**Department of Electrical Engineering**
**Indian Institute of Technology, Kanpur**

**EE 210** **Assignment #10** **Assigned: 17.3.21**

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 the modified npn cascode amplifier structure, as given in class (assume that $R_1$ and $R_2$ are the emitter resistance of $Q_1$ and the base resistance of $Q_2$ respectively).

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.

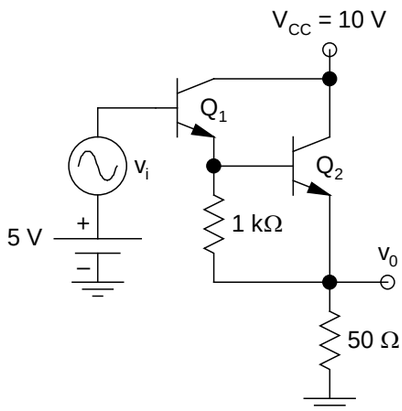


Fig.1

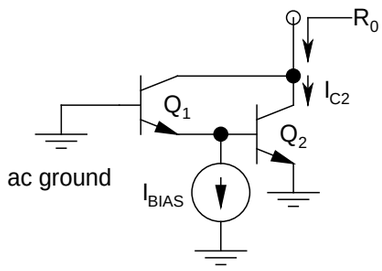


Fig.2

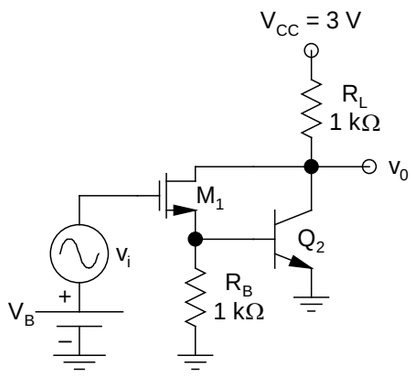


Fig.3

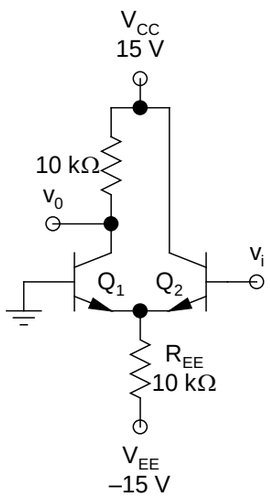


Fig.4