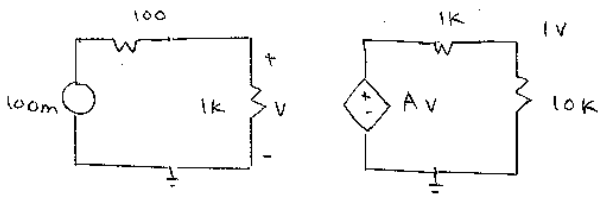
5. A voltage amplifier (with voltage gain A, input resistance of 1kΩ and output resistance of 1l is used to amplify a 100 mV voltage source (with source resistance of 100 Ω) to give a 1V outp a 10 kΩ load. Sketch the circuit model of the source-amplifier-load circuit and hence show that 12.1 . (16)



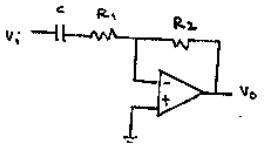
8

$$\therefore \quad 1 = A_V \frac{10K}{11K}$$

$$= A \; 100m \; \frac{1K}{1{\cdot}1K} \; \frac{10K}{11K} \qquad 8$$

$$\therefore \quad A = 12{\cdot}1$$

7. In the ideal op amp circuit, show that $H = V_o/V_i = -R_2 / (R_1 + 1/j\omega C)$.
If $C = 1\ \mu F$, $R_1 = 2\ k\Omega$ and $R_2 = 10\ k\Omega$, find the magnitude of H (|H|) when $\omega = 0$, $1/CR_1$ and ∞.
Hence sketch |H| versus ω. What filter is it? (27)



$$\frac{V_i - 0}{Z_1} = \frac{0 - V_o}{Z_2}$$

$$\therefore \quad \frac{V_o}{V_i} = -\frac{Z_2}{Z_1} = -\frac{R_2}{R_1 + \frac{1}{j\omega C}} \qquad 6$$

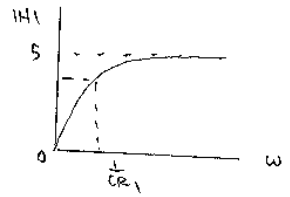
$$= H$$

$$|H| = \frac{\frac{R_2}{R_1}}{\sqrt{1 + \left(\frac{1}{\omega C R_1}\right)^2}} \qquad 3$$

$\omega = 0 \qquad |H| = 0 \qquad 4$

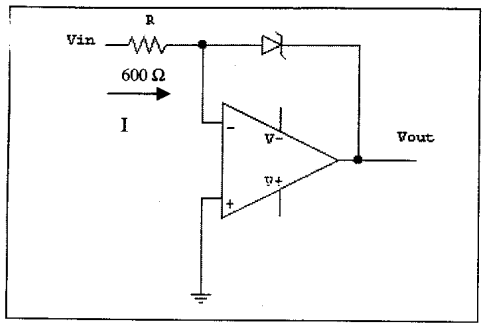
$\omega = \infty \qquad |H| = \frac{R_2}{R_1} = 5 \qquad 4$

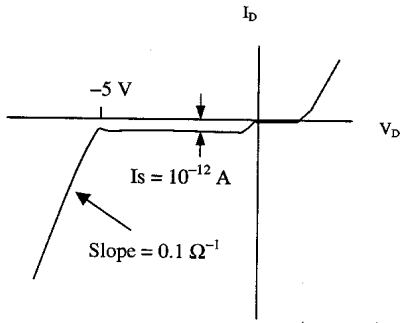
$\omega = \frac{1}{CR_1} \qquad |H| = \frac{\frac{R_2}{R_1}}{\sqrt{2}} = \frac{5}{\sqrt{2}} \qquad 4$



high pass filter . 6

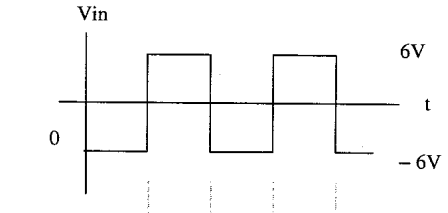
7. Given the following circuit diagram, the input voltage Vin and the I-V characteristics of the zener diode.



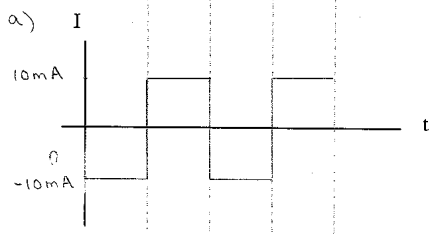


Diode equation : $I_D = Is \exp\left(\frac{V_D}{26mV}\right)$

a) Sketch the current I. Show your calculations clearly. (6 marks)
b) Sketch the output voltage Vout. Show your calculations clearly. (20 marks)



a) $I = \frac{Vin}{R} = \frac{6V}{600} = 10\,mA$ 2



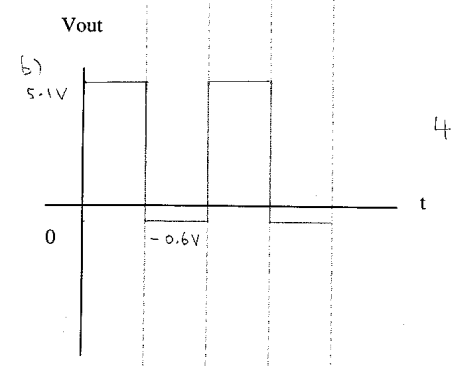
4

b) $I = 10\,mA$

diode is forward biassed

$I = 10m = Ip\ e^{-\frac{Vo}{26m}}$

$\therefore Vo = -0.6\,V$ 8



4

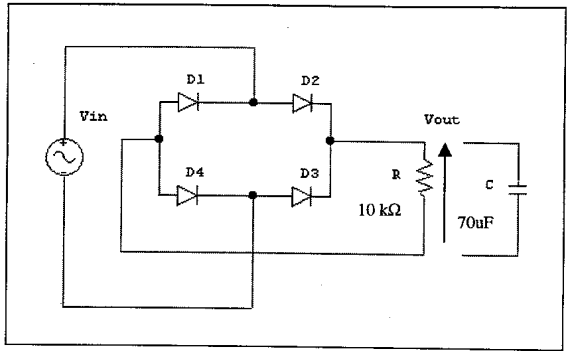
$I = -10\,mA$

diode is breakdown

$Vo = 5 + \frac{10m}{0.1} = 5.1\,V$ 8

8. Given the following ideal diode circuit diagram.

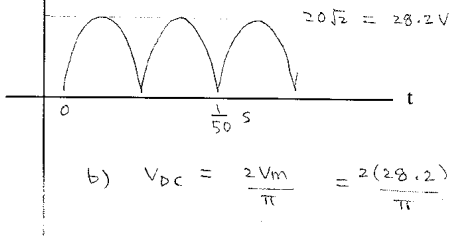
Vin = 20 Vrms
50Hz



a) Sketch the output voltage Vout. Show clearly the voltage and time intercepts. (5 marks)
b) Calculate the DC voltage V_{DC} across R ($V_{DC} = 2Vm / \pi$). (3 marks)
c) Find the peak inverse voltage (PIV) of the diode. (4 marks)
d) Show that the ripple voltage Vr = 0.4V after a capacitor of 70μF is connected across R. (6 marks)
Justify the assumption that you used. (3 marks)
e) Estimate the DC voltage across R after the capacitor is added. (4 marks)

Vout

a)



5

b) $V_{DC} = \frac{2Vm}{\pi} = \frac{2(28.2)}{\pi} = 18\,V$ 3

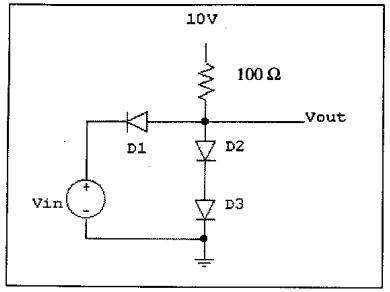
c) $PIV = Vm = 28.2\,V$ 4

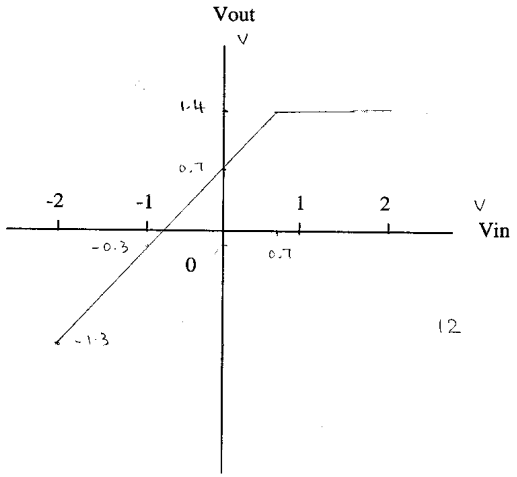
d) $Vr = \frac{Vm}{2fRC} = \frac{28.2}{2(50)\,10k\,(70\mu)} = 0.4\,V$ 6

$RC = 0.7\,s >> \frac{1}{50}\,s = T$ 3

e) $V_{DC} \approx Vm - \frac{Vr}{2} = 28.2 - 0.2 = 28\,V$ 4

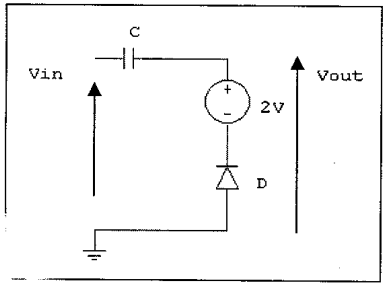
9. a) Plot the transfer curve Vout versus Vin for the following circuit ($-2V \le Vin \le 2V$). Assume $V_D = 0.7V$ when the diode is on. Show clearly the voltages. (12 marks)



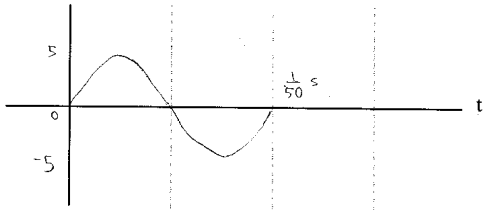


12

b) Sketch Vin and Vout for the following circuit. Assume the diode is ideal. Show clearly the voltage and time intercepts. (12 marks)



Vin = 5 sin 100π t V

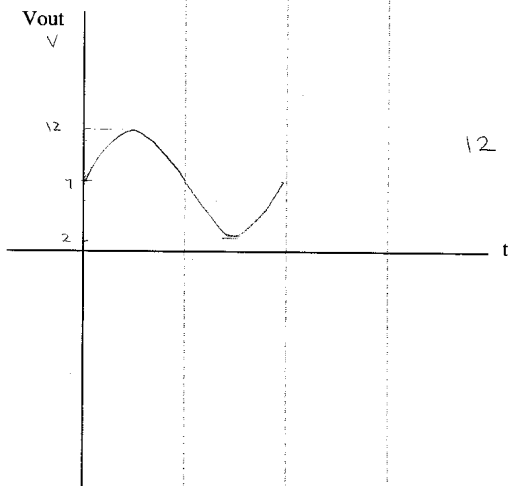


$\omega = 2\pi f$

$= 100\pi$

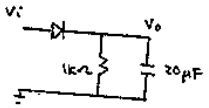
$\therefore f = 50\ Hz$

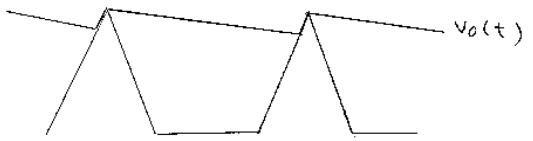
$T = \frac{1}{50}\ s$



12

9. In the ideal diode circuit, Vi is a 1 kHz triangular wave with 20V peak to peak (0V average).
(a) Sketch Vo(t). (6)
(b) Show that the ripple voltage is roughly 0.5V. (8)
(c) Show also that the peak inverse voltage (PIV) of the diode is 20V. (4)





6

$CR = 20\mu \cdot 1k = 20ms$

$>> \quad T = 1m$

$\therefore V_r = \frac{V_m T}{CR} = \frac{10\ V\ (1m)}{20m}$

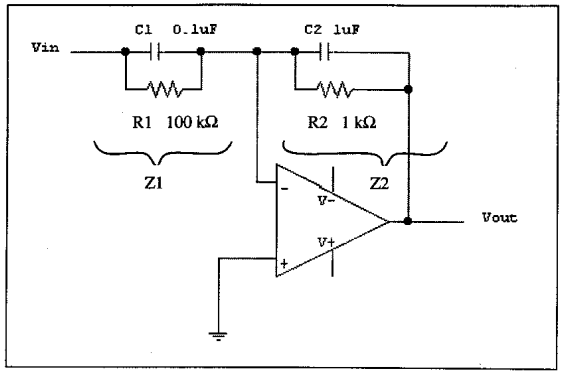
$= 0.5V$

8

$PIV = 2V_m = 20V$

4

11. Given the following circuit diagram. Assume ideal Op Amp.



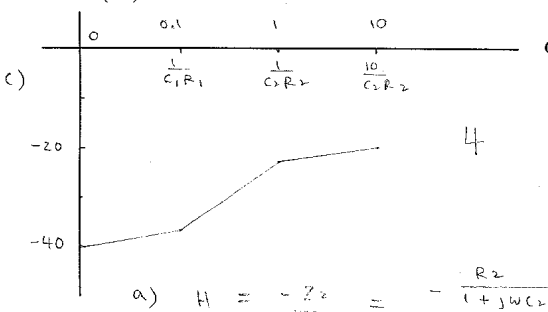
a) Write the transfer function H(jω) = Vout(jω) / Vin(jω). (10 marks)
Given : H = – Z2 / Z1 for an inverting amp.

b) Show that | H(ω) | = – 40dB when ω = 0 and | H(ω) | ≈ – 20dB when ω = 10 / $C_2 R_2$. (12 marks)
Appropriate assumption will be accepted.

c) Sketch the gain | H(ω) | versus the frequency. (4 marks)
Given : | H(ω) | ≈ – 23dB when ω = 1 / $C_2 R_2$ and | H(ω) | ≈ – 37dB when ω = 1 / $C_1 R_1$.

d) What is the type of this filter ? (2 marks)

c)



4

$R \,||\, \frac{1}{j\omega C} = \frac{R(\frac{1}{j\omega C})}{R + \frac{1}{j\omega C}} = \frac{R}{1 + j\omega CR}$

$C_1R_1 = 0.1\mu(100K) = 10\,ms$

$C_2R_2 = 1\mu(1K) = 1\,ms$

a) $H = \frac{-Z_2}{Z_1} = \frac{-\frac{R_2}{1 + j\omega C_2 R_2}}{\frac{R_1}{1 + j\omega C_1 R_1}} = -\frac{R_2}{R_1}\,\frac{1 + j\omega C_1 R_1}{1 + j\omega C_2 R_2}$ 10

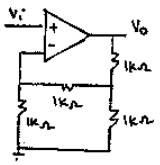
b) $\omega = 0 \quad H = \frac{-R_2}{R_1} = \frac{-1K}{100K}$ or $|H| = -40dB$ 6

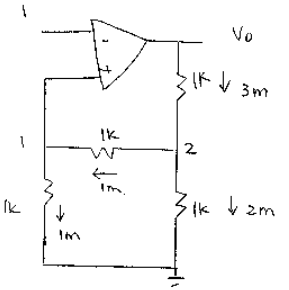
$\omega = \frac{10}{C_2R_2} \quad H = -\frac{1}{100}\,\frac{1 + j\frac{10C_1R_1}{C_2R_2}}{1 + j10} = -\frac{1}{100}\,\frac{1 + j100}{1 + j10}$

$\approx -\frac{1}{10} \quad \therefore |H| = -20\,dB$ 6

d) high pass filter 2

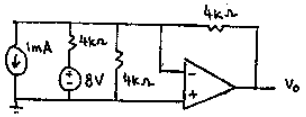
6. (a) In the ideal op amp circuit, if Vi = 1V, find Vo. (12)

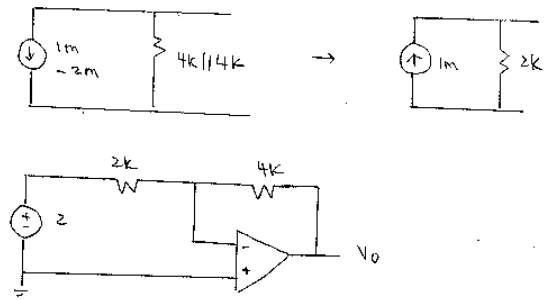




$\therefore V_o = 1K \times 3m + 1K \times 2m = 5V$ 12

(b) In the ideal op amp circuit, show that Vo = - 4V. (Hint: use source transform). (16)

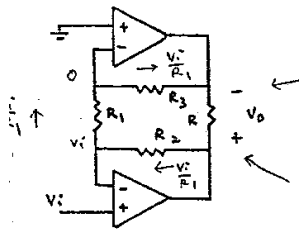




12

$\therefore V_o = -\frac{4k}{2k}\,2 = -4V$ 4

8. For the following circuit, assume ideal op amp, show that $V_o = V_i (1 + R_2/R_1 + R_3/R_1)$. (20)



$-\frac{V_i}{R_1} R_3$ 4

$V_i + \frac{V_i}{R_1} R_2$ 4

$\therefore V_o = V_i (1 + \frac{R_2}{R_1}) - (- V_i \frac{R_3}{R_1})$

$= V_i (1 + \frac{R_2}{R_1} + \frac{R_3}{R_1})$ 4

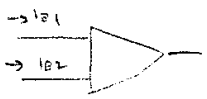
$R_i \sim \infty$

$A \propto R_1$ 4

can be a difference amp 1

9. Explain briefly the following real op amp properties: (i) input offset voltage, (ii) input bias current, (iii) slew rate. (9) .

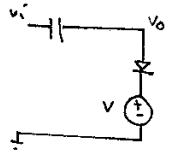
3

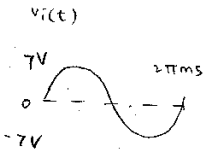


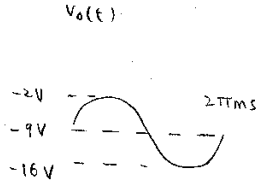
3

Slew rate ~ maximum rate of change of V_o 3

6. (a) If Vi (t) = 7 sin 1000t V and V = -2V, sketch Vi(t) and Vo(t) for the following ideal diode circuit. Show clearly the voltages and time in your sketch. (12)

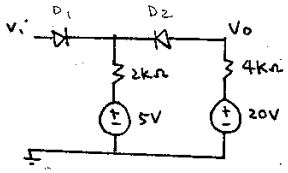


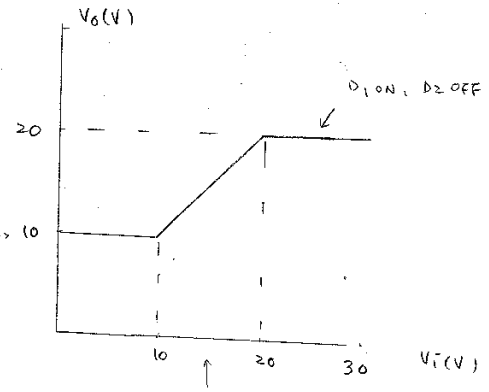




12

(b) Plot Vo versus Vi for $0V \le Vi \le 30V$ for the following ideal diode circuit. Show clearly all the voltages in your sketch. (13)





13

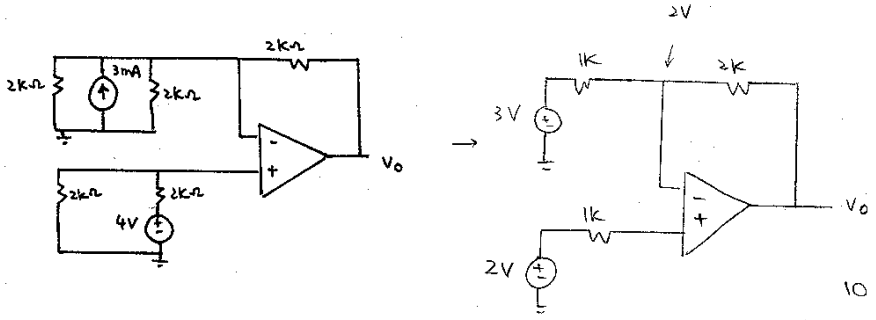
D_1 off, D_2 ON

$V_o = 5 + (20-5)\frac{2K}{2K+4K}$ → 10

D_1 ON, D_2 ON

$V_o = V_i$

8. (a) Find Vo for the following ideal op amp circuit. (14)



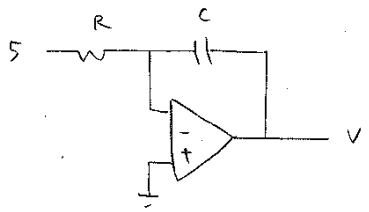
10

$\therefore \frac{3-2}{1K} = \frac{2-V_o}{2K}$

$\therefore V_o = 0V$ 4

(b) Design an ideal op amp circuit to obtain the solution of the following differential equation:

$5\frac{dv}{dt} + \frac{5}{7} = 0$. (14)



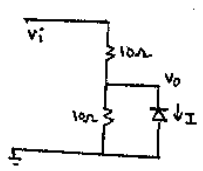
$\frac{5}{R} = -C\frac{dV}{dt}$

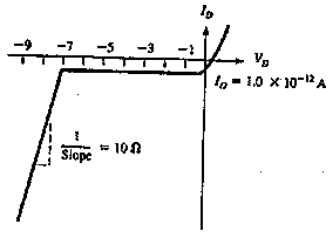
$\therefore \frac{dv}{dt} + \frac{5}{CR} = 0$ 14

Let $CR = 35$ $\sim$ $R = 35k\Omega$

$C = 1mF$

10. In the following diode circuit, the diode has the reverse characteristics as shown.
(a) Find Vo and I if Vi = 4V. (9)
(b) Show that I = 0.2A if Vi = 20V. (17)



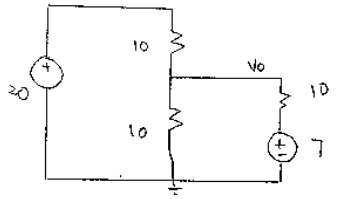


$V_i = 4V$

$V_o = 2V$ 5

$I = I_o = 1pA$ 4

$V_i = 20V$



6

$\therefore \frac{20-V_o}{10} = \frac{V_o-7}{10} + \frac{V_o}{10}$

$\therefore V_o = 9V$ 8

$\therefore I = \frac{9-7}{10} = 0.2A$ 3