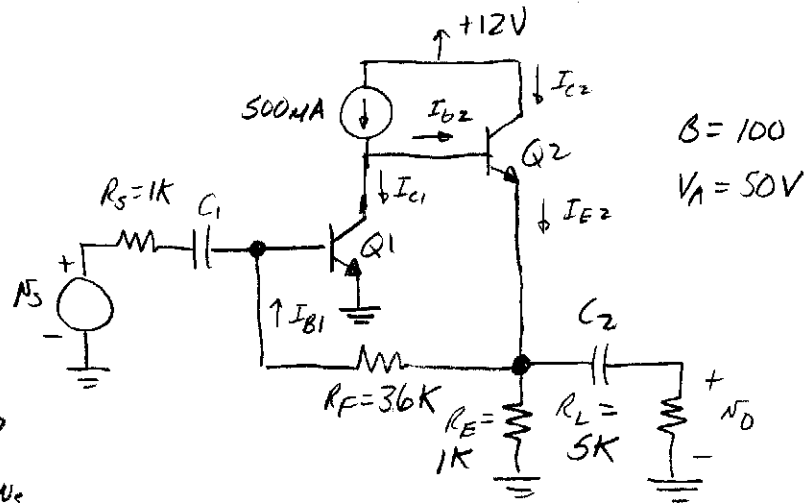


Problem 18.16

Find the input resistance, output resistance, and transresistance of the amplifier shown. What is the voltage gain of this amplifier?

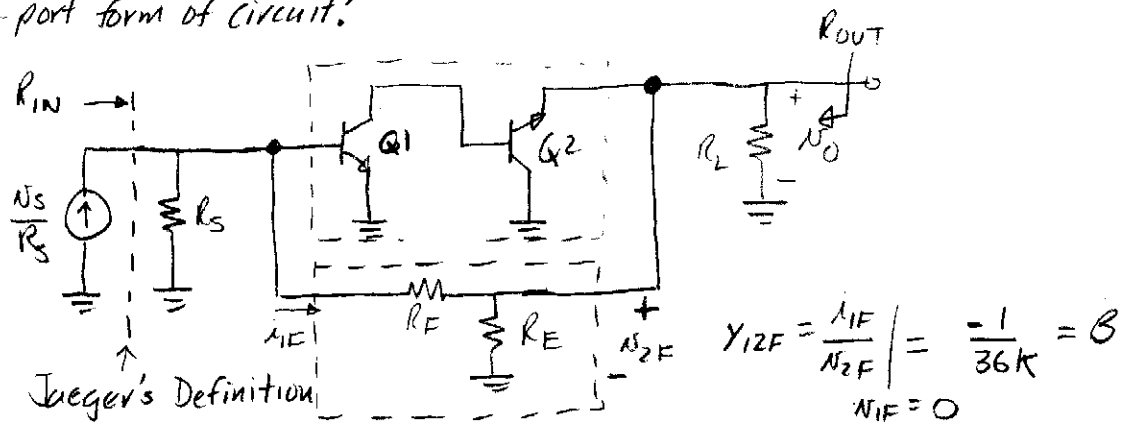
(Note: Represent N_S and R_S by a Norton eq. circuit.)

This circuit is shunt-shunt.

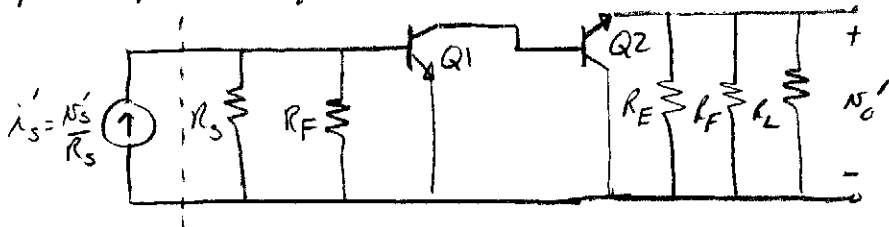


Solution

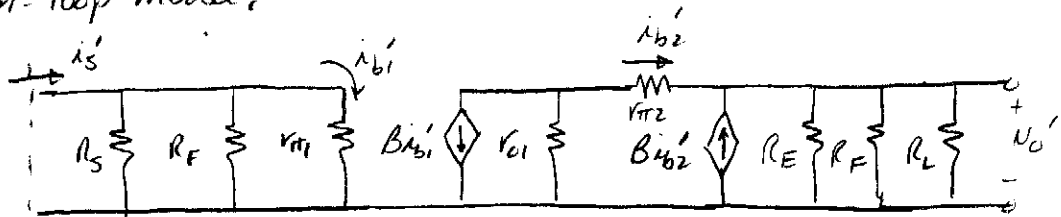
Two-port form of circuit:



Open-loop circuit:



Open-loop model:



Problem 18.16 - Cont'd

DC currents:

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

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

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

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

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

$$r_{o1} \approx \frac{50}{493\mu A} = 101.4K\Omega$$

$$A = \frac{N_0'}{N_S'} = \left(\frac{N_{b1}'}{N_{b2}'}\right) \left(\frac{N_{b2}'}{N_{b1}'}\right) \left(\frac{N_{b1}'}{N_S'}\right) = [101(R_E || R_F || R_L)] \left[\frac{-100r_{o1}}{r_{o1} + r_{\pi 2} + (101)(R_E || R_F || R_L)} \right]$$

$$= (101 \cdot 814) (-54.3E) \left(\frac{0.973}{6.663}\right) = -717.46K\Omega \quad \times \left[\frac{R_S || R_F}{r_{\pi 1} + R_S || R_F} \right]$$

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

$$R_{IN} = \frac{R_S || R_F || r_{\pi 1}}{1 + A\beta} = \frac{516\Omega}{20.93} = 39\Omega \left\{ \begin{array}{l} \text{How can } R_{IN} \text{ be less than } 1K? \\ \text{I don't agree with using the} \\ \text{Norton form.} \end{array} \right.$$

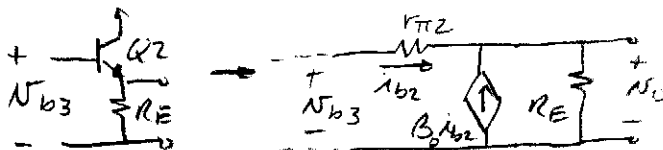
$$R_{OUT} = \frac{R_E || R_F || R_L || \left(\frac{r_{\pi 2} + r_{o1}}{101}\right)}{1 + A\beta} = \frac{514 || 1032}{20.93} = \frac{455\Omega}{20.93} = 22\Omega$$

$$A_V = \frac{N_0}{N_S} = \frac{N_0}{N_S R_S} = \frac{-34.8K\Omega}{1K\Omega} = -34.8 \frac{V}{V}$$

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

$$A = - \underbrace{\left(1K || 36K || 5.09K\right) \times g_{m1}}_{\text{Gain from } i_S \text{ to base of } Q_2, N_{b2}} \times \left[r_{o1} || \left(r_{\pi 2} + (1+\beta_o) R_E \right) \right] \times \left[\frac{r_{\pi 2} + (1+\beta_o) R_E}{r_{o1} + r_{\pi 2} + (1+\beta_o) R_E} \right]$$

Not correct



$$N_0 = i_{b2} (1+\beta_o) R_E = \frac{N_{b2}}{r_{\pi 2} + (1+\beta_o) R_E} \times (1+\beta_o) R_E \rightarrow \frac{N_0}{N_{b2}} = \frac{(1+\beta_o) R_E}{r_{\pi 2} + (1+\beta_o) R_E}$$

This is the correct term