Exercise ch4
Electronics 1
Part 1

D4.15 Design the circuit of Fig. E4.15 so that $V_O = 3$ V when $I_L = 0$, and V_O changes by 20 mV per 1 mA of load current.

(a) Use the small-signal model of the diode to find the value of R.

(b) Specify the value of I_S of each of the diodes.

(c) For this design, use the diode exponential model to determine the actual change in V_O when a current $I_L = 1$ mA is drawn from the regulator.

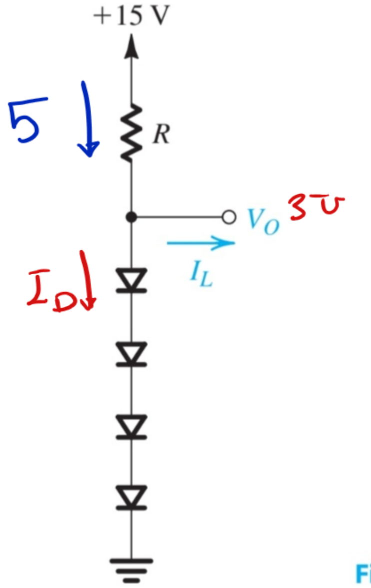


Figure E4.15

Ans. (a) $R = 2.4$ kΩ; (b) $I_S = 4.7 \times 10^{-16}$ A; (c) –23 mV

a) $\dfrac{\Delta V_o}{\Delta I_L} = \dfrac{20\,mV}{1\,mA} = 20\,\Omega$

$\therefore$ Total resistance $= 20\,\Omega$

For each Diode $\quad r_d = \dfrac{20}{4} = 5\,\Omega$

$\boxed{r_d = \dfrac{V_T}{I_D}} \Rightarrow 5 = \dfrac{25\,mV}{I_D}$

$\boxed{I_D = 5\,mA}$

$\boxed{R = \dfrac{15-3}{5\,mA} = 2.4\,k\Omega}$

$\boxed{b}$

$\because V_o = 3\,V$

Voltage Drod For each Diode

$$V_d = \frac{3}{4} = 0.75\,V$$

$$I_D = I_s\, e^{V_D/V_T}$$

$$I_s = \frac{I_D}{e^{V/V_T}} = \frac{5 * 10^{-3}}{e^{0.75/25 * 10^{-3}}} = 4.7 * 10^{-16} A$$

$\boxed{c}$ if $I_D = 5 - I_L$

$$= 5 - 1 = 4\,mA$$

$$\therefore V_D = V_T \ln\left(\frac{I_D}{I_s}\right)$$

$$V_D = 25 * 10^{-3} \ln \frac{4 * 10^{-3}}{4.7 * 10^{-16}}$$

$$V_D = 0.7443$$

$\therefore$ Voltage Drop across 4Diode $= 4 * 0.7443$

$= 2.977\,V$

$\therefore$ Chang $= V_o = 2.977 - 3 = -23\,mV$

EXERCISES

4.6 Find the change in diode voltage if the current changes from 0.1 mA to 10 mA.
Ans. 120 mV

4.7 A silicon junction diode has $v = 0.7$ V at $i = 1$ mA. Find the voltage drop at $i = 0.1$ mA and $i = 10$ mA.
Ans. 0.64 V; 0.76 V

4.6

$$V_2 - V_1 = 2.3\, V_T \log\left(\frac{I_2}{I_1}\right)$$

$$V_2 - V_1 = 2.3 * 25*10^{-3} \log\left(\frac{10}{0.1}\right)$$

$$\Delta V = V_2 - V_1 = 115\, mV$$

4.7

$$I = I_s\, e^{V/V_T} \quad (1)$$

$$\boxed{1 = I_s\, e^{0.7/V_T}} \quad (2)$$

Divide (1) by (2)

$$I\, mA = e^{(V-0.7)/V_T}$$

$$\boxed{\Rightarrow V = 0.7 + 0.025 \ln(I)}$$

if $I = 0.1\, mA$

$$V = 0.7 + 0.025 \ln(0.1) = 0.64\, V$$

if $I = 10\, mA$

$$V = 0.7 + 0.025 \ln(10) = 0.76\, V$$

حل اخر

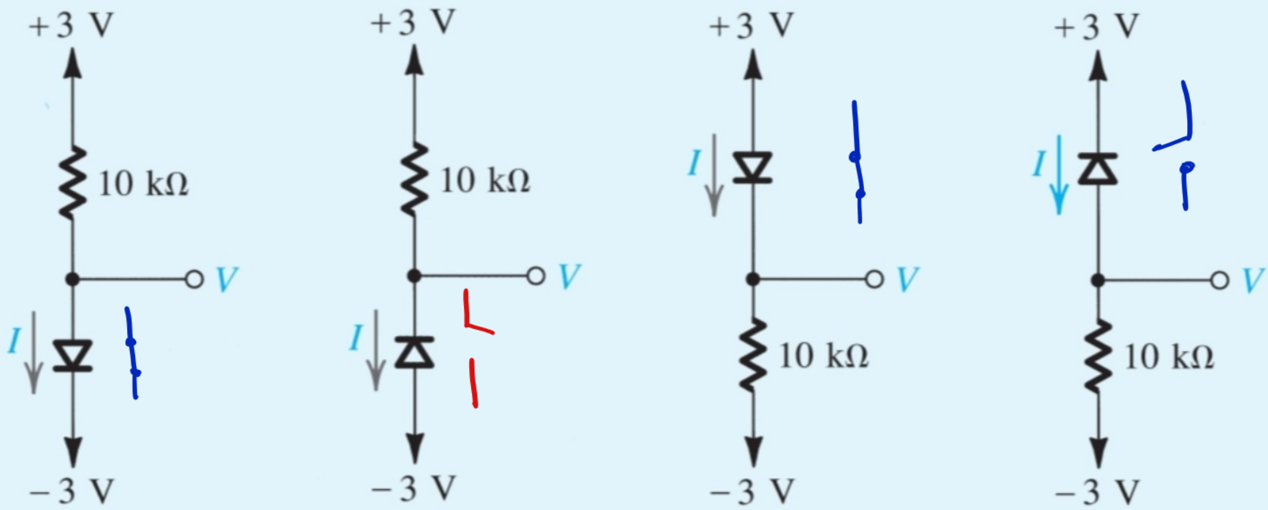
هلأ احسب I_s

ثم اعوض

$$\underbrace{I}_{10\quad 0.1} = I_s\, e^{V_D/0.025}$$

4.2 For the circuits shown in Fig. P4.2 using ideal diodes, find the values of the voltages and currents indicated.

4.3 For the circuits shown in Fig. P4.3 using ideal diodes, find the values of the labeled voltages and currents.



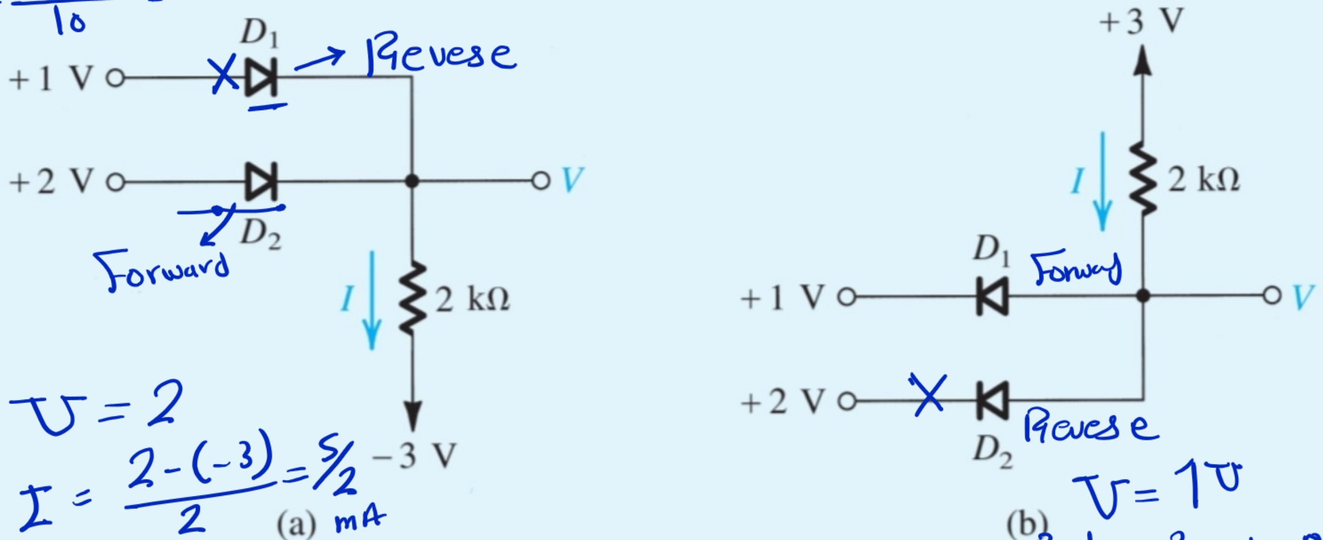
(a) Forward
$V = -3$
$I = \frac{3-(-3)}{10} = 0.6\,mA$

(b) reverse
$I = \text{Zero}$
$V = 3V$

(c) Forward
$V = 3$
$I = 0.6\,mA$

(d) Reverse
$I = 0$
$V = -3$

Figure P4.2



(a) D_1 → Revese
D_2 Forward
$V = 2$
$I = \frac{2-(-3)}{2} = 5/2$ mA

(b) D_1 Forward
D_2 Revese
$V = 1V$
$I = \frac{3-1}{2} = 2/2 = 1\,mA$

Figure P4.3

4.9 Assuming that the diodes in the circuits of Fig. P4.9 are ideal, find the values of the labeled voltages and currents.

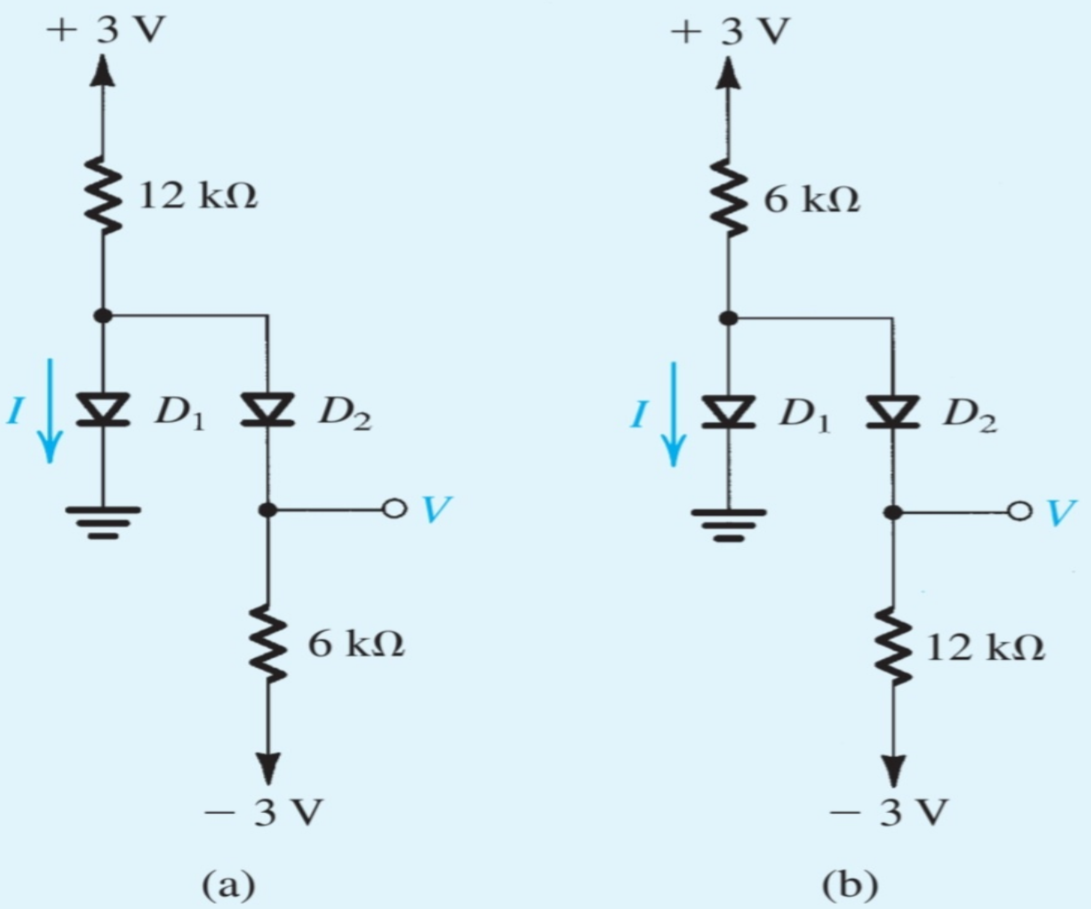
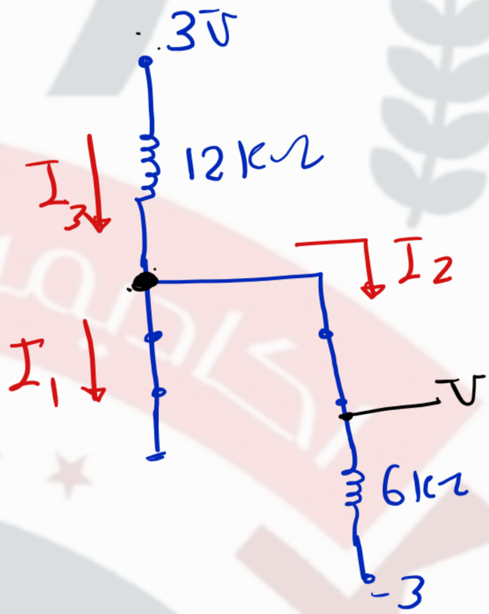


Figure P4.9

$\boxed{a}$ D_1 & $D_2 \Rightarrow$ F.W

$I_3 = I_1 + I_2$



$$\frac{3-0}{12} = I_1 + \frac{0-(-3)}{6}$$

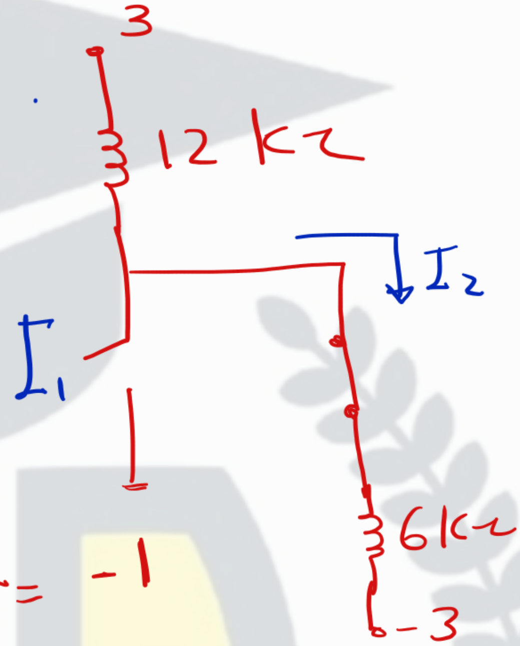
$$\frac{1}{4} = I_1 + \frac{1}{2}$$

$$I_1 = -\frac{1}{4}$$

V = Zero

Assume D_1 Reverse

D_2 Forward

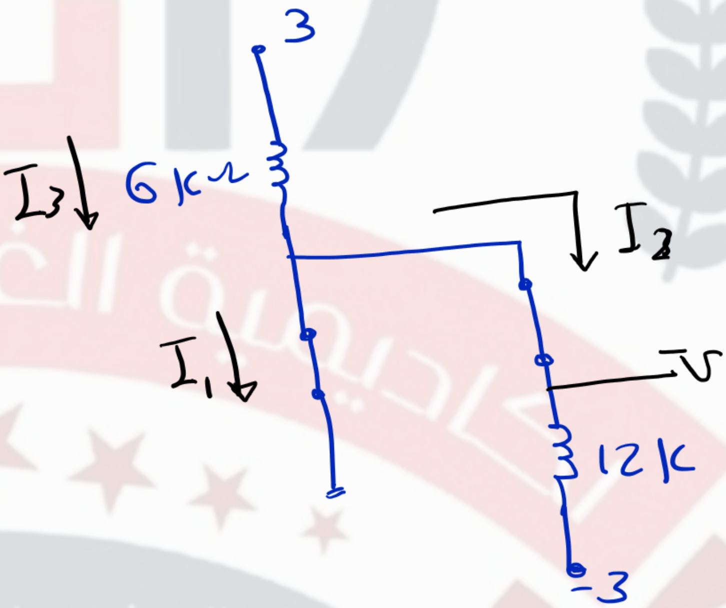


$I_{D_1} = \text{Zero}$

$$I_2 = \frac{3-(-3)}{12+6} = \frac{6}{18} = 1/3$$

$$\frac{3-V}{12} = 1/3 \Rightarrow V = -1$$

$\boxed{b}$ D_1 & D_2 F.W



$V = \text{Zero}$

$$I_3 = I_1 + I_2$$

$$\frac{3-0}{6} = I_1 + \frac{0-(-3)}{12}$$

$$1/2 = I_1 + 1/4$$

$$\boxed{I_1 = 1/4\ mA}$$

4.58 A particular design of a voltage regulator is shown in Fig. P4.58. Diodes D_1 and D_2 are 10-mA units; that is, each has a voltage drop of 0.7 V at a current of 10 mA. Use the diode exponential model and iterative analysis to answer the following questions:

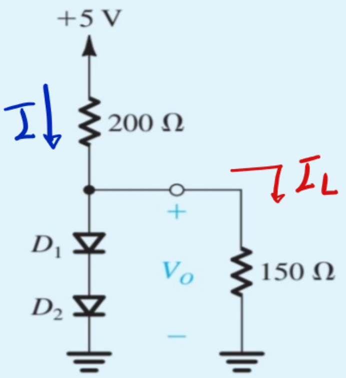


Figure P4.58

(a) What is the regulator output voltage V_O with the 150-Ω load connected?
(b) Find V_O with no load.
(c) With the load connected, to what value can the 5-V supply be lowered while maintaining the loaded output voltage within 0.1 V of its nominal value?
(d) What does the loaded output voltage become when the 5-V supply is raised by the same amount as the drop found in (c)?
(e) For the range of changes explored in (c) and (d), by what percentage does the output voltage change for each percentage change of supply voltage in the worst case?

a) Iteration ⇐

$V_D = 0.7\ V$

$V_o = 2V_D = 1.4\ V$

$I_L = \frac{V_o}{R_L} = \frac{1.4}{0.15} = 9.33\,mA$

$I = \frac{5 - V_o}{R} = \frac{5-1.4}{0.2\,k} = 18\,mA$

$I_D = I - I_L = 18 - 9.33 = 8.67\,mA$

Iteration 2

$V_D = \underbrace{0.7}_{given} + 0.025 \ln\left(\frac{8.67}{\underbrace{10}_{given}}\right)$

$V_D = 0.696\ V$

$\therefore\ V_o = 2V_D = 1.393\ V$

$I_L = 9.287\,mA$

$I = \frac{5-1.393}{0.2} = 18.04$

$I_D = 18.04 - 9.287 = 8.753\ mA$

Iteration 3

$V_D = 0.7 + 0.025 \ln\left(\frac{8.753}{10}\right) = 0.697$

$\boxed{V_o = 2V_D = 1.393\ V}$

b) with no load

$V_D = 0.7$

$V_o = 2V_D = 1.4$

$I = \frac{5-1.4}{0.2} = 18mA$

$I_D = I = 18mA$

Iteration 2

$V_D = 0.7 + 0.025 \ln\left(\frac{18}{10}\right) = 0.715V$

$V_o = 1.429V$

$I = 17.85$

$I_D = 17.85$

Iteration 3

$V_D = 0.7 + 0.025 \ln\left(\frac{17.85}{10}\right) = 0.714$

$\therefore V_o = 2V_D = \underline{\underline{1.43}}$

$\boxed{C}$

$V_o = 1.39 - 0.1 = \underline{1.29v}$

$I_L = \frac{1.29}{0.15} = 8.6\,mA$

$V_D = \frac{1.29}{2} = 0.645$

$I_D = I_o * e^{(\Delta v / v_T)}$

$I_D = I_o * e^{\left(\frac{0.645 - 0.7}{0.025}\right)}$

$I_D = 1.11\,mA$

$I = I_L + I_D = 8.6 + 1.11 = 9.71\,mA$

$\therefore \frac{V_{supply} - V_o}{R_1} = I$

$\frac{V_{supply} - 1.29}{0.2} = 9.71$

$V_{supply} = 3.232$