Quantum Science with Superconducting Circuits

Fall 2020, Examiner: Christopher Eichler

1. **Summary:**
   I just had QSSC. He started with the 5 criteria, then he asked me about the different ways to initialize, then about the readout mechanism (also the formulae for g and kappa)
   How to fabricate a josephson junction (sketch the different layers like on the slide)
   C phase gate, how to implement it
   Distance 2 surface code, explain how a 4 qubit X operator works.

2. **Summary:**
   Hey I just had my exam and here are the questions:
   -diVincenzo
   -why do we need anharmonicity
   -condition for a pulse (tau » 1/(2alpha))
   -initialization
   -measurement line (in fact he only wanted to know about JPA and HEMT no RT components)
   - tomography: how do you do it, physical results, Log Likelihood function

3. **Summary:**
   In my case, the questions are related to 3 parts: Initialization, Measurement of qubit. Decay mechanism, Surface code.
   Start: DiVincenzo Criteria (then he picked one of them to ask some more detailed questions)
   How do we initialize qubit? How long does it take usually? Do we have some other faster ways to achieve that?
   Draw the readout circuit and describe each component
   What are the expressions Of kappa(decay rate from LC resonator into the transmission line) and g(coupling strength between qubit and LC circuit)
   The expression Of the Purcell decay rate
   Could you briefly describe the measurement induced so glad that I read that problem set in detail yesterday night) In face he wants to
   see the partial trace after measurement.
   How to measure s (plot the Quadrature vs In Phase)? What we can quantify by rneasuring s?
   Tell me some sources of the decay mechanism(TI: coupling to EM environment. coupling to the TLS in defect. quasi particle transition)
   For the TLS in defect, how can we relate it to the quality factor Q?
   As for the participation ratio p_i, how can we decrease it during design and fabrication. (Simply by making the chip bigger)
   About surface code: draw the circuit diagram to show how to do the parity measurement (2 data qubits + 1 ancillary qubit + some rotation gates + C-
   phase gate)
   The expression of the logical error probability as the function of the physical error p and surface code distance d?

4. **Summary:**
   DiVincenzo
   Universal set of gates
   Why do we need the T-gate?
   Formula for γ
   How to implement single qubit gates
   Need for attenuation for qubit control pulses
   Dependence of qubit frequency on magnetic flux
   T_I and T_2 times, meaning and causes

Dispersive read-out coupling term in Hamiltonian
Why photon shot noise influences T_2 (photons in read-out resonator follow Poissonian statistics)
Formula for ξ
Formula for Q (with participation ratio), the defects that are most important and how to fix these
Shor-9 code
Circuit for bit-flip correction (3 data + 2 ancilla)

5. **Summary:**
Just had my exam, questions were:
-DiVincenzo
-Universal set of gates, why do we need T gate?
-Draw circuit with qubit & control line
-Formula for kappa, what order Of magnitude is it?
-How do we perform single qubit gates and CNOT?
-What do we have to do with signal before it reaches chip (attenuation)?
-Draw levels of attenuation
-Why do we distribute attenuation over different temperature stages?
-Draw readout elements (resonator + readout line) in circuit
-Write down coupling Hamiltonian needed for readout, in what regime is it? (dispersive limit)
-How does this (referring to coupling Hamiltonian) allow us to perform readout?
-How would we derive scattering parameters (write down equation of motion)?
-Detection efficiency, how can we find it out? (measurement induced dephasing)
-Explain how measurement induced dephasing works and how we get detection efficiency
-How do we get s? (ramsey experiment)
-Name reasons for decoherence (Tl and T 2)
-Explain how quasiparticle tunnelling works
-Write down formula for Q, explain the terms, how could you improve Q?

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1. **Summary:**
Hello guys, I just finished the oral exam. Topics included the five criteria, universal set of gates, how to implement a CZ gate. SQUID and how frequency changes with flux. Then he showed a picture of transmon and asked what are different parts. Finally we discussed sources of noise, particularly material defects. Hope that is helpful!

2. **Summary:**
Hey,guys! Here's how my exam went.
Started with 5 requirements and choose two of them.
For me: coherence time and universal gate.
What will influence coherence time? (He will go into details depending on what you answer, for example, in the effective two level system, the formula of Q factor and the meaning of each variables)
what is minimum set of gate to achieve arbitrary operation?
How to realize CNOT gate?
Then to explain some figures in the slides (he printed out)
Benchmarking, exponential decay of the g population
Surface code (logical operator for 5*5 lattice) & threshold prob.
Integration of quadrature, where does the noise come from? How to decrease the noise? Draw the Detection chain
(And in my exam, he doesn't cover Chapter2-Quantized electrical circuits, Chapter3-SC qubit and Chapter7-QO related experiments, I was not asked about any Hamiltonian and any math derivation.)

3. **Summary:**
Hey guys I had the exam. The main question were:
Di Vincenzo's criteria. How to initialize a qubit. The dephasing source. Ramsey experiment. Dephasing time and experiment. How to calculate the Hamiltonian associated to a pair Of qubit capacitively coupled. Two qubit gates, cz gate. Implementation with the bus resonator

4. **Summary:**
During my exam we talked about:
- DiVencenzo•s 5 criteria (obviously)
- How to perform two qubit operations on two distant qubit (i.e. with other qubits in
- SWAP gates and their decomposition
- What a universal set of gates means and of what gates it consists
- How you can physically apply single qubit gates
- What limits the width of such a pulse (in order to establish a single qubit gate for example)
- Speak about the different components of an X-mon from a picture
- Talk about the different components of a picture of the circuit board
- How to calculate scattering factors
- Write down equation of motion for this

5. **Summary:**
Hi everyone, I had my QSSC exam this morning. My topics cover:
1. DiVincenzo's criteria
2. Factors influencing qubit coherence time (both relaxation time and decoherence time)
3. Two level systems induced relaxation
4. Realization of single qubit gates
5. Set up for flux control line (attenuation)
6. Noise level at room temperature and at the input port of chip (Problem Set 07)
7. Calculation of coupling rate \kappa through charge Inie
8. Generaton of Bell state
9. How to perform state tomography
10. State tomography of Bell state