Basic amplifier architectures
Cascaded Amplifier Analysis and Operation

(applicable when all stages are unilateral)

\[ A_V = \frac{V_{out}}{V_{in}} = \left( \frac{R_{iX1}}{R_{iX1}+R_S} \right) A_{V01} \left( \frac{R_{L1}/R_{iX2}}{R_{L1}/R_{iX2}+R_{0X1}} \right) A_{V02} \left( \frac{R_L}{R_L+R_{0X2}} \right) \]

Accounts for all loading between stages!
Cascaded Amplifier Analysis and Operation

(when stages are not unilateral)

- Standard two-port cascade

Analysis quite tedious because of the reverse-gain elements

- Right-to-left nested $R_{inX}, A_{vX}$ approach

$R_{inX}$ includes effects of all loading
$A_{vX}$’s include all loading
Can not change any loading
Example:

Determine the voltage gain of the following circuit in terms of the small-signal parameters of the transistors. Assume $Q_1$ and $Q_2$ are operating in the Forward Active region and $C_1...C_4$ are large.

In this form, does not look “EXACTLY” like any of the basic amplifiers!
Example:

Will calculate $A_V$ by determining the three ratios (not voltage gains of dependent source):

$$A_V = \frac{V_{out}}{V_{in}} = \frac{V_{out}}{V_B} \frac{V_B}{V_A} \frac{V_A}{V_{in}} = A_{V2}A_{V1}A_{V0}$$
Example:

\[ A_{V2} = \frac{v_{out}}{v_B} \approx -\frac{R_6//R_8}{R_7} \]

\[ R_{in2} \approx \beta R_7 \]
Example:

\[ R_{\text{in2}} \approx \beta R_7 \]
Example:

\[ A_{v2} = \frac{v_{\text{out}}}{v_B} \approx -\frac{R_6 // R_8}{R_7} \]

\[ R_{in2} \approx \beta R_7 \]
Example:

\[ A_{V1} = \frac{v_B}{v_A} \approx -g_{m1} \left( R_3 // R_5 // R_{in2} \right) \]

\[ R_{in1} \approx r_{\pi 1} \]
Example:
Example:

$$A_{v0} = \frac{V_A}{V_{in}} \approx \frac{R_1//R_2 // R_{in1}}{R_S + R_1//R_2 // R_{in1}}$$
Example:

Thus we have

\[ A_V = \frac{V_{out}}{V_{in}} = \frac{V_{out}}{V_B} \frac{V_B}{V_A} \frac{V_A}{V_{in}} \]

where

\[ \frac{V_{out}}{V_B} \approx \frac{R_6//R_8}{R_7} \]

\[ \frac{V_B}{V_A} \approx -g_{m1}(R_3//R_5//R_{in2}) \]

\[ R_{in2} \approx \beta R_7 \]

\[ R_{in1} \approx r_{\pi 1} \]

\[ \frac{V_A}{V_{in}} \approx \frac{R_1//R_2//R_{in1}}{R_S + R_1//R_2//R_{in1}} \]
Example:

Observation: By working from the output back to the input we were able to create a sequence of steps where the circuit at each step looked EXACTLY like one of the four basic amplifiers even though stages were not unilateral. Engineers often follow a design approach that uses a cascade of the basic amplifiers and that is why it is often possible to follow this approach to analysis.

Will formalize what we have done (consider 3-stage unilateral cascade)