OTHER JFET AMPLIFIER CONFIGURATIONS

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<th>$Z_{out}$</th>
<th>$A_{v_o}$</th>
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<td>High</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td>Common – Drain (Source – Follower)</td>
<td>High</td>
<td>Low</td>
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<td>Common – Gate (High frequency applications)</td>
<td>Very Low</td>
<td>High</td>
<td>Medium</td>
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COMMON-DRAIN (SOURCE-FOLLOWER) JFET AMPLIFIER

Figure 1. Common-Drain (Source-Follower) SSAC JFET Amplifier

Note that $R_D$ is not needed and should be eliminated from the JFET circuit when operating in the common-drain configu
Note that $R_D$ is not needed and should be eliminated from the JFET circuit when operating in the common-drain configuration.

**INPUT IMPEDANCE OF COMMON-DRAIN AMPLIFIER**

$R_{in} = R_G$  
(By inspection of the SSAC equivalent)

*Comment:* In principle $R_G$ can be chosen as large as one wants. However, finite leakage current of the biased JFET chosen $R_G$. Practical values limit $R_G$ at 10 MΩ level for room temperature operation. For high temperature operation, JFET junction leakage currents getting very close to base-emitter forward bias current of a BJT.
VOLTAGE GAIN OF COMMON-DRAIN AMPLIFIER

Figure 3.

\[ \Delta V_{GS} = g_m (v_{in} - v_{out}) \]

\[ v_{out} = g_m (v_{in} - v_{out}) (r_{ds} \parallel R_S \parallel R_L) \]

\[ v_{out} [1 + g_m (r_{ds} \parallel R_S \parallel R_L)] = g_m v_{in} (r_{ds} \parallel R_S \parallel R_L) \]

\[ A_v = \frac{v_{out}}{v_{in}} = \frac{g_m (r_{ds} \parallel R_S \parallel R_L)}{1 + g_m (r_{ds} \parallel R_S \parallel R_L)} \]

\[ A_v = \frac{1}{1 + \frac{1}{g_m (r_{ds} \parallel R_S \parallel R_L)}} \leq 1 \quad \text{Unity Gain} \]

Since, \( r_{ds}, R_S, R_L \) are typically \( >> \frac{1}{g_m} \), \( A_v \) is close to unity.

Note that \( R_L \) does not change the unity gain significantly unless \( R_L \) becomes as low as \( \frac{1}{g_m} \).

This predicts \( R_{out} \) of the circuit to be in the order of \( \frac{1}{g_m} \), and, therefore, low.

Proof follows:
OUTPUT IMPEDANCE OF COMMON-DRAIN AMPLIFIER

Using \( V_{\text{test}} - I_{\text{test}} \), \( v_g = 0 \) and \( v_s = V_{\text{test}} \) if \( R_L \) excluded.

\[
R_{\text{out}} = \frac{V_{\text{test}}}{I_{\text{test}}} = \frac{1}{\left(\frac{1}{r_{ds} || R_s} + g_m\right)}
\]

Typically \( \left(\frac{1}{r_{ds} || R_s}\right) \ll g_m \) therefore \( R_{\text{out}} \approx \frac{1}{g_m} \)

From the design example,

\( g_m = 1 \text{ mS at } I_{DQ} \approx 0.41 \text{ mA, therefore, } R_{\text{out}} \approx 1 \text{ K}\Omega \)

Therefore, if we use the same bias except for common-drain rather than common-source \( R_{\text{out}} = 1\text{K}\Omega \). Note that BJT counterpart, the common-collector. For the common-collector stage,

\[
R_{\text{out}} \approx \frac{kT}{q} \frac{1}{I_{CQ}}
\]

which yields about 63 ohms, more than an order of magnitude smaller than the common-drain for the same bias. In conclusion, if low output impedance is of prime concern a BJT common-collector (emitter-follower) should be