Lecture 26

- Last time:
  - Finish methods for finding two-port model parameters
  - Start common-source amplifier

- Today:
  - Current-source supplies
  - Common-gate amplifier

Use these results!
Two-Port Parameters:

Find $R_{in}$, $R_{ou}$, $G_m$

$\frac{v_e}{i_e} = \frac{v_e}{R_{in}} = \frac{v_e}{0} = \infty$

$R_{out} = \frac{v_e}{i_e}$

$V_{out} = 0$ after $R_e$ on

$R_{in} = R_e$ before $R_e$ on

$V_{source} = 0$ (grounded)

$V_{out} = 0$

$R_{load} = 0$

$R_{in} \cdot R_{load} = 0$

$V_{out} = 0$

$R_{load} = 0$

$R_{source} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$

$R_{load} = 0$

$V_{source} = 0$

$V_{out} = 0$
Two-Port CS Model

Reattach source and load one-ports:

\[ v_{out} = -G_m \left[ R_{out} \| R_c \right] \cdot v_{in} \]

\[ A_v^\ast = \frac{v_{out}}{v_{in}} = -G_m \left[ \frac{r_o \| R_D}{11R_c} \right] \]
Non-Ideal Current Sources

- We want to have both $R_D$ and a very large $g_m$ at the same time... how to do it?

The gain depends on the small-signal resistance; the DC current can be set by a supply voltage $V_{SUP}$ and modified by the load line.

\[ V = \frac{V_{SUP}}{R_0} \]

$R_0 = \frac{1}{g_m} \times \frac{1}{100k \Omega}$

Big!
Current Source Supply
Common-Source Amplifier with Current Source Supply

\[
\text{Gray Circle}
\]

\[
\text{Gray Box Small-Signal}
\]

\[
\text{Not There for DC Bias}
\]

Dept. of EECS

University of California at Berkeley
Load Line for DC Biasing

Both the I-source and the transistor are idealized for DC bias analysis:

\[ I_D = I_{sW} = 2.5 \, \mu A = 0.25 \, mA \]
TRANSFER CURVE

\[ \frac{dV_{out}}{dV_{bias}} = -\infty \]
Two-Port Parameters

```
<table>
<thead>
<tr>
<th>Gm</th>
<th>fsw</th>
</tr>
</thead>
</table>
```


t_{out}  

\[ R_{\text{in}} = 0 \]  

\[ R_{\text{out}} = \frac{g_m}{\frac{1}{f_{\text{sw}}} + \frac{1}{f_{\text{oc}}}} \]

From current source supply

Not usable bias.
**P-Channel CS Amplifier**

DC bias: \( V_{SG} = V_{DD} - V_{BIAS} \) sets drain current \( -I_{DP} = I_{SUP} \)
Two-Port Model Parameters

Small-signal model for PMOS and for rest of circuit
Common Gate Amplifier

DC bias:

\[ V^+ \]

\[ I_{SUP} \leftarrow OA \]

\[ V^- \]

\[ I_{SUP} = I_D \]

\[ I^* = I_D \]

\[ I_{OUT1} = -I_D = -I_{SUP} \]

GATE IS "COMMON"

GARY...

S.S. ELEMENTS.

dept. of EECS
CG as a Current Amplifier: Find $A_i$

\[ i_{\text{out}} = i_d = -i_g - i_s = -i_t \]

\[ A_i = \frac{i_{\text{out}}}{i_t} \]

For $R_s = \infty$ and $R_L = 0$:

\[ A_i = \frac{-i_c}{i_t} = -1 \]