Analog Equations Cheat Sheet

Frequency

Ideal frequency response

Low-pass filter

$$A_V(s) = \frac{A_o\omega_H}{s+\omega_H} = \frac{A_o}{1+s/\omega_H}$$

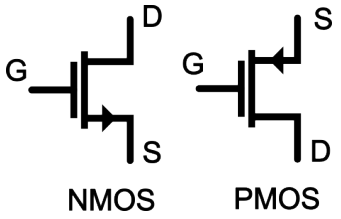
High-pass filter

$$A_V(s) = \frac{A_o s}{s+\omega_L}$$

Band-pass filter

$$A_V(s) = \frac{A_o s}{s+\omega_L}\frac{A_o}{1+s/\omega_H}$$

Mosfet



Aree di funzionamento

Saturazione N-mos

$$I_{DS} = \mu_n(\frac{W}{L})\frac{C_{ox}}{2}(V_{GS}-V_{th})^2(1+\lambda V_{DS})$$

ON $V_{GS} > V_{th}$

$V_{DS} > V_{OD}$

Triodo N-mos

$$I_{DS} = \mu_n(\frac{W}{L})\frac{C_{ox}}{2}(2V_{OD}V_{DS} - V_{DS}^2)$$

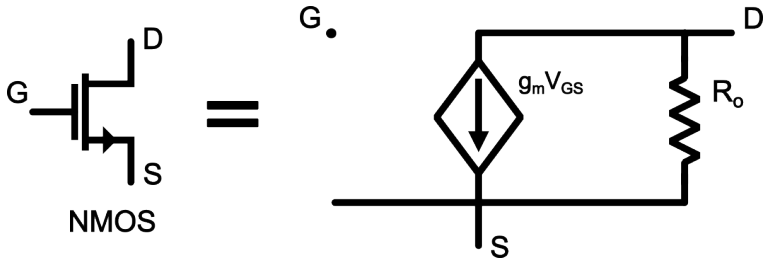
ON $V_{GS} > V_{th}$

$V_{DS} < V_{OD}$

Tensione di overdrive N-mos

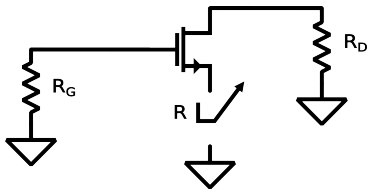
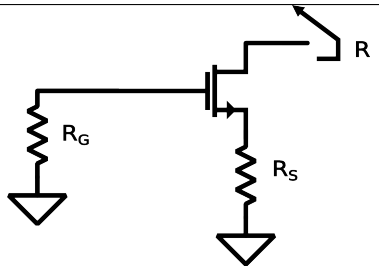
$$V_{OD} = V_{GS} - V_{th}$$

Piccolo segnale

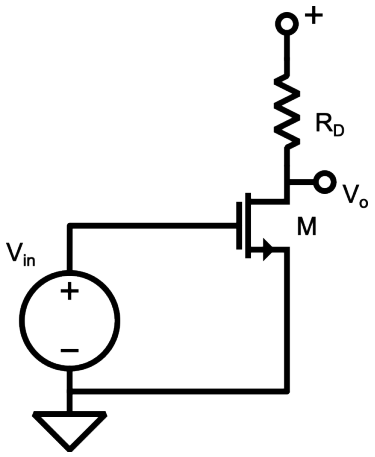
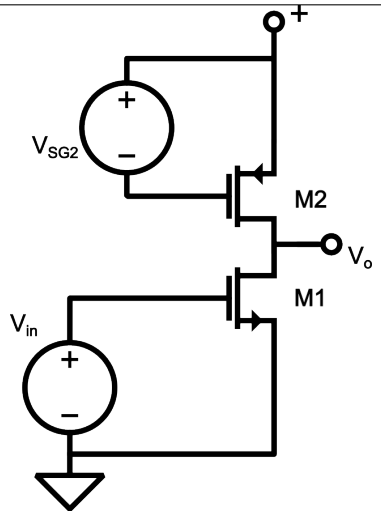
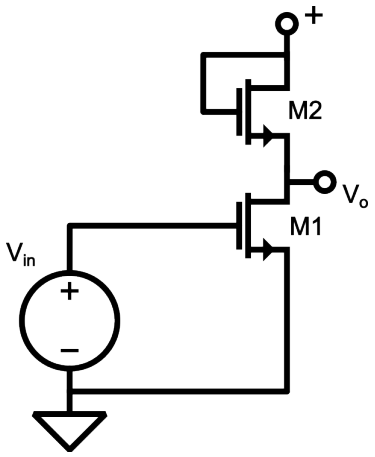


$$V_{OD} = (\frac{I_{DQ}}{\beta_n\frac{W}{L}})^{\frac{1}{2}} \qquad g_m = 2\beta_n\frac{W}{L}V_{OD} = (4\beta_n\frac{W}{L}I_{DQ})^{\frac{1}{2}} \qquad R_o = \frac{1}{\lambda I_{DQ}}$$

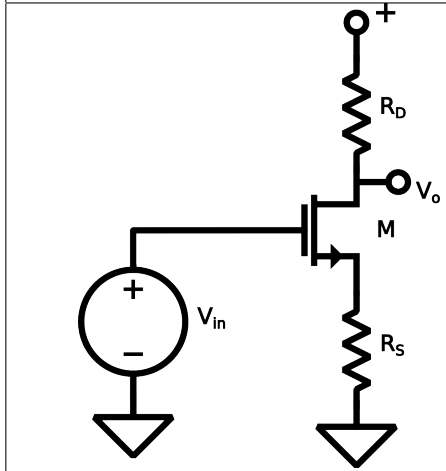
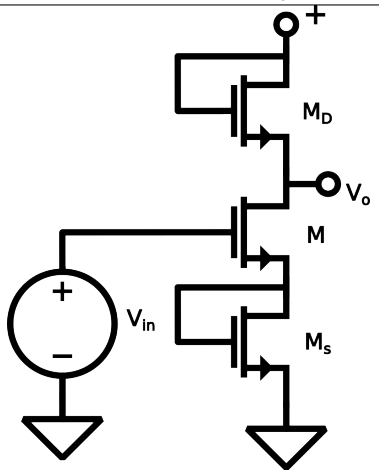
equivalent resistances

from source	from drain
	
$R = -\frac{R_D + R_o}{1 + g_m R_o} \approx \frac{1}{g_m}$	$R = R_S + R_o(1 + g_m R_S) \approx R_o g_m R_S$

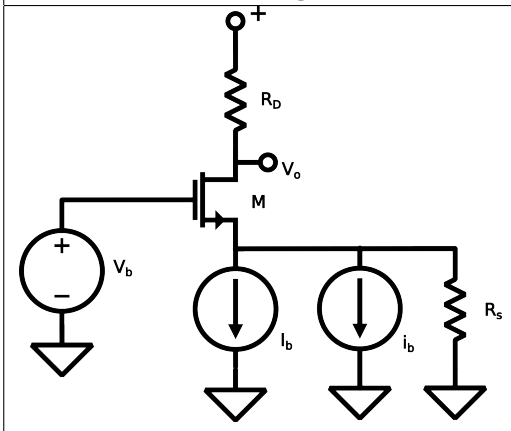
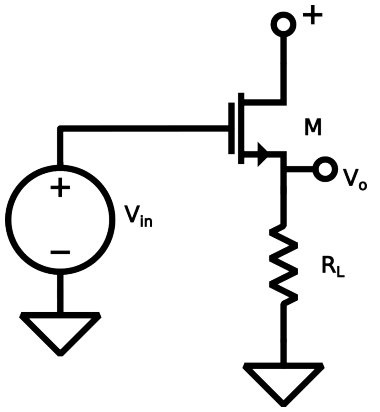
Common source

common source	common source active load	high linear
		
$A_v = -g_m R_D$	$A_v = -g_m(R_{o1} // R_{o1})$	$A_v = (\frac{(\frac{W}{L})_1}{(\frac{W}{L})_2})^{\frac{1}{2}}$
$Z_{in} = \infty$	$Z_{in} = \infty$	$Z_{in} = \infty$
$Z_{out} = R_D // R_{o2}$	$Z_{out} = R_{o1} // R_{o2}$	$Z_{out} = 1/g_{m2}$

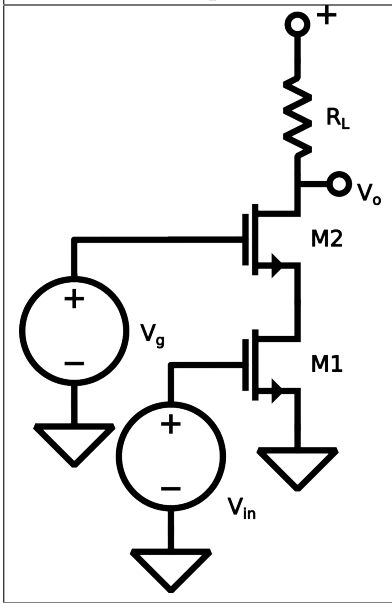
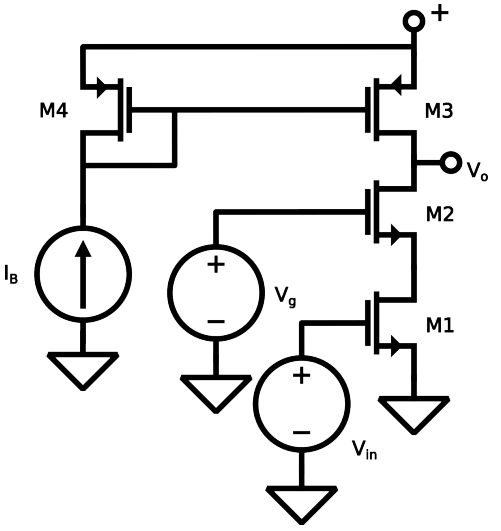
Common source with load

common source with passive source	common source totally active
	
$A_v = -\frac{g_m R_D}{1 + g_m R_S}$	$A_v = (\frac{(\frac{W}{L})_S}{(\frac{W}{L})_D})^{\frac{1}{2}}$
$Z_{out} = R_D // [R_s + R_o(1 + g_m R_s)]$	$Z_{out} = (1/g_{mD}) // [(1/g_{mS}) + R_o(1 + g_m(1/g_{mS}))]$

Other kinds of stages

common gate	common drain
	
$A_I = \frac{i_d}{i_s} = -\frac{g_m R_S}{1+g_m R_S} \approx 1$	$A_v = \frac{V_o}{V_{in}} = (\frac{g_m R_l}{1+g_m R_L}) \approx 1$

Amplificatore cascode

cascode passivo	cascode attivo
	
$A_v = -(g_{m1}R_{o1})(g_{m2}R_{o2})$	$A_v = -g_{m1}(R_{o3}//(R_{o1}(g_{m2}R_{o2})))$
$Z_{out} = R_{o1}(g_{m2}R_{o2})$	$Z_{out} = R_{o3}//(R_{o1}(g_{m2}R_{o2}))$