CE/CS Amplifier Response at Low Frequencies

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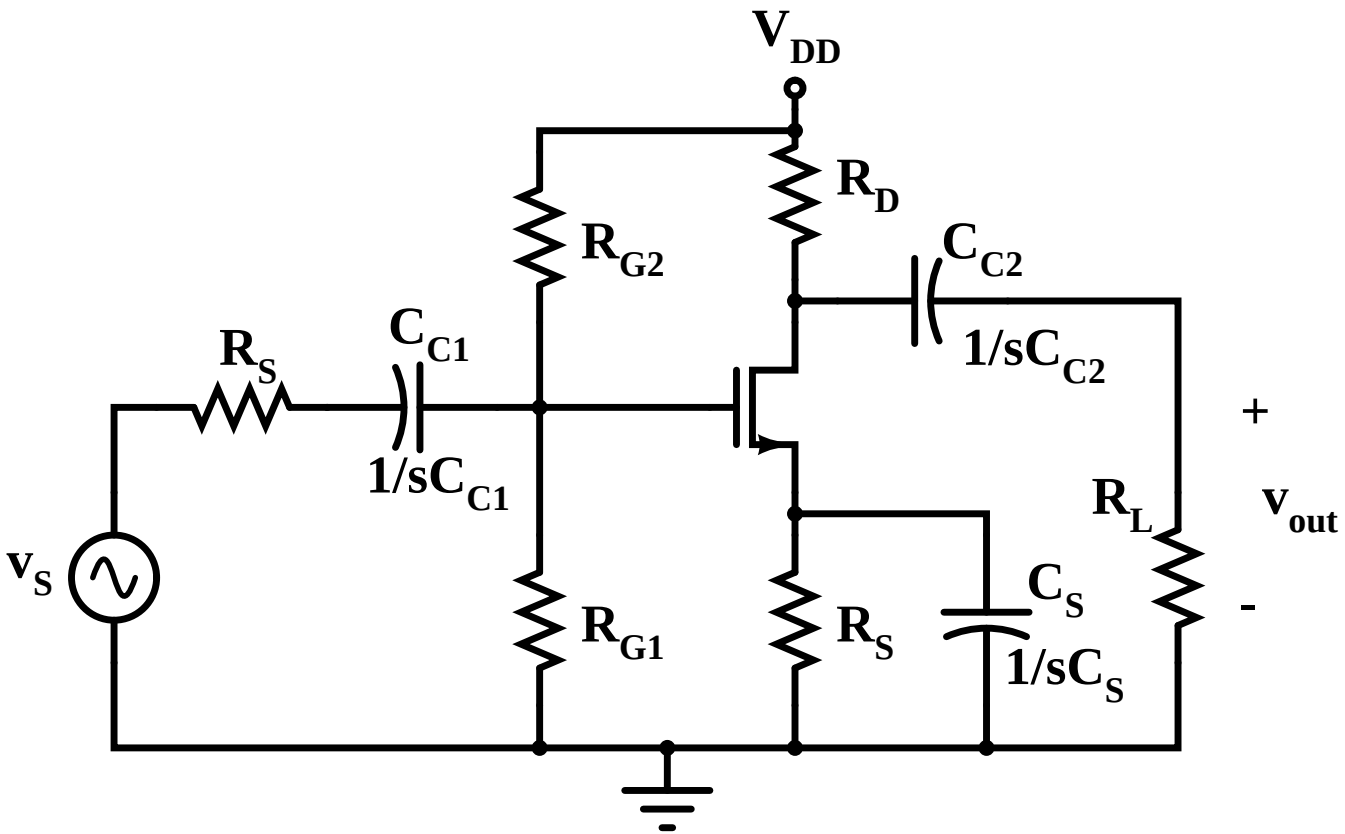
Outline

Amplifier Frequency Response

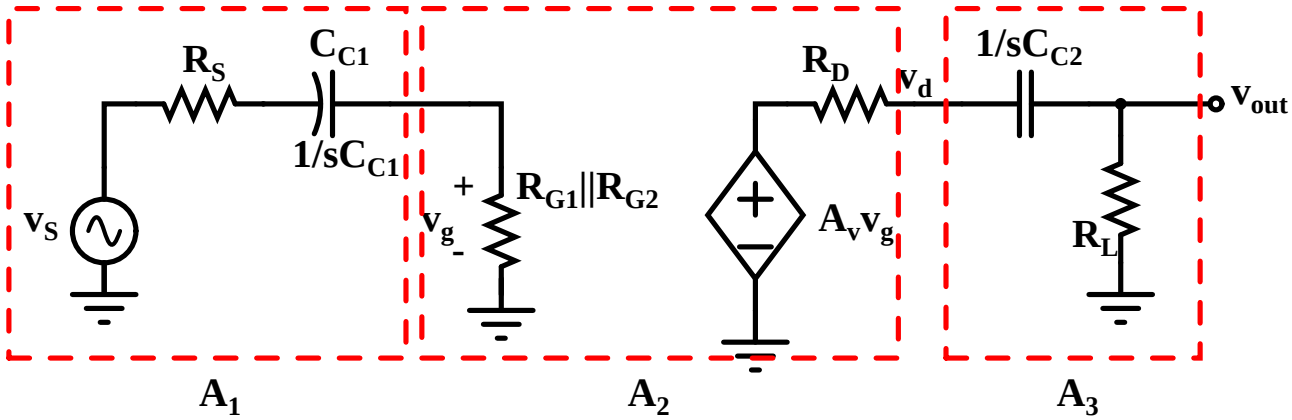
Gain is a function of frequency.
3 frequency bands:

- Low freqs: gain is reduced by coupling and bypass caps
- high freqs: gain is reduced by parasitic caps
- mid freqs: gain calculated in electronics 1

Common Source Amplifier

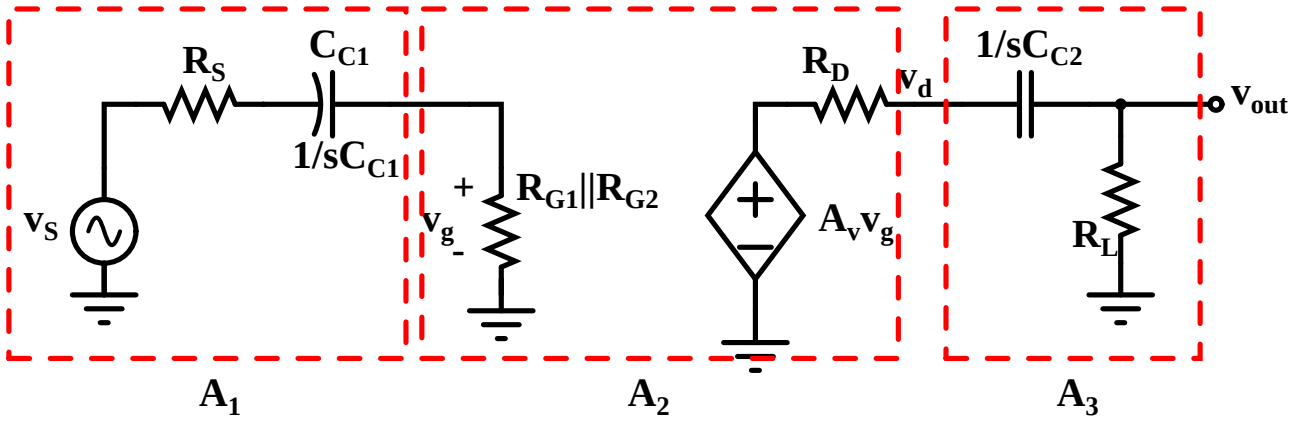


Common Source Amplifier



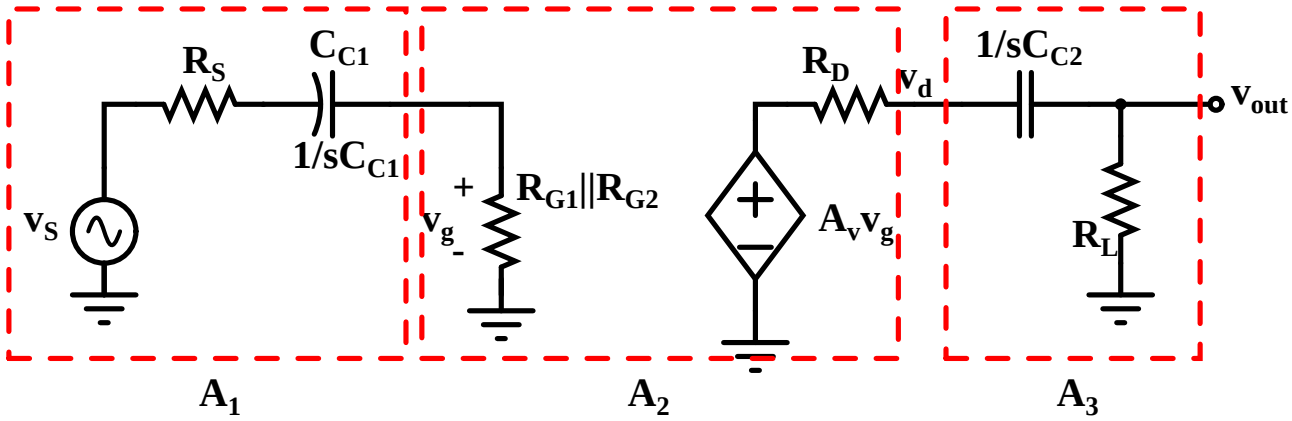
AC equivalent circuit.

$$A_v = A_1 A_2 A_3 = \frac{v_g}{v_s} \times \frac{v_d}{v_g} \times \frac{v_{out}}{v_d}$$



AC equivalent circuit.

$$A_1 = \frac{v_g}{v_s} = \frac{R_G}{R_{TH} + R_G} \times \frac{s}{s + \frac{1}{C_{C1}(R_S + R_G)}}$$



AC equivalent circuit.

$$A_3 = \frac{v_{out}}{v_d} = \frac{R_L}{R_L + R_D} \times \frac{s}{s + \frac{1}{C_L(R_L+R_D)}}$$

$$
\begin{aligned}
A_v &= A_1 A_2 A_3 = \frac{v_g}{v_s} \times \frac{v_d}{v_g} \times \frac{v_{out}}{v_d} \\
A_1 &= \frac{R_G}{R_{TH} + R_G} \times \frac{s}{s + \frac{1}{C_{C1}(R_S + R_G)}} \\
A_3 &= \frac{R_L}{R_L + R_D} \times \frac{s}{s + \frac{1}{C_L(R_L + R_D)}}
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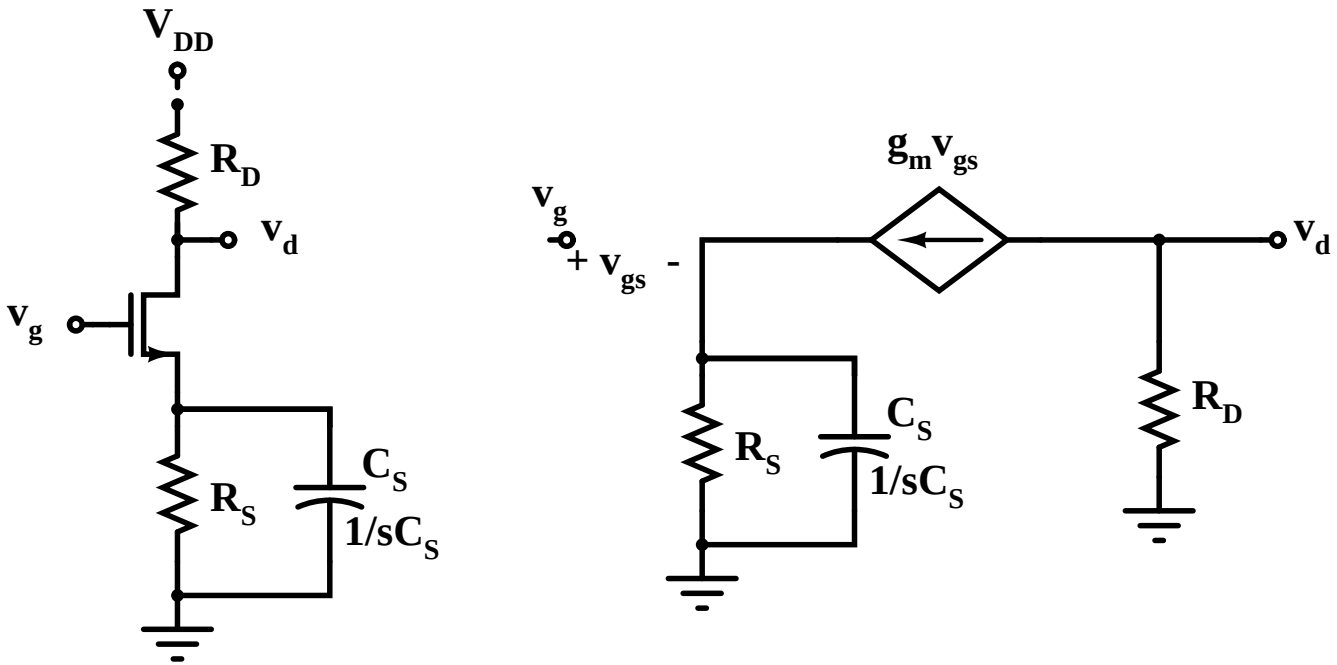
A_3 &= \frac{R_L}{R_L + R_D} \times \frac{s}{s + \frac{1}{C_L(R_L + R_D)}}
\end{aligned}
$$

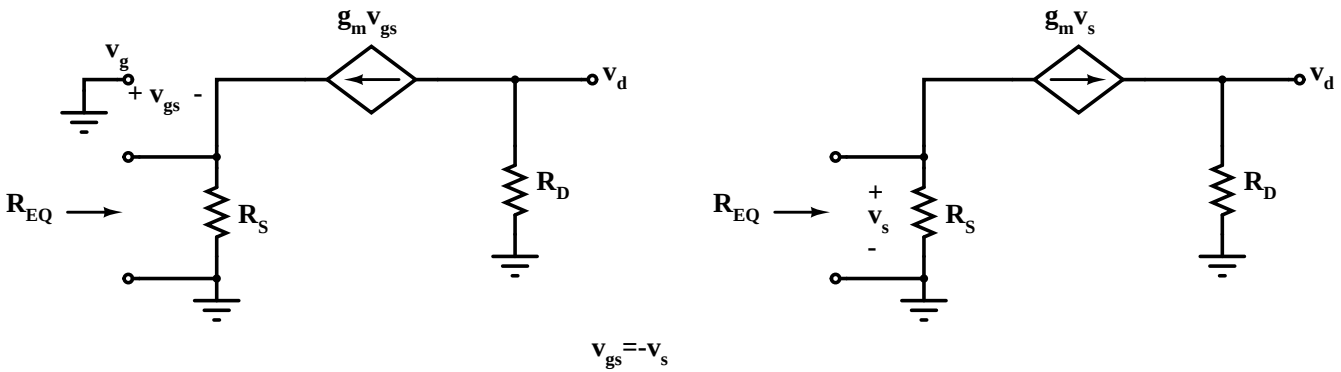
$$
\boxed{f_{pole} = \frac{1}{2\pi R_{EQ} C}}
$$

Bypass Capacitor



AC equivalent circuit with bypass cap.

$$R_{EQ} = R_s \parallel \frac{1}{g_m} = \frac{R_s}{1 + g_m R_s}$$



Resistance seen by bypass capacitor.

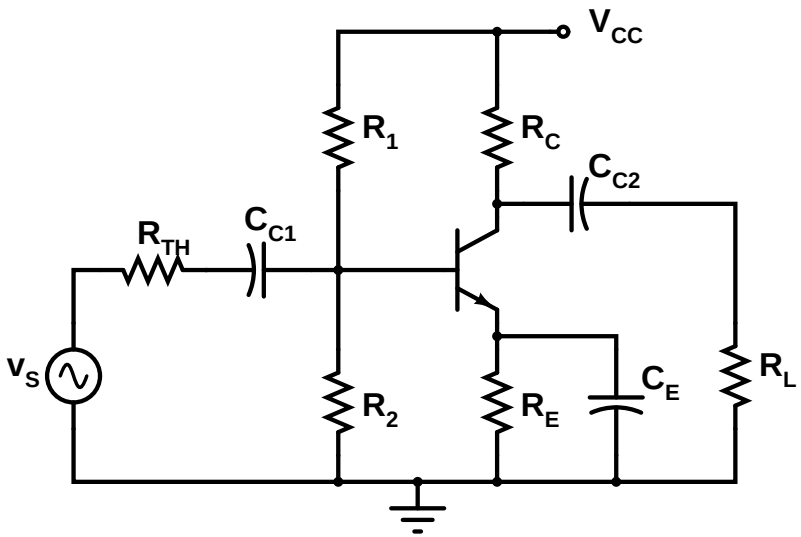
Approximate method

Used to find low-frequency poles. Also called the *short-circuit time-constant method*.

- For each cap
  - find resistance R_{EQ} seen by cap, with all other caps replaced by short circuits.
  - calculate pole frequency from $\omega_p = \frac{1}{CR_{EQ}}$
- for bypass cap use R_{EQ} in parallel with cap to find freq. of zero
- Find dominant low-frequency pole from:

$$\omega_L = \sum_{i=1}^{n} \omega_{L_n}$$

CE Stage



Find the poles and zeros using the simplified method.