25 Spring ECEN 607: Advanced Analog Circuit Tech Design Pre-lab Report

Lab 2: Two-Stage Amplifier Design with 3σ Driven Statistical Corner Extraction

Name: Yu-Hao Chen

UIN:435009528

Section:601

Professor: Jose Silva-Martinez

TA: Yoon, Sung J

1. A PMOS input, two-stage Miller compensated op-amp is shown below. Obtain the expressions for
   - From your background in ECEN-704/474, obtain the DC Gain (A_{v0}), frequency of the dominant pole (p1), Second pole (p2), Zero (z), Gain bandwidth product (GBW). Find the expression for Phase Margin (PM).

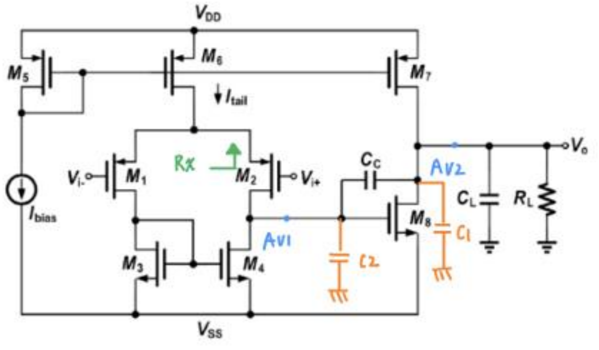


Figure 1: PMOS Two-Stage Miller Opamp

Avo : DC gain $= AV1 \times Av2$ $\quad RX = gm2\, rds2\, rds6 + rds2 + rds6$

$AV1$: $-gm2\,(RX \,//\, rds4)$

$AV2$: $-gm8\,(rds8 \,//\, rds7 \,//\, RL)$

$C2$: $(1 + Av2)\, Cc \approx Av2\, Cc$

$C1$: $(1 + \frac{1}{Av2})\, Cc \approx 0$

$Wp1$: $\dfrac{1}{(RX \,//\, rds4)(Av2\, cc)}$ $\quad (f = \frac{w}{2\pi})$

$Wp2 \Big|_{\text{high f} \quad cc = 0}$: $\dfrac{1}{(\frac{1}{gm8} \,//\, rds7 \,//\, rds8 \,//\, RL)\, CL} \approx \dfrac{gm8}{CL}$

WZ : $\dfrac{gm8}{Cc}$

$WGBW$: $\dfrac{gm2}{Cc}$

PM : $90^\circ - \tan^{-1}\left(\dfrac{WGBW}{Wp2}\right) - \tan^{-1}\left(\dfrac{WGBW}{WZ}\right)$

2. Select the current in different branches as well as dimensions of the transistors to satisfy the following specifications:

Table 1: Design specifications. Notice that VDD, VSS, CL and RL are given

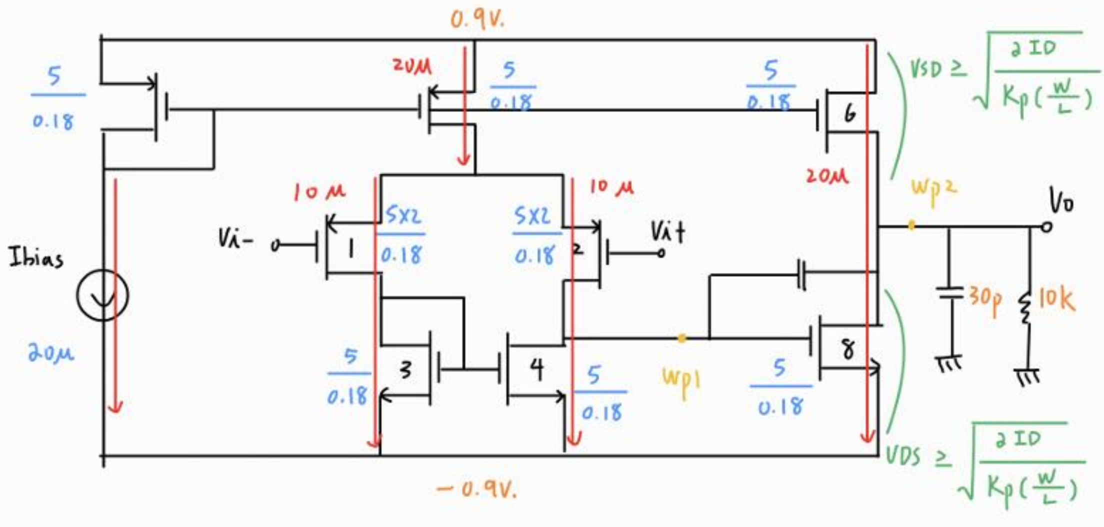
~~V_{DD}~~	~~0.9V~~
~~V_{SS}~~	~~-0.9V~~
A_{v0}	> 40 dB
GBW	> 2 MHz
PM	> 45°
Output Swing	> 1 V
~~C_L~~	~~30 pF~~
~~R_L~~	~~10kΩ~~

Table 2: Reference parameters of 1.8 V NMOS transistors..

Sl. No	W/L (μm/ μm)	V_{th} (mV)	μn*Cox (mF/Vs)	θ	λ (mV^{-1})	Ai (V)	Ai (dB)	f_t (GHz)
1	0.5/0.18	0.46	0.167	0.92	263	21.17	26.51	51.23
2	5/0.18	0.458	0.215	1.28	329.406	21.65	26.71	49.12
3	5/0.27	0.447	0.214	0.994	131.158	45.212	33.11	26.82

Table 3: Reference parameters of 1.8 V PMOS transistors

Sl. No	W/L (μm/ μm)	V_{tp} (mV)	μn*Cox (μF/Vs)	θ	λ (mV^{-1})	Ai (V)	Ai (dB)	f_t (GHz)
1	0.5/0.18	0.43	47.2	0.744	289.27	17.39	24.81	17.41
2	5/0.18	0.413	56.22	0.77	292.15	17.63	24.93	19.64
3	5/0.27	0.42	47.37	0.653	158.16	28.085	28.97	8.851



$$g_m = \sqrt{2 I_D \mu_n C_{ox} \frac{W}{L}} \qquad r_{ds} = \frac{1}{\lambda I_D}$$

160.882k

$g_{m2} = 249.93\mu$ $\boxed{r_{ds2} = 342.28k \quad r_{ds4} = 303.57k}$

$A_{v1} = 40.20$

10k

$g_{m8} = 488.76\mu$ $\boxed{r_{ds8} = 303.57k \quad r_{ds7} = 342.28k \quad R_L = 10k}$

$A_{v2} = 4.88$

$A_{vo} = 196.176 = 45.85\ dB$

$GBW = \frac{g_{m2}}{2\pi \cdot C_c} \geq 2M$ $C_c \leq 19.89\ pF$

$C_c = 10\ pF$ $GBW = 3.97\ M$

$f_{p1} = \frac{-1}{2\pi \times |A_{v2}| C_c \times 160.822k} = 20.289k$ $f_{p2} = \frac{-g_{m8}}{2\pi\ C_L} = 2.59\ MHz$

$W_z = \frac{g_{m8}}{2\pi \times C_c} = 7.78\ M\ Hz$

$PM = 90^\circ - \underbrace{\tan^{-1}\frac{GBW}{W_{p2}}}_{56.89^\circ} + \underbrace{\tan^{-1}\frac{GBW}{W_z}}_{27.07^\circ} = 60.18$

$-0.9 + \underbrace{\sqrt{\frac{2 I_D}{K_N (\frac{W}{L})}}}_{0.08} \leq V_o \leq 0.9 - \underbrace{\sqrt{\frac{2 I_D}{K_p (\frac{W}{L})}}}_{0.16}$

$-0.82 \leq V_o \leq 0.74$ Swing : 1.56