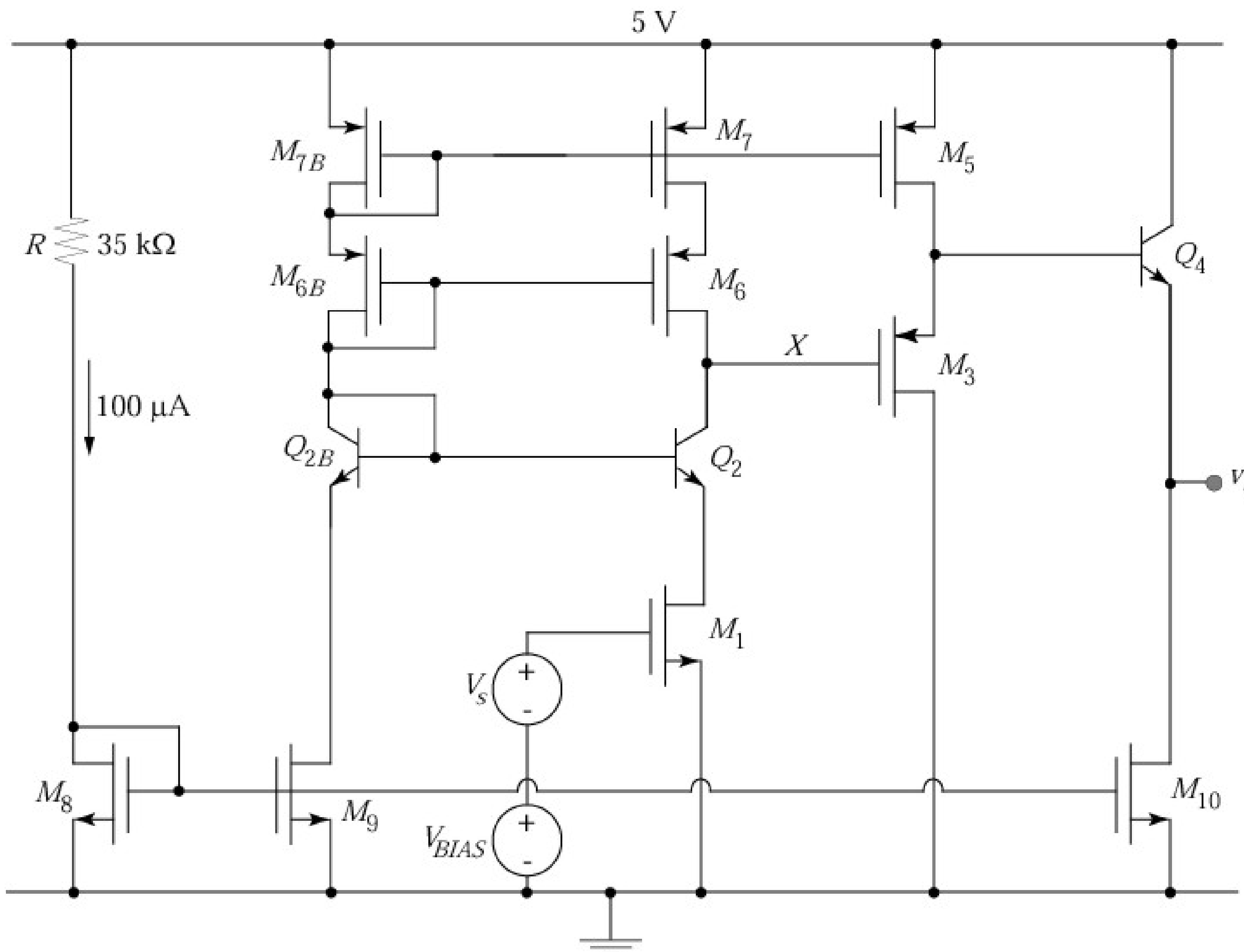
Lecture 41

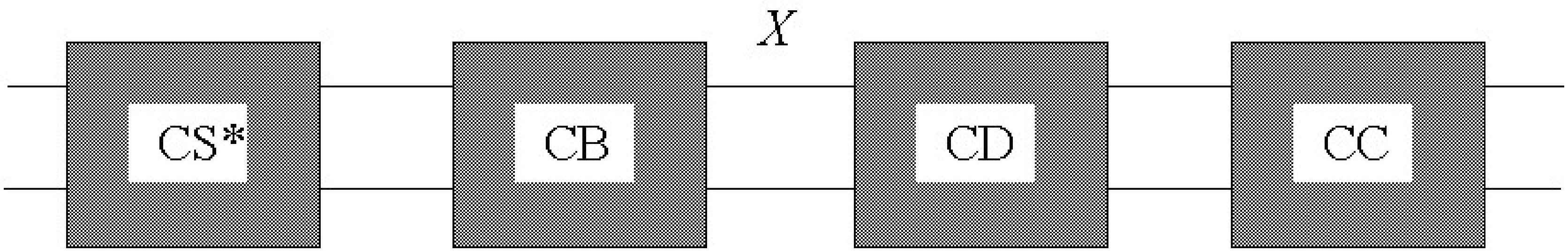
- Last time:
  - Applications of open-circuit time constant analysis: CE amplifier and cascode amplifier
- Today :
  - The four-stage voltage amplifier: using OCTC to find the dominant pole
  - Introduction to differential amplifiers

Insight into the Frequency Response



Qualitative Insight

Could always do “brute force” open-circuit time constants



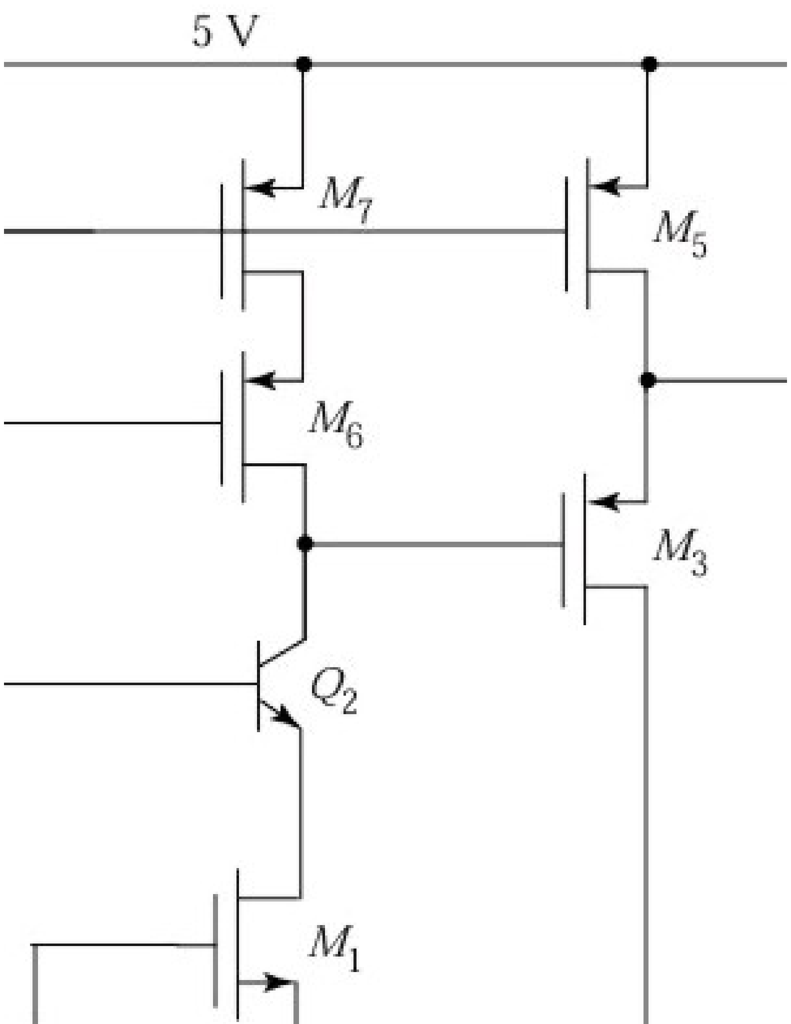
CS*-CB is a wideband stage … so is the CD-CC buffer

Look for large $R_{Tx}C_x$ products: high-impedance nodes are likely candidates

Node *X*

CS*-CB is a wideband stage … so is the CD-CC buffer

"High impedance node" is node X … look at $R_{Tx}C_x$

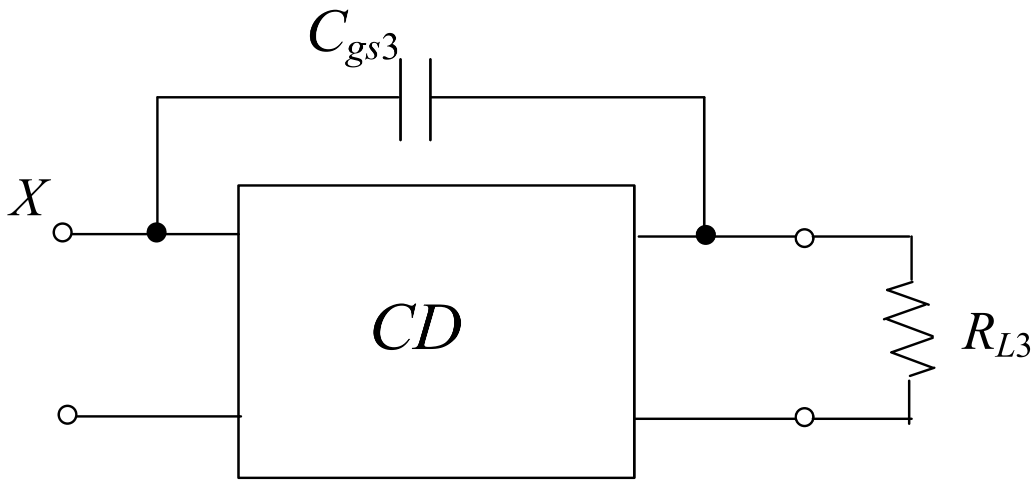


Capacitance:

$$C_x = C_{gd6} + C_{db6} + C_{\mu 2} + C_{cs2} + C_{gd3} + C_{M3}$$

Miller for CD stage (M_3)

Finding the Miller Capacitance C_{M3}



Gain across C_{gs3}: $A_{vC_{gs3}} = \dfrac{R_{L3}}{1/g_{m3} + R_{L3}}$

$R_{L3} = R_{in4} =$

Dominant Pole of Voltage Amplifier

Thévenin resistance for C_X:

$$R_{Tx} = R_{out2} \,||\, R_{in3} = R_{out,CB} \,||\, R_{in,CD}$$

$$R_{Tx} = r_{oc} \,||\, r_{o2}(1 + g_{m2}(r_{\pi 2} \,||\, R_{S2})) \cong r_{o6}(1 + g_{m6} r_{o7}) \,||\, r_{o2}\beta_o$$

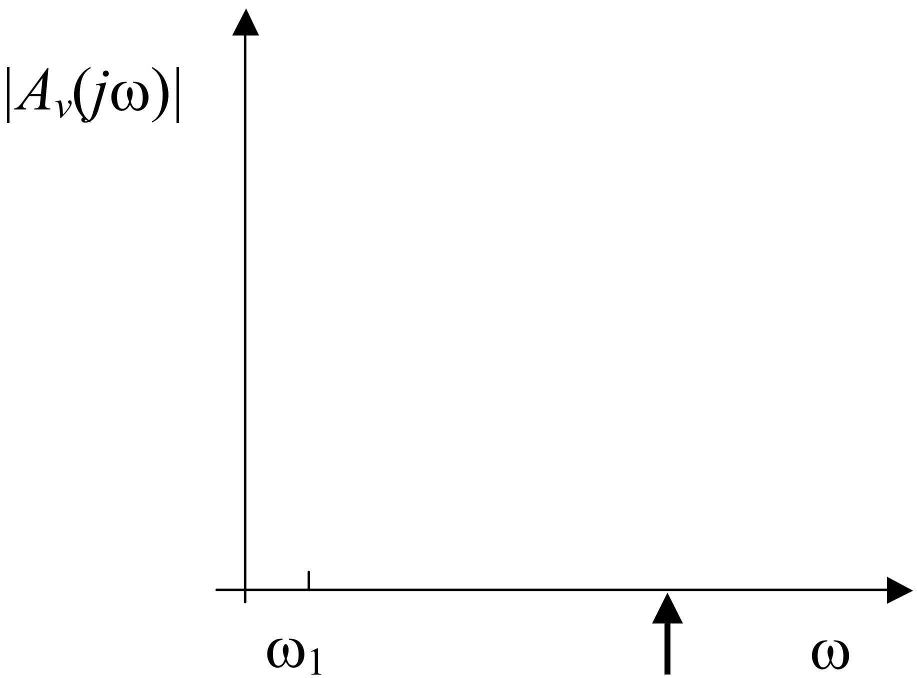
Dominant pole: $\omega_1^{-1} \approx R_{Tx} C_x$

Magnitude Bode Plot

Low-frequency voltage gain was found in Lecture 38:

$$A_v = -g_{m1}\left(\beta_o r_{o2} \parallel r_{o6}\left(1 + g_{m6} r_{o7}\right)\right)$$

(neglect loading at output ($R_L >> R_{out}$)



Gain-Bandwidth product = unity gain frequency

Differential Amplifiers

What's wrong with our EE 105 amplifiers?

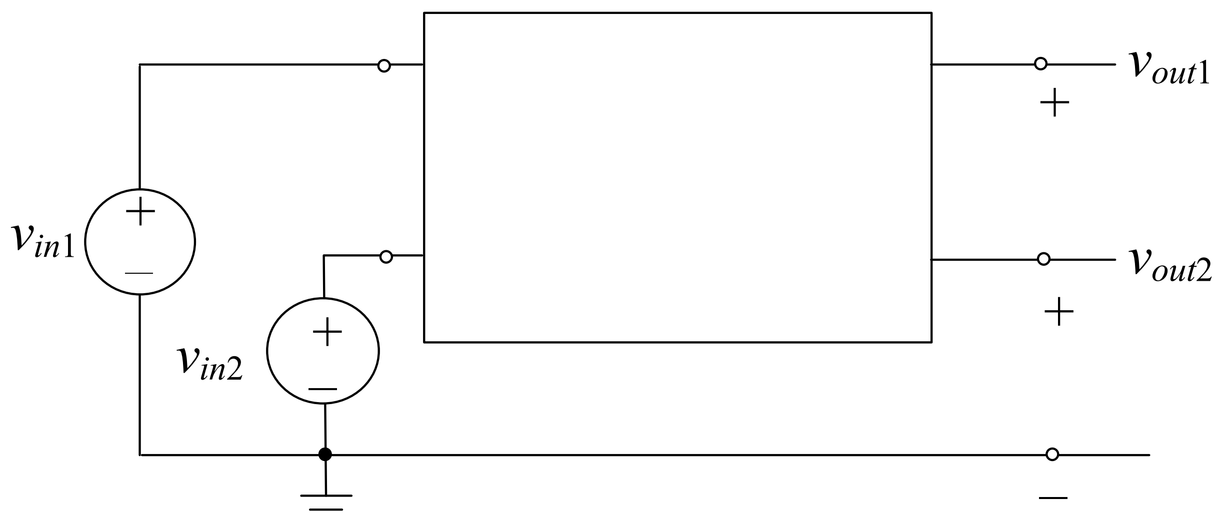
1. Customer must supply V_{BIAS} or I_{BIAS} – impractical!

2. The input signals and output signals are referenced to ground or "single-ended" →

   they're easily corrupted by a variety of interfering signals (e.g., loops in your circuit picking up radio stations or cell phones, V_{DD} has high-frequency components from lightning strikes in the Sierra, etc.)

The Differential Amplifier Concept

The basic idea: amplify the *difference* between two inputs and reject the common component



$$v_{out,diff} = A_{v,diff}(v_{in,diff}) = A_{v,diff}(v_{in1} - v_{in2}) \text{ … large}$$

$$v_{out,\ comm} = A_{v,comm}(v_{in,com}) = A_{v,comm}[(v_{in1} + v_{in2})/2] \text{ … small}$$

A Simple MOS Differential Amplifier