ENGR4300
Spring 2006
Quiz 4A

Name Soln.

Section ______________________

Question 1 (20 points) __________

Question 2 (20 points) __________

Question 3 (20 points) __________

Question 4 (20 points) __________

Question 5 (20 points) __________

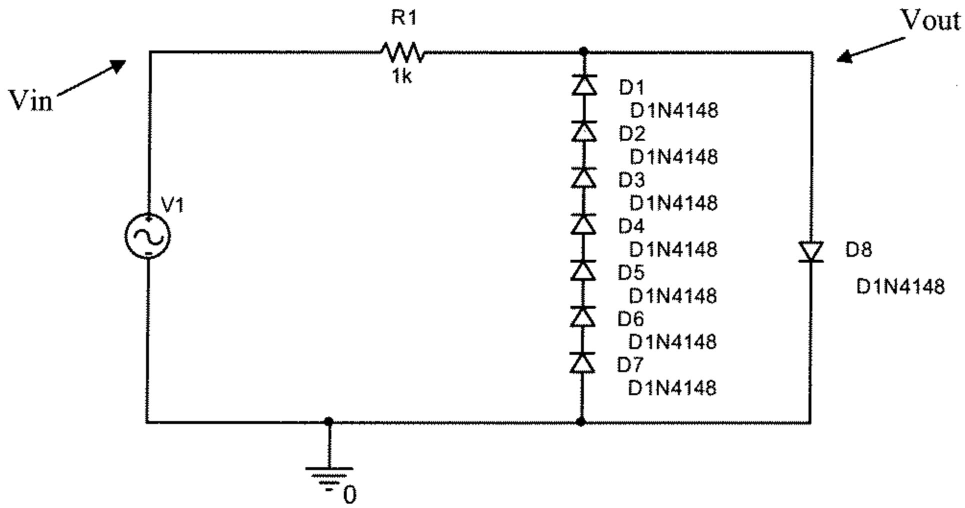
Total (100 points): ____________

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Soln

Question 1A – Diode Circuits (20 points)

You are given the following circuit:



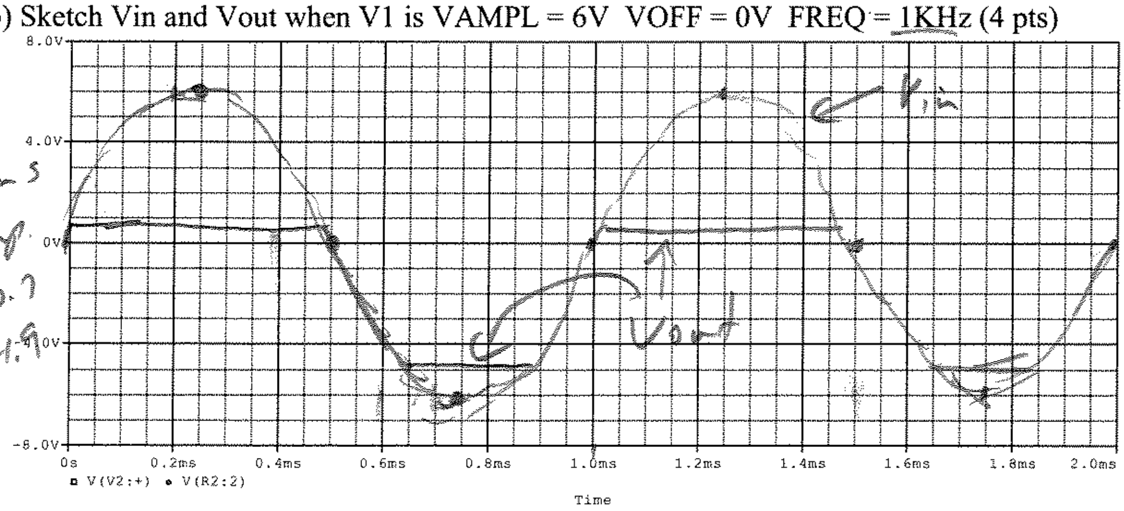
a) What are the minimum and maximum voltages that can ever occur at Vout? (4 pts)

$V_{max} = 0.7$

$V_{min} = -7 \times 0.7 = -4.9V$

b) Sketch Vin and Vout when V1 is VAMPL = 6V VOFF = 0V FREQ = 1KHz (4 pts)

Period = 1ms
V_{in} = 6V amp.
V_{out} max = 0.7
V_{out} min = -4.9



c) What are the minimum and maximum currents through R1 for part b) above? (2 pts)

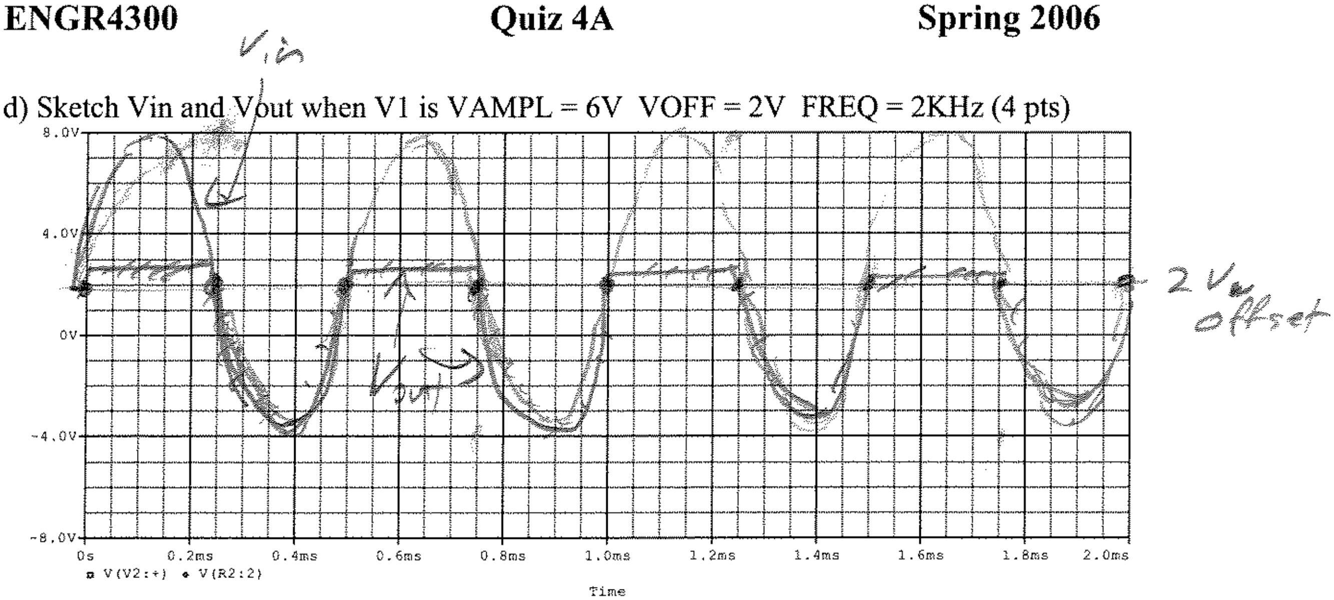
I_{max} $V_{in} = 6$, $V_{out} = 0.7$ $V_{R_1} = 5.3V$

$I_{R_1} = 5.3mA = I_{max}$

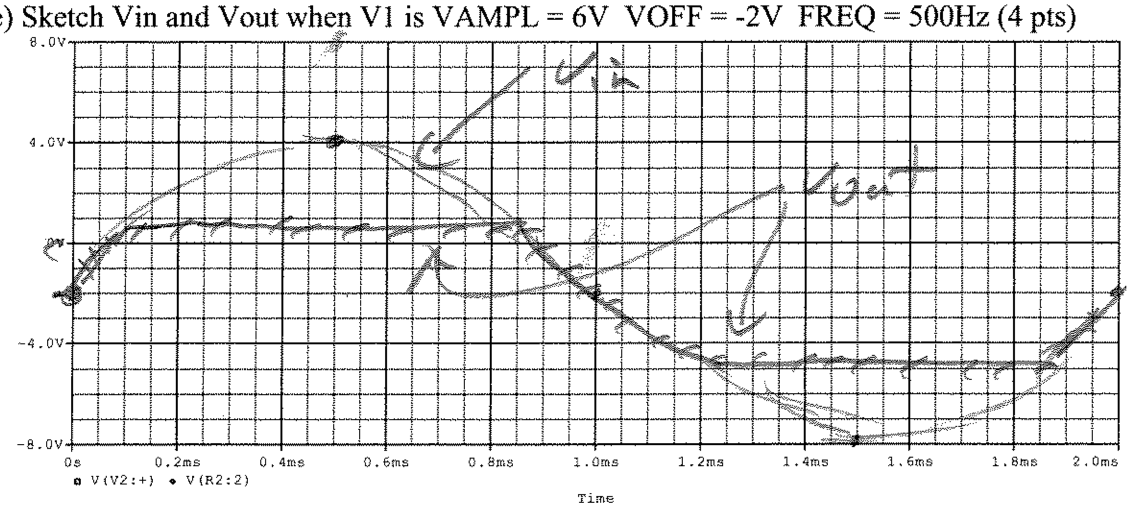
I_{min} $V_{in} = -6$, $V_{out} = -4.9V$ $V_{R_1} = -1.1V$ $I_{R_1}(min) = -1.1mA$

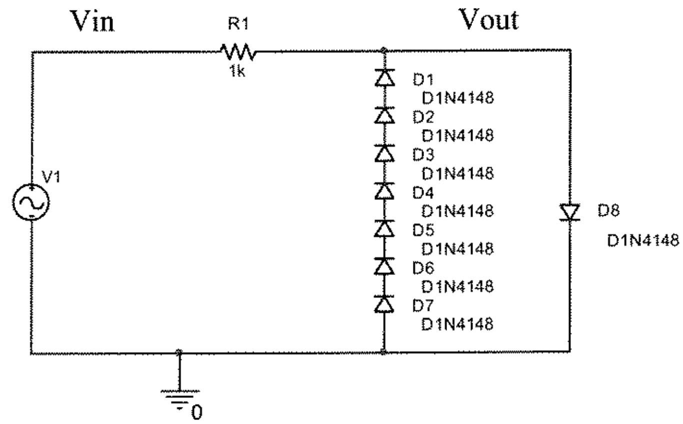
Soln

d) Sketch Vin and Vout when V1 is VAMPL = 6V VOFF = 2V FREQ = 2KHz (4 pts)

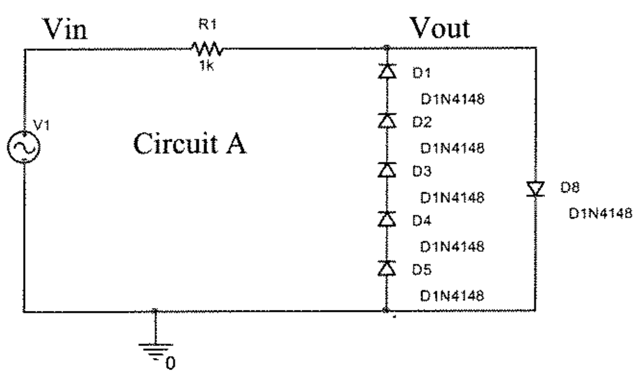


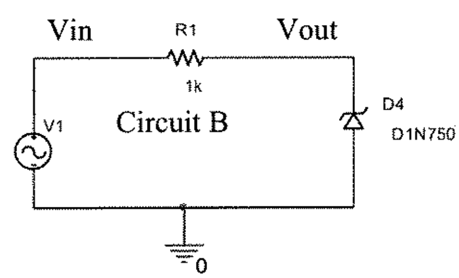
e) Sketch Vin and Vout when V1 is VAMPL = 6V VOFF = -2V FREQ = 500Hz (4 pts)

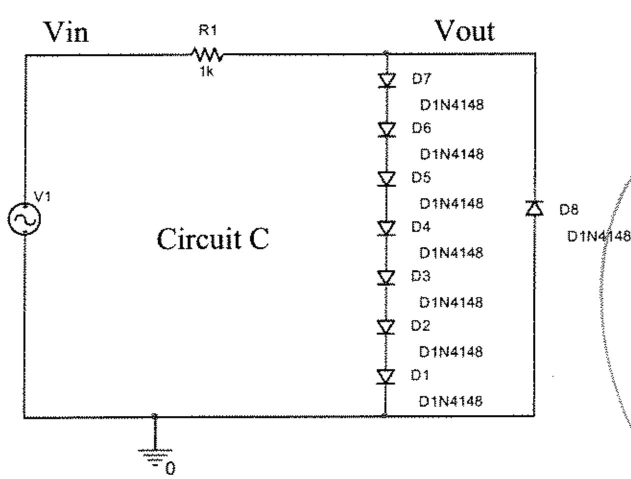


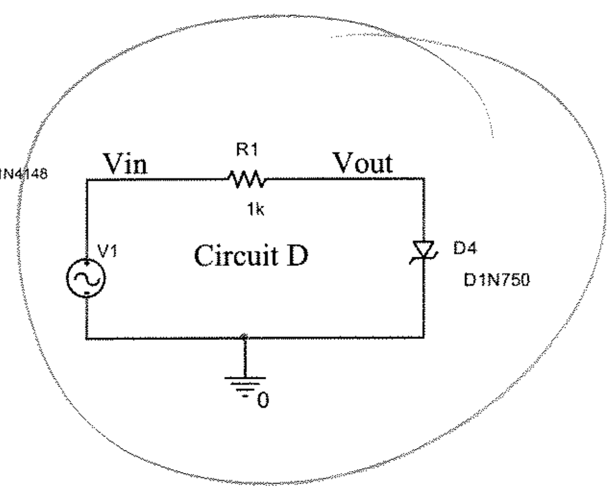


f) Indicate the circuit below that would produce output most like the circuit above. (Note that this is the same circuit as the one at the beginning of this question.) (2 pts)





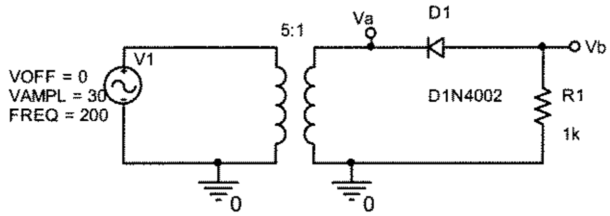




50/n.

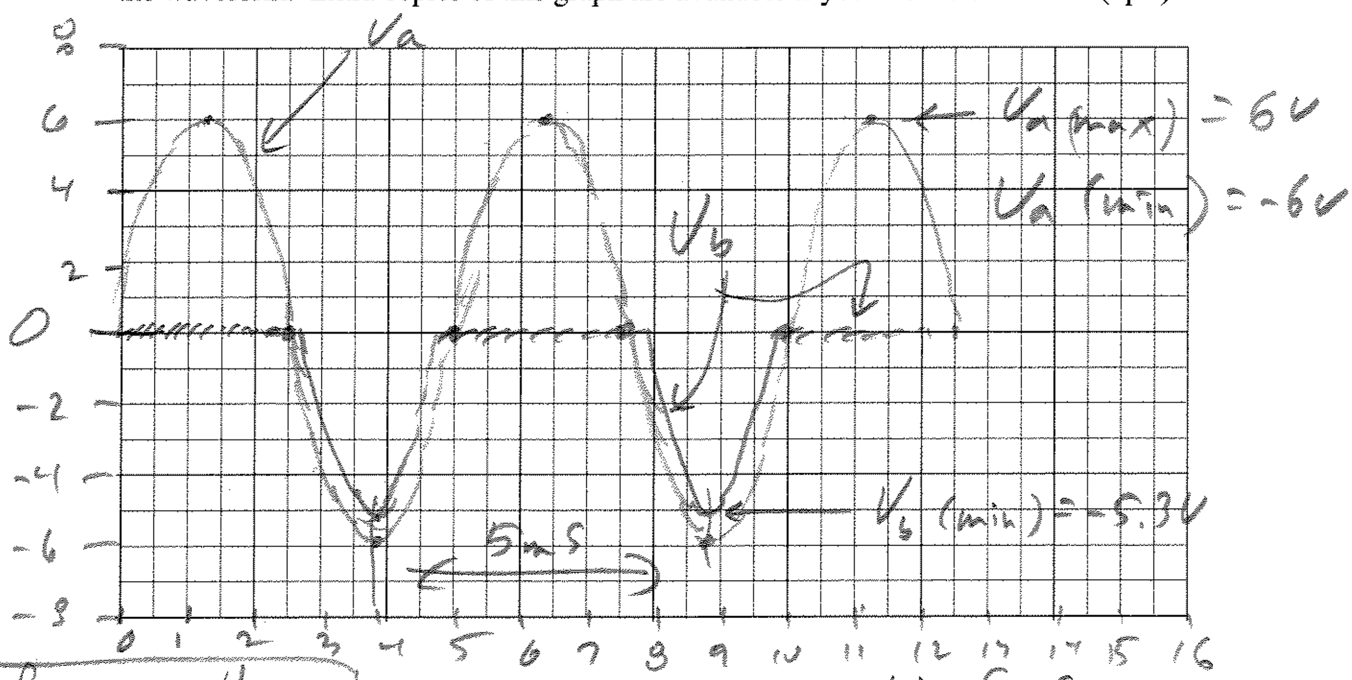
Question 2A – Rectifiers (20 points)

You are given the following circuit:
Assume that the diode is has a 0.7V forward drop, otherwise it is ideal.



The transformer has5:1 turns ratio, with 5 primary turns for each secondary turn.

a) The transformer above has a turns ratio of 5:1 Sketch in the plot below, the Va and Vb. You must 1) label the time axis, 2) label the voltage axis, 3) clearly indicate which trace is which, 4) clearly indicate the extreme voltages for each trace, 5) clearly indicate the period of the waveform. Extra copies of this graph are available if you wish to start over. (7pts)



f = 200 Hz
5 ms/cycle

5:1 turns ratio

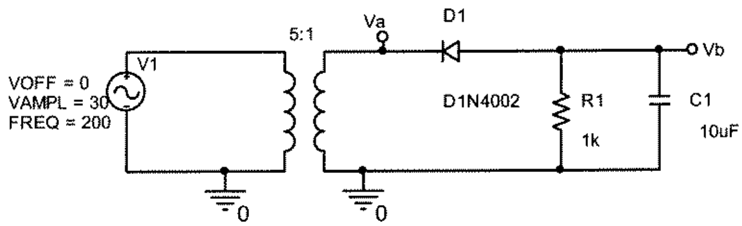
Va(amplitude) = 30/5 = 6v

Vb (min) = -6 + 0.7 = -5.3V

b) What is the time between the peaks of the magnitude of Vb? This should also be indicated on the plot. (1pt)

5 ms

Soln



c) The circuit above is the same as the previous one, but with a capacitor added across R1. Assume that the diode is has a 0.7V forward drop, otherwise it is ideal. The diode will turn off exactly at the time that the magnitude of the voltage on the capacitor reaches a maximum. At this point in time, what is the **current in R1, I_{R1}**? And also, just after the diode has turned off, what is the **time rate of change of the capacitor voltage, dV_c/dt** ? (See the crib sheet for Quiz 1 for the general equation for a capacitor.)(5pts)

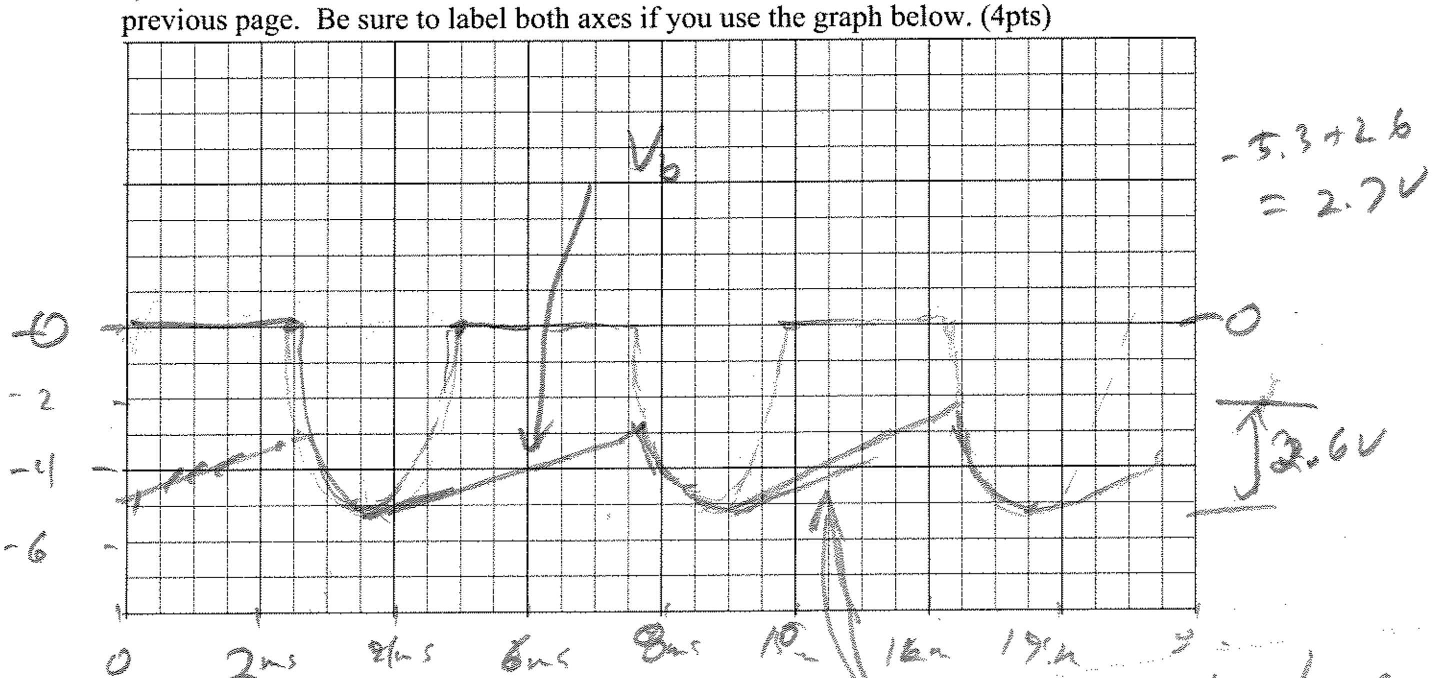
I_{R1}= $-5.3mA$ ($+5.3mA$ allowed)   at $|V_c|_{max}$ $V_b = -5.3V$ $I_{R1} = -5.3mA$

dV_c/dt = $+530 V/sec = +0.53V/ms$ $I = C\frac{dv}{dt}$ $\frac{dv}{dt} = \frac{+5.3\times10^{-3}}{10^{-5}} = +530V/s$

d) Estimate the peak to peak voltage ripple at Vb by using the answers from part c) and b). In other words, assume that the capacitor voltage will decay linearly (part c) and will do so for a period of time equal to the time between peaks of the output voltage (part b)). (3pts)

Vb(peak to peak ripple) ≈ $(+0.53V/ms)(5ms) = +2.6V$

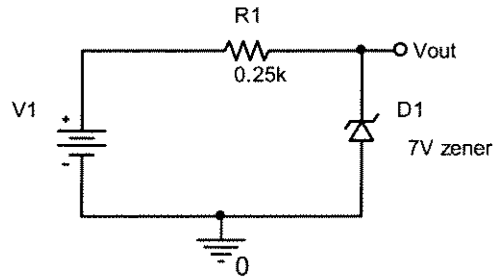
e) Sketch the Vb waveform for the circuit above. Do it below or add it to the plot on the previous page. Be sure to label both axes if you use the graph below. (4pts)



either match slope
slope = +0.53V/ms
or Ripple = 2.6V

Soln.

Question 3A – Zeners (20 points)



one should be pos. diode, one negative

For the circuit shown, D1 is a zener diode with a zener voltage of 7V, a knee current of 1mA and a forward "on" voltage of 0.7V

a) Fill in the table below. For zener state us the words: **on, off, or zener. (6pts)**

V1	Vout	I_{R1}	Zener State
9V	7V	8mA	Zener
-0.5V	0V	0	OFF
-9V	-0.7V	-33mA	ON

b) What is the smallest V1 allowed that will result in zener operating in the zener region? Remember V_Z=7V, I_{knee}=1mA, and zener forward voltage drop is 0.7V. (3pts)

$I_{min} = 1mA \quad V_1 = (1mA)(0.25k) + 7 = 7.25V$

c) The zener is rated for a maximum power dissapation of 0.2 Watts. If the zener is operated in the on (or forward bias) state, what is the maximum current that can pass through the zener without exceeding the power rating? Remember $Power = V * I$, see the crip sheet for quiz 1. (2pts)

$V = -0.7V, \quad I = ?, \quad P = 0.2$ Watts

$0.2 = (-0.7)(I)$

$I = \frac{0.2}{-0.7} = -286mA \approx -290mA$

Soln.

d) The zener is still rated for a maximum power dissapation of 0.2 Watts. If the zener is operated in the zener state, what is the maximum current that can pass through the zener without exceeding the power rating? (2pts)

$0.2 = (7)(I_z) \Rightarrow I_z = \underline{28.6\ mA}$

e) What is the range of allowed voltages for V1 such that the power rating of the zener isn't exceeded? (5pts)

$-290mA < I_z < 28.6mA$

"ON" $V1 = (-290mA)(0.25k\Omega) - 0.7V \approx \underline{-73V}$

"Zener" $V1 = (28.6)(0.25) + 7 = \underline{14.1 \text{ or } 14.2V}$

$$\boxed{-73V < V1 < 14.1V}$$

f) For the range of voltages found in part e), what is the maximum power dissiapated in R1 ? (2pt)

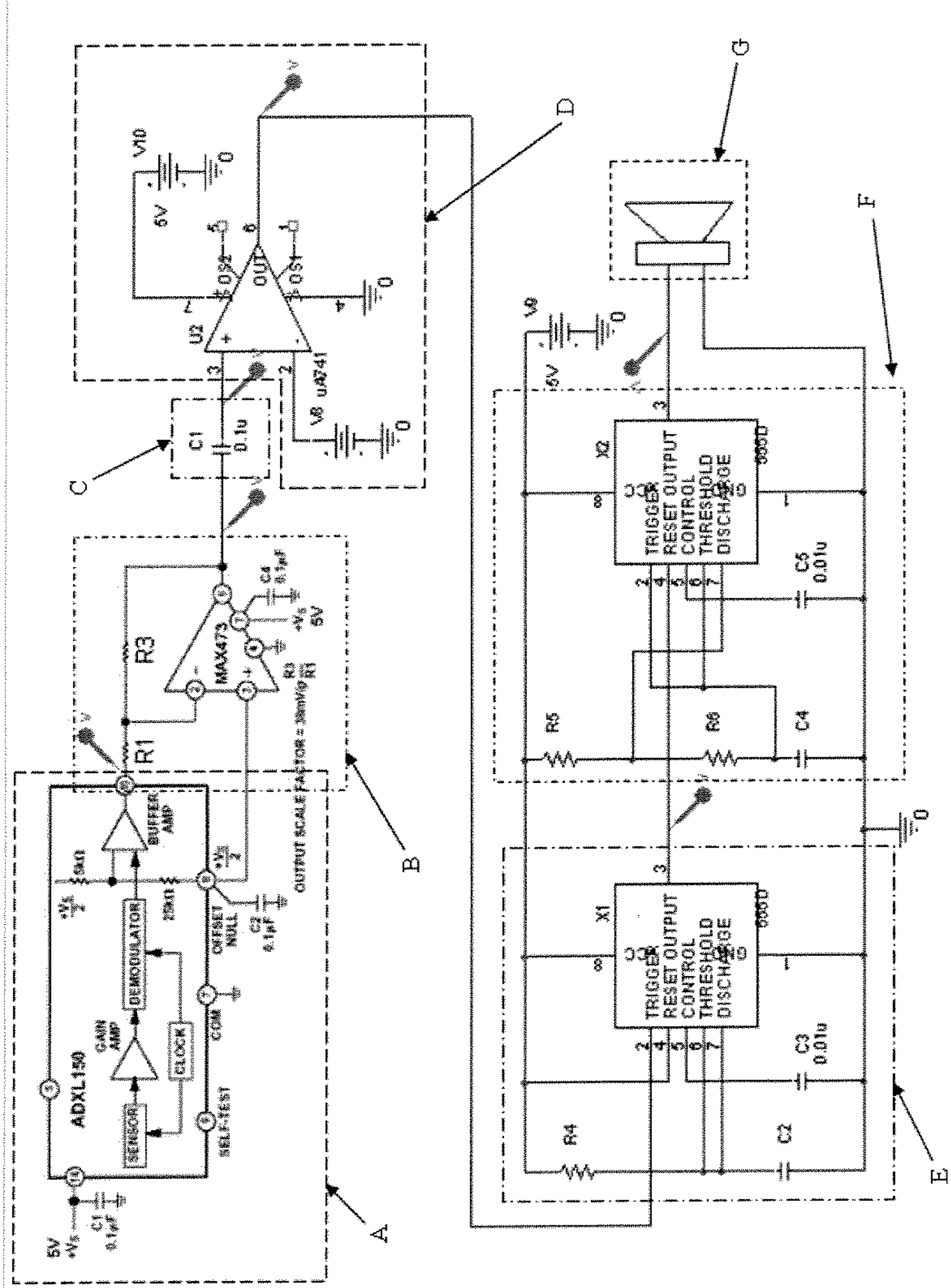
Max power at max I

$P = I^2R = V \cdot I = (V \cdot I) \cdot I$

$P = (0.29)^2 \cdot 250 = \underline{21\ \text{Watts}}$

Soln.

Question 4A – Circuit Analysis I (20 points)



R1 = 500Ω ; R3 = 22kΩ ; C1=0.1μF ; V8 = 2V ; R4=10kΩ ; C2 = 47μF ;
R5 = 1kΩ ; R6 = 4.7kΩ; C4 = 0.1μF

Soln.

This circuit on the previous page contains many elements you have seen. The component values not already indicated on the schematic are as follows:
R1 = 500Ω ; R3 = 22kΩ ; C1=0.1μF ; V8 = 2V ; R4=10kΩ ; C2 = 47μF ;
R5 = 1kΩ ; R6 = 4.7kΩ; C4 = 0.1μF
Note: A low input on the **Reset pin** forces the output of a 555 timer to go low and stay low as long as the **Reset** is held low. A high on the **Reset pin** allows the 555 time to operate.

1) Indicate the letter of the block in the circuit that has the indicated name (7 pts)

- -- Non-inverting Comparator D
- -- DC blocking capacitor C
- -- Astable Multivibrator F
- -- Inverting Amplifier B
- -- Speaker G
- -- One-shot (or Monostable Multivibrator) E
- -- Accelerometer Chip A

2) The output scale factor for the ADXL150 (at point B) is given as 38mV/g * (R3/R1), where g=9.8 m/s^2. If the amplitude of the voltage after box B spikes up to 3.6V, how much acceleration (in m/s^2) is being experienced by the chip at that moment? (2 pts)

$R3/R1 = \frac{22k}{0.5k} = 44$ $k_1 = \frac{38\times10^{-3}}{9.8} \cdot 44 \left(\frac{V}{m/s^2}\right)$

$\frac{3.6}{k} = \frac{3.6}{.17} = 21\ m/sec^2$ $k_1 = \frac{0.17\ V}{m/s^2}$

3) If, after box B, the amplitude is 3.6V and the DC offset is 2.5V, what are the amplitude and DC offset of the signal after box C? (1 pt)

Amplitude = 3.6V
DC = 0

4) Given the signal in part 3, what is the voltage after box D? (1 pt)

While output of box B is high, D is ~5V!

Soln.

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5) A one shot (monostable multivibrator) works in a similar manner to an astable multivibrator in that it will remain on when the capacitor is charging. Also, the components in the one-shot circuit determine the length of the pulse. Use the one-shot circuit to find the time constant, τ_{ON}, for the monostable multivibrator shown. (2 pt)

$\tau = R4 \cdot C2 = 10k\Omega \cdot 47 \times 10^{-6} F$
$= 0.47$ sec

$\tau_{on} = 0.47$ sec

6) The input to a one-shot is a signal at the trigger (pin 2), which causes the capacitor to begin charging up from ground. The equation to find T_{ON} for the monostable multivibrator is given by $T_{ON} = K\tau_{ON}$., where K is a constant that represents the portion of the charge cycle between 0V and the reference voltage of the Threshold Comparator (2/3Vcc) attached inside the 55-timer to pin 6. If the charge equation for a capacitor is $V_C = V_0\left(1 - e^{-t/\tau}\right)$, then what is the on-time for the monostable multivibrator shown? (2 pt)

$\frac{V_c}{V_0} = \frac{2}{3} = 1 - e^{-t/\tau}$ $\quad e^{-t/\tau} = \frac{1}{3}$

$\ln e^{-t/\tau} = \ln 1/3$

$-t/\tau = \ln 1/3 = -1.099$

$t = (\tau)(1.099) = 0.52$ sec

7) What is the frequency of the astable multivibrator in the circuit? (1 pt)

$T = 0.69(R_A + 2R_B)C$

$T = 0.69(R5 + 2R6)(C4)$

$= 0.69\ (1k + 2 \cdot 4.7k)\ 10^{-7}$

$= 0.718$ ms

$f = \frac{1}{T} = 1.4$ kHz

Soln.

8) Which ONE of the following is true? (2 pt)

a) The buzzer will sound all the time because the astable multivibrator generates a constant string of pulses.

b) The buzzer will sound only when the output from box D is around 5V.

c) The buzzer will sound only when the output from box D is around 0V.

d) The buzzer will sound only when the output from the monostable multivibrator is high.

e) The buzzer will sound only when the output from the monostable multivibrator is low.

f) The buzzer will never sound because its input frequency is never in the audible range.

9) This circuit is only activated by acceleration in one direction (up or down depending upon its orientation). Which of the following would allow it to be activated by acceleration in both positive and negative directions? (2 pt)

a) Add a full wave rectifier after box C.

b) Connect pin 4 (the enable pin) of the second 555 timer (X2) to +5V

c) Remove block C

d) Replace block D with an integrator

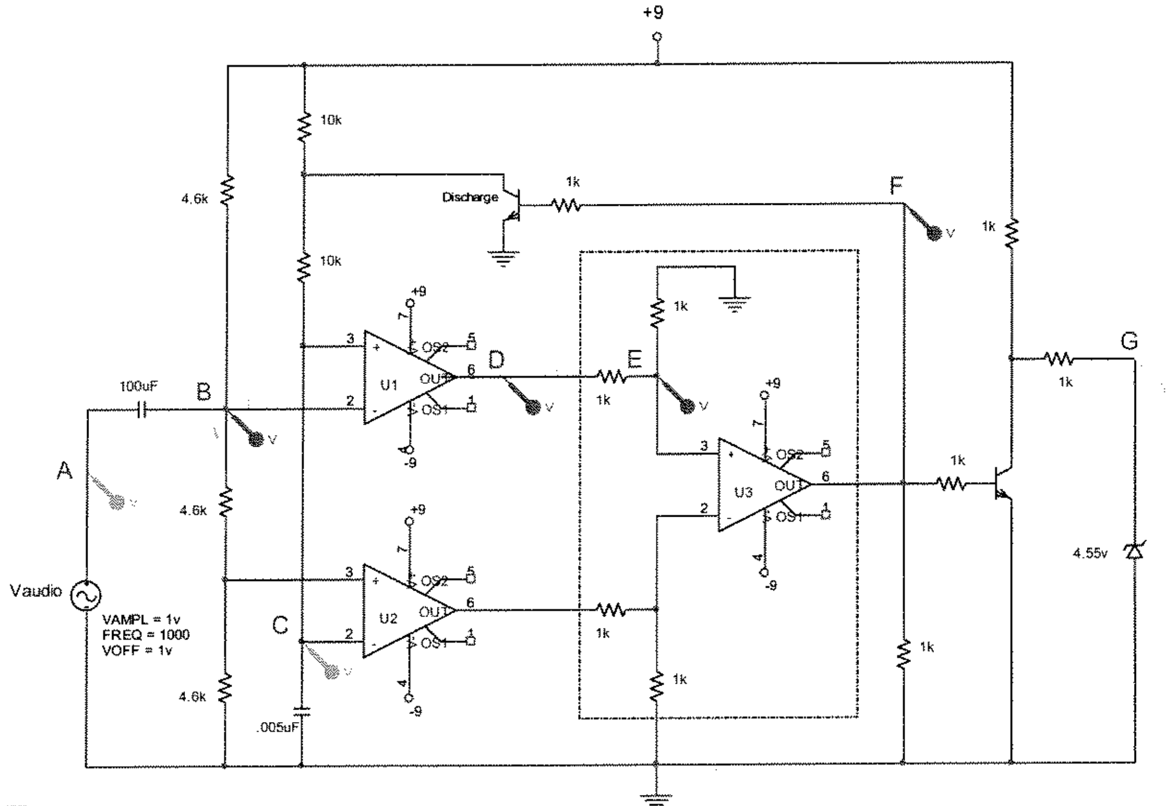
e) Add a smoothing capacitor after block F

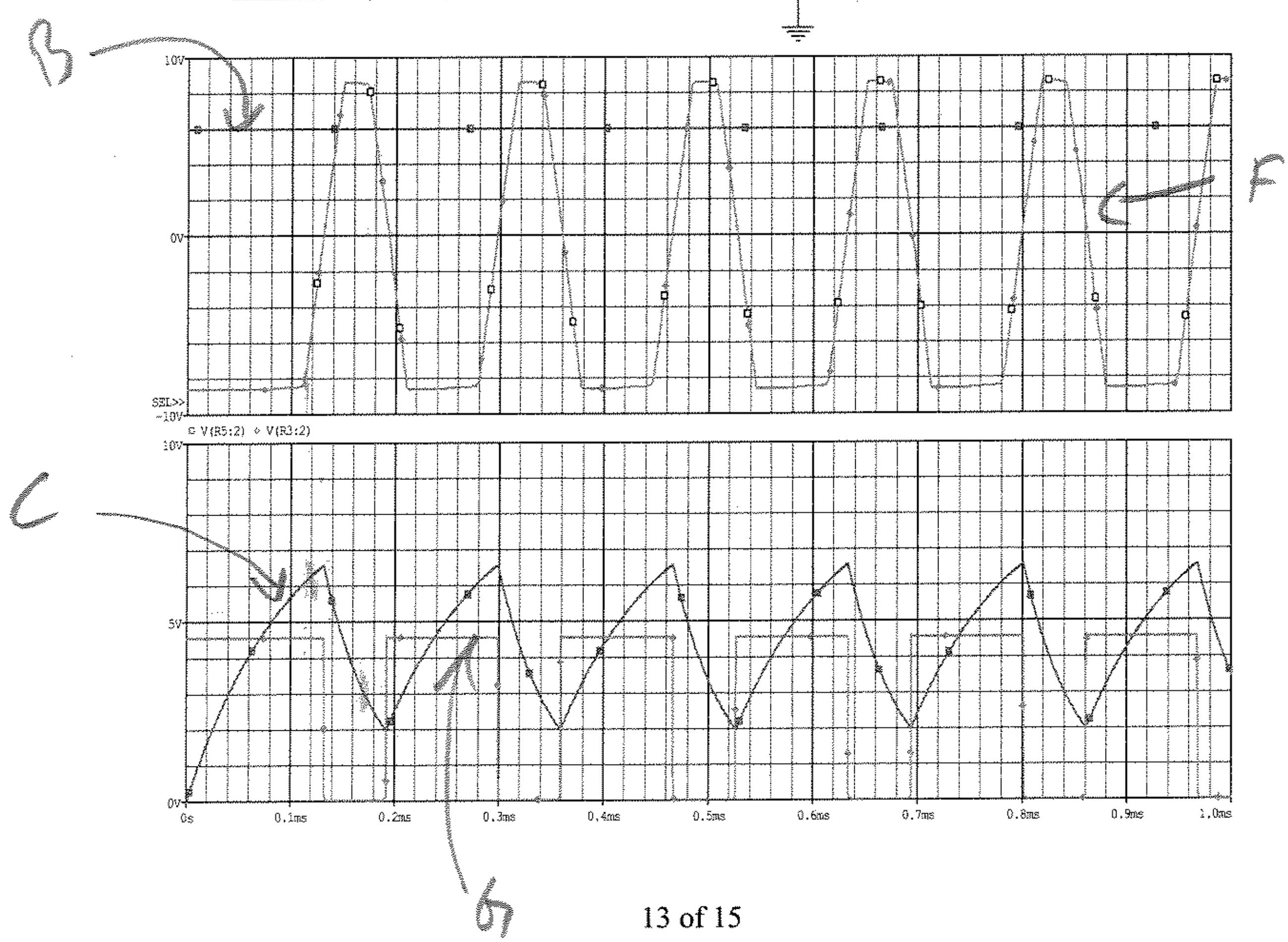
Extra credit: The buzzer will sound when the acceleration exceeds what value in m/s^2? How many g's is this? (1 pt)

$V_{amp} > 2V$

$\frac{2V}{K_1} = \frac{2}{0.17} = 11.8\ m/sec^2 \Rightarrow 1.2g$

Question 5A – Circuit Analysis II (20 points)





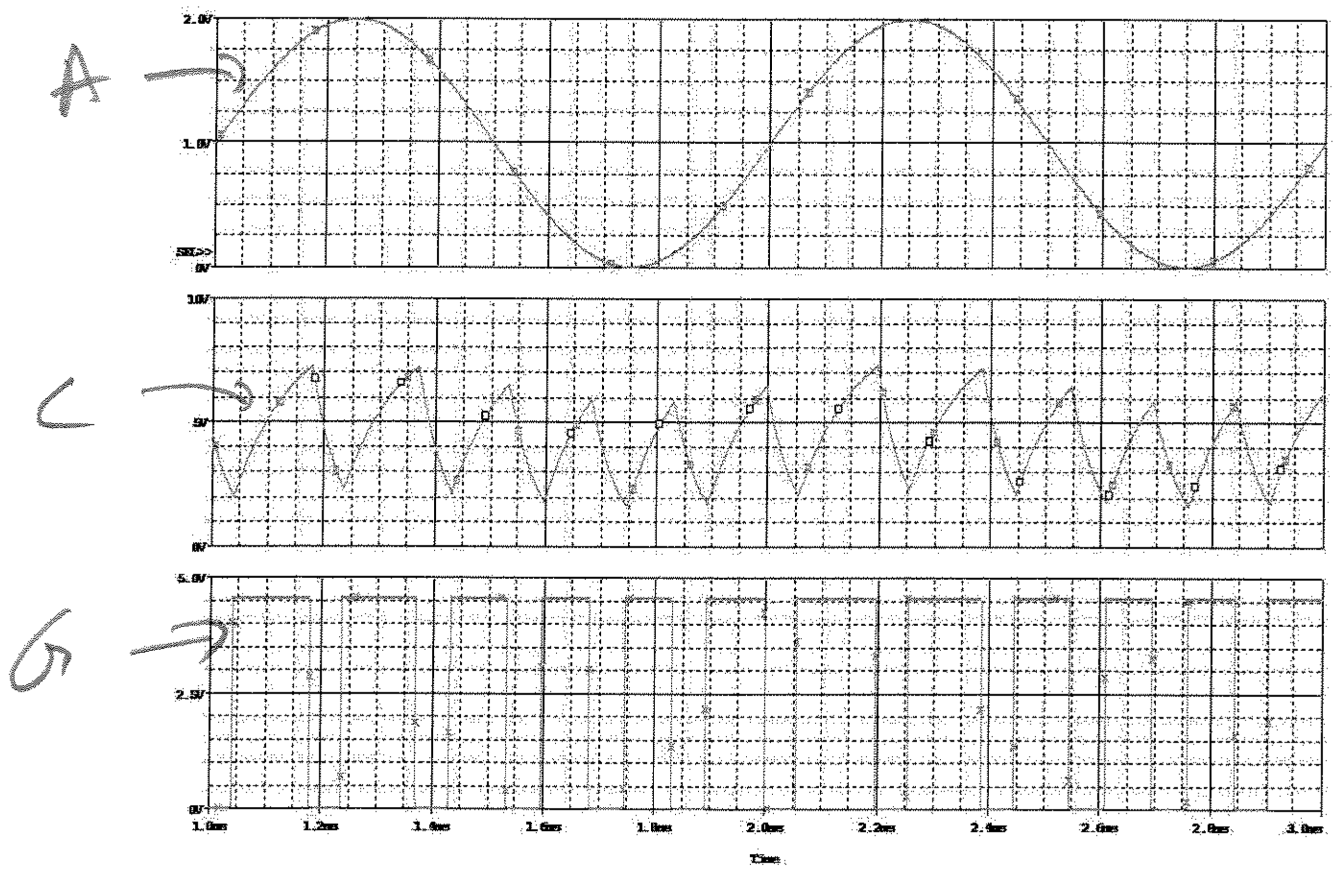
Poor choice

a) Label the four graphs shown on the previous page with the most likely probe designations (A, B, C…G), noting that only four locations were plotted. (Hint: The op-amp output is has a slew rate limit of about 500V/msec. The output can't change faster than this value.) (8pts).

b) Find the value of the probe voltage at location B (at t = .3ms).(1pt) 6V

c) Find the value of the probe voltage at location G (at t = .3ms) if the zener diode is operating in the zener region.(1pt) 4.55 V

d) Find the relationship between the voltage at location D and the voltage at location E (at t = 3ms).(1pt) $V_E = \frac{1}{2} V_D$ at all times



e) Label the graphs with the most likely probe designations for the waveforms shown above, noting that only three locations were plotted (5pts).

f) Briefly describe the operation of the circuit in the dashed box.(2pts)

1) Takes the place of the flip-flop of the 555 timer

OR 2) It is a comparator, It compares the outputs of U1 & U2. If output of U1 is high ⇒ this circuit will cause the discharge transistor to drain and discharge the cap. Turns off the transistor when U2 output changes

g) Briefly describe how this circuit might be used to create a communication link.(2pts)

A signal can be applied to voltage divider at pin 13. This modulates the duty cycle of the circuit. That modulation carries the information.

Also valid to say that it modulates the frequency.