Homework #9 of「類比積體電路導論」

作業繳交截止日期:Dec. 17, 2024 12:00 (上傳E3數位平台繳交)

本次作業共兩大題, 9.1~9.2

請將作業轉成一個 PDF 檔案(file size 小於 10MB)，檔名請使用「AIC_HW9_自己的學號」(例如: AIC_HW9_109700018)，於作業繳交截止日期/時間前，上傳到指定的E3 數位平台繳交。

Unless otherwise stated, in the following problems, use the device data shown in Table 1 and assume that VDD=$3V$. The Dielectric constant of gate oxide is 3.9 and ε_o=$8.854\times10^{-12}F/m$.

Table 1. Level 1 SPICE models for NMOS and PMOS devices.

NMOS Model			
LEVEL = 1	VTO = 0.7	GAMMA = 0.45	PHI = 0.9
NSUB = 9e+14	LD = 0.08e−6	UO = 350	LAMBDA = 0.1
TOX = 9e−9	PB = 0.9	CJ = 0.56e−3	CJSW = 0.35e−11
MJ = 0.45	MJSW = 0.2	CGDO = 0.4e−9	JS = 1.0e−8
PMOS Model			
LEVEL = 1	VTO = −0.8	GAMMA = 0.4	PHI = 0.8
NSUB = 5e+14	LD = 0.09e−6	UO = 100	LAMBDA = 0.2
TOX = 9e−9	PB = 0.9	CJ = 0.94e−3	CJSW = 0.32e−11
MJ = 0.5	MJSW = 0.3	CGDO = 0.3e−9	JS = 0.5e−8

VTO: threshold voltage with zero V_{SB} (unit: V)
GAMMA: body-effect coefficient (unit: $V^{1/2}$)
PHI: $2\Phi_F$ (unit: V)
TOX: gate-oxide thickness (unit: m)
NSUB: substrate doping (unit: cm^{-3})
LD: source/drain side diffusion (unit: m)
UO: channel mobility (unit: $cm^2/V/s$)
LAMBDA: channel-length modulation coefficient (unit: V^{-1})
CJ: source/drain bottom-plate junction capacitance per unit area (unit: F/m^2)
CJSW: source/drain sidewall junction capacitance per unit length (unit: F/m)
PB: source/drain junction built-in potential (unit: V)
MJ: exponent in CJ equation (unitless)
MJSW: exponent in CJSW equation (unitless)
CGDO: gate-drain overlap capacitance per unit width (unit: F/m)
CGSO: gate-source overlap capacitance per unit width (unit: F/m)
JS: source/drain leakage current per unit area (unit: A/m^2)

9.1 The circuit of Fig.1 is designed with $2 * \left(\frac{W}{L}\right)_3 = 4 * \mathbf{K} * \left(\frac{W}{L}\right)_4 = \mathbf{K} * \left(\frac{W}{L}\right)_5$,

R_1= 1.5kΩ, and R_2 =2kΩ. Assume that **λ=γ=0.** $\mathbf{Q_1}$, $\mathbf{Q_2}$, and $\mathbf{Q_3}$ are identical. Determine K such the Vout has a zero TC. Use the parameters listed below.

$$\frac{\partial V_{BE}}{\partial T} = -1.5mV/K \text{ and } \frac{\partial V_T}{\partial T} \approx +0.087mV/K$$

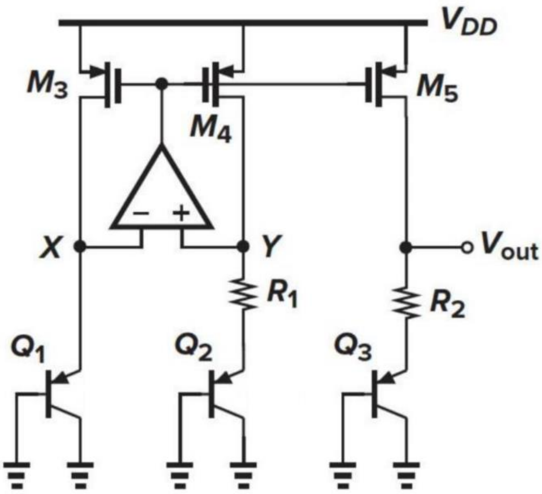

Fig.1

9.2 Consider the bandgap reference shown below. The opamp is ideal. For Q_1 and Q_2, $\beta_F = \infty$, $V_A = \infty$, $I_{S2} = 6$ pA $= 6I_{S1}$. At T = T_0, let $V_T = kT_0/q = 26$ mV, $dV_T/dT = +0.087$ mV/°C, and $d|V_{BE}|/dT = -1.74$ mV/°C.

(a)Let $V_{os} = 0$ mV, $R_1 = R_2 = R$. Find R to make $dV_o/dT = 0$ at $T = T_0$.

(b)Let $V_{os} = 20$ mV. Calculate V_o in terms of V_{BE2}. Use the R found in (a).

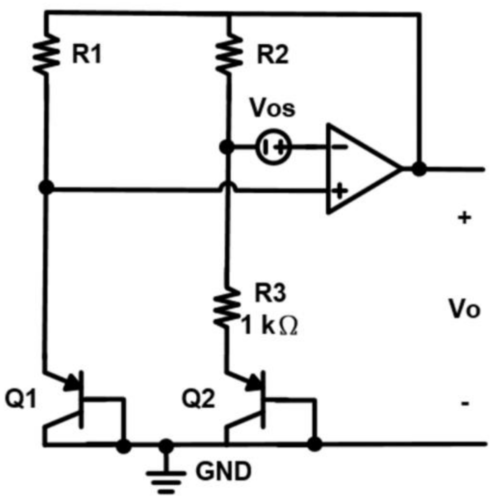

Fig.2