Q-CTRL QChack Summary

Team name: Q-Team

Team members:
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Other team members were matched with the team but unfortunately didn't participate or contribute to this work. This entire work was done entirely by the above two members.

1. Figuring out the Hamiltonian of the cloud qubit:

Since we don't know the Hamiltonian of the cloud qubit and only have access to projection measurement. The first task is to figure out the ground state of the cloud qubit as a linear combination of |0> and |1> states on measurement basis. This was done in the following way:

- Send pulses with zero amplitude to the cloud qubit and then do the measurements
- Repeat the above measurements for 8192 times
- Obtain the probability of getting |0> and |1>

Result: we got the population of 99% on |0> state and 1% on |1> state. We assume that the cloud qubit is at the |0> state of the measurement basis. The 1% error could be due to SPAM error or the qubit is in pure state (superposition state) or mixed state (|0> (99%) and |1> (1%)). But with the time constraint of the event, we decided to go with our simplest assumption.

2. Choosing the quantum control method:

We chose the automated closed loop method due to its ability to work with model-free experiments. While model-based method is powerful, it has some limitations in this challenge. To obtain the parameters of the qubit such as frequency, the magnitude in shift and drift will require a long time and many small measurements to determine each parameters.

3. Devising the cost function:
- General approach:
+ Set repetition counts to be large so that the error rate is large and can be optimized
+ For each pulse sent to the cloud qubit, there are two experiments are done (ne with even number of repetition, one with odd number). This is the same as initializing the cloud qubit to two different states. This will make sure that the generated gate works with the all of the basis vector rather than only the |0>.

Not Gate: even number of repetition will result in identity operation, odd number will result in the NOT operation (turning the initial state to the orthogonal state, in this case turning |0> to |1> in two levels systems).

H Gate: even number of repetition will result in identity operation, odd number will result making the target state the superposition of |0> and |1> (50% each).
+ Cost function is the difference between expected population and the population on these states obtained from measurement.

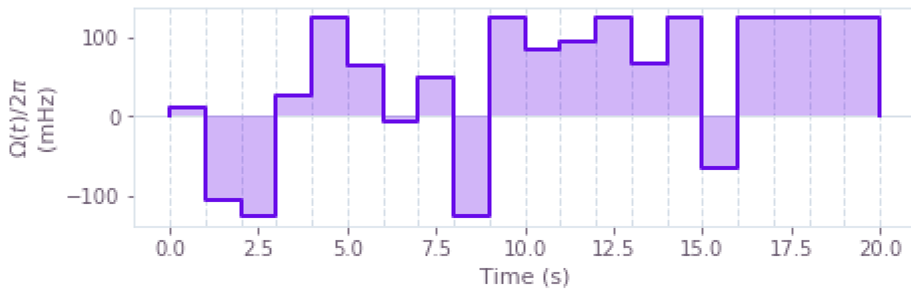
4. Fine tuning of the optimizer

- Initially, Gaussian Processes initializer was used. However, it didn’t work very well. We then changed to Neural Network initializer and it worked better.

- The segment_count and duration was also adjusted in order to speed up the optimization and improve the fidelity. More segment_count means the pulse is more flexible but it also makes the optimization longer.

5. Results

NOT gate



H gate