**Analog Electronics Problems 3**

**D 7.21** In a MOS cascode amplifier, the cascode transistor is required to raise the output resistance by a factor of 40. If the transistor is operated at \( V_{OV} = 0.2 \) V, what must its \( V_A' \) be? If the process technology specifies \( V_A' \) as 5 V/\( \mu \)m, what channel length must the transistor have?

**D 7.24** Design the cascode amplifier of Fig. 7.9(a) to obtain \( g_m = 1 \) mA/V and \( R_o = 400 \) kΩ. Use a 0.18-\( \mu \)m technology for which \( V_m = 0.5 \) V, \( V_A = 5 \) V/\( \mu \)m and \( k_n' = 400 \) \( \mu \)A/V². Determine \( L, W/L, V_{G2} \), and \( I \). Use identical transistors operated at \( V_{OV} = 0.2 \) V, and design for the maximum possible negative signal swing at the output. What is the value of the minimum permitted output voltage?

**D 7.27** Design the circuit of Fig. 7.10 to provide an output current of 100 \( \mu \)A. Use \( V_{DD} = 3.3 \) V, and assume the PMOS transistors to have \( \mu_p C_{ox} = 60 \) \( \mu \)A/V², \( V_{tp} = -0.8 \) V, and \( |V_A'| = 5 \) V. The current source is to have the widest possible signal swing at its output. Design for \( V_{OV} = 0.2 \) V, and specify the values of the transistor \( W/L \) ratios and of \( V_{G3} \) and \( V_{G4} \). What is the highest allowable voltage at the output? What is the value of \( R_o' \)?

**D 7.46** For \( V_{DD} = 1.8 \) V and using \( I_{REF} = 100 \) \( \mu \)A, it is required to design the circuit of Fig. 7.22 to obtain an output current whose nominal value is 100 \( \mu \)A. Find \( R \) if \( Q_1 \) and \( Q_2 \) are matched with channel lengths of 0.5 \( \mu \)m, channel widths of 4 \( \mu \)m, \( V_t = 0.5 \) V, and \( k_n' = 400 \) \( \mu \)A/V². What is the lowest possible value of \( V_o' \)? Assuming that for this process technology the Early voltage \( V_A' = 10 \) V/\( \mu \)m, find the output resistance of the current source. Also, find the change in output current resulting from a +0.5-V change in \( V_o' \).