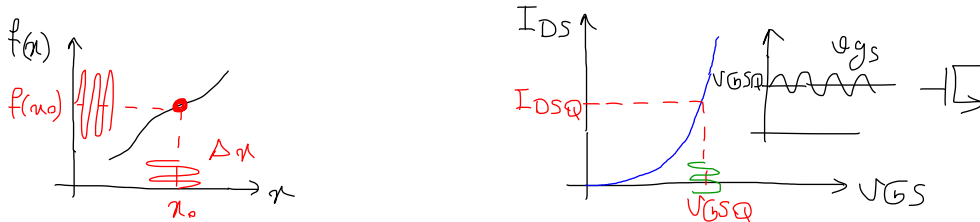


*** long-channel Mosfet equation**

$$I_{DS} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2, \lambda \approx 0$$



$$f(n) = f(n_0 + \Delta n) = f(n_0) + \Delta n \left. \frac{\partial f(n)}{\partial n} \right|_{n_0} + \frac{\Delta n^2}{2!} \left. \frac{\partial^2 f(n)}{\partial n^2} \right|_{n_0} + \frac{\Delta n^3}{3!} \left. \frac{\partial^3 f(n)}{\partial n^3} \right|_{n_0} + \dots$$

$$f(n) = I_{DS}, \quad f(n_0) = I_{DSQ}, \quad \Delta n = V_{gs}, \quad n = V_{GS}$$

$$n = n_0 + \Delta n \implies V_{GS} = V_{GSQ} + V_{gs}$$

$$\left. \frac{\partial f(n)}{\partial n} \right|_{n_0} = \left. \frac{\partial I_{DS}}{\partial V_{GS}} \right|_{V_{GSQ}} = \mu_n C_{ox} \frac{W}{L} (V_{GSQ} - V_{th}) = g_m$$

$$\left. \frac{\partial^2 f(n)}{\partial n^2} \right|_{n_0} = \left. \frac{\partial^2 I_{DS}}{\partial V_{GS}^2} \right|_{V_{GSQ}} = \mu_n C_{ox} \frac{W}{L} = \frac{g_m}{V_{GSQ} - V_{th}} = \frac{g_m}{V_{eff}}$$

$$\left. \frac{\partial^3 f(n)}{\partial n^3} \right|_{n_0} = 0$$

$$\Rightarrow I_{DS} = I_{DSQ} + V_{gs} \cdot g_m + \frac{V_{gs}^2}{2} \frac{g_m}{V_{eff}} + 0$$

$$\Rightarrow i_{ds} = g_m V_{gs} + \frac{g_m}{2V_{eff}} V_{gs}^2$$

small-signal model

$$g_m V_{gs}$$

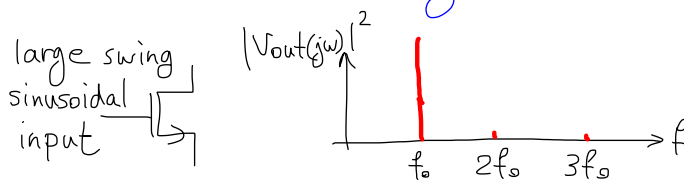
i_{ds}

large signal model

$$g_m V_{gs} + \frac{g_m}{2V_{eff}} V_{gs}^2$$

*** fictual model including 3rd-order distortion**

$$i_{ds} = g_m V_{gs} + \frac{g_m}{2V_{eff}} V_{gs}^2 + \frac{g_m}{4V_{eff}^2} V_{gs}^3$$



$$g_m V_{gs} > 10 \times \frac{g_m}{2V_{eff}} V_{gs}^2$$

$$V_{gs} < \frac{V_{eff}}{5}$$