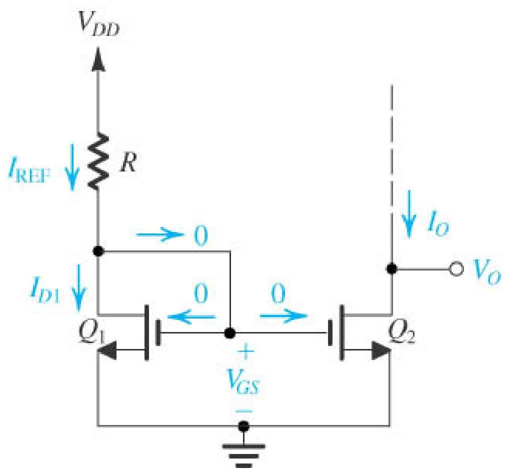
전자 회로 2

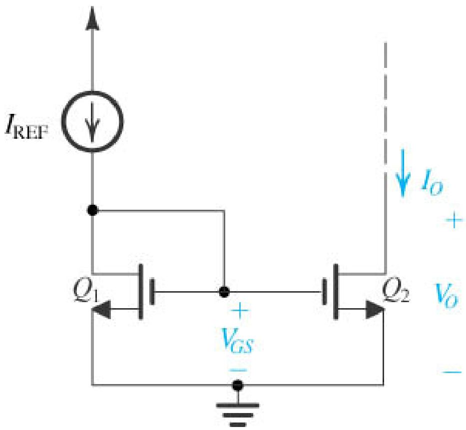
Lecture 5 (IC Biasing)

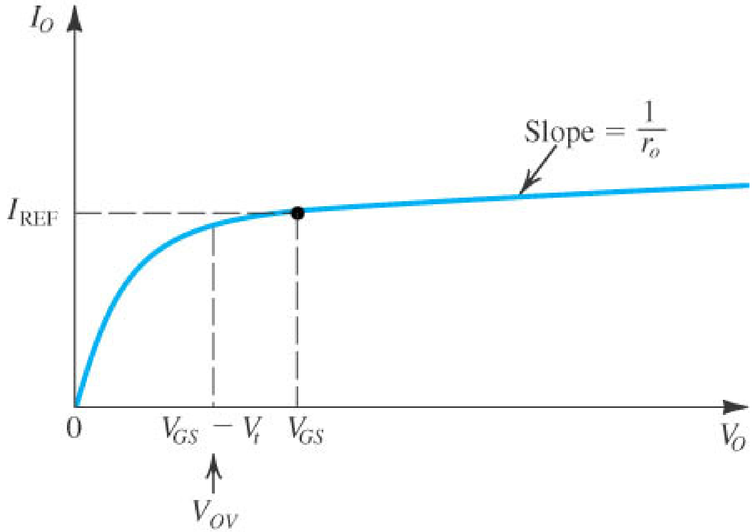
숙제 3: Due 10/16 (목)

- Chap 6. problems
  - 6.12
  - 6.34
  - 6.98
  - 6.101
  - 6.124
  - 6.134
  - 6.144

MOSFET Current Mirror (Chap. 6.3)







$$I_{D1} = \frac{1}{2} k_n' \left(\frac{W}{L} \right)_1 (V_{GS} - V_t)^2$$

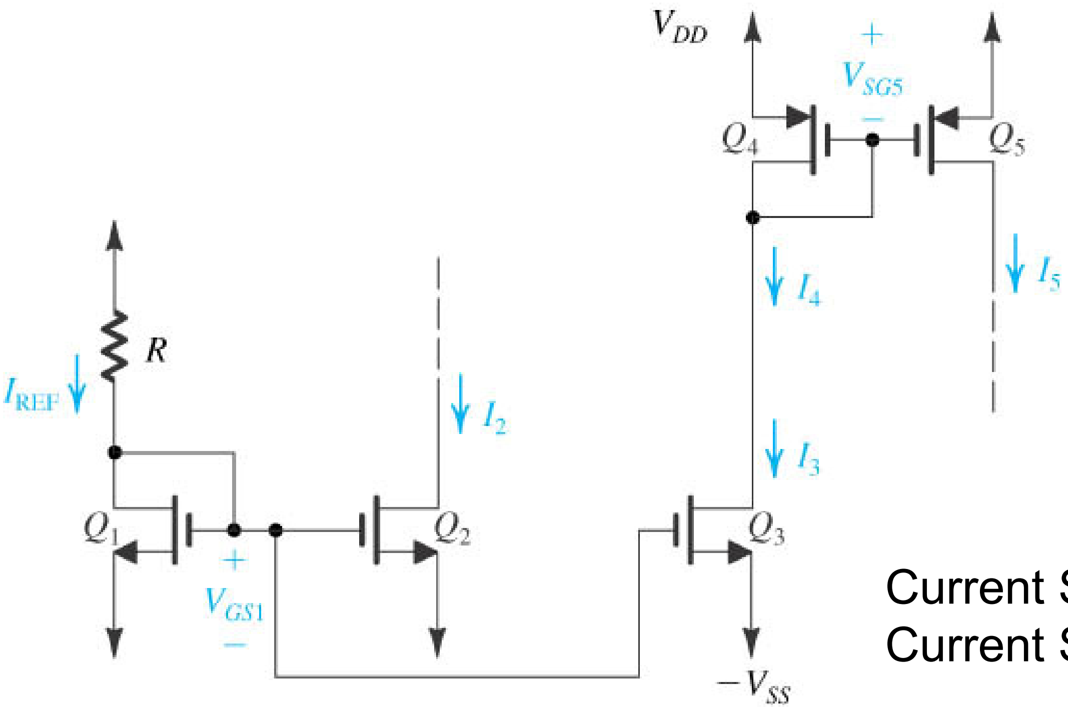
$$I_{D1} = I_{REF} = \frac{V_{DD} - V_{GS}}{R}$$

$$\frac{I_O}{I_{REF}} = \frac{(W/L)_2}{(W/L)_1} \quad : \text{if } r_o = \infty$$

$$I_O = \frac{(W/L)_2}{(W/L)_1} I_{REF} \left(1 + \frac{V_O - V_{GS}}{V_{A2}} \right)$$

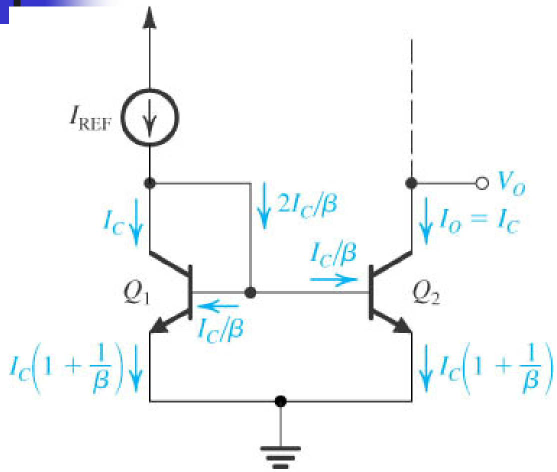
$$: \text{if } \; r_{o2} = \frac{V_{A2}}{I_O} \neq \infty$$

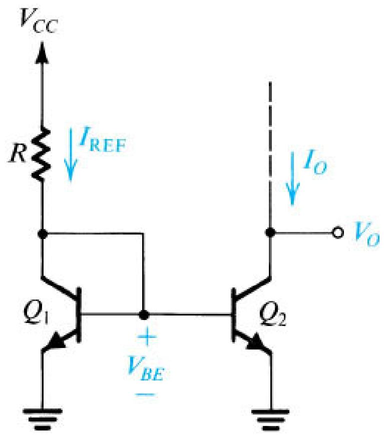
MOS Current-Steering Circuits

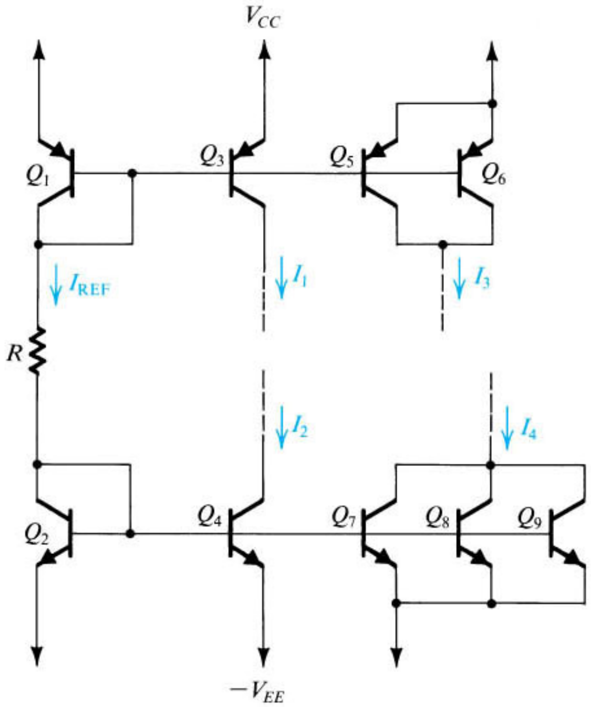


Current Source: Q5
Current Sink: Q2

BJT Current Mirror







$$\frac{I_O}{I_{REF}} = \frac{I_{s2}}{I_{s1}} = \frac{Q_2\ EBJ\text{의 면적}}{Q_1\ EBJ\text{의 면적}} = m$$

$$I_{REF} = I_C + 2I_B = I_C\left(1 + \frac{2}{\beta}\right)$$

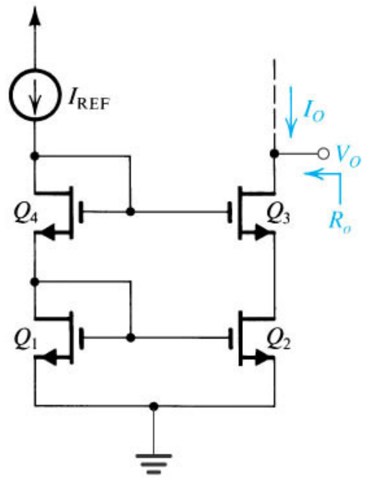
$$I_O = I_C \quad \text{if } r_o = \infty$$

$$\frac{I_O}{I_{REF}} = \frac{\beta}{\beta+2} \quad \text{if } I_{s2} = I_{s1}$$

$$\frac{I_O}{I_{REF}} = \frac{\beta}{\beta+2} = \frac{m\beta}{\beta+m+1}$$

$$I_O = I_{REF}\left(\frac{m\beta}{\beta+m+1}\right)\left(1 + \frac{V_O - V_{BE}}{V_{A2}}\right)$$

Cascode MOS Mirrors (Chap. 6.12)



$I_{D2} = I_{D1}$ ← $V_{GS2} = V_{GS1}$

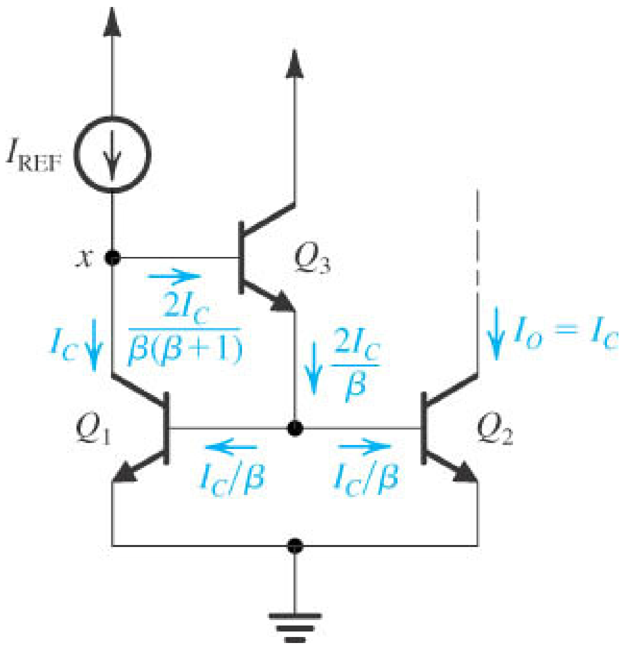
$I_{D2} = I_{D3}$ → V_{GS3} 는 자동으로 결정됨

$$R_o = r_{o3} + [1 + g_{m3} r_{o3}] r_{o2}$$
$$\cong g_{m3} r_{o3} r_{o2} = A_{03} r_{o2}$$

장점: **R_o가 굉장히 커짐** → channel length modulation effect가 완화됨

단점: Q_1,Q_4 / Q_2,Q_3가 series로 연결되므로 V_{DD}가 커야 biasing이 됨

BJT Mirror w. Base-Current Compensation



$$I_{REF} = I_C + \frac{2I_B}{\beta+1} = I_C\left(1 + \frac{2}{\beta(\beta+1)}\right)$$

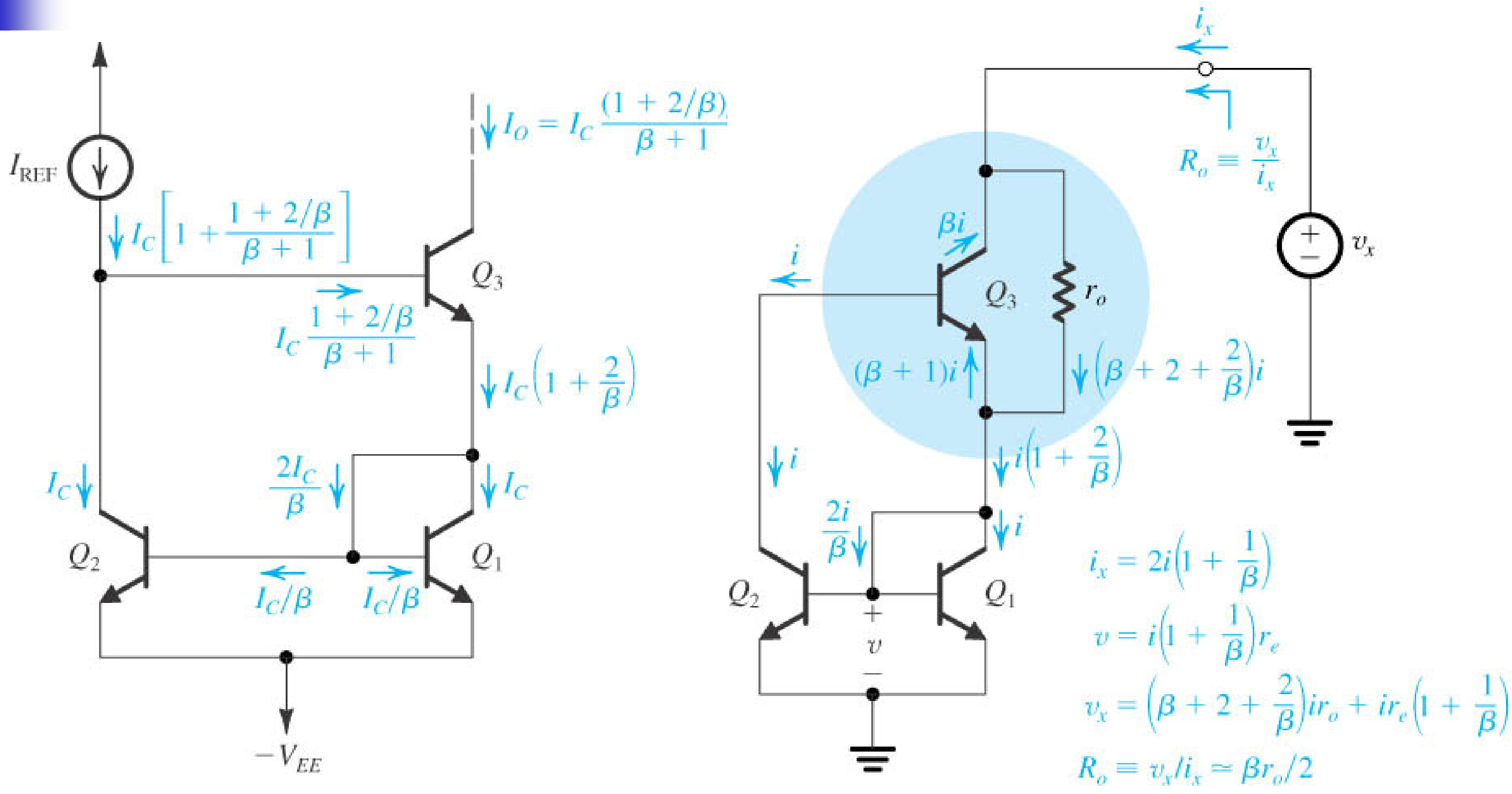
$$I_O = I_C$$

$$\frac{I_O}{I_{REF}} = \frac{1}{1+2/\beta(\beta+1)} \simeq \frac{1}{1+2/\beta^2}$$

$$I_{REF} = \frac{V_{CC} - V_{BE1} - V_{BE3}}{R}$$

β 의 영향을 덜 받음

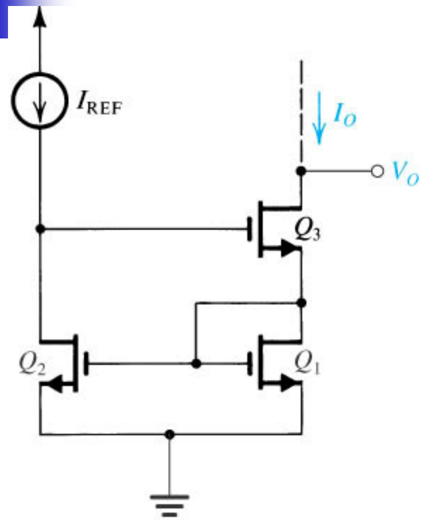
The Wilson Current Mirror

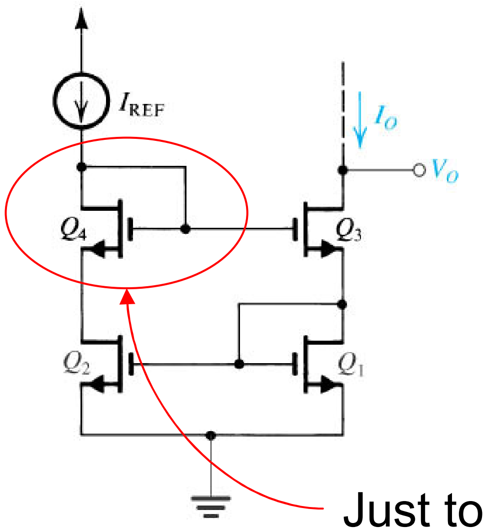


(a) (b)

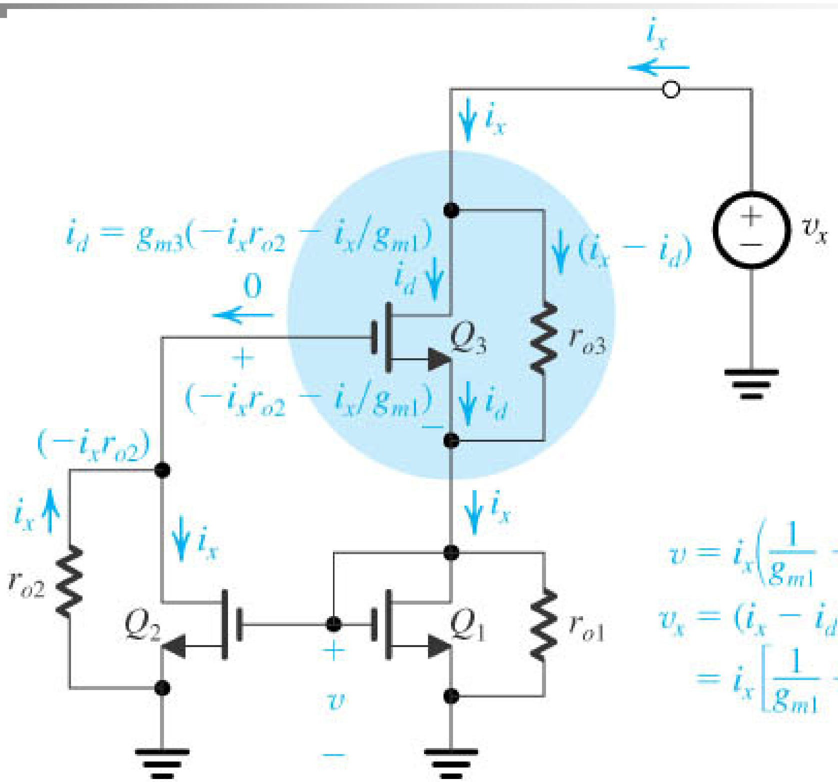
β의 영향을 덜 받음 또한 output 저항도 커짐

The Wilson MOS Mirror





(c)



(b)

$$v = i_x\left(\frac{1}{g_{m1}} + r_{o1}\right) \simeq i_x/g_{m1}$$

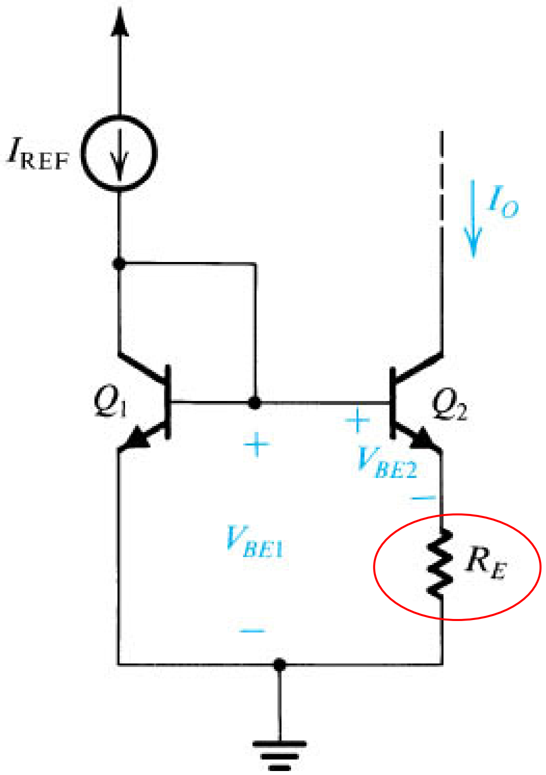
$$v_x = (i_x - i_d)r_{o3} + v$$

$$= i_x\left[\frac{1}{g_{m1}} + r_{o3}\left(1 + \frac{g_{m3}}{g_{m1}} + g_{m3}r_{o2}\right)\right]$$

$$R_o \cong g_{m3} r_{o3} r_{o2} = A_{03} r_{o2}$$

Just to balance current mismatch

The Widlar Current Source



$$V_{BE1} = V_T \ln\left(\frac{I_{REF}}{I_S}\right)$$

$$V_{BE2} = V_T \ln\left(\frac{I_O}{I_S}\right)$$

$$V_{BE1} - V_{BE2} = V_T \ln\left(\frac{I_{REF}}{I_O}\right)$$

$$V_{BE1} = V_{BE2} + I_O R_E$$

$$I_O R_E = V_T \ln\left(\frac{I_{REF}}{I_O}\right)$$

$$R_o \cong [1 + g_m (R_E \| r_\pi)] r_o$$