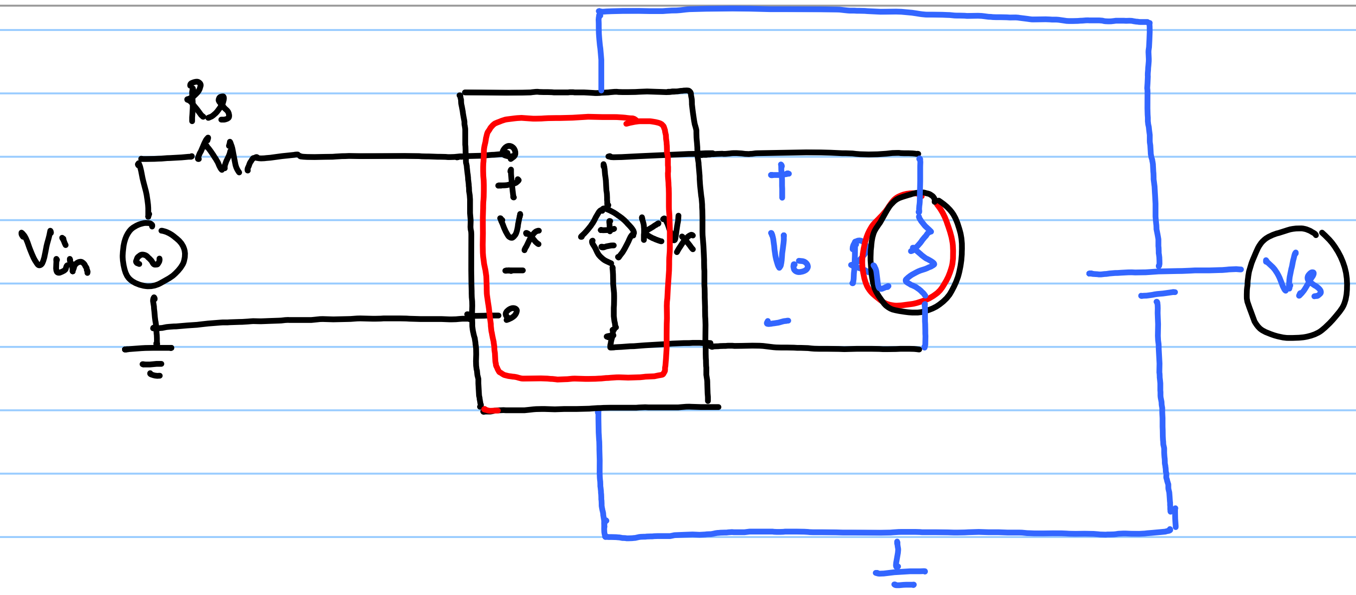
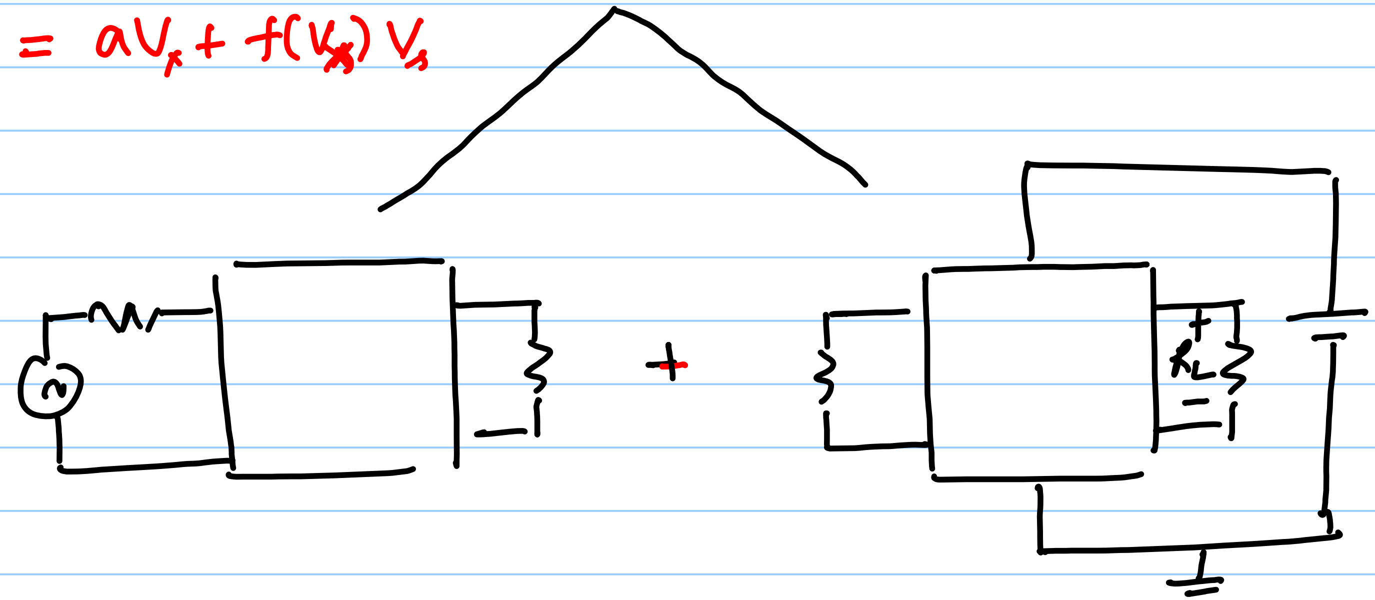
# lecture # 3






$$V_o = aV_x + bV_s = aV_x + f(V_s)V_s$$

$$V_{in} = A\sin(\omega_0 t)$$



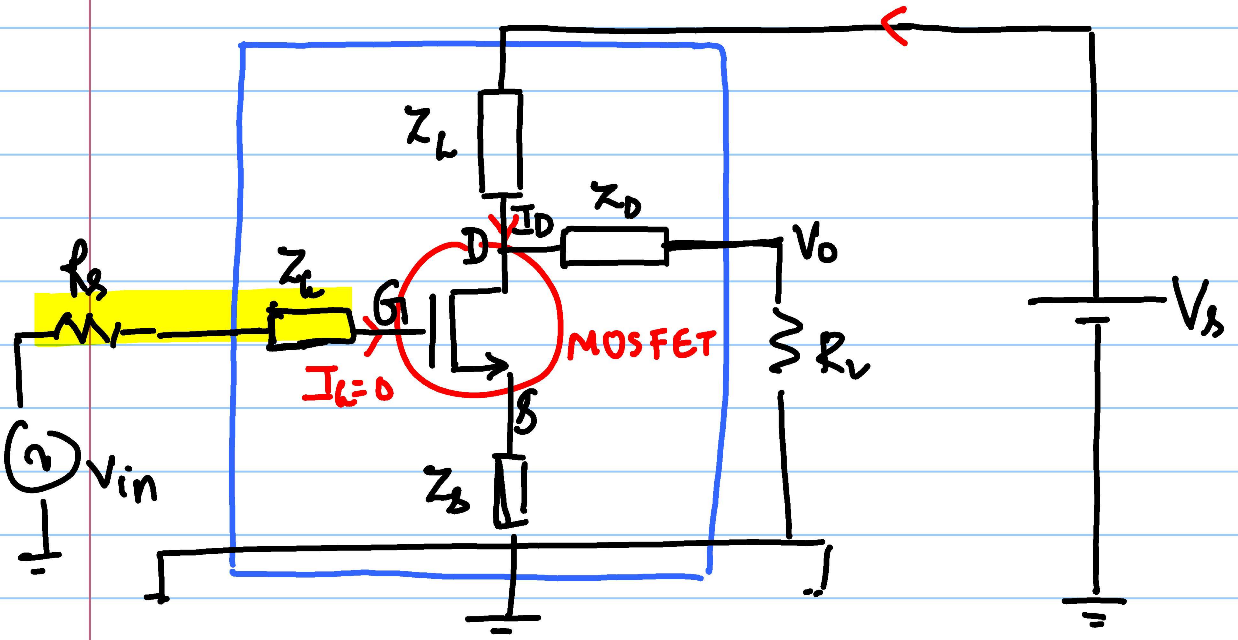
$$V_o = aV_x + f(V_x)\,V_s = aV_x + kV_x \cdot V_s = \frac{1}{2}V_x + 4V_x \cdot (10V)$$

$\omega_0$ $\omega_0$

$$f(V_x) = k_1 V_x$$

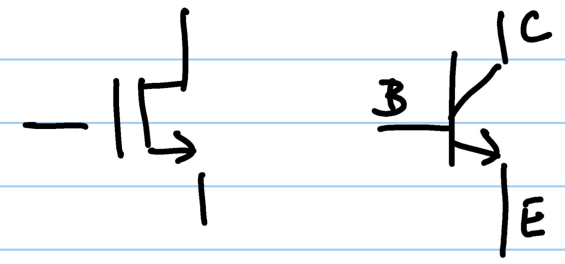
$$V_o = f(V_x, V_s)$$

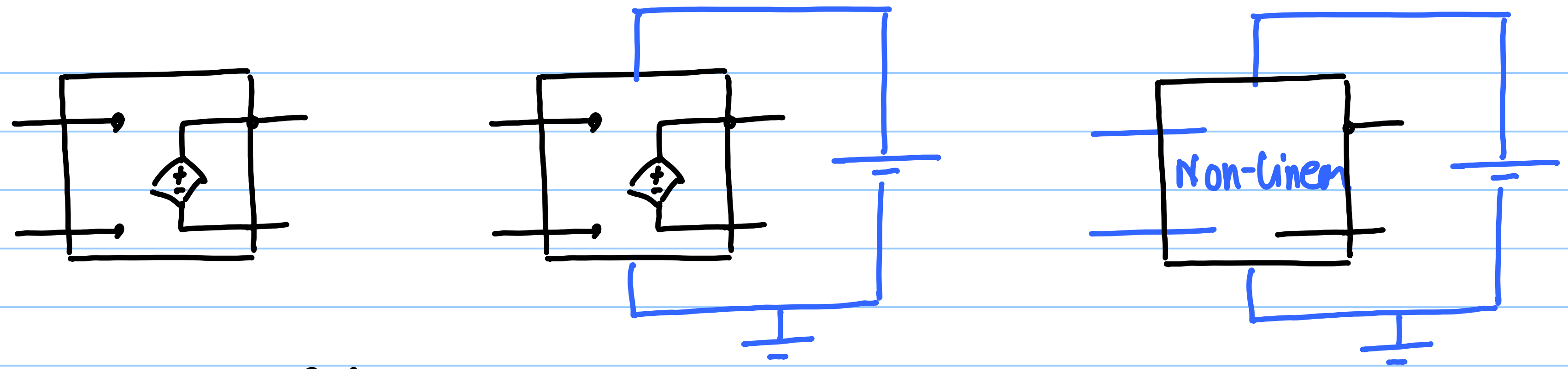
$$= a_0(\alpha V_x + \beta V_s) + a_1(\alpha V_x + \beta V_s)^2 + \ldots$$



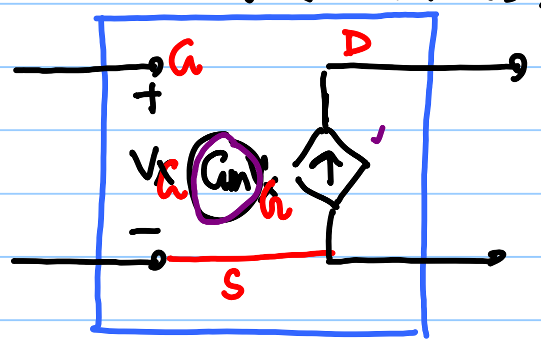

$$V_o = f(V_{in}, V_s)$$

$$I_{DS} = f(V_{in}, V_s)$$

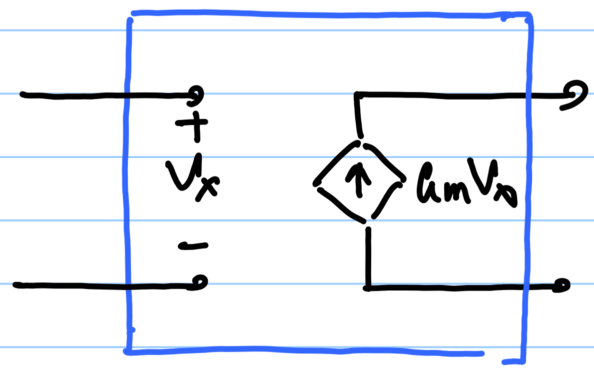




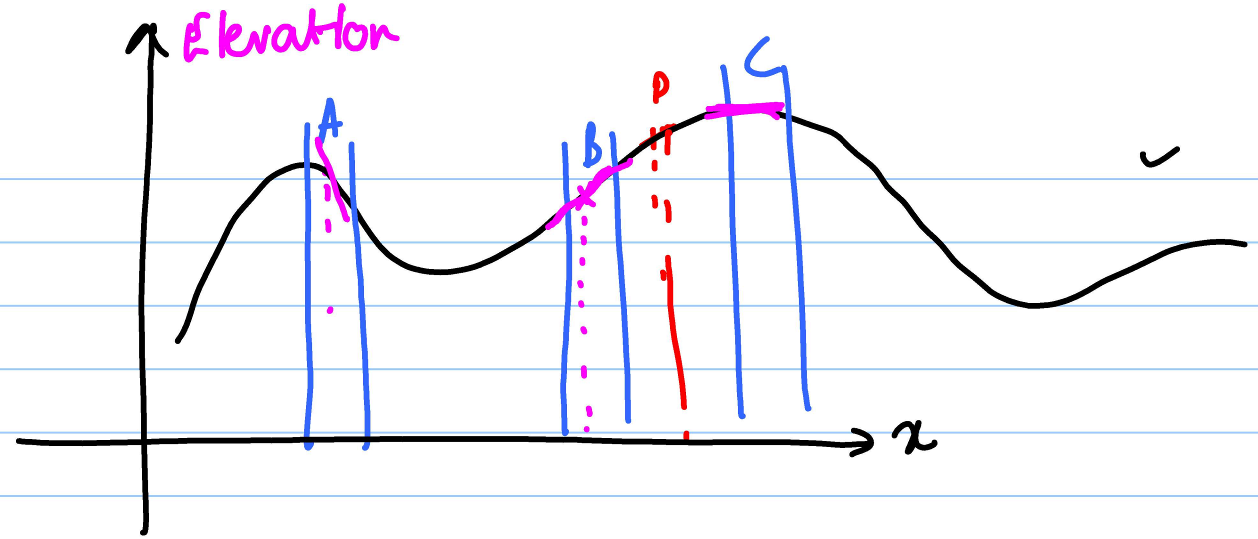

$V_o = f(V_{in}, V_s)$

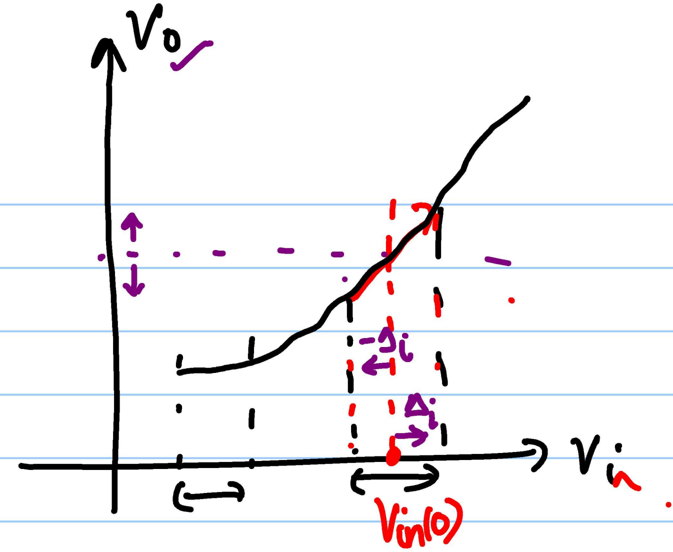


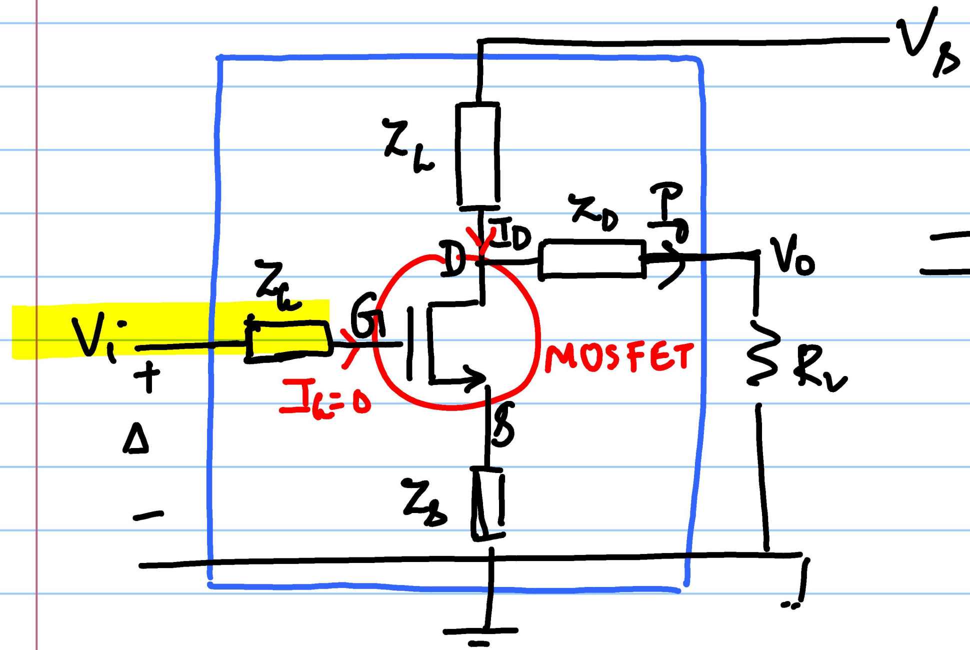

MOSFETs

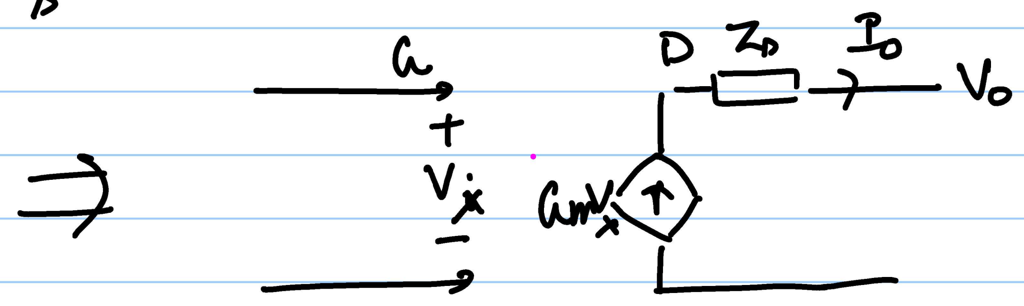



- Non-linear elements are required to implement voltage/power gain
- For analysis, non-linear circuit can be simplified as VCCS.
- Power is supplied by supply voltage.
- Gm depends on i/p & o/p voltages.




$$I_o = G_m \Delta$$

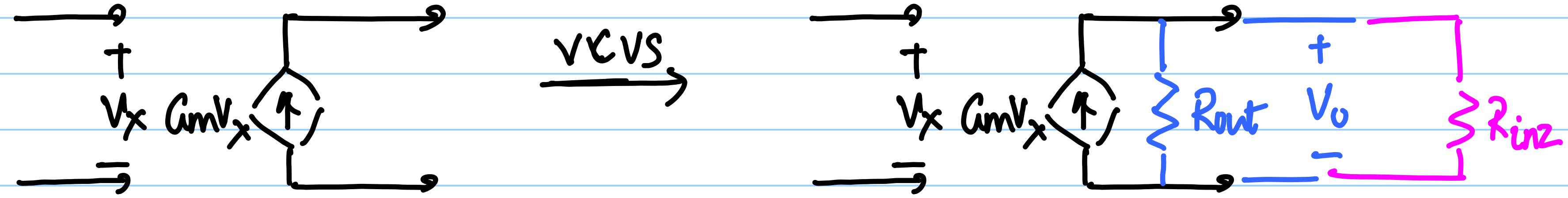
$$I_o = f(V_i, V_b)$$

$$\checkmark \; I_o = a_0(\alpha V_i + \beta V_s) + a_1(\alpha V_i + \beta V_s)^2 + \cdots$$

$$= a_0(\alpha \cdot \Delta + \beta V_s) + a_1(\alpha \cdot \Delta + \beta V_s)^2 + \cdots$$

$$= a_0(\alpha \cdot \Delta + \beta V_s) + a_1(\alpha^2 \cdot \Delta^2 + \beta^2 V_s^2 + 2\alpha\beta\, \Delta . V_s) + \cdots$$

$$i_o = \underbrace{(a_0 \alpha + a_1 2\alpha \beta V_s)}_{G_m} \underset{\sim}{\Delta} + \cdots$$




VCCS

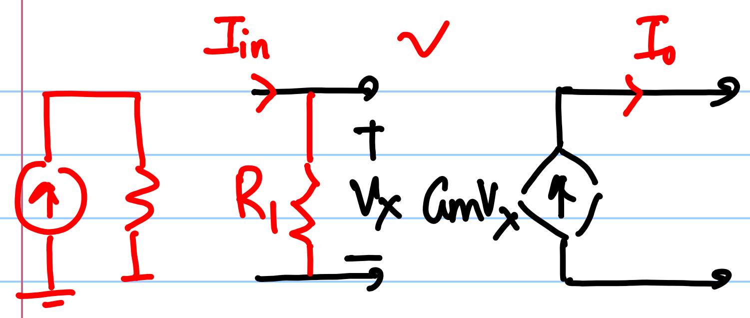
VCVS

$$V_o = (G_m R_{out}) V_x$$

$$= K . V_x$$

$$= G_m(R_{out} \| R_{in2}) V_x$$

$$\approx G_m R_{out} V_x$$

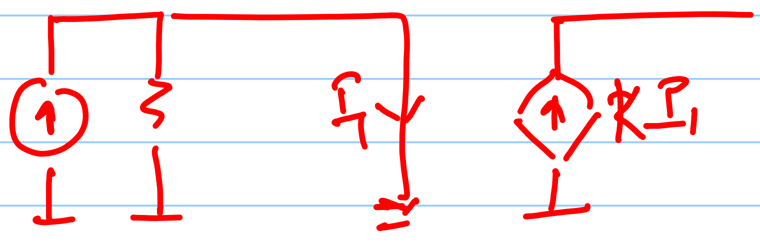


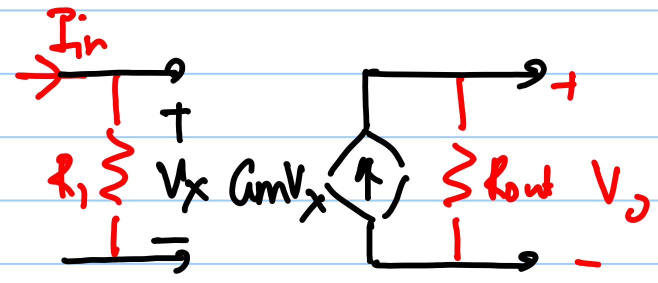

CCCS

$$I_o = G_m (I_{in} \cdot R_1)$$

$$= (G_m R_1) I_{in}$$

$$= K I_{in}$$




CCVS

$$V_o = G_m (I_{in} \cdot R_1) R_{out}$$

$$= (G_m R_1 R_{out}) I_{in}$$

$$= K I_{in}$$