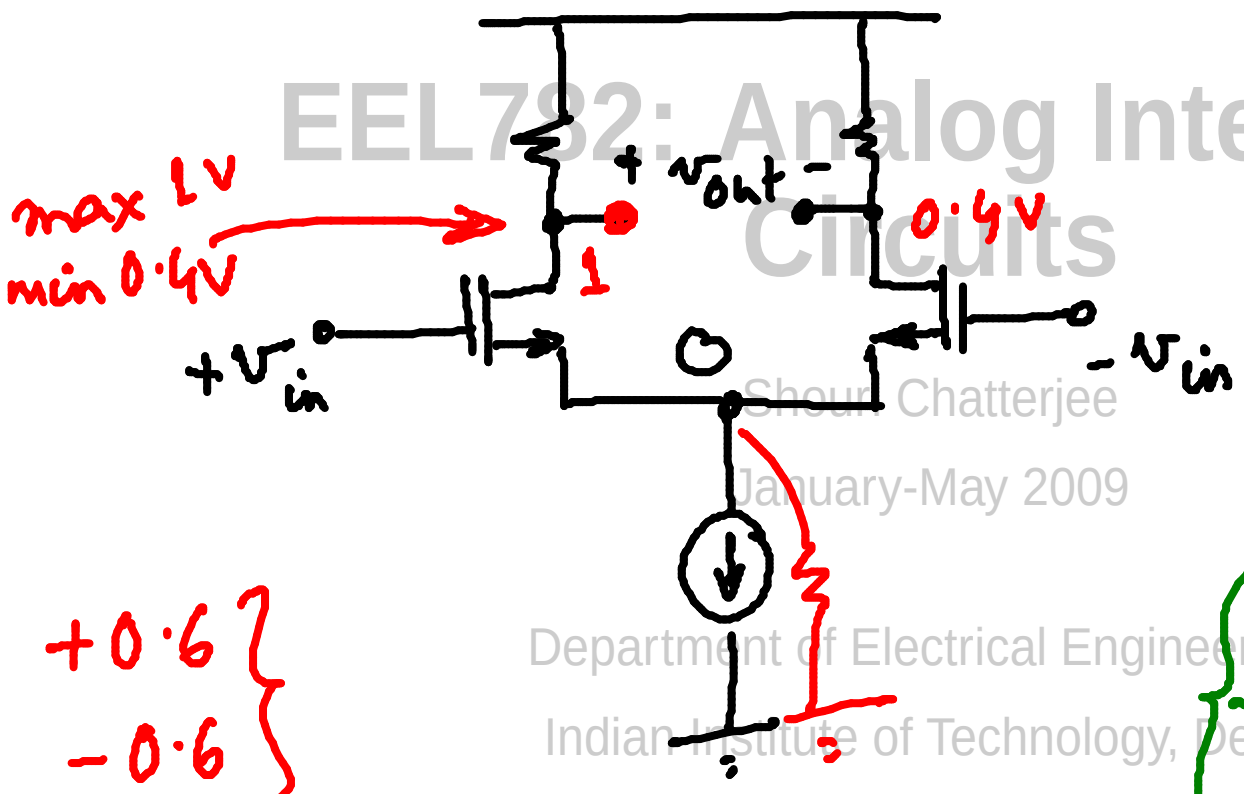
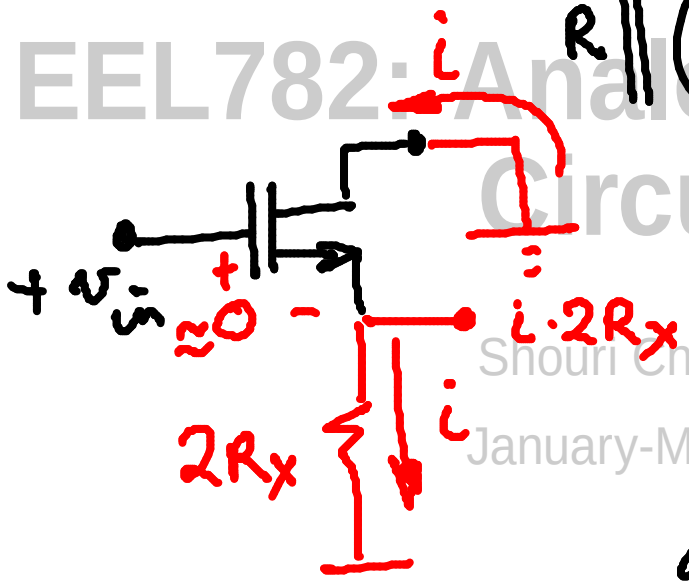
Differential amplifier



Why?

1. More immune to interference.
2. Swing is 2x
3. Power is 2x
4. Only odd harmonics

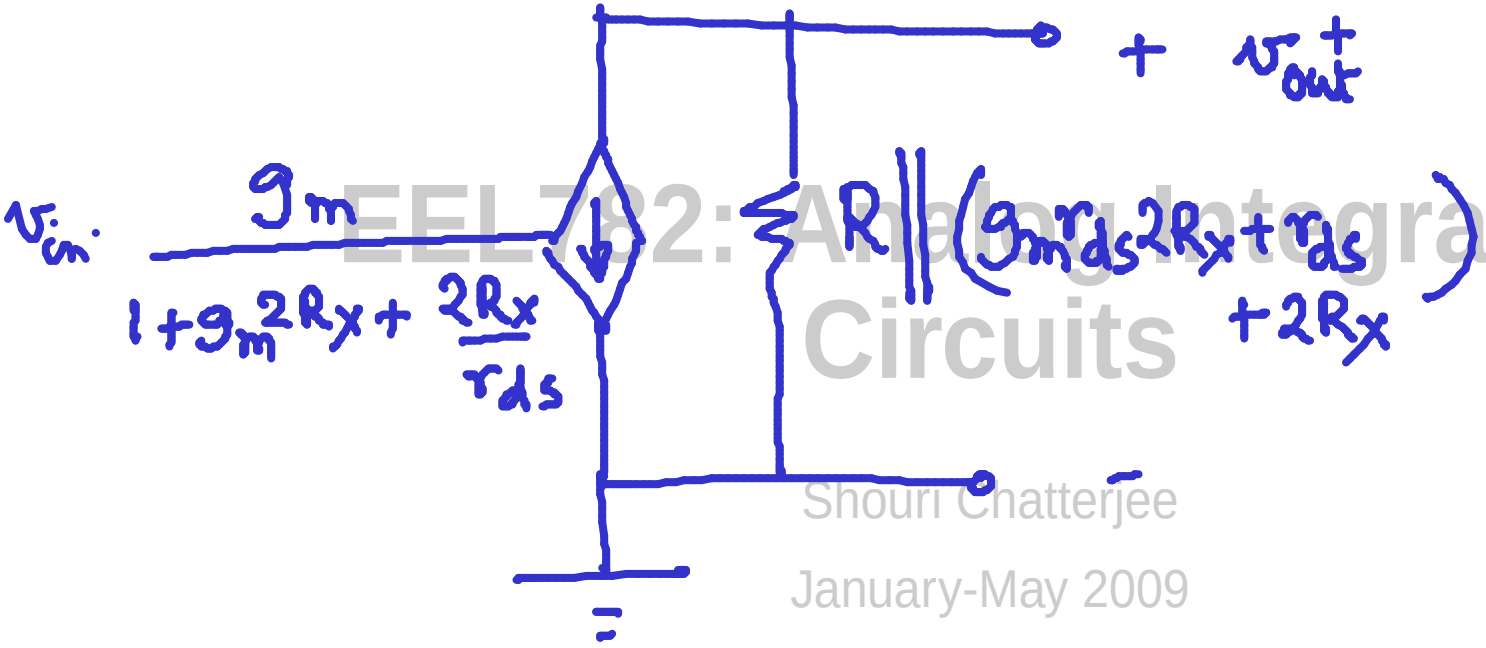
$$R \| \left(g_m r_{ds} \cdot 2R_x + r_{ds} + 2R_x \right)$$



$$g_m \left(v_{in} - i \cdot 2R_x \right) - \frac{i \cdot 2R_x}{r_{ds}} = i$$

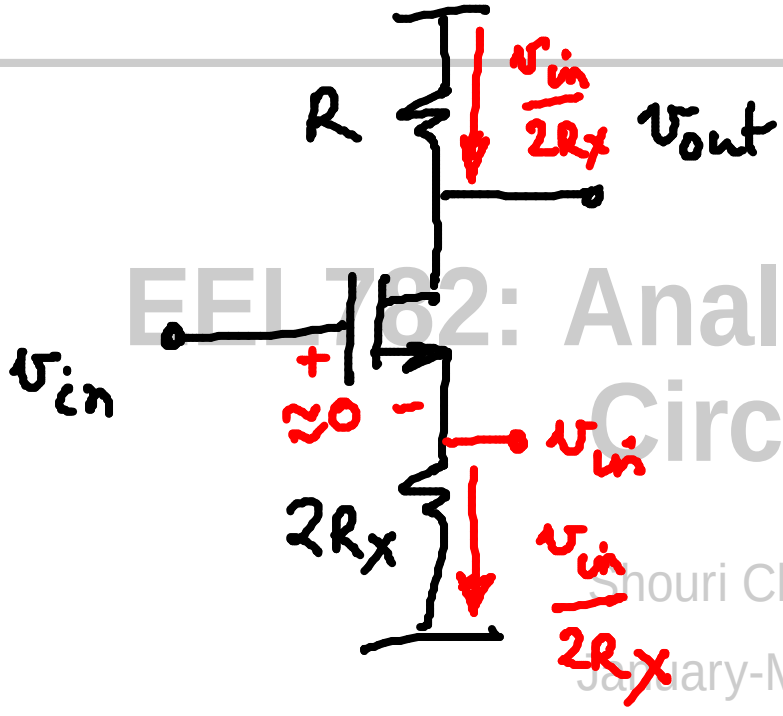
$$g_m v_{in} = i \left(g_m \cdot 2R_x + 1 + \frac{2R_x}{r_{ds}} \right)$$

$$i = v_{in} \cdot \frac{g_m}{1 + 2R_x/r_{ds} + g_m \cdot 2R_x} \simeq \frac{v_{in}}{2R_x}$$



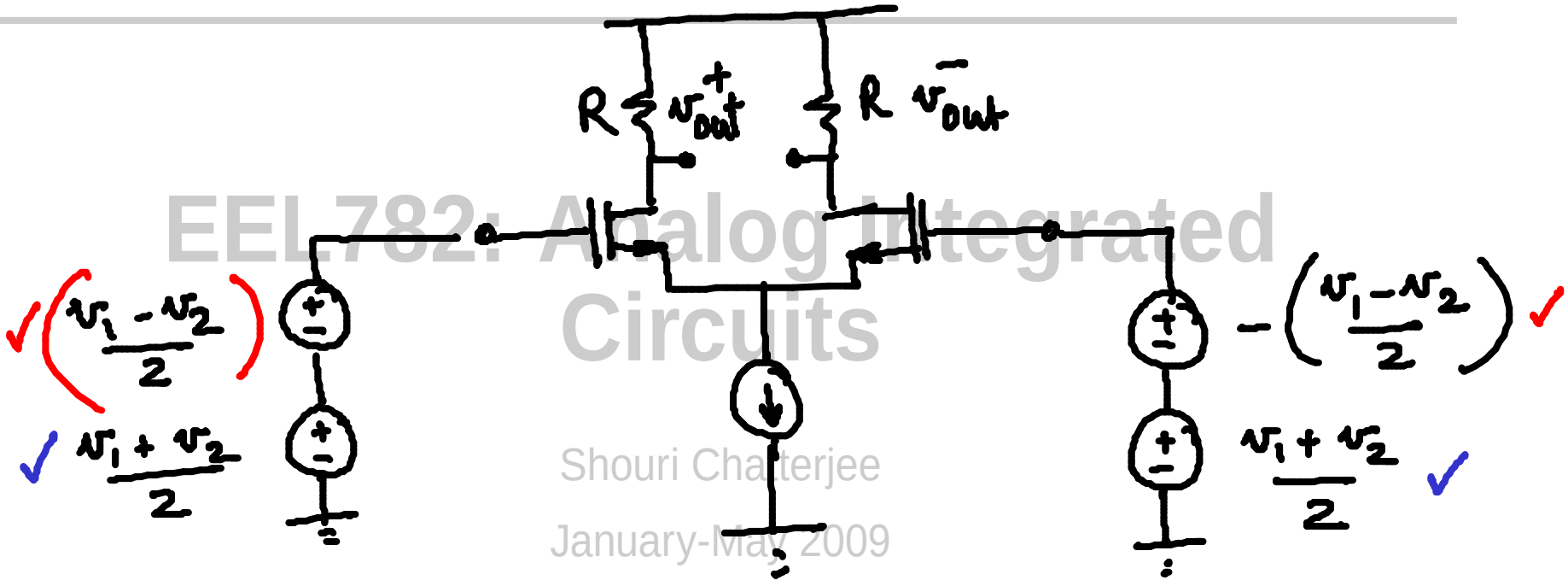
$$\text{Gain} = -\frac{g_m}{1+\frac{2R_x}{r_{ds}}+2g_mR_x} \cdot \frac{R \cdot r_{ds} \cdot \left(1+\frac{2R_x}{r_{ds}}+g_m 2R_x\right)}{R+r_{ds}+2R_x+g_m r_{ds} \cdot 2R_x}$$

$$= -\frac{g_m \cdot R \cdot r_{ds}}{R+r_{ds}+2R_x+g_m r_{ds} \cdot 2R_x} \simeq -\frac{R}{2R_x}$$



$$v_{out} \approx -\frac{R}{2R_x} \cdot v_{in}$$

Common-mode half circuit



$$v_{out}^+ = -g_m(r_{ds} \| R)\left(\frac{v_1 - v_2}{2}\right)$$

$$v_{out}^- = +g_m \cdots - - -$$

$$v_{out}^+ - v_{out}^- = -g_m(r_{ds} \| R)(v_1 - v_2)$$

1) $\dfrac{v_{out}^{+} - v_{out}^{-}}{v_1 - v_2}$ | $v_1 + v_2 = 0$

2) $\dfrac{v_{out}^{+} - v_{out}^{-}}{v_1 + v_2}$ | $v_1 - v_2 = 0$

3) $\dfrac{v_{out}^{+} + v_{out}^{-}}{v_1 - v_2}$ | $v_1 + v_2 = 0$

4) $\dfrac{v_{out}^{+} + v_{out}^{-}}{v_1 + v_2}$ | $v_1 - v_2 = 0$

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