

Homework #2

Due date : 10th April 2025

(1) Design of a rail-to-rail input amplifier with constant gm control

Consider the **rail-to-rail input amplifier** in Fig.1. $V_{DD}=1.8V$, $V_{SS}=0V$, and $C_L=2pF$. Please design I_{Bias} and the sizes of all transistors to satisfy the following specifications

	Specifications	Units
DC characteristics	$P_{diss} \leq 2$	mW
	$0 \leq ICMR \leq 1.8$	V
	$0.5 \leq V_{out} \text{ range} \leq 1.3$	V
	$\Delta g_m < 10\%$	%
AC characteristics	$A_v \geq 50dB$	dB
	3dB-bandwidth $\geq 80K$	Hz
	PM ≥ 65	°

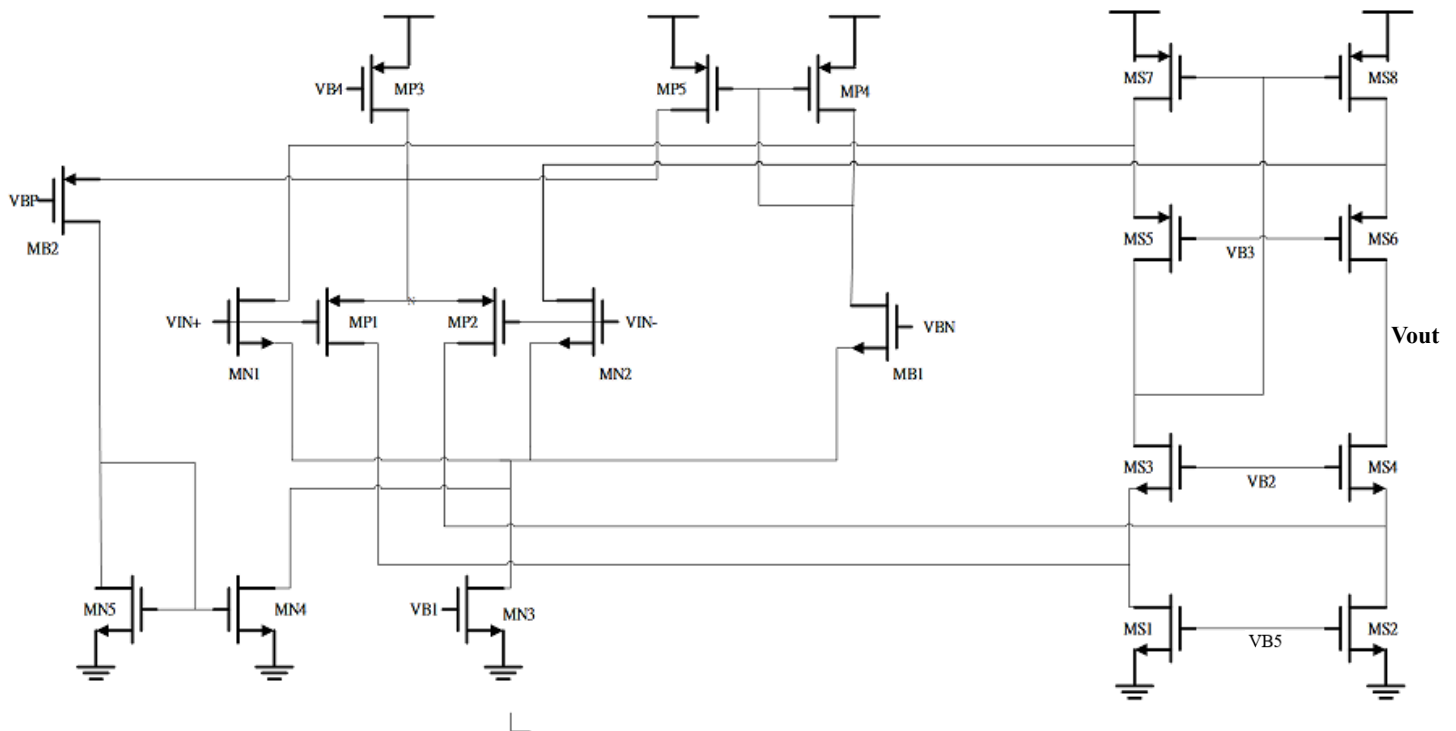


Fig1. rail-to-rail input amplifier

- (a) Design I_{Bias} and W/L of all transistors **by hand calculation**.
(Use the Level 1 parameters derived in your HW1)
- (b) In this design you are allowed to use only one current reference ($I_R = 20 \mu A$) and one voltage reference ($V_{REF} = 0.9 V$). Please design the circuit to generate the biasing voltages $V_{B1} \sim V_{B5}$, V_{BP} , and V_{BN} . Please describe your design in the report.
- (c) Use **Spectre** to check whether all specifications are satisfied. If not, **redesign** your circuit to meet the specifications. **The following results must be included in your report:**
- (i) Use **Spectre** to calculate the operating modes, g_m , r_o of all transistors when $v_I = v_{REF} = 0.9V$. Give the **summary of circuit operations** in your report.
 - (ii) Sweep the DC value of v_O with v_I sweeping from 0 to 1.8V. Give **the plot of v_O v.s. v_I** in your report, and **mark maximum gain value** and find the output dynamic range (hint: Slope(gain) at the V_{out} in the output dynamic range must all be larger than 50dB).
 - (iii) Plot the open-loop frequency response (both magnitude and phase) of the Op-amp. Mark explicitly **A_v , 3dB frequency**, and **PM** in the plot.
 - (iv) Sweep the DC value of the input common mode voltage from 0 to 1.8V. Give the plot of g_{mn} , g_{mp} , $g_{mt}(=g_{mn}+g_{mp})$ in your report. Please mark and calculate the ΔG_m in your simulation result
- (d) **Summarize the specifications** of the Op-amp in a table of the following form

	Specifications	Simulations	Units
DC characteristics	$P_{diss} \leq 2$		mW
	$0 \leq I_{CMR} \leq 1.8$		V
	$0.5 \leq V_{out} \text{ range} \leq 1.3$		V
	$\Delta g_m < 10\%$		%
AC characteristics	$A_v \geq 50\text{dB}$		dB
	3dB-bandwidth $\geq 80K$		Hz
	$PM \geq 65$		°

Please submit your **report (*.pdf)** and **netlist file (*.sp)** to the EECLASS system.
(Note: Don' use black color in background for your screen capture figures).
Please named your file as *hw2_student number.pdf*, *hw2_student number_x.sp*
e.g. *hw2_100061501_1c.sp* represents .sp file for question 1(c).