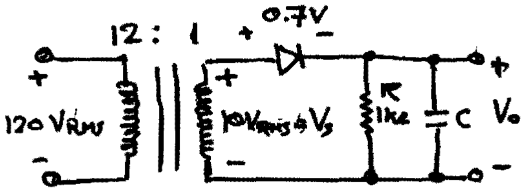
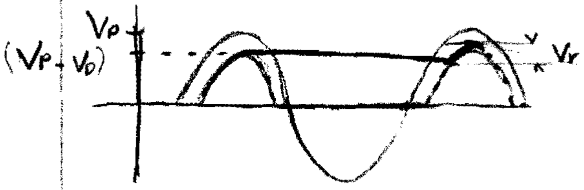
EE320 | Homework 5

① PROBLEM 4.77



$V_s = \frac{120}{12} = 10\,V_{RMS}$



(Eq. 4.28) $V_r \simeq (V_p - V_D)\frac{T}{CR}$ ∴ where $f = \frac{1}{T}$

10% $0.1\,(V_p - V_D) = (V_p - V_D)\frac{T}{CR}$

$C = \frac{1}{0.1 \times 1000 \times 60} = 166.7\ \mu F$

1% $0.01\,(V_p - V_D) = (V_p - V_D)\frac{T}{CR}$

$C = \frac{1}{0.01 \times 1000 \times 60} = 1666.7\ \mu F$

(a)

10% $V_{o,avg} = V_p - V_D - \frac{1}{2}V_r$ (Eq. 4.27)

RMS $= 10\sqrt{2} - 0.7 - \frac{1}{2}(10\sqrt{2} - 0.7)\,0.1$

$= \underline{12.77\,V}$

1% $= 10\sqrt{2} - 0.7 - \frac{1}{2}(10\sqrt{2} - 0.7)\,0.01$

$= \underline{13.37\,V}$

EE320 Homework 5

① Cont. Problem 4.77

(b)

(10%)

$$\omega\Delta t \simeq \sqrt{2V_r/(V_p-V_o)} = \sqrt{\frac{2\times 0.1(V_p-0.7)}{(V_p-0.7)}} \quad V_r$$

$$\omega\Delta t = \sqrt{0.2} = 0.4472 \text{ rad} \quad \text{of } 2\pi$$

So diode is conducting $\frac{0.4472}{2\pi}\times 100\% = \underline{7.2\%}$

(1%)

$$\omega\Delta t = \sqrt{2\times 0.01} = 0.1414 \text{ rad}$$

$\frac{0.1414}{2\pi}\times 100\% = \underline{2.25\%}$ diode is conducting

---

(c)

(10%)

(Eq. 4.31) $i_{D,avg} = I_L\left(1+\pi\sqrt{\frac{2(V_r-V_o)}{V_r}}\right)$

from part a $= \frac{V_{o,avg}}{R}\left(1+\pi\sqrt{\frac{2(V_P-V_o)}{0.1(V_P-V_o)}}\right) = \frac{12.77}{1000}\left(1+\pi\sqrt{\frac{2}{0.1}}\right)$

$I_{D,avg} = \underline{192.2 \text{ mA}}$

(1%)

$I_{D,avg} = \frac{13.37}{1000}\left(1+\pi\sqrt{\frac{2}{0.01}}\right) = \underline{607.4 \text{ mA}}$

(d)

(10%)

(Eq. 4.32) $i_{D\,peak} = I_L\left(1+2\pi\sqrt{\frac{2(V_P-V_o)}{V_r}}\right) \quad 0.1(V_P-V_O)$

$= \frac{V_{o,avg}}{R}\left(1+2\pi\sqrt{\frac{2(V_P-V_o)}{0.1(V_P-V_o)}}\right) = \frac{12.77}{10^3}\left(1+2\pi\sqrt{\frac{2}{0.1}}\right)$

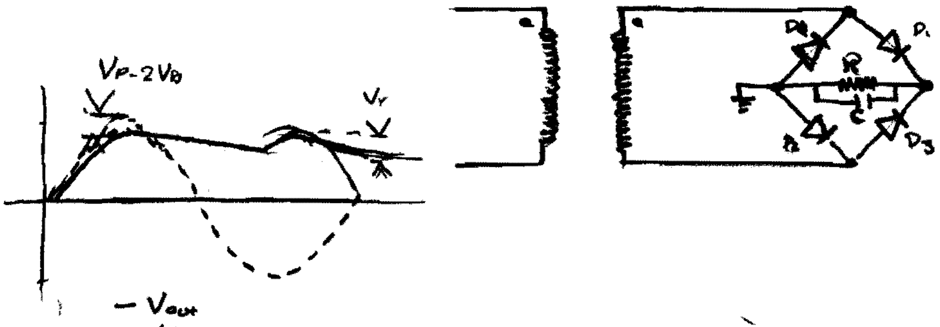
$= \underline{371.6 \text{ mA}}$

(1%)

$= \frac{13.37}{10^3}\cdot\left(1+2\pi\sqrt{\frac{2}{0.01}}\right) = \underline{1.201 \text{ A}}$

EE320 | Homework 5

(2) PROBLEM 4.79



See Problem 4.77

$$V_r = 0.1(V_P - V_D \times 2) = \frac{V_P - 2V_D}{2fCR} \quad \text{-(Eq. 4.28)}$$

(10%) $$C = \frac{(V_P - 2V_D)}{(V_P - 2V_D) \times 2 \times 0.1 \times fR} = \frac{1}{2 \times 0.1 \times 60 \times 10^3} = \underline{83.3\ \mu F}$$

(1%) $$C = \frac{1}{2 \times 0.01 \times 60 \times 10^3} = \underline{833.3\ \mu F}$$

(a)

$$V_O = V_P - 2V_D - \frac{1}{2}V_r \qquad \text{(Eq. 4.27)}$$

(10%) $$V_{O,10\%} = V_P - 2V_D - \frac{1}{2}(V_P - 2V_D) \times 0.1$$

$$= (V_P - 2V_D) \times (1 - \frac{1}{2} \times 0.1)$$

$$= (10\sqrt{2} - 2 \times 0.7) \times (0.95) = \underline{12.1\ V}$$

(1%) $$V_{O,1\%} = (10\sqrt{2} - 2 \times 0.7) \times (1 - \frac{1}{2} \times 0.01) = \underline{12.68\ V}$$

(b)

(10%) $$\text{fraction of cycle} = \frac{2\omega\Delta t}{2\pi} \times 100$$

(Eq. 4.30) $$\omega\Delta t = \sqrt{\frac{2V_r}{V_P - 2V_D}} = \sqrt{\frac{2(V_P - 2V_D) \times 0.1}{(V_P - 2V_D)}} = \sqrt{\frac{2 \times 0.1}{1}} = 0.4472 \text{ rad}$$

$$100 \times \frac{0.4472}{\pi} = \underline{14.24\ \%}$$

(1%)

$$= \sqrt{2 \times 0.01} = 0.1414 \text{ rad}$$

$$100 \times \frac{0.1414}{\pi} = \underline{4.5\%}$$

② Cont. PROBLEM 4.79

(c)

(10%)

$$i_{D,Avg} = I_L \left(1 + \pi \sqrt{\frac{V_P - V_0}{2 V_r}}\right) \quad \text{(Eq 4.34)}$$

$$= \frac{V_{o,avg}}{R}\left(1 + \pi\sqrt{\frac{(V_P - V_D)}{0.1 (V_P - V_0) \times 2}}\right)$$

from a

$$= \frac{12.1}{10^3}\left(1 + \pi\sqrt{\frac{1}{0.2}}\right) = 97.1 \text{ mA}$$

(1%)

$$i_{D,avg} = \frac{12.68}{10^3}\left(1 + \pi\sqrt{\frac{1}{0.02}}\right) = 294.4 \text{ mA}$$

(d)

(10%)

$$i_{D_{Peak}} = I_L\left(1 + 2\pi\sqrt{\frac{V_P - V_0}{2 V_r}}\right)$$

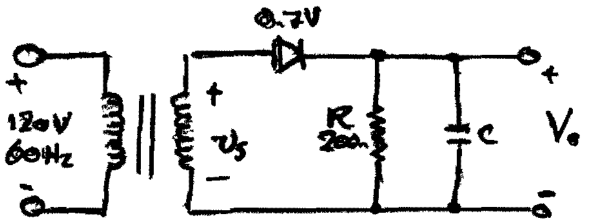
$$= \frac{V_{o,max}}{R}\left(1 + 2\pi\sqrt{\frac{V_P - V_D}{2 \times 0.1 (V_P - V_0)}}\right)$$

$$= \frac{12.1}{1000}\left(1 + 2\pi\sqrt{\frac{1}{0.2}}\right) = 182.1 \text{ mA}$$

(1%)

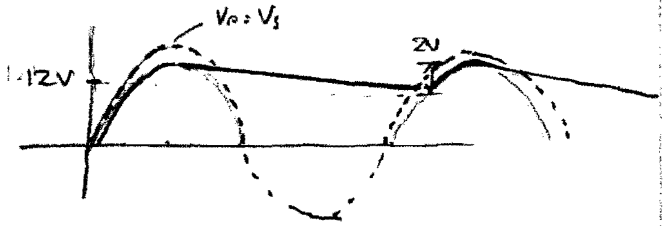
$$i_{D,Peak} = \frac{12.68}{1000}\left(1 + 2\pi\sqrt{\frac{1}{0.02}}\right) = 576.0 \text{ mA}$$

(3) PROBLEM 4.80



$V_O = 12V \pm 1\ V$ (Ripple)

$R_L = 200\,\Omega$



(a) $V_o = V_P - V_D - 1$

for half cycle $V_{s,avg} = V_P - V_D - \frac{V_r}{2}$ (4.27)

$V_P = 12 + 1 + V_D = 13.7V$, $V_{P,RMS} = \frac{13.7}{\sqrt{2}} = 9.7V$

(b) — $V_r = \frac{V_P - V_D}{fCR}$ (Eq. 4.29)

$C = \frac{V_P - V_D}{f \cdot R\,(V_r)} = \frac{13.7 - 0.7}{60 \times 200 \times 2} = 541.7\ \mu F$

(c) — When the diode is cutoff, the maximum reverse voltage across it will occur when $v_s = -V_P$. At this time, $v_o = V_o$ and maximum reverse voltage will be $V_o + V_P = 12 + 13.7 = 25.7V$

Using factor of safety of 1.5 $PIV = 1.5 \times 25.7 = 38.5V$

(d) —

(Eq. 4.31) $i_{Dav} = I_L \left(1 + \pi\sqrt{\frac{2(V_P - V_D)}{V_r}}\right) = \frac{12V}{200}\left(1 + \pi\sqrt{\frac{2(13.7-0.7)}{2}}\right) = 0.7396A$

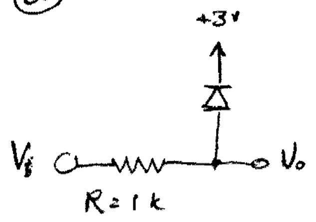
$I_L = \frac{V_{avg}}{R}$

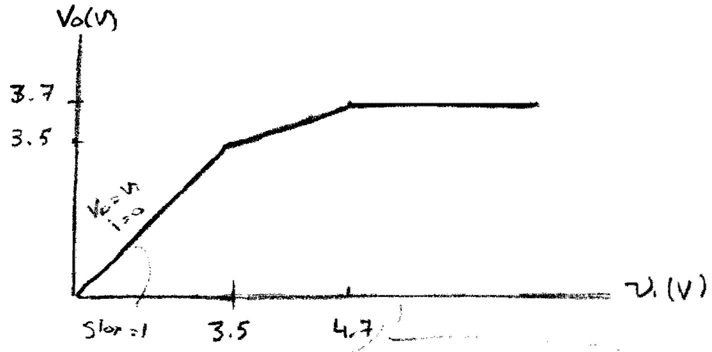
(e) —

(Eq. 4.32) $i_{D,MAX} = I_L\left[1 + 2\pi\sqrt{\frac{2(V_P - V_D)}{V_r}}\right] = \frac{12V}{200}\left[1 + 2\pi\sqrt{\frac{2(13.7+0.7)}{2}}\right] = 1.419A$

④ Problem 4.87

ⓐ





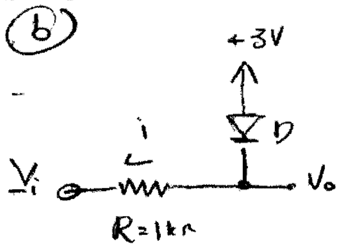
$v_I = v_o + iR$

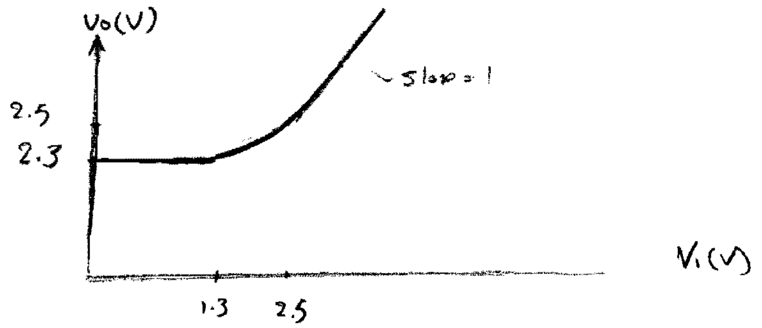
$v_I \leq 3.5V$, $i = 0$ and $v_o = v_I$

at $v_I = 3.7V$ the diode is conducting $i = 1mA$ so $v_I = V_o + 1mA \times 10^3 = \underline{4.7V}$

for $v_I > 4.7V$ the diode current at 0.7V, thus v_o flattens and Vo Vs Vi becomes a horizontal line. In practice, the diode current increases slowly and the line will have a small nonzero slop.

ⓑ





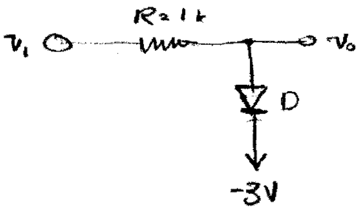
If $v_o > 2.5V$, $V_o = v_I$

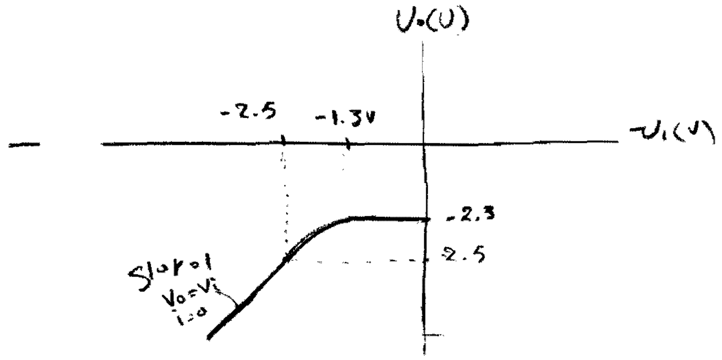
diode conducting when $V_o = 2.5V$ so $I_D = 1mA$ with drop of 0.7 at $V_o = 2.3$

So $V_I = v_o - iR = 2.3 - 1mA \times 10^3 = \underline{1.3V}$

(4) Cont. Problem 4.87

(c)





for $V_I \leq -2.5V$ the diode will be off and $v_O = V_I$. at $v_I = -2.5V$ the diode begins to conduct and its current reachs 1 mA at $v_I = -1.3V$ (corresponding to $V_O = -2.3V$). As V_I further increases, the diode current increases but it's voltage remains constant at 0.7V Thus v_O flattens

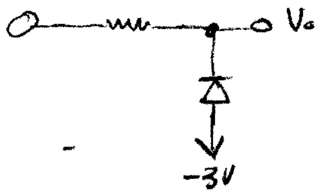
$v_O = -3V + 0.5 = -2.5V$

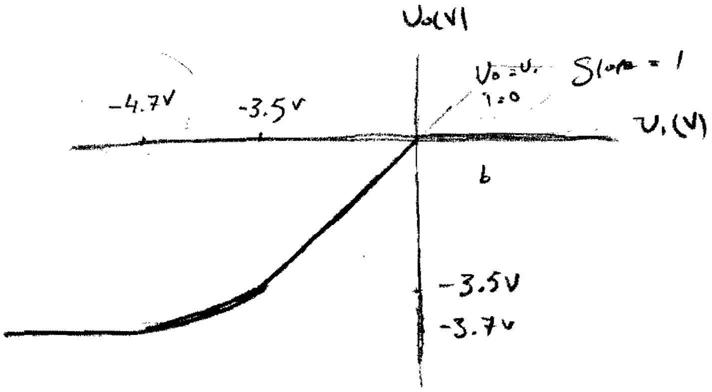
full conducting $V_D = 0.2V$

$V_O = -2.3V$

$V_I = -2.3 + 1mA \times 1000 = -4.3V$

(d)





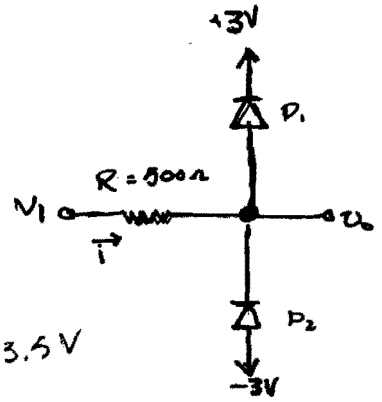
begin conducting at 0.5V

$V_O = -3.5V$

full conducting, $V_O = -3 - 0.7 = -3.7V$

$V_I = -3.7 - 1mA \times 1000 = -4.7V$

(5) PROBLEM 4.88



So $-3.5 \leq V_1 \leq +3.5V$

diodes D_1 and D_2 will be cutoff and $i = 0$, thus $V_o = V_1$, for $V_1 > 3.5V$ D_1 will begin conducting and it's Voltage reaches 0.7V (and thus $V_o = +3.7V$) at $i = 1mA$, the corresponding Value of v_1 is $V_1 = V_o - iR$,

$$V_1 = 3.7 + 1m \times 500 = +4.2V$$

for $v_1 > 4.2V$, the Voltage of diode D_1 remains 0.7V and V_o saturates at +3.7V

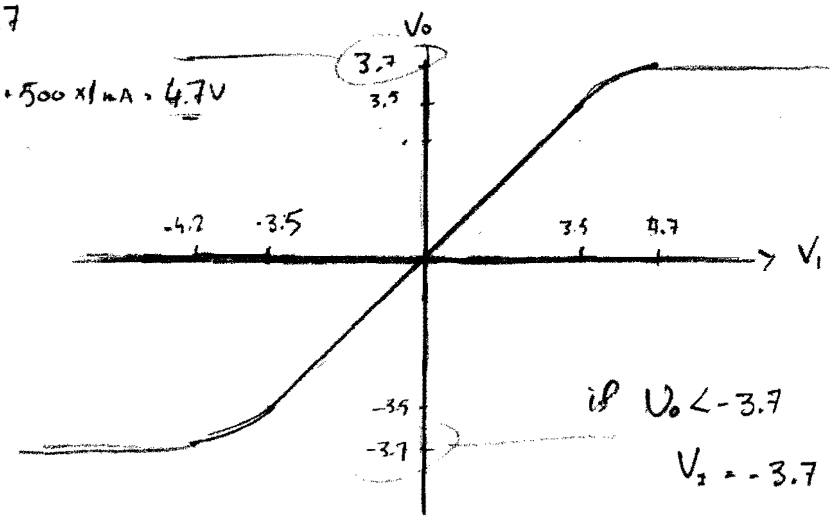
if $V \leq -3.5$ D_2 conducts at $V_1 = -3.5V$ and it's Voltage becomes 0.7

$v_o = -3.7$ at $i = 1mA$ (in the direction into v_1) at $V_1 = -4.2V$

for $v_1 \leq -4.2$, $V_o = -3.7V$

if $V_o > 3.7$

$V_I = 3.7 + 500 \times 1mA = 4.7V$



if $V_o < -3.7$ D_2 on

$V_I = -3.7 - 500 \times 1m = -4.2V$

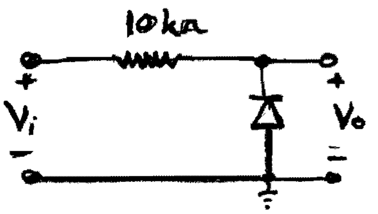
D2 ON, D1 off	D1 and D2 OFF	D1 ON, D2 off

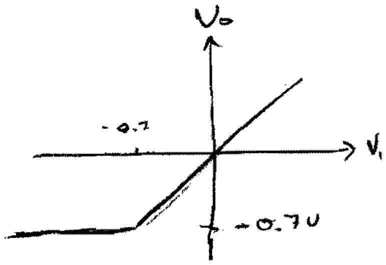
⑥ PROBLEM 4.92

limiting Circuit Using Diodes and 10 kΩ resistor

ⓐ -0.7V and above , ⓑ -2.1 V and above . ⓒ ± 1.4V

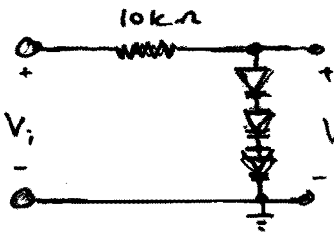
ⓐ

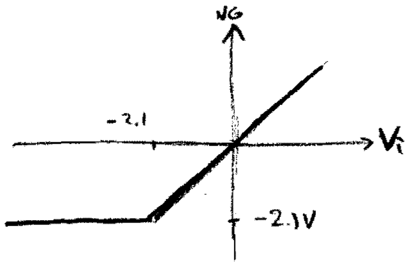




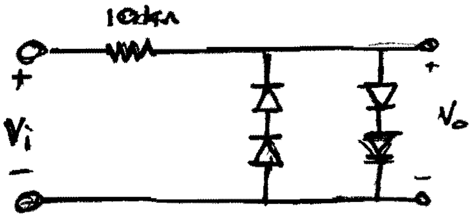
ⓑ

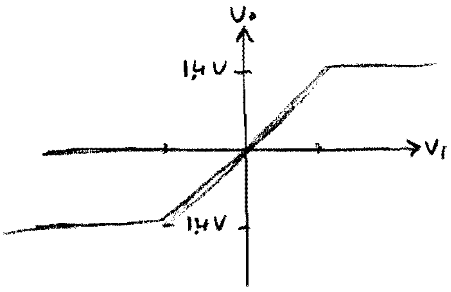
2.1/0.7 = 3 diodes





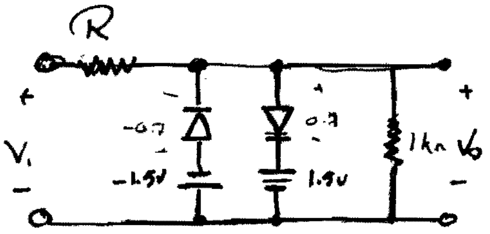
ⓒ





(7) Problem 4.93

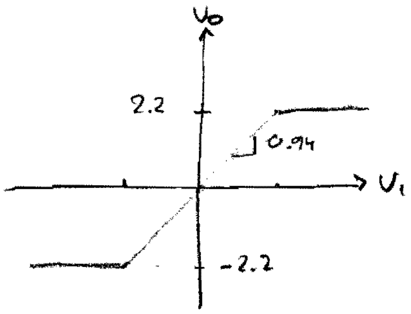
Two side limiting Circuit Using 2 Diodes and resistor. limiting level of ±3.8V



In the nonlimiting region

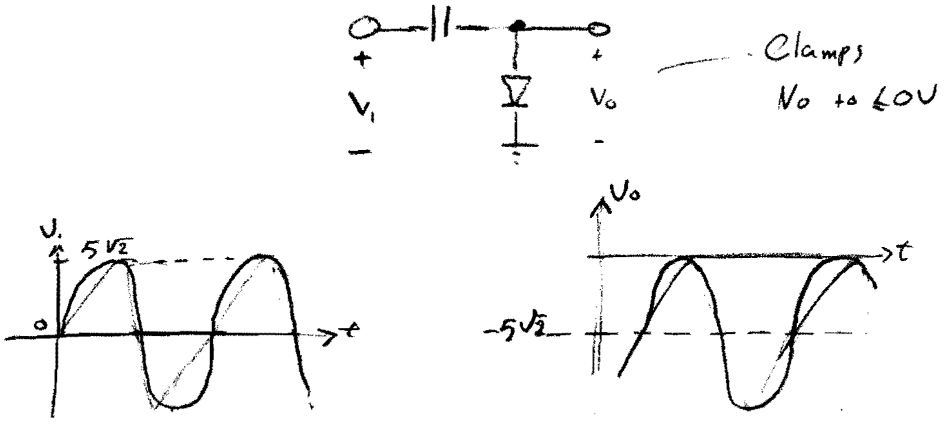
$$\frac{v_o}{v_i} = \frac{1000}{1000 + R} \geq 0.94$$

$R \leq 63.8\,\Omega$



(8) PROBLEM 4.96

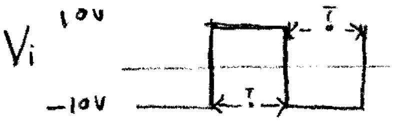
A Clamped Capacitor Using an ideal diode with Cathode grounded is supplied with a sine wave of 10-Vrms. What is the average (dc) Value of resulting output?



$$v_{o,avg} = -5\sqrt{2} = -7.071\text{ V}$$

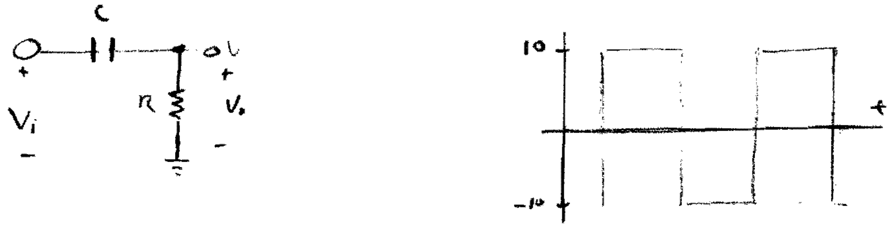
EE320 Homework 5

(9) Problem 4.97

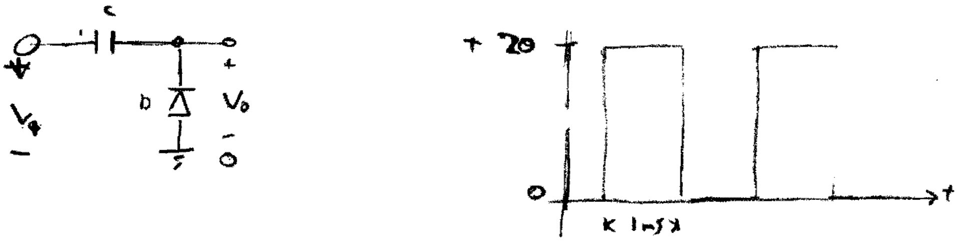


T = 1ms

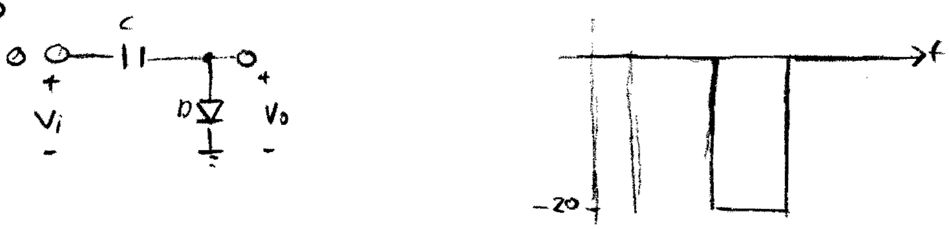
(a)



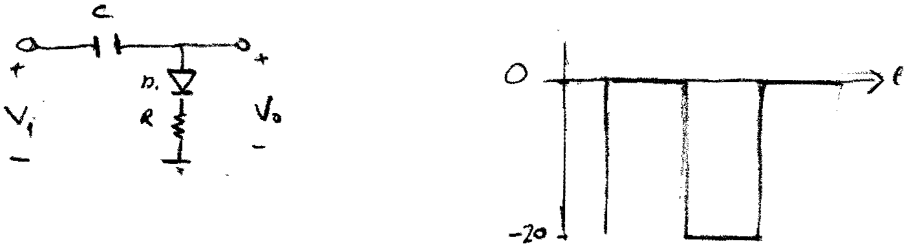
(b)



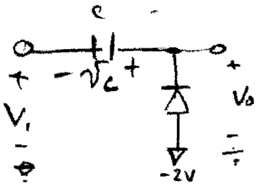
(c)

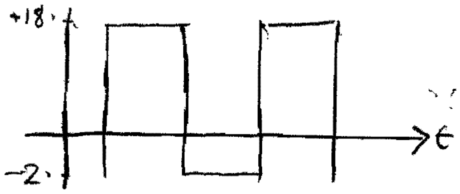


(d)



(e)





$v_C \rightarrow -2 - (-10) = -8V$

$v_o = V_I + V_C$

$-10 + 8 = -2V$

$+10 + 8 = 18$