Boulder Opal Challenge Summary

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Source code: Github repository

1 Goal

The goal of this exercise was obtain the control pulses that performs NOT and Hadamard gates, with gate fidelity greater than 90%, through the use of Boulder Opal.

2 Results

We modelled the pulse by using a segment count of 10, 50 ns duration, and shot count of 1000. The values of the pulse were modelled by the following parameters, α, β:

$$\text{values} = \alpha + i\ \beta \tag{1}$$

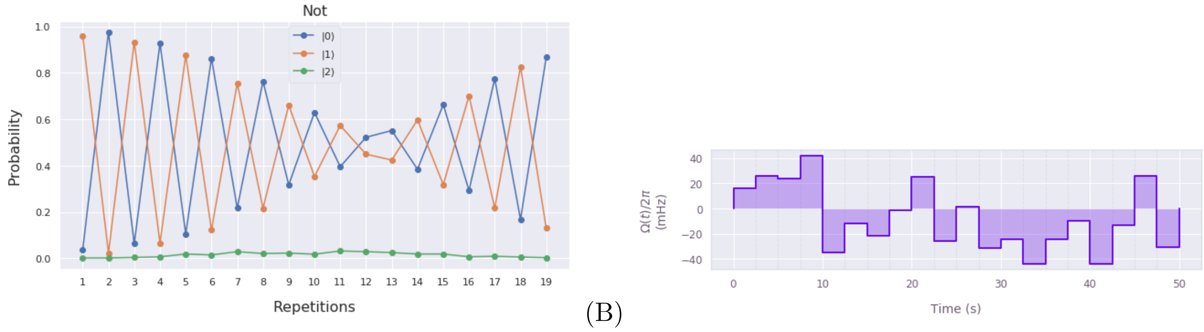
Our goal is to optimize the infidelity of the NOT gate, this is done by the following cost function:

$$f_{cost}(\alpha, \beta) = 1 - \mathrm{P}(|\psi\rangle = |1\rangle; \alpha, \beta) \tag{2}$$

We chose the Gaussian process for the optimization procedure, the length scale bound was chosen as a box constraint with the values of $l \in [10^{-10}, 10^{5}]$, the bound was chosen as $[\frac{-5\pi}{\text{duration}}, \frac{-5\pi}{\text{duration}}]$, and finally we set the random number generator (RNG) seed as 0.

We use the property that the duration of the Hadamard gate is half of the duration of the NOT gate, thus by obtaining the NOT gate, we get the Hadamard gate for free! We can see that in Ramsey experiment.

In order to see that we achieved the NOT gate, we apply that gate in sequence.



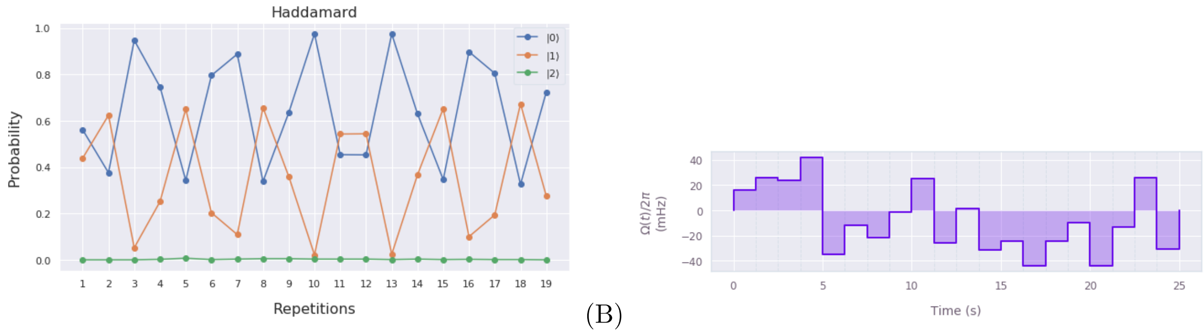
(A) (B)

Figure 1: NOT gate. (A) Probabilities of the states $|0\rangle$ e $|1\rangle$ (B) NOT Control pulse waveform.

Note that our results are in agreement with the theoretical predictions for the probabilities of measurement of the states

$$P(|\psi\rangle = |0\rangle) = \cos^2\left(\frac{\omega t}{2}\right) \tag{3}$$

$$P(\psi\rangle = |1\rangle) = \sin^2\left(\frac{\omega t}{2}\right) \tag{4}$$



(A) (B)

Figure 2: Hadamard gate. (A) Probabilities of the states $|0\rangle$ e $|1\rangle$ (B) Hadamard Control pulse waveform.