# Electronics 236, L22, Part1 & 2 Amp. Freq. Response

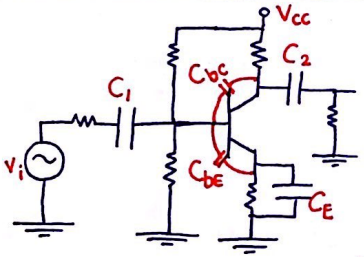
**Amplifier Frequancy Response :** Magnitude freq Response **only**!

- we will consider the Impedance of Capacitor ($\frac{1}{j\omega C}$) when Finding Av of BJT & FET amplifiers.

- The Bandwidth of Amplifiers must cover the entire range of frequency of Intrest.

- Depanding of **nature of signals to be amplified**, different requirments (BW) is imposed on Amplifiers
  Band width

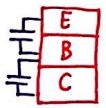
- Amplifier frequency response Is defined by external & Internal amplifier Caps & Impedence.




$C_1, C_2, C_E$ ← External Caps "physical Caps"

$A_V|_{C_1, C_2, C_E \text{ "Short Circuit"}}$

(But, Internal Caps) بالسبيو فاراد

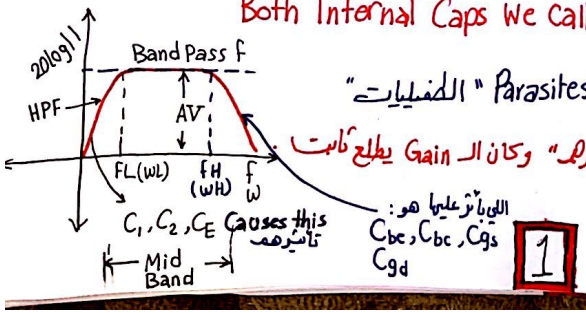



// PCB, mother boards
Between traces "Conducters"

Both Internal Caps we call **stray** or **Parasitic**

من كلمة "الضفيليات" Parasites

كنا نخليهم "نعتبرهم" open وكان الـ Gain يطلع كابت

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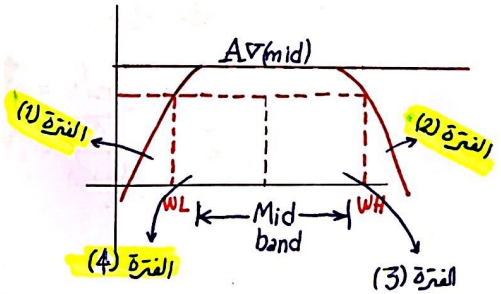
إذا طُلِب منا نطلع $A_{V_{mid}}$ بنحط الـ Caps ($C_1, C_2$ & $C_E$) ⇐ Short
و " " الـ Caps ($C_{bc}, C_{bE}$) ⇐ open

Band width ≡ Mid Band ⇒ هي المنطقة اللي ضمنها الـ Amplif يمرر الـ Components بدون ما يعمل Attenuation "تقليل تأثير" بعمل Amplification

$F_L$ & $F_M$ ⇒ $\frac{\text{Maximum}}{\sqrt{2}}$




- Corner (cut-off) frequancy
- $A_V(jw_L) = \frac{Av(mid)}{\sqrt{2}}$
- $A_V(jw_H) = \frac{Av(mid)}{\sqrt{2}}$
- $W_H - W_L = BW$
- Mid band $\cong 10 w_L - 0.1 * w_H$ // this is the range for which $C_1, C_2$ & $C_E$ were considered short & $C_{gs}, C_{be}, C_{gd}, C_{bc}$ where considered open

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Impedence of capacitor → $X_C = \frac{1}{2\pi fc}$

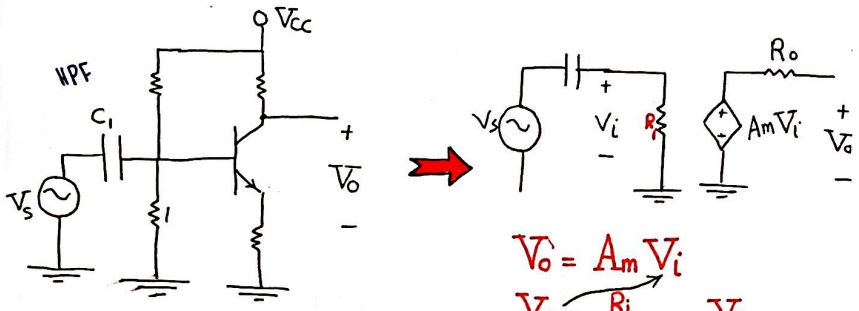
$Z_C = \frac{1}{jwc}$

1 for $f < f_L \rightarrow X_{C1}, X_{C2}, X_{CE} > 0$ & connot be concidered short as was done In L11 & L9

2 for $f > f_H \rightarrow$ Parasitic Caps (in pF) cannot be considered open as $X_{Cbe}, X_{Cbc}$ $X_{Cgd}$ & $X_{Cgs}$

- الفكرة انو اذا بحكي عن الفترة(1) معناته لازم نرجع $C_1, C_2, C_E$ والبقية open .
- " " " " الفترة(2) معناته لازم نخلي $C_{bc}, C_{gd}, C_{gs}, C_{be}$ Short والباقي open .
- اما بالفترة (3) اللي اسمه BW بكون للـ $C_1, C_2, C_E$ سوريت و open ↑ .
- اما بالفترة (4) بكون $C_1, C_2, C_E$ open و الباقي شورت.

# Series Capacitance & $w_L$




$$V_o = A_m V_i$$

$$V_i = \frac{R_i}{R_i + \frac{1}{jwc}} \cdot V_s$$

$$\frac{V_o}{V_s} = \frac{A_m R_i}{R_i + \frac{1}{jwc}} \quad , A_m \equiv A_V(mid)$$

$$|A_V(jw)| = \frac{A_m R_i}{R_i^2 + \left(\frac{1}{wc_1}\right)^2} \quad , \quad 1 \Leftarrow \frac{1}{wc}$$ نعوض حل صون ضرب

$w_{c1} = \frac{1}{R_i C_1}$ ← Cut-Off due to C1 "مش ضرب"

$$A_V(jw) = \frac{A_m}{\sqrt{1 + \left(\frac{wc_1}{w}\right)^2}}$$

HPF

- Let $A_m = 1$, $w = w_{c1} \rightarrow |\ | = \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} \Rightarrow 20\log\frac{1}{\sqrt{2}} = -3dB$
- Let $w = 0.1\, w_{c1} \rightarrow |\ | = \frac{1}{\sqrt{1+100}} \cong 0.1 \Rightarrow 20\log 0.1 \cong -20dB$

1. If only $C1 \rightarrow wc_1 = wL$
2. If $C_1$ & $C_2 \rightarrow w_L$ ?

$$A(jw) = A_m\left(\frac{1}{1 + \frac{wc_1}{jw}}\right)\left(\frac{1}{1 + \frac{wc_2}{jw}}\right)$$

$$|A(jw)| = \dots$$

$$|A(jw_L)| = \frac{A_m}{\sqrt{2}} = \dots$$

→ Solving for $w_L$ :

$$(w_L)^2 = \frac{wc_1^2 + wc_2^2}{2} + \frac{\sqrt{wc_1^4 + 6wc_1^2 wc_2^2 + w_{c2}^2}}{2}$$

حل من تفكيك الاقواس وعمل الـ Magnitude للمقدار (evaluation for $w_L$) ومساواة الـ

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1) $w_{c1}$ = 616 rad/sec
$w_{c2}$ = 17.86 rad/sec
$w_{c3}$ =
$w_L$ = 616.5 rad/sec

2) $w_{c1}$ = 200 rad/sec
$w_{c2}$ = 750 rad/sec
$w_L$ = 798 rad/sec

$w_L > \max(jw's)$ حتى لو شوما كان عدد الـ Caps // $\Sigma w's > w_L$

$$\Sigma w_s' \geq w_L \geq \max(w's)$$

1 Calculate each Wc alone.

$$w_{c_1} = \frac{1}{C_1 R_{eq1}}$$ ← اللي بشوفها Cap(1) الـ

$$w_{c_2} = \frac{1}{C_2 R_{eq2}}$$ ← اللي بشوفها Cap(2)

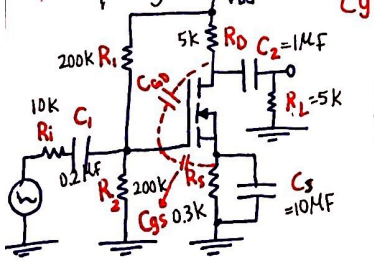
2 Estimate $w_L$:

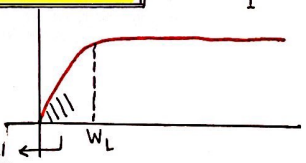
Max of w's $\leq w_L \leq$ sum of w's

## L.22, Part2 / Amplifer Frequency Response

Example

Low frequancy $W_L$ ? → Cgd, Cgs > open




$C_2, C_S$ "SC" ← $1/C_1 R_{eq(C_1)} = W_{C1}$
$C_1, C_S$ "SC" ← $1/C_2 R_{eq(C_2)} = W_{C2}$
$C_1, C_2$ "SC" ← $1/C_S R_{eq(C_S)} = W_{C3}$

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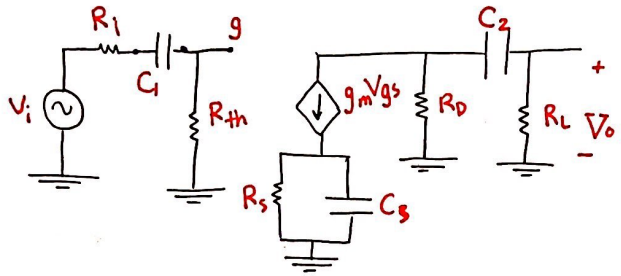
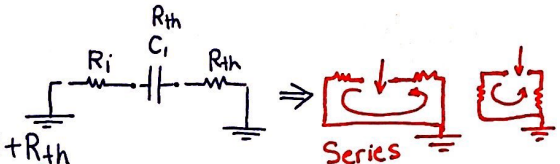
# Ac ss Low Frequency Eq. Circuit




**1** $W_{C1} = \frac{1}{C_1 R_{eq}(C_1)}$

$R_{eq}(C_1) = R_{th}\big|_{\text{Seen by } C_1} = R_{th}\big|_{V_i=0} = R_i + R_{th}$

kill Indep. Sources

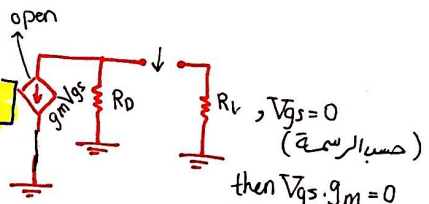



$W_{C1} = 45.45$ rad/sec

**2** $W_{C2} = \frac{1}{C_2 R_{eq}(C_2)} \Rightarrow$ [$C_1, C_s \Rightarrow$ Short]

$R_{eq}(C_2) = R_D + R_L$

$W_{C2} = 100$ rad/sec




$R_L$, $V_{gs} = 0$ (حسب السعة)

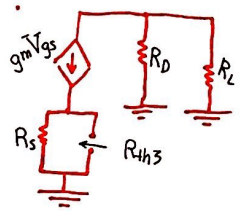
then $V_{gs} \cdot g_m = 0$ "open"

**3** $W_{CS} = \frac{1}{C_s R_{th}(3)} \Rightarrow$ [$C_1, C_2 \Rightarrow$ Short]

$R_{th}(3) = R_s \,//\, \frac{1}{g_m}$

$r_{ds} \to \infty$

$W_{CS} = 1050$ rad/sec




$W_{C1} = 45.45$ rad/sec
$W_{C2} = 100$ rad/sec
$W_{CS} = 1050$ rad/sec

max $< W_L <$ ~~max~~ Sum

$1050 < W_L < 1195.45$

## Design for Certain $W_L$ ← given "1000 rad/sec"

$$\max(w's) \leq W_L \leq w_1 + w_2 + \dots w_n$$

assume $W_L = W_{C1} + W_{C2} + W_{CS}$

[تبدا نقسم الـ 1000 على 3Caps لبس مش بالتساوي]

### [Design Criteria]

$$W_{CE} \text{ or } W_{CS} = \left(\frac{70}{100} - \frac{80}{100}\right) W_L = (0.7 - 0.8) W_L$$

بتوخد اكبر حصة زي ماشفنا بالمثال السابق

$$W_{C_1} = W_{C_2} = (0.1 - 0.15) W_L$$

$$\Sigma = W_L$$