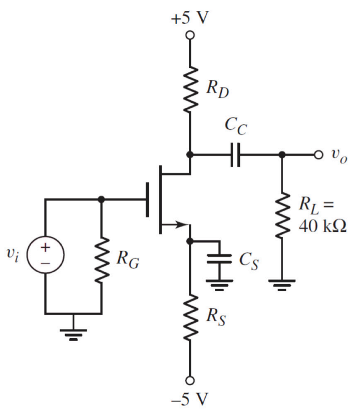
1.



(a) $V_{DSQ} = 5-(-5) - I_{DQ}(R_S + R_D)$

$5.5 = 5-(-5) - 0.1(R_S+R_D)$

$\therefore R_S + R_D = 45\ k\Omega$

$I_{DQ} = K_n(V_{GS} - V_{TN})^2$

$0.1 = 0.85(V_{GS} - 0.8)^2$

$\therefore V_{GS} \approx 1.143\ V$

$V_{GS} + I_D R_S = 5$

$1.143 + 0.1 R_S = 5$

$R_S = 38.57\ k\Omega$

$R_D = 45 - R_S = 6.43\ k\Omega$

(b) $g_m = 2\sqrt{K_n I_{DQ}} = 2\sqrt{0.85 \times 0.1} = 0.583\ mA/V$

$r_o = \dfrac{1}{\lambda I_{DQ}} = \dfrac{1}{0.02 \times 0.1} = 500\ k\Omega$

(c) $R_D \| r_o \| R_L$

$= 6.43 \| 500 \| 40 \approx 6.348 \| 40$

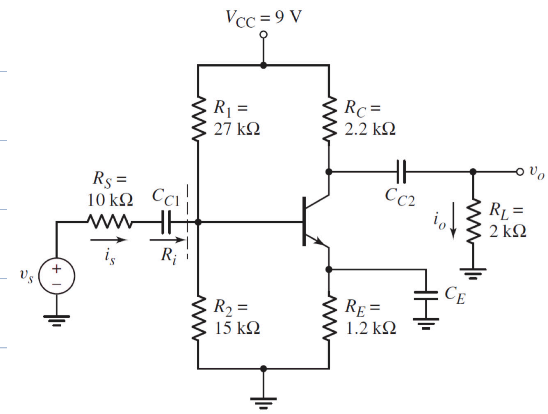
≈ 5.479

$A_v = -g_m(R_D \| r_o \| R_L)$

$= -0.583 \times 5.479$

≈ -3.194

2.



(a) $R_{TH} = R_1 \| R_2 = 27 \| 15 = 9.64\ k\Omega$

$V_{TH} = \left(\dfrac{R_2}{R_1+R_2}\right) V_{CC} = \left(\dfrac{15}{15+27}\right) \times 9$

$= 3.214\ V$

$I_{BQ} = \dfrac{V_{TH} - V_{BE(on)}}{R_{TH} + (1+\beta) R_E}$

$= \dfrac{3.214 - 0.7}{9.64 - 101 \times 1.2}$

$= 0.0192\ mA$

$I_{CQ} = \beta I_{BQ} = 100 \times 0.0192\ mA = 1.92\ mA$

$g_m = \dfrac{I_{CQ}}{V_T} = \dfrac{1.92}{0.026} = 73.9\ mA/V$

$r_\pi = \dfrac{V_T \beta}{I_{CQ}} = \dfrac{0.026 \times 100}{1.92} = 1.35\ k\Omega$

$R_i = R_{TH} \| r_\pi = 9.64 \| 1.35 \approx 1.184\ k\Omega$

(b) $r_o = \dfrac{V_A}{I_{CQ}} = \dfrac{100}{1.92} = 52.1\ k\Omega$

$V_\pi = \left(\dfrac{r_\pi \| R_{TH}}{r_\pi \| R_{TH} + R_S}\right) V_s$

$= \left(\dfrac{1.184}{1.184 + 10}\right) V_s$

$= 0.1059\ V_s$

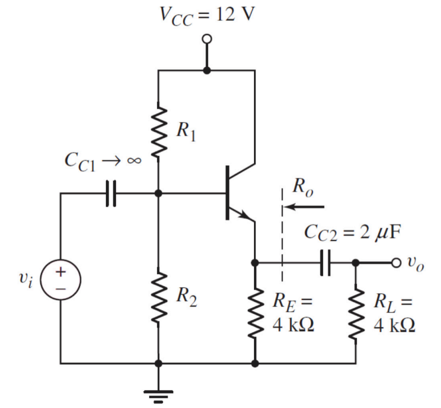
$A_v = \dfrac{V_o}{V_s} = \dfrac{-g_m V_\pi (r_o \| R_C \| R_L)}{V_s}$

$= -73.9 \times 0.1059 \times (52.1 \| 2.2 \| 2)$

$= -73.9\ mA/V \times 0.1059 \times 1.027\ k\Omega$

≈ -8.04

3.



(a) $R_{TH} = 0.1(1+\beta)R_E$

$= 0.1(1+120)\times 4$

$= 48.4\ k\Omega$

$I_{BQ} = \frac{I_{EQ}}{1+\beta} = \frac{1.5}{1+120} = 0.0124\ mA$

Apply Thevenin Theorem.

$V_{TH} = I_{BQ} \cdot R_{TH} + V_{BE(on)} + I_{EQ}R_E$

$= (0.0124\times 10^{-3})(48.4\times 10^{3}) + 0.7$

$+ (1.5\times 10^{-3})(4\times 10^{3})$

$= 7.3\ V$

$V_{TH} = \frac{R_{TH}}{R_1} \cdot V_{cc}$

$7.3 = \frac{48.4k}{R_1} \cdot 12$

$R_1 = 79.6\ k\Omega$

$R_{TH} = R_1 \| R_2$

$48.4 = \frac{79.6 R_2}{R_2 + 79.6}$

$R_2 = 123.5\ k\Omega$

(b) $I_{CQ} = \beta I_{BQ} = 120 \times 0.0124 = 1.49\ mA$

$r_\pi = \frac{\beta V_T}{I_{CQ}} = \frac{120\times 0.026}{1.49} = 2.094\ k\Omega$

$r_o = \frac{V_A}{I_{CQ}} = \frac{50}{1.49} = 33.5\ k\Omega$

$A_V = \frac{(1+\beta)(r_o \| R_E \| R_L)}{r_\pi + (1+\beta)(r_o \| R_E \| R_L)}$

$= \frac{(1+120)(33.5 \| 4 \| 4)}{2.094 + (1+120)(33.5 \| 4 \| 4)}$

$= 0.991$

(C) $R_o = R_E \| R_o \| \frac{r_\pi}{1+\beta}$

$= 4 \| 33.5 \| \frac{2.094}{1+120}$

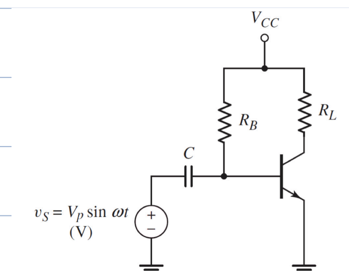
$= 17.32\ \Omega$

(d) $f_L = \frac{1}{2\pi(R_o + R_L)C_L}$

$= \frac{1}{2\pi(17.32 + 4000)(2\times 10^{-6})}$

$= 19.81\ Hz.$

4.



At the maximum power point

$P_{Q,max} = V_{CEQ} \cdot I_{CQ}$

$25 = \left(\frac{24}{2}\right) \cdot I_{CQ}$

$I_{CQ} = 2.083\ A$

$R_L = \frac{V_{cc} - V_{CEQ}}{I_{CQ}} = \frac{24-12}{2.083}$

$= 5.76\ \Omega$

$I_{BQ} = \frac{I_{CQ}}{\beta} = \frac{2.083}{60}$

$= 0.03472\ A$

$R_B = \frac{V_{cc} - V_{BE(on)}}{I_{BQ}}$

$= \frac{24-0.7}{0.03472} = 671\ \Omega$