EE 330
Lecture 28

High Gain Amplifiers
Cascaded Amplifier (cascode)
MOS Amplifiers
Amplifier Biasing
3 Basic Amplifiers

Common Emitter
- High input gain
- Reasonable Rin
- "Workhorse" amplifier

Common Collector
- High Rin
- $A_v \approx 1$ (slightly less)
- Buffer

Common Base
- High noninverting gain
- Really low Rin 😞 😊
- Useful as a Transresistance amplifier
High Gain Amplifiers

\[ \frac{U_o}{U_i} = -9mR = -\frac{I_cqR}{V_t} \]

1) Increasing I_cqR will increase A_v
2) For a given I_cq (or Power), increasing R will increase the gain
3) Signal swing at output varies with
   I_cqR
   (bound by I_cqR = Vcc & practically
   bound by I_cqR = \frac{Vcc}{2} for good sign)
   \[ \frac{U_o}{U_i} = \frac{Vcc}{2V_t} \]
   \[ A_v = -\frac{10}{50mv} = -200 \]
Load line

\[ V_{CC} = I_c R + V_{CE} \]

\[ I_c = f (V_{CE}, V_{BE}) \]

\[ I_c \leq \frac{V_{CC}}{2} \]

\[ V_{OE} = \begin{cases} 
V_{CC} - V_{CEQ} & V_{CEQ} > \frac{V_{CC}}{2} \\
V_{CEQ} & V_{CEQ} \leq \frac{V_{CC}}{2} 
\end{cases} \]

\[ A + Q - point \]

\[ V_{CEQ} = V_{CC} - I_c R \]

\[ J_{c} = \frac{V_{CC}}{2}, \text{ max. swing} \]

\[ \text{max. } I_c R \leq V_{CC} \]
Is this an inherent limitation on the BJT?

Is there a different circuit that may give more gain and a good signal swing?
Consider

Pick $R_B$ so that obtain desired $V_{CC}$

$\lim_{R_x \to \infty} \frac{V_0}{V_i} = \frac{V_0}{V_i}$

$V_0 = -g_m R_x \Rightarrow A_v = -g_m R_x$

$\lim_{A_v \to -\infty} R_x = \infty$
Result \( Av = -20 \) is fantastic! Too good to be believable

Consider more accurate model or BT7

\[
\frac{V_o}{V_i} = -\frac{gm}{g_0} = -\frac{I_{CA}}{V_t \cdot \frac{I_{CA}}{V_{AF}}} = -\frac{V_{AF}}{V_t}
\]

\[
= -\frac{200V}{25mV} = -8000 \quad \text{Fantastic Gain!}
\]

- Reliable Model
(Can we build a current source?)

\[ I = \beta I_b \]

\[ I_a = \frac{V_{cc} - 6}{R_a} \]

\[ I_c = \beta I_b \]

Sinking current source
\[
\frac{V_o}{V_i} = -\frac{g_m}{g_{m1} + g_{o2}} = -\frac{\frac{I_{CE}}{V_T}}{\frac{I_{CE}}{V_T} + \frac{I_{CE}}{V_{AF2}}} = -\frac{V_{AF}}{2V_T}
\]