Lecture 31: Generally Loaded Transistor

Announcements:
- HW#10 online due Friday via Gradescope
- Lab#5 1st checkpoint due this week
  - Just send your spice file to your lab GSI
- Remarks on Lab#5
  - If you are using excel or matlab to compute equations for Lab#5 → you will regret doing this when taking your next exam
  - You should design by hand at least 3 times before going to a computer, since this is the only way to get familiar with the process
  - You cannot see the trade-offs without analyzing by hand
  - You need to put the work in to be able to recognize things; put the work in and you will be rewarded
- Z-scores available soon
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- Lecture Topics:
  - Generally-Loaded Transistor
    - Terminal Resistances
    - Terminal-to-Terminal Gains
    - Inspection Analysis Sheet
    - Examples
- -------------------------------------
- Last Time:
  - Took a look at different amplifier configurations
  - Now, generalize inspection analysis to nearly any amplifier configuration …
Generally Loaded Transistor

Find the terminal resistances: (i.e., find the resistances seen looking into each terminal)

Re: we're already derived this in association w/ finding Ref in wL using SCTL analysis!

\[
Re = \frac{R_m + R_g}{\beta + 1} \approx \frac{1}{\beta m} + \frac{R_b}{\beta + 1} \quad [G >\geq Re]
\]

If not the case, the expression will be different!
Generally Loaded Transistor

\[ I_E = \beta I_B \]

\[ R_b = \frac{N_x}{I_X} = V_{II} + (\beta+1)I_X R_E \approx V_{II} (1 + \beta m_{II}) R_E \]

\[ N_x = I_X R_{II} + (\beta+1)I_X R_E \]

\[ R_b = \frac{N_x}{I_X} = R_{II} + (\beta+1)R_E \]

KVL: \( N_x = N_{be} + N_C \)

\( N_{be} = I_X R_{II} \)

\( N_C = (I_X + g_m V_0) R_E = I_X (1 + g_m R_{II}) R_E \)

\( R_b = \frac{N_x}{I_X} = V_{II} + (\beta+1)R_E \approx V_{II} (1 + \beta m_{II}) R_E \)

\( N_x = (\beta+1)I_X (R_E + R_E) \)

\( R_b = \frac{N_x}{I_X} = (\beta+1) (\frac{1}{g_m} + R_E) \)

Yet, another form is

\( R_b = \frac{N_x}{I_X} = V_{II} + (\beta+1)R_E \)

Find \( R_E \) (note that \( R_b \) can influence this, so include \( R_b \) in the analysis)

This comes about due to amplification of \( I_b \)
Remarks:

- $R_c \approx (1+(0.04)(1k))(100k) \approx 4.1M\Omega$ (this is huge)
- Rarely use $R_c$ in discrete circuits, since it is generally much larger than $R_C$
- In integrated circuits, however, the loading can be very large, especially if it comes from another transistor
- For example:

\[
\begin{align*}
R_c &= R_C \approx 4M\Omega \\
R_o &= R_{o2} \approx 4M\Omega \\
R_1 &= R_{o1} \approx 4M\Omega
\end{align*}
\]