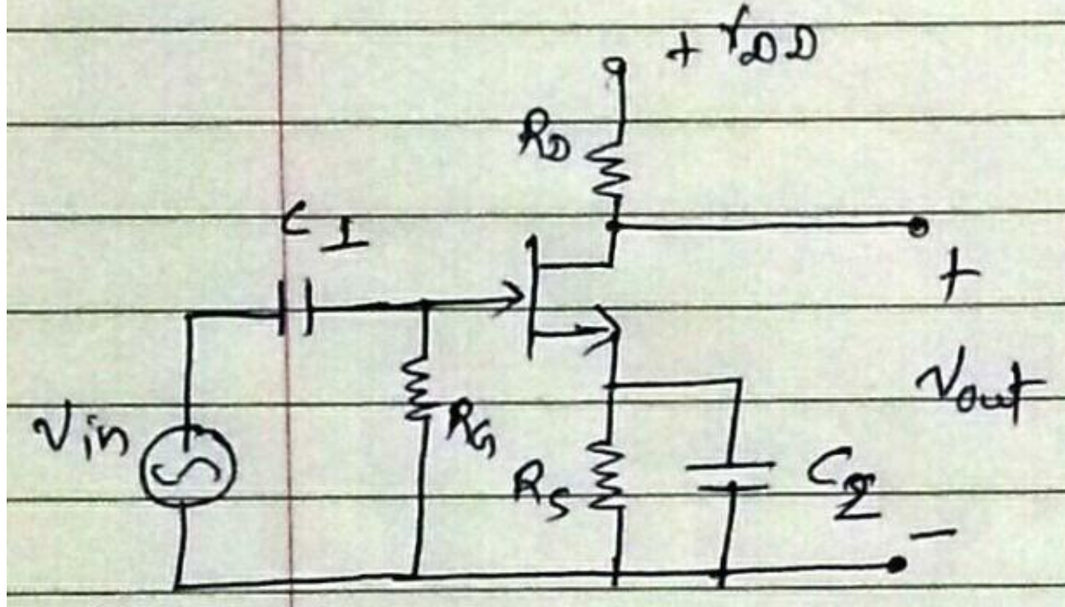
FET Amplifiers

- ★ Common Source Amplifier
- ★ Common Drain Amplifier or Source follower
- ★ Common Gate Amplifier

Common Source Amplifier



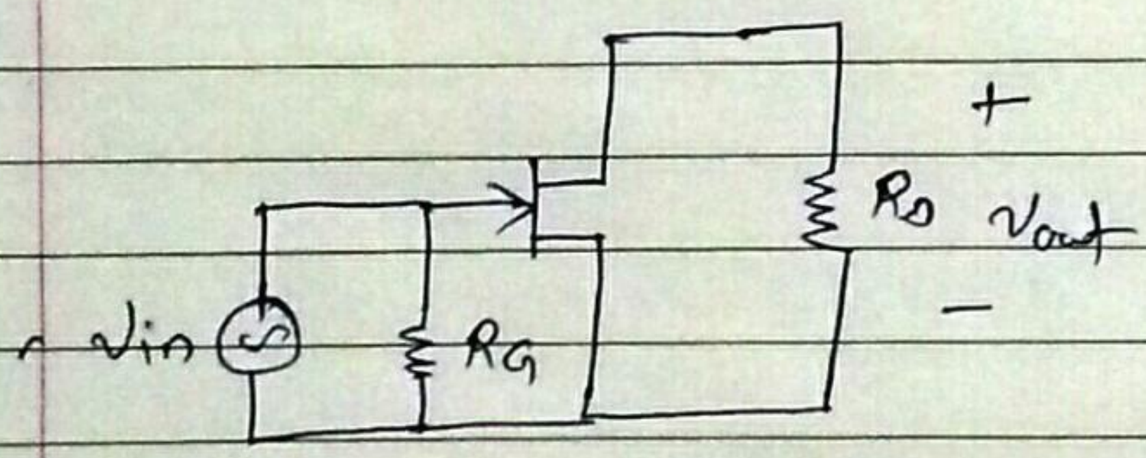
C_1 = Coupling Capacitor

C_2 = Bypass Capacitor

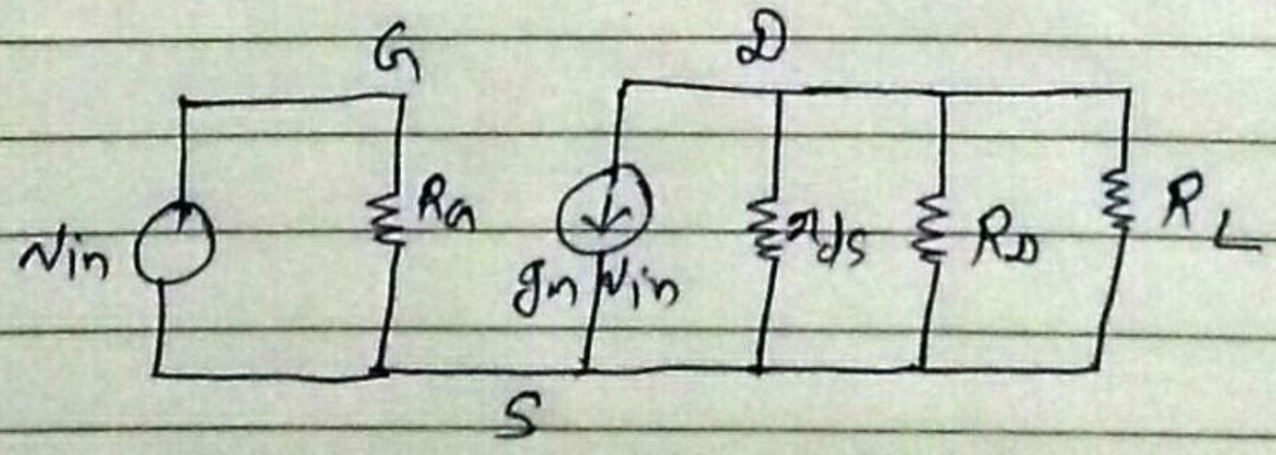
For drawing AC equiv. ckt.

(1) DC voltage sources are grounded

(2) Capacitors C_1 & C_2 are taken as short ckt.

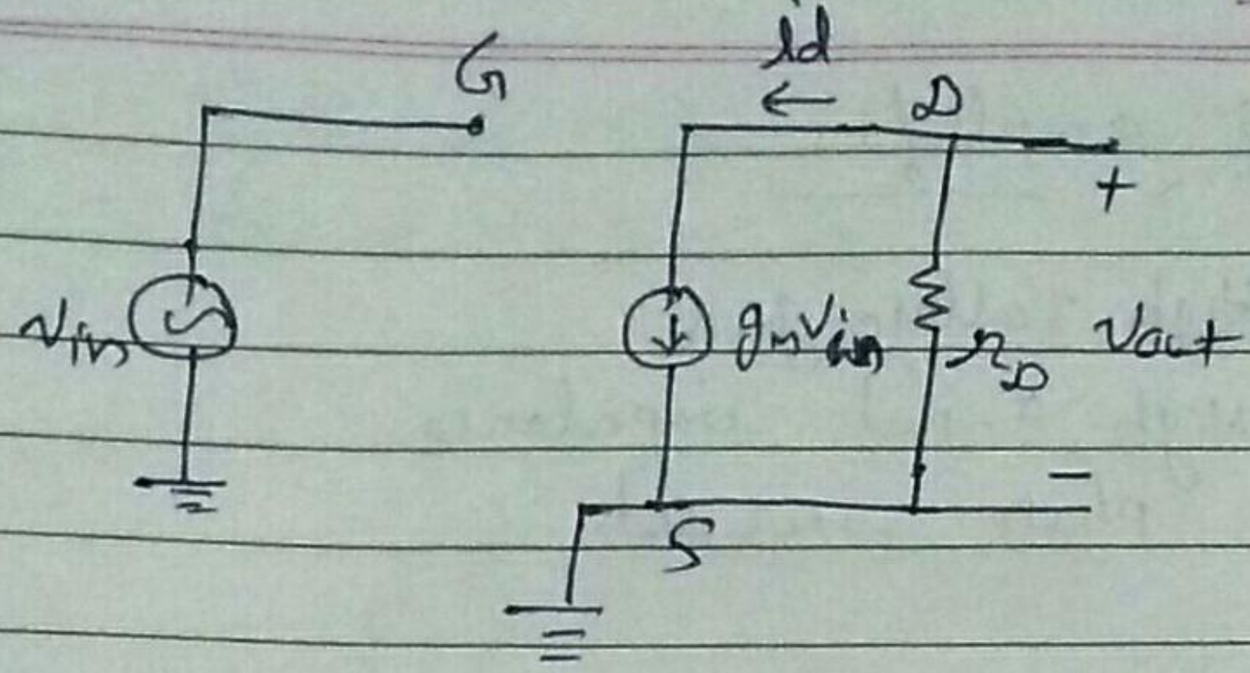


AC equivalent ckt



$V_{in} = V_{gs}$ True because R_G is very high.

$r_D = r_{ds} \| R_D \| R_L \approx R_D \| R_L$



$=$

$$i_d = g_m V_{in}$$

$$V_{out} = -r_D i_d$$

$$V_{out} = -g_m r_D V_{in}$$

Voltage gain

$$A_V = \frac{V_{out}}{V_{in}} = \ominus g_m r_D$$ → phase inversion

magnitude $\boxed{A_V = g_m r_D}$

$g_m = 4000\,\mu S$, let $r_D = 4\,K\Omega$

$$A_V = 4 \times 10^{-3} \times 4 \times 10^{3}$$

$$\boxed{A_V = 16}$$

If R_S is not by-passed

$$\boxed{A_V = \frac{g_m r_D}{1 + g_m R_S}}$$

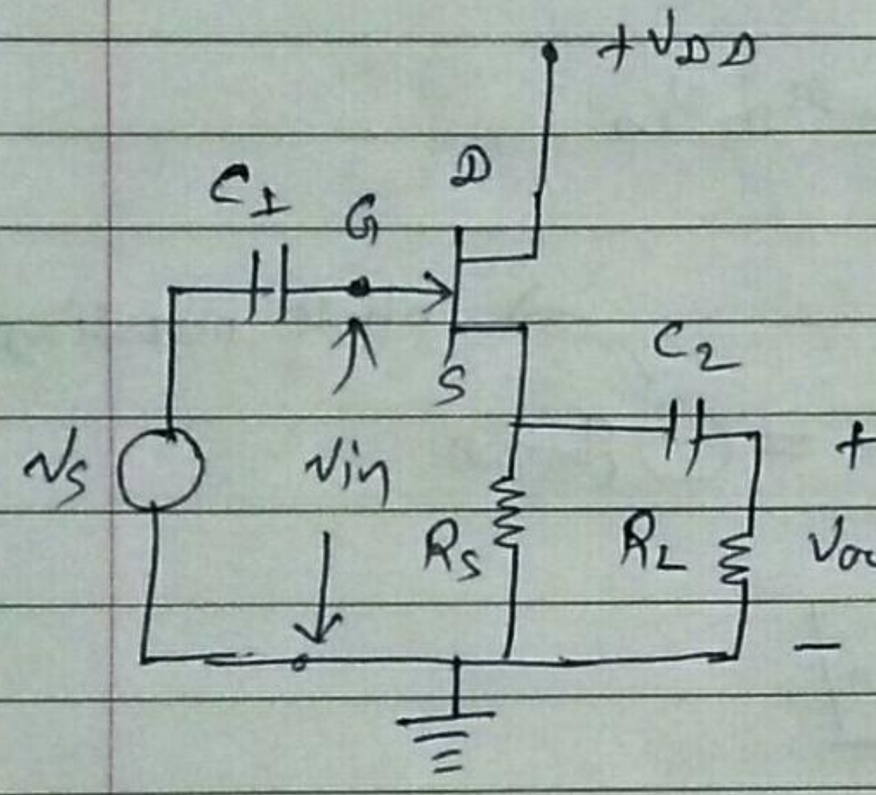
Input impedance of the Amplifier

$Z_i = R_G$ Very high R_G — 100K Ω – 1000K

CS amplifier

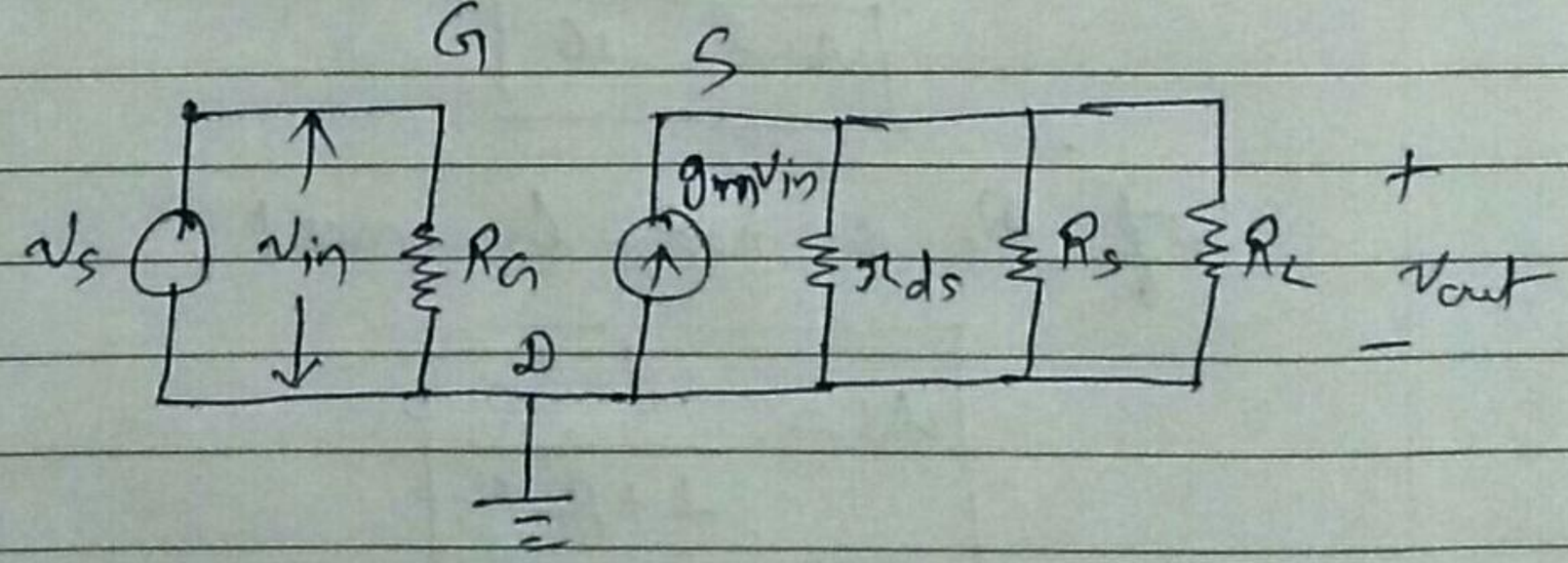
1. High Voltage gain
2. High Input impedance
3. phase reversal

Common Drain Amplifier



* Drain is at ac ground
* load is connected at source.
* output is taken from source with respect to ground

AC equivalent of CD Amplifier

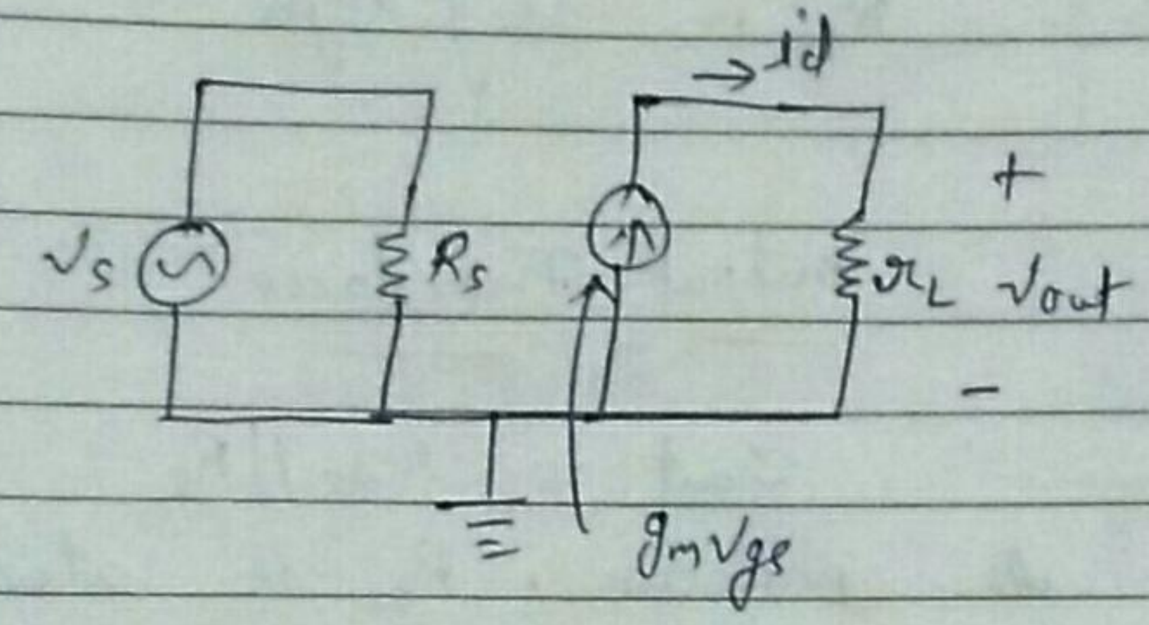


$$r_L = r_{ds} \| R_S \| R_L$$

$$r_L = R_S \| R_L$$

Gate at v_{in} with respect to ground
Source is at v_{out} with respect to ground

$$v_{gs} = v_{in} - v_{out} \quad \text{— (1)}$$



$$v_{out} = i_d R_L \; i_d \cdot r_L$$

Since $i_d = g_m v_{gs}$

$$v_{out} = g_m r_L \cdot v_{gs}$$

Putting for v_{gs} from Eq. (1)

$$v_{out} = g_m r_L (v_{in} - v_{out})$$

or $$v_{out}(1 + g_m r_L) = g_m r_L v_{in}$$

Voltage gain

$$\boxed{A_V = \frac{v_{out}}{v_{in}} = \frac{g_m r_L}{1 + g_m r_L}}$$

Normally $g_m r_L >> 1$

$$\boxed{A_V \cong 1}$$

Input Impedance

$$Z_{in} = R_G$$

R_G is very high

Output Impedance

$$Z_{out} = r_{ds} \,||\, R_S$$

As practice, R_L is always removed from the ckt. to measure Z_{out}.

$$\boxed{Z_{out} \cong R_S}$$ Low o/p impedance

$$R_S = 200 - 400\,\Omega$$

CD amplifier

★ Known as Source follower

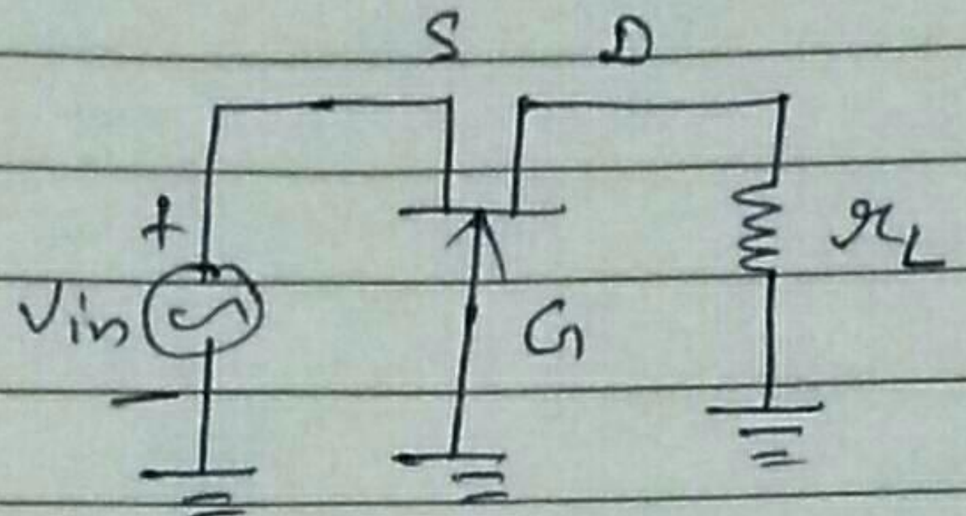
$A_V \cong +, \quad A_V < 1$

$Z_{in} = R_G$ (high)

$Z_{out} = R_S$ (low)

used as buffer

Common gate Amplifier



$$V_{out} = I'_d R_L \qquad I'_d = g_m V_{gs}$$
$$V_{gs} = V_{in}$$

$$V_{out} = g_m V_{in} R_L$$

$$\text{or} \quad A_V = \frac{V_{out}}{V_{in}} = g_m R_L \quad (\text{High})$$

Input Impedance

$$I'_{in} = I'_d = g_m V_{gs}$$
$$= g_m V_{in}$$

$$Z_{in} = \frac{V_{in}}{I'_{in}} = \frac{1}{g_m} \quad (\text{very low})$$

Let $g_m = 4000\ \mu S$, Ω

$$Z_{in} = \frac{1}{4 \times 10^{-3}} = 250\ \Omega$$