Last time: BJT CE amplifier biased by current source

Assume FA regime, then

\[ I_B = \frac{I_E}{\beta + 1}, \quad I_C = \frac{I_E}{\beta}, \quad V_{BE} \approx 0.7V \]

Calculate \( V_{CE} \) and confirm it is > 0.2V, then BJT can be replaced with model.
Common Emitter

*Biased by current source and without $R_E$*

- Input to Base

- Output from Collector

Must have bypass cap to get AC gain.

The circuit can have both voltage and current gains:

- **Thevenin form**, can be replaced with Norton form with current source $-g_m V_{in}$.
CE amp biased by current source; with and without $R_E$ (neglect $r_o$).

Case 1

$R_E = 0$

$R_{in} = (R_B \parallel \pi) \approx r_\pi$

$A_{v0} = -g_m \cdot R_C$

Case 2

$R_E \neq 0$

$R_{in} = (R_B \parallel (r_\pi + R_E \cdot [\beta + 1])) > r_\pi$

$A_{v0} = -\frac{\beta \cdot R_C}{r_\pi + R_E \cdot [\beta + 1]} = \frac{-g_m \cdot R_C}{1 + \frac{R_E}{r_\pi} \cdot [\beta + 1]}$

Negative feedback resistor $R_E$ improves input impedance for the expense of gain
Common Base amplifier.

No need for $C_E$!

Equivalent circuit for AC analysis
Common Base amplifier.

Redraw equivalent circuit in more convenient form and neglect $r_o$. 

\[ V_{out} \]
Common Base amplifier.

Voltage gain

\[ A_V = \frac{V_{out}}{V_{in}} = -\frac{-2e^* (R_L || R_C)}{V_{BE}} = g_m \left( R_L || R_C \right) \]

Noninverting amplifier with open circuit voltage gain value similar to that of CE amp

\[ A_{V0} = g_m \cdot R_C \]

Short circuit current gain

\[ A_I = \left| I_{out} \right| = \frac{I_{out}}{I_{in}} = \frac{g_m V_{BE}}{V_{BE} \left( g_m \cdot \frac{1}{R_A} \right)} = \alpha \]

i.e. no current gain!
Common Base amplifier.

**Input impedance**

\[ R_{in} = \frac{V_{in}}{i_{in}} = ? \]

\[ V_{in} = -V_{BE} ; \quad i_{in} = -g_m V_{BE} - \frac{V_{BE}}{r_a} \]

\[ R_{in} = \frac{1}{g_m + \frac{1}{r_a}} = \frac{1}{\frac{\beta}{r_a} + \frac{1}{r_a}} = \frac{r_a}{\beta + 1} \]

Very small – PROBLEM for voltage amplifier

**Output impedance**

\[ R_{out} = \frac{V_{out}}{i_{out}} \bigg|_{V_S=0} = r_C \quad (\text{for } r_0=\infty) \]
Common Base amplifier.

Net voltage gain

\[ G_v = \frac{V_{out}}{V_s} = A_v \cdot \frac{R_s}{R_s + R_s} = g_m \left( \frac{R_L || R_C}{R_s} \right) \frac{1}{1 + \frac{R_s}{R_s} (\beta + 1)} \approx \frac{R_L || R_C}{R_s} \]

Could we guess this without analysis?

Observe current buffer action of CB amp

Equivalent circuit of amp with current gain equal to one.