Discussion 6

Outline:

- **Common Collector Amplifier**
  - Analyze Gain, input and output impedances
- **Summary of the 3 basic Amplifiers (CE, CB, CC)—Discuss differences and circuit applications**
  - Compare the characteristics
- **Examples on how to cascade multiple transistors to create better amplifiers**
  - Voltage Amplifier: High Gain, large input impedance, small output impedance (CE-CC amplifier)
  - Transconductance Amplifier: High \( G_m \), large input impedance, large output impedance (CE-CB amplifier)

**Common Collector Amplifier/Emitter Follower:**

Figure 1 below shows the basic common collector amplifier. Draw its small signal model and verify that the gain, input impedance, and output impedance are as follows:

![Common Collector Amplifier Diagram](image)

\[
A_v = \frac{g_m R_E}{1 + g_m R_E} \implies \text{implies } A_v \text{ is at most } 1.
\]

\[
R_{in} = r_\pi + (1 + \beta) R_E
\]

\[
R_{out} = \frac{1}{g_m} || r_\pi || R_E \approx \frac{1}{g_m} || R_E
\]

Quick way to see the output impedance is looking at the output node. The impedance seen at the output node is the impedance looking up (into the emitter of \( Q_1 \)) in parallel with the impedance looking down. Recall that impedance seen looking into the emitter of an amplifier is \( 1/g_m \), which means that the output impedance is approximately \( 1/g_m \) in parallel with \( R_E \).
Small signal Model of CC:

Summary of 3 basic amplifiers:

CE Amplifier: High gain, Large input resistance, large output resistance
CB Amplifier: High gain, Small input resistance, large output resistance
CC Amplifier: Unity gain, Large input resistance, small output resistance

Cascading multiple transistors:
To make better amplifiers, i.e. to have amplifiers with higher gain and more ideal-like input and output resistances, we need to cascade the various types of amplifiers we’ve learned about.

Cascading: So far, we’ve only discussed single-stage amplifiers, but by placing amplifiers one after the other, we create multiple-stage amplifiers.

Tips for multiple-stage amplifiers:
Gain=Product of gains from each stage
Input resistance=input resistance of first stage
Output resistance=output resistance of final stage

Building ideal-like amplifiers:
Voltage Amplifiers: Want high gain, high input impedance, and low output impedance
CE amplifier has a high gain, large input impedance, and large output impedance. So, using this amplifier for the 1st stage will provide us with the desired high input impedance, and a large gain; however, its large input impedance is undesired. Solution: Use a CC second stage, so its small output impedance can be used.

Final Result: Gain approximately that of the CE stage (since gain of CC amplifier is approximately unity). High input impedance of CE stage, and low output impedance of the CC stage:

Transconductance Amplifiers: Want high gain, high input impedance, high output impedance
CE amplifier has high gain, large input impedance, and large output impedance, but suppose we wish to increase the output impedance.
Solution: Use a CB second stage, since its output impedance will become even higher.

Final Result: Gain is approximately that of CE stage (since current gain of CB stage is approximately unity). High input impedance of CE stage, and output impedance of CB stage degenerated by output impedance of the CE stage \((g_{m,cb}(r_o,cb)ro,ce))\).