Design Considerations for Integrated Control Electronics for a Large-scale Solid State Quantum Processor

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***Abstract* – Given that useful universal quantum computers will likely require the parallel operation of at least 10^6 qubits, an attractive and arguably the only truly scalable approach to engineer the required classical control electronics is a fully integrated one. Thus, each qubit would be controlled and read out by nearby circuitry that is connected via microfabricated interconnects without macroscopic components. To minimize requirements imposed on the qubit technology, it is highly advantageous for the qubit controllers to provide a similar capability as current room temperature arbitrary waveform generators. Depending on the qubit technology, DC bias voltages or currents and the modulation of microwave signals may also be required.**

For a quantum processor operated at temperatures below 100 mK, as required for leading solid state qubits, these circuits would have to be realized with an extremely tight power budget of a few nW per qubit. While meeting this constraint seems daunting at first, estimates indicate that such a low dissipation may actually be achievable if transistor characteristics are optimized to leverage the small subthreshold swing at ultra-low temperatures for supply voltages on the order of 10 mV. Furthermore, dedicated circuit designs making use of the extremely low dissipation of qubits will be required. One possibility is thus to leverage capacitive voltage division. This presentation discusses a number of design constraints for such circuits from a physics perspective, considering noise requirements, power dissipation and the required area.

***Keywords (Index Terms)* – Solid state quantum computing, semiconductor cryoelectronics, ultra-low power electronics.**

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