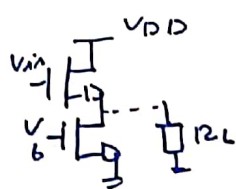
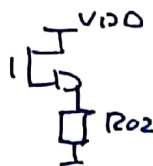


## amplifier 9

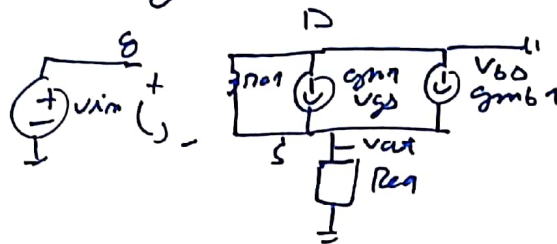


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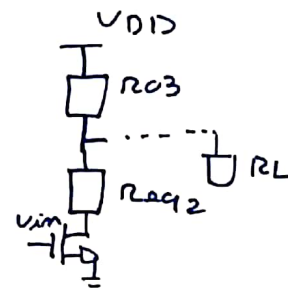
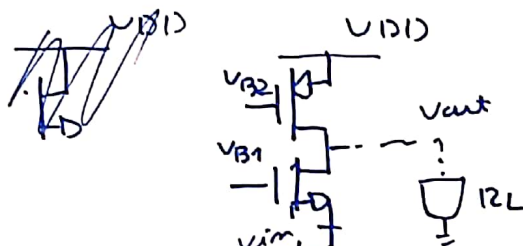


→

$$\frac{v_{out}}{v_{in}} = \frac{g_{m1}}{\frac{1}{r_{O2}} + \frac{1}{R_L} + \frac{1}{r_{O1}} + g_{m1} + g_{m2}b_1}$$

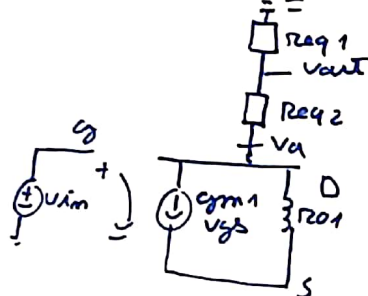


## amplifier 10



$$R_{eq2} = \frac{1}{g_{m2} + g_{m2}b_1 + \frac{1}{R_{O2}}}$$

$$R_{eq1} = R_{O3} || R_L$$



currents I in VA

$$-\frac{V_A}{r_{O1}} - g_{m1}v_{in} - \frac{V_A}{R_{eq2} + R_{eq1}} = 0$$

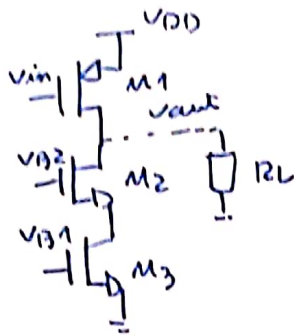
$$g_{m1}v_{in} = -V_A \left( \frac{1}{r_{O1}} + \frac{1}{R_{eq2} + R_{eq1}} \right)$$

$$V_A = \frac{-g_{m1}v_{in}}{\frac{1}{r_{O1}} + \frac{1}{R_{eq2} + R_{eq1}}}$$

$$v_{out} = V_A \frac{R_{eq1}}{R_{eq2} + R_{eq1}}$$

$$\frac{v_{out}}{v_{in}} = \frac{-g_{m1} R_{eq1}}{\frac{R_{eq2} + R_{eq1}}{r_{O1}} + 1} = \frac{-g_{m1} R_{eq1} r_{O1}}{R_{eq2} + R_{eq1} + r_{O1}} \rightarrow \text{gain equation}$$

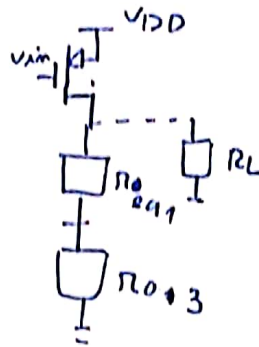
## amplifier 11



$$R_{eq1} = \frac{1}{g_{m2} + g_{m3} + \frac{1}{R_{o2}}}$$

$$R_{eq2} = R_{eq1} + R_{o3}$$

$$R_{eq3} = R_{eq2} \parallel R_L$$



$$v_{sg} = -v_{in}$$

$$-\frac{v_{out}}{R_{eq3}} - \frac{v_{out}}{R_{o1}} + g_{m1}(v_{sg}) = 0$$

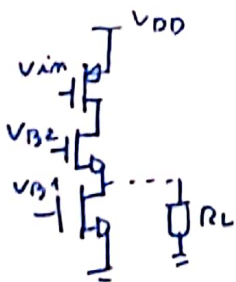
$$\frac{v_{out}}{v_{in}} = \frac{-g_{m1}}{\frac{1}{R_{eq3}} + \frac{1}{R_{o1}}}$$

$$A_v = \frac{-g_{m1}}{\frac{1}{R_L} + \frac{1}{R_{eq2}} + \frac{1}{R_{o1}}}$$

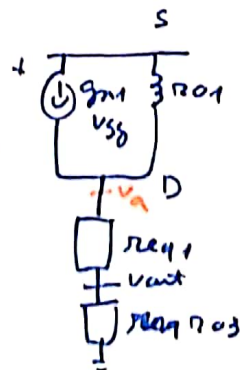
$R_{eq2}$  decreases  
with increase  
in  $g_{m2}$   
and decrease  
of  $R_{o3}$   
is increase  
in  $g_{m3}$

So Basically Increase  
all  $g_{m}$ s and keep  
swirling in saturation

## amplifier 12



$$v_{sg} = -v_{in}$$



$$-\frac{v_A}{R_{o1}} - g_{m1}v_{in} - \frac{v_A}{R_{eq1} + \frac{v_{out}}{R_{o3}}} = 0$$

$$-g_{m1}v_{in} = v_A \left( \frac{1}{R_{o1}} + \frac{1}{R_{eq1} + R_{o3}} \right)$$

$$v_A = \frac{-g_{m1}v_{in}}{\frac{1}{R_{o1}} + \frac{1}{R_{eq1} + R_{o3}}}$$

$$v_{out} = v_A \frac{R_{o3}}{R_{o3} + R_{eq1}}$$

$$v_{out} = \frac{-g_{m1}v_{in} R_{o3}}{(R_{o3} + R_{eq1}) \left( \frac{1}{R_{o1}} + \frac{1}{R_{eq1} + R_{o3}} \right)}$$

$$A_v = \frac{-g_{m1} R_{o3}}{\frac{R_{o3} + R_{eq1}}{R_{o1}} + 1} = \frac{-g_{m1} R_{o3} R_{o1}}{R_{o3} + R_{eq1} + R_{o1}}$$