High Frequency Model

\[ \omega \uparrow \Rightarrow \frac{1}{j \omega C} \downarrow \]

\[ \Rightarrow V_{ab} \downarrow \]

\[ \Rightarrow V_{out} \downarrow \]

High-frequency fall of voltage gain
Low-pass filter

Example: Single-pole circuit

\[ R_s \xrightarrow{\downarrow} Z_{ab} \]

\[ V_s \]

\[ R_s \]

\[ C_{in} \]

\[ R_{in} \]

\[ V_{out} \]
Single-pole circuit (High Freq.)

\[ A_{vs} = \frac{Z_{ab}}{Z_{ab} + R_s} \cdot A \cdot \frac{R_L}{R_L + R_{out}} \]

\[ Z_{ab} = \frac{R_{in}}{1 + j\omega C_{in} R_{in}} \]

\[ A_{vs} = \frac{R_{in}}{R_{in} + R_s} \cdot A \cdot \frac{R_L}{R_L + R_{out}} \times \frac{1}{1 + j\omega C_{in} \frac{R_{in} R_s}{R_{in} + R_s}} \]

Let \( f_2 = \frac{1}{2\pi C_{in} \frac{R_{in} R_s}{R_{in} + R_s}} \)

\[ |A_{MB}| \]

\[ f \]

\[ f_2 \]
\[ T_p = C_{in} \left( \frac{R_{in} R_s}{R_{in} + R_s} \right) : \text{short-circuit time constant} \]

\[ C_{ci} \text{ is shorted} \]

\[ \begin{circuitikz}
\draw (0,0) to [short, v] (0,-1) to [short, v] (1,-1) to (1,0) to (0,0); \end{circuitikz} \]

Thevenin equivalent impedance seen by

\[ C_{in} \text{ is } \left( \frac{R_{in} R_s}{R_{in} + R_s} \right) \]

\[ \omega_2 = 2\pi f_2 = \frac{1}{T_p} = \frac{1}{C_{in} \left( \frac{R_{in} R_s}{R_{in} + R_s} \right)} \]
Double-pole circuit

\[ \tau_{p1} = C_{in} \left( \frac{R_{in} R_s}{R_{in} + R_s} \right) \]

\[ \tau_{p2} = C_{out} \left( \frac{R_{out} R_L}{R_{out} + R_L} \right) \]

\[ A_{VS} = \frac{R_{in}}{R_{in} + R_s} A \frac{R_L}{R_L + R_{out}} \]

\[ \frac{1}{1 + \frac{j f}{2 \pi \tau_{p1}}} \cdot \frac{1}{1 + \frac{j f}{2 \pi \tau_{p2}}} \]

\[ f_2 = \frac{1}{2 \pi \tau_{p1}} \quad , \quad f'_2 = \frac{1}{2 \pi \tau_{p2}} \]

Overall higher corner frequency

\[ [1 + \left( \frac{f_2}{f'_2} \right)^2][1 + \left( \frac{f_H}{f'_2} \right)^2] = 2 \]

\[ f_H^4 + \left( f_2^2 + f'_2^2 \right) f_H^2 - f_2^2 f'_2^2 = 0 \]
Approximation for $f_H$

1. For each internal parasitic capacitors $C_i$,
   
   Determine $R_{eff}$ seen by $C_i$
   
   assuming that other int. parasitic capacitors are open
   
   Calculate $\tau_i = R_{eff} \cdot C_i$

2. Approximate $\omega_H = \frac{1}{\tau_1 + \tau_2 + \ldots}$
   
   $< \text{true higher corner freq.}$

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Approximation for $AVS$

$$AVS = \text{AMB} \cdot \frac{1}{1 - j\frac{f}{f_H}} \cdot \frac{1}{1 + j\frac{f}{f_H}}$$