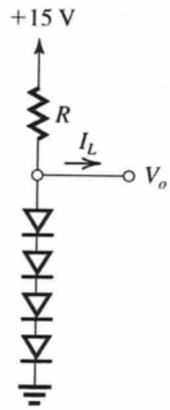
Ex: 4.15



a. In this problem $\frac{\Delta V_O}{\Delta i_L} = \frac{20\text{ mV}}{1\text{ mA}} = 20\ \Omega$

$\therefore$ Total small signal resistance of the four diodes $= 20\ \Omega$

$\therefore$ For each diode $r_d = \frac{20}{4} = 5\ \Omega$

But $r_d = \frac{V_T}{I_D} \Rightarrow 5 = \frac{25\text{ mV}}{I_D}$

$\therefore I_D = 5\text{ mA}$

and $R = \frac{15 - 3}{5\text{ mA}} = 2.4\text{ k}\Omega$

b. For $V_O = 3\text{ V}$, voltage drop across each diode $= \frac{3}{4} = 0.75\text{ V}$

$i_D = I_S e^{V/V_T}$

$I_S = \frac{i_D}{e^{V/V_T}} = \frac{5}{e^{0.75/25 \times 10^{-3}}} = 4.7 \times 10^{-16}\text{A}$

c. If $i_D = 5 - i_L = 5 - 1 = 4\text{ mA}$

Across each diode the voltage drop is

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

$= 25 \times 10^{-3} \times \ln\left(\frac{4 \times 10^{-3}}{4.7 \times 10^{-16}}\right)$

$= 0.7443\text{ V}$

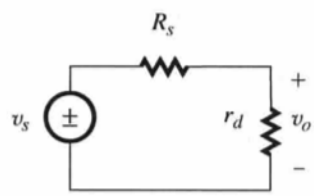
Voltage drop across 4 diodes

$= 4 \times 0.7443 = 2.977\text{ V}$

so change in $V_O = 3 - 2.977 = 23\text{ mV}$

4.46

The dc current I flows through the diode giving rise to the diode resistance $r_d\left(=\frac{V_T}{I}\right)$ and the Small-Signal equivalent circuit is represented by



$$v_O = v_S \times \frac{r_d}{r_d + R_S} = v_S \frac{V_T/I}{\frac{V_T}{I} + R_S}$$

$$= v_S \frac{V_T}{V_T + IR_S}$$

Now $v_O = 5\text{ mV} \times \frac{25\text{ mV}}{25\text{ mV} + 10^3 I}$

$$= 0.005 \times \frac{0.025}{0.025 + 10^3 I}$$

I	v_O
1 mA	0.122 mV
0.1 mA	1.0 mV
1 μA	5.0 mV

For $v_O = \frac{1}{2}V_S = v_S \times \frac{0.025}{0.025 + 10^3 I}$

$\Rightarrow I = 25\ \mu\text{A}$