Common Drain (CD) Amplifier

Also called a source follower

D is at AC gnd and is common to both the input port (G and AC gnd), and the output port (S and AC gnd).

Note: input port is identical to input port of CS-CD amp.; output port is similar to "" "" CG amp.

Small-signal model

Note: $r_{ds}$ is in parallel with $R_s$. 
Therefore,

\[ v_{gs} = \frac{2i}{1 + g_m (R_s || r_{ds})} \]

\[ v_o = g_m v_{gs} (R_s || r_{ds}) \]

\[ = \frac{g_m (R_s || r_{ds})}{1 + g_m (R_s || r_{ds})} 2i \]

\[ A_v = \frac{g_m (R_s || r_{ds})}{1 + g_m (R_s || r_{ds})} \]

Note: As \( g_m (R_s || r_{ds}) \gg 1 \) \( \Rightarrow A_v \) is close to 1.0 but less than 1.0.
\[ R_i = \infty. \]

\[ R_o: \]

\[ R_o = R_{up} \parallel R_{dn} \]

\[ R_{dn} = R_s \parallel R_{ds} \quad ; \quad R_{up} = \frac{1}{g_m} \]

\[ \therefore R_o = \frac{1}{g_m} \parallel R_s \parallel R_{ds} = \frac{1}{g_m} \]

\[ \therefore \text{CD amp. is a very good voltage buffer} \]

\[ A_v \approx 1; \quad R_i = \infty \text{ (large); } R_o = \text{ small.} \]
CD as a source follower: Assume $R_{ds} = \infty$.

As $I_d = I_B$, for any input $V_i = V_I + V_i$
and $I_D = I_B$, i.e., $I_d = I_D + i_d = I_B$

$\Rightarrow i_d = 0 = g_m V_{gs} \Rightarrow V_{gs} = 0 = V_i - V_o$

$\therefore V_i = V_o \rightarrow$ output follows the input.

**CD as a level-shifter:** Consider DC levels

$V_{ov} = V_I - V_O - V_{tn}$

$\therefore V_o = V_I - (V_{ov} + V_{tn})$

Output DC level = Input DC level - ($V_{ov} + V_{tn}$)