Table 6.1

Parameter Symbol	Parameter Description	Typical Parameter Value n-Channel	p-Channel	Units
V_{T0}	Threshold voltage ($V_{BS} = 0$)	0.7 ± 0.15	-0.7 ± 0.15	V
K'	Transconductance parameter (in saturation)	$110.0 \pm 10\%$	$50.0 \pm 10\%$	$\mu A/V^2$
γ	Bulk threshold parameter	0.4	0.57	$V^{1/2}$
λ	Channel length modulation parameter	0.04 ($L = 1\ \mu m$) 0.01 ($L = 2\ \mu m$)	0.05 ($L = 1\ \mu m$) 0.01 ($L = 2\ \mu m$)	V^{-1}
$2\|\phi_F\|$	Surface potential at strong inversion	0.7	0.8	V

6.1 Determine V_{ref} (Output Voltage) in Fig 6.1 and the conditions under which the TC of V_{ref} is zero. Assume K=10. Assume $(\partial V_T)/\partial T=0.085mV/°C$, $(\partial V_{BE})/\partial T=-2mV/°C$, $V_{BE}=0.75V$, $V_T=26mV$.

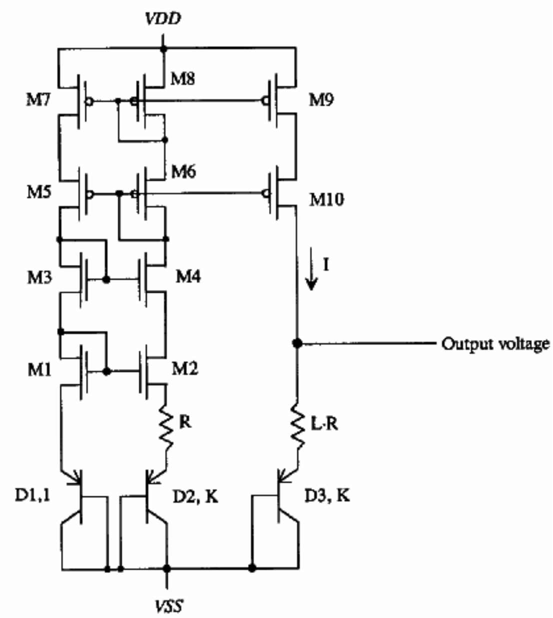

Fig 6.1

解：

For the circuit in Fig 6.1, we get

$$V_{ref} = L\ln K \times V_T + V_{BE(D3)}.$$

V_{ref} is dependent on temperature and we get

$$\frac{\partial V_{ref}}{\partial T} = L \cdot \ln K \cdot \frac{\partial V_T}{\partial T} + \frac{\partial V_{d3}}{\partial T}$$

$$\frac{\partial V_T}{\partial T} = 0.085mV/^\circ C \quad \text{and} \quad \frac{\partial V_{d3}}{\partial T} = -2mV/^\circ C$$

Let V_{ref} has zero temperature coefficient and get

$$\frac{\partial V_{ref}}{\partial T} = L \cdot \ln K \cdot \frac{\partial V_T}{\partial T} + \frac{\partial V_{d3}}{\partial T} = 0$$

It can be derived that while $L \cdot lnK$=2/0.085=23.5， $\frac{\partial V_{ref}}{\partial T}=0$, or $TC(V_{ref})=0$.

Assuming K=10， the corresponding L＝10.2≈10

Under these conditions the V_{ref} that has zero TC is

$$V_{REF}=L\ln K\times V_T+V_{BE(D3)}=1.35V$$

6.2 Derive an expression for I_{out} in Fig 6.2. Assume all transistors are in saturation region, and $(W/L)_4=(W/L)_3$, $\lambda=0$.

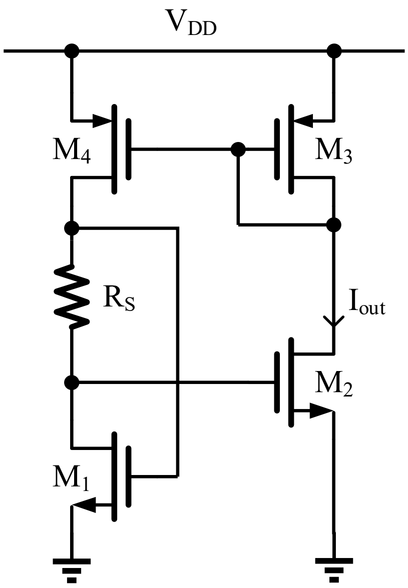

Fig 6.2

解：

$$I_{out}R_S+\sqrt{\frac{2I_{out}}{\mu_n C_{ox}\left(\frac{W}{L}\right)_2}}+V_{TH2}=\sqrt{\frac{2I_{out}}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}}+V_{TH1}$$

解得： $$I_{out}=\frac{2}{\mu_n C_{ox}R_S^2}\left(\sqrt{\left(\frac{L}{W}\right)_1}-\sqrt{\left(\frac{L}{W}\right)_2}\right)^2$$

Homework for this week is a few choice questions.

6.3 A current mirror circuit is shown in Fig 6.3. In order to make I_o strictly equals to I_{ref}, what is the expression of V_b? $\lambda=0$. (　　　)

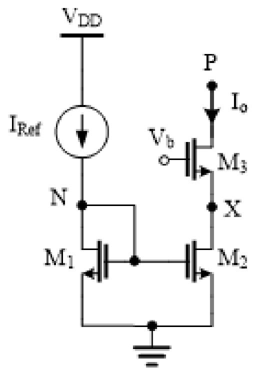

Fig 6.3

A. $2V_{OD} + 2V_{th}$
B. $2V_{OD} + 2V_{GS}$
C. $2V_{OD} + V_{th}$
D. $2V_{OD}$

Answer: A or C

6.4 In Fig 6.3, what is the minimum value of I_o? λ=0. ( )
A. $2V_{OD} + 2V_{th}$
B. $2V_{OD} + 2V_{GS}$
C. $2V_{OD} + V_{th}$
D. $2V_{OD}$

Answer: D

6.5 How many current mirror circuit blocks exist in Fig 6.4? ( )

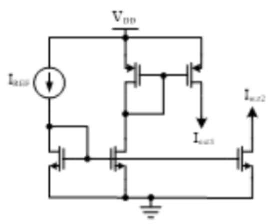

Fig 6.4

A. 1
B. 2
C. 3
D. 4

Answer: C

6.6 Assume you are an analog IC designer. When you are designing a current mirror, what device parameter should be the same to reduce mismatch? ( )

A. W
B. L
C. W/L

Answer: B