We have looked at the frequency response of C-S, C-E Amplifiers, today we will look at the frequency response of other linear Amplifiers.

1. Common Collector Amplifier: (C-B will be equivalent, with different \( \beta \), \( V_{in}, V_{out} \), etc.)

We can try to do the small signal circuit of the left by translating every element to its linear model, but it is much easier to directly use the two port models (Lect. 18).

With the two port model, we need to identify the input, output, etc., so we can add capacitors:

From Lect 19, we find:

\[
R_i = r_e + (\beta + 1) r_e' = r_e + (\beta + 1) (\frac{V_{oc}}{C_v} C_v + r_e) \\
R_o = \frac{r_e + r_e'}{\beta + 1} = \frac{r_e + r_e'}{\beta + 1} \\
A_v \approx 1
\]

Now \( C_{12} \) is in the input/output feedback position, use Miller approximation first:
the low freq. (mid band) voltage gain across $C_C$:

$$A_{VC} = \frac{V_{out}}{V_{in}} = \frac{V_{in}}{V_{in}} \cdot \frac{R_L}{R_L + R_o} = \frac{R_L}{R_L + R_s + \frac{1}{j \omega C_C}}$$

$$\therefore C_M = \left(1 - A_{VC}\right) \cdot C_C = \frac{\frac{R_L}{R_L + R_s + \frac{1}{j \omega C_C}}}{R_L + \frac{1}{j \omega C_C}} \cdot C_C < C_C$$

Use OTC: the $R_{th}$ (net $C_M + C_C$) seen is $R_s || R_i$.

$$\omega_{HI} = \left((R_s || R_i) \cdot (C_M + C_C)\right)^{-1}$$

**Conclusion here: Miller effect reduces the effect of $C_C$ on the frequency response.**

(C-D similar)

Use of C-C. For multistage Amplifiers, can enable high $R_i$, low $R_o$, won't degrade freq. response.

2. **Common base Amplifier** (Common gate analogous)

![Common Base Amplifier Diagram]

Small signal circuit: (Lect.18, Slide 20)

Identify input (collector), output (collector) and s.s. common (g base), and add capacitors.

In this case, no capacitor in the feedback position, no need for Miller Approximation

Use OTC:

1. $C_M$: $R_{th} = R_s || R_i$, if $R_s$ is large, $\gg R_i$, $R_{th} \approx R_i = \frac{1}{j \omega C_M}$, $C_M = \frac{C_C}{g_m}$

2. $C_C$: $R_{th} = \frac{R_o}{R_L}$

If $R_o \gg R_L$, $R_{th} \approx R_L$

$$\Rightarrow \omega_{HI} = \frac{1}{\frac{C_C}{g_m} + g_m R_L} \quad \text{if} \quad R_L < \frac{1}{j \omega C_C}, \quad \omega_{HI} \rightarrow \frac{g_m}{C_C} \quad \text{(close to $f_T$ of the device)}$$

$$\Rightarrow \text{good frequency response}$$

Recall freq. response of CS:

\[ V_{out} = \frac{V_s}{sC_{gs1} + g_m V_{gs1}} \]

Due to Miller effect, \( C_{gd} \) multiplied by voltage gain, limit the frequency response.

Now combined with C-B stage:

\[ \frac{V_{out}}{V_{in}} \approx \frac{1}{g_m} \] (typically MOSFET \( g_m < g_m \), \( |A_{gd1}| < 1 \))

Because of the presence of \( R_i \) for the C-B stage, the voltage gain across \( C_{gd} \) is much reduced, \( \Rightarrow \) better for frequency response.

(C-S gain without Miller effect penalty)

Use OCTC:

1. \( g_{ds1} + C_i \), \( R_{th} = R_s \)
2. \( g_m \cdot \frac{V_{gs1}}{V_{ds1}} \approx \frac{1}{A_{gd1}} \)
$C_{p_2} : R_{0\parallel R_L} \approx R_L$

\[ \therefore \quad \omega_{\text{HI}} = \frac{1}{R_s \left( C_{gs} + C_{gd} \left( 1 + \frac{g_m}{g_m} \right) \right) + \frac{g_m}{g_m^2} + \kappa \epsilon R_L} \]