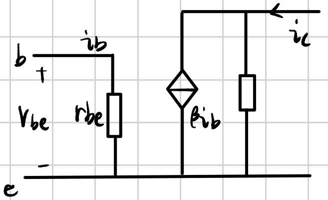
BJT管低频小信号模型

最简模型



只适用于低频小信号条件

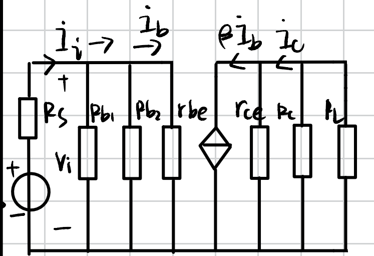
变化量或交流分量

模型中各参数与Q点有关，不是固定常数

$r_{be}=r_{bb'}+(1+\beta)\frac{V_T}{I_{EQ}}=r_{bb'}+\frac{V_T}{I_{BQ}}$，$V_T\approx 26mV$

→ 若是共射，射极上的电阻会降低增益（负反馈作用）

共射极放大电路



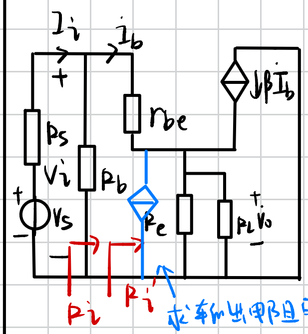
$$\dot{A}_v=\frac{\dot{V}_o}{\dot{V}_i}=\frac{-\beta\dot{I}_b\times R_c//R_L}{\dot{I}_b\cdot r_{be}}=-\frac{\beta R_L'}{r_{be}}$$

$$R_i=\frac{\dot{V}_i}{\dot{I}_i}=\frac{\dot{V}_i}{\frac{\dot{V}_i}{R_{b1}}+\frac{\dot{V}_i}{R_{b2}}+\frac{\dot{V}_i}{r_{be}}}=R_{b1}//R_{b2}//r_{be}$$

信号源短路，此时 $\dot{I}_b=0$，$\beta\dot{I}_b=0$

$$\therefore R_o=\frac{\dot{V}_o'}{\dot{I}_o'}=R_c//r_{ce}\approx R_c \quad (\text{加压法})$$

共集极放大电路



$$\dot{A}_v=\frac{\dot{V}_o}{\dot{V}_i}=\frac{(1+\beta)\dot{I}_bR_L'}{\dot{I}_b[r_{be}+(1+\beta)R_L']}=\frac{(1+\beta)R_L'}{r_{be}+(1+\beta)R_L'}\le 1$$

$(1+\beta)R_L'\gg r_{be}$　$A_v\approx 1$

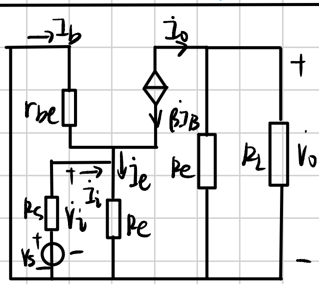
$$R_i'=\frac{\dot{V}_i}{\dot{I}_b}=\frac{\dot{I}_b(r_{be}+(1+\beta)R_L')}{\dot{I}_b}=r_{be}+(1+\beta)R_L'$$

$$R_i=R_i'//R_b$$

$$R_o'=\frac{\dot{V}_o'}{\dot{I}_o'}=\frac{(r_{be}+R_b//R_s)\dot{I}_b}{(1+\beta)\dot{I}_b}$$

$$R_o=R_e//R_o'=R_e//\frac{r_{be}+R_b//R_s}{1+\beta}$$

共基极放大电路



$$\dot{A}_v=\frac{\dot{V}_o}{\dot{V}_i}=\frac{-\beta\dot{I}_bR_L'}{-\dot{I}_br_{be}}=\frac{\beta R_L'}{r_{be}}$$

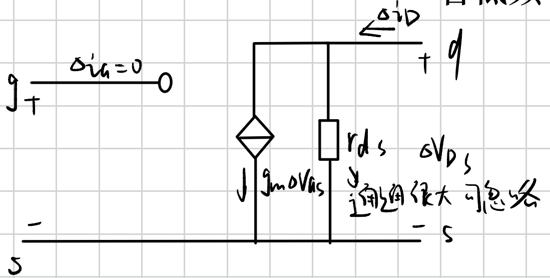
$$R_i'=\frac{\dot{V}_i}{-\dot{I}_e}=\frac{-\dot{I}_br_{be}}{-(1+\beta)\dot{I}_b}=\frac{r_{be}}{1+\beta}$$

$$R_i=R_e//R_i'=R_e//\frac{r_{be}}{1+\beta}$$

$\dot{I}_br_{be}+(1+\beta)\dot{I}_b\times R_e//R_s=0\Rightarrow \dot{I}_b=0$

$\therefore R_o\approx R_c$

FET管低频小信号模型



只适用于低频小信号条件

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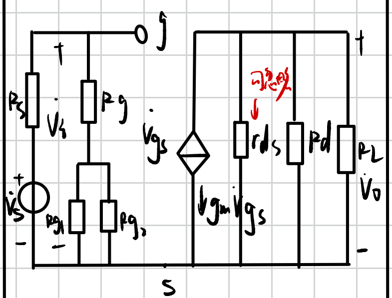
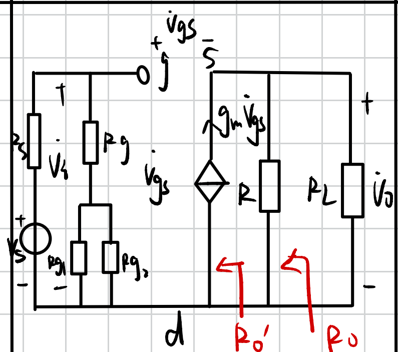
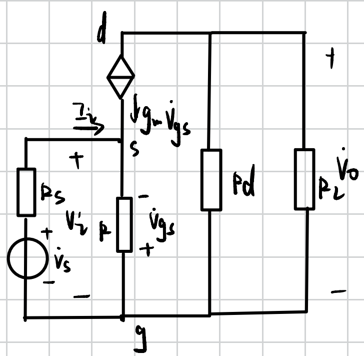
模型中的参数与Q点有关，不是固定常数

共源极放大电路		$\dot{A}_V = \frac{\dot V_o}{\dot V_i} = \frac{-g_m \dot V_{gs}\, r_{ds}\|R_d\|R_L}{\dot V_{gs}} = -g_m R_L'$ $R_i = R_g + R_{g1}\|R_{g2}$ $R_o = \frac{\dot V_o}{\dot I_o} = R_d\|r_{ds}$ 约 R_d
共漏极放大电路		$\dot{A}_V = \frac{\dot V_o}{\dot V_i} = \frac{g_m \dot V_{gs} R_L'}{\dot V_{gs} + g_m \dot V_{gs} R_L'} = \frac{g_m R_L'}{1+g_m R_L'} \approx 1$ $R_i = R_g + R_{g1}\|R_{g2}$ $R_o' = \frac{\dot V_o'}{\dot I_o'} = \frac{\dot V_o'}{-g_m \dot V_{gs}} = \frac{-\dot V_{gs}}{-g_m \dot V_{gs}} = \frac{1}{g_m}$ $R_o = R\|\frac{1}{g_m}$
共栅极放大电路		$\dot{A}_V = \frac{\dot V_o}{\dot V_i} = \frac{-g_m \dot V_{gs} R_L'}{-\dot V_{gs}} = g_m R_L'$ $R_i' = \frac{\dot V_i}{\dot I_i} = \frac{-\dot V_{gs}}{-g_m \dot V_{gs}} = \frac{1}{g_m}$ $R_i = \frac{\dot V_i}{\dot I_i} = R\|\frac{1}{g_m}$ $R_o = R_d$

放大电路三种组态性能指标的比较

	电压增益	输入电阻	输出电阻
共射 (CE) 共源 (CS)	反相，大于 100 几---几十	几百--几千欧 几兆欧	几百--几千欧 几百--几千欧
共集 (CC) 共漏 (CD)	同相，均小于 1	几十--几百千欧 几兆欧	最小可达几十欧 几百欧
共基 (CB) 共栅 (CG)	同相，大于 100 几---几十	最小可达几十欧 几百欧	几百--几千欧 几百--几千欧