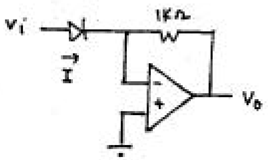
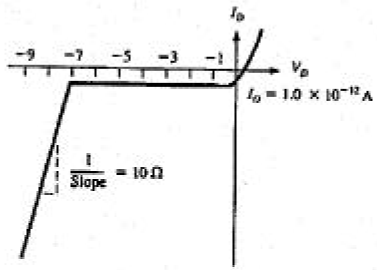
7. In the ideal op amp circuit, the diode has the reverse characteristics as shown. The diode equation is $I_D = I_O \exp\frac{V_D}{26mV}$. (a) Find I and Vo if Vi = 0.6V.
(b) Find I and Vo if Vi = -7.1V. Sketch also the model of the diode at breakdown. (27)





(a) $I = I_o \exp \frac{V_D}{26m}$

$= (10^{-12}) \exp\left(\frac{600m}{26m}\right)$

$= 10.5$ mA

$\therefore V_o = -I(1K) = -10.5V$ 12

(b) diode breakdown

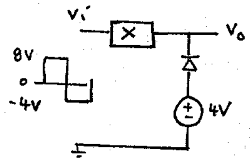
$I = -\frac{0.1V}{10\Omega} = -0.01$ A

12

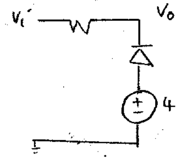
$\therefore V_o = -I(1K) = 10V$

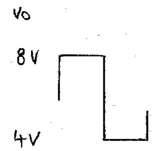
3

8. (a) In the ideal diode circuit, sketch Vo(t) (i) if X is a resistor R, and (ii) if X is a capacitor C. Show clearly the voltages in your sketch. (19)



(i)





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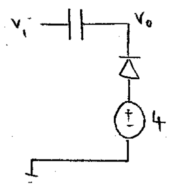
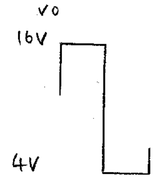
(ii)





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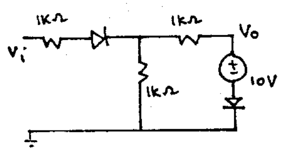
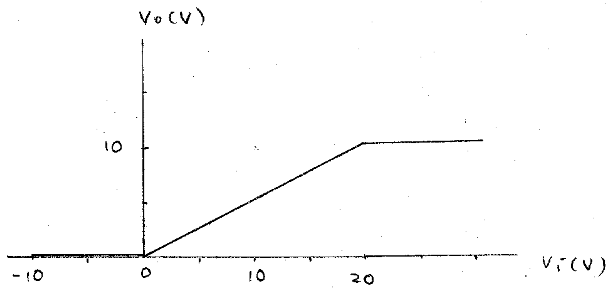
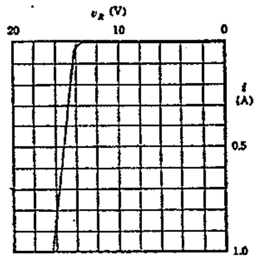
(b) In the ideal diode circuit, plot Vo versus Vi for -10V ≤ Vi ≤ 30V. Show clearly all voltages in your sketch. (12)

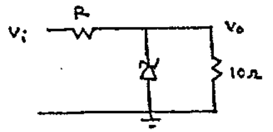




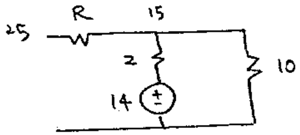
12

5. In the following re__or circuit, the Zener diode has the reverse characteristics as shown.
(a) If V_O = 15V when V_i = 25V, show that R is around 5 Ω. (b) If R is 5 Ω, estimate the minimum V_i for the regulator circuit. (16)





(a)



$r_z \sim \frac{2V}{1A} \sim 2\Omega$

$V_z \sim 14V$

$$\frac{25-15}{R} = \frac{15-14}{2} + \frac{15}{10}$$

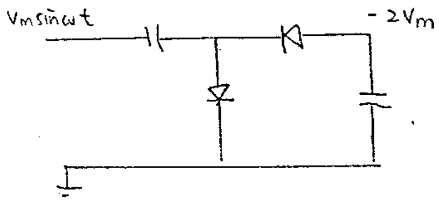
$\therefore R = 5\Omega$ 9

(b) min V_i when $I_Z \sim 0.05$ A, $V_o \sim 14.1$ V

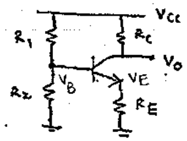
$$\frac{V_i - 14.1}{5} = \frac{14.1}{10} + 0.05$$

$V_i = 21.4V$ 7

(6) Design a diode circuit that can give an output voltage of -2Vm if the input voltage is Vm sinωt. (10)



9. For the following self-bias CE BJT amplifier, explain briefly how this circuit stabilises the collector current. (6)

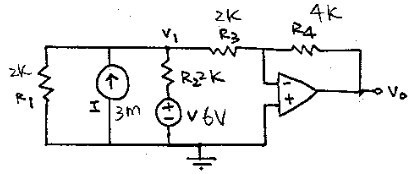


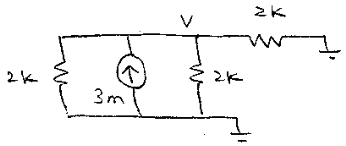
e.g. $I_c \uparrow$ $I_E \uparrow$ $V_E \uparrow$

$\because V_B = V_{BE} + V_E = \text{constant}$

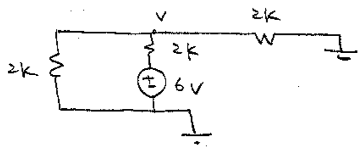
$\therefore V_{BE} \downarrow$ $I_B \downarrow$ $I_c \downarrow$ 6

10. Use superposition theorem or otherwise, find V_1 and show that Vo = - 8V for the circuit below. Assume the op amp is ideal and operating in the linear region. Given V = 6V, $R_1 = R_2 = R_3 = 2k\Omega$, $R_4 = 4k\Omega$, I = 3mA. (16)





$V_{3mA} = 1m \times 2K$
$= 2V$ 6



$V_{6V} = 6V \times \frac{1K}{3K}$
$= 2V$ 6

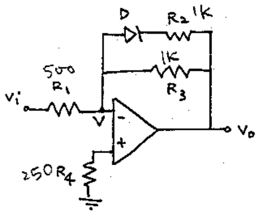
$\therefore V_o = -\frac{4K}{2K}(2V + 2V)$
$= -8V$ 4

(c) at resonance, $Z = R = \frac{1}{2}\Omega$ 3

$$\therefore P = \frac{V^2}{R} = \frac{\left(\frac{1}{\sqrt{2}}\right)^2}{\frac{1}{2}}$$ 5

$$= 1W$$

15. Assume the op amp and diode are ideal. The op amp is operating in the linear region.
Given $R_2 = R_3 = 1k\Omega$, $R_1 = 500\Omega$, $R_4 = 250\Omega$. (a) Show that V = 0V. (2)
(b) For $-2V \le Vi \le 2V$, find Vo/Vi and plot Vo versus Vi. Label all slopes and intercepts. (18)



$\because v_+ = 0$

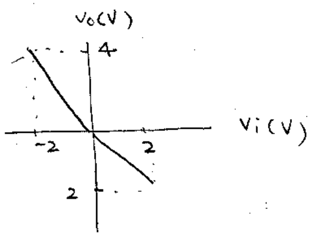
$\therefore v = v_- = 0\,V$ 2

For $v_i > 0$ D on

$$\frac{V_o}{V_i} = -\frac{500}{500} = -1$$ 6

For $v_i < 0$ D off

$$\frac{V_o}{V_i} = \frac{-1k}{500} = -2$$ 6



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