

Homework Set 6 due Monday 03/12/07

For these problems, if needed use the Spice model parameters for the 4007 CMOS transistors, these being nch and pch in the CA3600E part in the Anl\_misc libraries. Also use  $V_{DD} = -V_{SS} = 5V$ .

1. [50 points] (PMOS and pnp OTAs)

- a) Draw a schematic for a PMOS differential pair (with an active load), the complement of that of Figure 7.28 (a), p. 728. Use only voltage sources and transistors.
- b) Repeat part a) for the pnp differential pair (with an active load), the complement of that of Figure 7.32, p. 734.
- c) For the pnp differential pair of part b) used as an OTA (=Operational Transconductance Amplifier), give the formula for  $i_o = i_{C2} - i_{C1}$  as a function of the input differential voltage,  $v_{id} = v_{B2} - v_{B1}$  and sketch this function.

The following problem is not to be graded as it is not for credit but for practice.

2. [no points as not for grading] (transistor-R current sources)

- a) Design a current {sink} source using the 4007 NMOS transistors in the circuit of Figure 6.4, p. 563 (but with bottom potential being  $V_{SS} = -5$  rather than ground). It is desired that the output current  $I_o$  be 2mA. Give the value of R and sketch the diode curve for the left transistor (called Q1 in Fig. 6.4 but should be M1 for Spice conventions) [use the 4007 parameters for key points on the curves]; include the load line determined by R in your sketch.
- b) Repeat by making a current (sink) source for the same output current using 2N3904 (=Spice Q2N3904) transistors and a resistor.
- c) Repeat by using 2N3906 transistors (and a resistor) for a current (source) source.