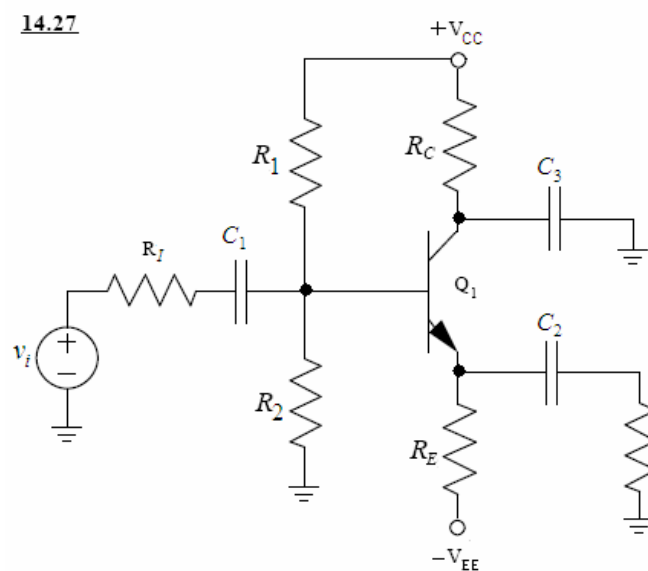
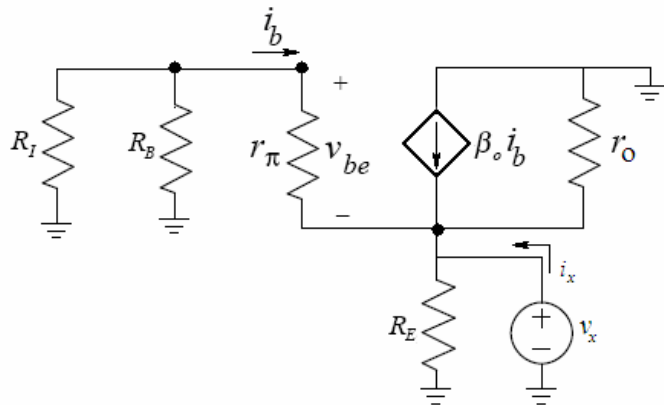
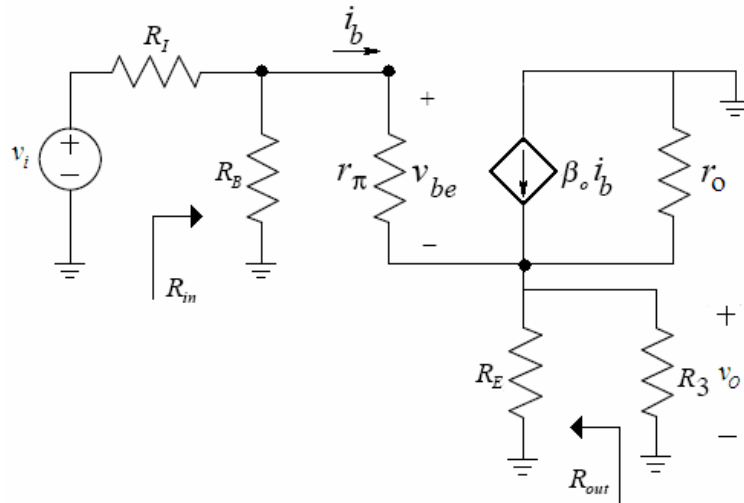
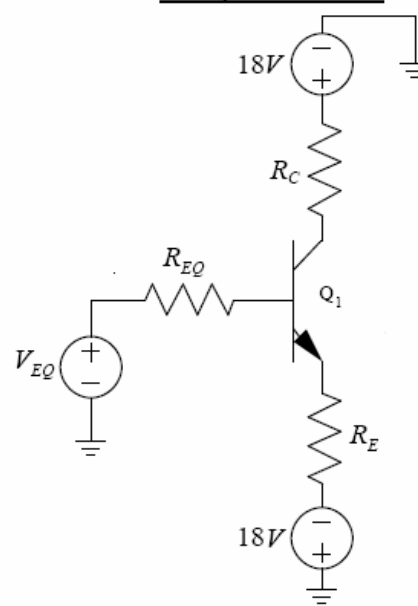


14.27

**AC Equivalent Circuit with BJT replaced by Small Signal Model****DC Equivalent Circuit**

$$V_{EQ} = 18 \frac{51k\Omega}{51k\Omega + 100k\Omega} = 6.08V$$

$$R_{EQ} = 51k\Omega \parallel 100k\Omega = 33.8k\Omega$$

Assume Transistor Operates in Forward Active Region ;

$$I_B = \frac{(6.08 - 0.7 + 18)V}{33.8k\Omega + (126)(4.7k\Omega)} = 37.3\mu A$$

$$I_C = 4.67mA$$

$$V_{CE} = 36 - 2000I_C - 4700I_E = 4.54V$$

$$V_{BE} = 0.7 \quad V_{BC} = 0.7 - 4.54 = -3.76V$$

Assumption is Correct

$$r_\pi = \frac{125(0.025V)}{4.67mA} = 669\Omega$$

$$r_o = \frac{(50 + 4.54)V}{4.67mA} = 11.7k\Omega$$

$$R_B = R_1 \parallel R_2 = 51k\Omega \parallel 100k\Omega = 33.8k\Omega \quad R_L = R_3 \parallel R_E \parallel r_o = 24k\Omega \parallel 4.7k\Omega \parallel 11.7k\Omega = 2.94k\Omega$$

$$R_{in} = R_B \parallel [r_\pi + (\beta_o + 1)R_L] = 33.8k\Omega \parallel [669\Omega + (126)2.94k\Omega] = 31.0k\Omega$$

$$v_O = R_L i_b (\beta_o + 1) \quad \left| \quad v_O + v_{be} = v_i \cdot \left(\frac{R_{in}}{R_I + R_{in}} \right) \quad \left| \quad i_b \left(r_\pi + (\beta_o + 1)R_L \right) = v_i \cdot \left(\frac{R_{in}}{R_I + R_{in}} \right) \right.$$

$$A_v = \frac{v_O}{v_i} = + \frac{(\beta_o + 1)R_L}{r_\pi + (\beta_o + 1)R_L} \left(\frac{R_{in}}{R_I + R_{in}} \right) = 0.982$$

$$v_{be} = v_i \left(\frac{R_{in}}{R_I + R_{in}} \right) \left(\frac{r_\pi}{r_\pi + (\beta_o + 1)R_L} \right) = \left(\frac{31.0k\Omega}{500\Omega + 31.0k\Omega} \right) \left[\frac{0.669k\Omega}{0.669k\Omega + 126(2.94k\Omega)} \right]$$

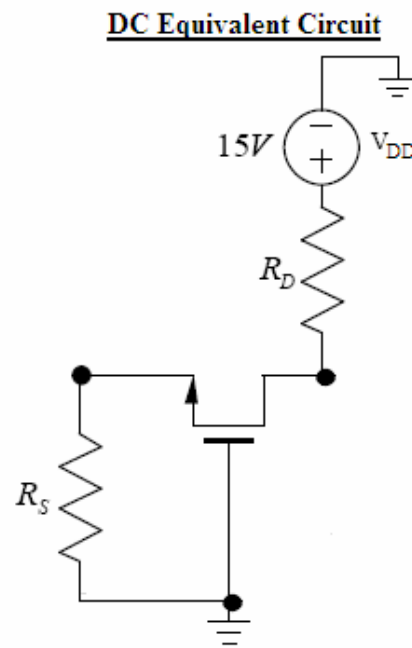
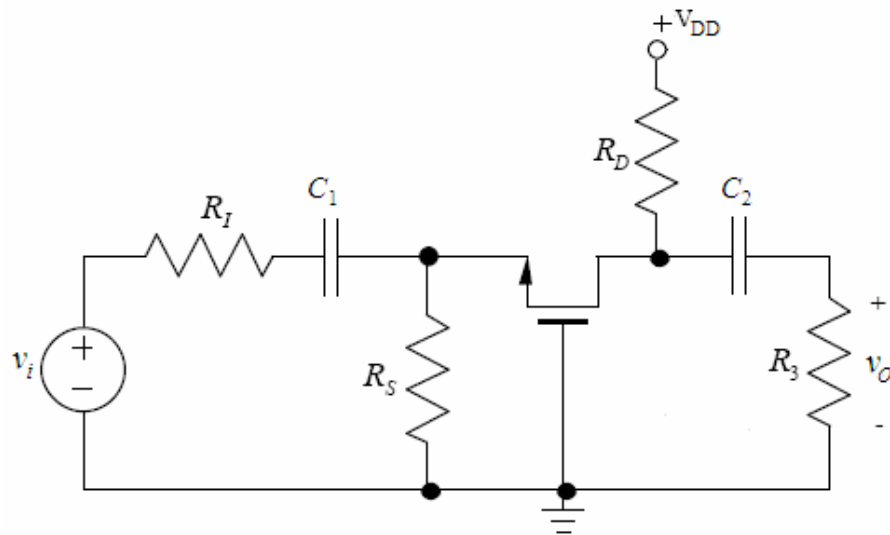
$$v_{be} = 1.77 \times 10^{-3} v_i \quad \left| \quad v_i \leq \frac{0.005V}{1.77 \times 10^{-3}} = 2.82V$$

$$v_x = -i_b \left((R_B \parallel R_I) + r_\pi \right) \quad \left| \quad v_x = \left(i_x + i_b (\beta_o + 1) \right) R_E \parallel r_o$$

$$v_x = \left(i_x - \frac{v_x}{(R_B \parallel R_I) + r_\pi} (\beta_o + 1) \right) R_E \parallel r_o$$

$$R_{out} = \frac{v_x}{i_x} = R_E \parallel r_o \parallel \frac{(R_B \parallel R_I) + r_\pi}{\beta_o + 1} = 9.22\Omega$$

14.41



Assume Transistor Operates in Saturation Region;

$$V_{GS} = -3900 I_D = -3900 \frac{(5 \times 10^{-4})}{2} (V_{GS} + 2)^2$$

$$V_{GS} = -0.975 (V_{GS} + 2)^2 \rightarrow V_{GS} = -0.9915 V$$

$$I_D = \frac{(5 \times 10^{-4})}{2} (V_{GS} + 2)^2 = 254 \mu A$$

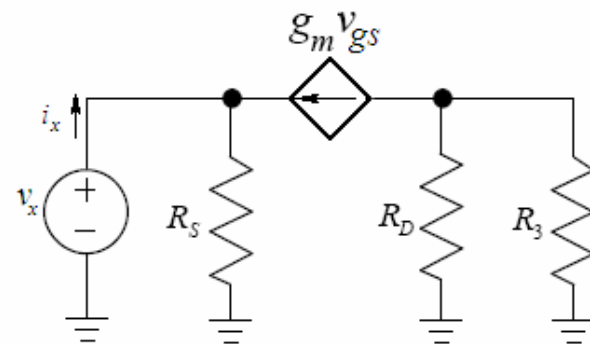
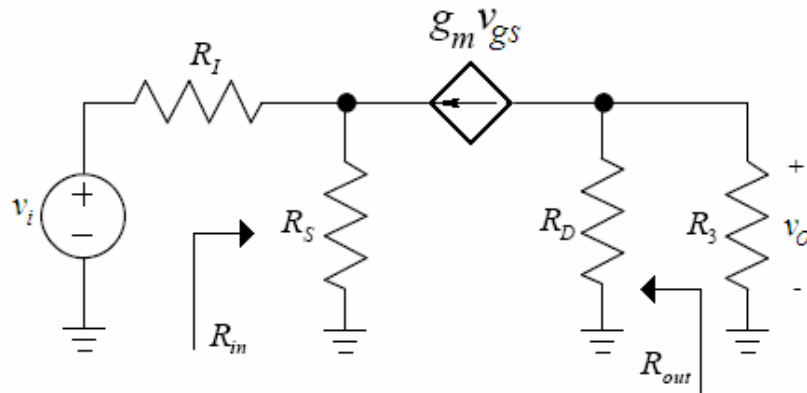
$$V_{DS} = 15 - 23.9 k\Omega I_D = 8.92 V$$

$$V_{GS} - V_{TN} = 1.0085 V \quad V_{DS} > (V_{GS} - V_{TN})$$

Assumption is Correct

$$g_m = \frac{2(254 \mu A)}{2 - 0.992} = 0.504 mS$$

$$R_L = R_3 \parallel R_D = 20 k\Omega \parallel 51 k\Omega = 14.4 k\Omega$$

AC Equivalent Circuit with Mosfet replaced by Small Signal Model

$$v_x = (i_x - g_m v_s) R_S$$

$$\frac{v_x}{i_x} = \frac{R_S}{1 + g_m R_S}$$

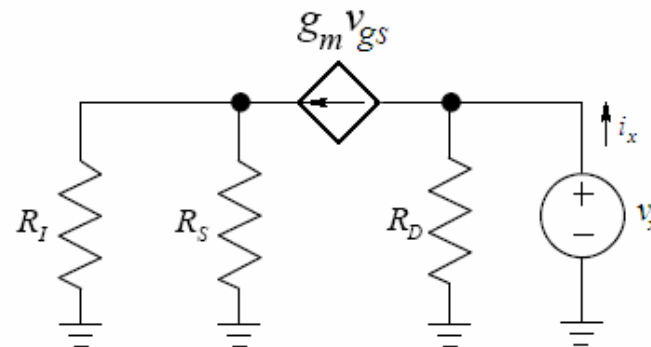
$$R_{in} = \frac{v_x}{i_x} = R_S \parallel \frac{1}{g_m} = 1.32 k\Omega$$

$$\frac{v_O}{v_s} = g_m R_L \quad \left| \frac{v_s}{v_i} = \frac{R_{in}}{R_I + R_{in}} \right.$$

$$A_v = \frac{v_O}{v_s} \times \frac{v_s}{v_i} = \frac{g_m R_L}{1 + g_m (R_I \parallel R_S)} \left(\frac{R_S}{R_I + R_S} \right) = 4.12$$

$$|v_{gs}| = v_i \frac{1.32 k\Omega}{1 k\Omega + 1.32 k\Omega} \leq 0.2 (V_{GS} + 2)$$

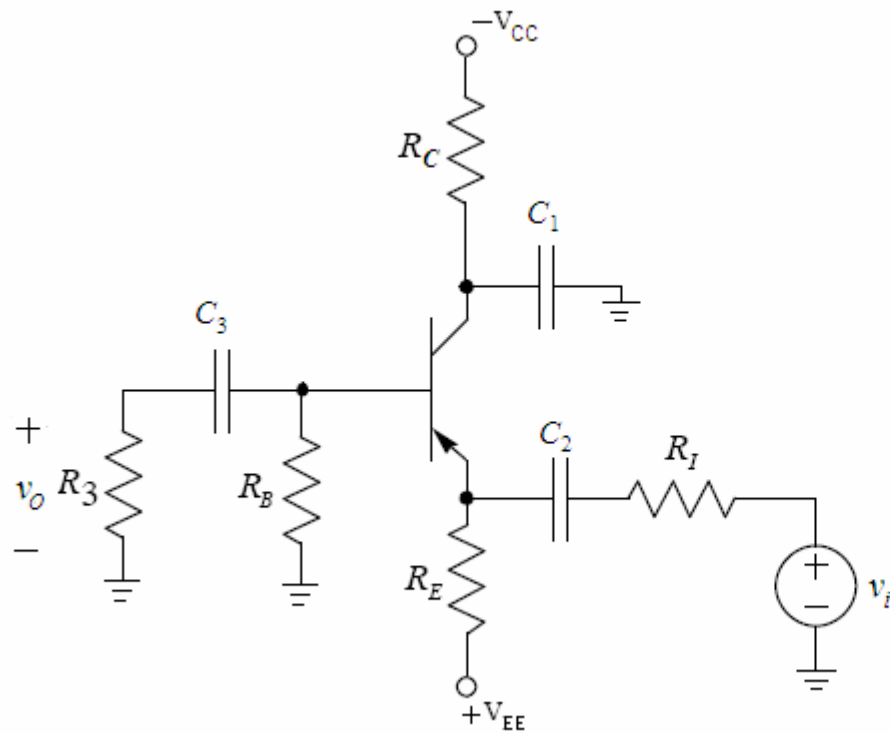
$$v_i \frac{1.32 k\Omega}{1 k\Omega + 1.32 k\Omega} \leq 0.2 (-0.992 + 2) \rightarrow v_i \leq 0.354 V$$



$$v_s = 0$$

$$R_{out} = \frac{v_x}{i_x} = R_D = 20 k\Omega$$

3



The voltage gain is approximately 0, because the signal is removed from amplifier at the base terminal which makes the amplifier not useful.