EECS 105 – Microelectronic Devices and Circuits

Spring 2001, Prof. A. R. Neureuther
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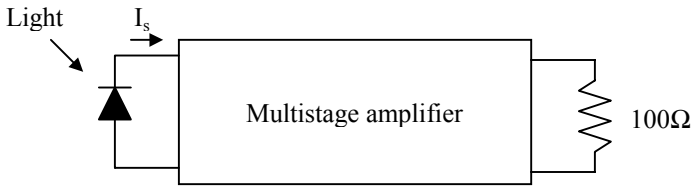
Homework Assignment # 12, Due April 20, 2001

11.1 Multistage Amplifier

Design a multistage amplifier to convert a 1pA photodiode current at the input into an output signal larger than 1V on a 100Ω telephone line. The source resistance from the photodiode is extremely high and can be neglected. The multistage amplifier needs to have an input stage that has low input impedance and a voltage buffer for the output.



You should use the building blocks in the table below to design your multistage amplifier

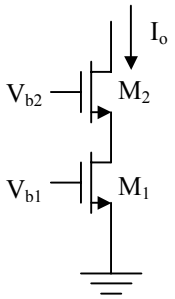
	CE	CB	CC
R_{in} (kΩ)	100	0.1	100
R_{out} (kΩ)	400	400	0.1
Controlled source	G_m=4mS	$\|A_i\|$=1	A_v=1

(1) At least how many building blocks are needed for the multistage amplifier?
(2) Draw the small-signal model of the multistage amplifier based on the parameters given in the table.
(3) What is the overall transresistance?

11.2 Cascode Current Source

A cascode current source is shown along with the n-channel device data. Assume that the back gates are all shorted to their respective sources and M_1 and M_2 have the same W/L. If V_{b2}= 1.9V, and $V_{DS1}=2V_{DS1\_sat}$

(1) Find V_{b1} and W/L such that I_o=1mA
(2) Calculate the incremental source resistance of the current source
(3) Draw the small-signal model of the current source
(4) If W/L of M_1 and M_2 are doubled and I_o is kept at 1mA, how does the incremental source resistance of the current source change?
(5) If I_o is reduced to 0.5mA and W/L of M1 and M2 remain the same as in part (1), how does the incremental source resistance of the current source change?



Device Data

V_{Tn} = 0.7V
$\mu_n C_{ox}$ = 50μA/V^2
λn = 0.05V^{-1}

12.3 Current Sources

Design current sources which provide 20μA and 50μA DC currents and a current sink with a DC current value of 100μA using the minimum number of MOS transistors. You are given one reference current source of 10μA with which you can use to derive the others. V_{DS_sat} of current sources should be 0.6V, V_{DS_sat} of the current sink should be 0.3V.

Device data
V_{Tn} = 1V
V_{Tp} = -1V
$\mu_n C_{ox}$ = 50μA/V^2
$\mu_p C_{ox}$ = 25μA/V^2
$\lambda_n = \lambda_p$ = 0.01V^{-1}

(1) Draw the schematic of the current sources and specify W/L of all MOS devices
(2) Calculate r_{oc} of all current sources