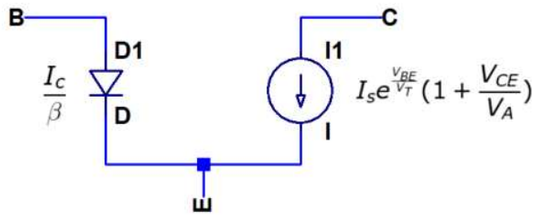
BJT

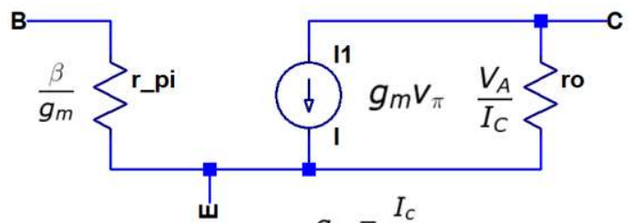
$$I_S = \frac{A_E q D_n n_i^2}{N_B W_B}$$

Ae=area, q=charge, Dn=diffusion constant, ni=electron density
Nb=base acceptors, Wb=base width

Large Signal

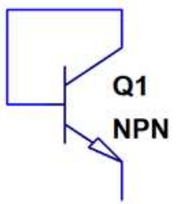


Small Signal



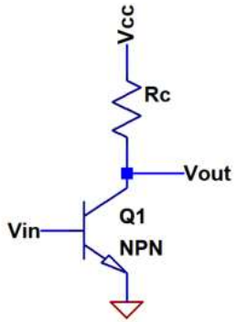
$$g_m = \frac{I_C}{V_T}$$

Diode-Connected



$$R_{eq} = \frac{1}{g_m}$$

Common-Emitter

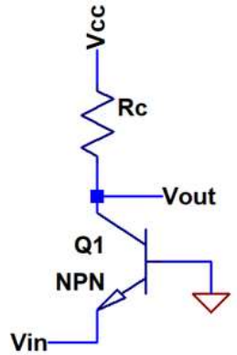


$$A_v = -g_m(R_c \,||\, ro)$$

$$R_{in} = r_\pi$$

$$R_{out} = R_c \,||\, ro$$

Common-Base

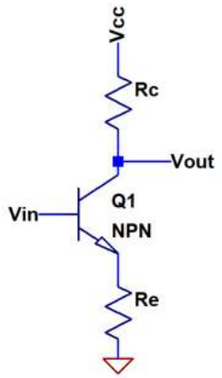


$$A_v = g_m(R_c \,||\, ro)$$

$$R_{in} = \frac{1}{g_m}$$

$$R_{out} = (R_c \,||\, ro)$$

Common-Emitter with Degeneration

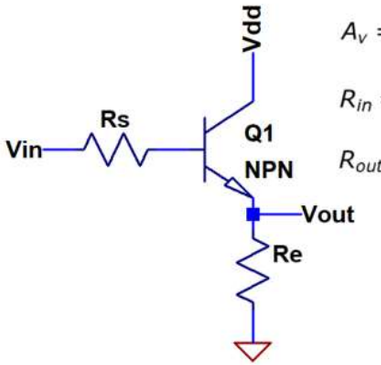


$$A_v = \frac{-(R_c \,||\, ro)}{\frac{1}{g_m} + R_e}$$

$$R_{in} = r_\pi + (\beta + 1)R_e$$

$$R_{out} = R_c \,||\, ro$$

Common-Collector (Emitter Follower)

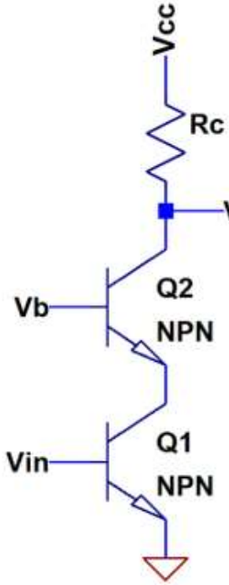


$$A_v = \frac{Re}{\frac{1}{g_m} + R_e}$$

$$R_{in} = r_\pi + (\beta + 1)R_e$$

$$R_{out} = R_e \,||\, (\frac{R_s}{\beta + 1} + \frac{1}{g_m})$$

BJT Cascode



$$A_v = -g_{m1}(R_c || [g_{m2} r_{o2}(r_{o1} || r_{\pi 2}) + r_{o1} || r_{\pi 2}])$$

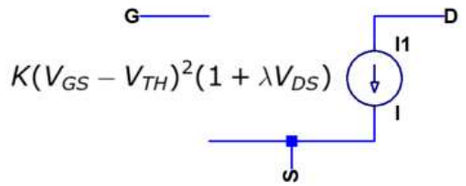
$$R_{in} = r_\pi$$

$$R_{out} = R_c || [g_{m2} r_{o2}(r_{o1} || r_{\pi 2}) + r_{o1} || r_{\pi 2}]$$

MOSFET

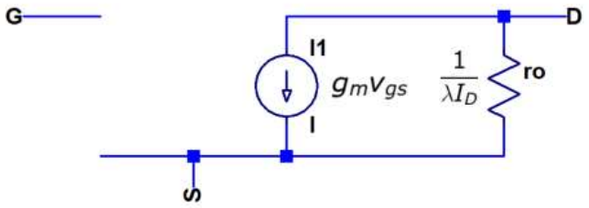
$K = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$ µn=carrier mobility, Cox=capacitance per area, W=width, L=length

Large Signal



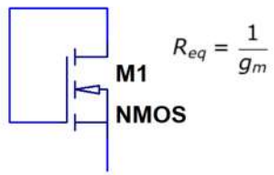
$K(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$

Small Signal



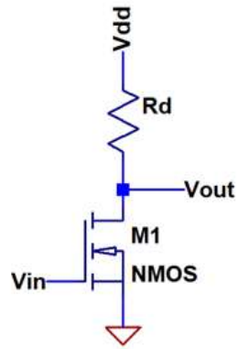
$$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH}) = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} = \frac{2I_D}{V_{GS} - V_{TH}}$$

Diode-Connected



$R_{eq} = \frac{1}{g_m}$

Common-Source

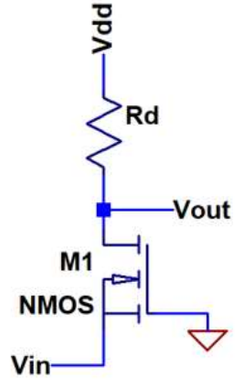


$A_v = -g_m(R_d \,||\, ro)$

$R_{in} = \infty$

$R_{out} = R_d \,||\, ro$

Common-Gate

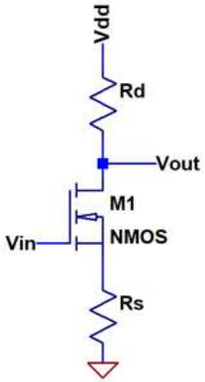


$A_v = g_m(R_d||r_o)$

$R_{in} = \frac{1}{g_m}$

$R_{out} = R_d||r_o$

Common-Source with Degeneration

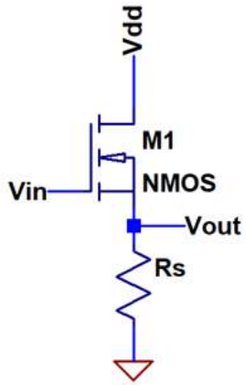


$A_v = \frac{-(R_d||r_o)}{\frac{1}{g_m} + R_s}$

$R_{in} = \infty$

$R_{out} = (g_m R_s + 1)r_o$

Common-Drain (Source Follower)

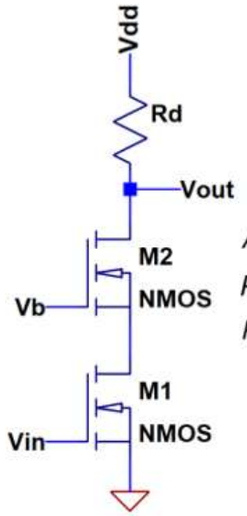


$A_v = \frac{r_o||R_s}{\frac{1}{g_m} + r_o||R_s}$

$R_{in} = \infty$

$R_{out} = \frac{1}{g_m}||r_o||R_s$

MOSFET Cascode



$A_v = -g_{m2}(R_d||[(1 + g_{m1}r_{o1})r_{o2} + r_{o1}])$

$R_{in} = \infty$

$R_{out} = R_d||[(1 + g_{m1}r_{o1})r_{o2} + r_{o1}]$