Summary

Lecture 29

R_in can't depend

Last time:
- Bipolar single-stage amplifiers: biasing, common-emitter, common-base, common-collector

Today:
- For limits to today:
  - Low values of R_in

Overview of single-stage amplifiers
- Frequency response of CS stage operated as a current amplifier

Summary of Two-Port Parameters for
CE/CS, CB/CG, CC/CD Amplifiers

<table>
<thead>
<tr>
<th>Amplifier Type</th>
<th>Controlled Source</th>
<th>Input Resistance $R_{in}$</th>
<th>Output Resistance $R_{out}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Emitter</td>
<td>$g_m = g_m$</td>
<td>$r_s$</td>
<td>$r_o \parallel r_{oc}$</td>
</tr>
<tr>
<td>Common Source</td>
<td>$g_m = g_m$</td>
<td>$\infty$</td>
<td>$r_o \parallel r_{oc}$</td>
</tr>
<tr>
<td>Common Base</td>
<td>$A_i = -1$</td>
<td>$1/g_m$</td>
<td>$[r_{oc} \parallel (1 + g_m (r_o \parallel R_o)) r_o]$ for $g_m R_o \gg 1$</td>
</tr>
<tr>
<td>Common Gate</td>
<td>$A_i = -1$</td>
<td>$1/g_m$</td>
<td>$r_{oc} \parallel [(1 + g_m R_o) r_o]$, $\nu_{sb} = 0$</td>
</tr>
<tr>
<td>Common Collector</td>
<td>$A_o = -1$</td>
<td>$r_s + \beta_o r_o \parallel r_{oc} \parallel R_o$</td>
<td>$(1/g_m) + R_o / R_o$</td>
</tr>
<tr>
<td>Common Drain</td>
<td>$A_p = 1$ if $\nu_{sb} = 0$, otherwise $g_m / (g_m + g_m)$</td>
<td>$\infty$</td>
<td>$1/g_m$ if $\nu_{sb} = 0$, otherwise $1/(g_m + g_m)$</td>
</tr>
</tbody>
</table>
The "Chapter 8" Method for Single-Stage Amplifier Analysis

1. What is it?
2. DC Bias
3. Small-signal 2-port model
4. Output swing

DC Bias for CE

\[ I_{c, IB} = 500 \mu A \]
\[ R_E = 500 \Omega \]
\[ I_c R_E = 100 \mu A \cdot 500 \Omega = 0.05 V \]

\[ V_{\text{bias}} = V_{BE} + I_c R_E = \left[ V_{\text{BE(ON)} \left( \frac{I_c}{I_s} \right)} \right] + I_c R_E \]
Two-Port Model for CE<sub>deg</sub>

- Input looks like CC $\Rightarrow R_{in} \approx \frac{2n + (B + R) \text{RE}}{2m}$
- Output looks like CB (see p. 504 for details) $\Rightarrow R_{out} \approx \frac{2n}{(1 + 9m \text{RE})/2m}$
- Transconductance: $G_m = \frac{g_m}{1 + 9m \text{RE}}$

\[ g_m = \frac{2I_c}{K_T} \quad \text{sensitive to temperature} \]

\[ G_m \approx \frac{1}{\text{RE}} \]
Two-Port Model for $CE_{\text{deg}}$ (cont.)

- Find $G_m = \frac{g_m}{g_m+R_e+1}$

\[ V_{\text{in}} = R_m (1+Q_m R_e) \quad R_{\text{out}} = \frac{20c}{10} (1+Q_m R_e) \]

- Voltage Gain: unloaded $=-G_m \cdot R_{\text{out}}$

\[ \text{LOADED} = \frac{V_{\text{in}}}{R_{\text{in}} + R_{\text{in}}} \cdot G_m \cdot \left( \frac{R_{\text{out}}}{R_e} \right) \]

- Is it a good voltage amplifier (vs. CE)?
Output “Swing”

- Maximum $v_{OUT} = V_{OUT} + v_{out} = v_{out}$

- Minimum $v_{OUT}$

$V_T - V_{SCE_{min}} \approx 0.1V$

$V_{CE_{min}} = 0.1 \sim 0.2V$

$0.2V$ drawn $V_-$