Lecture 7

• Last time:
  – Underdamped 2nd order transfer functions

• Today :
  – Bode plots for general transfer functions
  – Start: semiconductor properties of Si
Electronic Properties of Silicon

• Silicon is in Group IV
  – Electronic structure: $1s^22s^22p^63(sp)^4$
  – Diamond lattice, with 0.235 nm bond length

• Very poor conductor at room temperature: why?
Bond Model for Silicon
Thermal Equilibrium (Pure Si)

• Balance between generation and recombination determines $n_o = p_o$

• Strong function of temperature: $T = 300$ K
Doping with Group V Elements

• P, As: extra bonding electron ... lost to crystal at room temperature
Doping with Group III Elements

• Boron: 3 bonding electrons $\rightarrow$ one bond is unsaturated
Mass Action Law

• Balance between generation and recombination:
  \[ p_o \cdot n_o = n_i^2 \]

• N-type case:

• P-type case:
Compensation

- Dope with *both* donors and acceptors
Compensation (cont.)

- More donors than acceptors: \( N_d > N_a \)

\[
n_o =
\]

- Hole concentration:

\[
p_o =
\]