Common emitter

\[ R_{\text{in}} = r_h \]

\[ A_v = -g_m (R_c || r_o) \approx -g_m R_c \]

\[ R_o = R_c || r_o \]

Common emitter with source resistance

\[ R_{\text{in}} = r_{\text{in}} (1 + \beta + 1) R_e = (1 + \beta) (R_e + R_e) = r_H (1 + g_m R_e) \]

\[ A_v = - \frac{g_m R_c}{1 + g_m R_e} \]

\[ R_o \geq R_e \ (\text{if } r_o = \infty) \quad \text{or} \quad R_o = R_c || \left[ r_o (1 + g_m R_e) \right] \]

If \( r_o \) is taken into account
Common Source

\[ R_{in} = \infty \quad A_{v0} = -g_m(R_D || r_0) \approx -g_m R_D \]

\[ R_o = R_D || r_0 \approx R_D \]

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Common Source with Source Resistance

\[ A_{v0} = -\frac{g_m R_D}{1 + g_m R_S} \approx -\frac{R_D}{R_S} \quad R_{in} = \infty \]

\[ R_0 = R_D \quad \text{if} \quad r_0 = \infty \]

\[ \text{if not} \quad R_0 = R_D || \left[ r_0 (1 + g_m R_S) \right] \]
Common Gate

\[ R_{in} = \frac{1}{g_m} \quad A_{vo} = g_m R_0 \ (R_0 = \infty) \]

\[ R_0 = R_D \ (R_0 = \infty) \ or \ R_L \parallel R_0 \left[ 1 + g_m (R_i \parallel R_0) \right] \]

Common Base is similar

\[ R_{in} = \frac{1}{g_m} \quad A_{vo} = g_m R_0 \quad R_0 = R_L \parallel R_0 \left[ 1 + g_m (R_i \parallel R_0) \right] \]
Common emitter

\[ R_0 = R_0 \left(1 + \beta \cdot R_C \right) \]

\[ R'_0 = R_0 \parallel R_L \text{ if ignore } R_0 = 0 \Rightarrow R'_0 = R_L \]

Similar for common source with source resistance

\[ R_0 = R_0 \left(1 + \beta \cdot R_S \right) \]
Common Base & Common Gate

\[ R_o = r_o \left[ 1 + g_m (R_e \cdot R_B) \right] \]

For common gate \( R_o = r_o \left[ 1 + g_m (R_e \cdot R_G) \right] \)

Similar to CB

Common Collector

\[ R_o = \frac{1}{g_m} R_L \]

Common Drain

\[ R_o = \frac{1}{g_m} S R_L \]
\[ R_0 = r_{o2} \left[ 1 + g_{m2} \left( r_{o1} || r_{\pi2} \right) \right] \approx g_{m2} r_{o2} \left( r_{o1} || r_{\pi2} \right) \approx g_{m2} r_{o2} r_{\pi2} \]

\[ R_0 \approx g_{m2} r_{o2} r_{\pi2} \]

Total Gain = \(-g_{m1} \left( r_{o1} || r_{\pi2} \right) \cdot g_{m2} r_{o2} \)

Ignoring \( r_{o1} \) and \( r_{\pi2} \):

\[ A_v = -g_{m1} \cdot \frac{1}{g_{m2}} \times \frac{g_{m2}}{R_L} = -g_{m1} R_L \]
MOS Cascode

\[ R_0 = r_{o2} (1 + g_{m2} r_{o1}) \approx g_{m2} r_{o1} r_{o2} \]

Gain ignoring \( r_0 \):

\[ \left( - g_{m1} \cdot \frac{1}{g_{m2}} \right) \times \left( g_{m2} \cdot R_D \right) = - g_{m1} R_D \]