

※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (10%) Please explain the following terminologies: a) diode, b) BJT, c) MOSFET, d) CMOS, e) signal ground.
2. (15%) Figure 1 shows a folded-cascode CMOS operational amplifier, please derive the differential gain of the circuit.

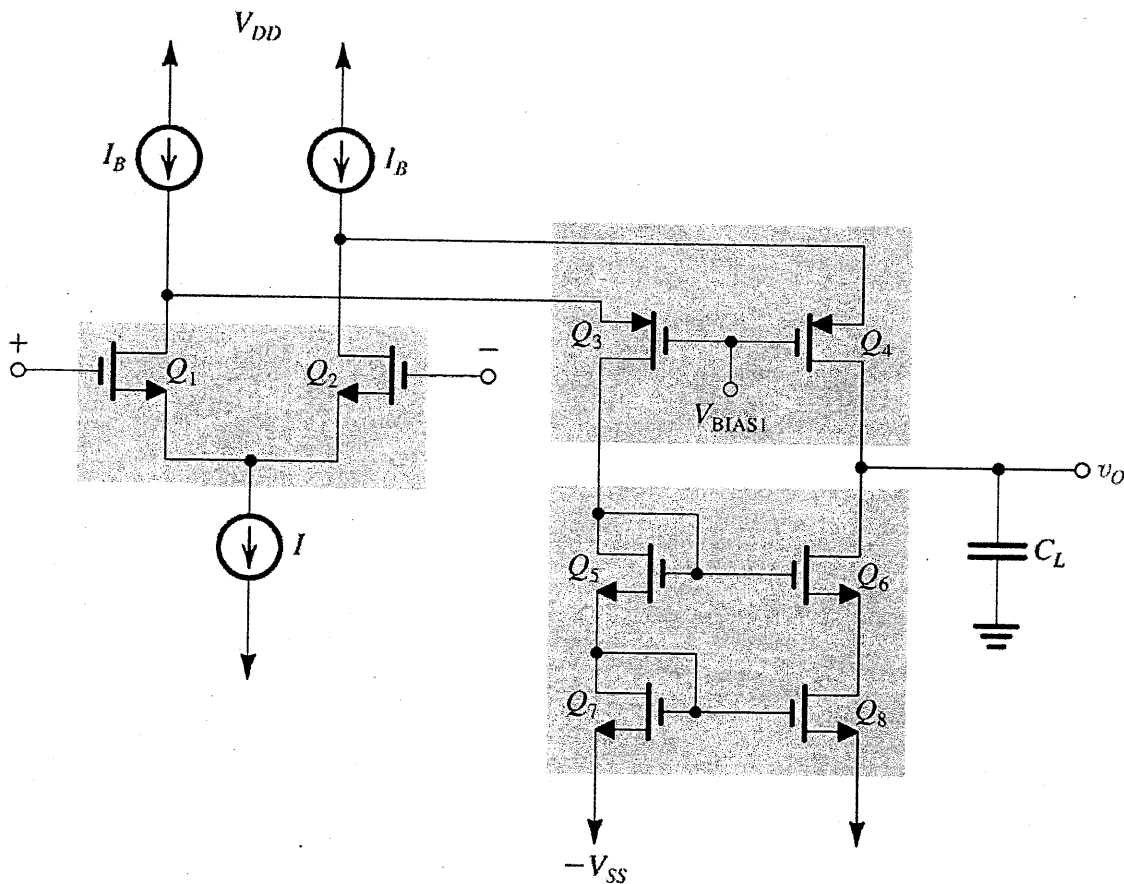


Figure 1 Circuit of a folded-cascode CMOS operational amplifier

3. (15%) Please draw the circuit of the Wilson bipolar current mirror and derive the relationship between reference current (I_{REF}) and output current (I_O).
4. (10%) Please draw the physical structure of a *npn* BJT and a *N*-channel MOSFET.
5. (10%) Transcranial direct current stimulation (tDCS) is a useful treatment in rehabilitation, one of important characteristics of tDCS is to provide a tunable constant current source, please explain how to make a tunable constant current source based on the knowledge you learned in microelectronics.
6. (20%) Transistor Q_1 in the circuit of Figure 2 is operating as a CE amplifier with an active load provided by transistor Q_2 which is the output transistor in a current mirror formed by Q_2 and Q_3 (Note that the biasing arrangement for Q_1 is not shown.)
 - (a) Neglecting the finite base currents of Q_2 and Q_3 and assuming that their $V_{BE} \cong 0.7V$ and that Q_2 has five times the area of Q_3 , find the value of I . (5%)
 - (b) If Q_1 and Q_2 are specified to have $|V_{CE}| = 30V$ find $r_{\pi 1}$ and $r_{\pi 2}$ and hence the total resistance at the collector

of Q_1 . (5%)

(c) Find $r_{\pi 1}$ and g_{m1} assuming that $\beta_1 = 50$. (5%)

(d) Find R_{in} , A_v , and R_o . (5%)

7. (20%) For the Darlington voltage follower shown in Figure 3, please derive the following characteristics of the Darlington voltage follower.

$$R_{in} = (\beta + 1)[r_{e1} + (\beta_2 + 1)(r_{e2} + R_E)]$$

$$R_{out} = R_E \parallel \left[r_{e2} + \frac{r_{e1} + [R_{sig}/(\beta_1 + 1)]}{\beta_2 + 1} \right]$$

$$\frac{v_o}{v_{sig}} = \frac{R_E}{R_E + r_{e2} + [r_{e1} + R_{sig}/(\beta_1 + 1)]/(\beta_2 + 1)}$$

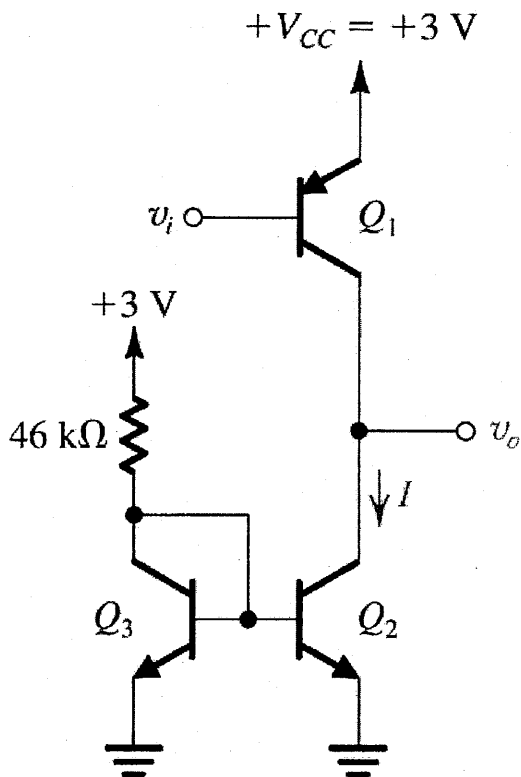


Figure 2 CE amplifier with an active load

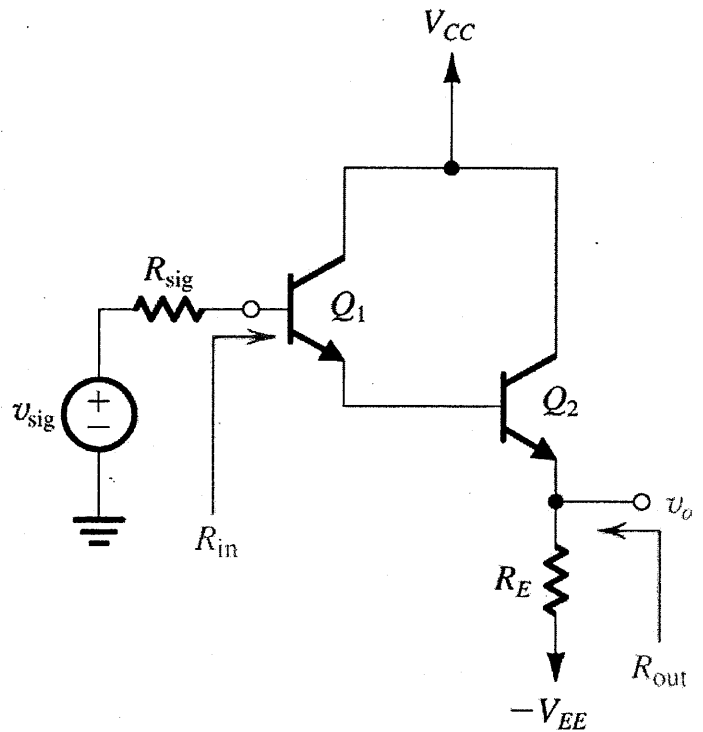


Figure 3 Darlington voltage follower