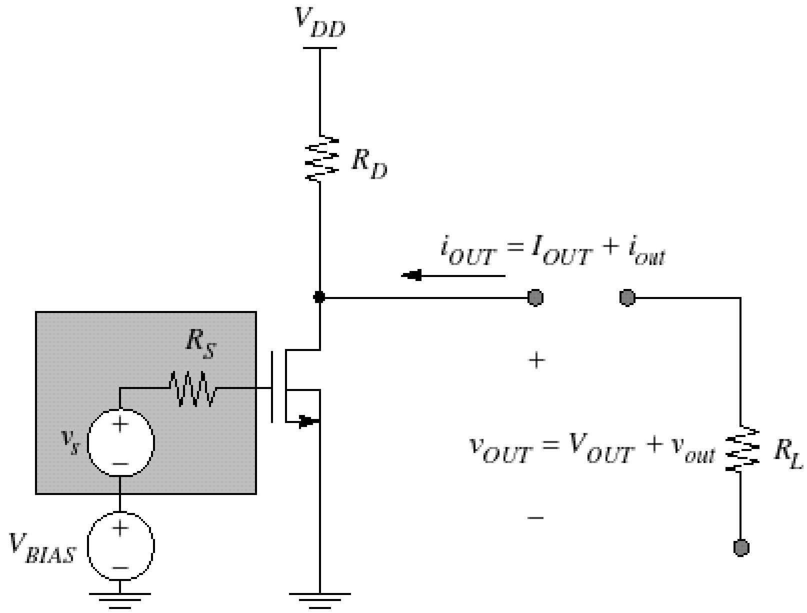
Common-Source Amplifier

* “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

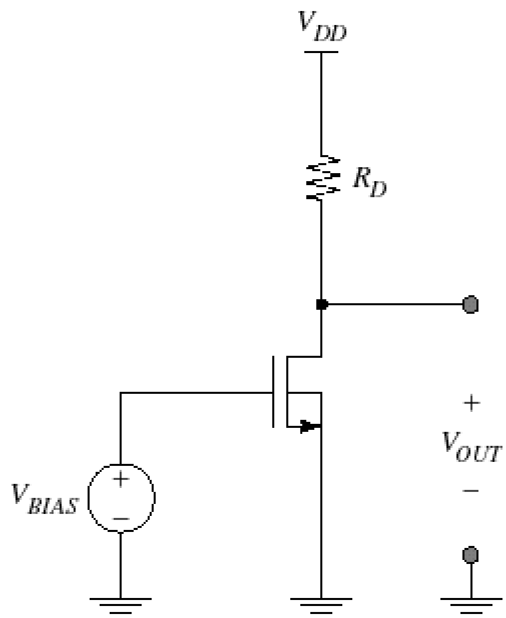
A “typical load” does not draw much if any DC current ... because it is non-linear and the load resistor is the load’s small-signal model!

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 --> 0 Ω
2. ignore the load resistor (since it's a small-signal resistance, too): R_L --> inf. Ω



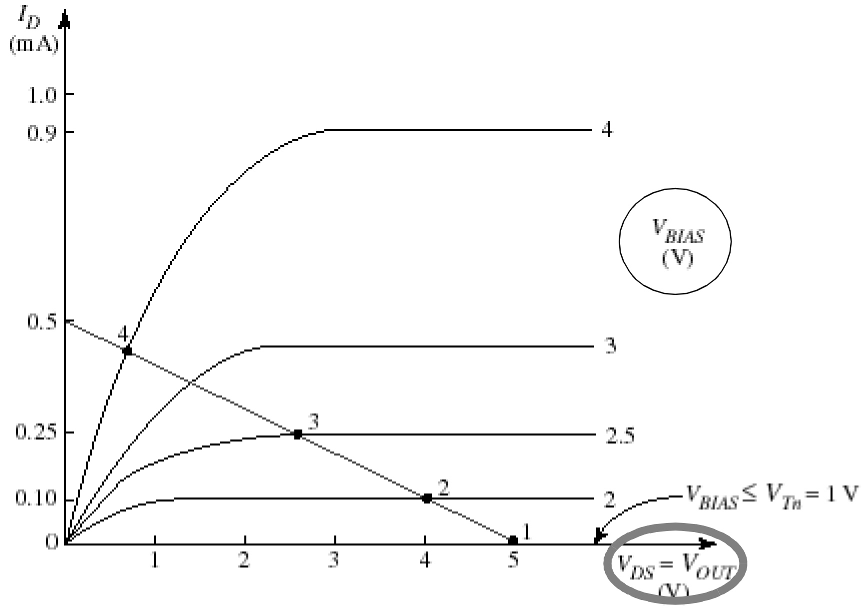
Where to set V_{OUT}?

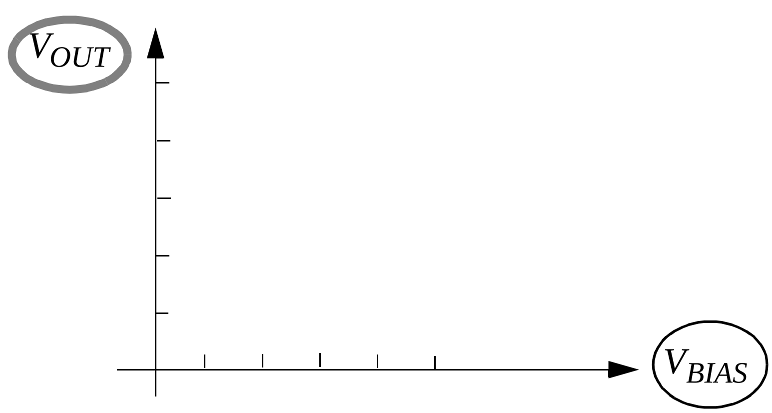
Graphical "Load-Line" Analysis

The current through R_D must equal the drain current.

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

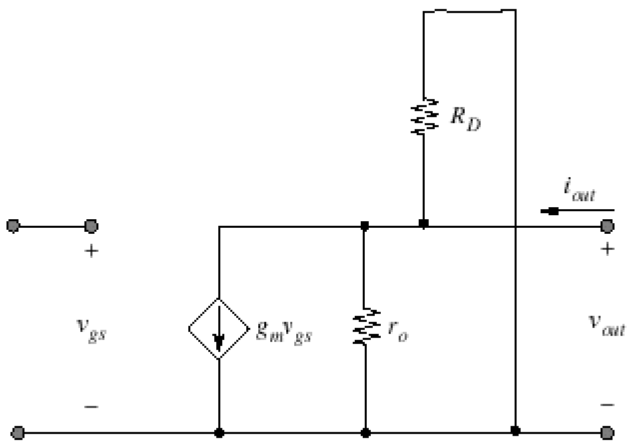
What does this equation mean?





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

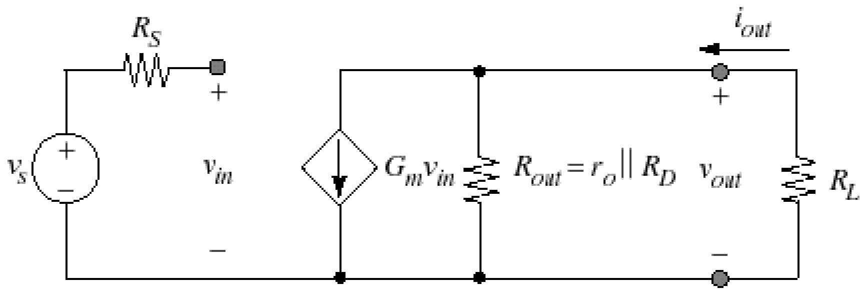
R_{in} =

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

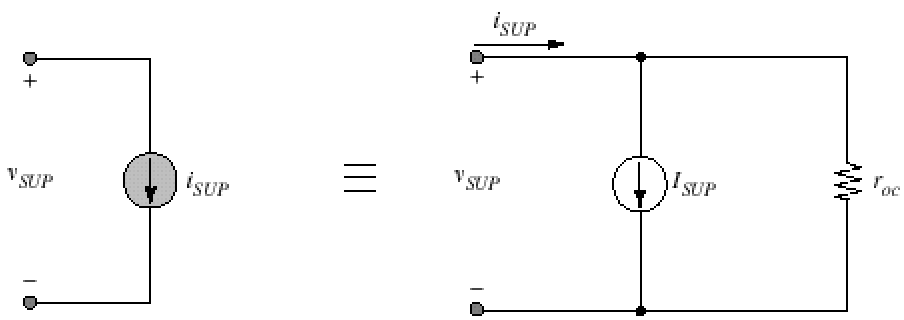


Infinite input resistance is ideal for a voltage input

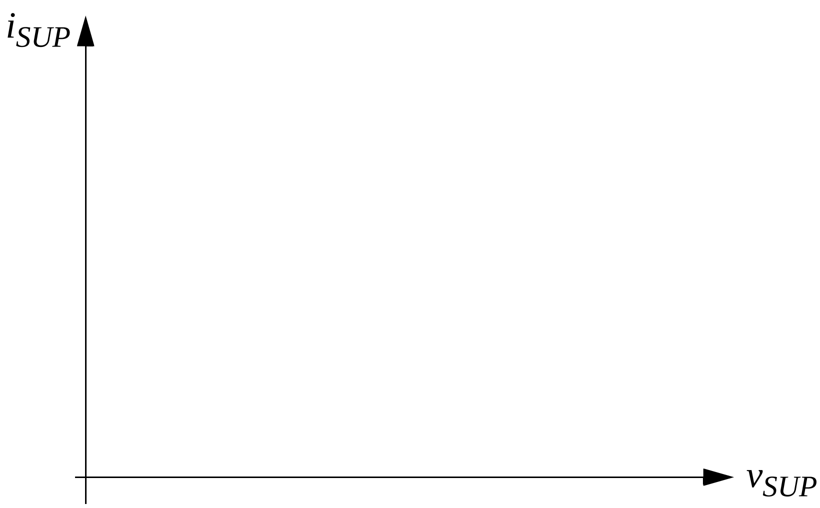
Output resistance increases with R_D increasing, but DC drain current I_D will decrease and g_m will decrease with $I_D^{1/2}$

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

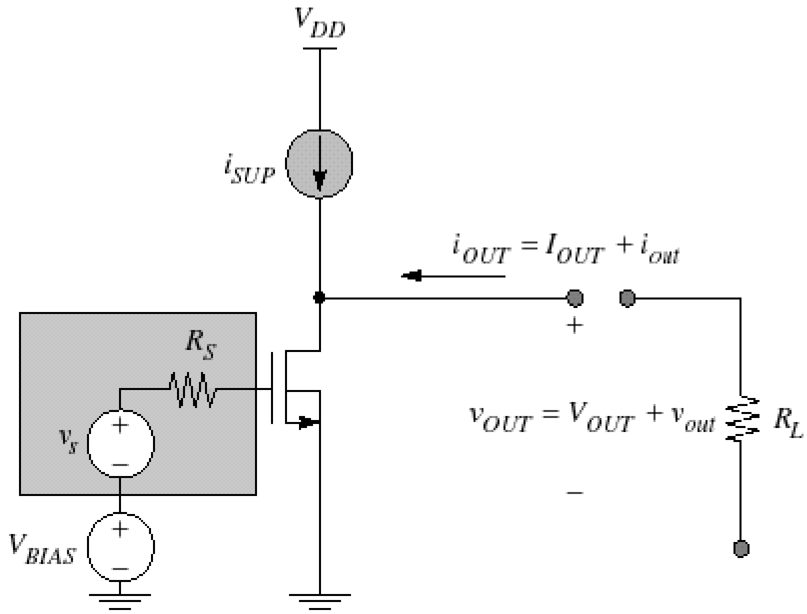


The plot of i_{SUP} vs. v_{SUP} is: (note that v_{SUP} *must* be positive)

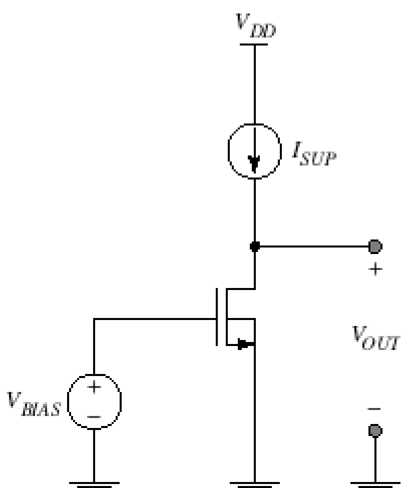


Common-Source with Current Source Supply

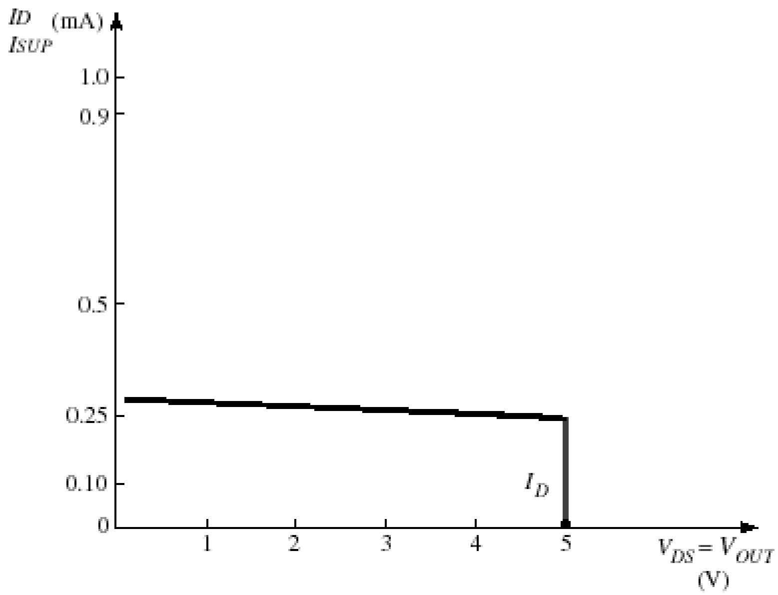
* R_D is replaced with idealized current source with internal resistance



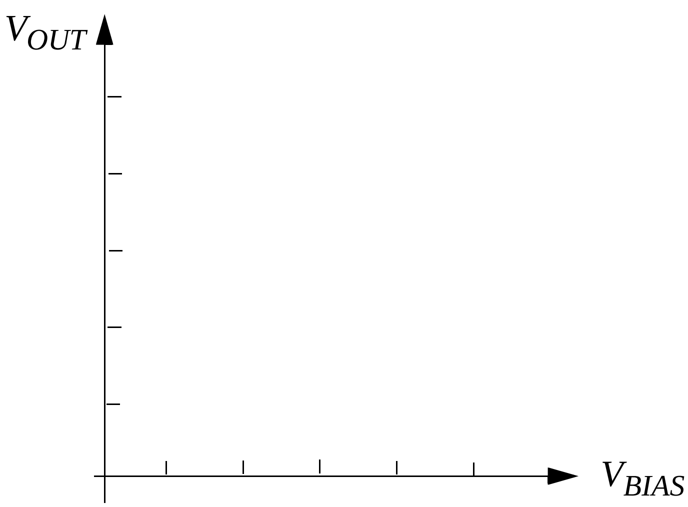
* For DC bias analysis, the small-signal source (with R_S) and the load resistor R_L are eliminated, along with the internal resistance r_{oc} of the current source



Graphical Analysis of CS Amplifier with Current-Source Supply

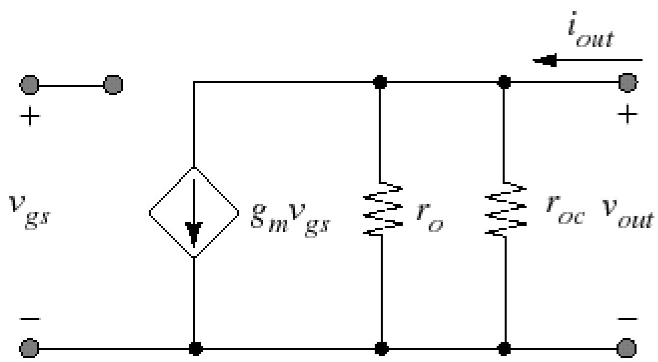


The region of input bias voltage V_{BIAS} for which the current source and the MOSFET are in their constant-current regions is *extremely* small ....



Common-Source/Current-Source Supply Models

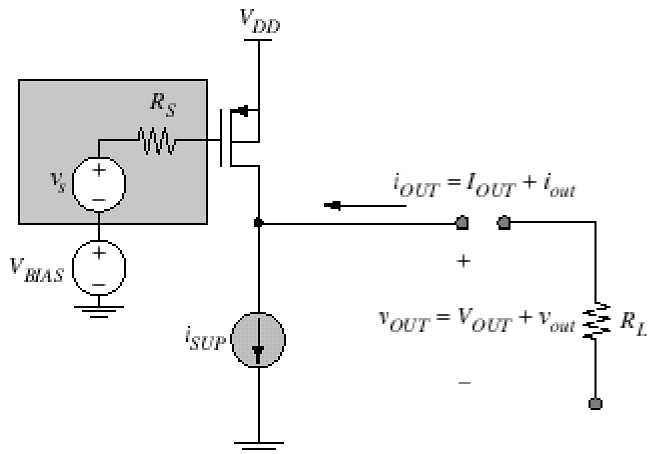
* The small-signal model is identical to the resistor supply, except that the current source's internal resistance r_{oc} replaces R_D



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

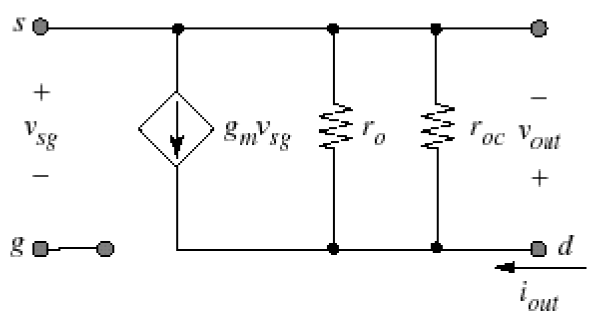


* DC bias:

  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