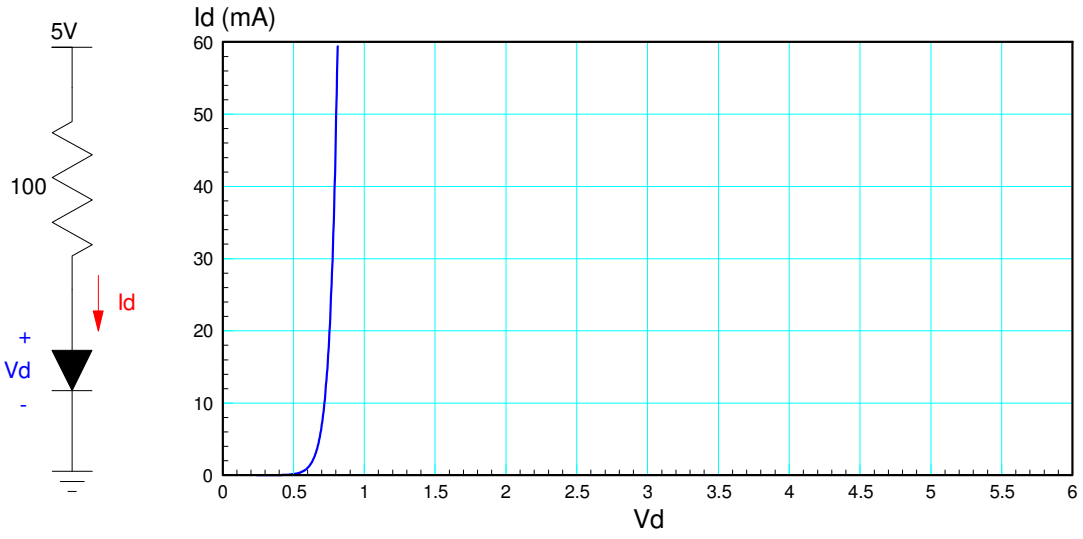
ECE 320 - Homework #3

Ideal Diodes, LEDs, AC to DC Converters. Due February 1st

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 (Vf = 0.7V). Determine the voltage and the current



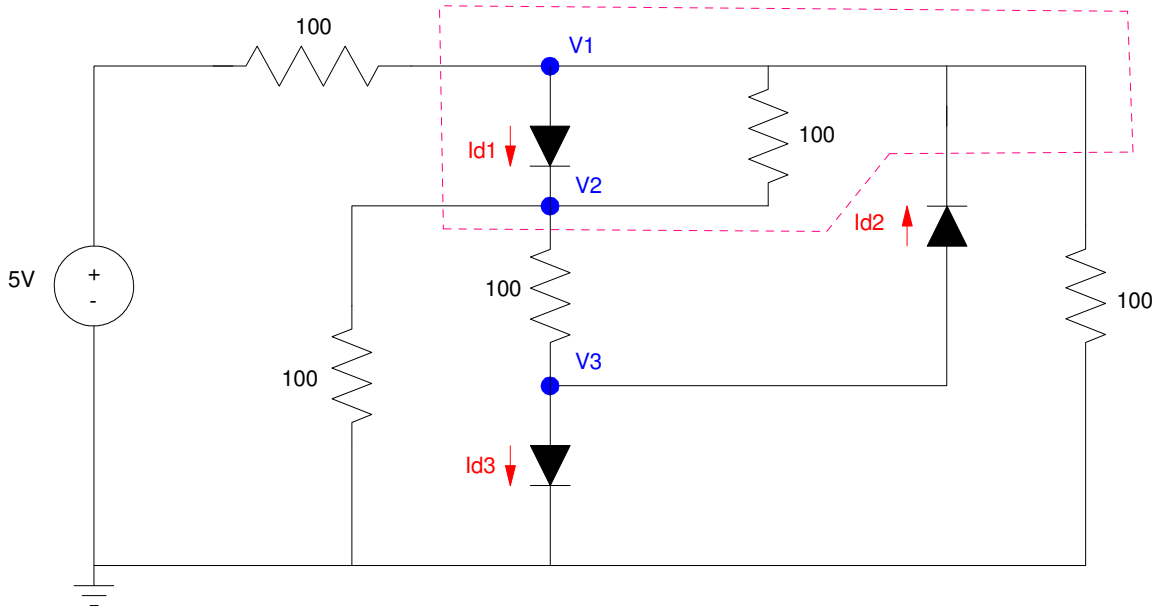
Assume the diode is on

$$V_d = 0.7V$$

$$I_d = \left(\frac{5V - 0.7V}{100}\right) = 43.0mA$$

*note: This was **way** easier than solving nonlinear equaitons.*

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



Assume (this is a guess)

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

Then

$$V_3 = 0.7V$$

$$V_2 = V_1 - 0.7V$$

The third equation is a supernode

$$\left(\frac{V_1-5}{100}\right)+\left(\frac{V_2}{100}\right)+\left(\frac{V_2-V_3}{100}\right)-I_{d2}+\left(\frac{V_1}{100}\right)=0$$

Substituting for V2 and V3 and multiplying by 100 to clear the denominator

$$(V_1-5)+(V_1-0.7)+(V_1-1.4)+(V_1)=0$$

Solving

$V_1 = 1.775V$ (1.7255V solving the nonlinear equations)

$V_2 = 1.075V$ (1.0801V solving the nonlinear equations)

$V_3 = 0.700V$ (0.6113V solving the nonlinear equations)

Also note that the resistor values don't matter: as long as they are all the same, the voltages remain unchanged for ideal diodes.

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

3) Design a circuit to drive these LEDs with a 5V source to produce baby blue:

- Red = 8470 mcd (216/255)
- Green = 9647 mcd (246/255)
- Blue = 9921 mcd (253/255)

$$I_r = \left(\frac{8470mcd}{10000mcd}\right) 20mA = 16.94mA$$

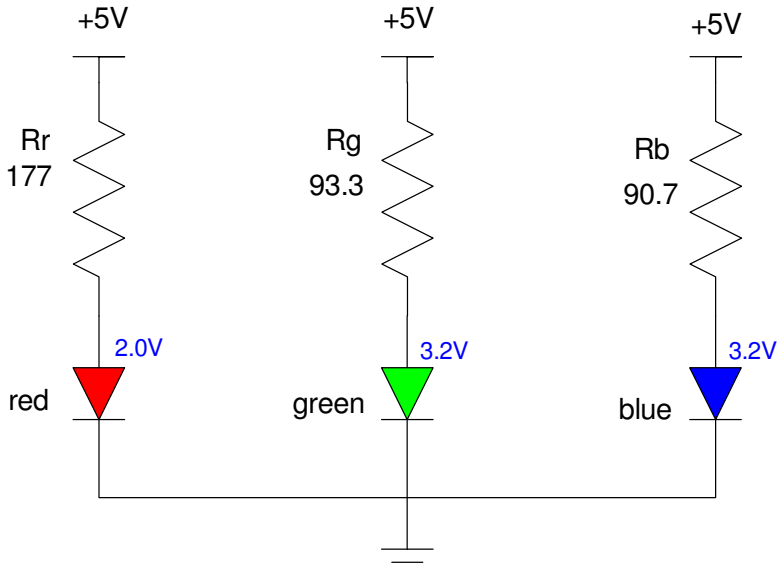
$$R_r = \left(\frac{5V-2.0V}{16.94mA}\right) = 177\Omega$$

$$I_g = \left(\frac{9647mcd}{10000mcd}\right) 20mA = 19.29mA$$

$$R_g = \left(\frac{5V-3.2V}{19.29mA}\right) = 93.3\Omega$$

$$I_b = \left(\frac{9921mcd}{10000mcd}\right) 20mA = 19.84mA$$

$$R_b = \left(\frac{5V-3.2V}{19.84mA}\right) = 90.7\Omega$$



4) Design a circuit to drive these LEDs with a 5V source producing burgundy red:

- Red = 6274 mcd (160/255)
- Green = 313 mcd (8/255)
- Blue = 745 mcd (19/255)

$$I_r = \left(\frac{6274mcd}{10000mcd}\right)20mA = 12.55mA$$

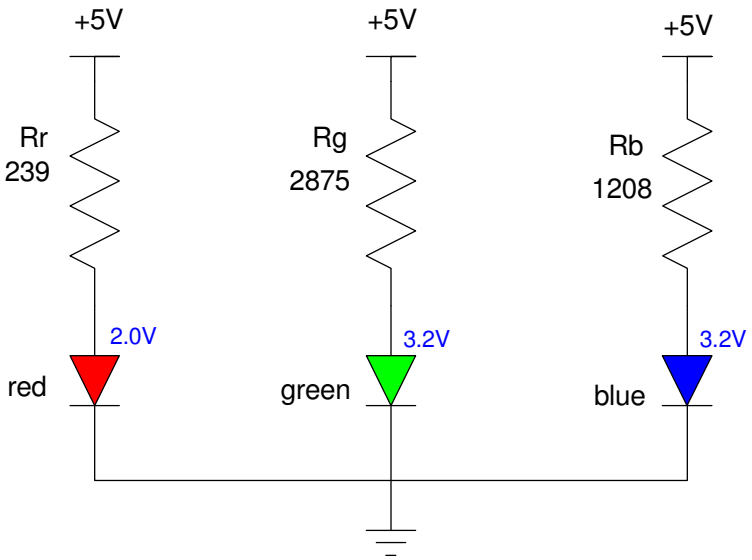
$$R_r = \left(\frac{5V-2.0V}{12.55mA}\right) = 239\Omega$$

$$I_g = \left(\frac{313mcd}{10000mcd}\right)20mA = 0.6269mA$$

$$R_g = \left(\frac{5V-3.2V}{0.626mA}\right) = 2875\Omega$$

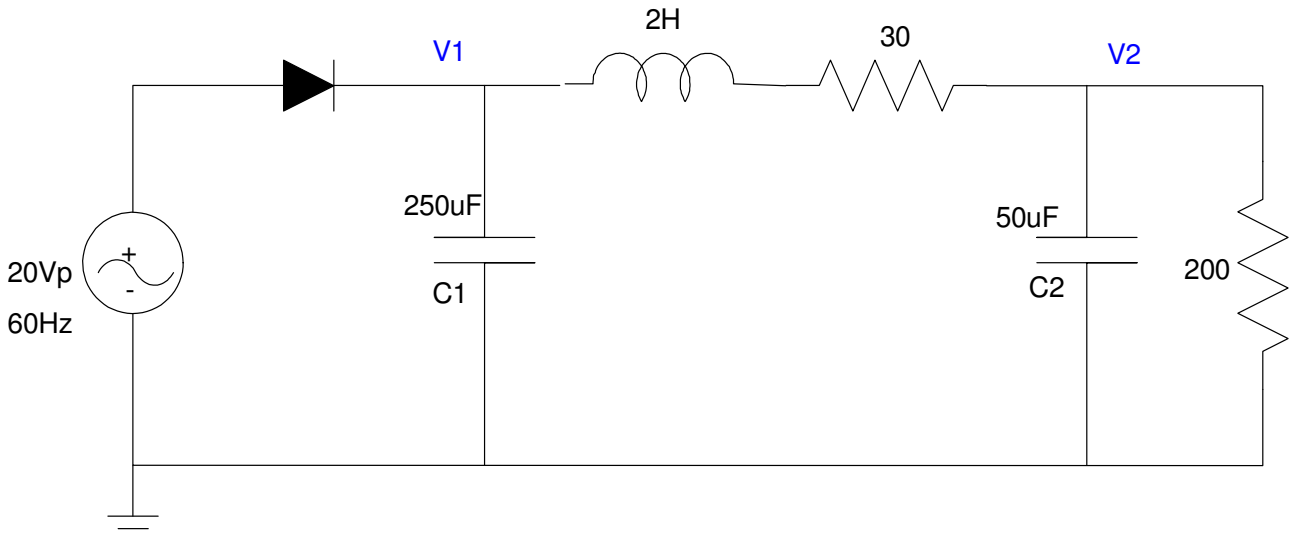
$$I_b = \left(\frac{745mcd}{10000mcd}\right)20mA = 1.490mA$$

$$R_b = \left(\frac{5V-3.2V}{1.490mA}\right) = 1208\Omega$$



AC to DC Converters

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



$$\max(V_1) = 19.3V$$

$$I \approx \left(\frac{19.3V}{230\Omega}\right) = 83.91mA \qquad \textit{worst case}$$

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

$$83.91mA = 250\mu F\,\frac{dV}{1/60s}$$

V1 Analysis

$$V_1(AC) = dV = 5.594V_{pp}$$

$$V_1(DC) = 19.3V - \tfrac{1}{2}V_1(AC)$$

$$V_1(DC) = 16.50V$$

V2 Analysis

$$V_2(DC) = \left(\frac{200}{200+30}\right)V_1(DC) = 14.35V$$

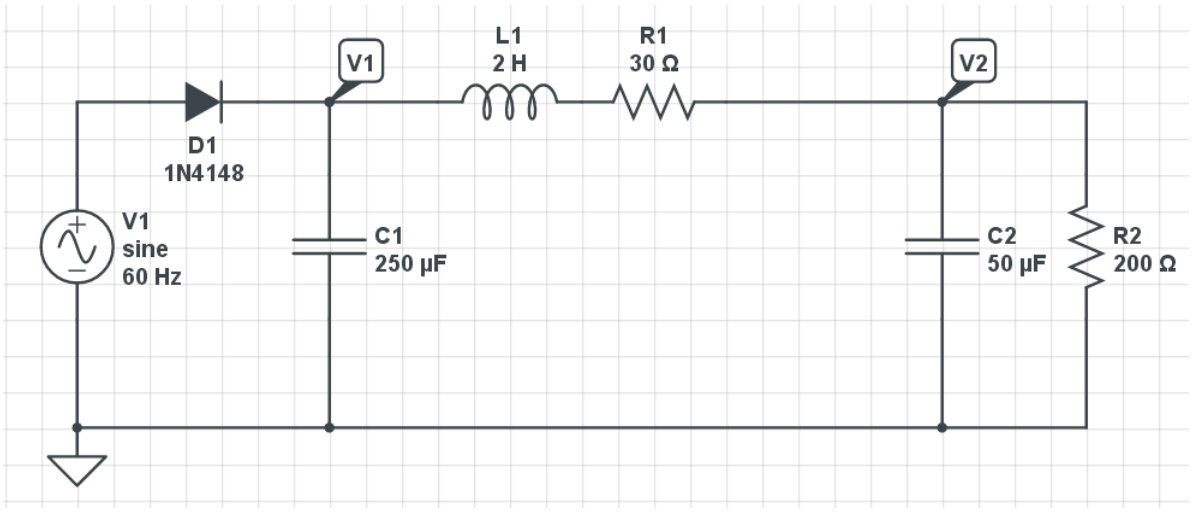
200 Ohms || 50uF = 200 || -j53.05 = 13.147 - j49.563

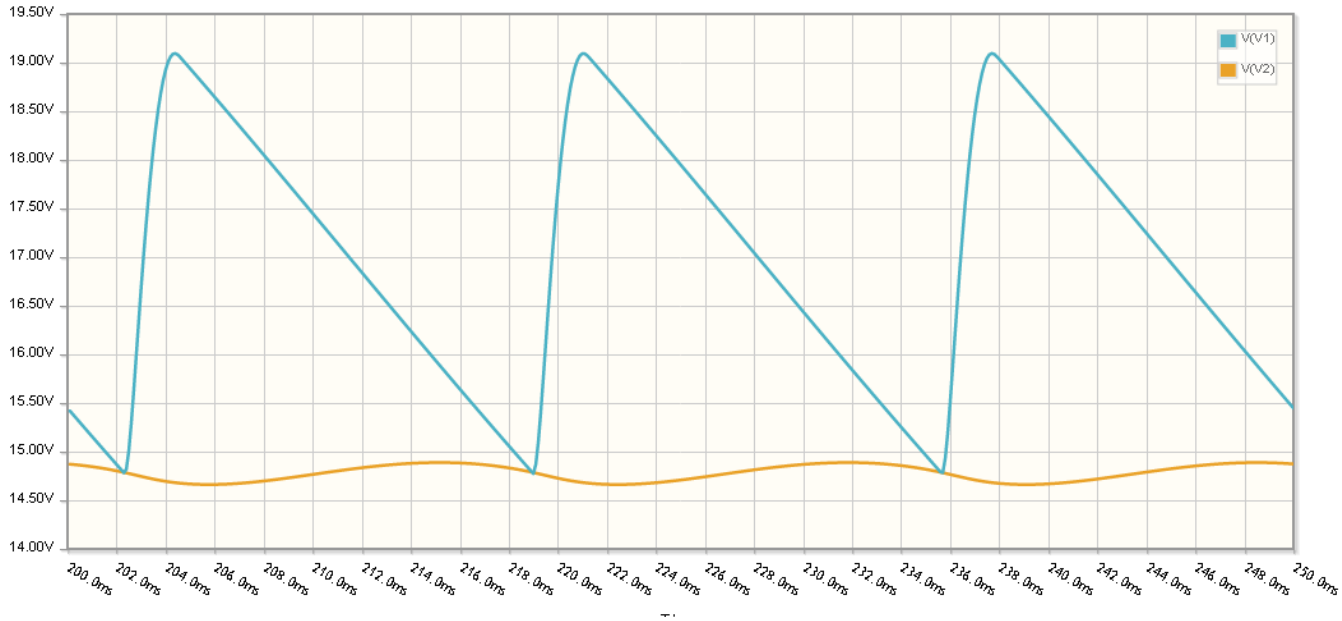
2H >> j754 Ohms

$$V_2(AC) = \left(\frac{(13.147-j49.563)}{(13.147-j49.563)+(30+j754)}\right)5.594V_{pp}$$

$$V_2(AC) = 406mV_{pp}$$

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





V1 (Blue)

- Max = 19.09V
- Min = 14.78V
- DC = (Max + Min)/2 = 16.93V (16.50V computed)
- AC = (Max - Min) = 4.310Vpp (5.594V computed)

V2 (orange)

- Max = 14.89V
- Min = 14.66V
- DC = 14.77V (14.35V computed)
- AC = 230mVpp (406mVpp computed)

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

$$V_1(AC) = 2V_{pp} \qquad given$$

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

$$V_2(DC) = \left(\tfrac{200}{200+30}\right) V_1(DC) = 15.913V$$

Finding C1:

$$I = \left(\tfrac{18.3V}{230\Omega}\right) = 79.57mA$$

$$I = C_1 \, \tfrac{dV}{dt}$$

$$79.57mA = C_1 \, \tfrac{2V_{pp}}{1/60s}$$

$$C_1 = 663\mu F$$

Finding C2: Assume C2 = 0.

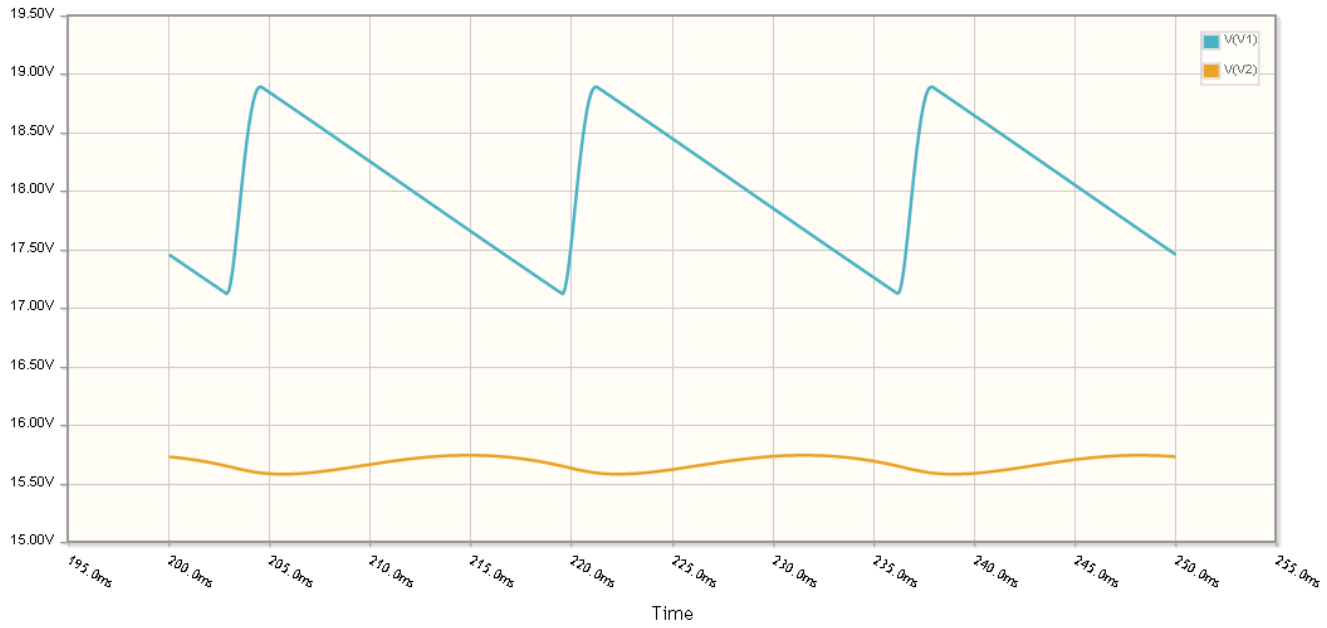
$$V_2(AC) = \left(\tfrac{200}{(200)+(5+j754)}\right) 2V_{pp} = 512mV_{pp}$$

For V2(AC) to be 250mVpp

$$\left|\tfrac{1}{j\omega C}\right| = \left(\tfrac{250mV}{512mV}\right) 200\Omega = 97.65\Omega$$

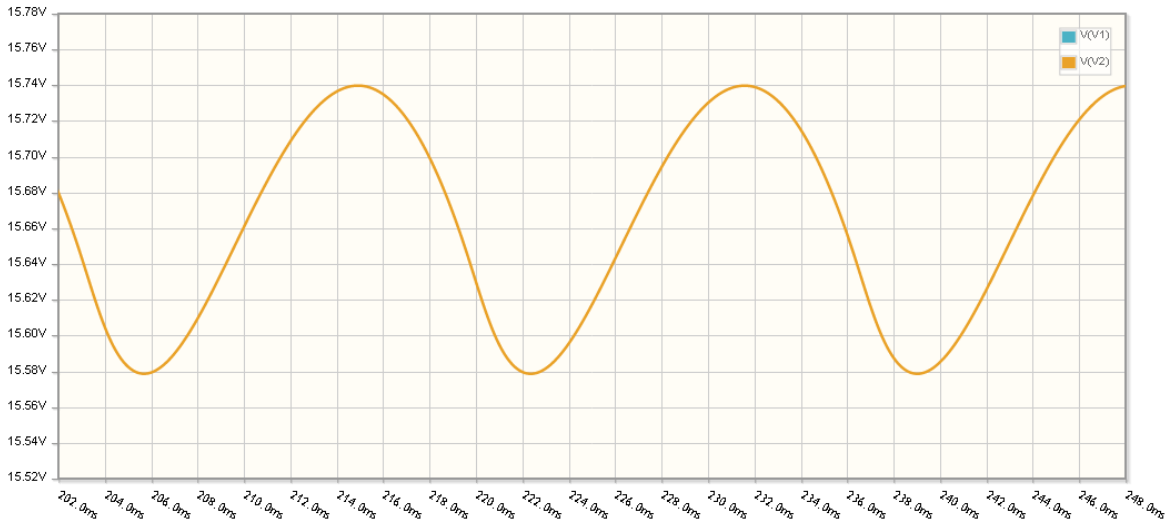
$$C_2 = 27.16\mu F$$

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



V1: (blue)

- max(V1) = 18.89V
- min(V1) = 17.13V
- V1(DC) = 18.01V (vs. 18.30V computed)
- V1(AC) = 1.76Vpp (vs. 2.00Vpp computed)



V2 (orange)

- max(V2) = 15.74V
- min(V2) = 15.58V
- V2(DC) = 15.66V (vs. 15.913V comptued)
- V2(AC) = 160mVpp (vs. 250mVpp computed)