Homework Assignment No. 12

Due Friday, April 11, 2003 in class

Problem 1 - (10 points)
Problem 7.3-7 of Allen and Holberg, 2nd edition

Problem 2 – (10 points)
Calculate the small-signal voltage gain, the $SR$ ($C_L = 1pF$), and the $P_{diss}$ for the op amp shown where $I_5 = 100nA$ and all transistors M1-M11 have a $W/L$ of 10µm/1µm and $V_{DD} = -V_{SS} = 1.5V$. If the minimum voltage across the drain-source of M6 and M7 are to be 0.1V, design the $W/L$ ratios of M12-M15 that give the maximum plus and minus output voltage swing assuming that transistors M12 and M15 have a current of 50nA. The transistors are working in weak inversion and are modeled by the large signal model of

$$i_D = \frac{W}{L} I_{DO} \exp\left(\frac{v_{GS}}{nV_t}\right)$$

where $I_{DO} = 2nA$ for PMOS and NMOS and $n_P = 2.5$ and $n_N = 1.5$. Assume $V_t = 26mV$ and $\lambda_N=0.4V^{-1}$ and $\lambda_P=0.5V^{-1}$.

Problem 3 – (10 points)
Problem 7.4-3 of Allen and Holberg, 2nd edition

Problem 4 - (10 points)
Problem 7.5-5 of Allen and Holberg, 2nd edition
Problem 5 - (10 points)

A CMOS op amp capable of operating from 1.5V power supply is shown. All device lengths are 1µm and are to operate in the saturation region. Design all of the W values of every transistor of this op amp to meet the following specifications.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Slew rate = ±10V/µs</td>
<td>V_{out}(max) = 1.25V</td>
</tr>
<tr>
<td>V_{ic}(min) = 1V</td>
<td>V_{out}(min) = 0.75V</td>
</tr>
<tr>
<td>V_{ic}(max) = 2V</td>
<td>GB = 10MHz</td>
</tr>
<tr>
<td>Phase margin = 60°</td>
<td>when the output pole = 2GB and the RHP zero = 10GB.</td>
</tr>
<tr>
<td>Great than 10GB</td>
<td>(C_{ox} = 0.5fF/µm²).</td>
</tr>
</tbody>
</table>

Your design should meet or exceed these specifications. Ignore bulk effects in this problem and summarize your W values to the nearest micron, the value of C_{c}(pF), and I(µA) in the following table. Use the following model parameters: K_N' = 24µA/V², K_P' = 8µA/V², V_TN = V_TP = 0.75V, λ_N = 0.01V⁻¹ and λ_P = 0.02V⁻¹.

<table>
<thead>
<tr>
<th>C_{c}</th>
<th>I</th>
<th>W1=W2</th>
<th>W3 = W4</th>
<th>W5 = W8</th>
<th>W6</th>
<th>W7</th>
<th>W9 = W10</th>
<th>W11 = W12</th>
<th>P_{diss}</th>
</tr>
</thead>
</table>