

1. [0 points] Download the transistor file bicmos12.olb (or for PSpice 8 the two equivalent files bicomosis12.lib & bicmos12.slb) from the web. Install these on the computers or folders from which you will run Spice. Similarly for the BJT transistors Q2N3904 & 2N3906 along with the CMOS 4007 transistors via the CA3600 files.
2. [35 points] Since different transistors give different results there are different models for them. Print out the models for the mnmosis and for the mam12l3n and compare; repeat for the mpmosis and the mam12l3p. Some of the parameters, such as KP, and VTO have the same name; create a table of these two parameters for these four transistors for comparison purposes. Note differences. Repeat for the two different models (level 3 and level 4) for the same transistor, mam12l3n and mam12l4n.
3. [33 points] {data for this and the following problem is on the course web page}
  - a) For the CMOS 4007 transistors give KP, W, L, VTO and LAMBDA for the NMOS & PMOS and compare. Calculate  $(KP/2)(W/L)$  for these and again compare.
  - b) For the NMOS 4007 show that at  $V_{GS}=2$ ,  $V_{DS}=4$ , you can use eq. (4.6),  $I_D=(KP/2)(W/L)(V_{GS}-V_{TO})^2$ ; use this and compare with what the Spice curves give.
  - c) Modify this equation for channel length modulation, via eq. (4.22), that is by multiplying eq. (4.6) by  $(1+LAMBDA(V_{DS}))$  and again check against the Spice curves.
4. [32 points]
  - a) For the 2N3904 & 2N3906 give BF & BR (the forward and reverse betas) ISE and VAF & VAR (forward and reverse Early voltages; **default for VAR is infinity**).
  - b) For this npn transistor, 2N3904, at  $V_{BE}=0.7$ ,  $V_{CE}=7$ , use the Ebers-Moll eq. (5.27),  $I_C=ISE([\exp(V_{BE}/VT)]-1)-(ISE/\alpha_R)([\exp(V_{BC}/VT)]-1)$  and compare with the Spice curve.
  - c) Then repeat incorporating the Early effect by multiplying by  $(1+(V_{CE}/VAF))$ , as per eq. (5.36).

