Chapter 1:

Chapter 2: Quantum Computers in Silicon

Chapter 1 Design Principles

1. The Power and Limitations of Quantum Computing
2. Formalism
3. Fault Tolerant Quantum Computing
4. Silicon Phosphorus
5. Optimal Control

Chapter 2 Surface codes

Chapter 2: Architecture design

1. The heavy hexagon surface code
2. The dipole surface code
3. The exchange surface code
4. **Heavy hexagon in silicon**
   * Design specifications
   * Why it’s a bad idea
     + Reduced frequency collisions not applicable to global control SiP
     + Criss cross wire maps poorly onto hexagonal lattice
     + Hexagon maps poorly onto silicon lattice.
       - Reduced symmetry results in greater number of variations due to placement imprecision
5. Heavy square?
6. Light hexagon (unlikely)?

Chapter 3: Quantum control

1. Overview of Quantum control
2. A useful example: Nuclear electron spin swap
3. 2 qubit CNOT
4. 3 qubit CNOT

Chapter 4: Parallel CNOT Optimisation

1. Multi-System control with GRAPE
2. Two qubit CNOTs in parallel
3. Three qubit CNOTs in parallel
4. Problems – **couplers must be abandoned**
   1. Performing all 3 qubit CNOTs has failed, cannot perform in groups since we have insufficient control over loading.
   2. Overlooked in exchange paper: Can’t do electron-nuclear swaps before electron loading, as this causes decoherence due to uncertain loading time.
      1. O(ps) loading required to avoid decoherence.
      2. GHz tunnel rates => O(ns) loading time is considered very fast
   3. Nuclear-electron after coupler load is hard. Exchange is active and pulses will depend on exchange coupling.
   4. The only solution to the uncertain load moment problem is to load all electrons in spin down.
      1. After swap, all nuclei are spin down.
      2. CNOT is **impossible** with all nuclear spins down
   5. Can’t do direct nuclear-nuclear CNOT. Counterexample:
      1. Have all nuclear spins in same direction. This can happen since we don’t know spins of target and control.
      2. Load all electrons as same direction. This is necessary due to uncertain load moment.
      3. This counterexample isn’t great but its still impossible.
   6. Nuclear-electron swaps are slow as hell. Doing them before and after every CNOT is impractical.

Chapter 5: Tying together into a feasible architecture?

1. No placement imprecision
   1. Couplers become much more feasible
   2. Nuclear spin – nuclear spin 3 qubit CNOT with GRAPE ?
2. ~~Placement imprecision incompatible with coupler architecture~~
   1. ~~Assume control over exchange~~
   2. ~~All 2 qubit CNOTs can be done in parallel~~
3. ~~Coupler architecture with full control over individual loading and unloading~~
   1. ~~Can do groups of 3 qubit CNOTs (if NE swap works)~~

Chapter 6 (if time): Noise

1. Minimize noise for single 2 qubit CNOT
2. Minimize noise for multiple 2 qubit CNOTs
3. Minimize noise for single 3 qubit CNOT.