ECE 523/421 – Analog Electronics

Lecture 16: Frequency Response: Low-frequency Response

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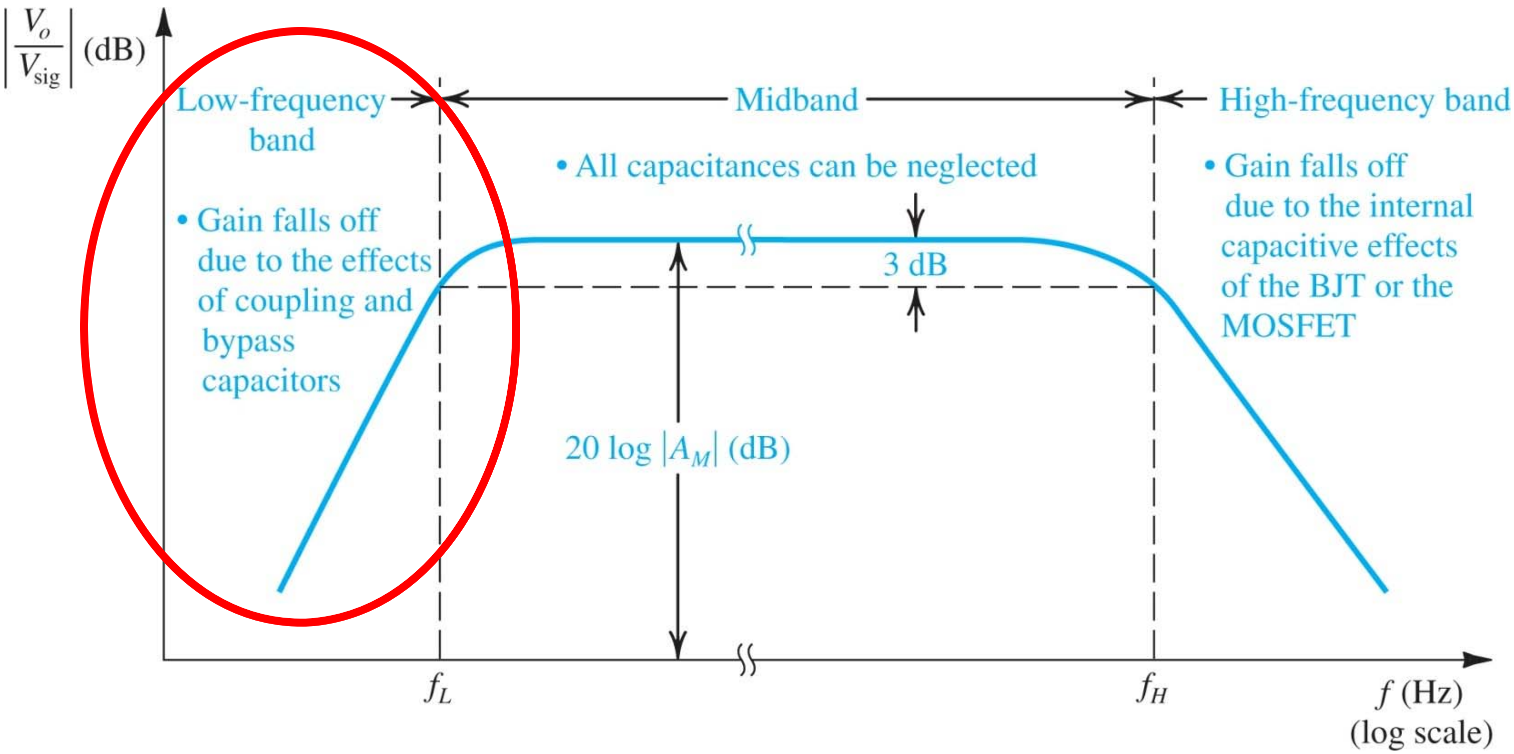
Review of Last Lecture

- Differential Gain of Active-Loaded MOS Pair
- Common Gain of Active-Loaded MOS Pair
- CMRR of Active-Loaded MOS Pair
- Differential Gain of Active-Loaded BJT Pair
- Common Gain of Active-Loaded BJT Pair
- CMRR of Active-Loaded BJT Pair
- Examples: Multistage Differential Amplifier

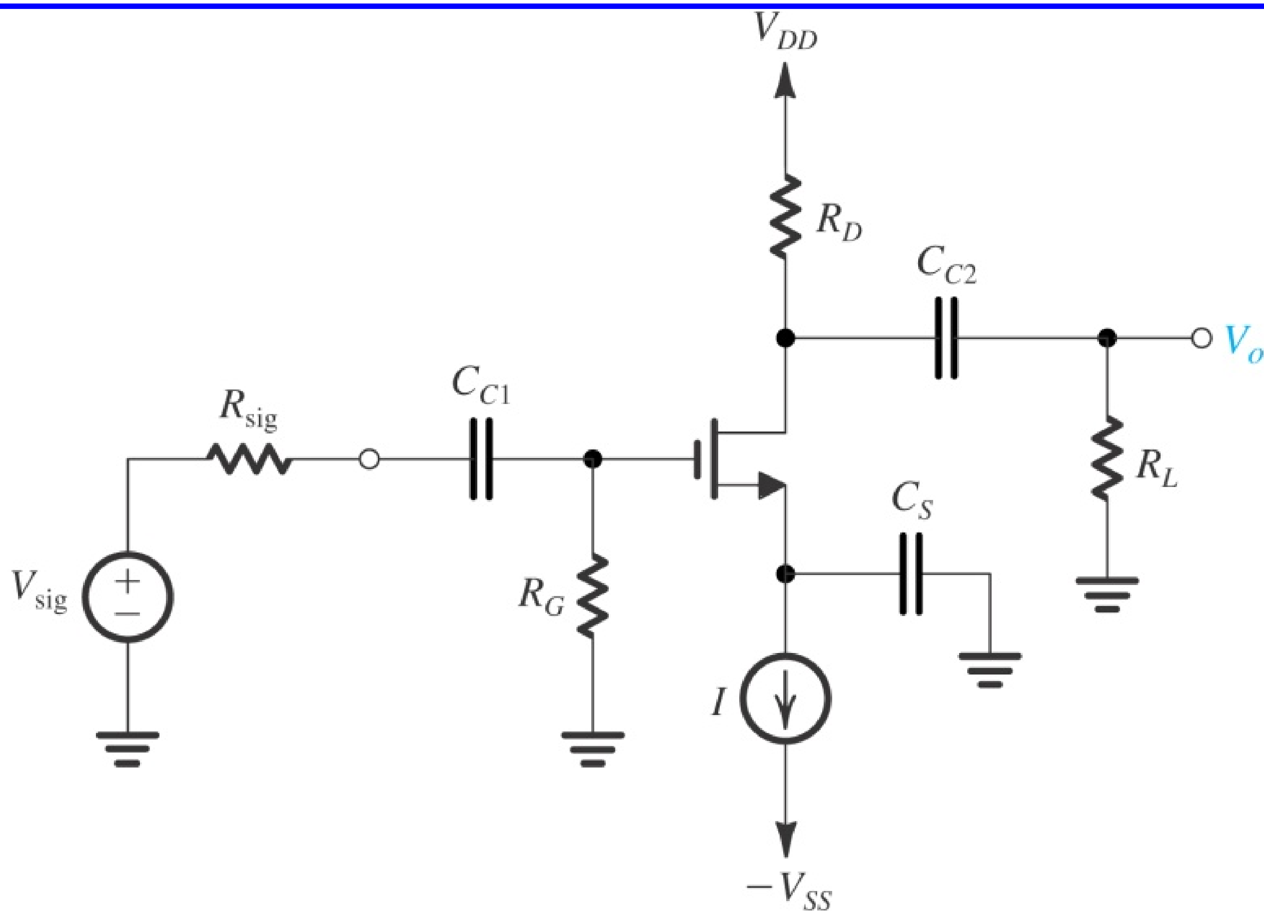
Today's Lecture

- Estimation of lower 3dB frequency in CS amplifier
- Estimation of lower 3dB frequency in CE amplifier

Frequency Response of a typical Amplifier

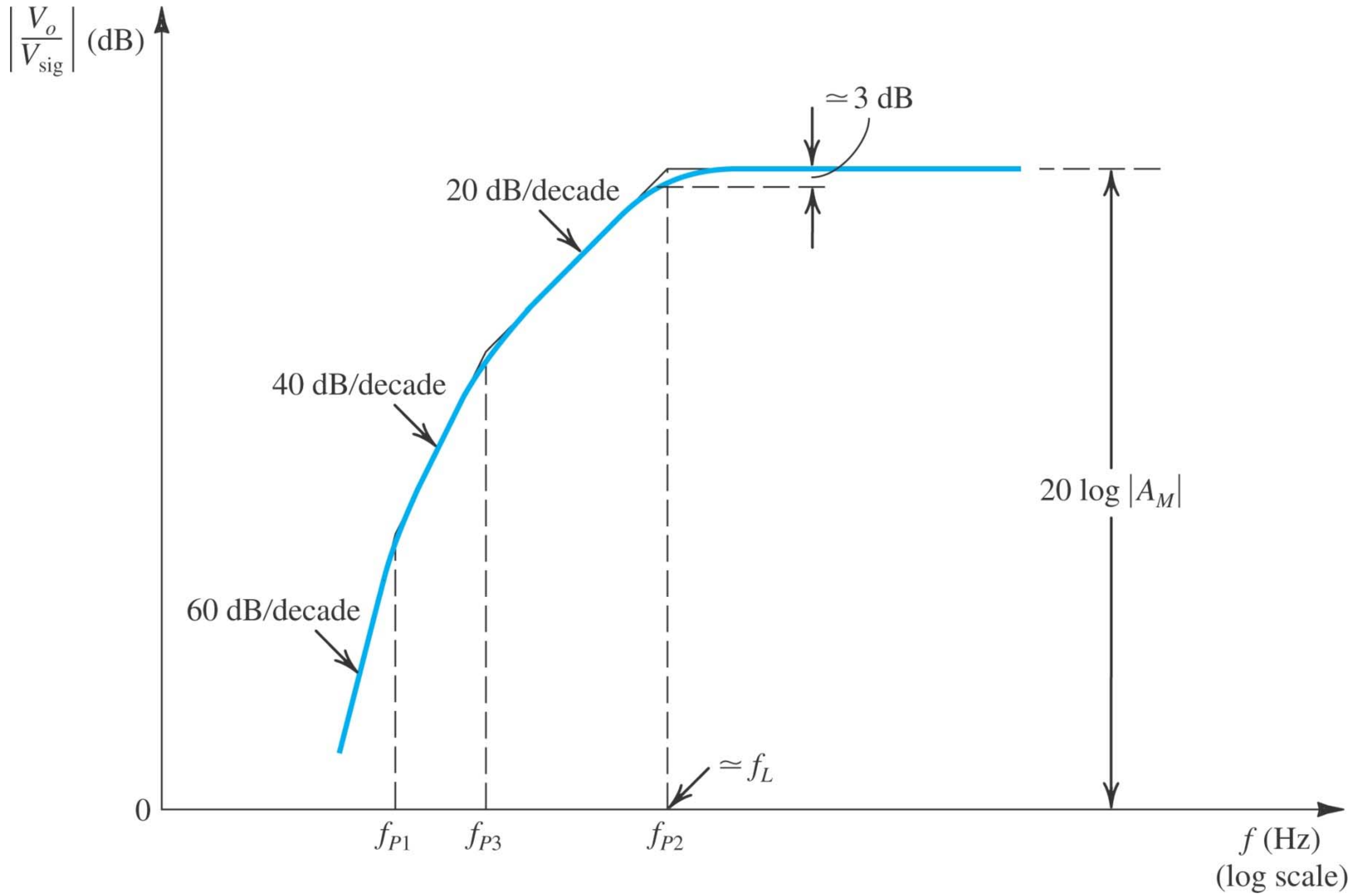


A Typical CS Amplifier: Estimation of Poles

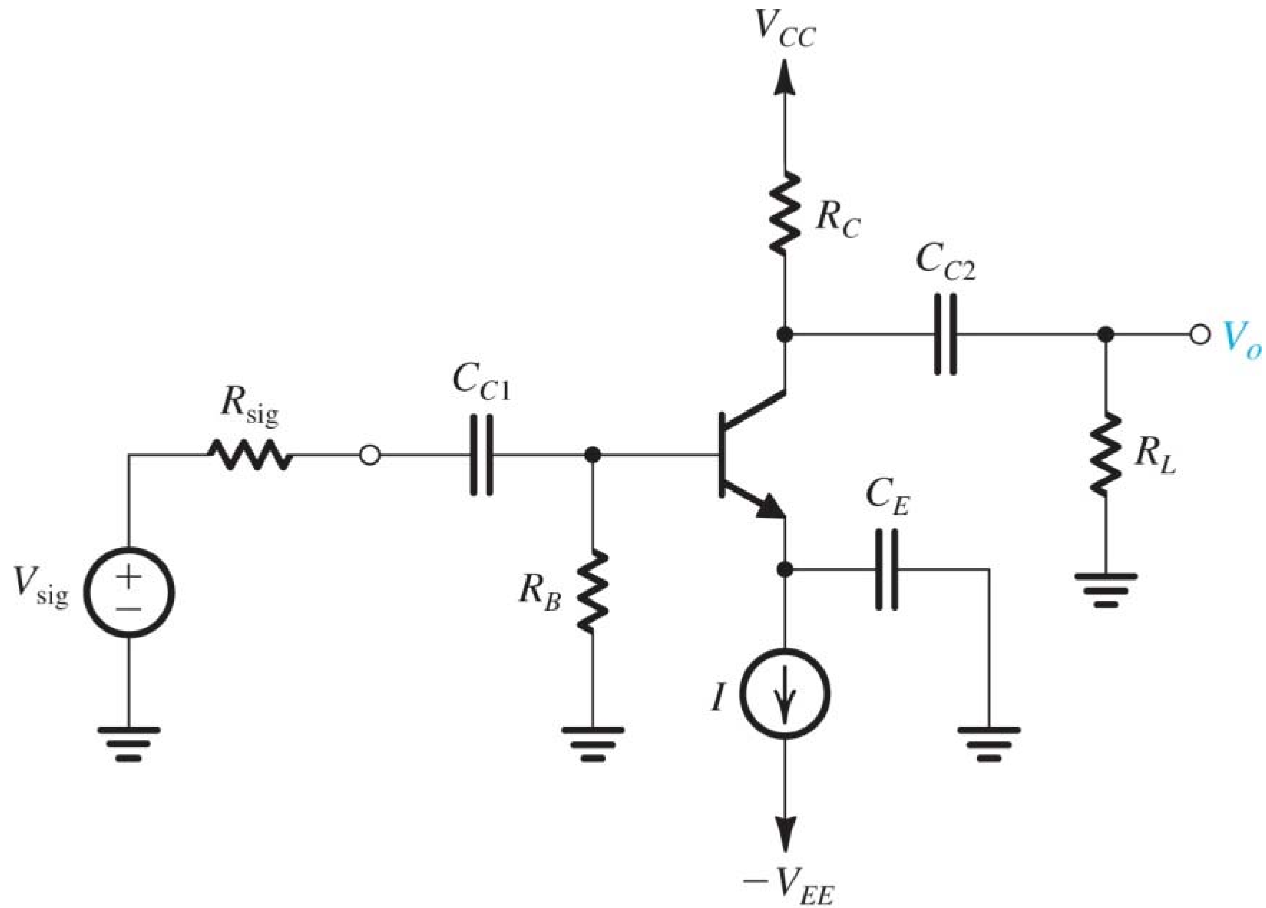


$$\frac{v_o}{v_{sig}} = -\left(\frac{R_G}{R_G + R_{sig}}\right)\left[g_m\left(R_D \| R_L\right)\right]\left(\frac{s}{s+\omega_{p1}}\right)\left(\frac{s}{s+\omega_{p2}}\right)\left(\frac{s}{s+\omega_{p3}}\right)$$

Low-frequency Magnitude Response of CS



A Typical CE Amplifier: Estimation of Poles



$$\frac{v_o}{v_{sig}} \approx -\left(\frac{R_B \| r_\pi}{R_B \| r_\pi + R_{sig}}\right)\left[g_m\left(R_C \| R_L\right)\right]\left(\frac{s}{s+\omega_{p1}}\right)\left(\frac{s}{s+\omega_{p2}}\right)\left(\frac{s}{s+\omega_{p3}}\right)$$

Lower 3dB frequency Estimation

- Usually we design the circuits such that one pole becomes dominant (10x larger than others)
- This is the concept of dominant pole
- The lower 3dB frequency is simply the highest frequency of the poles
- How do we select the values of decoupling capacitance?
  - Use the port with minimum impedance for dominant pole
  - Design other poles to be 10X smaller than the dominant pole

- IF the poles are close, then the lower 3db frequency can be approximated using short-circuit time constant technique shown below:

$$f_L \approx f_{P1} + f_{P2} + f_{P3} = \frac{1}{2\pi}\sum_i \frac{1}{R_{is}C_i}$$