Department of Electrical Engineering
Indian Institute of Technology, Kanpur

EE 210 **Assignment #10** **Assigned: 17.3.25**

1. Determine the DC collector currents of Q_1 and Q_2, and then the ac small-signal midband input resistance and voltage gain for the Darlington emitter follower, as shown in Fig.1. Assume $\beta = 200$ for both Q_1 and Q_2, and neglect r_0.

2. Calculate the output resistance R_0 of the common-emitter Darlington configuration, as shown in Fig.2, as a function of I_{BIAS}. Do not neglect either r_{01} or r_{02} in this calculation. If $I_{C2} = 1$ mA, what is R_0 for I_{BIAS} of: i) 1 mA and ii) 0?

3. A BiMOS Darlington is shown in Fig.3. The bias voltage V_B is adjusted for a DC output voltage of 2 V. Calculate the bias currents in both devices and then calculate the ac small-signal midband voltage gain v_0/v_i of the circuit. For the MOSFET, assume W = 10 μm, L = 1 μm, $k'_N = 200\ \mu A/V^2$, $V_{TN0} = 0.6$ V, $\gamma = 0.25\ V^{1/2}$, $\phi_F = 0.3$ V, and $\lambda = 0$. For the BJT, assume $I_S = 10^{-16}$ A, $\beta = 100$, and $V_A \rightarrow \infty$.

4. Derive the expression of the output resistance R_0 for a modified npn cascode amplifier structure, where a resistance R_1 is put in the emitter of Q_1, and another resistance R_2 is put in the base of Q_2.

5. Consider the NMOS cascode amplifier circuit, as given in class, and show that its output impedance can be given by $R_0 = [r_{01} + r_{02} + (g_{m2} + g_{mb2})r_{01}r_{02}]$, where all notations carry their usual meanings.

6. Determine the differential-mode gain, common-mode gain, common-mode rejection ratio, differential-mode input resistance, and common-mode input resistance for the BJT differential amplifier, as given in class. Assume $I_{EE} = 20\ \mu A$, R_{EE} (the output resistance of the current source I_{EE}) = 10 MΩ, $R_C = 100$ kΩ, and $V_{CC} = -V_{EE} = 5$ V. Neglect base currents for DC analysis, and assume $\beta = 200$ for ac analysis.

7. Repeat Prob.6, but with the addition of emitter degeneration resistors of value 4 kΩ in each of the emitters to the common point.

8. Consider the circuit shown in Fig.4. What type of compound connection is this? Determine the overall input resistance, voltage gain, and output resistance. Assume $\beta = 200$, and neglect Early effect.

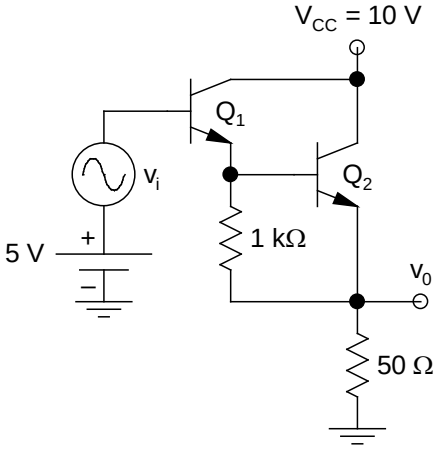

Fig.1

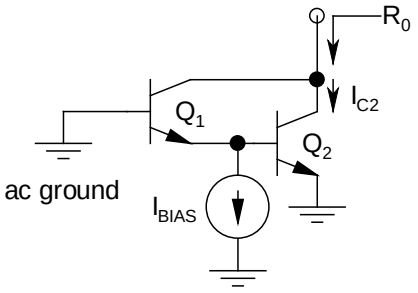

Fig.2

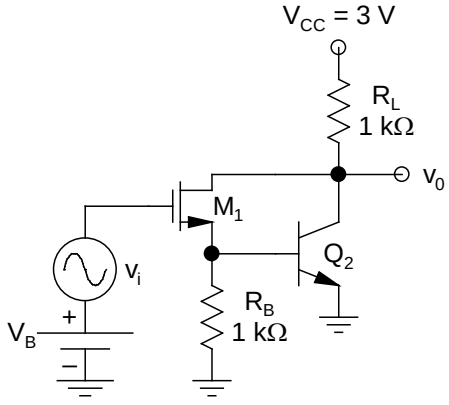

Fig.3

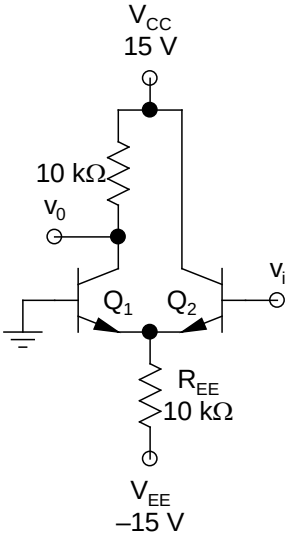

Fig.4