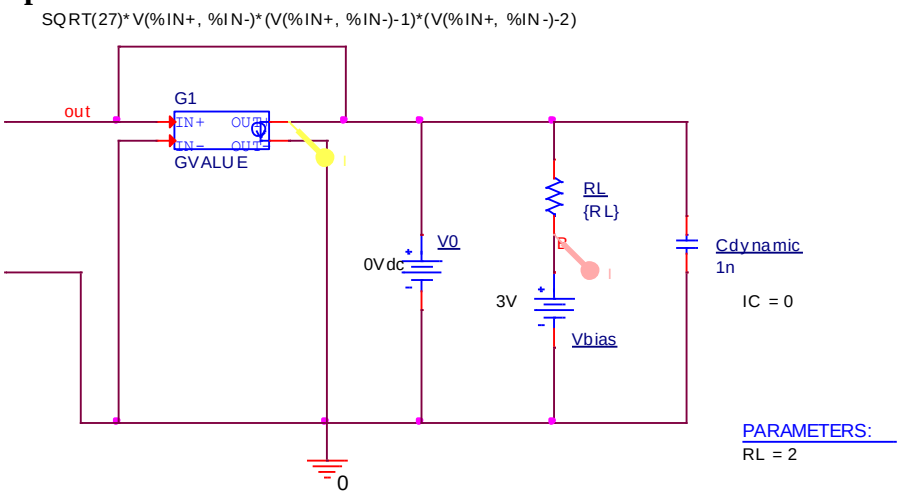
Homework 2

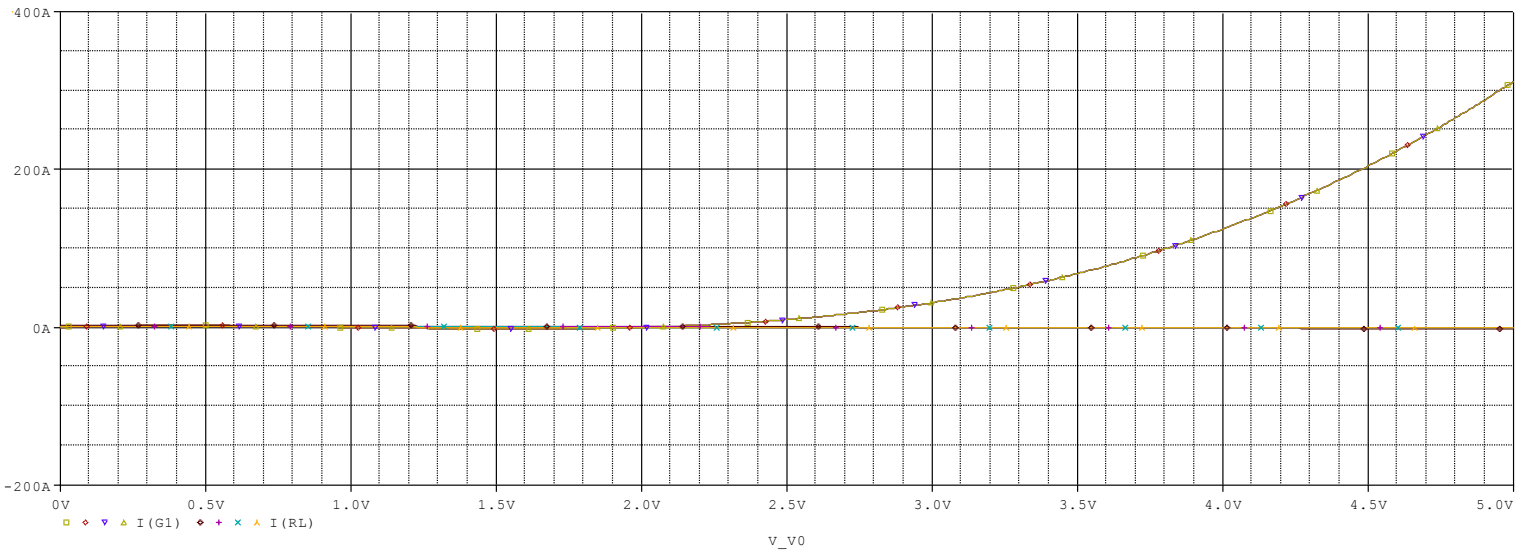
Question 1

a)

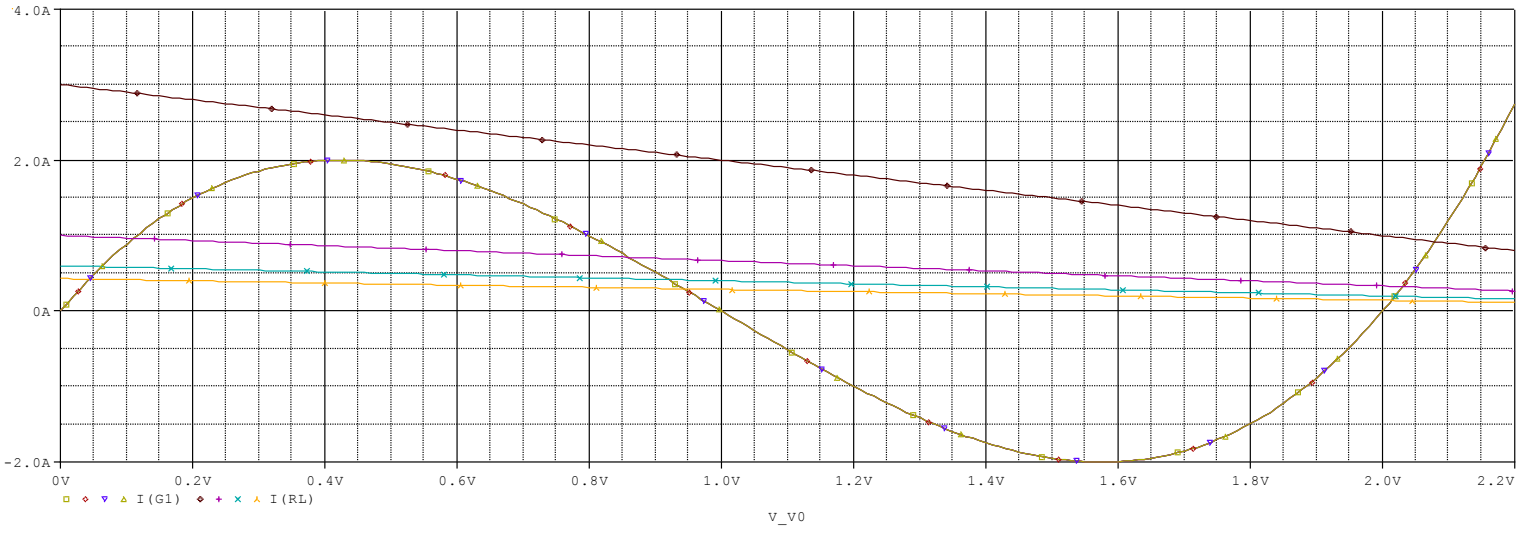
PSpice Schematic



Plot of diode current and load line (VO : 0 to 5V)

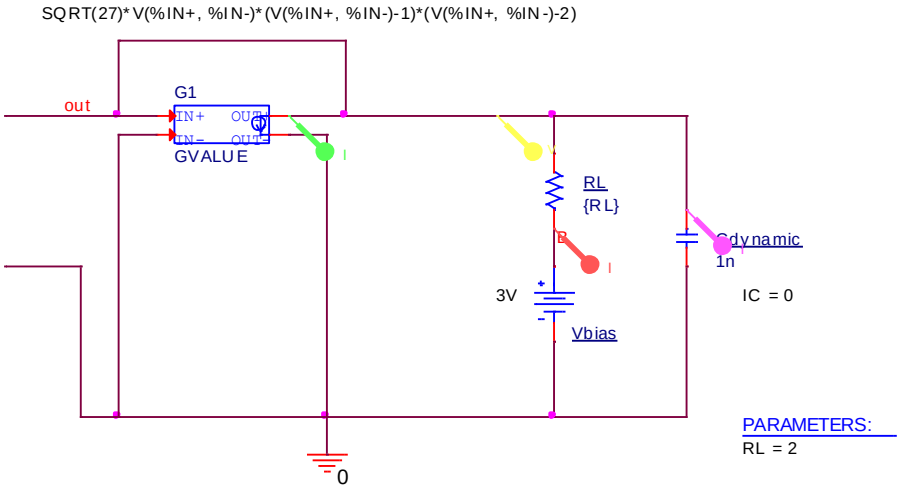


Plot of diode current and load line (VO : 0 to 2.2V)

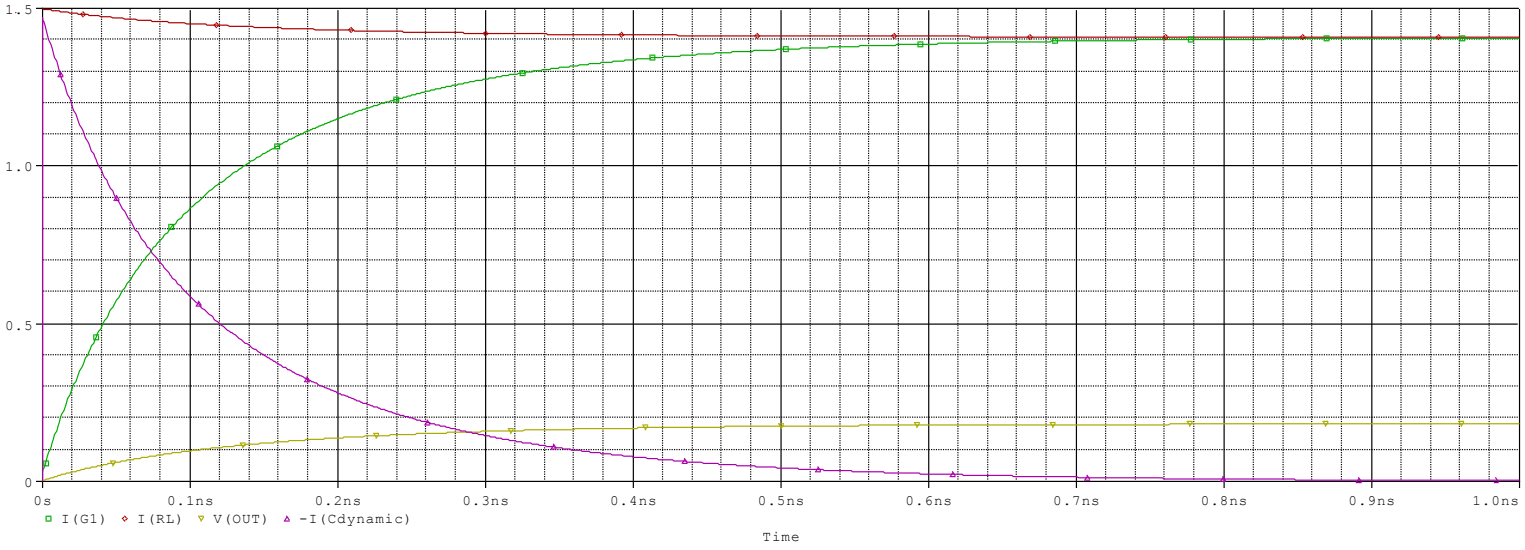


b)

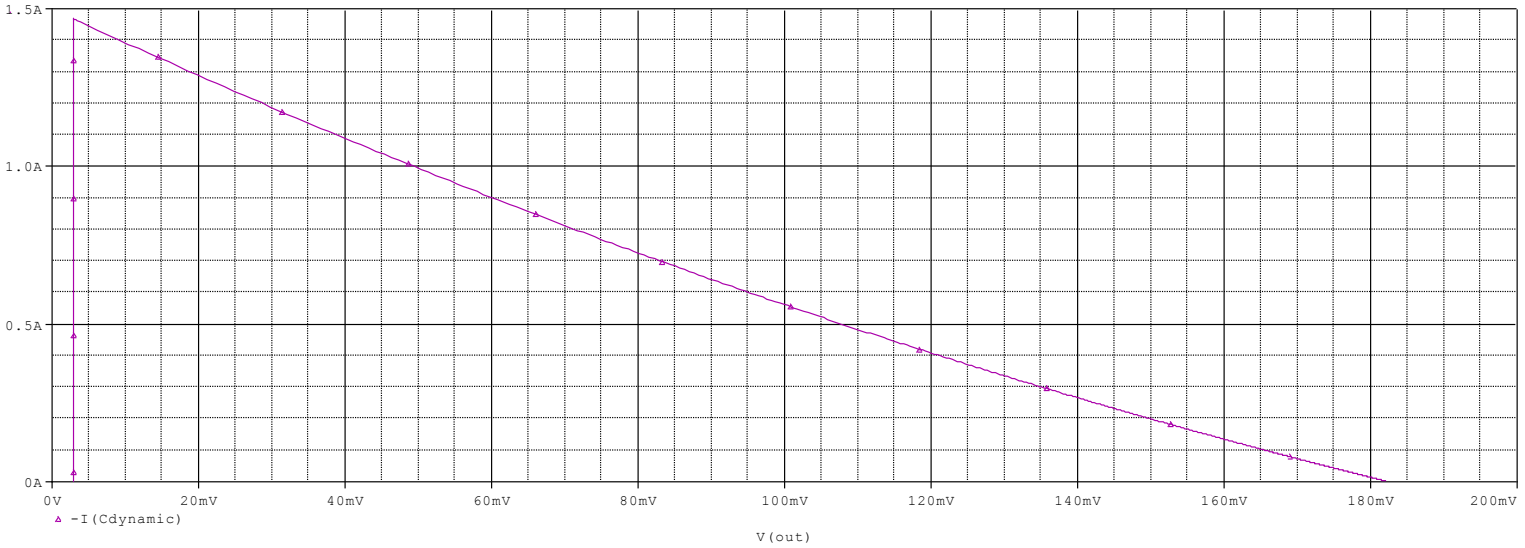
Updated schematic with VO removed



Plot of transient run data (I_{RL}, I_C, I_D, V_{Out} vs. Time)

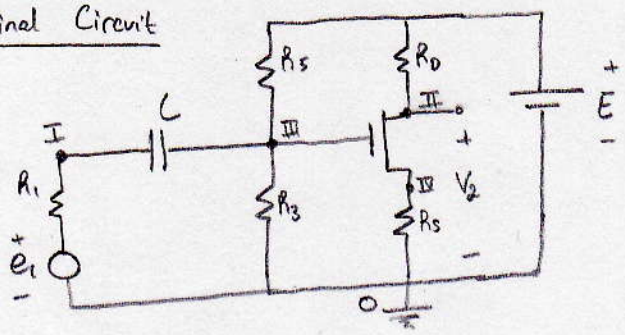


Plot of transient run data (I_C vs. V_{Out})

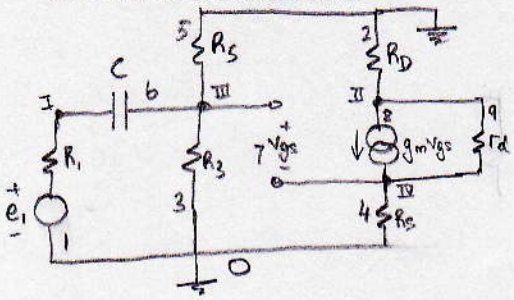


Problem 2

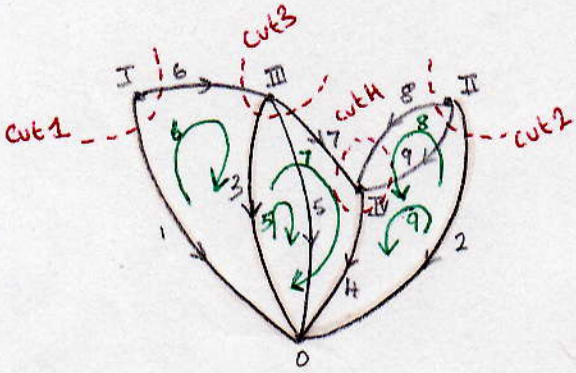
a) Original Circuit



Small-signal equivalent



b) Oriented Graph



— = tree branches $(b_1 \to b_{11})$

c)

KVL

$$0 = -V_{b3} + V_{b5}$$
$$0 = -V_{b1} + V_{b3} + V_{b6}$$
$$0 = -V_{b3} + V_{b4} + V_{b7}$$
$$0 = -V_{b2} + V_{b4} + V_{b8}$$
$$0 = -V_{b2} + V_{b4} + V_{b9}$$

$$\therefore T = \begin{bmatrix} 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Tie-set matrix

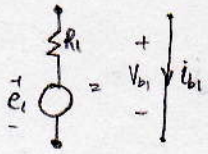
KCL

$$0 = i_{b1} + i_{b6}$$
$$0 = i_{b2} + i_{b8} + i_{b9}$$
$$0 = i_{b3} + i_{b5} - i_{b6} + i_{b7}$$
$$0 = i_{b4} - i_{b7} - i_{b8} - i_{b9}$$

$$\therefore C = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & -1 & -1 & -1 \end{bmatrix}$$

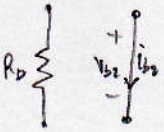
Cut-set matrix

d) Branch admittances



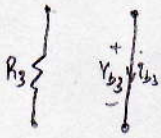
$i_{b1} = G_1 V_{b1}$

$G_1 = \frac{1}{R_1}$



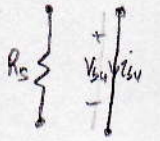
$i_{b2} = G_D V_{b2}$

$G_D = \frac{1}{R_D}$



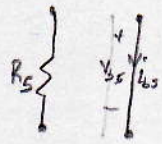
$i_{b3} = G_3 V_{b3}$

$G_3 = \frac{1}{R_3}$



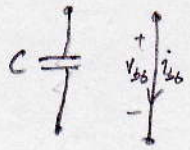
$i_{b4} = G_S V_{b4}$

$G_S = \frac{1}{R_S}$

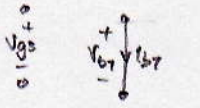


$i_{b5} = G_5 V_{b5}$

$G_5 = \frac{1}{R_5}$

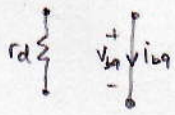


$i_{b6} = sC V_{b6}$



$i_{b7} = 0$

$i_{b8} = g_m V_{b7}$



$i_{b9} = g_d V_{b9}$

$g_d = \frac{1}{r_d}$

$\therefore$

$$\begin{bmatrix} i_{b1} \\ i_{b2} \\ i_{b3} \\ i_{b4} \\ i_{b5} \\ i_{b6} \\ i_{b7} \\ i_{b8} \\ i_{b9} \end{bmatrix} = \begin{bmatrix} G_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & G_D & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & G_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & G_S & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & G_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & sC & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & g_m & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & g_d \end{bmatrix} \begin{bmatrix} V_{b1} \\ V_{b2} \\ V_{b3} \\ V_{b4} \\ V_{b5} \\ V_{b6} \\ V_{b7} \\ V_{b8} \\ V_{b9} \end{bmatrix}$$

Y_{bxb} = Branch-by-branch admittance matrix.