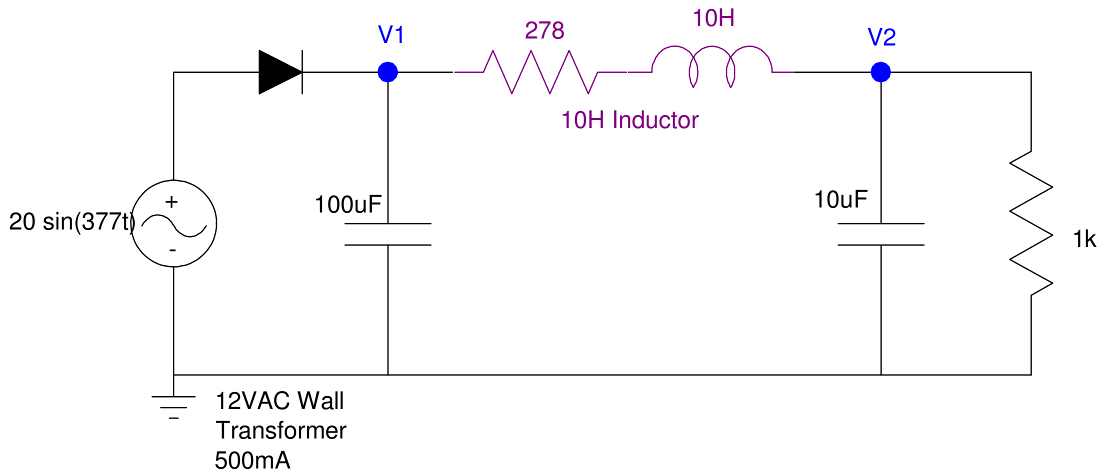
$$I_b = \left(\frac{8235mcd}{10{,}000mcd}\right)20mA = 16.47mA$$

$$R_b = \left(\frac{10V - 3.2V}{16.47mA}\right) = 413\Omega$$



AC to DC Converters

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



The peak voltage at V1 is 19.3V (20.0V minus the 0.7V drop across the diode). Assume there is no ripple (worst case). The current is then

$$I = \left(\frac{19.3V}{1278\Omega}\right) = 15.1mA$$

The ripple at V1 is then

$$I = C\frac{dV}{dt}$$

$$15.1mA = 100\mu F \cdot \frac{dV}{1/60s}$$

$$dV = 2.517V_{pp}$$

The DC voltage at V1 is then (approximately)

$$V_1 = V_{1\max} - \frac{1}{2}V_{1pp}$$

$$V_1 = 19.3 - \frac{1}{2} \cdot 2.517V_{pp}$$

$$V_1 = 18.04V$$

The AC votlage at V1 is

$$V_{1pp} = 2.517V_{pp}$$

The DC voltage at V2 is

$$V_2 = \left(\frac{1000}{1000+278}\right)18.04V$$

$$V_2 = 14.117V$$

The AC voltage at V2 is...

The AC impedance of the capacitor is

$$Z_c = \frac{1}{j\omega C} = \frac{1}{j \cdot 377 \cdot 10uF} = -j265\Omega$$

The AC impedance of the inductor is

$$Z_L = j\omega L = j3770\Omega$$

1000 Ohms in parallel with -j265 Ohms is

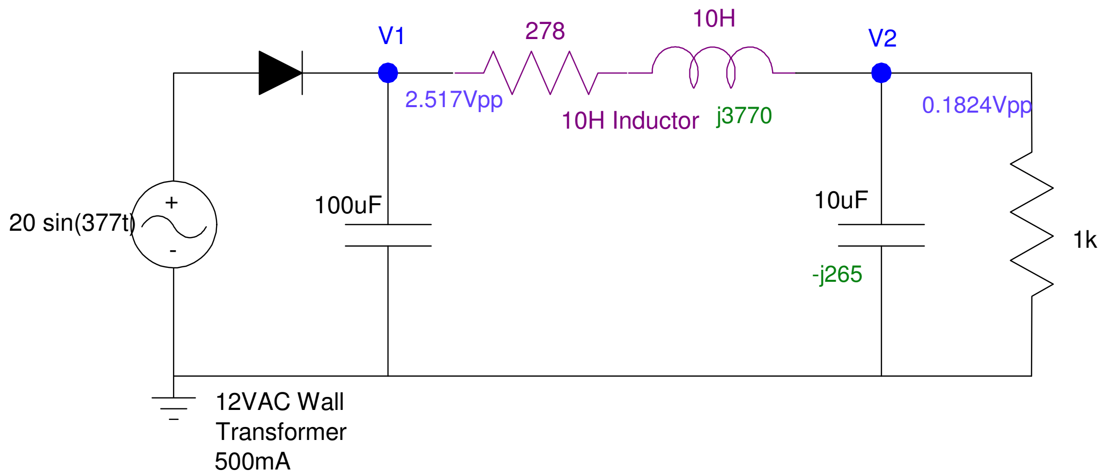
$$\left(\frac{1}{1000} + \frac{1}{-j265}\right)^{-1} = 65.73 - j247.8$$

By voltage division

$$V_{2pp} = \left(\frac{(65.73 - j247.8)}{(65.73 - j247.8) + (278 + j3770)}\right) V_{1pp}$$

$$V_{2pp} = \left(\frac{(65.73 - j247.8)}{(65.73 - j247.8) + (278 + j3770)}\right) \cdot 2.517 V_{pp}$$

$$V_{2pp} = 0.1824 V_{pp}$$

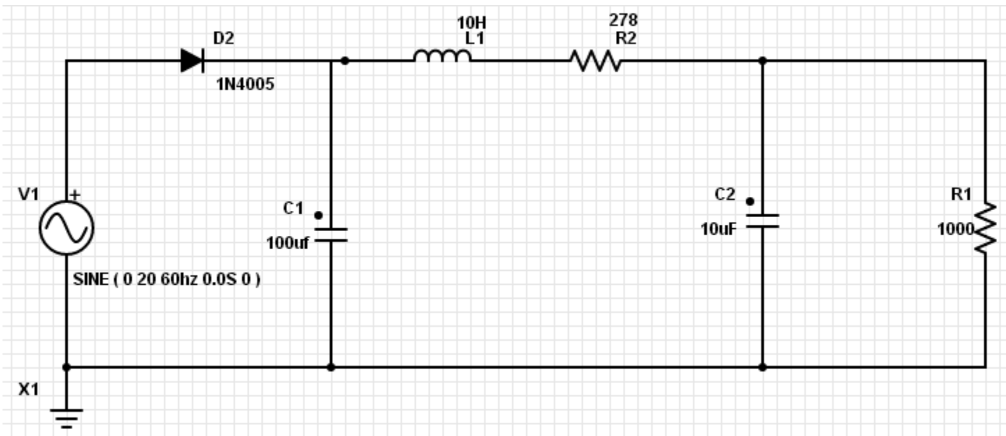


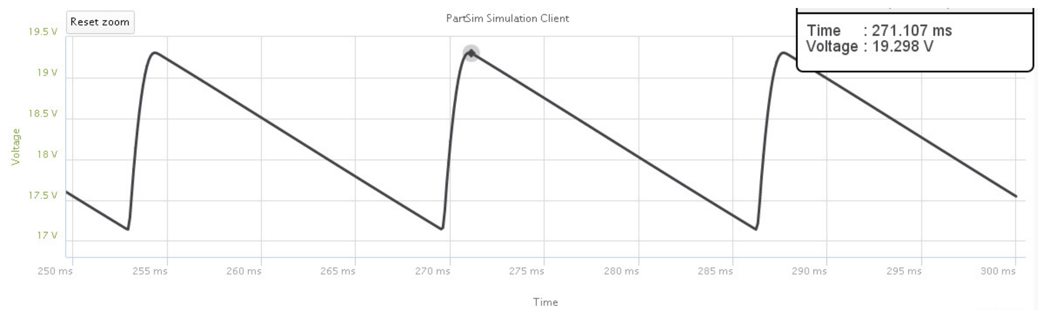
Net Result

	V1	V2
DC	18.04V	14.12V
AC	2.517Vpp	0.1824Vpp

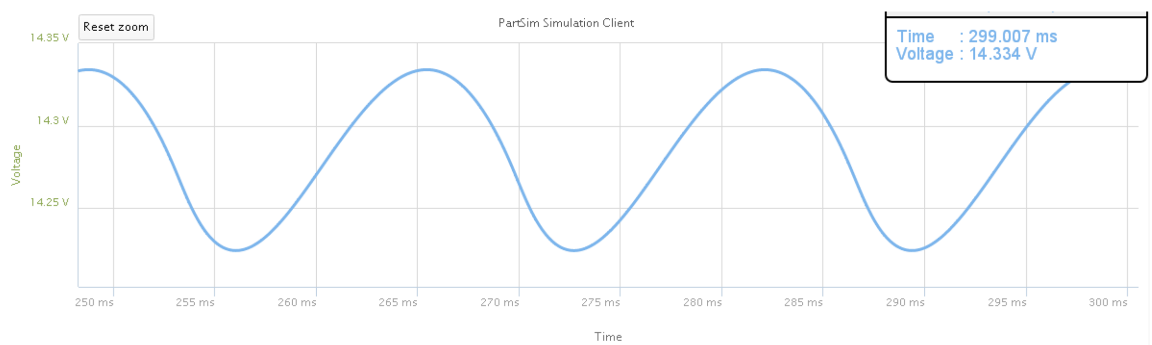
Note: The values are a little off since the current was assumed to be 15.1mA (from assuming V1 is 19.3V) This is a little high, so the actual numbers should be slightly less.

6) Simulate this circuit in PartSim and check the voltages at V1 and V2 (DC and AC)





Voltage V1



Voltage V2

Comparing the simulation and calculations

	Calculated		Simulated		Measured	
	DC	AC	DC	AC	DC	AC
V1	18.04V	2.517Vpp	18.22V	2.16Vpp		
V2	14.12V	0.1824Vpp	14.26V	0.143Vpp		

7) **Lab:** Build this circuit in lab and check the voltages at V1 and V2 (DC and AC)

8) Modify this circuit (change the capacitors) so that

- The AC voltage at V1 is 2Vpp
- The AC voltage at V2 is 0.2Vpp

Start with V1

DC: max(V1) = 19.3V

V1(DC) = 18.3

$$I = \left(\frac{18.3V}{1278\Omega}\right) = 14.3mA$$

$$I = C\frac{dV}{dt}$$

$$14.3mA = C \cdot \frac{2V_{pp}}{1/60s}$$

$$C = 119.3\mu F$$

V2: If you let C = 0, the ripple at V2 will be

$$V_2 = \left(\frac{1000}{1000+278+j3780}\right) \cdot 2V_{pp}$$

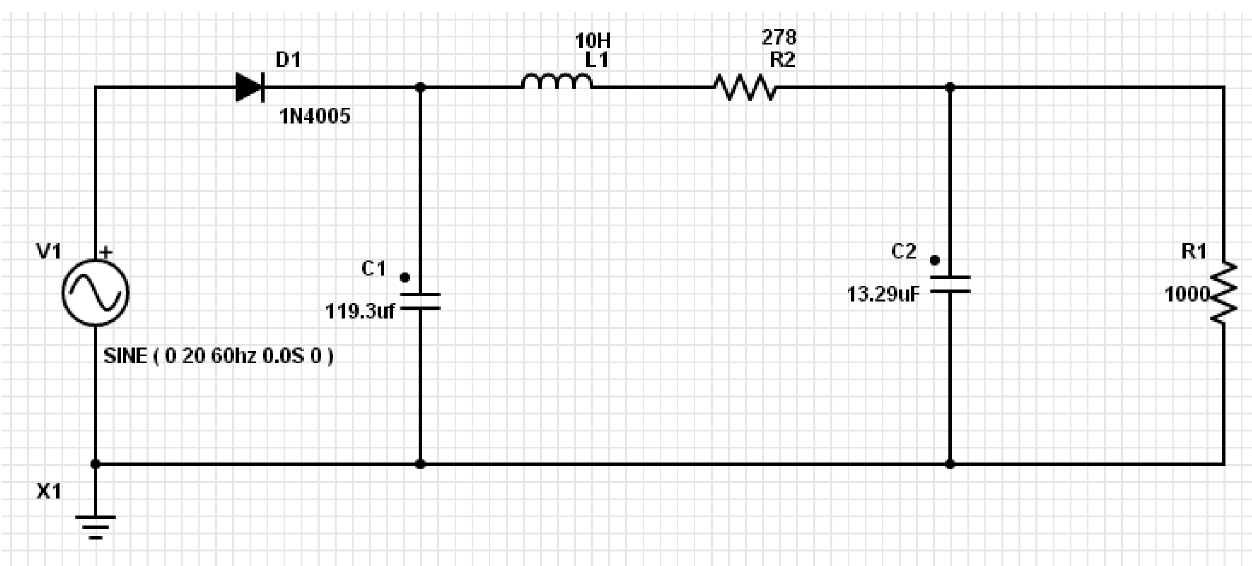
$$V_2 = 501mV_{pp}$$

This is 5.01 times too large. So, let

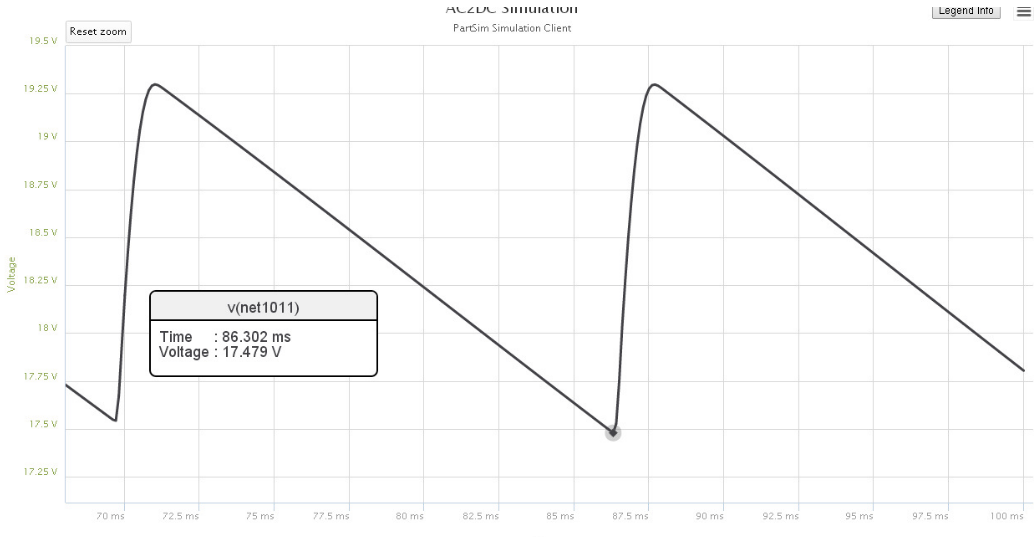
$$Z_c = \frac{1}{5.01} \cdot 1000\Omega = 199.5\Omega$$

$$\frac{1}{\omega C} = 199.5\Omega$$

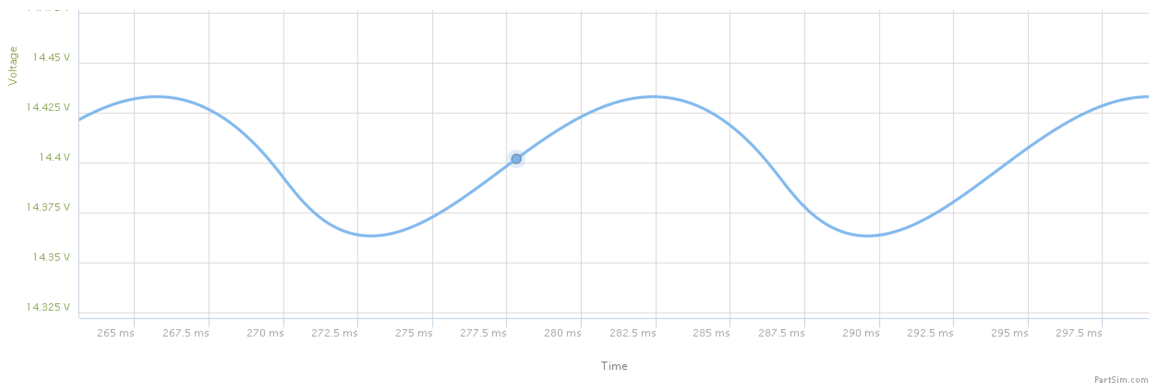
$$C = 13.29\mu F$$



Checking in PartSim



Voltage V1



Voltage V2

	Calculated		Simulated	
	DC	AC	DC	AC
V1	18.3V	2Vpp	18.22V	1.82Vpp
V2	14.32V	100mVpp	14.40V	80mVpp