EE 618 (ZELE)
CMOS Analog VLSI Design
Quiz-1

Date : 28th August 2023 **Duration**: 1 Hour **Max. Marks** : 25

ACADEMIC HONESTY POLICY—IIT BOMBAY (https://www.iitb.ac.in/newacadhome/rules.jsp)
Copying in exams has serious consequences.

Do not communicate with other students during exams
Do not carry unauthorized material during exams
Do not make changes in valued answer books
Do not communicate with others during toilet breaks during exams

State your assumptions clearly, if any.

Ignore body effect ($\gamma = 0$) unless it is explicitly mentioned or shown in the circuits below.

Q1. Find the expressions for effective G_m, output resistance R_{out} and small signal voltage gain A_v. [12 Marks]

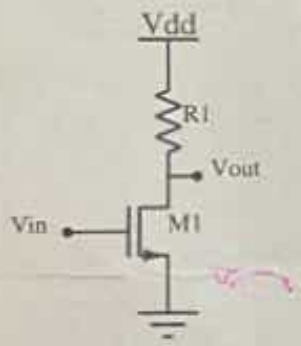


Fig. 1 (a)

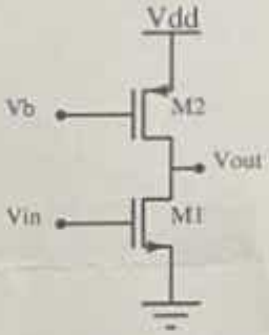


Fig. 1 (b)

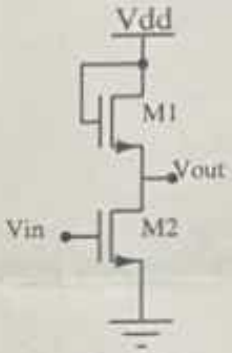


Fig. 1 (c)

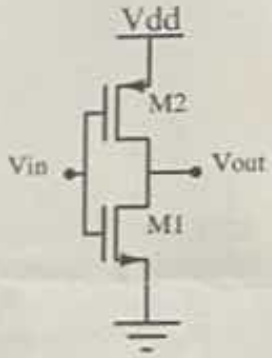


Fig. 1 (d)

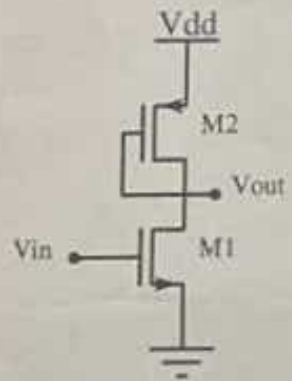


Fig. 1 (e)

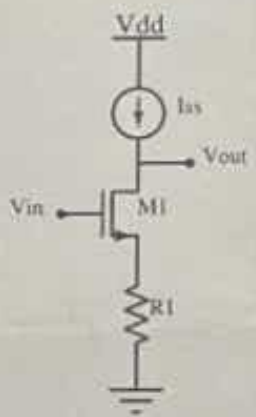


Fig. 1 (f)

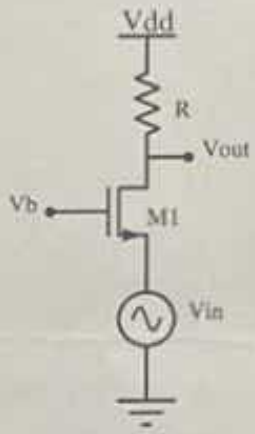


Fig. 1 (g)

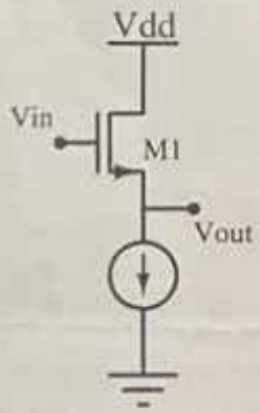


Fig. 1 (h)

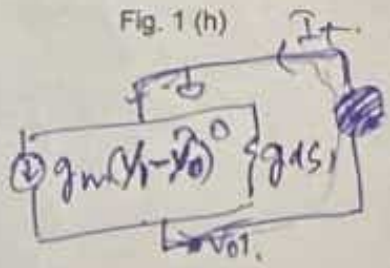
$\frac{V_o}{V_1} = \frac{g_{m1}}{g_{ds1} + g_{m1}}$.

$-g_m V_o + V_t g_{ds1} = I_t$.

$g_m = \frac{I}{V}$.

$g_m V_1 = V_o(g_{ds1} + g_m)$ $g_m(V_1 - V_o) = V_o g_{ds1}$

$g_m V_1 - g_m V_o = V_o g_{ds1}$



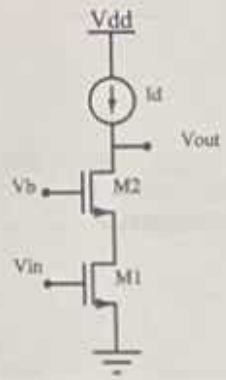


Fig. 1 (i)

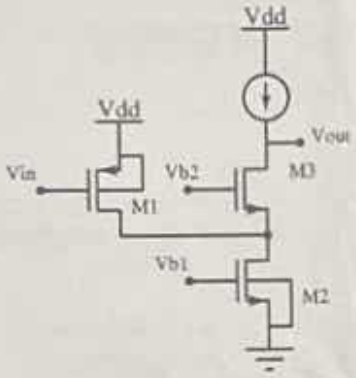


Fig. 1 (j)

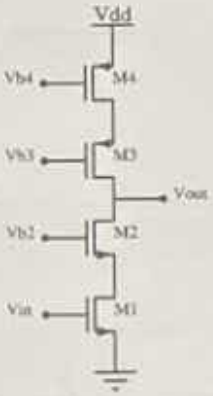


Fig. 1 (k)

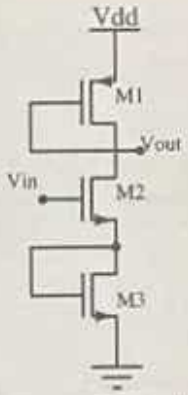


Fig. 1 (l)

Q2. For the circuit shown in Fig. 2,

(a) Draw the small signal model with proper polarity and labels. [1.5 Marks]

(b) Derive an expression for small signal voltage gain A_v using KVL and KCL. [1.5 Marks]

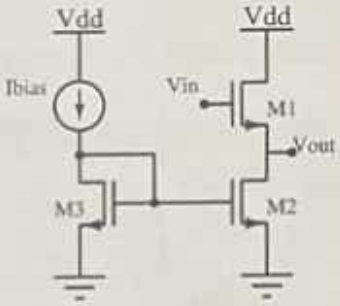


Fig. 2

Q3. For the circuits given in Fig. 3(a) and Fig. 3(b), Evaluate the expression for the following in terms of V_{DD}, V_{DSAT} and V_{TN} of each transistor:

(a) Minimum output voltage

(b) Maximum output voltage

(c) Output voltage swing [5 Marks]

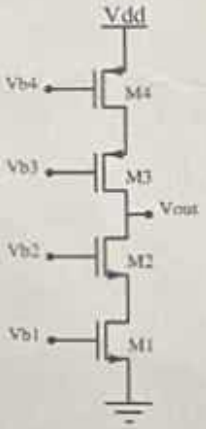


Fig. 3(a)

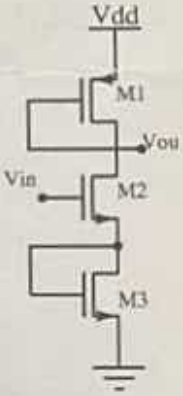


Fig. 3(b)

Q4. As V_x varies from 0 V to 1.5 V, for the circuit shown in Fig.4

(a) Find the region of operation of transistor M1

(b) Plot I_x vs V_x [5 Marks]

Use the technology parameters given below (as required):-

$t_{ox} = 9nm$, $\mu_n = 350 \frac{cm^2}{V-s}$, $\mu_p = 100 \frac{cm^2}{V-s}$, $C_{ox} = 3.38 \frac{fF}{(\mu m)^2}$, $\lambda_p = 0.2V^{-1}$, $\lambda_n = 0.1V^{-1}$ and $V_{TNO} = 0.5V$

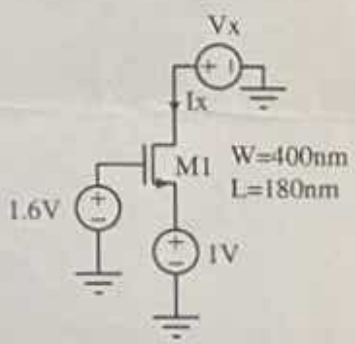


Fig. 4