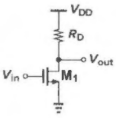
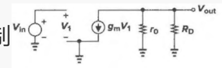
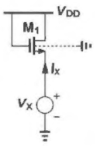
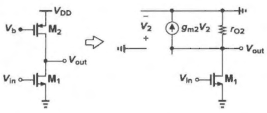
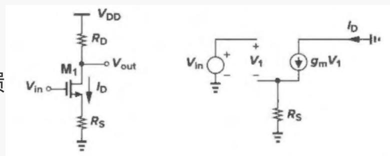
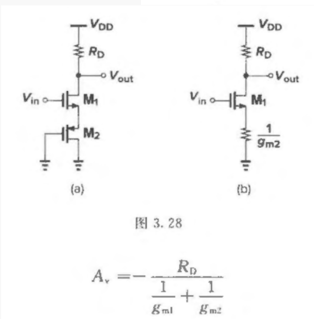
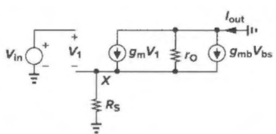
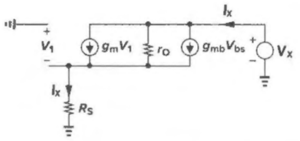
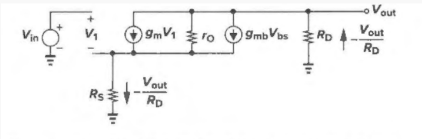
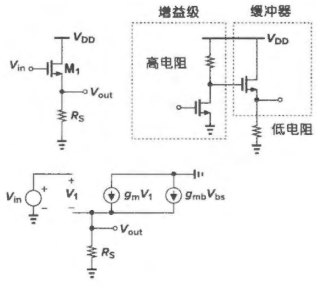
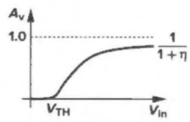
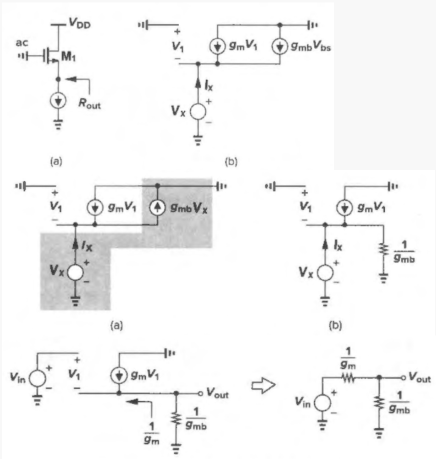
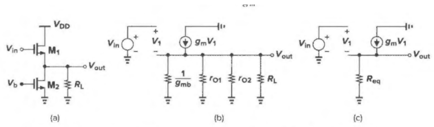
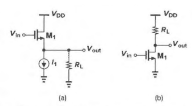
单管放大

共源

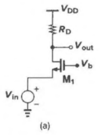
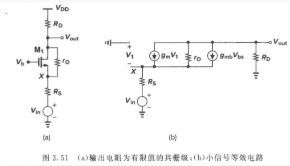
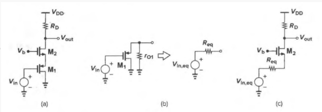
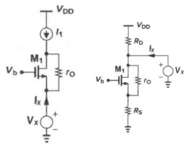
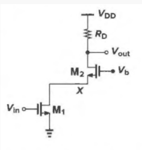
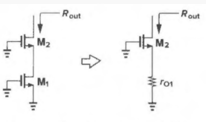
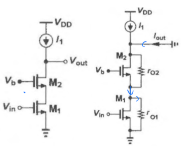
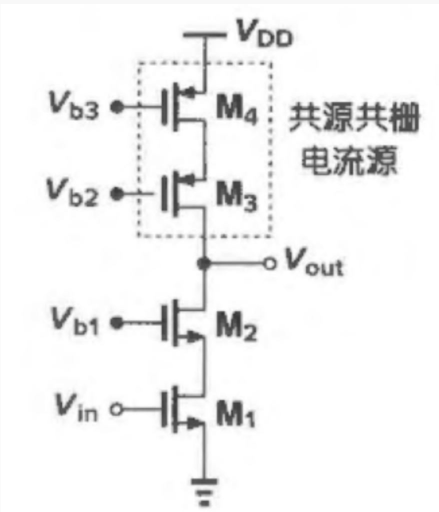
	共源放大	
电阻负载 	$A_{\mathrm{v}}=\frac{\partial V_{\mathrm{ow}}}{\partial V_{\mathrm{in}}} =-R_{\mathrm{D}}\mu_{\mathrm{n}}C_{\mathrm{ox}}\frac{W}{L}(V_{\mathrm{in}}-V_{\mathrm{TH}}) =-g_{\mathrm{m}}R_{\mathrm{D}}$	
考虑沟长调制 	$A_v=-g_{\mathrm{m}}\left(r_0 \| R_{\mathrm{D}}\right)$	
二极管负载 	$\frac{V_x}{I_x}=\frac{1}{g_{\mathrm{m}}+g_{\mathrm{mb}}+r_{\mathrm{n}}^{-1}} =\frac{1}{g_m+g_{mb}}\|r_0 \approx\frac{1}{g_m+g_{ml}}$	
二极管负载增益	$A_{\mathrm{v}}=-g_{\mathrm{m}1}\frac{1}{g_{\mathrm{m}2}+g_{\mathrm{mb}2}} =-\frac{g_{\mathrm{m}1}}{g_{\mathrm{m}2}}\frac{1}{1+\eta} =-\sqrt{\frac{(W/L)_1}{(W/L)_2}}\frac{1}{1+\eta}$	
电流源负载 	$A_v=-g_{\mathrm{m}}\left(r_{O1}\|r_{O2}\right)$	
带源极负反馈  	$G_{\mathrm{m}}=\frac{g_{\mathrm{m}}}{1+g_{\mathrm{m}}R_{\mathrm{s}}}=\frac{1}{\frac{1}{g_{\mathrm{m}}}+R_{\mathrm{s}}}$「在源极通路上看到的电阻」 $A_{\mathrm{v}}=-G_{\mathrm{m}}R_{\mathrm{D}} =\frac{-g_mR_D}{1+g_mR_s}$	
考虑沟长调制与体效应:  输		

出阻抗： 	$$G_m = \frac{I_{out}}{V_{in}} = \frac{V_{out}}{V_{in}}\cdot\frac{I_{out}}{V_{out}} = g_m r_o\cdot\frac{1}{R_{out}} = \frac{g_m r_o}{r_o+[1+(g_m+g_{mb})r_o]R_s} \to A_v = -G_m R_{out}$$ $$R_{out} = [1+(g_m+g_{mb})R_s]r_0 + R_s = [1+(g_m+g_{mb})r_b]R_s + r_0$$	
带负载  图 3.31 带有限的输出电阻的负反馈共源级的小信号等效电路	$$A_v = \frac{g_m r_o}{r_o+[1+(g_m+g_{mb})r_o]R_s}(R_D//R_{out}) - \frac{g_m r_0}{R_s+r_0+(g_m+g_{mb})R_s r_0}\times\frac{R_D\left[R_s+r_0+(g_m+g_{ml})R_s r_0\right]}{R_D+R_s+r_0+(g_m+g_{mb})R_s r_0}$$	

共漏

	源跟随器（共漏极）	
忽略沟长调制  图 3.35 源跟随器的小信号等效电路	$$A_v = \frac{g_m R_s}{1+(g_m+g_{mb})R_s} = \frac{R_s}{\frac{1}{g_m}+\left(\frac{g_m+g_{mb}}{g_m}\right)R_s}$$ $$g_m = \mu_n C_{ox}\frac{W}{L}(V_m - V_{TH} - V_{ott})$$ 小信号方法： $$\begin{cases} V_{in}-V_1 = V_{out}, V_{bs} = -V_{out} \\ g_m V_1 - g_{mb}V_{out} = V_{out}/R_s \\ A_v = \frac{V_{out}}{V_{in}} = g_m R_s/[1+(g_m+g_{mb})R_s] \end{cases}$$	$A_v < 1$ 
电流源代替电阻  图 3.41 以戴维南等效表示本征源跟随器	$$R_{out} = \frac{1}{g_m}\Vert\frac{1}{g_{mb}} = \frac{1}{g_m+g_{mb}}$$ $$A_v = \frac{\frac{1}{g_{mb}}}{\frac{1}{g_m}+\frac{1}{g_{mb}}} = \frac{g_m}{g_m+g_{mb}}$$	
驱动负载的源随器  图 3.42 (a)驱动电阻负载的源跟随器；(b)小信号等效电路；(c)简化模式	$$A_v = \frac{R_{eq}}{R_{eq}+\frac{1}{g_m}}, R_{eq} = \left(\frac{1}{g_{mb}}\right)\Vert r_{o1}\Vert r_{o2}\Vert R_L$$	源随器不一定是有效的驱动器。  图 3.46 (a)源跟随器；(b)驱动负载电阻的共源级

共栅

	共栅极	
	共栅极	
不考虑沟长调制 	$\frac{\partial V_{out}}{\partial V_{in}} = \mu_n C_{ox}\frac{W}{L}R_D(V_b - V_{in} - V_{TH})(1+\eta)$ $= g_m(1+\eta)R_D$	体效应使共栅级的等效跨导变大了
考虑MOS输出阻抗R_0及V_{in}阻抗R_s 	$r_{ov}\left(\frac{-V_{out}}{R_D} - g_m V_1 - g_{inb} V_1\right)_{流过r_o电流}$ $-\frac{V_{out}}{R_D}R_S + V_{in} = V_{out}$ $and: V_1 - \frac{V_{out}}{R_D}R_s + V_{in} = 0$ $\to: \frac{V_{out}}{V_{in}} = \frac{(g_m+g_{mb})r_o+1}{r_o+(g_m+g_{mb})r_oR_s+R_s+R_D}R_D$	
	共源共栅级(cascade)	
考虑沟长调制及体效应 	$V_{in,eq} = \frac{r_{o1}\Vert\frac{1}{g_{mb1}}}{r_{o1}\Vert\frac{1}{g_{mbl}}+\frac{1}{g_{m1}}}V_{in}, R_{eq} = r_{on}\left\Vert\frac{1}{g_{mb1}}\right\Vert\frac{1}{g_{m1}}$ $Replace\ it\ with: \frac{V_{out}}{V_{in}}$	
共栅极输入输出阻抗： 	$R_x = \frac{V_x}{I_x} = \frac{r_0}{1+(g_m+g_{mb})r_0}$ $= \frac{1}{\frac{1}{r_0}+g_m+g_{mht}}$ $= r_o\Vert\frac{1}{g_m}\Vert\frac{1}{g_{mb}}$ 理想电流源负载的共栅极输入电阻 $R_{out} = \{[1+(g_m+g_{mb})r_o]R_S + r_o\}\Vert R_D$ 带源级负反馈共栅极的输出电阻	
输出电阻：  图 3.59 共源共栅结构  图 3.65 共源共栅级输出电阻的计算	$R_{out} = [1+(g_{m2}+g_{mb2})r_{o2}]r_{o1}+r_{o2}$ $\approx (g_{m2}+g_{mb2})\cdot r_{o1}r_{o2}$ 「共源共栅输出阻抗」	
带电流源负载的Cascade 	$R_x = r_o\Vert\frac{1}{g_m}\Vert\frac{1}{g_{mb}}$ M_1漏端看进去的负载 $I_{out} = g_{m1}V_{in}\frac{r_{o1}}{r_{o1}+r_o\Vert\frac{1}{g_m}\Vert\frac{1}{g_{mb}}}$ $G_m = \frac{I_{out}}{V_{in}} = \frac{g_{m1}r_{o1}[r_{o2}(g_{m2}+g_{mb2})+1]}{r_{o1}r_{o2}(g_{m2}+g_{mb2})+r_{o1}+r_{o2}}$ $\lvert A_v\rvert = G_mR_{out} = g_{m1}r_{o1}[r_{o2}(g_{m2}+g_{mb2})+1]$	$if\ G_m \approx g_m$ $then\ \lvert A_v\rvert = g_{m1}R_{out}$
上图电流源用PMOS Cascade实现： 	$R_{out} = \{[1+(g_{m2}+g_{mb2})r_{o2}]r_{o1}+r_{02}\}$ $\Vert\{[1+(g_{m3}+g_{mb3})r_{o3}]r_{o4}+r_{o3}\}$ $\lvert A_v\rvert \approx g_{m1}[(g_{m2}r_{n2}r_{m1})\Vert(g_{m3}r_{03}r_{m3})]$	