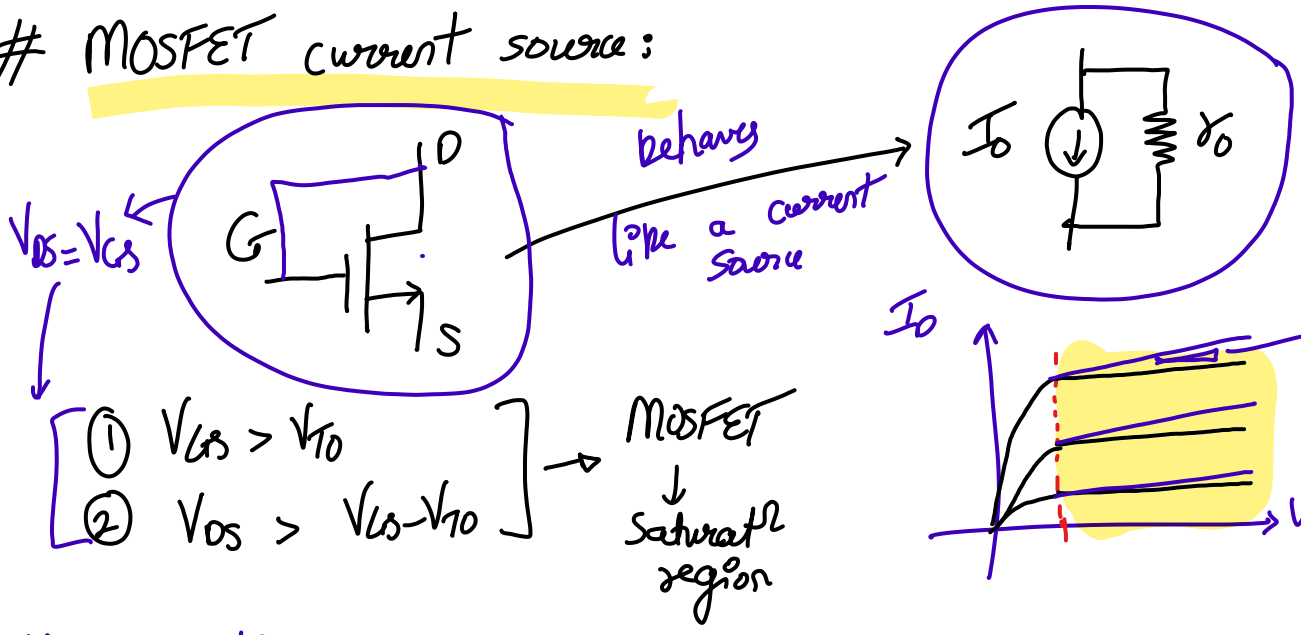
AEC lec 40 23/10/23

MOSFET current source:

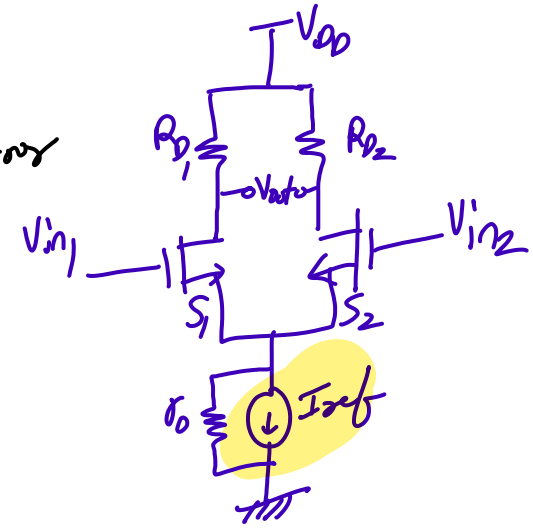


① $V_{GS} > V_{TO}$
② $V_{DS} > V_{GS}-V_{TO}$
→ MOSFET ↓ Saturation region

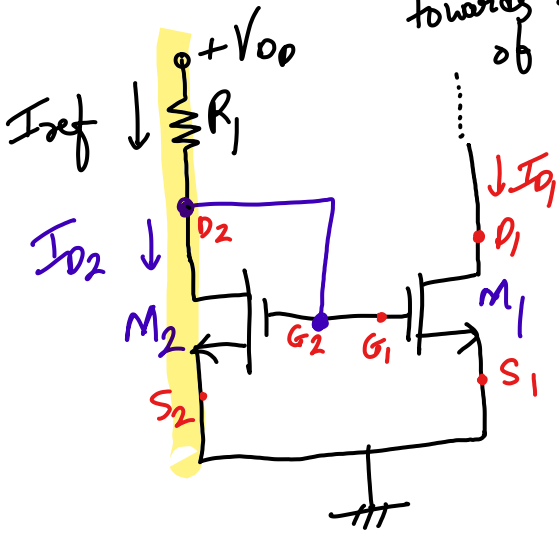
Voltage compliance range:
↳ It is the voltage range over which the circuit can maintain a constant current.

Types of Current mirrors:

1. Basic two transistor current mirror
2. Three transistor current mirror
3. Cascode current mirror
4. Wilson current mirror



Basic two-transistor current mirror:



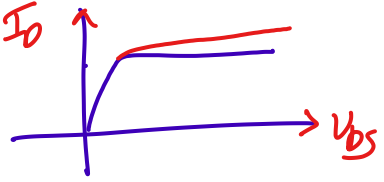
M_1 & M_2 ↓ identical ↓ $V_{t_1}=V_{t_2}$

M_2 → always in saturation
M_2: $V_{GS_2}=V_{DS_2}$
✓ $V_{GS_2}=V_{GS_1}$
$I_D = k_n(V_{GS}-V_{TN})^2$
$I_D \propto V_{GS}$

M_1: ↓ sat^n region
$V_{GS_1} > V_{TN_1}$
$V_{DS_1} > V_{GS_1}-V_{TN_1} > V_{GS_2}-V_{TN_2}$

Current relationship,

$$I_{Dsat} = k_n (V_{GS} - V_{TN})^2 (1 + \lambda V_{DS}) \quad -(1)$$



$k_n = \frac{\mu_n C_{ox}}{2} \frac{W}{L}$

λ - channel length modulation parameter

$$\rightarrow I_{out} = I_{D_1} = k_{n_1} (V_{GS_1} - V_{TN_1})^2 (1 + \lambda V_{DS_1}) \quad -(2)$$

$$\rightarrow I_{D_2} = I_{ref} = k_{n_2} (V_{GS_2} - V_{TN_2})^2 (1 + \lambda V_{DS_2}) \quad -(3)$$

M_1 & M_2 are matched → same physical parameters (V_{TN}, μ_n, C_{ox} & λ)

↳ in same IC

$$\therefore \frac{I_{out}}{I_{ref}} = \frac{I_{D_1}}{I_{D_2}} = \frac{k_{n_1} (V_{GS_1} - V_{TN_1})^2 (1 + \lambda V_{DS_1})}{k_{n_2} (V_{GS_2} - V_{TN_2})^2 (1 + \lambda V_{DS_2})}$$

$$\therefore \frac{I_{out}}{I_{ref}} = \frac{\cancel{\frac{\mu_n C_{ox}}{2}} \left(\frac{W}{L}\right)_1 \cancel{(V_{GS_1} - V_{TN_1})^2} (1 + \lambda V_{DS_1})}{\cancel{\frac{\mu_n C_{ox}}{2}} \left(\frac{W}{L}\right)_2 \cancel{(V_{GS_2} - V_{TN_2})^2} (1 + \lambda V_{DS_2})}$$

$V_{GS_1} = V_{GS_2}$, $V_{TN_1} = V_{TN_2}$

$$\boxed{\frac{I_{out}}{I_{ref}} = \frac{(W/L)_1}{(W/L)_2} \times \left(\frac{1 + \lambda V_{DS_1}}{1 + \lambda V_{DS_2}}\right)} \quad -(4)$$

$\lambda V_{DS} << 1$ → approximation

$$\frac{I_{out}}{I_{ref}} = \frac{(W/L)_1}{(W/L)_2}$$

$$I_{out} = \frac{(W/L)_1}{(W/L)_2} I_{ref}$$

→ basis of current mirror

$I_{ref} = 1\mu A$; $I_{out} = 10\, I_{ref}$

→ $V_{GS_2} = V_{DD} - I_{ref} R_1$; $V_{GS_2} = V_{DS_2}$

$$I_{ref} = I_{D_2} = k_{n_2} (V_{GS_2} - V_{TN_2})^2 (1 + \lambda V_{GS_2})$$

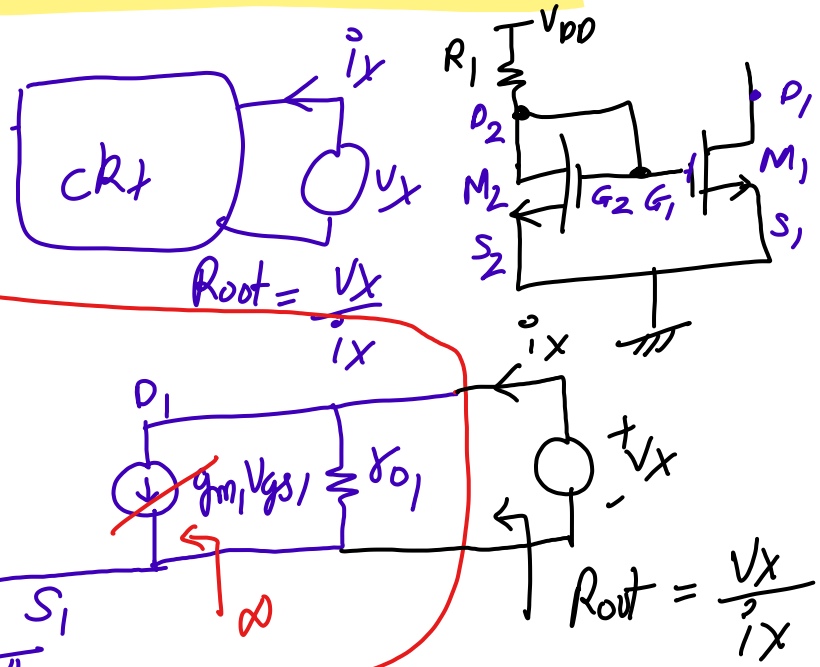
$\lambda V_{DS_2} << 1$

$$I_{ref} = I_{D_2} = K_{n_2}(V_{DD} - I_{ref}R_1 - V_{TN_2})^2$$

$R_1, V_{DD}, V_{TN_2}, K_{n_2} \rightarrow I_{ref} \downarrow$

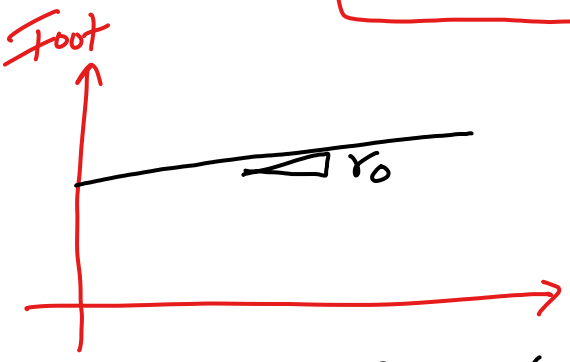
O/p resistance of 2 transistor current mirror:-

$r_o = ?$



$$R_{out} = r_{o_1}$$

$$r_{o_1} = \frac{1}{\lambda_1 I_{D_1}}$$



Limitation:- Use of R_1 → (occupy more space in IC)

3 transistor MOSFET current mirror:-