Cascode Amplifier Transfer Characteristic

The two-transistor configuration shown below, called a 'cascode' connection has certain advantages in some application. The purpose of this illustration however simply is the comparison of the input-output transfer characteristic calculated using a PWL model with a computed (PSpice) analysis.

Cascode Amplifier
RB3  6  4  68K
RB2  4  2  15K
RB1  2  7  18K
RC2  6  5  3.9K
RE1  1  0  1K
VCC  6  0  DC  10
Q2  5  4  3  Q2N3904
Q1  3  2  1  Q2N3904
VIN  7  0  DC  1

The PWL ('flag' transistors) model is drawn to the left.

Neglect base current compared to emitter and collector as an approximation likely to be endorsed later by calculations based on this assumption. The Q1 base voltage is (approx.)

\[ V_{in}(15+68)/(18+15+68) + 10(18/(18+15+68)) = 0.822V_{in} + 1.782 \]

When \( V_{in} \) is sufficiently negative Q1 will be cutoff, forcing Q2 to be cutoff as well. In this condition \( V_{out} = 10v \). The cutoff state persists for \( 0.822V_{in} + 1.782 \leq 0.7 \) or \( V_{in} \leq -1.316v \).
When Q1 is turned ON, so also is Q2. Again neglecting the base currents use the expression for the Q1 base voltage to estimate the Q1 emitter current. Arguing on the basis of a large β use the Q1 emitter current as an estimate of the Q2 collector current. From this obtain the expression shown as an estimate of the Q2 collector voltage variation as a function of Vin.

$$v_{out} \approx 10 - \left( \frac{0.622 \, v_{in} + 1.782}{3.9K} \right) \frac{1K}{1K} = 5.788 - 3.198 \, v_{in}$$

A PROBE plot of the Q2 collector voltage is drawn below; superimposed is a plot of the line corresponding to the estimated operation. Note the cutoff starting at ≈ -1.4 volts also as estimated. Estimate the onset of saturation by equating the emitter voltage of Q2 (neglect base currents as before to estimate base voltage) to the collector voltage as given by the equation above, i.e., when the voltage difference across Q2 is about zero; the estimate obtained this way is $V_{in} \approx 1.35\,v$. 

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