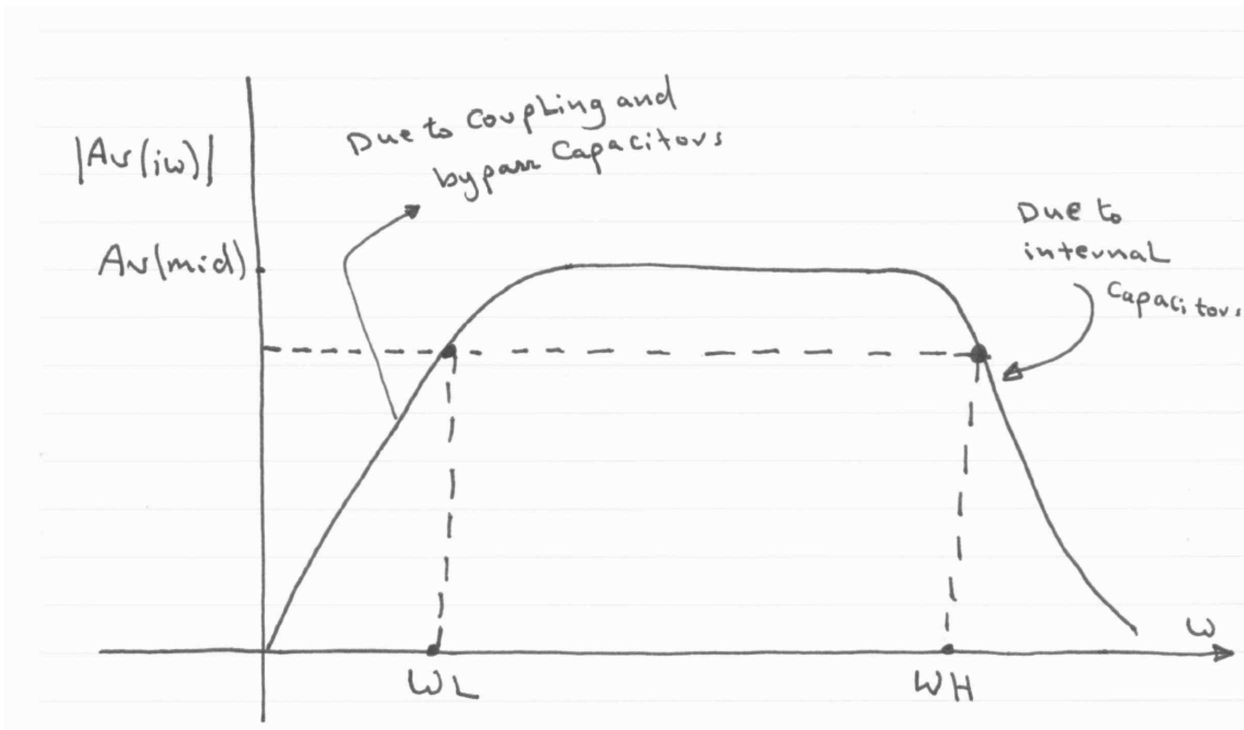
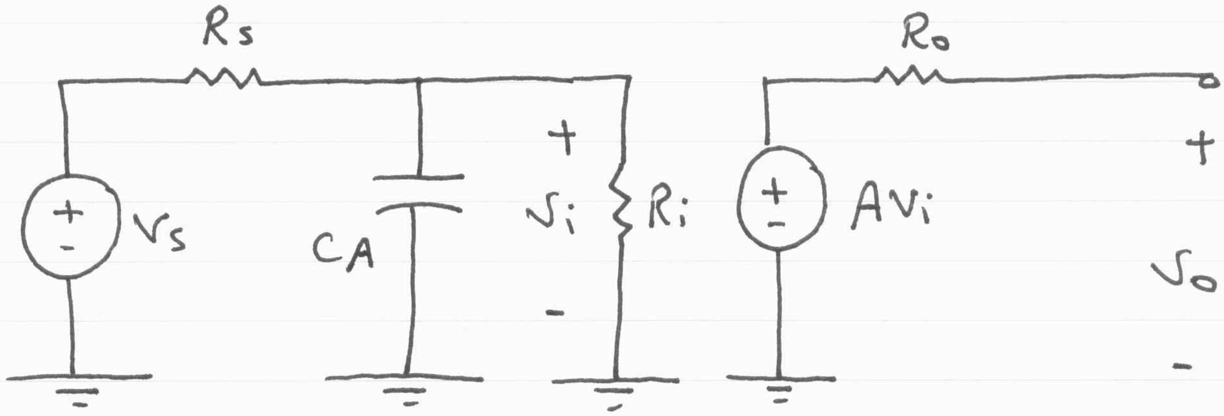
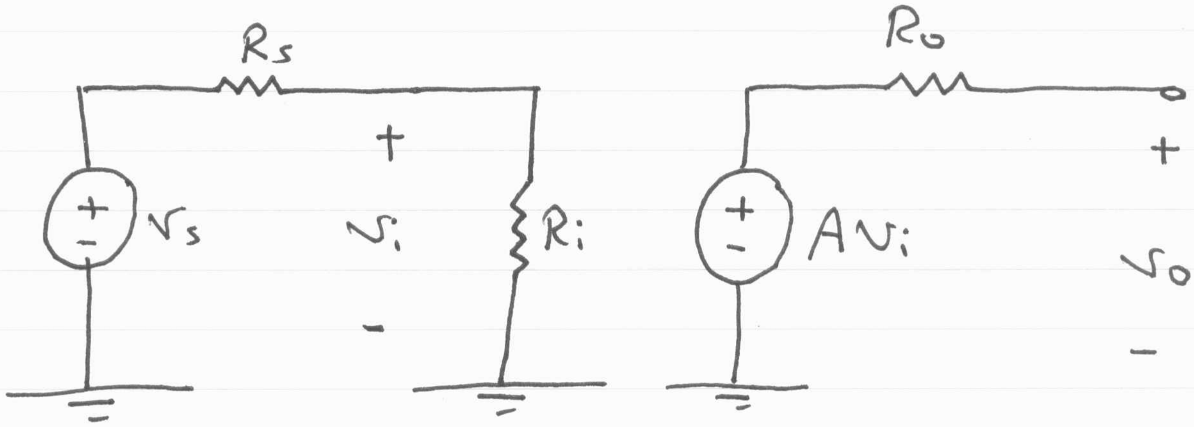
Amplifier frequency response



Shunt Capacitance and the high-frequency Response



1) At midband

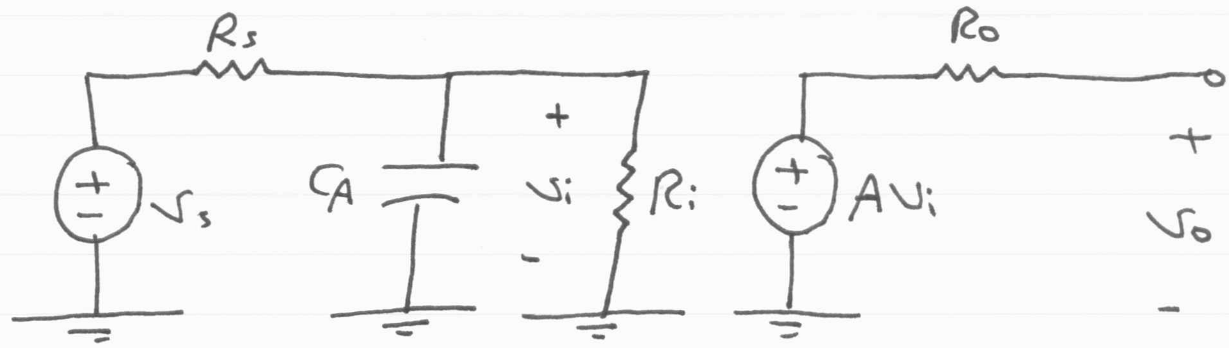


$$v_o = A v_i$$

$$v_i = \frac{R_i}{R_i + R_s} v_s$$

$$\therefore \quad A_v(mid) = \frac{v_o}{v_s} = A \frac{R_i}{R_i + R_s}$$

2) At high frequency



$$\vec{V_o} = A\vec{V_i}$$

$$\vec{V_i} = \frac{R_i \parallel \frac{1}{j\omega C_A}}{R_i \parallel \frac{1}{j\omega C_A} + R_s}\vec{V_s}$$

$$\therefore \quad A_v(j\omega) = \frac{\vec{V_o}}{\vec{V_s}} = A\,\frac{R_i}{R_i + R_s}\;\frac{1}{1 + j\omega C_A(R_s \parallel R_i)}$$

$$\therefore \quad A_v(j\omega) = A_v(\text{mid})\;\frac{1}{1 + j\omega C_A(R_s \parallel R_i)}$$

$$|A_v(j\omega)| = A_v(\text{mid})\;\frac{1}{\sqrt{1 + [\omega C_A(R_s \parallel R_i)]^2}}$$

a) For small ω ; $|A_v(j\omega)| = A_v(\text{mid})$

b) For Large ω ; $|A_v(j\omega)| \approx 0$

c) For $\omega = \dfrac{1}{C_A(R_s \parallel R_i)}$; $|A_v(j\omega)| = \dfrac{A_v(\text{mid})}{\sqrt{2}}$

$$\therefore \quad \omega_H = \frac{1}{C_A\,(R_s \parallel R_i)}$$

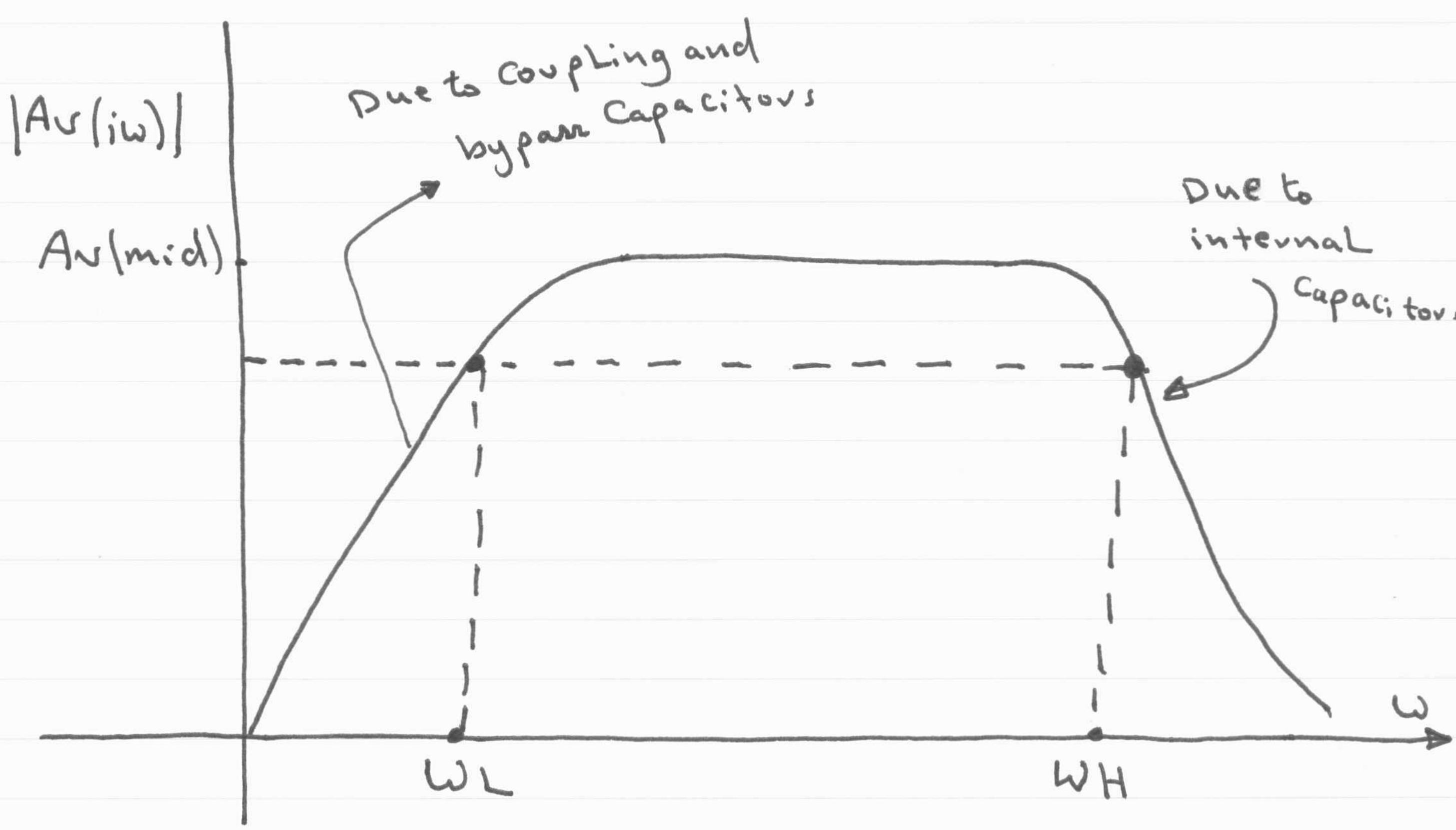
but $$\omega_{CA} = \frac{1}{C_A\, R_{TH}}$$

$$\omega_{CA} = \frac{1}{C_A\,(R_s \parallel R_i)}$$

$$\therefore \quad \omega_H = \omega_{CA}$$

ω_H : The Upper Cutoff frequency of the CKT

ω_{CA} : The Corner frequency of C_A



$$A_v(j\omega) = A_v(mid) \frac{1}{1 + j\omega C_A (R_s \| R_i)}$$

$$\omega_{CA} = \frac{1}{C_A (R_s \| R_i)}$$

$$\therefore \quad A_v(j\omega) = A_v(mid) \frac{1}{1 + \frac{j\omega}{\omega_{CA}}}$$

<u>If we have two internal Capacitors :</u>

$$A_v(j\omega) = A_v(mid) \frac{1}{\left(1 + \frac{j\omega}{\omega_A}\right)\left(1 + \frac{j\omega}{\omega_B}\right)}$$

if $\omega_A = 1\,Mr/s$, and $\omega_B = 5\,Mr/s$

$\therefore \quad \omega_H = 0.964\,Mr/s$

$\therefore$ if $\omega_A < \omega_B$; $\omega_H < \omega_A$

$$A_v(j\omega) = \frac{A_v(\text{mid})}{\left(1+\frac{j\omega}{\omega_A}\right)\left(1+\frac{j\omega}{\omega_B}\right)}$$

assuming $\omega_A < \omega_B$

$$\left|A_v(j\omega_H)\right| = \frac{A_v(\text{mid})}{\left|\left(1+\frac{j\omega_H}{\omega_A}\right)\left(1+\frac{j\omega_H}{\omega_B}\right)\right|} = \frac{A_v(\text{mid})}{\sqrt{2}}$$

$$\therefore \quad \left|\left(1+\frac{j\omega_H}{\omega_A}\right)\left(1+\frac{j\omega_H}{\omega_B}\right)\right| = \sqrt{2}$$

Since $\omega_H < \omega_A$, and $\omega_H << \omega_B$

$$\therefore \quad \frac{j\omega_H}{\omega_B} \longrightarrow 0$$

$$\left|\left(1+\frac{j\omega_H}{\omega_A}\right)\right| = \sqrt{2}$$

$$\sqrt{1+\left(\frac{\omega_H}{\omega_A}\right)^2} = \sqrt{2}$$

$$\therefore \quad \omega_H = \omega_A \qquad \text{(upper Limit)}$$

$$\left| \left(1 + \frac{j\omega_H}{\omega_A}\right)\left(1 + \frac{j\omega_H}{\omega_B}\right) \right| = \sqrt{2}$$

$$\left| 1 + j\omega_H \left(\frac{1}{\omega_A} + \frac{1}{\omega_B} \right) - \frac{\omega_H}{\omega_A} \cdot \frac{\omega_H}{\omega_B} \right| = \sqrt{2}$$

Since $\dfrac{\omega_H}{\omega_A} < 1$; and $\dfrac{\omega_H}{\omega_B} << 1$

$$\therefore \quad \frac{\omega_H}{\omega_A} \cdot \frac{\omega_H}{\omega_B} <<< 1$$

$$\left| 1 + j\omega_H \left(\frac{1}{\omega_A} + \frac{1}{\omega_B} \right) \right| = \sqrt{2}$$

$$\therefore \quad \omega_H = \frac{1}{\dfrac{1}{\omega_A} + \dfrac{1}{\omega_B}}$$

(Lower Limit)

$\therefore$ if $\omega_A < \omega_B$

$$\frac{1}{\frac{1}{\omega_A} + \frac{1}{\omega_B}} < \omega_H < \omega_A$$

if $\omega_A = 1\,\mathrm{Mv/s}$, $\omega_B = 5\,\mathrm{Mv/s}$

$\omega_H \equiv 0.964\,\mathrm{Mv/s}$

$$\frac{1}{\frac{1}{\omega_A} + \frac{1}{\omega_B}} < \omega_H < \omega_A$$

$$0.83\,\mathrm{Mv/s} < \omega_H < 1\,\mathrm{Mv/s}$$

$$0.83\,\mathrm{Mv/s} < 0.964\,\mathrm{Mv/s} < 1\,\mathrm{Mv/s}$$