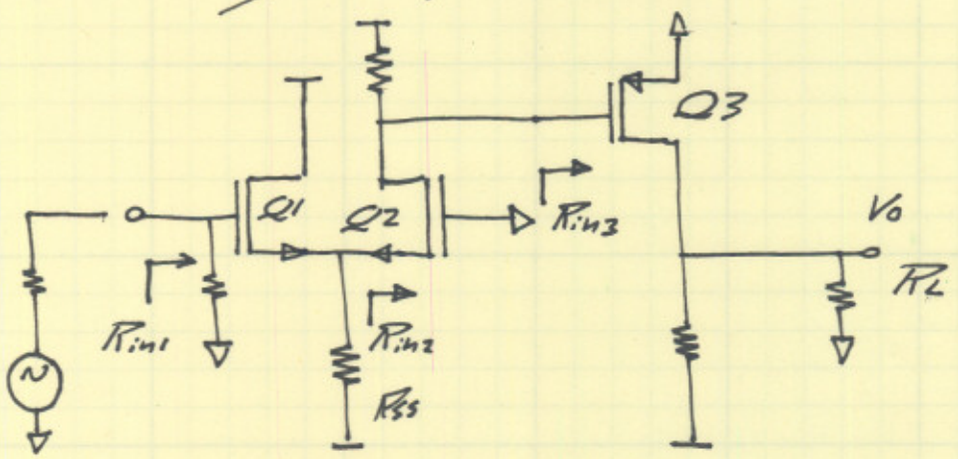
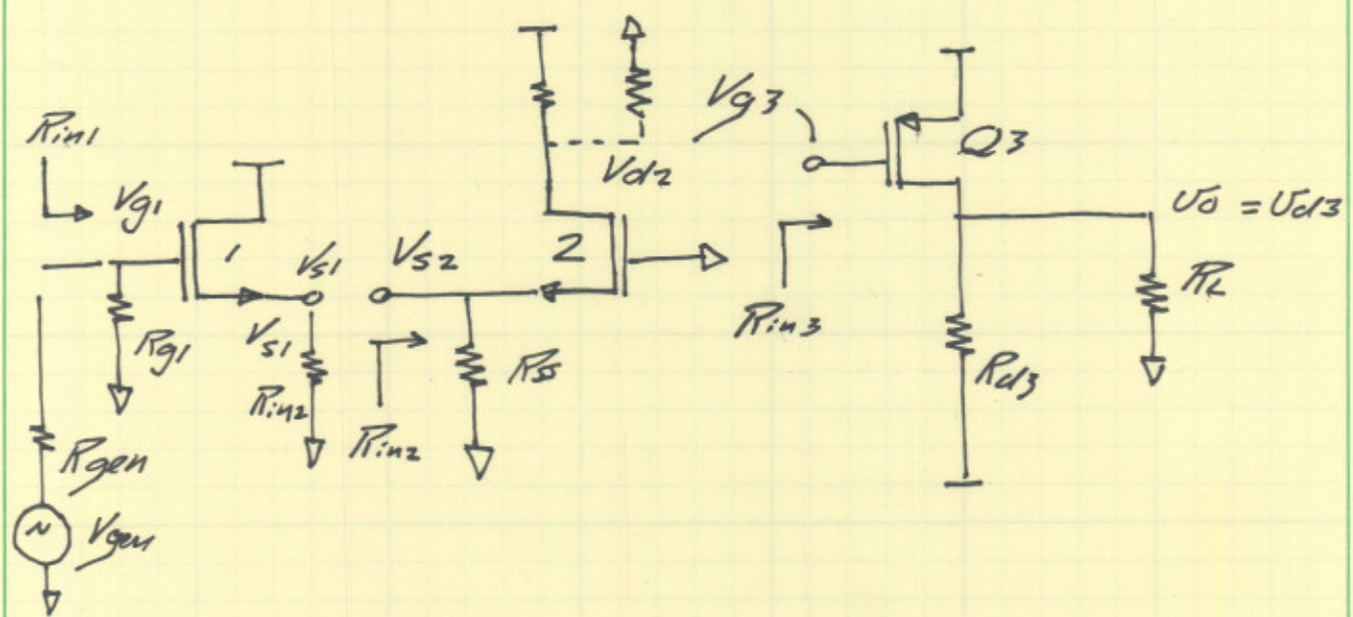
ECE 137A | Notes set 7

Multistage amplifiers



To analyze

1) Find bias, working from input to output
2) Separate into individual stages



= First find v_{d3}/v_{g3} and find R_{in3}

= Then find v_{d2}/v_{s2} and R_{in2}

- Note that R_{in3} enters into the above calculation

= Then find v_{s1}/v_{g1} and R_{in1}

- Note that R_{in2} enters into the above calculation.

= Then find v_{g1}/v_{gen}

- depends upon R_{gen} and R_{in1}

We can then find

$$\frac{v_o}{v_{gen}}\Big/_{overall} = \frac{v_{in}}{v_{gen}} \cdot \frac{v_{s1}}{v_{g1}} \cdot \frac{v_{d2}}{v_{s2}} \cdot \frac{v_{d3}}{v_{g3}}$$

Explicitly:

Q3:

$$R_{Leq3} = R_L \parallel R_{D3} \parallel R_{DS3}$$

$$A_V = v_{d3}/v_{g3} = -g_{m3} R_{Leq3}$$

$$R_{in3} = \infty$$

Q2/

$$R_{Leq2} = R_{in3} \parallel R_{D2} = \infty \parallel R_{D2} = R_{D2}$$

$$R_{in,source,2} = (1/g_{m2})\left(\frac{R_{Leq2} + R_{DS2}}{R_{DS2}}\right)$$

$$A_V = v_{d2}/v_{s2} = R_{Leq2}/R_{in,source2}$$

$$R_{in2} = R_{in,source2} \parallel R_{SS}$$

Q1/

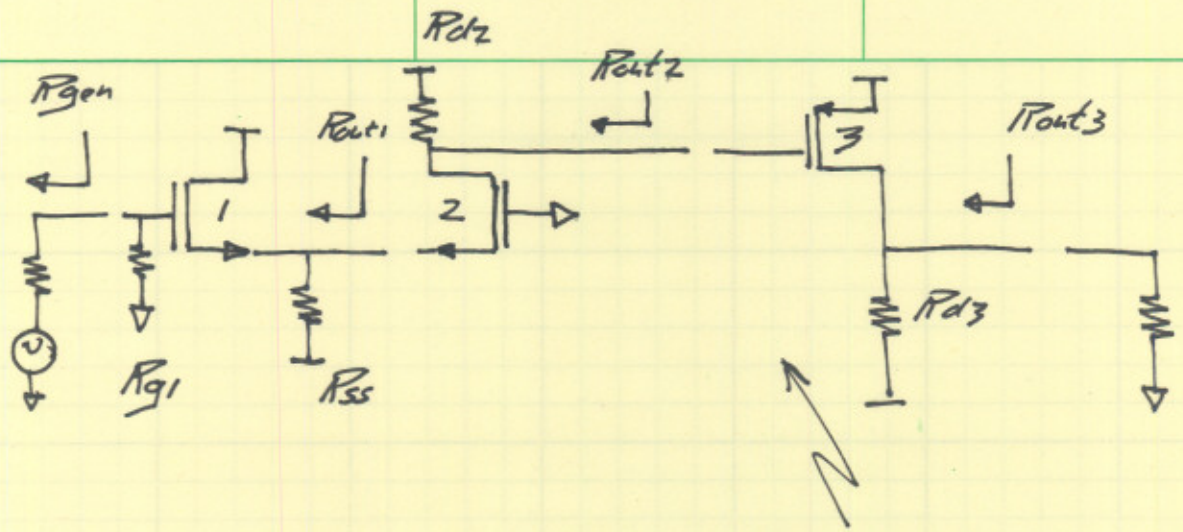
$$R_{Leq1} = R_{DS1} \parallel R_{in2}$$

$$A_{v1} = V_{s1}/V_{g1} = \frac{R_{Leq1}}{R_{Leq1} + 1/g_{m1}}$$

$$R_{in1} = R_{g1}$$

generator/

$$v_{in}/v_{gen} = R_{in1}/(R_{in1} + R_{gen})$$



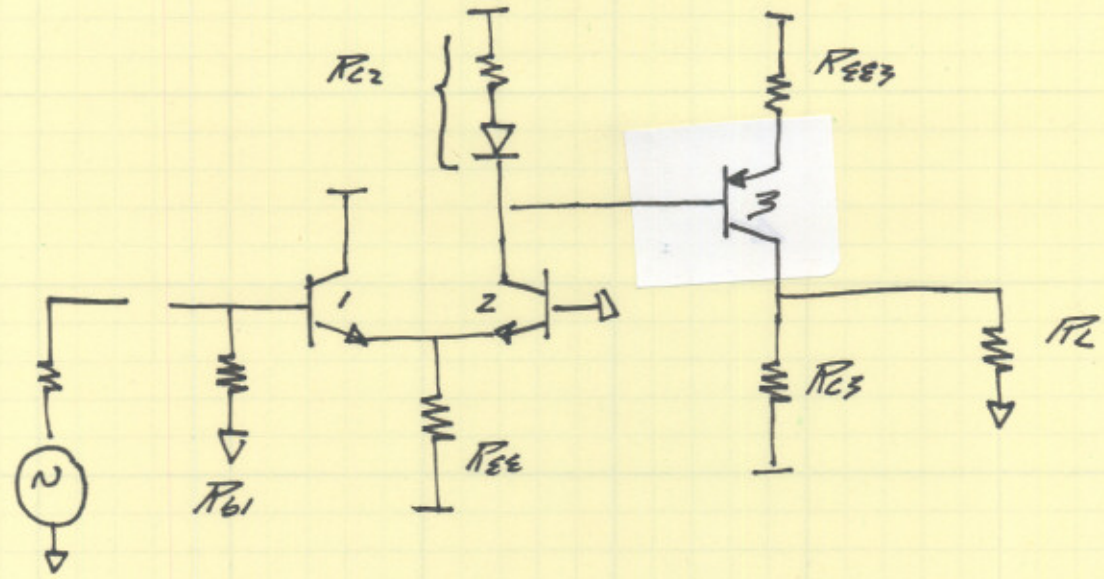
To find output impedances, we must work in the opposite direction...

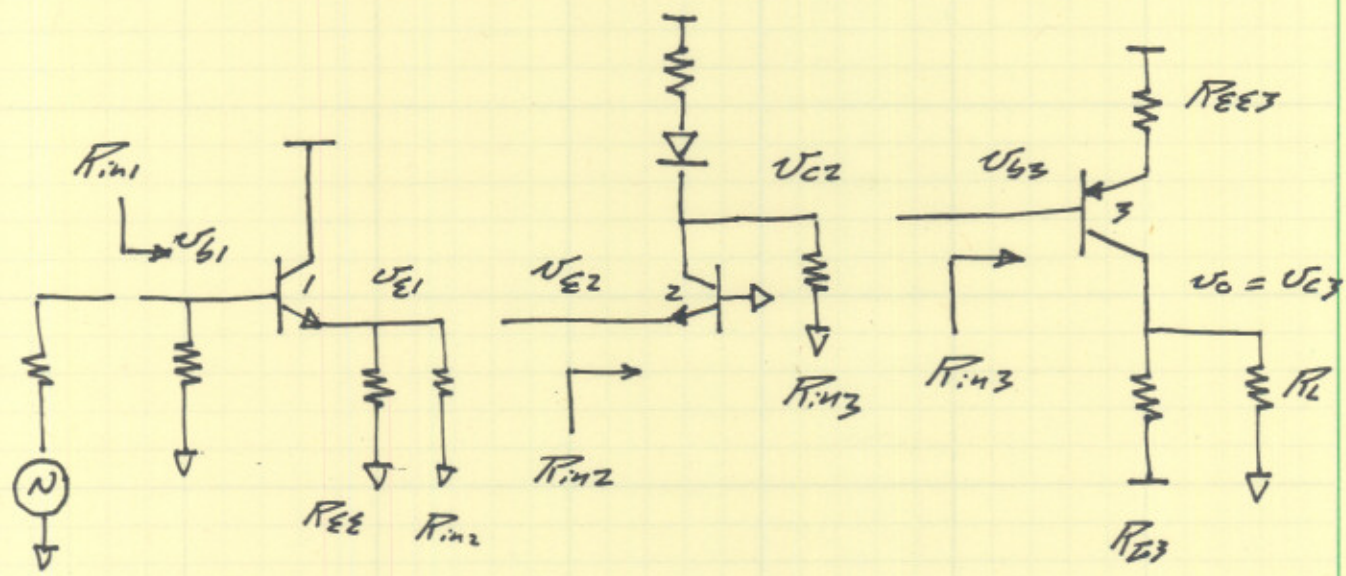
$$R_{out1} = R_{ss} \parallel \frac{1}{g_{m1}}$$

$$R_{out2} = R_{d2} \parallel \{ R_{ds2} \cdot (1 + g_{m2} \cdot R_{out1}) \}$$

$$R_{out3} = R_{d3} \parallel R_{ds3}$$

The stage-stage interactions are much more significant with bipolar transistors:





for this bipolar example:

Q3/ common-emitter with degeneration.

$R_{Leq3} = R_{C3} // R_L // R_{out,\,collectors}$

$\sim r_{E3} \cdot (1 + R_{EE3}/r_{E3})$

$A_V = v_{C3}/v_{b3} = -R_{Leq3}/(r_{E3} + R_{EE3})$

$R_{in3} = \beta (r_{E3} + R_{EE3})$

Q2/ common-base

$R_{Leq2} = R_{in3} // R_{C2} // R_{out,\,collectors}$

$R_{in,\,emitter2} = r_{E2} (1 + R_{Leq2}/R_{CE2}) = R_{in2}$

$A_V = v_{C2}/v_{E2} = R_{Leq2}/R_{in,\,emitter2}$

Q1/ common-collector

$R_{Leq1} = r_{CE1} // R_{EE} // R_{in2}$

$A_V = v_{E1}/v_{b1} = R_{Leq1}/(R_{Leq1} + r_{E1})$

$R_{in1} = \beta (R_{Leq1} + r_{E1}) // R_{b1}$