ECE 320 - Homework #4

Clippers, Min/Max, AC to DC. Due monday, September 21st

20 points per problem

Problem 1) Requirement: Clipper Circuit

- Input: 0..10V DC, capable of driving 100mA
- Output: 0..10V, capable of driving 1uA
- Relationship: Match the following curve within 500mV

Analysis: Design a circuit to meed these requirements

note: So that diodes can be found in lab with the correct voltage drop, draw the straight-line approximations at 0.7V and 2.1V (allowing one and three silicon diodes to be used in replace of zener diodes)



Let R1 = 1k

- Max current = 10mA < 100mA (requirement)
- 10mA >> 1uA (load is negligable)

Slope = 0.3111: (R1 turned on)

$$\left(\frac{R_1}{R_1 + 1000}\right) = 0.3111$$

R1 = 451 Ohms

Slope = 0.0625 (R1 and R2 turned on

$$\left(\frac{R_2||R_1}{R_2||R_1+1000}\right) = 0.0625$$
$$R_2||R_1 = 66.666$$

 $R_2 = 78\Omega$



In PartSim



Prolem 2) Requirement: Max / Min Circuit

- Input: Three voltages, 0..10V, each capable of driving 100mA
- Output: One voltage (Y), capable of driving 1uA
- Relationship: Match the following relationship within 1V
 - $Y = A{+}B{+}AC$
 - Y = max(A, B, min(A, C))
- 2) Analysis: Design a circuit to meed these requirements



Analysis: Check three cases: one where each diode on the right (max) turns on



Test (PartSim)





Problem 3) Requirement: AC to DC Circuit:

- Input: 60Hz, 10V peak sine wave, capable of driving 20mA (i.e. a function generator)
- Output: 10k resistor (1mA @ 10V)
- Relationship: The output should be a DC signal with Vo > 8V and less than 1V ripple.
- 3) Analysis: Design a circuit to meed these requirements

Assume a full-bridge rectifier

Vmax = 10 - 1.4 = 8.6V

For Vo > 8V, the ripple must be less than 0.6V

$$dV = 0.6V$$

The load current is then (worst case)

$$I_L = \frac{8.6V}{10k\Omega} = 860\mu A$$

Case 1: Assume no inductor (blue). The peak-to-peak ripple should be 0.6V to keep the min voltage above 8V. The capacitor value should be:

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

$$860\mu A = C\frac{0.6V}{\frac{1}{120} \sec}$$

$$C = 11.9\mu F$$



4) Test in PartSim:



Building and running the simulation in PartSim verifies my calculations:

- The maximum voltage is 8.71V (vs 8.60V calculated).
- The ripple is 483mV (vs 600mV calculated). Analysis is slightly conservative as expected
- The minimum voltage is 8.227V (vs. 8.00V calculated) meeting the design requirements



PartSim Simulation: 8.227V < Vo < 8.71V

Lab:

5) Validation: Build the circuit you tested in problem 4. Collect data validate that your design actually does meet the requirements.

(Include lab data to check your calculations and simulation results)