Homework Assignment No. 11 - Solutions

18.1

$$S_A^{A_V} = \frac{A}{A_V}\frac{\partial A_V}{\partial A} \qquad A_V = \frac{A}{1+A\beta}$$

$$\frac{\partial A_V}{\partial A} = \frac{(1+A\beta)1 - A\beta}{(1+A\beta)^2} = \frac{1}{(1+A\beta)^2} \qquad S_A^{A_V} = \frac{A}{\frac{A}{1+A\beta}}\frac{1}{(1+A\beta)^2} = \frac{1}{1+A\beta} \approx \frac{1}{A\beta}$$

$$S_A^{A_V} = \frac{1}{1+10^5(0.01)} = \frac{1}{1001}$$

$$\frac{\partial A_V}{A_V} = S_A^{A_V}\frac{\partial A}{A} = \frac{1}{1001}10\% = 9.99\text{x}10^{-3}\%$$

18.4

$$A_V = \frac{A}{1+A\beta} \quad | \quad \text{From Chapter 12, } GE = \frac{1}{1+A\beta} \approx \frac{1}{A\beta}$$

$$\frac{1}{\beta} = 200 \quad | \quad GE = \frac{200}{A} \le 0.002 \rightarrow A \ge \frac{200}{0.002} = 10^5 \quad | \quad A \ge 100 \text{ dB}$$

18.6 (a) Series-shunt (b) Shunt-series (c) Series-series (d) Shunt-shunt

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18.9 (a)

$$h_{11}^A = \left.\frac{v_1}{i_1}\right|_{v_2=0} = 15\text{k}\Omega \quad | \quad h_{11}^F = 4.3\text{k}\Omega \| 39\text{k}\Omega = 3.87\text{k}\Omega \quad | \quad h_{11}^T = 18.9\text{k}\Omega$$

$$h_{22}^A = \left.\frac{i_2}{v_2}\right|_{i_1=0} = (1\text{k}\Omega)^{-1} = (1\text{k}\Omega)^{-1} \quad | \quad h_{22}^F = (39\text{k}\Omega + 4.3\text{k}\Omega)^{-1} = (43.3\text{k}\Omega)^{-1} \quad | \quad h_{22}^T = 1.02\text{mS}$$

$$h_{21}^A = \left.\frac{i_2}{i_1}\right|_{v_2=0} = -\frac{15\text{k}\Omega(5000)}{1\text{k}\Omega} = -75{,}000 \quad | \quad h_{21}^F = \left.\frac{i_2}{i_1}\right|_{v_2=0} = -\frac{4.3\text{k}\Omega}{39\text{k}\Omega + 4.3\text{k}\Omega} = -0.0993$$

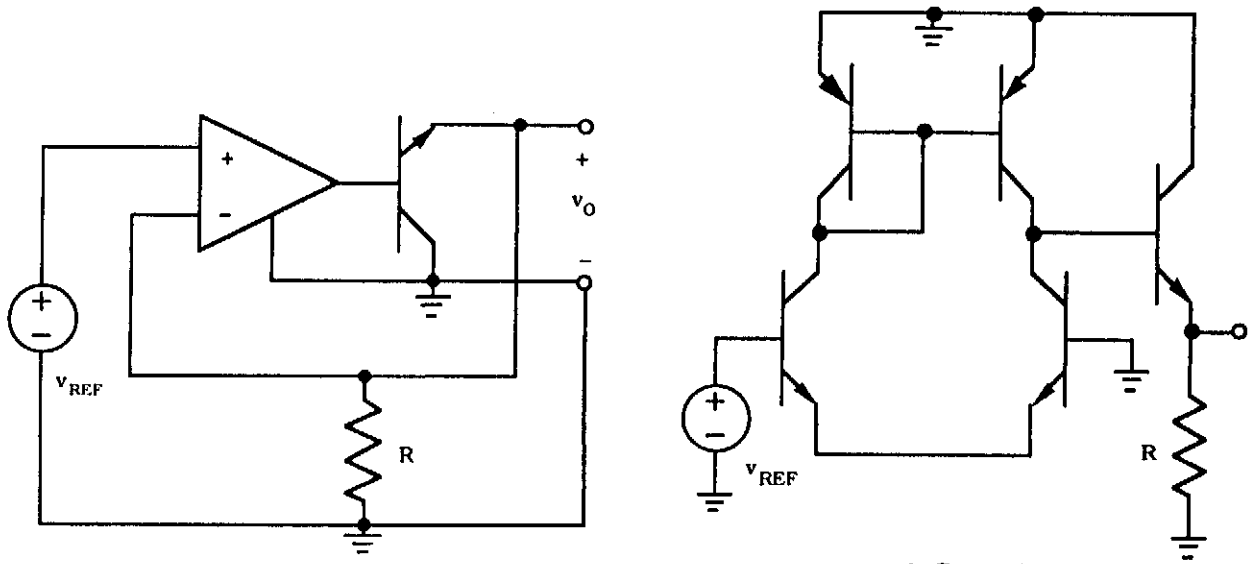
$$h_{12}^A = \left.\frac{v_1}{v_2}\right|_{i_1=0} = 0 \quad | \quad h_{12}^F = \left.\frac{v_1}{v_2}\right|_{i_2=0} = \frac{4.3\text{k}\Omega}{39\text{k}\Omega + 4.3\text{k}\Omega} = 0.0993$$

(b) $$A = \frac{-h_{21}^A}{\left(R_S + h_{11}^T\right)\left(h_{22}^T + G_L\right)} = \frac{-(-75000)}{(1\text{k}\Omega + 15\text{k}\Omega + 3.87\text{k}\Omega)\left(\frac{1}{5.6\text{k}\Omega} + \frac{1}{1\text{k}\Omega} + \frac{1}{43.3\text{k}\Omega}\right)} = 3140$$

$$\beta = 0.0993$$

(c) $$A_V = \frac{3140}{1+3140(0.0993)} = 10.0 \quad | \quad h_{21}^A >> h_{21}^F \quad | \quad h_{12}^F >> h_{12}^A \quad | \quad (R_{IN} = 6.22\ \text{M}\Omega, R_{OUT} = 2.66\ \Omega)$$

18.11



A-Circuit

$$h_{11}^F = \left.\frac{v_1}{i_1}\right|_{v_2=0} = 0 \quad | \quad h_{22}^F = \left.\frac{i_2}{v_2}\right|_{i_1=0} = \frac{1}{R} \quad | \quad h_{12}^F = \left.\frac{v_1}{v_2}\right|_{i_2=0} = 1$$

$$A = g_{m1}\left(r_{o1}\|r_{o4}\|\left[r_{\pi 5} + (\beta_o + 1)R\right]\right)\frac{(\beta_o + 1)R}{r_{\pi 5} + (\beta_o + 1)R} = g_{m1}\frac{r_{o1}\|r_{o4}}{(r_{o1}\|r_{o4}) + r_{\pi 5} + (\beta_o + 1)R}(\beta_o + 1)R$$

$$r_{o1} = \frac{50 + 1.4}{10^{-4}} = 514\text{k}\Omega \quad | \quad r_{o4} = \frac{50 + 11.3}{10^{-4}} = 613\text{k}\Omega \quad | \quad r_{o1}\|r_{o4} = 280\text{k}\Omega$$

$$I_{C5} = \frac{12}{10^4} = 1.2\text{mA} \quad | \quad r_{\pi 5} = \frac{100(.025)}{1.2\text{mA}} = 2.08\text{k}\Omega$$

$$A = 40\left(10^{-4}\right)(280\text{k}\Omega)\frac{(101)10\text{k}\Omega}{280\text{k}\Omega + 2.08\text{k}\Omega + (101)10\text{k}\Omega} = 876$$

$$A_V = \frac{A}{1 + T} = \frac{876}{1 + 876(1)} = \frac{109}{110} = 0.999$$

$$R_{IN} = R_{ID}(1 + T) = 2r_{\pi 1}(1 + T) = 2\frac{100(0.025)}{10^{-4}}(877) = 43.9\ \text{M}\Omega$$

$$R_{OUT} = \frac{R\left\|\frac{r_{\pi 5} + r_{o2}\|r_{o4}}{\beta_o + 1}\right.}{1 + T} = \frac{10\text{k}\Omega\left\|\frac{2.08\text{k}\Omega + 280\text{k}\Omega}{101}\right.}{877} = 2.49\ \Omega$$

$$i_o = \alpha_o i_e = \alpha_o \frac{v_o}{R} \quad | \quad \frac{i_o}{v_{ref}} = \frac{\alpha_o}{R}\frac{v_o}{v_{ref}} = \frac{100}{101}\left(\frac{1}{10^4}\right)(0.999) = 98.9\ \mu\text{S}$$