EE 4345 - Semiconductor Electronics Design Project
Spring 2002 - Lecture 26

Professor Ronald L. Carter
ronc@uta.edu
http://www.uta.edu/ronc/
Fig 5.1* Emitter-follower output stage with current-mirror bias.

- Q3 is gummel conf
- \( I_R \approx \frac{(V_{CC}-V_{be})}{(R_3+R_1)} \)
- \( I_Q \sim I_R \cdot \frac{R_1}{R_2} \)
- If Q1 & Q2 FA, then
  \[ V_i = V_o + V_t \ln\left(\frac{(I_Q+V_o/RL)/I_S}\right) \]
  - If RL large, \( I_o \ll I_Q \), so
  - \( V_i > 0, V_i = V_o + \text{const.}, \) until Q1 saturates
  - \( V_i < 0, \) the same until Q2 sat at \(-V_{CC} + V_{CE2\text{sat}}\)
- RL starts significant conduction at
  \[ RL_3 = \frac{(2V_{CC} + V_{CE2\text{sat}})}{I_Q} \]

L25 04/16/02
Fig 5.2* Transfer char. of the circuit of Fig 5.1 for low (RL2) and high (RL1) values of RL

- For RL = RL1 > RL3, negl load curr
- For RL = RL2 < RL3, incl load curr
Fig 5.3* (a) Q1 doesn’t cutoff (b) Q1 does cutoff

- (1) low input
- (2) input high enough, or RL low enough to c/o Q1
Fig 5.4* Load lines for RLs

\[(2V_{CC} + V_{CE2\text{sat}})/I_Q\]

\[\equiv RL3\]

- Gives max power (C)
- \(RL2 < RL3\)
  \[\Rightarrow\] power (B)
- \(RL1 > RL3\)
  \[\Rightarrow\] power (A)

\[\eta_{\text{max}} = \left(1 - \frac{V_{CE\text{sat}}}{V_{CC}}\right)/4\]

\[\sim 1/4\]
Fig 5.6*
Max power
Load, tang.
@ mid-point
o.c. load

$R_L = R_{L3}$

$R_L \rightarrow \infty$

2$V_{CC} > BV_{CEO}$

Low transistor power dissipation

High transistor power dissipation

$P_3 = I_c V_{ce1}$

$P_2$

$P_1$

$[2V_{CC} - V_{CE2\text{sat}}]$
Fig 5.7* Low-frequency, small-signal equivalent circuit for the emitter follower

Class A: Drive device has an appreciable current (no-cutoff)

$$A_v = \frac{v_o}{v_i} = \frac{R_L}{(R_L + 1/g_m + R_s/\beta_o)}$$

$$R_o = \frac{1}{g_m + R_s/\beta_o}$$

(... + R_L)
Fig 5.10* Simplified ic Class B output stage

- Q1 (nnp) and Q2 (pnp), are a complementary pair \( \Rightarrow \beta_1 = \beta_2 \)
- Q1 off if \( V_i < V_{beOn} \)
- Q2 off if \( V_i > -V_{beOn} \)

Dead zone: \( I_L = 0 \) if \( -V_{beOn} < V_i < V_{beOn} \)
Fig 5.11* Transfer Characteristic of the Class B Stage

\[ V_{o} \]

\[ V_{CC} - V_{CE1(sat)} \]

\[ [ -V_{CC} + V_{be2} - V_{CE2(sat)} ] \]

Slope \( \approx 1 \)

\( Q_1 \) on, \( Q_2 \) off

\[ V_{BE(on)} \]

\[ -V_{BE(on)} \]

\[ V_{CC} + |V_{CE2(sat)}| \]

\[ Q_2 \] saturates

\[ Q_1 \] saturates

Slope \( \approx 1 \)

\( Q_1 \) off, \( Q_2 \) on

\[ [ V_{CC} + V_{be1} - V_{CE1(sat)} ] \]
Fig 5.13* Class AB output stage. The gummel diodes reduce crossover distortion.
Fig 5.20a* Simplified schematic of the 741 output stage

Group Project will be similar

Optimize current, voltage gain, fT

Use Cadence to capture schematic, set bias, etc. and generate outputs
References