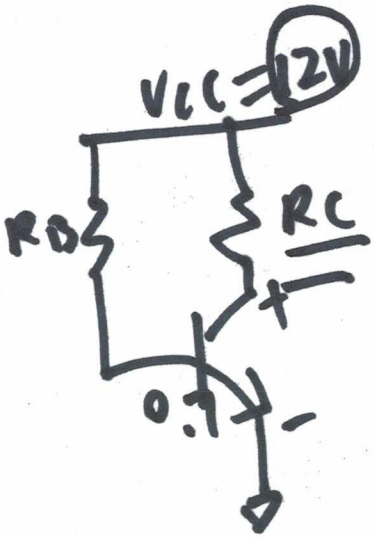
$\beta = 100$

Example: Determine whether the transistor is biased in cutoff, saturation, or linear region

(a) $R_B = 75K\Omega$, $R_C = 1K\Omega$



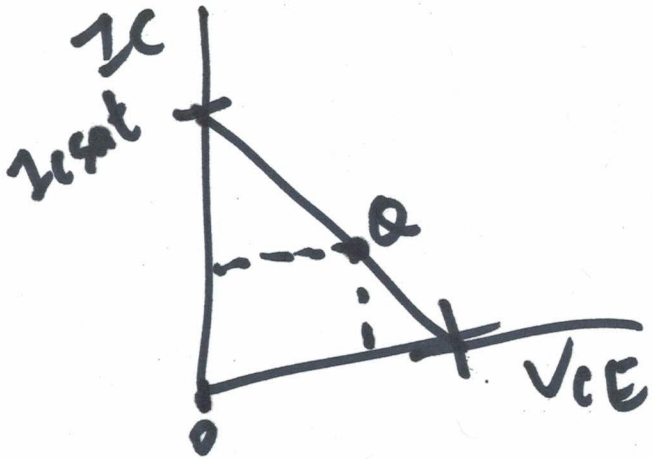
$$I_{csat} = \frac{12 - 0}{R_C}$$

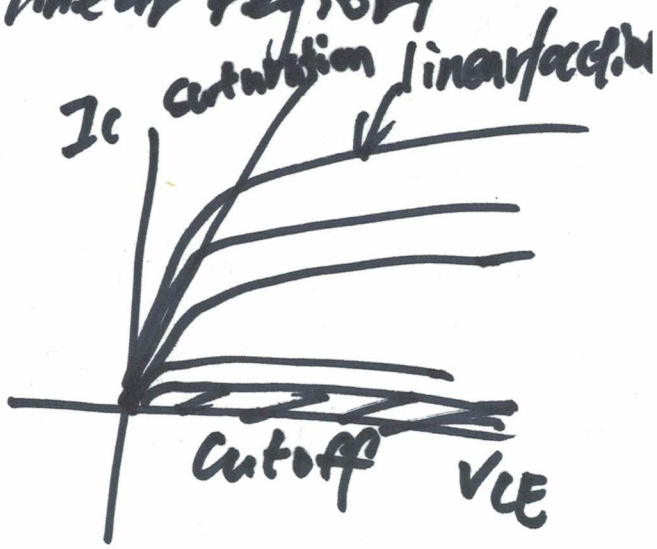
$$= \frac{12}{1K\Omega} = 12mA$$

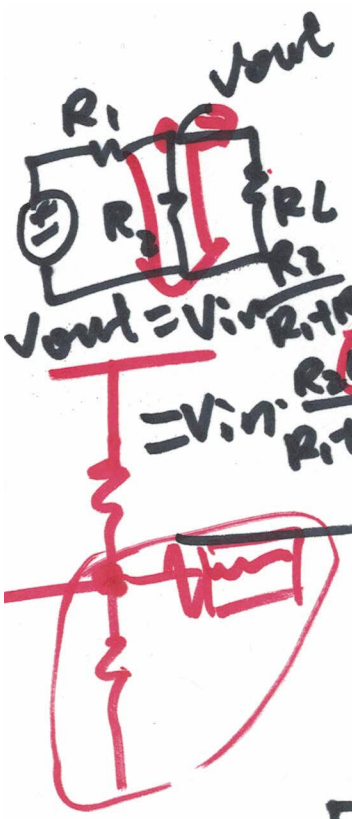
$$I_{cQ} = \frac{12 - 0.7}{R_B} \cdot \beta$$

$$= 15mA > I_{csat}$$

Impossible.
So it is operated in the saturation region





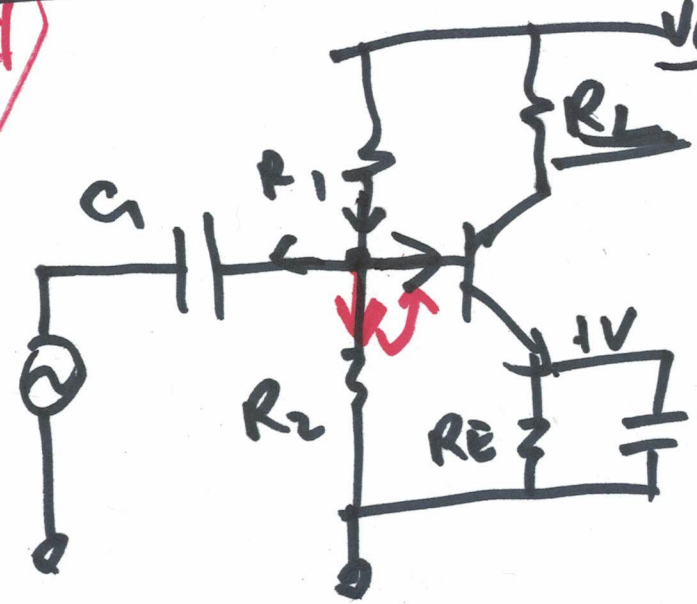


$V_{out} = V_{in} \cdot \frac{R_2 \| R_L}{R_1 + R_2 \| R_L}$

△ When $R_B = 150\,K\Omega$, $R_C = 1\,K\Omega$

$I_{csat} = \frac{12-0}{1K\Omega} = 12\,mA$

$I_C = \beta \cdot \frac{12-0.7}{150K\Omega} = 7.5\,mA < 12\,mA \Rightarrow$ linear region / active region



$R_L = 1.2K$, $V_{CC} = 12V$, $V_{RE} = 1V$

$\beta = 100$

$I_{csat} = \frac{V_{CC} - 1}{R_L} = 9.2\,mA$

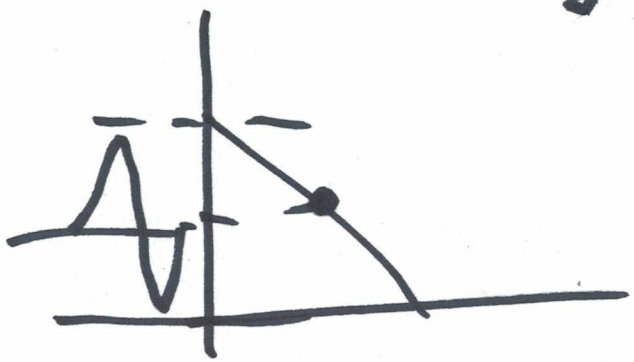
$I_{CQ} = \frac{I_{csat}}{2} = 4.6\,mA$

$I_{BQ} = \frac{1}{\beta} \cdot I_{CQ} = 0.046\,mA = \underline{46\,\mu A}$

$I_{R2} = 10 I_{BQ} = \underline{460\,\mu A}$

$I_{R1} = I_{R2} + I_{BQ} = 506\,\mu A$

$V_B = 0.7V + 1V = 1.7V$



$$R_{R1} = \frac{V_{CC} - V_B}{I_{R1}} = \frac{12 - 1.7V}{506\mu A} = 20.45k\Omega$$

$$R_2 = \frac{V_B}{I_{R2}} = \frac{1.7V}{460\mu A} = 1.2k\Omega$$

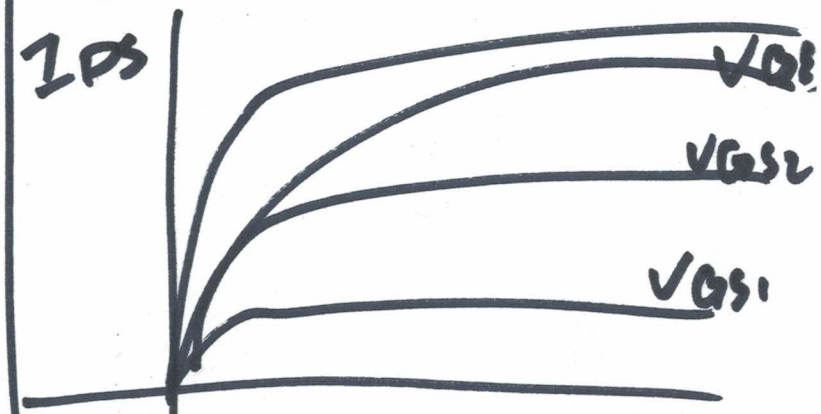
$$R_E = \frac{1V}{I_C + I_B} = \frac{1V}{46mA + 4.6mA} = 216\Omega$$

BJTs

current controlled current source

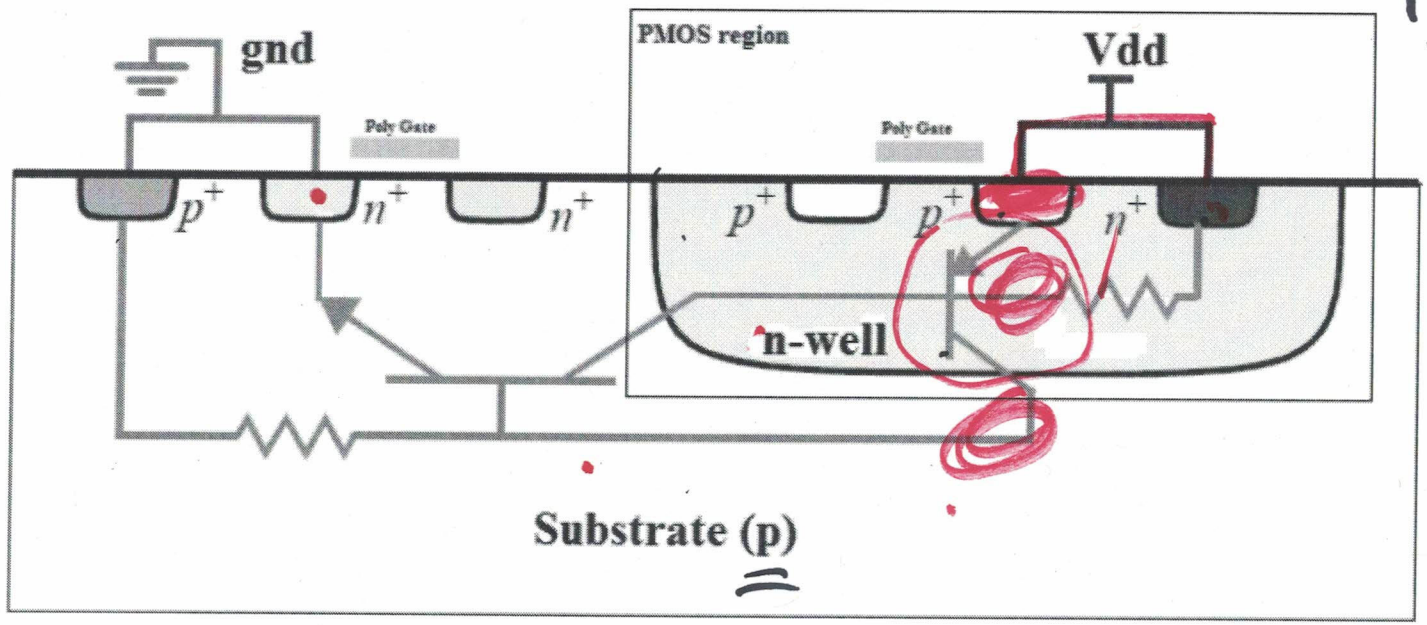
CMOS

Voltage controlled ~~voltage~~ current source



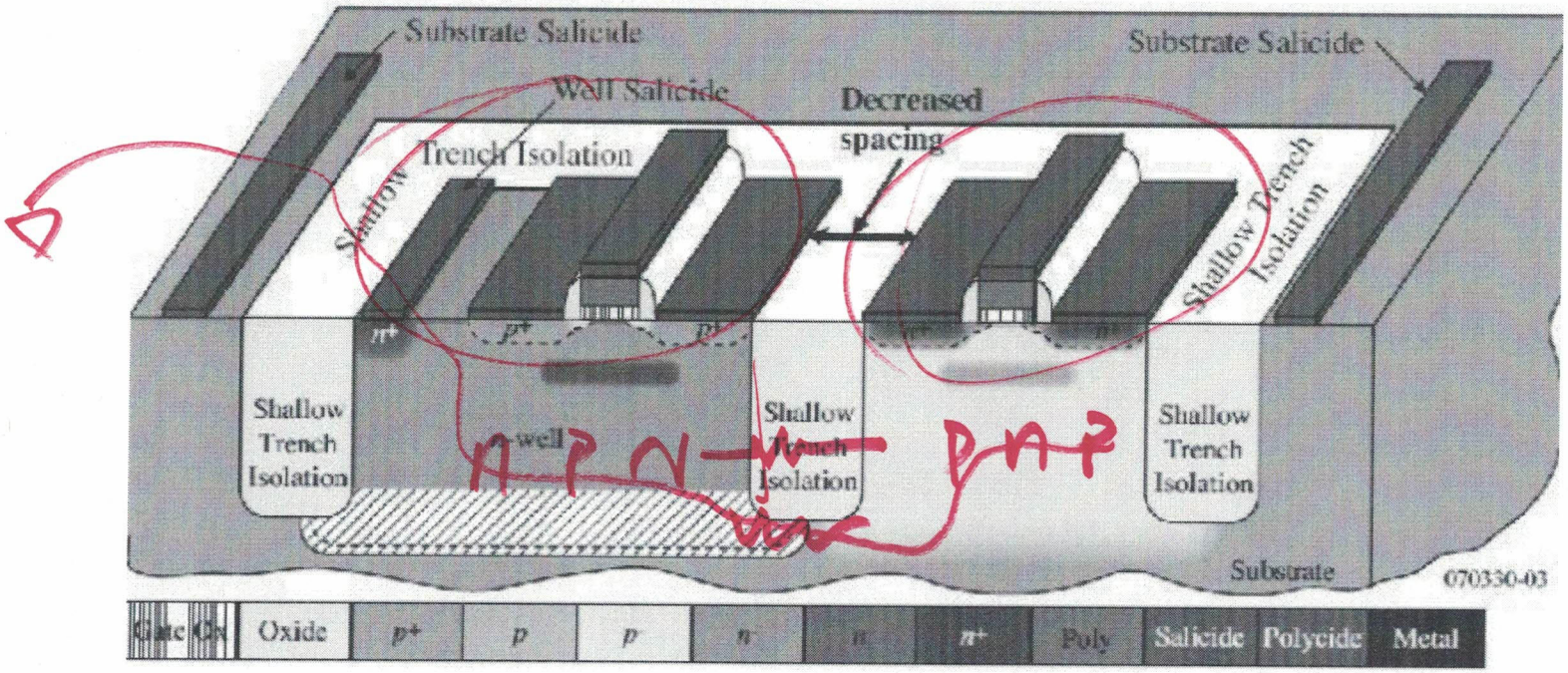
$$I_{DS} = \frac{K_P}{2}\frac{W}{L}(V_{GS} - V_{TH})^2$$

Latch - up

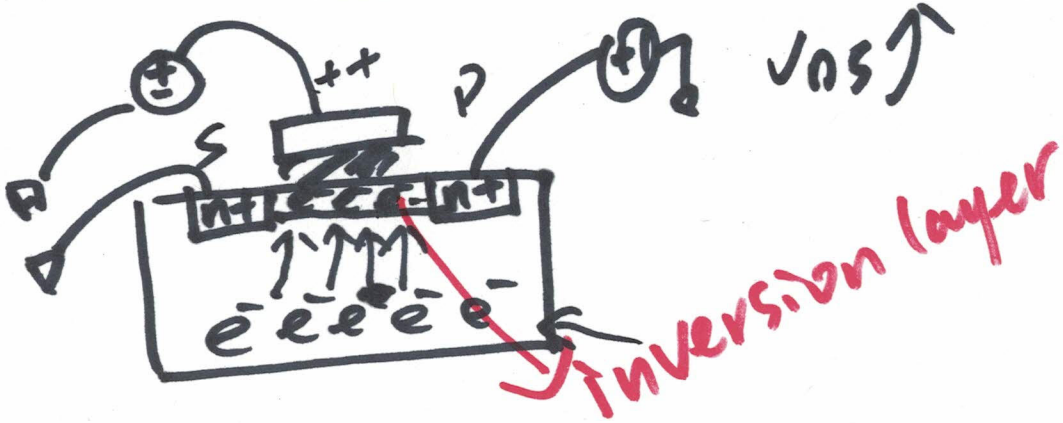

gnd
Poly Gate
PMOS region
Vdd
Poly Gate
p^+
n^+
n^+
p^+
p^+
n^+
n-well
Substrate (p)

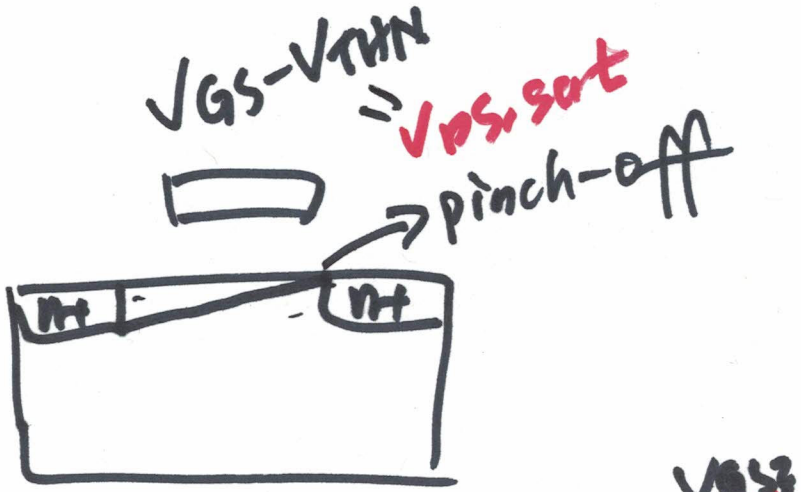
Shallow Trench Isolation Technology

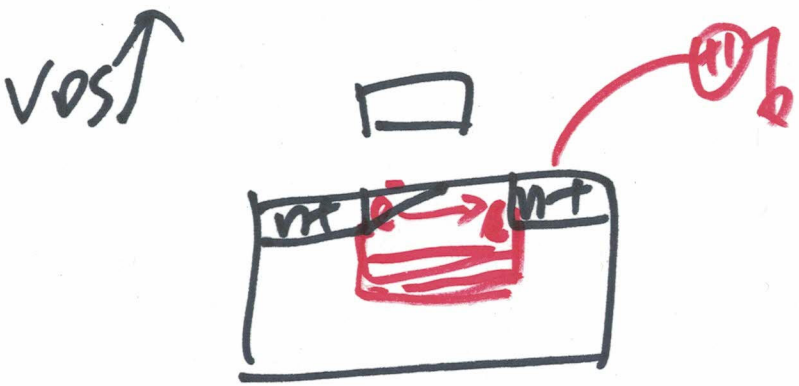
- Allowing transistors to be spaced closer

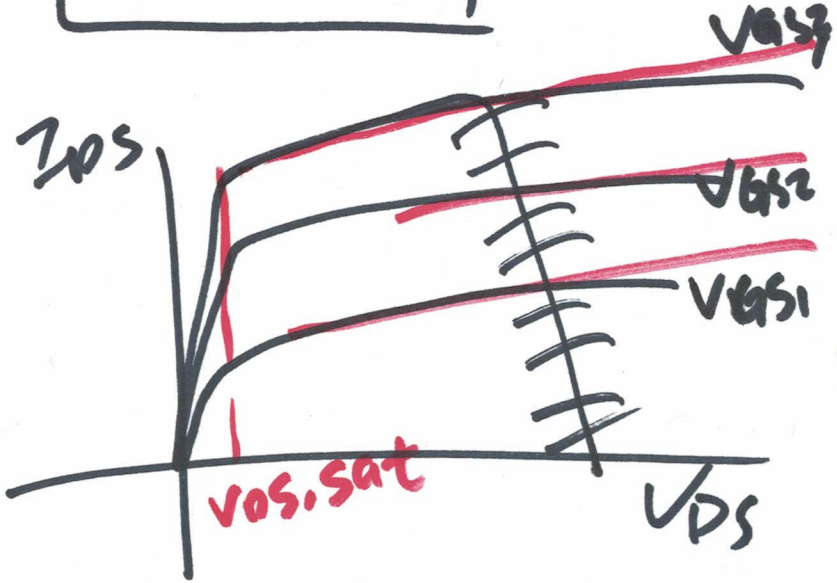


Pinch-off









Channel-length Modulation

CLM

↓

more significant for smaller technologies

500nM 2nM

Body Effect