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Homework Set 3 due Friday 02/16/07

1. [50 points] (transistors as diodes)

For this problem use the Spice models for the 2N3904 and 2N3906 transistors. Note carefully polarities and in all cases keep the emitters at ground potential.

a) (for collector - base diode)

a1) Make each (of the 2N3904 and the 2N3906) into a diode by connecting the base to the emitter and run Spice curves of the diode current versus diode voltage ($I_C$ versus $V_{CE}$) (one for each transistor) .

a2) Find the Q point voltage if the magnitude of the Q point current is $|I_C|$=2mA.

a3) Find the small signal resistance of the diodes at the Q point.

a4) Then using a 5V battery, $V_{CC}$, find the load resistances (one for each diode), $R_L$, to bias your diodes at the Q point.

a5) Find the voltage, versus time, on $R_L$ (positive on the side attached to the transistor) if a signal of v=0.000001sin(2t) is added (in series) to $V_{CC}$.

b) (for emitter-base diode)

Repeat all parts of part a) by connecting the base to the collector (rather than to the emitter) and using the emitter-base junction| as the diode and bias for $|I_E|$=2mA (and using $I_E$ and $V_{CE}$ as the diode variables).

2. [50 points] (CMOS current mirrors)

In this problem use the Spice models for the 4007 CMOS. Note that the transistors labeled Q in the text would normally be labeled M.

a) For the circuit of Figure 6.4, p. 563, create a current Io of 2mA with a supply voltage, $V_{DD}$, of 9V. Give a Spice plot of Io versus Vo for Vo ranging from 0 to $V_{DD}$ (use enough points to obtain a smooth curve).

b) Repeat part a) for the circuit of Figure 6.58, p. 649.

c) Repeat part a) for the circuit of Figure 6.7, p. 566, for Io=$I_5$ and Vo at the drain of transistor Q5 and $V_{SS}$ = 0 (that is, at ground).