CMOS DESIGN CHALLENGE

Submitted by

Name : Saujal Vaishnav

Roll no : 133079029

Phone no : 9833518784

Email Id : saujalvaishnav@gmail.com

(*) CMOS Design challange

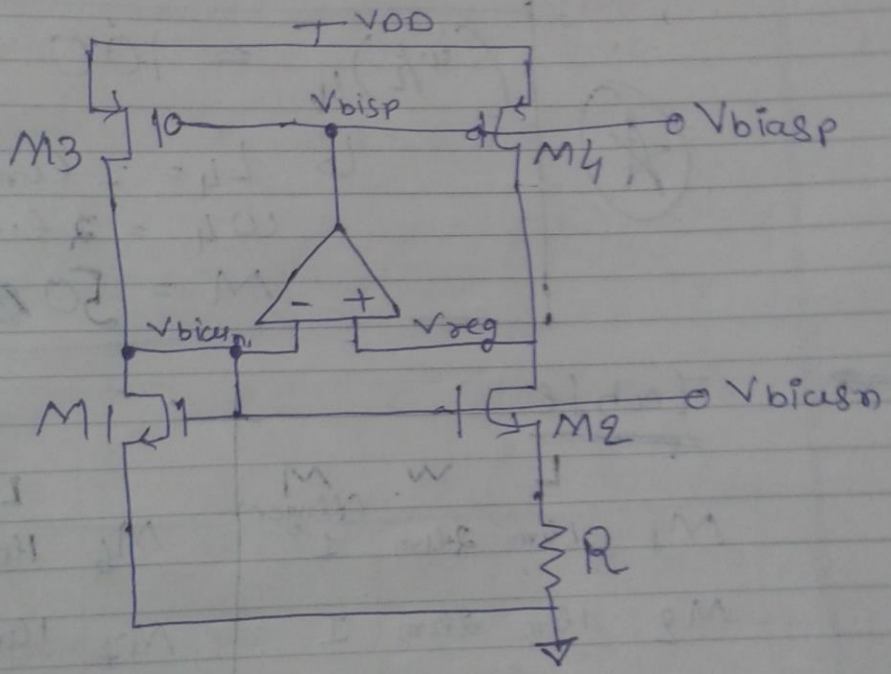
Date: / /

www.adister.in

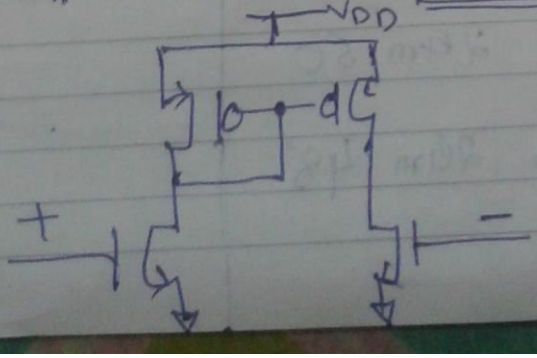
Q. 1

(1) Modified circuit to maintain constant current independent of V_{DD} for short channel.

→ Add differential amplifier to the Basic beta Multiplier

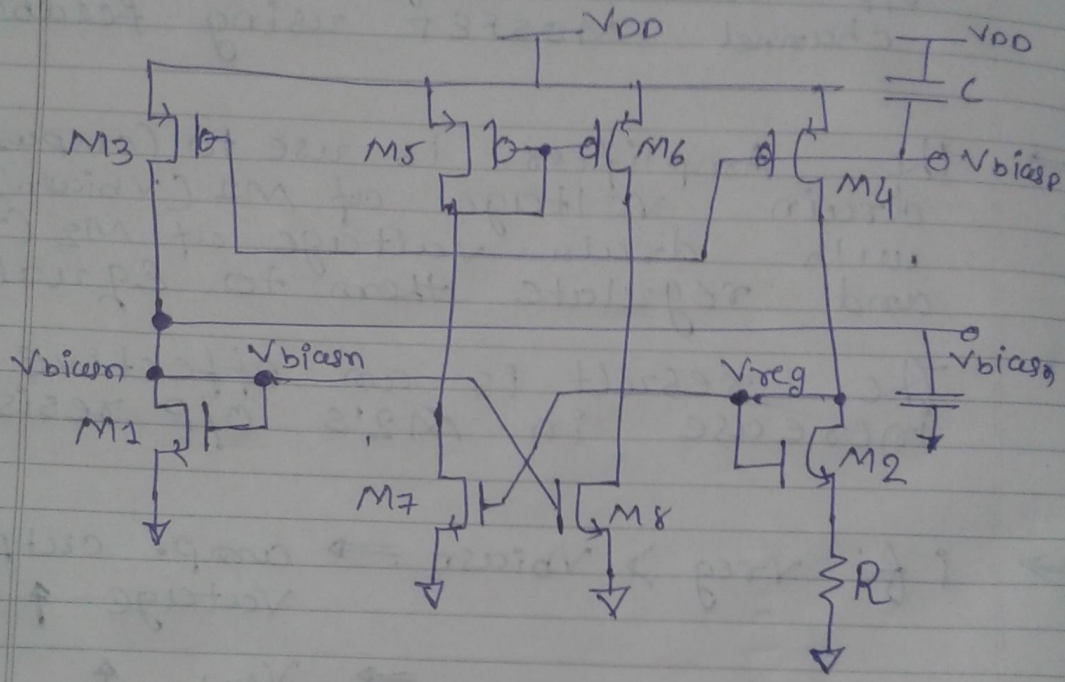


⇒ here OP-Amp is diff-Amp



Date: / /
www.adister.in

Final circuit



(2) Explaination

⇒ To reduce the sensitivity, we need to reduce the variations in drain to source voltage (V_{DS}) of NMOS Device with changes in V_{DD}.

Date: / /
www.adister.in

→ The basic idea is increasing o/p resistance of short-channel MOSFET using feedback.

→ The Amplifier is use to compare drain voltage of M1 (Vbiasn) with drain voltage of M2 (Vreg) and regulate them to Equal.

The result is an effective increase in M2's o/p resistance.

→ if. Vreg > Vbiasn ⟹ amp. output voltage ↑

⟹ V_{GS4} ↑

⟹ lowering the current it supplies

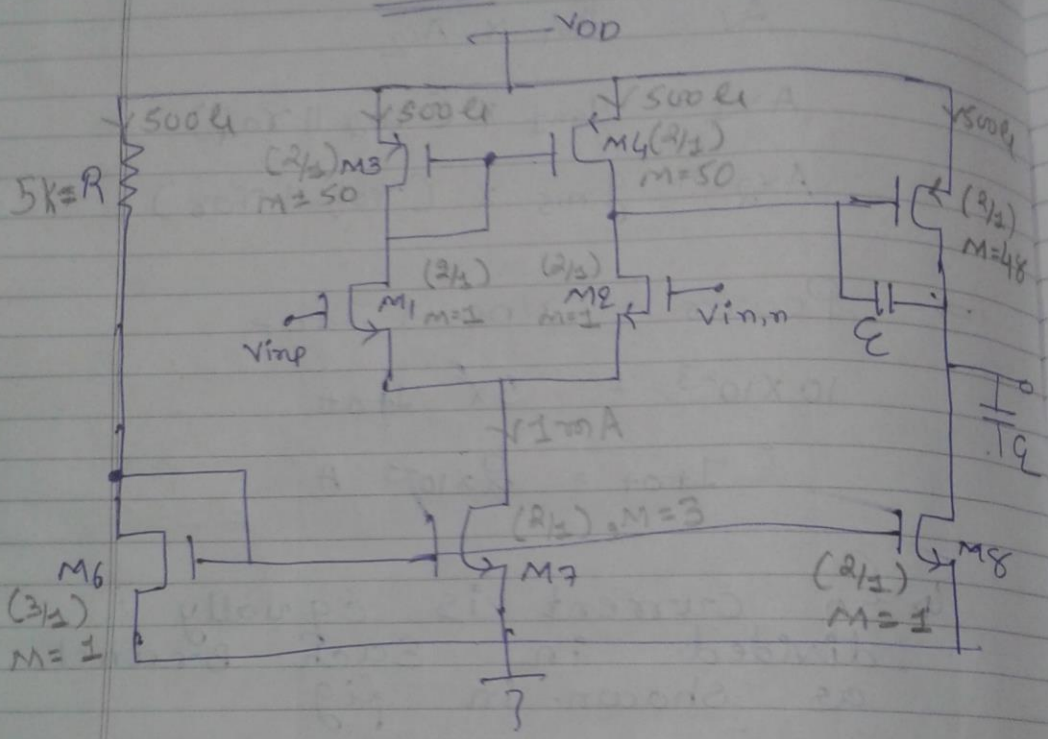
⟹ Vreg ↓

at same time V_{GS3} ↑ causing it to source less current. this causes a drop in Vbiasn.

→ To make reference stable Capacitors are added to o/p.

Date: / /

Q = 2



→ Designed for :→

* Gain ≈ 51 dB ≈ 350
* 3 dB B.W ≈ 2 KHz
* Unity GBW ≈ 3 MHz
* Power ≈ 10 mW
* CL ≈ 1.2 pF

Date: / /

Here total gain

$A_V = A_{V1} \times A_{V2}$

$A_{V1} = g_{m1} \times (r_{o2} \parallel r_{o4})$

$A_{V2} = g_{m5} \times (r_{o5} \parallel r_{o8})$

⇒ Power = $V_{DD} \times I_{tot}$

$10 \times 10^{-3} = 5 \times I_{tot}$

$I_{tot} = 2 \times 10^{-3}$ A

↳ So current is Equally divided in Each Branch as shown in fig

↳ Current in Each Branch = 500 μA

now $\lambda_n = 0.01\,V^{-1}$, $\lambda_p = 0.0125\,V^{-1}$ given;

$r_o = 1/\lambda I_D$

$\therefore r_{o4} = r_{o5} = 1/\lambda_p \times I_D = 1/0.0125 \times 500 \times 10^{-6}$

$= 160\,K\Omega$

Date: / /

$\rightarrow r_{o2} = r_{o8} = 1/\lambda_n \times I_D$

$= 1/0.01 \times 500 \times 10^{-6}$

$= 200\ K\Omega$

$\therefore A_V = A_{V1} \times A_{V2}$

$= g_{m4} \times (r_{o4} \| r_{o2}) \times g_{m5} (r_{o5} \| r_{o8})$

$A_V = g_{m4} \times g_{m5} \times (88.88\ K\Omega) \times (88.88 K\Omega)$ — (1)

$\Rightarrow$ Now; $\boxed{f_u = g_{m1}/2\pi C_L}$

$f_u = 3 \times 10^6$, $C_L = 1.2\ pF$

$\therefore \boxed{g_{m1} = 2.26 \times 10^{-5}\ A/V}$

Now, $g_{m1} = \mu_n C_{ox} \times (W/L)_1 \times (V_{GS1})$

↳ Here $V_{GS1} = 0.1$

$\therefore \boxed{(W/L)_1 = 1.88 \approx 2}$

(7)

Date: / /

www.adister.in

(A) $(W/L)_1 = 2$

↳ $L = 1\ \mu m,\ W_1 = 2\ \mu m$

⇒ Now, $A_V = g_{m4} \times g_{m5} \times (88.88K) \times (88.88K)$

$$g_{m5} = \frac{350}{(88.88K) \times (88.88K) \times 2.26 \times 10^{-5}}$$

$[\because A_V = 350,\ g_{m1} = 2.26 \times 10^{-5}]$

$$\boxed{g_{m5} = 1.96 \times 10^{-3}\ A/V}$$

↳ $g_{m5} = \frac{2 I_{D5}}{|V_{GS5}|}$

$$\boxed{|V_{GS5}| = 0.51}$$

⇒ $g_{m5} = \mu_p C_{ox} \times (W/L)_5 \times (|V_{GS5}|)$

(A) $(W/L)_5 = 96.1$

↳ $L = 1\ \mu m,\ W = [illegible]\ \mu m$

$M = \frac{[illegible]}{48}$ (fingers)

Date: / /

⇒ Consider $R = 5\ K\Omega$

$\therefore V_{D6} = V_{G6} = V_{DD} - (I_{D6} \times 5K\Omega)$

$\therefore V_{D6} = V_{G6} = 5 - (500 \times 10^{-6} \times 5 \times 10^{3})$

$= 2.5\ V$

⇒ $V_{G6} = V_{G7} = V_{G8} = 2.5\ V$.

$V_{Tn} = 0.8\ V$

$\therefore \boxed{V_{GST6} = V_{GST7} = V_{GST8} = 1.7\ V}$

$I_{D6} = \frac{\mu_n C_{ox}}{2} \times \left(\frac{W}{L}\right)_6 \times (V_{GST6})^2$

(★) $\boxed{\left(\frac{W}{L}\right)_6 = 2.88 \simeq 3}$

$\hookrightarrow L_6 = 1\ \mu m$

$W_6 = 3\ \mu m.$

(9)

Date: / /
www.adiator.in

Now $I_{D8} = I_{D8}$ & $V_{GS16} = V_{GS78}$

(A) $(W/L)_8 \approx 3$
$\therefore L_8 = 1\ \mu m$
$\therefore W_8 = 3\ \mu m$

$I_{D7} = \frac{\mu_n C_{ox}}{2} \times (W/L)_7 \times (V_{GS} - V_t)^2$

$2 \times 10^{-3} \quad \therefore I_{D7} = 1\ mA$

$\frac{2 \times 10^{-3}}{(120 \times 10^{-6}) \times (1.7)^2} = (W/L)_7$

(A) $(W/L)_7 = 5.76 \approx 6$
$\therefore L_7 = 1\ \mu m$
$W_7 = 6\ \mu m$
$M = 3$
(Fingers)

Date: / /
www.adister.in

→ Now, for proper design
choose $|V_{GS15}| = |V_{GS14}| = 0.5$

$I_{D4} = 500\ \mu A$

∴ from $I_D = \frac{\mu_n C_{ox}}{2} \times \left(\frac{W}{L}\right)_4 \times (V_{GS14})^2$

(★)

$$\left(\frac{W}{L}\right)_4 = 100$$

↳ $L_4 = 1\ \mu m$
$W_4 = 2\ \mu m$
$M = 50$ (fingers)

→ Table

	L	W	M (fingers)
M_1	1 μm	2 μm	1
M_2	1 μm	2 μm	1
M_3	1 μm	2 μm	50
M_4	1 μm	2 μm	50
M_5	1 μm	2 μm	48

	L	W	M (fingers)
M_6	1 μm	3 μm	1
M_7	1 μm	2 μm	3
M_8	1 μm	3 μm	1