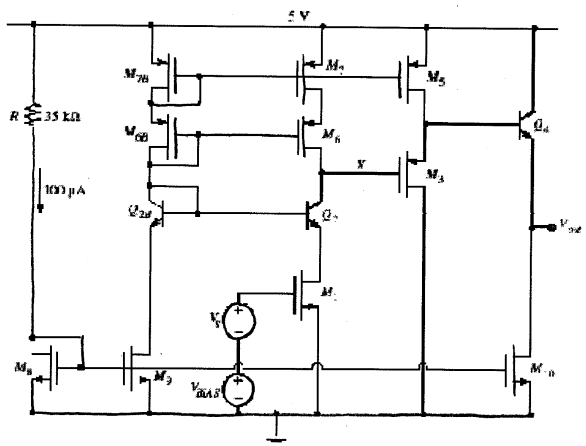
Voltage Amplifier Frequency Response

* Chapter 9 multistage voltage amplifier



* Approaches:

  1. brute force OCTC -- do for all capacitances in the circuit
  2. identify the largest contributor(s) and calculate the Thévenin resistance associated with them

Try second approach: identify four nodes in signal path

Qualitative Evaluation of Time Constants

1. Input node: no contribution since $R_S = 0$
2. Drain of M_1: "low impedance node" since $R_{in(CB)} = 1/g_{m2}$
3. **Node** X: extremely high resistance ... could be a big time constant
4. Source of M_3: "low impedance node" since $R_{out(CD)} = 1/g_{m3}$
5. Output node: "low impedance node" since $R_{o(CC)} = 1/g_{m4}$

Note: we are *not* considering capacitances *between* nodes here ... since we are doing an approximate analysis, we will use Miller's theorem to find their effective capacitance to ground

Small-Signal Model of Node X

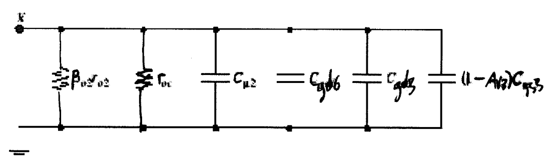
* Account for all of the capacitances from node X to *small-signal* ground:

1. Base-collector capacitance $C_{\mu 2}$ of Q_2 (since it is connected to diode-connected transistors M_{6B} and M_{7B} that are in turn connected to V_{DD})
2. Gate-drain capacitance C_{gd6} of M_6 (since it is connected to the same node as $C_{\mu 2}$)
3. Gate-drain capacitance C_{gd3} of M_3 (since it is connected directly to ground)
4. Effective capacitance due to C_{gs3} connected between the input and the output of the common-drain stage:

$$C_{eff} = C_{gs3}(1 - A_{vC_{gs3}})$$

The gain across C_{gs3} is about 1, but an accurate calculation would include any backgate effect on M_3 if present.

* Small-signal model with all (*non-parasitic*) capacitances



additional parasitic capacitors: $C_{db6} + C_{cs2} + C_{wire}$

Gain-Bandwidth Product

* Considering only the time constant from node X

$$\omega_{3dB} \approx \frac{1}{[(\beta_{o2} r_{o2} \| g_{m6} r_{o6} r_{o7})](C_{\mu 2} + C_{gd6} + C_{gd3} + (1 - A_{vC_{gs3}})C_{gs3})}$$

* Approximate low-frequency gain -- from Chapter 9

$$A_{vo} \approx -g_{m1}(\beta_{o2} r_{o2} \| g_{m6} r_{o6} r_{o7})$$

* Gain-bandwidth product

$$|A_{vo}|\omega_{3dB} \approx \frac{g_{m1}}{C_{\mu 2} + C_{gd6} + C_{gd3} + (1 - A_{vC_{gs3}})C_{gs3}}$$