Problem Set 6

❒ Section 6.4 (High-Frequency Response - general considerations):

- **Problem 1:** 6.54 in the textbook.

❒ Sections 6.6 and 6.8 (High-Frequency Response of Amplifiers)

- **Problem 2:** 6.99 in the textbook.

- **Problem 3:**
  For the amplifiers in Figures 1 and 2, derive an expression for:

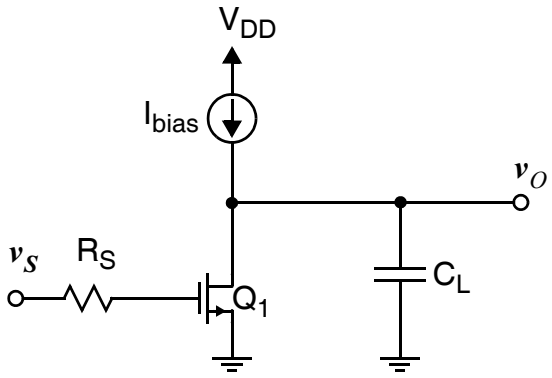
  i) the midband voltage gain $A_M = v_o / v_s$;

  ii) the 3dB-frequency ω_H, assuming a dominant pole exist.

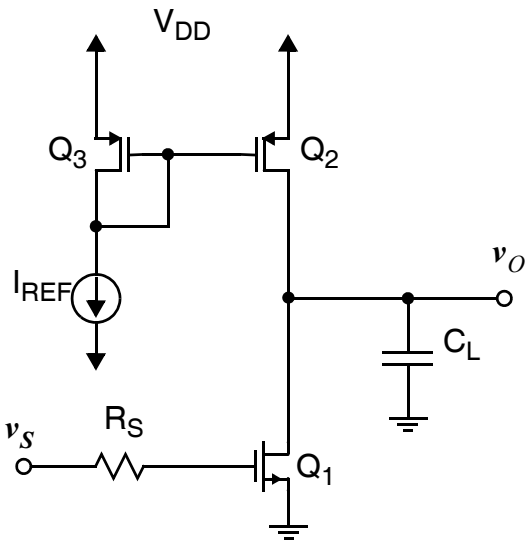
  Hint: Follow the following steps to find ω_H:
  1) apply Miller's theorem;
  2) find the open-circuit time constants (poles) associated with each node;
  3) find ω_H based on the open-circuit time-constant approximation, assuming a dominant pole exists.

  Assume:

  - Biasing:
    - each current source has an output resistance of R_L.
    - the dc-bias voltage level at the output is stabilized by negative feedback, with all BJTs and MOSFETs biased in the active and saturation modes, respectively.
  - For the MOS amplifiers in Figure 1:
    - the body effect is negligible.
    - the substrate (Body) terminal of the NMOS transistors is connected to *GND*.
    - the substrate (Body) terminal of the PMOS transistors is connected to V_{DD}.
  - For the BJT amplifiers in Figure 2:
    - neglect the small-signal base resistance r_x.

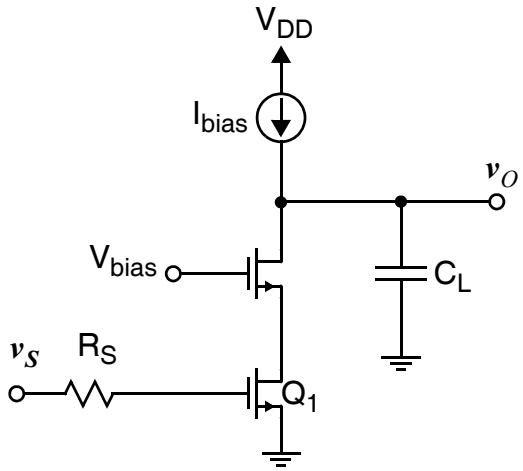


(a) Common-Source Amplifier



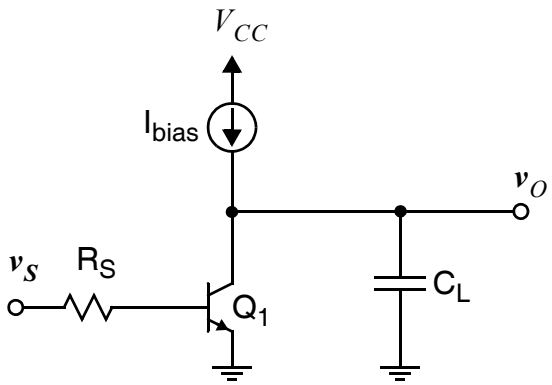
b) Common-Source Amplifier with Active Load

(assume the gate of Q_2 is at signal *GND*)

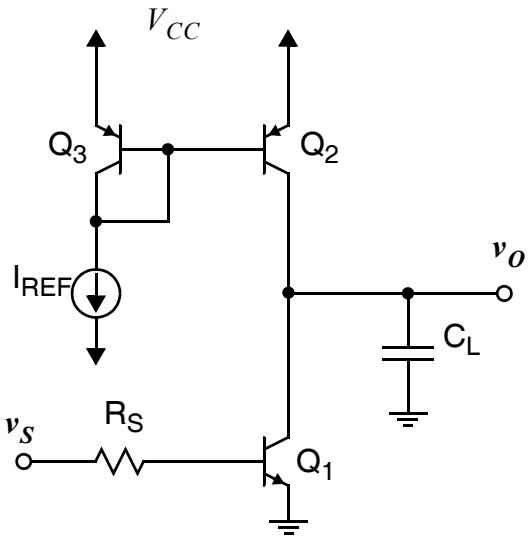


(c) MOS Cascode Amplifier

Figure 1 MOS amplifiers.

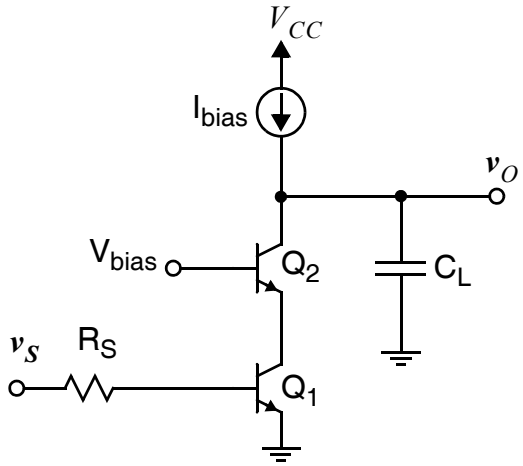


(a) Common-Emitter Amplifier



(b) Common-Emitter Amplifier with Active Load

(assume the base of Q_2 is at signal *GND*)



(c) BJT Cascode Amplifier

Figure 2 BJT amplifiers.

❒ **Sections 6.12** (Advanced Current Mirrors) **and 7.7** (Multistage Amplifiers)

• **Problem 4:**

For the 2-stage differential amplifier in Figure3 *(where the bias-voltage level at the output is assumed to be stabilized by feedback to about 0 V)*, find:

i) the small-signal voltage gain $\frac{v_{out}}{v_{in}}$.

ii) the input common-mode range of the amplifier, assuming $|V_{BEon}| = 0.7V$ and $|V_{CEsat}| = 0.3V$ for **every** transistor, and ±3.3 -V power supplies.

Assume that the resistance looking into the collector of Q9 (i.e. R_{o9}) is approximately equal to the output resistance of the BJT (i.e. r_{o9}).

All pnp transistors have β = 50 and $|V_A| = 80V$, and all npn transistors have β = 250 and $|V_A| = 125V$. When calculating the dc currents, you can ignore the base current of every transistor.

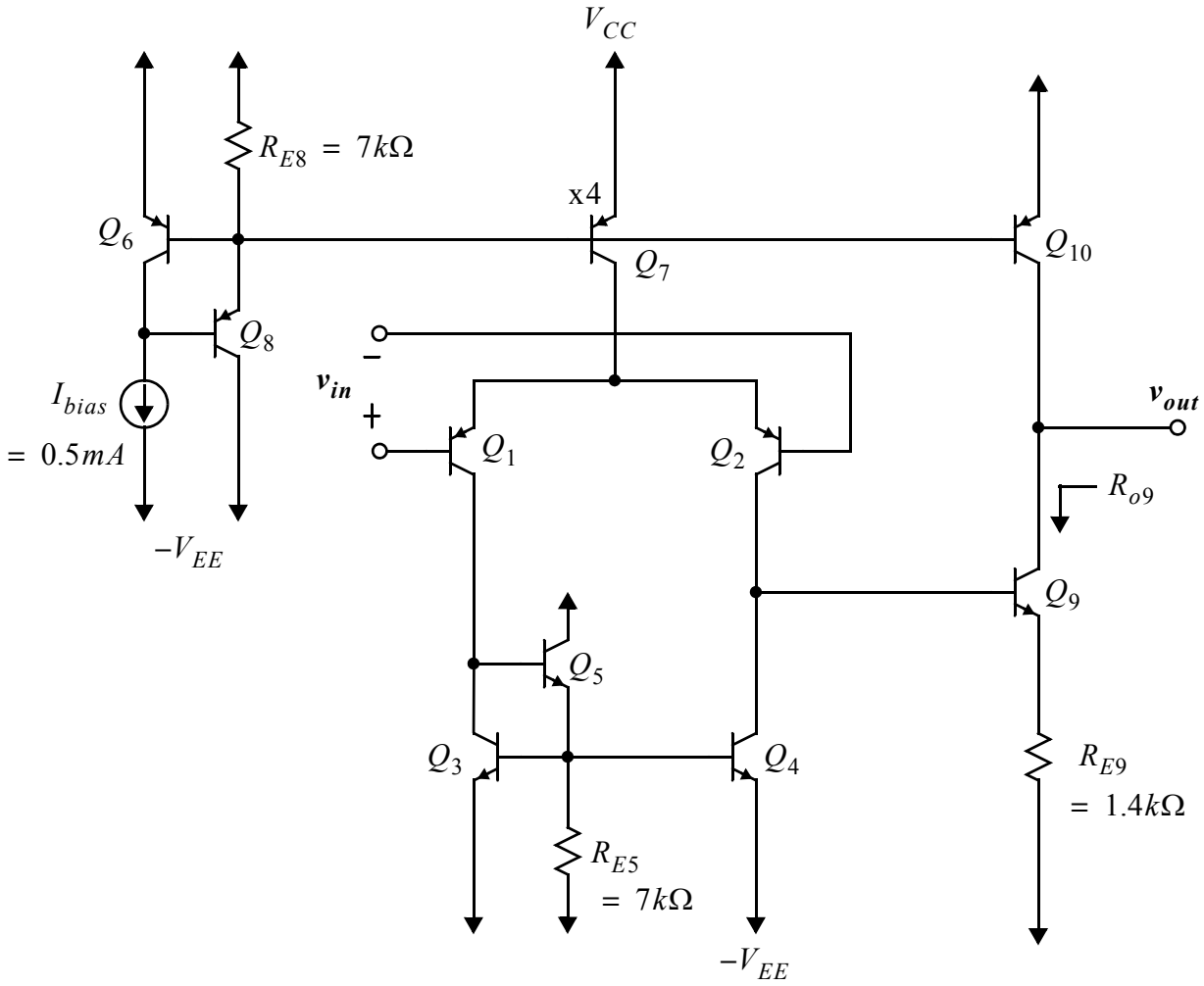


Figure 3 A BJT realization of a 2-stage differential amplifier.