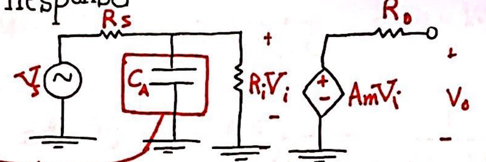
Shunt Caps & high Frequancy Response

بين G و S
اوبين B و E



$V_o = A_m V_i$, Am Gain @ mid band

$$V_i = \frac{R_i // \frac{1}{j\omega C_A}}{R_i + \frac{1}{j\omega C_A} + R_s} \times V_s$$

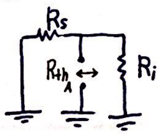
$$A(j\omega) = A_m \left(\frac{R_i}{R_i + R_s}\right) \cdot \left(\frac{1}{1 + j\omega C_A (R_s // R_i)}\right)$$

$$|A(j\omega)| = A_m \frac{R_i}{R_i + R_s} \frac{1}{\sqrt{1 + [\omega C_A R_s // R_i]^2}} \quad ; \text{ @ } \omega = \omega_{CA}$$

$$\therefore \left|A(j\omega_{CA})\right| = \underbrace{A_v(mid)}_{A_m \frac{R_i}{R_i + R_s}} \frac{1}{\sqrt{2}}$$

$\therefore \rightarrow \omega_{HCA} (R_s // R_i) = 1 \Rightarrow \omega_H = \frac{1}{C_A (R_s // R_i)}$ ← high freq. Corner freq.

$(R_s // R_i) \equiv R_{th_A} \Big|_{V_s = 0}$ thevenin's Impedence seen by CA



Parallel

[For $A_v(mid) = A_m = 1$]

@ $\omega = \omega_{CA} \rightarrow 20\log|\ | = 20\log \frac{1}{\sqrt{2}} = -3\,dB$

@ $\omega = 10\omega_{CA} \rightarrow 20\log 10 = -20\,dB$

$\therefore$ This is LPF

Notes

1. If there is one Cap of this type we find $W_{CA} = \frac{1}{R_{thA} C_A}$; & $w_H = W_{CA}$

2. If there is two Caps C_A & C_B ➡ $A(jw) = Av(mid) \frac{1}{(1+\frac{jw}{WCA})} \cdot \frac{1}{(1+\frac{jw}{WCB})}$

➡ To find w_H "على فرض انهم لا توالي ولا توازي _ بعاد عن بعض" LPF

$$|A(jw_H)| = \frac{Am(mid)}{\sqrt{2}} = \frac{Av(mid)}{\left|\sqrt{(1+\frac{jw}{WCA})(1+\frac{jw}{WCB})}\right|}$$

By solving For $|A(jw_H)|$ @ $w = w_H$, we get an approximate experssion to Evaluate W_H

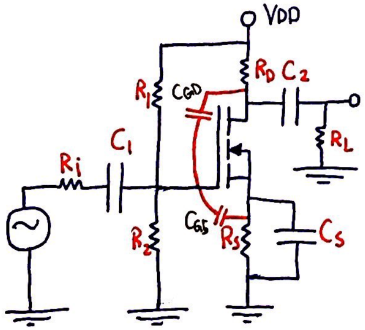
- Assuming $W_{CA} > W_{CB}$

$$1/\left(\frac{1}{WCA}+\frac{1}{WCB}\right) < W_H < W_{CB}$$

$$\frac{WCA \cdot WCB}{WCA + WCB} < W_H < W_{CB}$$

$$\text{lower limit} < W_H < \min(W's)$$

Example _ high Freq. W_H ?



اول سؤال هو شو هي الكاباسترز اللي بيأثروا بقيمة W_H
$[C_{GD}, C_{GS}]$

↳ C_1, C_2, C_s → short

C_{GD}, C_{GS} → are considered one @ a time while all other high freq are open

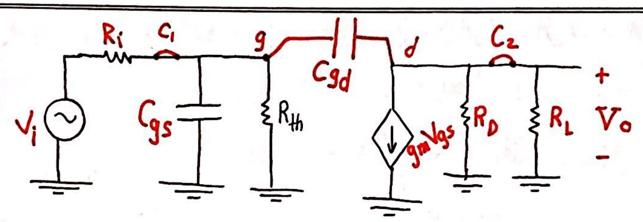
Example - High Freq.

- high Freq. ss Eq. Circuit.
  - ↳ $C_1, C_2, C_s \rightarrow$ Short
  - ↳ $C_{gs}, C_{gd} \rightarrow$ 1 @ a time, while others high freq. open!

- W_H is estimated using Formmula.

$$\frac{1}{\frac{1}{W_{CA}} + \frac{1}{W_{CB}}} \leqslant W_H \leqslant \min(w_n's)$$

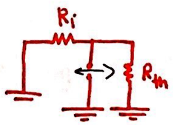
High Freq ss Eq. Circuit



1. Consider C_{gs} (C_{gd} open)

$$W_{cgs} = \frac{1}{C_{gs} R_{gs'}}$$

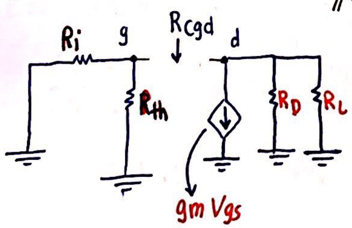
$R_{gs'} \rightarrow$ هي عبارة عن المقاومة اللي بشوفها Cap لما كل الـ Indep. Sources Killed



$$R_{gs}\Big|_{V_i=0} = R_i \,//\, R_{th}$$

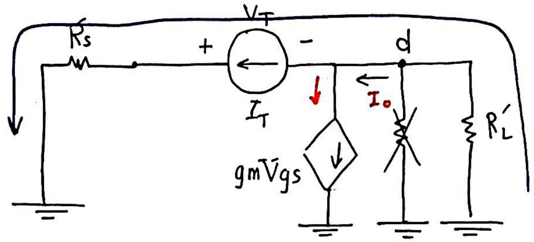
$W_{cgs} = \underline{668.45\,M}$ rad/sec // $(6.28) = 2\pi$ نفس القيمة لو بدنا F بنقسم

2.



بنادخل السيركت على V_T و I_T

$$R_{gd}\Big|_{V_i=0} = \frac{V_T}{I_T}$$



- $I_o = I_T + g_m V_{gs}$
- $V_{gs} = V_g = I_T \times R_s'$
- $I_o R_L' + I_T R_s' = V_T$

$\rightarrow (g_m V_{gs} + I_T) R_L' + I_T R_s' = V_T$

$(g_m I_T R_s' + I_T) R_L' + I_T R_s' = V_T \Rightarrow g_m R_s' R_L' I_T + R_L' I_T + R_s' I_T = V_T$

$I_T (g_m R_s' R_L' + R_L' + R_s') = V_T$

$\therefore \frac{V_T}{I_T} = g_m R_s' R_L' + R_L' + R_s'$

$= R_{gs}$

بالكامل

2. Consider C_{gd} ($C_{gs} \rightarrow$ open)

$W_{gd} = \frac{1}{C_{gd} R_{gd}}$; R_{gd} is calculated using $\frac{V_T}{I_T}$ method.

$W_{gd} = \frac{1}{C_{gd} R_{cgd}} = 48.54 M$ rad/sec.

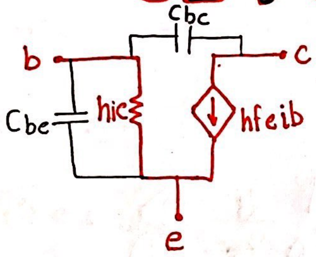
3. Estimation of w_H

$$\frac{668 * 48}{668 + 48} \leqslant w_H \leqslant 48.58 \text{ Mrad/sec}$$

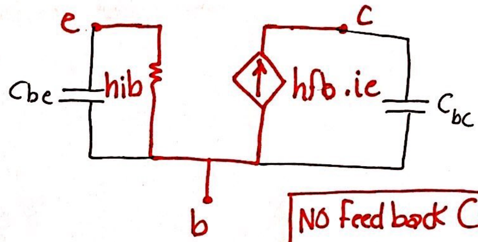
$$[45.25 \leqslant w_H \leqslant 48.58] \text{ M rad/sec}$$

BJTś

CE , CC



CB



NO feed back Cap

$$h_{fe} i_b = h_{fe} \cdot \frac{V_{be}}{h_{ie}}$$

$$= g_m \cdot V_{be}$$

$$\boxed{g_m = \frac{h_{fe}}{h_{ie}}}$$

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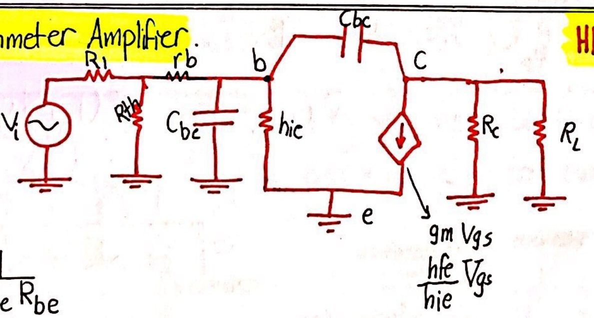
* Common Emmeter Amplifier

* Example

HF ac ss eq. Circuit

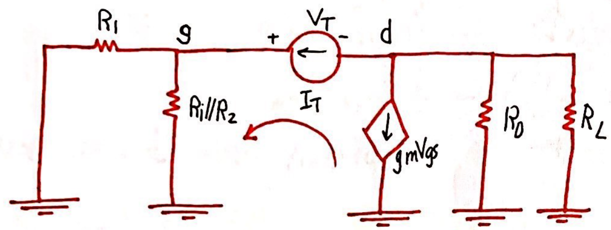


$\boxed{1}$ $w_{be} = \frac{1}{C_{be} R_{be}}$

$$R_{be}\Big|_{V_i=0} = \left([R_1 // R_{th}] + r_b \right)$$

2 Consider C_{gd} ($C_{gs} \to$ open)

$\omega_{gd} = \frac{1}{C_{gd} R_{gd}}$; R_{gd} is Calculated using $\frac{V_T}{I_T}$ method.



; $R_L, R_D, R_L' \to$ Parallel ?

Find ω_H ?

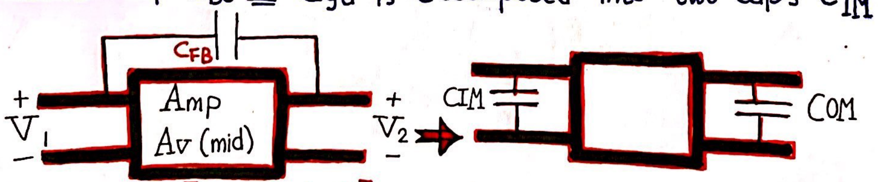
2 ~~choose~~ $\omega_{be} = \frac{1}{C_{be} R_{be}} = \dots$

$R_{be}\Big|_{V=\infty} = R_i // ((R_1 // R_{th}) + r_b)$

Note To Self: FET → has high Freq Response Better than BJT

Miller Theorm: Used in Inverting amplifiers to find ω_H.

- Feedback Cap C_{bc} or C_{gd} is decomposed into two Caps C_{IM} C_{OM}



$C_{IM} = C_{FB}[1 - A_v(mid)]$

$C_{OM} = C_{FB}[1 - \frac{1}{A_v(mid)}]$

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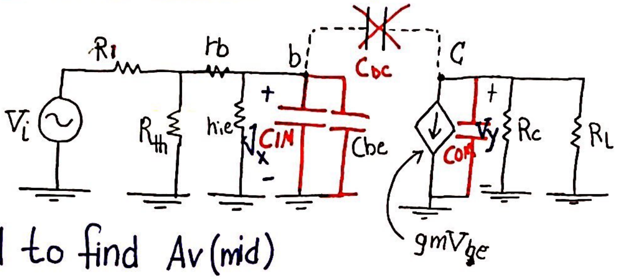


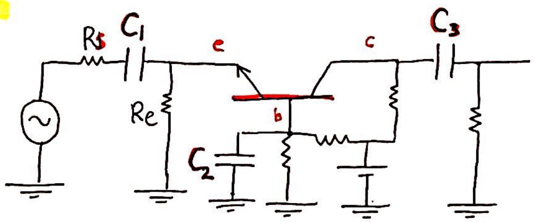
We need to find Av(mid)

- $A_V(\text{mid}) = \dfrac{V_y}{V_x}$, $C_{FB} = C_{bc}$

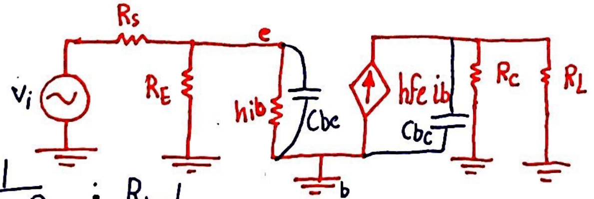
Miller Theorm

- $W_I = \dfrac{1}{(C_{be} + C_{IM})\, R_I}$
- $R_I = R_{be}$ "found earlier" $= (R_1 // R_{th}) + rd$
- $W_o = \dfrac{1}{C_{OM}\, R_o}$; $R_o\big|_{V_i=0} = R_c // R_L$

CB Example



WH



$W_{be} = \dfrac{1}{C_{be} R_{be}}$; $R_{be}\big|_{V_i=0} = R_s // R_E // hib$

$W_{bc} = \dfrac{1}{C_{bc} R_{bc}}$; $R_{bc}\big|_{V_i=0} = R_c // R_L$

$\boxed{7}$ $\dfrac{w_{bc} \times w_{be}}{w_{bc} + w_{be}} \leqslant W_H \leqslant \min(w\text{'s})$

Homework →

Estimate the value of low & high frequency Corner frequencies & Calcultae the mid-range voltage gain of the following Amplifie

Important

$g_m = 1mS$

$C_{gs} = 5PF$

$C_{gd} = 2PF$

$R_1 = 200K\Omega$