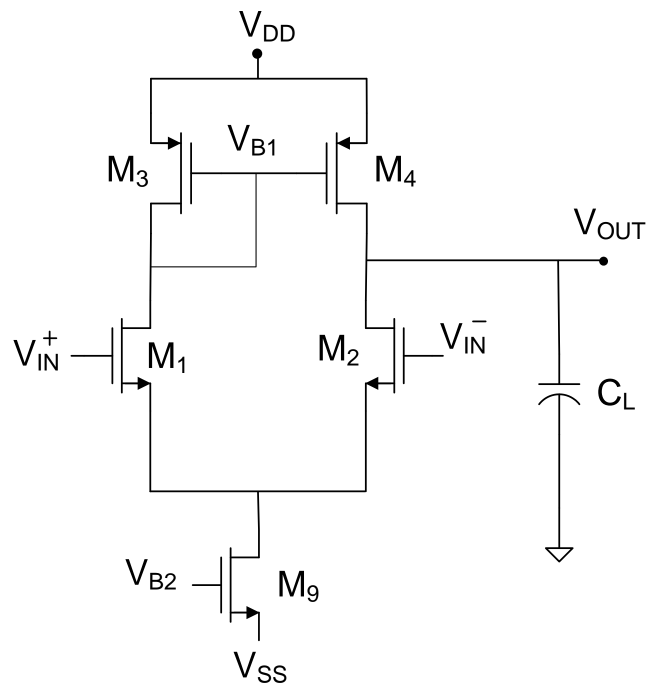
EE 435
Homework 4
Spring 2009

In the following problems, if reference to a semiconductor process is needed, assume processes with the following characteristics: CMOS Process -- $\mu_n C_{OX} = 100\mu A/v^2$,$\mu_p C_{OX} = \mu_n C_{OX}/3$, $V_{TNO} = 0.5V$, $V_{TPO} = -0.5V$, $C_{OX} = 2fF/\mu^2$, $\lambda_n = \lambda p = 0.01V^{-1}$, and $\gamma = 0.4V^{-1/2}$, Bipolar Process -- $J_S = 10^{-15} A/\mu^2$, $\beta = 100$ and $V_{AF} = 150V$. If more extensive parasitic capacitance parameters, use the model parameters in the attachment for the AMI 0.5u CMOS process.

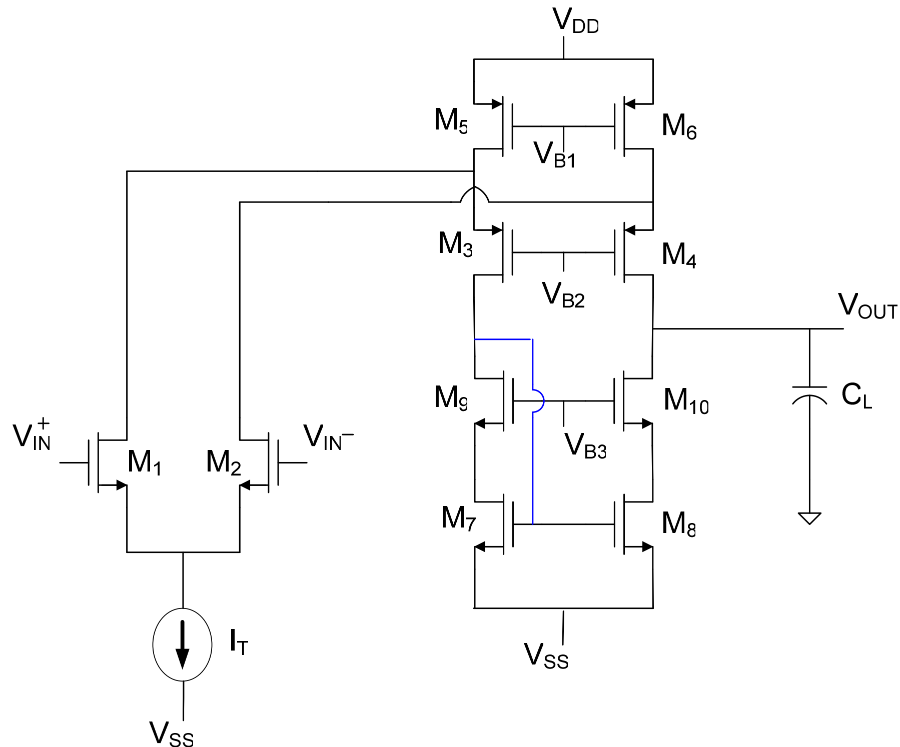
Problem 1 A reference op amp was designed with $V_{EB1} = V_{EB3} = 500mV$. If the supply voltages were V_{DD}=2.5V, V_{SS}=-2.5V, determine

a) The systematic output offset voltage
b) The systematic input-referred offset voltage
(assume V_{IC}=0V and the desired output voltage is 0V)



Problem 2 Assume that a folded-cascode op amp with n-channel inputs, tail-current input bias, and current-mirror n-channel biasing was designed so that all transistors had V_{EB}=0.25V. If V_{DD} = 2.5V, V_{SS} = -2.5V, V_{B2}=1.4V, V_{B3} = -1.4V, and the bias current in transistors {M_1,M_2,M_3, M_4, M_7, M_8, M_9, and M_{10}} are all the same,

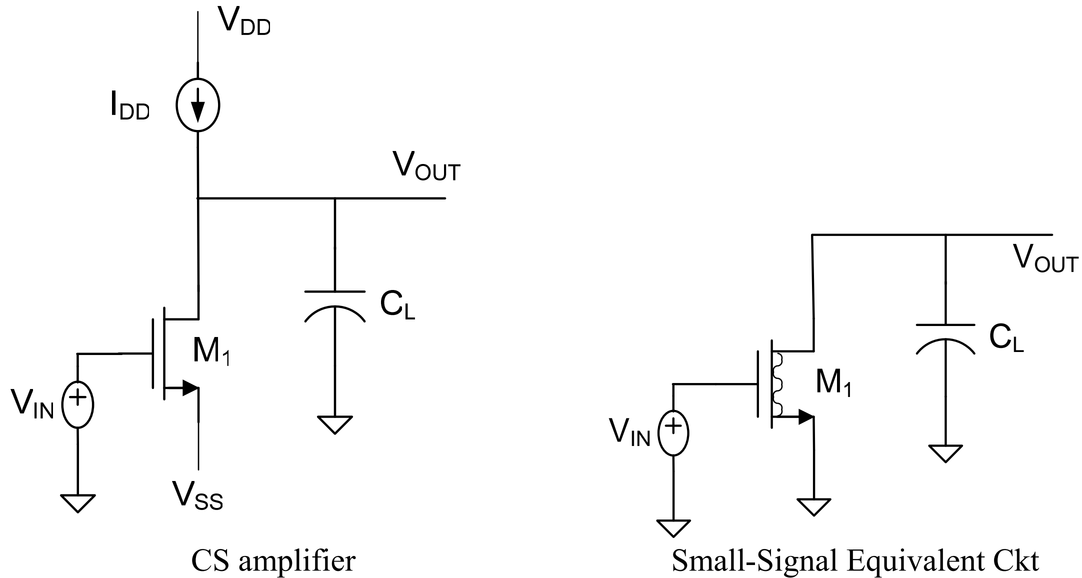
a) Determine the devices sizes if P=2mW
b) Determine the SR if the load capacitance is 2pF
c) What is the output signal swing?
d) What is the dc gain of the amplifier?



Problem 3 Analytically compare the power dissipation and the gain for the folded cascode amplifier discussed in Problem 2 with that of the reference op amp with the same excess biases and the same GB?

Problem 4 Analytically compare the power dissipation and the gain for the folded cascode amplifier discussed in Problem 2 with that of the telescopic cascode op amp with the same excess biases and the same GB?

Problem 5 The GB of the CS amplifier was shown to be g_m/C_L. In this derivation, C_L is the total load capacitance on the output node and the high-frequency coupling capacitance, C_C, from Gate to Drain was neglected.



CS amplifier Small-Signal Equivalent Ckt

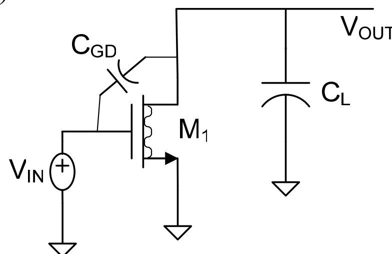
a) What is the GB of this amplifier if V_{SS} is chosen so that V_{EB}=0.2V and P=100uW (assume V_{DD}=2.5V)?

b) What is the W/L ratio required for V_{EB}=0.2V and P=100uW

c) With the W/L ratio obtained in part b) and a length of L=2u, determine the parasitic drain-substrate capacitance, C_{DSUB}.

d) If the load capacitance of 500fF is entirely an external load, how much will the dc gain and the GB change if the parasitic capacitance C_{DSUB} is present?

e) What effect will the parasitic capacitance C_{GD} that has been neglected up to this point have on the GB of the amplifier? (Analytically derive GB if CGD effects are included)



f) Estimate the value of C_{GD} if the MOS device is fabricated in a 0.5u AMI process assuming the same biasing as in part a)

TRANSISTOR PARAMETERS

	W/L	N-CHANNEL	P-CHANNEL	UNITS
MINIMUM	3.0/0.6			
Vth		0.78	-0.93	volts
SHORT	20.0/0.6			
Idss		439	-238	uA/um
Vth		0.69	-0.90	volts
Vpt		10.0	-10.0	volts
WIDE	20.0/0.6			
Ids0		< 2.5	< 2.5	pA/um
LARGE	50/50			
Vth		0.70	-0.95	volts
Vjbkd		11.4	-11.7	volts
Ijlk		<50.0	<50.0	pA
Gamma		0.50	0.58	V$^{0.5}$
K' (Uo*Cox/2)		56.9	-18.4	uA/V^2
Low-field Mobility		474.57	153.46	cm^2/V*s

COMMENTS: XL_AMI_C5F

FOX TRANSISTORS	GATE	N+ACTIVE	P+ACTIVE	UNITS
Vth	Poly	>15.0	<-15.0	volts

PROCESS PARAMETERS	N+ACTV	P+ACTV	POLY	PLY2_HR	POLY2	MTL1	MTL2	UNITS
Sheet Resistance	82.7	103.2	21.7	984	39.7	0.09	0.09	ohms/sq
Contact Resistance	56.2	118.4	14.6		24.0		0.78	ohms
Gate Oxide Thickness	144							angstrom

PROCESS PARAMETERS	MTL3	N\PLY	N_WELL	UNITS
Sheet Resistance	0.05	824	815	ohms/sq
Contact Resistance	0.78			ohms

COMMENTS: N\POLY is N-well under polysilicon.

CAPACITANCE PARAMETERS	N+ACTV	P+ACTV	POLY	POLY2	M1	M2	M3	N_WELL	UNITS
Area (substrate)	429	721	82		32	17	10	40	aF/um^2
Area (N+active)			2401		36	16	12		aF/um^2
Area (P+active)			2308						aF/um^2
Area (poly)				864	61	17	9		aF/um^2
Area (poly2)					53				aF/um^2
Area (metal1)						34	13		aF/um^2
Area (metal2)							32		aF/um^2
Fringe (substrate)	311	256			74	58	39		aF/um
Fringe (poly)					53	40	28		aF/um
Fringe (metal1)						55	32		aF/um
Fringe (metal2)							48		aF/um
Overlap (N+active)			206						aF/um
Overlap (P+active)			278						aF/um