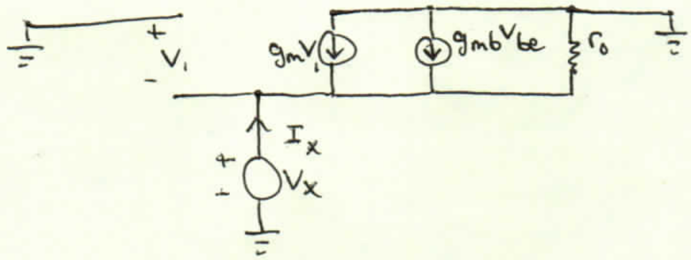
3.1



$$(g_m + g_{mb}) V_x + \frac{V_x}{r_0} = I_x$$

$$\frac{V_x}{I_x} = \frac{1}{g_m + g_{mb} + r_0^{-1}}$$

$$= \frac{1}{g_m + g_{mb}} // r_0$$

equivalent resistance of diode-connected MOSFET $\approx \dfrac{1}{g_m + g_{mb}}$, $g_m >> g_{mb}$

$$\approx \frac{1}{g_m}$$

What is gain if

- M_2 is NMOS?

$$A_v = -g_{m_1} \cdot R_{eq} = -g_{m_1} \cdot \frac{1}{g_{m_2}} = \frac{-g_{m_1}}{g_{m_2}}$$

$I_{D_1} = I_{D_2} = 0.5\,mA$

$$A_v = \frac{-\sqrt{2\mu_n C_{ox} (W/L)_1 I_{D_1}}}{\sqrt{2\mu_n C_{ox} (W/L)_2 I_{D_2}}} = \frac{-\sqrt{(W/L)_1}}{\sqrt{(W/L)_2}}$$

$(W/L)_1 = \dfrac{50}{0.5} = 100$

$(W/L)_2 = \dfrac{10}{0.5} = 20$

$$A_v = -\sqrt{\frac{100}{20}} = -\sqrt{5}\ V/V \approx -2.4\ V/V$$

- What is gain if M_2 is PMOS?

$$A_v = \frac{-\sqrt{2\mu_n C_{ox} (W/L)_1 I_{D_1}}}{\sqrt{2\mu_p C_{ox} (W/L)_2 I_{D_2}}} = \frac{-\sqrt{\mu_n (W/L)_1}}{\sqrt{\mu_p (W/L)_2}}$$

$$A_v = -\sqrt{\frac{350\,(cm^2/V/s) \cdot 100}{100\,(cm^2/V/s) \cdot 20}} = -\sqrt{\frac{35000}{2000}}$$

$$A_v = -\frac{\sqrt{70}}{2}\ V/V \approx -4.18\ V/V$$