Common Drain or Source Follower Amplifier

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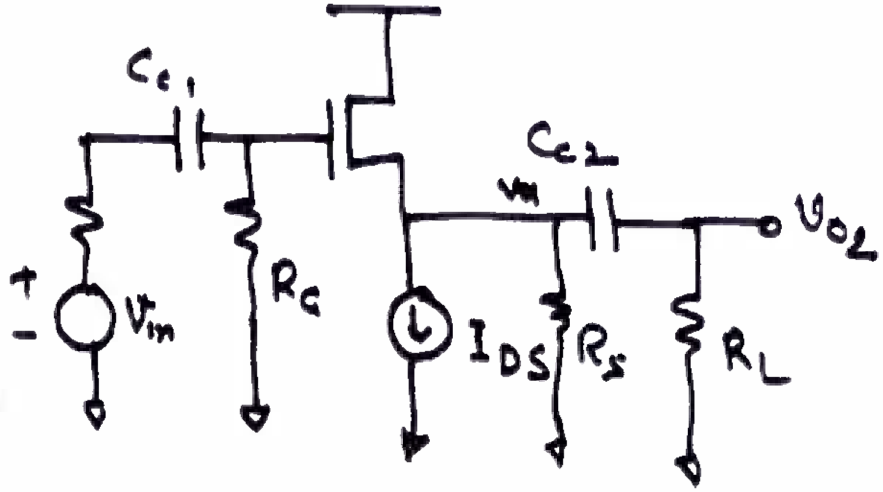

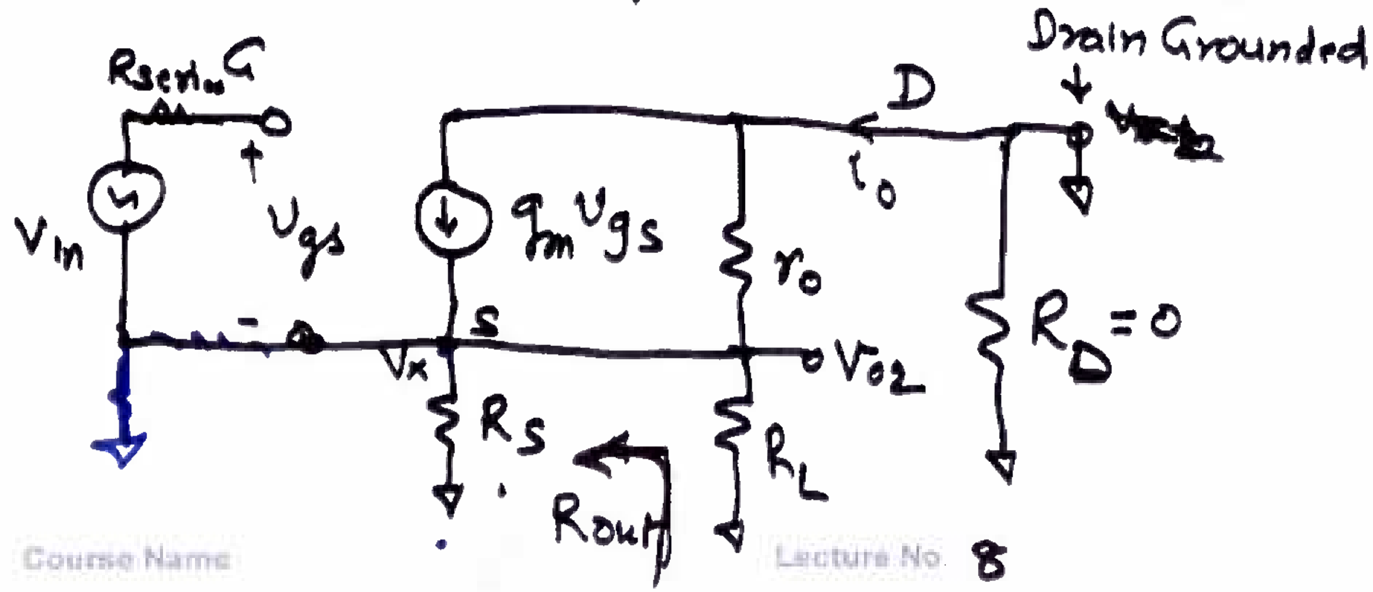

Load $= R_S \parallel R_L$
$= R_{SL}$

Assuming $r_o \to \infty$

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$v_{gs} = f(v_{in})$

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$$v_{o2} = \frac{g_m v_{gs} R_{SL}}{1 + g_m R_{SL}}$$

$\times$ $v_{gs} = v_{in}$ as $i_G = 0$

$$A_v = \frac{v_{o2}}{v_{in}} = \frac{g_m R_{SL}}{1 + g_m R_{SL}}$$

If $g_m R_{SL} > 1$

$$A_v \cong 1$$

$\therefore$ Output Follows Input as it is

$\therefore$ The name Source Follower

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If r_o is finite

$$R_{SL} = R_S \| R_L \| r_o$$

If we consider Bias Network & Source Input signal Generator Resistance

Then $$v_{gs} = \frac{R_G}{R_G + R_{series}} v_{in}$$

Clearly Input resistance $R_{in} = R_G$

We need to evaluate Output resistance R_o

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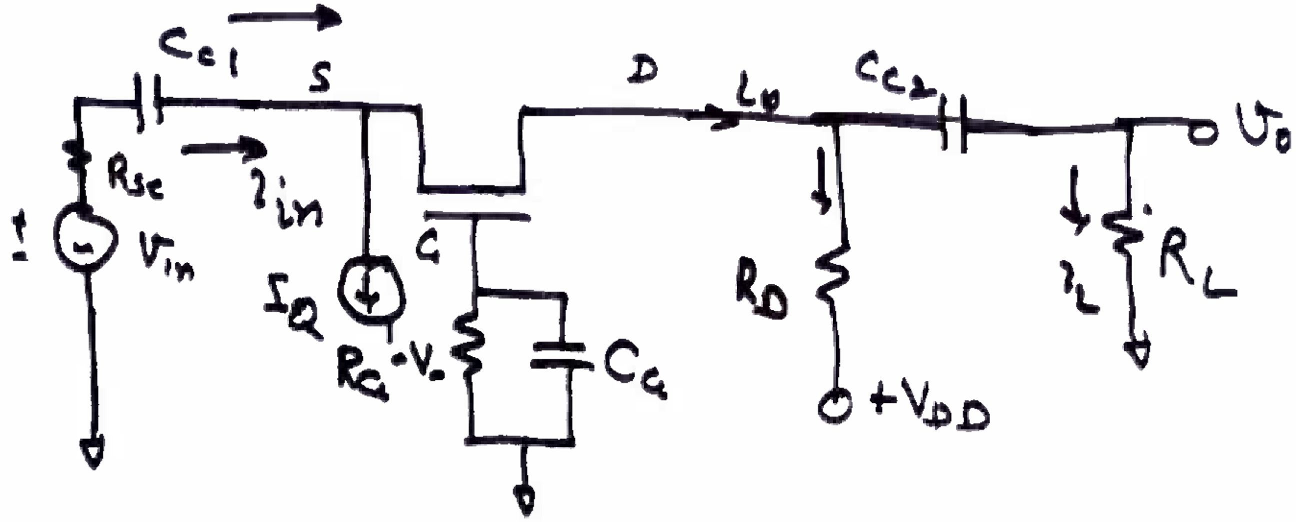
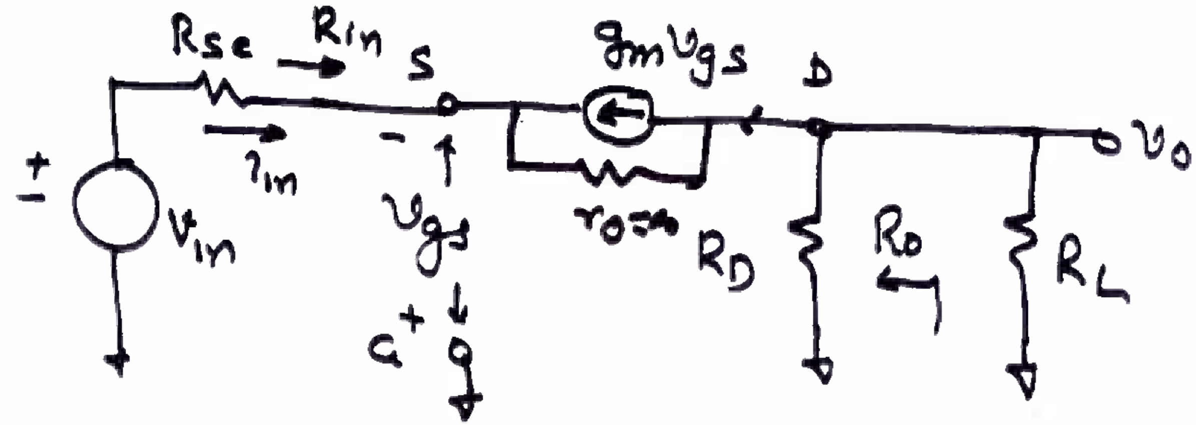
Common Gate Configuration





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Input Side

$$v_{in} = i_{in}R_{se} - v_{gs} \quad \text{from Input Loop} \quad - (1)$$

However $i_{in} = -g_m v_{gs}$ — (2)

or $$v_{in} = -(g_m R_{se} + 1)\, v_{gs}$$

or $$v_{gs} = \frac{-v_{in}}{1 + g_m R_{se}} \quad - (3)$$

Output Side $$v_o = -g_m v_{gs}\,(R_D \| R_L) \quad - (4)$$

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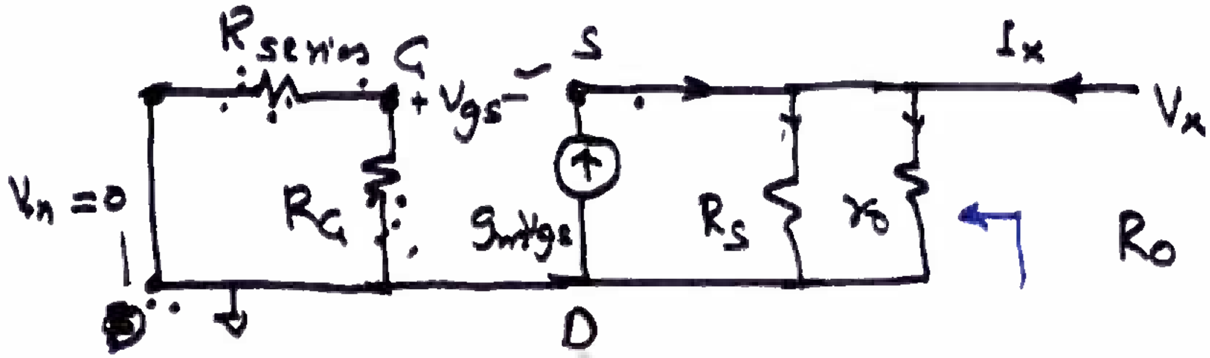
Output Resistance evaluation



$$R_o = \frac{V_x}{I_x}$$

KLaw → $I_x + g_m v_{gs} = \frac{V_x}{R_s} + \frac{V_x}{r_o}$

However $V_x = -v_{gs}$ As no current in Input Side

$\therefore \quad I_x = g_m v_x + v_x\left(\frac{1}{R_s} + \frac{1}{r_o}\right) = \left(g_m + \frac{1}{R_s} + \frac{1}{r_o}\right) v_x$

$= \left(\frac{1}{1/g_m} + \frac{1}{R_s} + \frac{1}{r_o}\right) = \frac{1}{g_m} \| R_s \| r_o) v_x$

or $R_o = \frac{v_x}{I_x} = \frac{1}{g_m + (R_s \| r_o)}$

$R_o = \frac{1}{\frac{1}{g_m} \| R_s \|}$

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or $$v_o = -g_m(R_D \| R_L)\left[-\frac{v_{in}}{1+g_m R_{se}}\right]$$

or $$\frac{v_o}{v_{in}} = A_v = + \frac{g_m(R_D \| R_L)}{1+g_m R_{se}}$$

Here v_o and v_{in} are "<u>In - Phase</u>"

Exercise :-

find $A_i = \frac{i_o}{i_{in}}$

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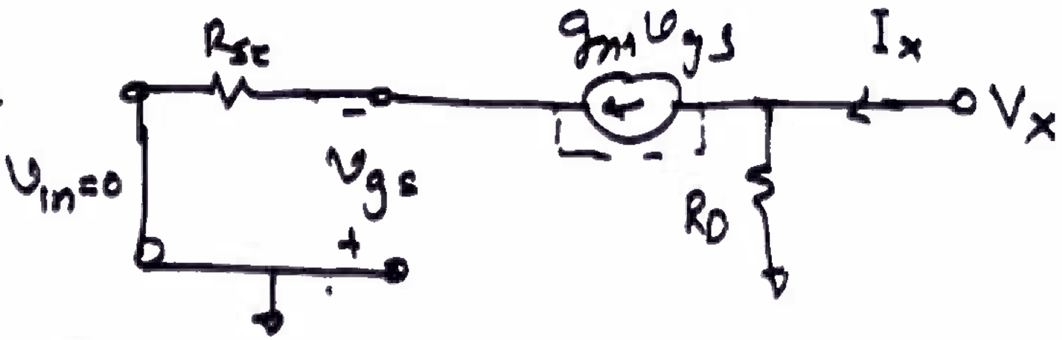
Input Resistance : $R_{in} = \frac{-v_{gs}}{I_{in}}$

However $i_{in} = -g_m v_{gs}$

$$\therefore \boxed{R_{in} = \frac{1}{g_m}}$$

Output Resistance



$$\therefore \boxed{R_o = \frac{V_x}{I_x} = R_D}$$

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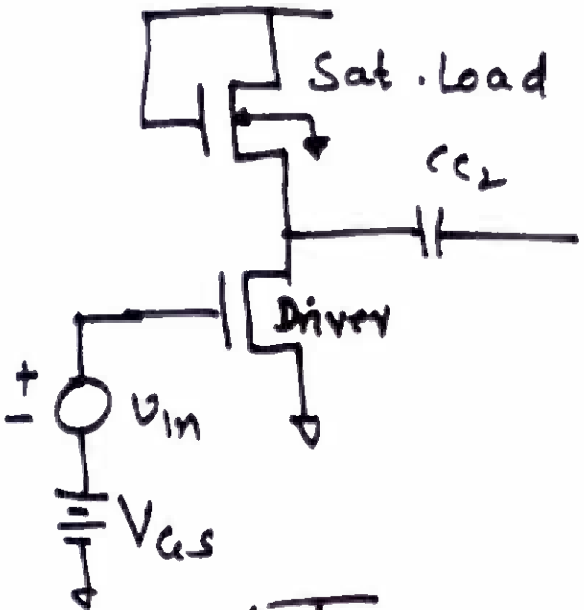
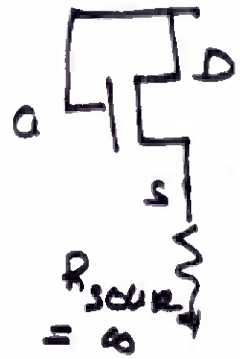
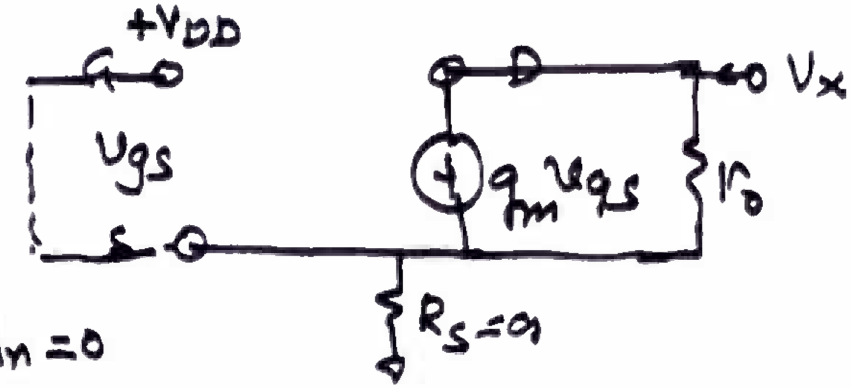
NMOS Amplifier with Sat. Load



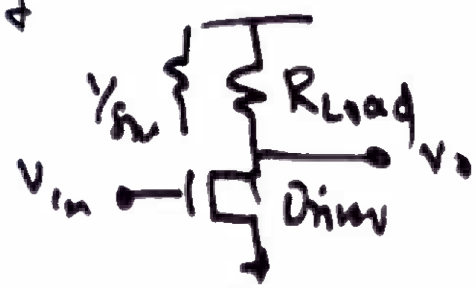




$v_{in} = 0$

$$R_o = \frac{V_x}{I_x} = \left(\frac{1}{g_m} \parallel r_o\right) \cong 1/g_m$$

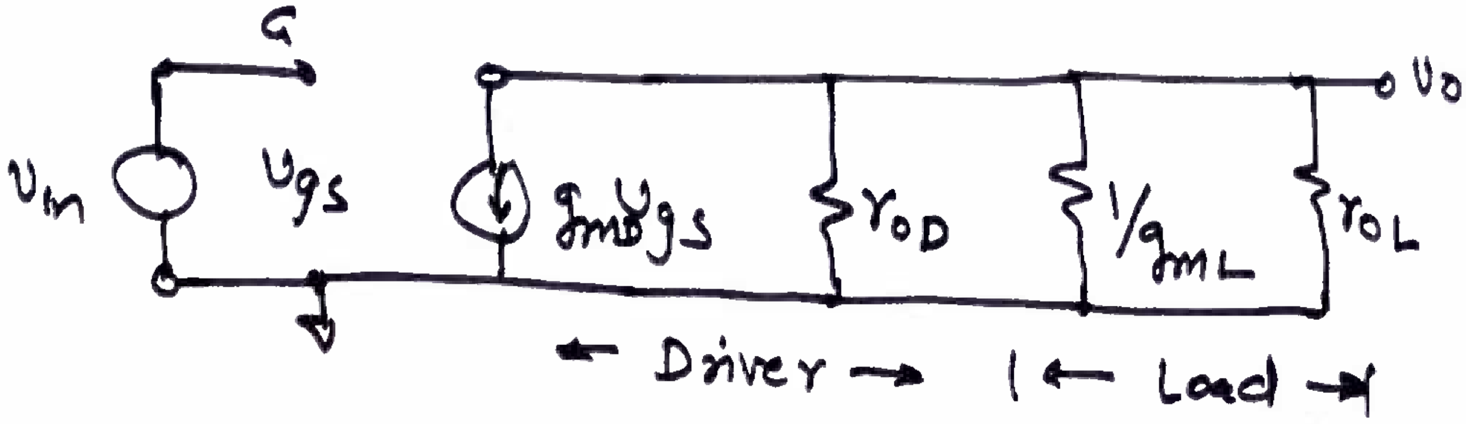
$$\left(\frac{R_S}{1+g_m R_S}\right) \cong 1/g_m$$



Course Name: Analog Circuits

Lecture No. 8

Instructor's Name: Prof. A. N. Chandorkar



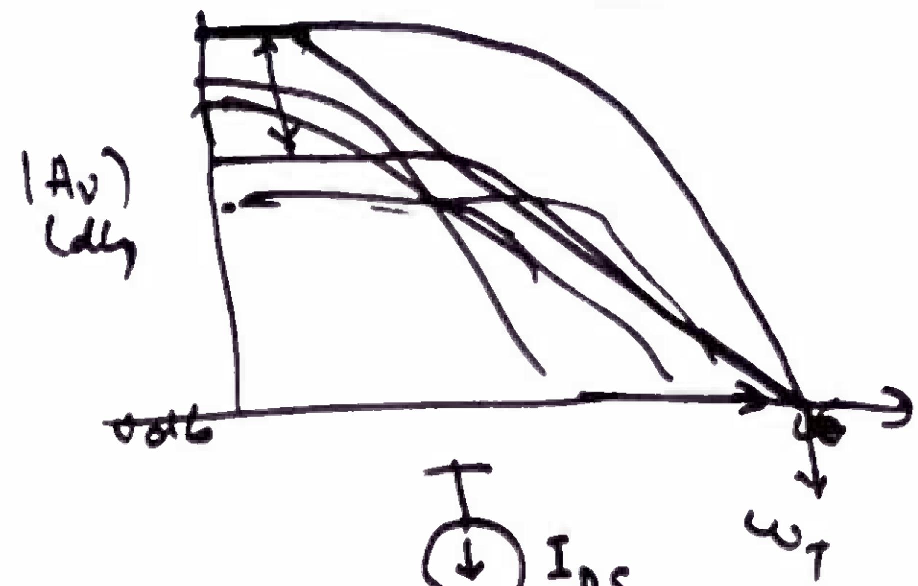
$$A_v = \frac{v_o}{v_{in}} \simeq -\frac{g_{mD}}{g_{mL}} = -\frac{\sqrt{2\beta_n' (W/L)_D I_{DSQ}}}{\sqrt{2\beta_n' (W/L)_L I_{DSQ}}}$$

$$r_{oD} >> \frac{1}{g_{mD}} \qquad r_{oL} >> \frac{1}{g_{mL}}$$

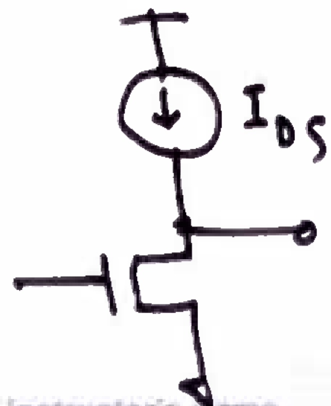
$$\therefore \quad A_v = -\sqrt{\frac{(W/L)_D}{(W/L)_L}}$$

Cascode Amplifier

$$\omega_T = GBW = \frac{g_m}{C_{in}}$$



→ Cascode



$$A = A_1 A_2 A_3$$

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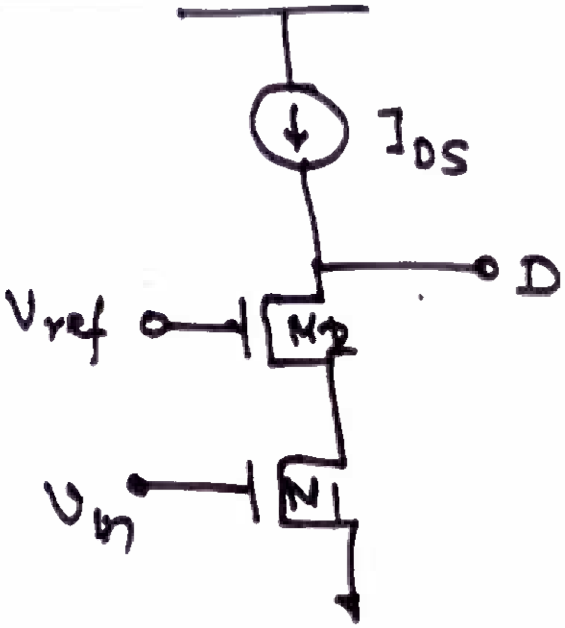
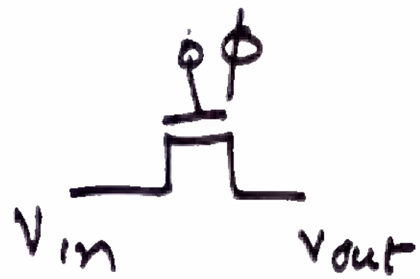


$$g_m = \frac{\partial I_{DS}}{\partial V_{GS}}$$

M_1 – CS

M_2 – CG



$$|A| = g_m r_o$$

$g_m r_o' \uparrow$

$$g_{m\,new} = g_{m\,old}$$