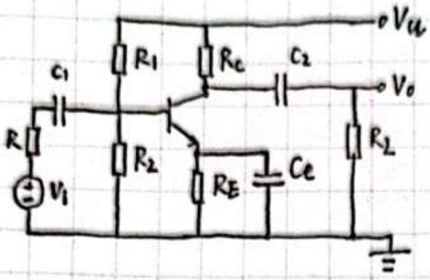
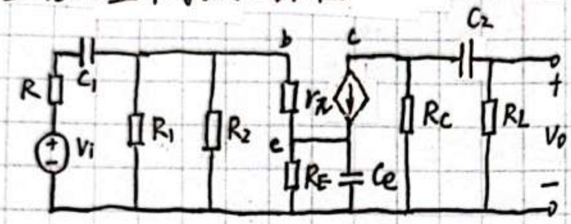
[共射和共源放大器频率响应]

6.2.1 共射和共源放大器的低频响应

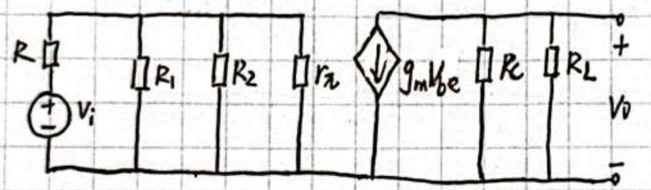
[一. 共射放大器的低频响应]



△先画整个等效电路图:



STEP1: 求中频增益 (C 均短路)



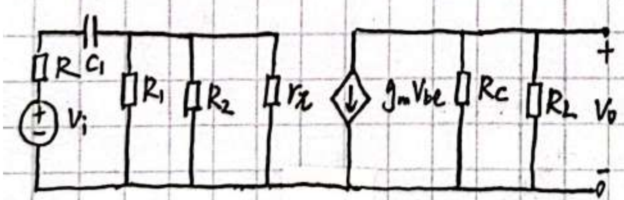
$$A_u = \frac{u_o}{u_i} = \frac{-g_m V_{be}(R_c /\!/ R_L)}{V_{be}} \cdot \frac{R_i}{R+R_i}$$

$R_i = R_1 /\!/ R_2 /\!/ r_\pi$.

STEP2: 分别求解 C:

2-1: C_1 作用. 其他电容短路

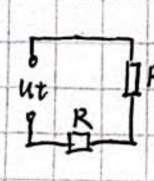
C_1: 高通:



$$A_v = A_M \frac{j w / w_{LC_1}}{1 + j w / w_{LC_1}}$$

$w_{LC_1} \longrightarrow C_1$ 电容
↓
低频截止频率

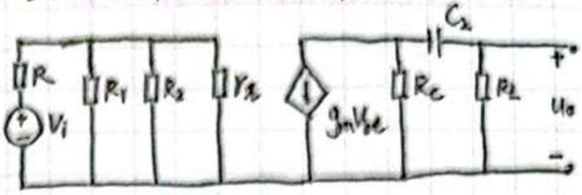
w_{LC_1}: 求 C_1 两端等效电阻. 断开 C_1. 加上 U_t.



$R_{eq} = R + R_i$

$$\therefore w_{LC_1} = \frac{1}{(R+R_i)C_1}$$

2-2: C_2 作用, 其他短路:

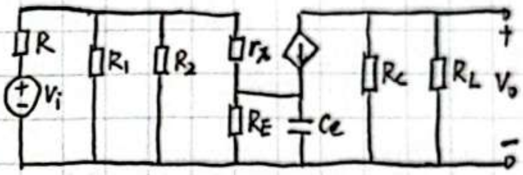


$$A_v = \frac{j w / w_{LC_2}}{1 + j w / w_{LC_2}}$$

$R_{eq} = R_c + R_L \quad w_{LC_2} = \frac{1}{C_2(R_c + R_L)}$

2-3: C_e 作用. 其他短路:

[事实上 C_e 不太影响结果]

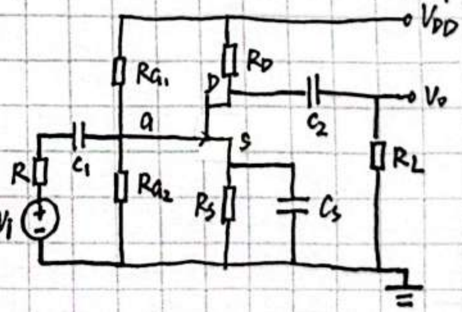


$$\therefore R_E' = R_E + \frac{r_\pi + R_1 /\!/ R_2 /\!/ R}{1+\beta}$$

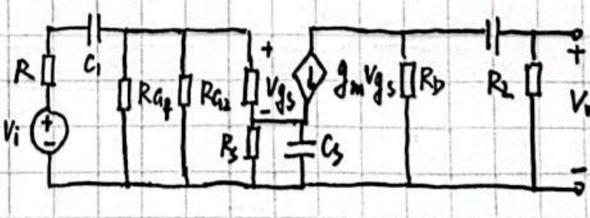
$$w_{LCe} = \frac{1}{R_E' C_e}$$

STEP3: 比较 w_{c_1}, w_{c_2}, 确定主极点, 从而确
低频截止频率

[二. 共源放大器的截止频率]



△先画整个等效电路:

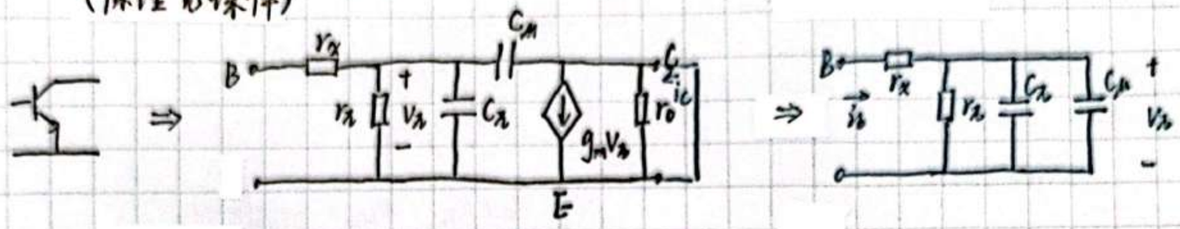


[和 bjt 情况太像了, 略]

6.2.2 共射和共源放大器的高频响应

[一. 晶体管的高频等效电路]

(原理见课件)



此时假设 i_c 为某一恒定值,

$$\therefore \beta=\frac{i_c}{i_b}=\frac{g_mV_\pi}{i_b}=\frac{g_m i_b\cdot\left[r_\pi // \frac{1}{j\omega(C_\pi+C_\mu)}\right]}{i_b}=\frac{g_m r_\pi}{1+j\omega r_\pi(C_\pi+C_\mu)}=\frac{\beta_0}{1+j\omega/\omega_\beta}$$，其中 $\omega_\beta=\frac{1}{r_\pi(C_\pi+C_\mu)}$

$$\begin{cases}20\lg|\beta|=20\lg\frac{\beta_0}{\sqrt{1+(\omega/\omega_\beta)^2}}\\ \varphi=tg^{-1}(\omega/\omega_\beta)\end{cases}$$

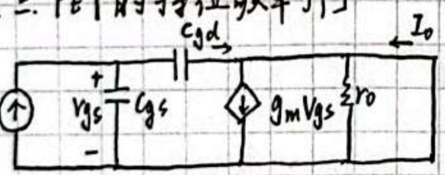
$20\lg\left|\frac{\beta(f)}{\beta(0)}\right|=-3\Rightarrow$ 截止频率 f_β

$20\lg|\beta|=0\quad\Rightarrow$ 特征频率 f_T

[此时 $|\beta|=1$, $\frac{\beta_0}{\sqrt{1+(\omega_T/\omega_\beta)^2}}=1$, $\frac{\beta_0}{\omega_T/\omega_\beta}\approx1.\Rightarrow f_T=\beta_0f_\beta$]

由 $f_\beta=\frac{1}{2\pi r_\pi(C_\pi+C_\mu)}\Rightarrow f_T=\frac{\beta_0}{2\pi r_\pi(C_\pi+C_\mu)}=\frac{g_m}{2\pi(C_\pi+C_\mu)}$

[二. FET的特征频率 f_T]

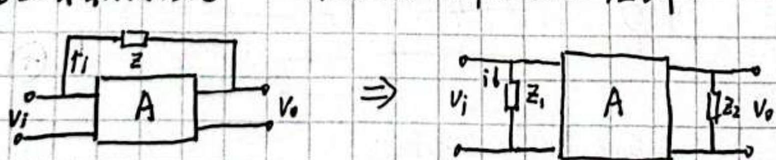


$I_o=g_mV_{gs}-\underbrace{sC_{gd}V_{gs}}_{小,忽略}\approx g_mV_{gs}$

$V_{gs}=\frac{I_i}{s(C_{gs}+C_{gd})}\qquad\therefore\frac{I_o}{I_i}=\frac{g_m}{s(C_{gs}+C_{gd})}$

求解 f_T: $\left|\frac{I_o}{I_i}\right|=\frac{g_m}{\omega(C_{gs}+C_{gd})}$　　令 $|\beta|=\left|\frac{I_o}{I_i}\right|=1\quad\therefore\omega_T=\frac{g_m}{C_{gs}+C_{gd}}$, $f_T=\frac{g_m}{2\pi(C_{gs}+C_{gd})}$

[三. 米勒定理]　(假设A内部无电流:虚断)



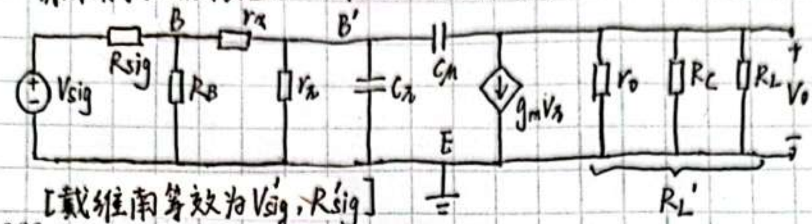
原电路中, $i=\frac{V_i-V_o}{Z}=\frac{V_i-AV_i}{Z}=\frac{V_i}{Z/(1-A)}=\frac{V_i}{Z_1}.\Rightarrow Z_1=\frac{Z}{1-A}$

同理, $Z_2=\frac{A}{A-1}Z$

△ 若跨接电容是C. 易知, $C_1=(1-A)C$, $C_2=\frac{A-1}{A}C\approx C$

[四. 共射放大器的频率响应]

原来的交流模型：（取 $R_B = R_{B1}//R_{B2}$）



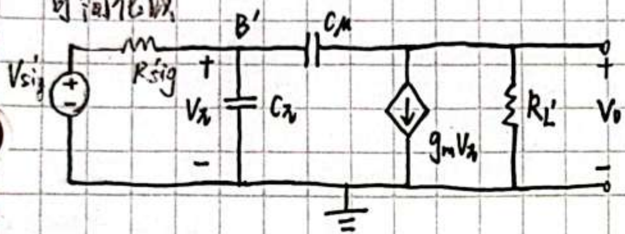
[戴维南等效为 V_{sig}'，R_{sig}']

???

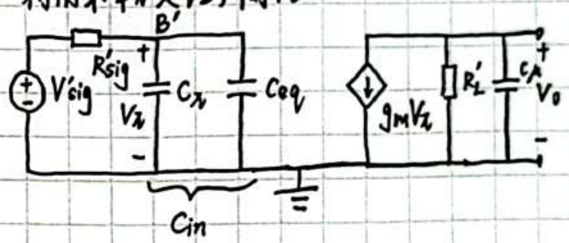
$$V_{sig}' = V_{sig}\cdot\frac{R_B}{R_B+R_{sig}}\cdot\frac{r_\pi}{r_\pi+r_x+(R_{sig}//R_B)}$$

$$R_{sig}' = r_\pi//(r_x+R_B//R_{sig}) \qquad R_L' = r_o//R_C//R_L$$

可简化成



→ 利用米勒定理，简化：



$$A=\frac{V_o}{V_i}=\frac{-g_mV_\pi R_L'}{V_\pi}=-g_mR_L' \qquad \therefore C_{in}=C_\pi+C_{eq}=C_\pi+(1+g_mR_L')C_\mu$$

而 $C_1=(1-A)C=(1+g_mR_L')C_\mu$

又 $\because C_\mu \ll C_{in}$ $\therefore C_{in}$ 对高频截止频率占主导

$\therefore \dfrac{V_o}{V_{sig}} = A_M\cdot\dfrac{1}{1+j\omega/\omega_H}$ 求得 C_{in} 对应的 R_{sig}'，有 $\omega_H=\dfrac{1}{R_{sig}'C_{in}}$

[五. 多级放大电路频率响应]

$$\begin{cases} 20\lg|A_u| = \sum\limits_{k=1}^{n} 20\lg|A_{uk}| \\ \varphi = \sum\limits_{k=1}^{n}\varphi_k \end{cases}$$