Common-Source Amplifier

* “Common” means “grounded” or more generally, “connected to a DC supply”

What is going on with the load resistor $R_L$?

DC level of the output voltage is NOT zero ... but

A “typical load” does not draw much if any DC current ... because it is non-linear and the load resistor is the load’s small-signal model!

What is a “typical load”?  

DC Bias Point of the Common-Source Amplifier

For biasing, we

1. ignore the small-signal source vs and its small-signal resistance: \( R_S \to 0 \, \Omega \)
2. ignore the load resistor (since it’s a small-signal resistance, too): \( R_L \to \infty \, \Omega \)

Where to set \( V_{OUT} \)?
Graphical “Load-Line” Analysis

The current through $R_D$ must equal the drain current.

$$I_D = \frac{V_{DD} - V_{OUT}}{R_D} = I_{R_D}$$

What does this equation mean?
Small-Signal Model of CS Amplifier

* Substitute parameters at operating point selected so that $V_{OUT} \approx V_{DD}/2$

* Find two-port parameters of this amplifier:
  “natural” to use the transconductance form

\[ R_{in} = \]

\[ R_{out} = \]

\[ G_m = \]
Two-Port Model of Common-Source Amplifier

* Attach the source and load to find output current as a function of the source voltage

Infinite input resistance is ideal for a voltage input

Output resistance increases with $R_D$ increasing, but DC drain current $I_D$ will decrease and $g_m$ will decrease with $I_D^{1/2}$
Current-Source Supplies

* A current source to supply current, rather than a resistor, allows a high DC current for the device with a large incremental (small-signal) resistance.

The plot of $i_{SUP}$ vs. $v_{SUP}$ is: (note that $v_{SUP}$ must be positive)
Common-Source with Current Source Supply

* $R_D$ is replaced with idealized current source with internal resistance

$$i_{OUT} = I_{OUT} + i_{cut}$$

$$v_{OUT} = v_{OUT} + v_{out}$$

* For DC bias analysis, the small-signal source (with $R_S$) and the load resistor $R_L$ are eliminated, along with the internal resistance $r_{oc}$ of the current source
Graphical Analysis of CS Amplifier with Current-Source Supply

The region of input bias voltage $V_{BIAS}$ for which the current source and the MOSFET are in their constant-current regions is extremely small ....
Common-Source/Current-Source Supply Models

* The small-signal model is identical to the resistor supply, except that the current source’s internal resistance $r_{oc}$ replaces $R_D$

Tradeoffs are different from case of resistor load since $I_D$ is now decoupled from the small-signal current supply resistance $r_{oc}$
**p-Channel Common-Source Amplifier**

* Source of p-channel is tied to positive supply; current supply sinks $I_{SUP}$ to ground or to lower supply

![](image)

* DC bias:

  Eliminate small-signal sources; control voltage is $V_{SG} = V_{DD} - V_{BIAS}$
p-Channel CS Small-Signal Model

p-channel MOSFET small-signal model has the source at the top

Transform this into a circuit with $v_{gs}$ as the control voltage

\[ + \quad v_{gs} \quad - \]
\[ s \quad g \quad d \]
\[ g_m v_{sg} \quad r_o \quad r_{oc} v_{out} \]
\[ + \quad - \]
\[ i_{out} \]