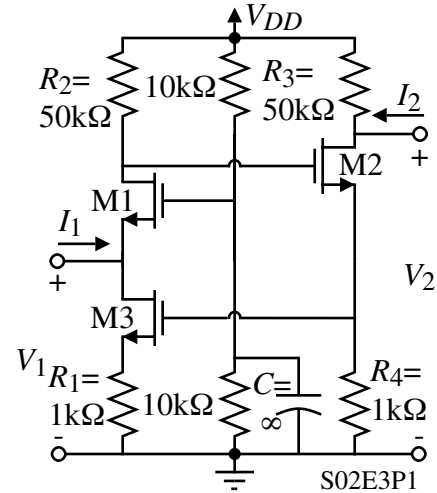# Homework Assignment No. 11

Due Friday, April 4, 2002 in class

Problem 1 - (10 points)

The simplified schematic of a feedback amplifier is shown.   Use the method of feedback analysis to find V_2/V_1, $R_{in} = V_1/I_1$, and $R_{out} = V_2/I_2$.   Assume that all transistors are matched and that $g_m = 1mA/V$ and $r_{ds} = \infty$.
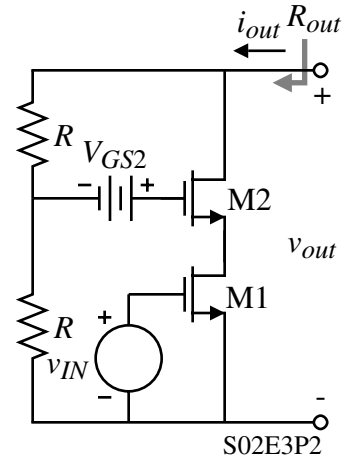
Problem 2 – (10 points)

Problem 8.30 of GHLM

Problem 3 - (10 points)

Use the Blackman's formula (see below) to calculate the small-signal output resistance of the stacked MOSFET configuration having identical drain-source drops for both transistors. Express your answer in terms of all the pertinent small-signal parameters and then simplify your answer if $g_m > g_{ds} > (1/R)$. Assume the MOSFETs are identical.

$$R_{out} = R_{out}\ (g_m{=}0)\left[\frac{1 + RR(\text{output port shorted})}{1 + RR(\text{output port open})}\right]$$

(You may use small-signal analysis if you wish but this circuit seems to be one of the rare cases where feedback analysis is more efficient.)

Problem 4 – (10 points)

Problem 7.1-10 of Allen and Holberg, 2nd edition.

Problem 5 - (10 points)

Problem 7.2-1 of Allen and Holberg, 2nd edition.

(Design challenge problem – see back of this sheet)

Design Challenge to Analog CMOS Designers

<u>Challenge</u>

The lower input common mode voltage range of the familiar NMOS source-coupled pair has been a serious limit as the power supplies become smaller. The objective of this challenge is to come up with a new differential amplifier that has an upper input common mode voltage range at least $V_{DD} - V_{DS}$(sat) and a lower input common mode voltage range of at least $V_{SS}+V_{DS}$(sat) while maintaining the following requirements:

1.) The new differential amplifier can use no more current than a regular differential amplifier.

2.) The transconductance of the new differential amplifier must be at least that of the regular differential amplifier.

3.) The W/Ls of the new differential amplifier cannot be any greater than those of a regular differential amplifier.

4.) The new differential amplifier must provide true differential operation and at least as good of common mode rejection as a regular differential amplifier.

5.) The input referred noise and input referred offset voltage must be no worse than that of a regular differential amplifier.

Regular Differential Amplifier

<u>Reward</u>

You should be advised that this is a tough problem and you should not attempt it unless you have the time. The reward for a solution judged by your professors to be satisfactory would be +15 points added to your class score (which is a maximum 100 points possible).

If you should try this challenge, you should submit your design by April 21, 2003 with sufficient documentation, hand calculations supported by SPICE, to allow your professors to judge the merit of your design. *There will be no partial points in this challenge. You either get all 15 points or none.* Welcome to the real world!