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2015 Spring CS210001 Circuits and Electronics (I) Midterm II

Class: ____________

ID: 102062129

Name: 許毓軒

Part One: Calculation (78%)

1. (29%) For the voltage regulator circuit in Fig. 1, let $V_Z = 5.6\text{V}$ at $I_{ZT} = 2$ mA, $r_Z = 50\Omega$, $R = 0.5\text{k}\Omega$, $I_{ZK} = 0.2$ mA.

   (a) (7%) Show that $V_O = (R/(R+r_Z))\,V_{Z0} + (r_Z/(R+r_Z))\,V_S - (R//r_Z)\,I_L$, if Zener diode is operated in the breakdown region.

   (b) (3%) If $V_S = 10\text{V}$, $R_L = \infty$, determine V_O.

   (c) (4%) If $V_S = 10\pm1\text{V}$ ($\Delta V_S = \pm1\text{V}$), $R_L = \infty$, determine ΔV_O and line regulation as compared with (b).

   (d) (6%) If $V_S = 10\text{V}$, $R_L = 4\text{k}\Omega$, determine ΔI_L and load regulation as compared with (b). The load regulation is a negative value, what is the meaning of this sign?

   (e) (3%) If $V_S = 10\text{V}$, $R_L = 0.5\text{k}\Omega$, determine V_O.

   (f) (6%) If $V_S = 10\pm1\text{V}$, determine the minimum R_L such that the Zener diode is operated in the breakdown region.

$I_{min} = 0.2\text{mA}$

$r_Z = 50\Omega$

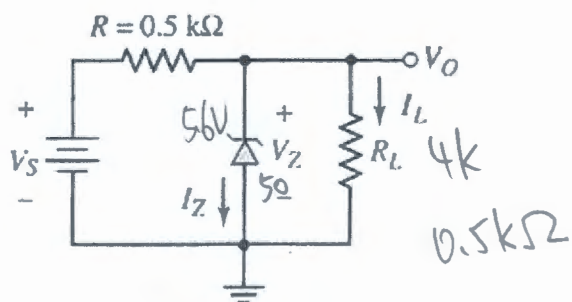


Fig. 1

2. (8%) Design a clipping circuit such that its input and output waveforms are as shown in Figs. 2(a) and 2(b), respectively. Assume the $V_\gamma = 0.7$ V. Remember to indicate the Vo terminals in your design.

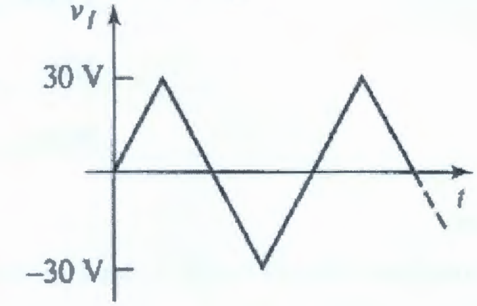


Fig. 2(a)

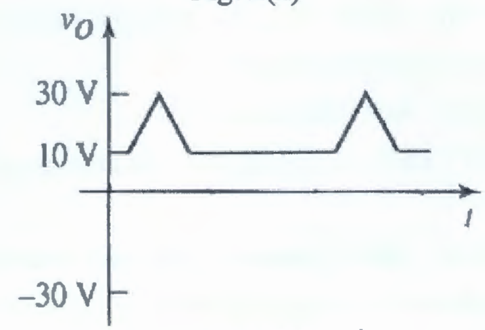
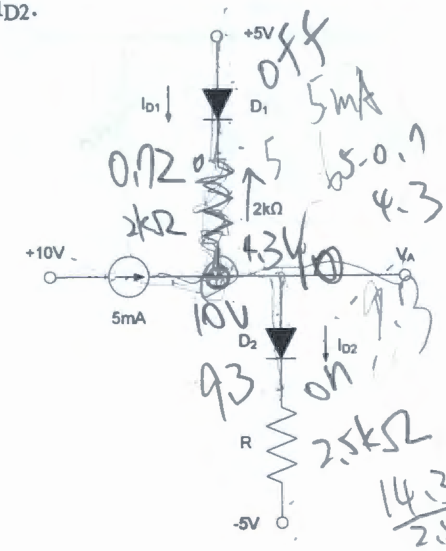


Fig. 2(b)

3. (6%) Consider the circuit in Fig. 3. The cut-in voltage of each diode is $V_\gamma = 0.7$ V. (a) For R=2.5KΩ, determine I_{D1}, I_{D2} and V_A. (b) Find R such that $V_A = 0$, what are the values of I_{D1} and I_{D2}.



on, on X

on, off X

off, on

off off X

5x2.5kΩ

15.5

Fig. 3

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4. (4%) Determine the Boolean expression for V_O in terms of the five input voltages for the circuit in Fig. 4.

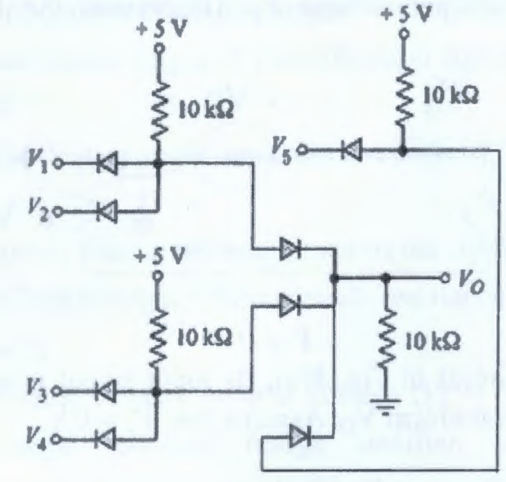


Fig. 4

5. (6%) Let $V_\gamma = 0.7\,\text{V}$ for the diode in the circuit of Fig. 5. Determine I_D and V_D when $V_1 = 12\,\text{V},\ V_2 = 16\,\text{V}$.

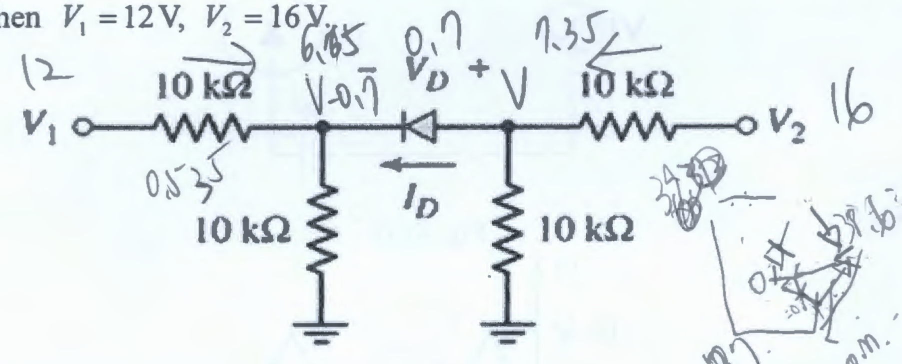
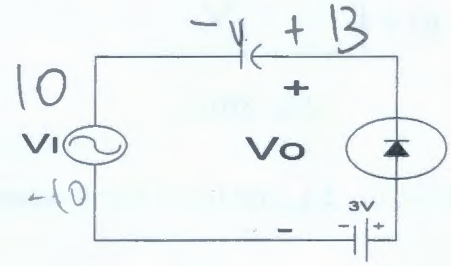


Fig. 5

6. (5%) Consider the circuit in Fig. 6(a), its input signal is as shown in Fig. 6(b). Drawing the output waveform V_O. (Label all the appropriate values in the waveform.)



Vi + 3V

Vp+3

Fig. 6(a)

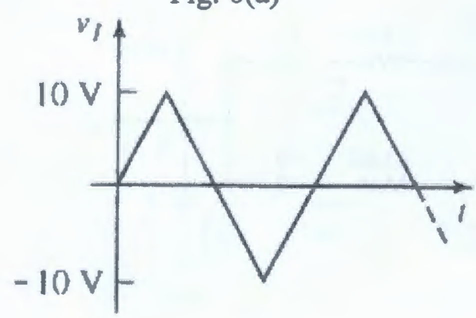
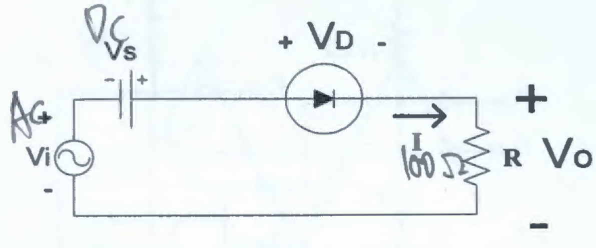


Fig. 6(b)

7. (6%) Consider the circuit in Fig. 7, V_S =10V, V_i =0.1sin(ϖt)V, R =100Ω, V_T=26mV, the diode has piecewise linear parameters of n=2, V_r= 0.6V and r_f= 30Ω. Calculate the output voltage V_O. (Expressed the V_O with DC and AC components.)

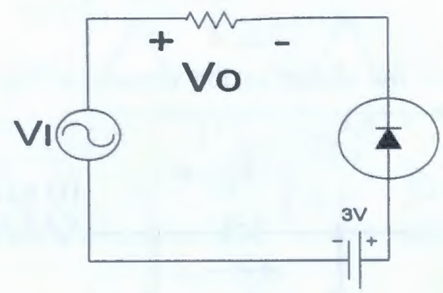


$= V_s - V_D$

$V_i - V_D$

Fig. 7

8. (6%) Consider the circuit in Fig. 8(a), its input signal is as shown in Fig. 8(b). Drawing the output waveform V_O. Assume the $V_r = 0$ V.



$V_i = 0 \quad V_o = -3$

$V_i < 0 \quad V_o = -3 + V_i$

$V_i \geq 3 \quad V_o = 0$

Fig. 8(a)

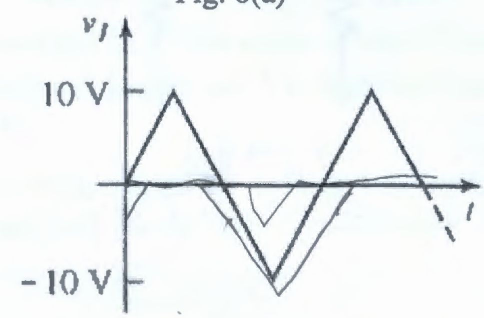


Fig. 8(b)

9. (8%) Determine the Vo, I_{D1}, I_{D2}, and I_{D3} in Fig. 9 when V_1=6V, V_2=2V.

$V_r = 0.6$

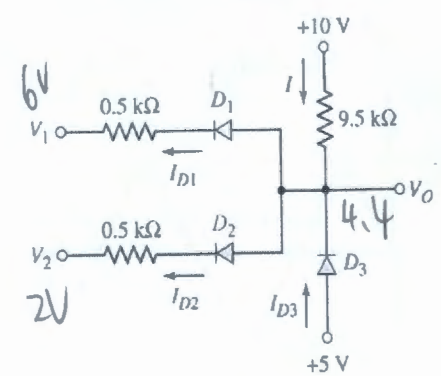


Fig. 9

Part Two: Brief Answer (22%)

1. (6%) List three applications of diode circuits that contain capacitors.
2. (3%) What are three major stages of a rectification circuit, i.e., input signal is AC, output signal is DC ?
3. (4%) What does the "cut-in angle" mean in a rectifier ? You can explain it using a figure.
4. (4%) State two ways to reduce the magnitude of the ripple voltage.
5. (2%) What is the small-signal incremental resistance r_d of a diode? Use an equation to express it.
6. (3%) What is the value of peak inverse voltage (PIV) of diodes in center-tapped transformer full-wave rectifier, bridge rectifier, and half-wave rectifier, respectively? Assume that the input signal is $V_p\sin(\varpi t)$V and the cut-in voltage of the diode is V_r.

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1、

(a)

$$I = \frac{V_s - V_o}{R}$$

$$I_Z = I - I_L$$

$$V_o = V_{Z0} + r_Z \cdot I_Z$$

$$V_o = V_{Z0} + r_Z \left[\frac{V_s - V_o}{R} - I_L\right]$$

$$V_o = V_{Z0} + \frac{r_Z}{R} \cdot V_s - \frac{r_Z}{R} V_o - r_Z I_L$$

$$\left(1+\frac{r_Z}{R}\right) V_o = V_{Z0} + \frac{r_Z}{R} V_s - r_Z I_L$$

$$V_o = \frac{R}{R+r_Z} V_{Z0} + \frac{r_Z}{R+r_Z} V_s - (R // r_Z) I_L \ \#$$

(b)

$$5.6 = V_{Z0} + 2m \cdot 50$$

$$V_{Z0} = 5.6 - 0.1 = 5.5\ V$$

$$I = \frac{10 - 5.5}{0.5k + 50} = \frac{\cancel{4.5}\ 9}{\cancel{5500}\ 1100} = 8.18 \times 10^{-3}$$

$$5.5 + \frac{9}{1100} \times 50 = 5.909$$

A: $V_o = 5.909\ V$

(c)

$$\left.\frac{\Delta V_o}{\Delta V_s}\right|_{\Delta I_L = 0} = \frac{r_Z}{R + r_Z} = \frac{50}{550} = \frac{1}{11}$$

$$\Delta V_o = \frac{1}{11} \times 2 = \frac{2}{11}$$

A: $\Delta V_o = \frac{2}{11}\ V$

line regulation $= \frac{1}{11}$

(d)

$$\left.\frac{\Delta V_o}{\Delta I_L}\right|_{\Delta V_S=0} = -R//r_Z = -\frac{500\times 50}{\cancel{550}_{11}} = -\frac{500}{11}\ (\Omega)$$

$$V_o = \underset{(V_S)}{V_{o1}} + \underset{(V_{Z0})}{V_{o2}} = 0.899 + 4.94 = 5.84$$

$$V_{o1} = V_S \times \frac{(50//4000)}{500+(50//4000)} = V_S \times \frac{49.38}{549.38} = 10\times\frac{49.38}{549.38} = 0.899$$

$$V_{o2} = V_{Z0}\times\frac{(500//4000)}{50+(500//4000)} = V_{Z0}\times\frac{444.44}{494.44} = 5.5\times\frac{444.44}{494.44} = 4.94$$

$$\Delta V_o = 5.84 - 5.909 = -0.069$$

$$-0.069\times\left(-\frac{11}{500}\right) = 1.518\text{mA}$$

A = (a) load regulation: $-\frac{500}{11}$, $\Delta I_L = 1.518\text{mA}$

(b) 負號代表ΔI_L與ΔV_o為負相關

$\Delta I_L \uparrow\ \Delta V_o \downarrow$

(e)

Zener無發生

$$V_o = 10\times\frac{500}{500+500} = 5$$

A: $V_o = 5V$

(f)

Zener恰發生

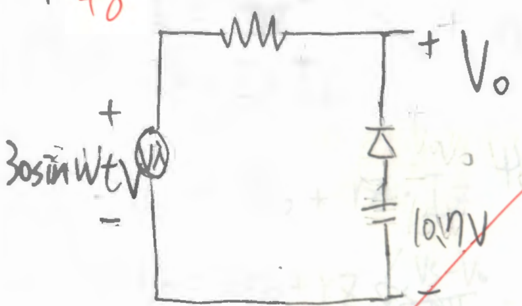
$$R_L = \frac{V_o}{I_L} = \frac{V_o}{I - I_Z} = \frac{V_o}{\frac{V_S - V_o}{R} - I_Z}$$

$$V_o = 5.5 + 50\times 0.2m = 5.51$$

$$R_{Lmin} = \frac{5.51}{\frac{9.5.51}{500} - 0.2m} = \frac{5.51}{6.78m} = 0.813\,k\Omega$$

A: $0.813\ k\Omega$

2. +8



$V_i = 0$ D on $V_o = 10.7V - 0.7 = 10V$

$V_i < 0$ D on $V_o = 10.7V - 0.7 = 10V$

$V_i \geq 10.7 + 0.7$ D off $V_o = V_i$

3. +3

(a) D_1 on, D_2 on

$$\frac{4.3 - V_A}{2k} + 5mA = \frac{V_A + 0.7 + 5}{2.5k}$$

$$\frac{4.3 - V_A}{2} + 5 = \frac{V_A + 4.3}{2.5}$$

$$2.15 - \frac{V_A}{2} + 5 = \frac{V_A}{2.5} + 1.72$$

$$\frac{9}{10} V_A = 5.43$$

$$V_A = 6.0333 \quad X$$

D_1 on, D_2 off

$$\frac{5 - 0.7}{2k} = 2.15mA$$

$$I_{D_1} = 2.15 + 5 = 7.15$$

$I_{D_1} = 0$

$I_{D_2} = 5\ mA$

$V_A = 8.2V$

$5mA \times 2.5k\Omega$

$= 12.5V$

$-5 + 12.5 + 0.7$

$= 8.2V$

(b)

$V_A = 0$

$$I_{D_1} = \frac{5 - 0.7}{2k} = 2.15mA$$

$I_{D_2} = 5 + 2.15mA = 7.15mA$

$R = 601\Omega$

4.

+4 (V_1 and V_2) or (V_3 and V_4) or V_5

5.

+6 $\frac{16-V}{10k} = I_D + \frac{V}{10k}$

$I_D = \frac{V-0.7-12}{10k} + \frac{V-0.7}{10k}$

$\frac{16-V}{10k} = \frac{V-0.7-12}{10k} + \frac{V-0.7}{10k} + \frac{V}{10k}$

$16-V = V-12.7+V-0.7+V$

$4V = 16+12.7+0.7$

$V = 7.35$

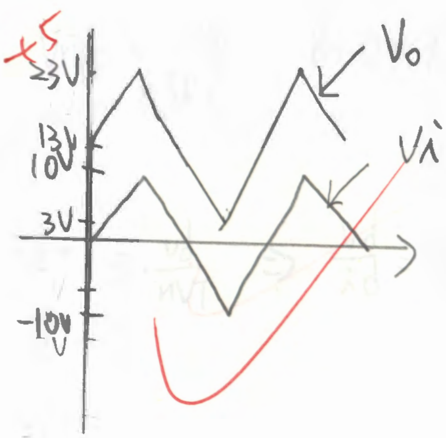
$\frac{16-7.35}{10k} = 0.865mA$

$I_D = 0.865mA - 0.735mA = 0.13mA$

A: $V_D = 0.7V$
$I_D = 0.13mA$

6.

+5



7. +6

$V_o = (\underbrace{V_S - V_D}_{DC}) + (\underbrace{V_i - v_d}_{AC})$

$= 7.23V + 0.099 \sin(wt)$

$10 - 0.6 - I_D r_f - I_D R = 0$

$9.4 - I_D \cdot 130 = 0$

$I_D = \frac{9.4}{130} = 72mA$

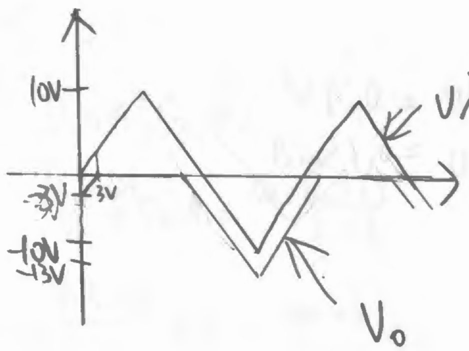
$I_D R = 7.23V$

$r_d = \frac{2.26 mV}{72 mA} = 0.72\ \Omega$

$0.1 \sin(wt) \times \frac{100}{100 + 0.72} = 0.099$

$A = V_o = 7.23 + 0.099 \sin(wt)\ V$

8.



$V_i = 0 \quad V_o = -3$

$V_i < 0 \quad V_o = -3 + V_i$

$V_i \geq 3 \quad V_o = 0$

9. D_1 off, D_2 on, D_3 on

$V_o = 4.4$

$I_{D1} = 0 \qquad I_{D2} = \frac{3.8 - 2}{0.5k} = 3.6 mA$

$I + I_{D3} = I_{D2}$

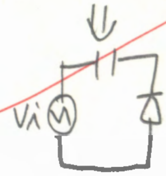
$\frac{10 - 4.4}{9.5} + I_{D3} = \frac{3.8 - 2}{0.5k}$

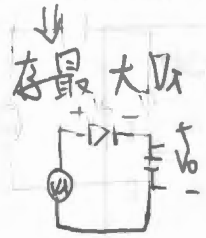
$I_{D3} = 3.6 - 0.589$

$= 3.01$

A: $V_o = 4.4\ V$
$I_{D1} = 0\ mA$
$I_{D2} = 3.6 mA$
$I_{D3} = 3.01 mA$

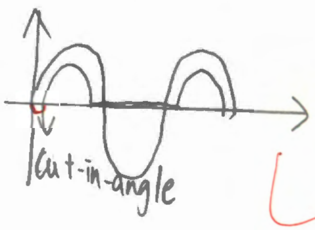
1、 filter, 箝位電路, peak circuit





2. diode rectifier ⇒ capacitor filter ⇒ zener diode ragulator

3、



Cut-in-angle代表真正開始產生V_o的點

4、

$V_{ripp} = \frac{V_M}{n f R C}$ 因加大電容、電阻或頻率可降低ripple voltage.

5、

$i_d = I \cdot \frac{v_d}{nV_T} \Rightarrow \frac{v_d}{i_d} = \frac{nV_T}{I} = r_d$

6、

full-wave : $2V_p - V_r$

bridge : $V_p - V_r$

half-wave : V_p