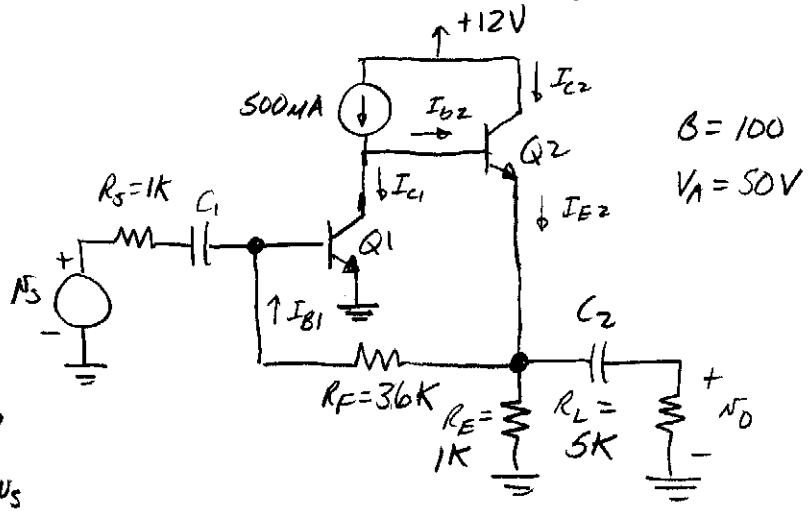
Problem 18.16

Find the input resistance, output resistance, and transresistance of the amplifier shown. What is the voltage gain of this amplifier? (Note: Represent v_s and R_s by a Norton eq. circuit.)



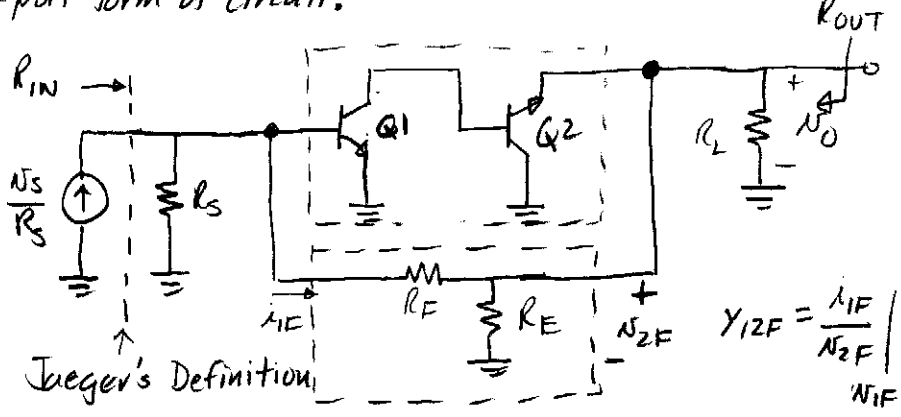
$\beta = 100$

$V_A = 50V$

This circuit is shunt-shunt.

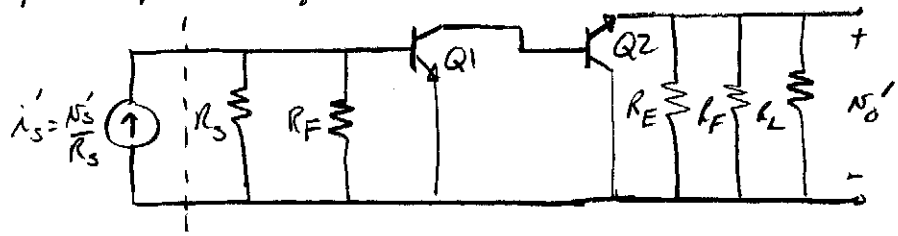
Solution

Two-port form of circuit:

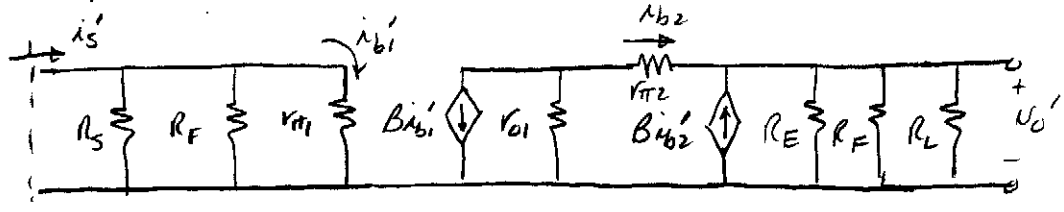


$$y_{12F} = \frac{i_{1F}}{v_{2F}}\bigg|_{v_{1F}=0} = \frac{-1}{36K} = \beta$$

Open-loop circuit:



Open-loop model:



Problem 18.16 - Cont'd

DC currents:

$$I_{C1} = 500\mu A - I_{B2}, \quad I_{E2} = I_{B1} + \frac{36000 I_{B1} + 0.7}{1000} = 37 I_{B1} + 700\mu A$$

$$I_{C1} = 500\mu A - \frac{I_{E2}}{101} = 500\mu A - \frac{37 I_{B1}}{101} - \frac{700\mu A}{101} = 493\mu A - 0.366 I_{B1}$$

$$I_{C1} = 493\mu A - 0.366\frac{I_{C1}}{100} \rightarrow I_{C1} = 491\mu A$$

$$I_{E2} = 37\frac{I_{C1}}{100} + 700\mu A = 882\mu A \rightarrow I_{C2} = \frac{100}{101} I_{E2} = 873\mu A$$

$$\therefore r_{\pi 1} = \frac{100(0.025)}{491\mu A} = 5.09K \qquad r_{\pi 2} = \frac{100(0.025)}{873\mu A} = 2.86K$$

$$r_{O1} \cong \frac{50}{493\mu A} = 101.4K\Omega$$

$$A = \frac{v_o'}{i_s'} = \left(\frac{v_o'}{i_{b2}'}\right)\left(\frac{i_{b2}'}{i_{b1}'}\right)\left(\frac{i_{b1}'}{i_s'}\right) = \left[101(R_E \| R_F \| R_L)\right]\left[\frac{-100 r_{O1}}{r_{O1} + r_{\pi 2} + (101)(R_E \| R_F \| R_L)}\right] \times \left[\frac{R_s \| R_F}{r_{\pi 1} + R_s \| R_F}\right]$$

$$= (101 \cdot 814)(-54.3E)\left(\frac{0.973}{6.663}\right) = -717.46K\Omega$$

$$A_F = \frac{A}{1 + AB} = \frac{-717.46K}{1 + \frac{717.46}{36}} = \frac{-717.46K}{20.93} = -34.8K\Omega$$

$$R_{IN} = \frac{R_s \| R_F \| r_{\pi 1}}{1 + AB} = \frac{816\Omega}{20.98} = 39\Omega$$

← How can R_{IN} be less than 1K? I don't agree with using the Norton form.

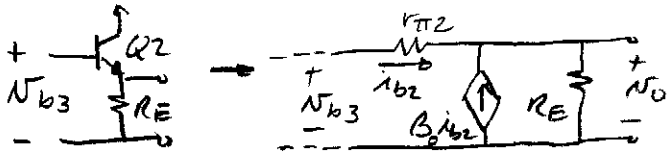
$$R_{OUT} = \frac{R_E \| R_F \| R_L \| \left(\frac{r_{\pi 2} + r_{O1}}{101}\right)}{1 + AB} = \frac{614 \| 1032}{20.93} = \frac{455\Omega}{20.93} = 22\Omega$$

$$A_V = \frac{v_o}{v_s} = \frac{v_o}{i_s R_s} = \frac{-34.8K\Omega}{1K\Omega} = -34.8\ \frac{V}{V}$$

The solutions have an error in them for the calculation of A. A in the solutions is,

$$A = -\underbrace{(1K \| 36K \| 5.09K) \times g_{m1} \times \left[r_{O1} \| (r_{\pi 2} + (1+\beta_o) R_E\right]}_{\text{Gain from } i_s \text{ to base of Q2, } v_{b2}} \times \left[\frac{r_{\pi 2} + (1+\beta_o) R_E}{r_{O1} + r_{\pi 2} + (1+\beta_o) R_E}\right]$$

↑ No + correct



This is the correct term ↓

$$v_o = i_{b2}(1+\beta_o) R_E = \frac{v_{b2}}{r_{\pi 2} + (1+\beta_o) R_E} \times (1+\beta_o) R_E \rightarrow \frac{v_o}{v_{b2}} = \frac{(1+\beta_o) R_E}{r_{\pi 2} + (1+\beta_o) R_E}$$