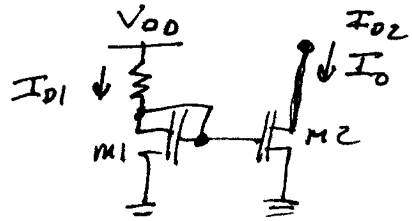
LAYOUT & MATCHING

I. VARIATIONS & Effect. on Matching

A. Effect of lateral diffusion



$$L = L_{drawn} - DL$$

$$W = W_{drawn} - DW$$

- Choose $L_{1drawn} = L_{2drawn}$
- Scale current using W_2 / W_1 ratio

Coose $\frac{W_2}{W_1} = 10$

Want $I_{D2} = 10 I_{D1}$.

If you set $W_{1drawn} = 1\,um$, $W_{2drawn} = 10\,um$ ~~W_{1drawn}~~, then

$$\frac{I_{D2}}{I_{D1}} \sim \frac{W_{2drawn} - DW}{W_{1drawn} - DW}$$

$$= \frac{10 - DW}{1 - DW}$$

$$= \frac{10 - 0.1}{1 - 0.1} = 11 \qquad (DW = 0.1\,um)$$

B. Threshold V_{TH} variations

$$V_{TH1} = V_{TH}$$

$$V_{TH2} = V_{TH} + \Delta V$$

$$\frac{I_o}{I_{D1}} = \frac{(V_{GS} - V_{TH} - \Delta V)^2}{(V_{GS} - V_{TH})^2} \underset{\substack{\text{1st order} \\ \Delta V}}{\approx} 1 - \frac{2\Delta V}{V_{GS} - V_{TH}}$$

$\Longrightarrow$ Want $V_{GS} - V_{TH}$ large to minimize differene between I_o & I_{D1}

C. $\mu_n C_{ox}$ ~~= KP~~ variations

$$I_D = \frac{\mu_n C_{ox}}{2}\frac{W}{L}(V_{GS} - V_{TH})^2$$

$$\mu_{n2} C_{ox2} = \mu_{n1} C_{ox1} + \Delta$$

$$\frac{I_D}{I_{D1}} = 1 + \frac{\Delta}{\mu_{n1} C_{ox1}}$$

D. V_{DS} & λ

$$I_D = \frac{\mu_n C_{ox}}{2}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$

$$\lambda = \lambda_c + \lambda_m$$

λ_c: channel L modulation

λ_m: μ_n modulation.

Let $V_{DS1} = 2V$, $V_{DS2} = 4V$, $\lambda_1 = 0.04$, $\lambda_2 = 0.05$.

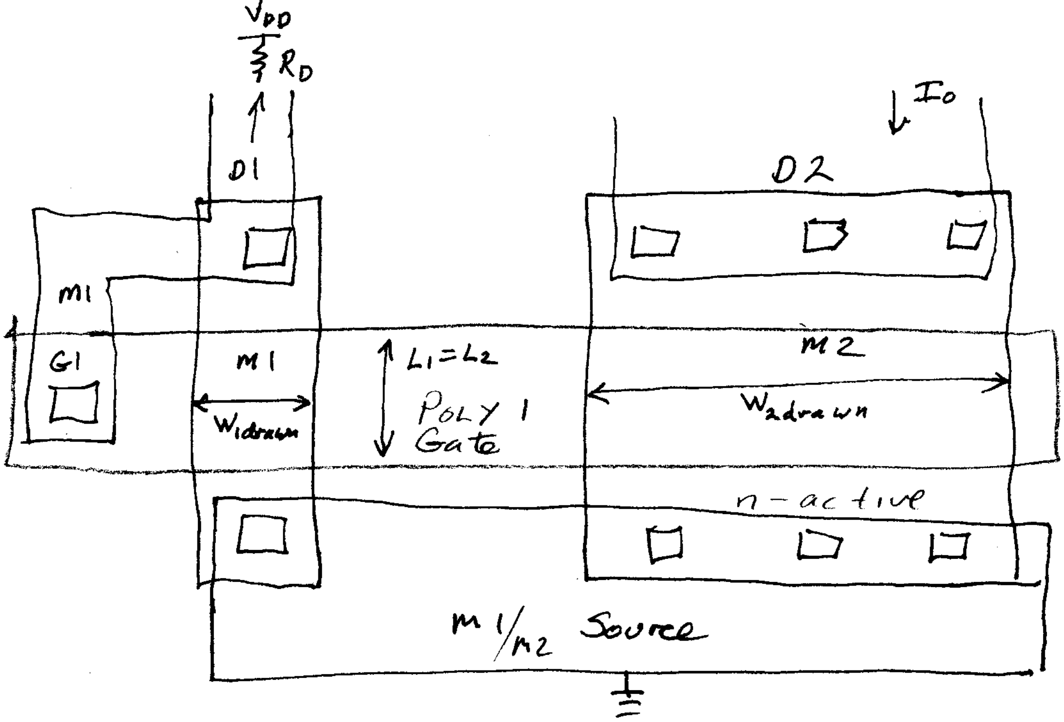
$$\frac{I_D}{I_{D1}} = \frac{1 + \lambda_2 V_{DS2}}{1 + \lambda_1 V_{DS1}} = \frac{1 + (0.05)4}{1 + (0.04)2}$$

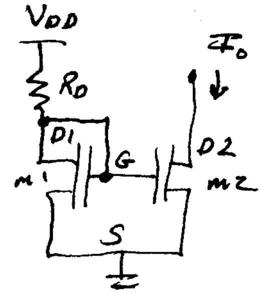
$$= \frac{1.2}{1.08} = 1.11$$

- λ is reduced for larger L
  $\lambda \downarrow$ as $L \uparrow$.
- Design for $V_{DS1} \cong V_{DS2}$.

II. LAYOUT SOLUTIONS (20.1.6) p 446

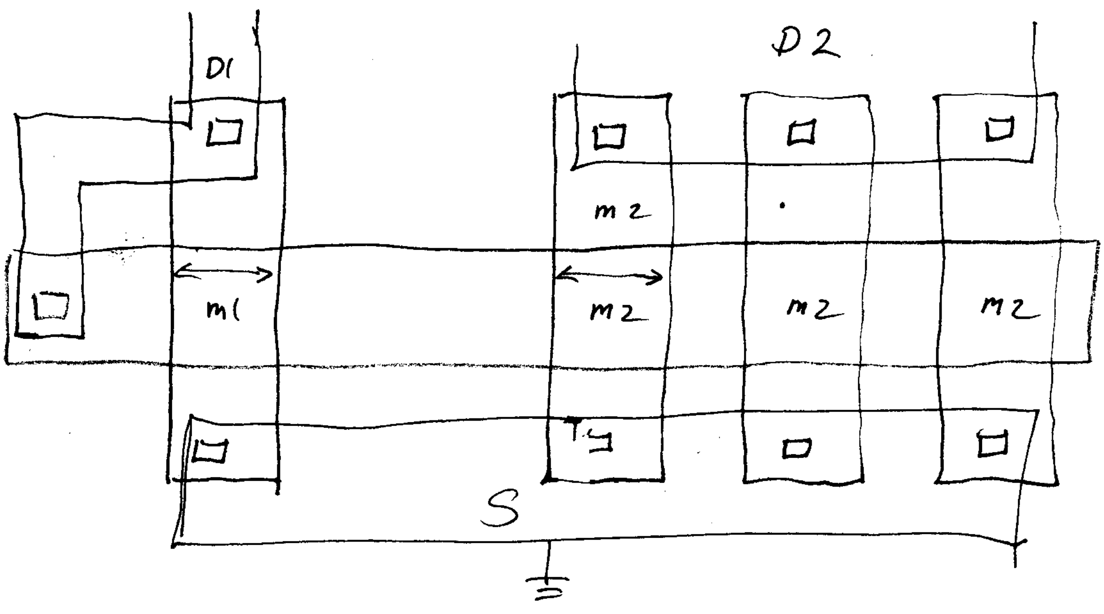
A. LATERAL DIFFUSION





$$\frac{I_O}{I_{D1}} = \frac{W_{2drawn} - DW}{W_{1drawn} - DW} \neq \frac{W_{2drawn}}{W_{1drawn}}$$

$$\Downarrow$$



$$W_{1drawn} = W_{2drawn}$$

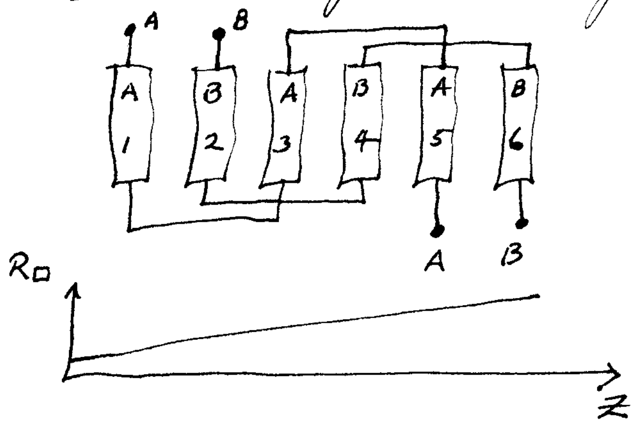
$$W_1 = W_{1drawn} - DW$$

$$W_2 = n(W_{1drawn} - DW)$$

$$\frac{W_2}{W_1} = n$$

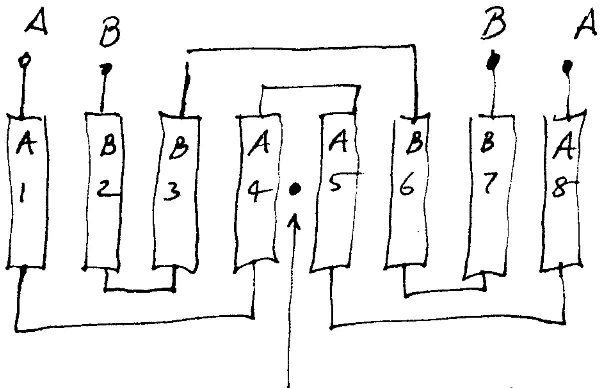
REVIEW p. 138 - 9

A. Interdigitated Layout



$R_A = 9$
$R_B = 12$

B. Common Centroid



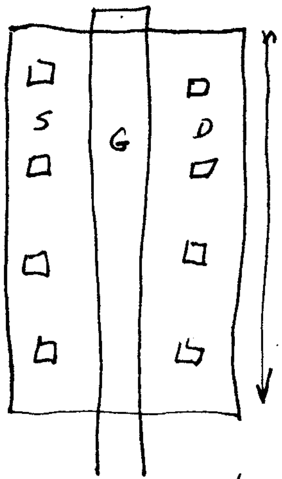
$R_A = 18$
$R_B = 18$

Common center
'Center of mass'

$\frac{1}{A}\int_A d^2r \; \vec{r}$

B. General Matching & Layout.

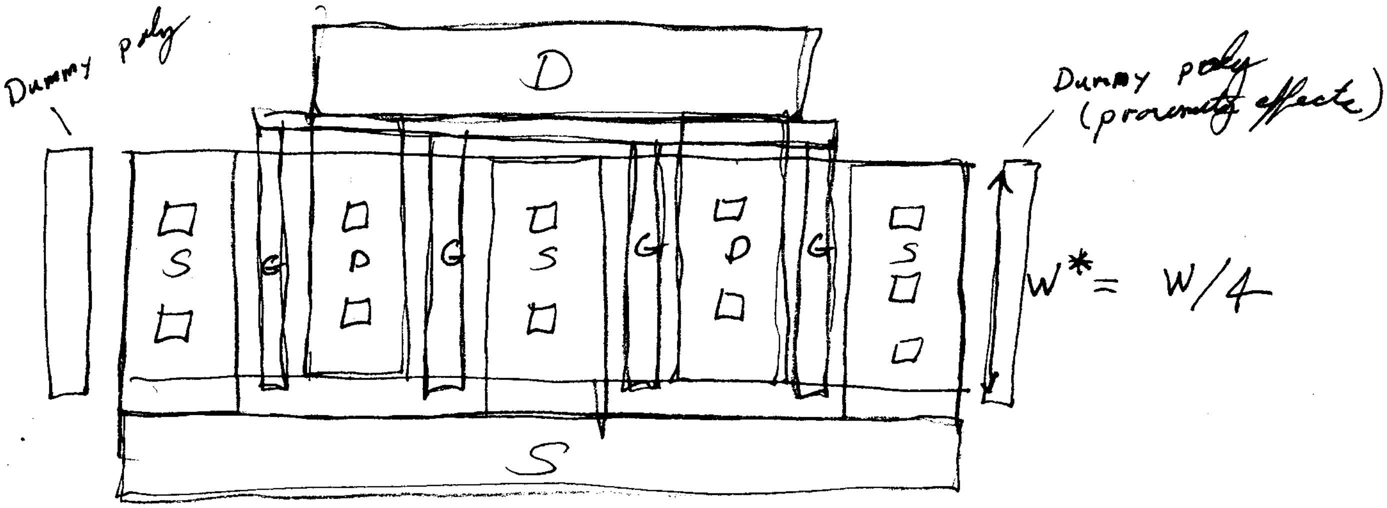
- Large W transistor layout



Large W

$C_{sd} = C'_{sd} W$

⇓

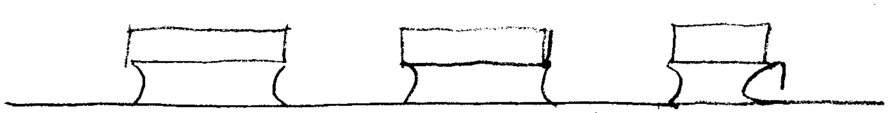


$$C^*_{sb} = C'_{sb} \frac{3W}{4}$$

$$C^*_{db} = C'_{db} \frac{2W}{4}$$

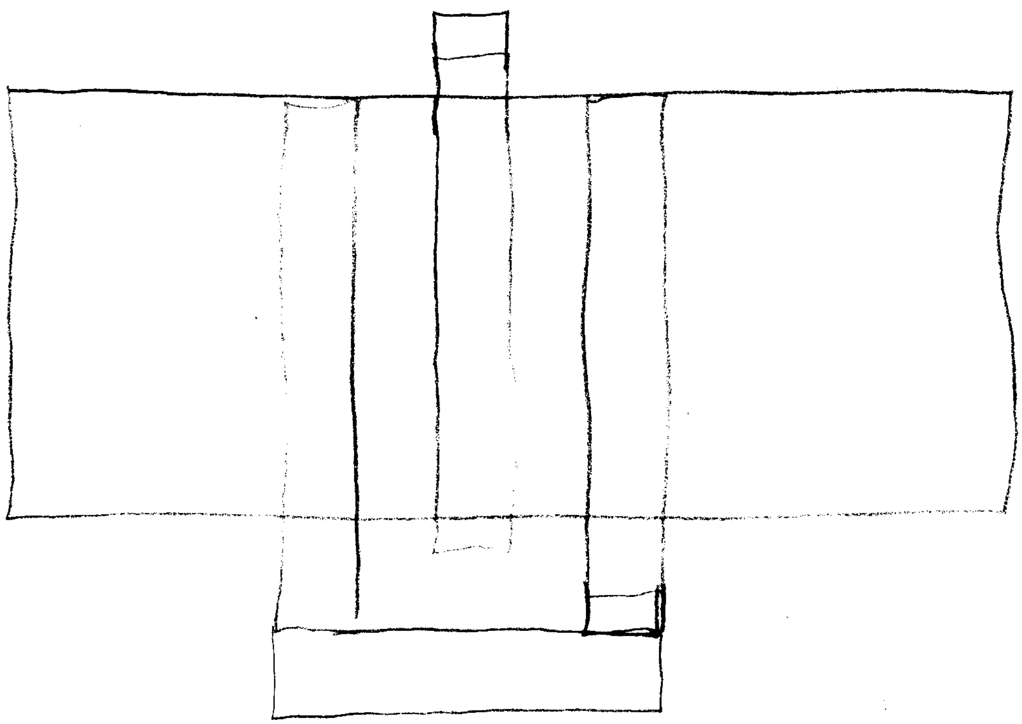
} Reduces parasitic C_{sb}, C_{db}

Dummy Poly (Proximity Effect)

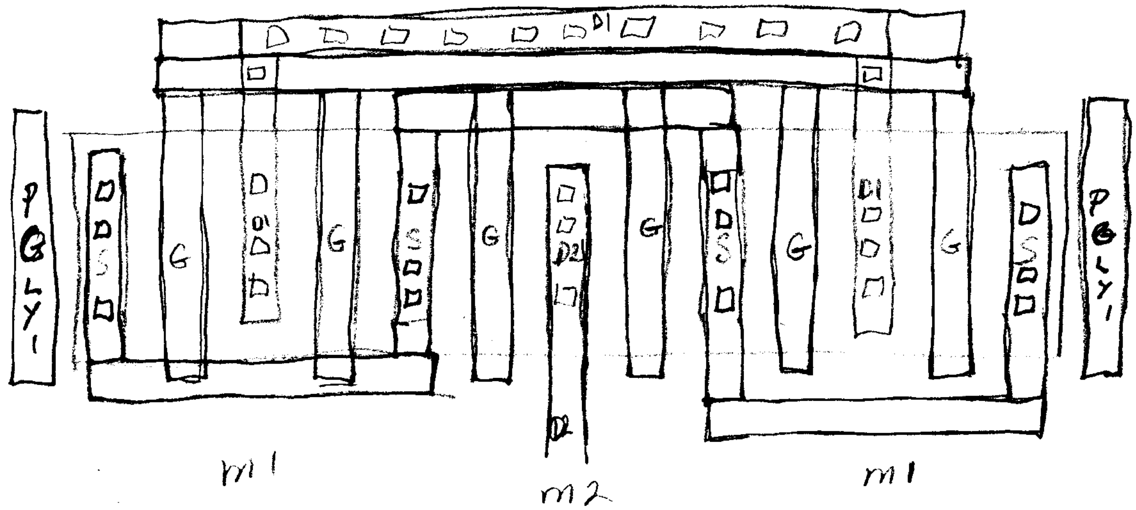


- Matching
  - transistors spatially close
  - Same orientation
  - Interdigitated FIG. 20.18 & 7.6
  - Common Centroid (LAB THURS.) FIG. (7.7)

- Interdigitated layout

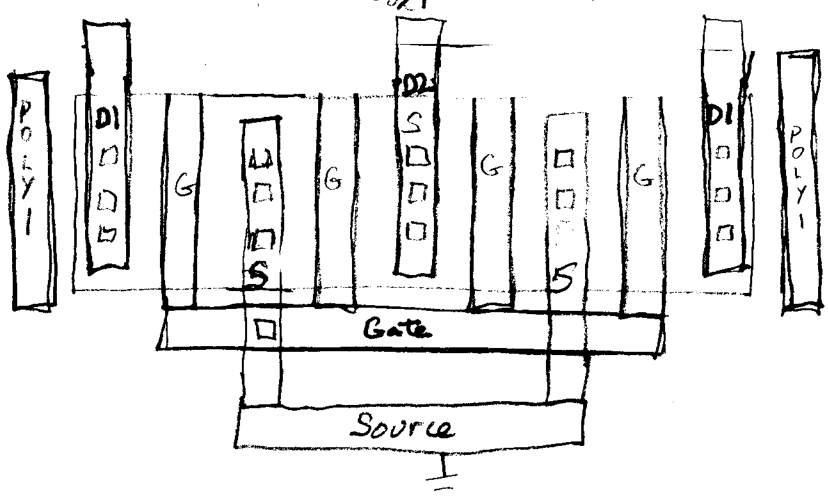


Common Centroid



$\overline{\qquad\qquad}\!\!\rightarrow$

$\frac{Cox}{Cox1}$ gradient $= Cox2$



dummy element for proximity effect