Exercise 4.4

a) Plot the i_A vs. v_A characteristics for the nonlinear network shown in Figure 4.3. Assume the diode is ideal.

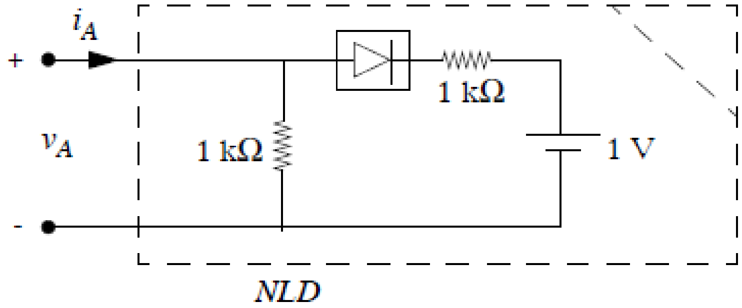


Figure 4.3:

b) The nonlinear network from part (a) is connected as shown in Figure 4.4. Draw the load line on your $i-v$ characteristic from part (a), and find i_T.

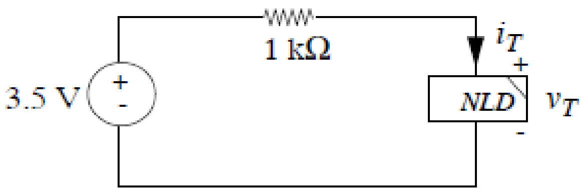


Figure 4.4:

Solution:

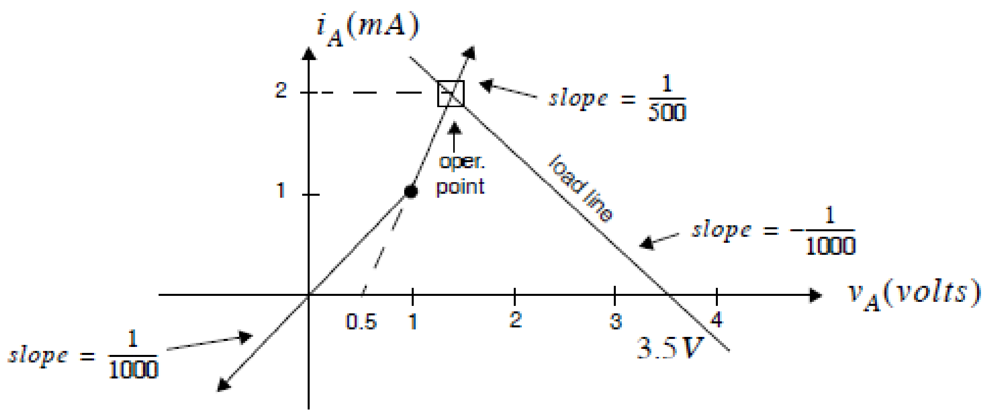


Figure 4.5:

a) $v_A > 1$: Diode on

$$i_A = \frac{v_A}{1000 \,||\, 1000}$$

$v_A < 1$: Diode off

$$i_A = \frac{v_A}{1000}$$

b) Load line:

KVL:

$$3.5V - i_T\,(1000) - v_T = 0$$

$$i_T = \frac{3.5 - v_T}{1000}$$

Operating point occurs at intersection, and we find that

$$i_T = 2mA$$

ANS:: (b) $i_T = 2\text{mA}$

Exercise 4.6 For the circuit in Figure 4.7, find the input characteristic, i versus v, and the transfer characteristic i_2 versus v. I is fixed and positive. Express your results in graphs, labeling all slopes, intercepts, and coordinates of any break points.

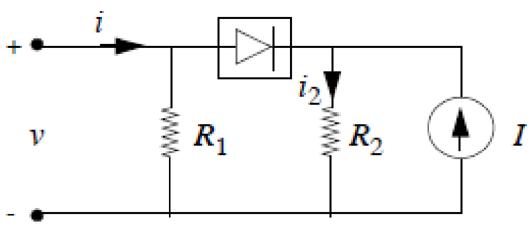


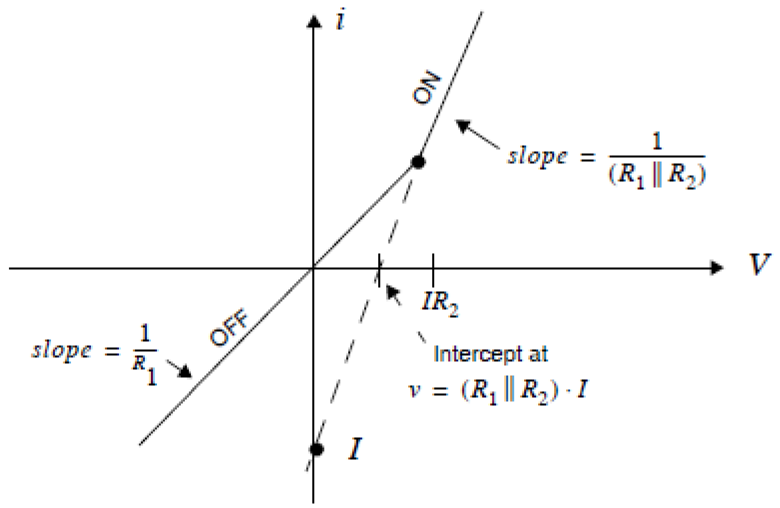
Figure 4.7:

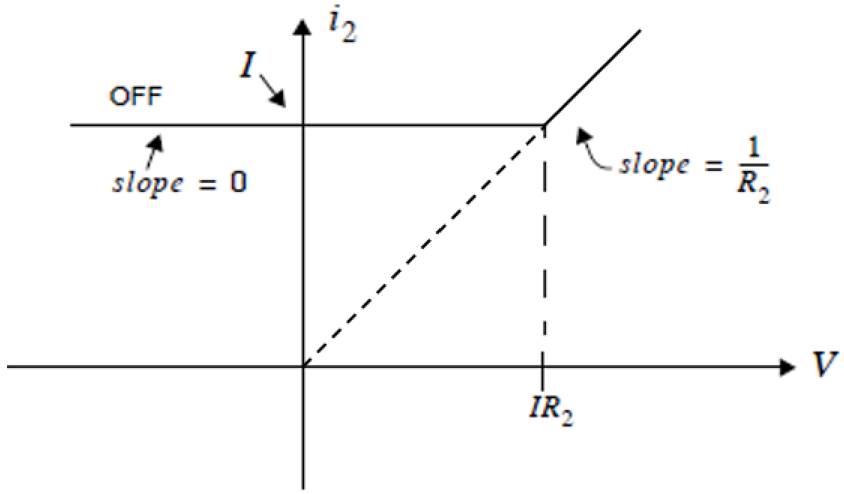
Solution)

When diode is on,

$$i_2 = \frac{v}{R_2}$$

$$i = \frac{V(R_1 + R_2)}{R_1 R_2}$$





Problem 4.11 This problem concerns the circuit illustrated in Figure 4.29:

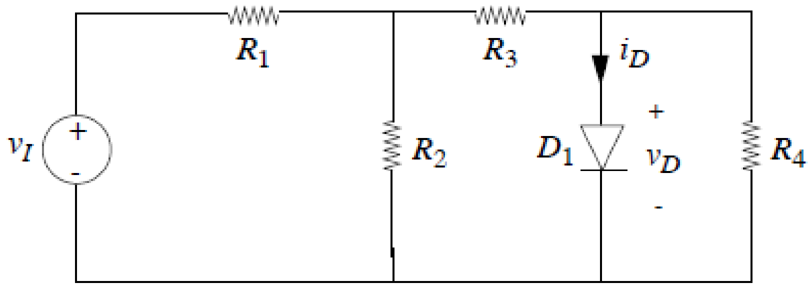


Figure 4.29:

$R_1 = 1.0k\Omega \quad R_2 = 1.0k\Omega \quad R_3 = 0.5k\Omega \quad R_4 = 1k\Omega$

For $D_1 : i_D = I_S(e^{v_D/V_{TH}} - 1)$ with $I_S = 1 \times 10^{-9}A$ and $V_{TH} = 25$mV.

a) Find the Thévenin equivalent circuit for the circuit connected to the diode.

b) Assume that for bias point determination the diode can be modeled by an ideal diode and a 0.6 volt battery. What are v_D and i_D when $v_1 = 4$ volts?

c) Find a linear equivalent model for this diode valid for small signal incremental operation about the bias point determined from part b.

d) Use your model of part c) to find $v_d(t)$ if $v_I = 4 + 0.004 \ \cos\omega t$ volts.

Solution:

a) $R_{TH} = 0.5$ kΩ $V_{OC} = \frac{1}{4}v_I$

b) $v_D = 0.6$V, $i_D = 0.8$mA

c) $r_d = \frac{V_{TH}}{I_S}\exp(\frac{-V_D}{V_{TH}}) = 9.44 \times 10^{-4}\Omega$

d) $v_d = 1.88 \times 10^{-9} \cos\omega t$

Problem 4.12 Consider the circuit in Figure 4.30. The voltage source and the current source are the sum of a dc-level and an ac-perturbation:

$$v = V + \Delta v$$
$$i = I + \Delta i$$

such that $V = 30V$ (dc), $I = 10A$ (dc), $\Delta v = 100mV$ (ac), $\Delta i = 50mA$ (ac).

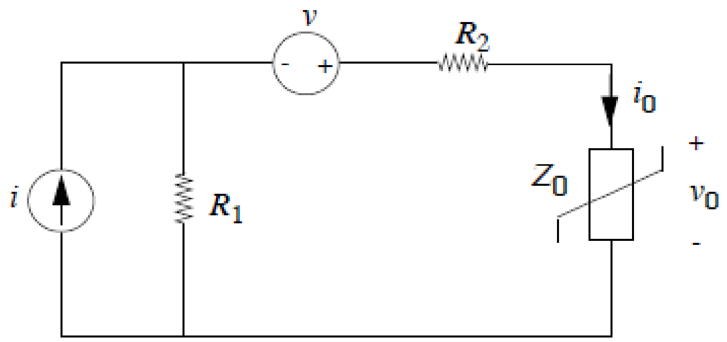


Figure 4.30:

The resistors have the following values: $R_1 = R_2 = 1/2$ ohm. The nonlinear element Z_0 has the characteristic:

$$i_0 = v_0 + v_0^2$$

Find, by incremental analysis, the DC and AC components of the output voltage v_0.

Remark: You can assume in your analysis that the nonlinear element is behaving as a passive element, i.e., is consuming power.

Solution: DC component: $5V$

AC component from current source: $0.002V$

AC component from voltage source: $0.008V$

ANS:: DC:$5V$, AC from current:$0.002V$, AC from voltage: $0.008V$