Schuster Lab - Autumn 2019 Report

Thomas Propson | tcpropson@uchicago.edu

November 18, 2019

1 Simulation Parameters

1.1 Spin System

Dave told me these system parameters on 08/25/2019. The system hamiltonian is

$$\begin{aligned} H = \omega_q \frac{\sigma_z}{2} \\ + \epsilon(t) \frac{\sigma_x}{2} \end{aligned}$$

$\omega_q = 1 * 10^{-2}$GHz, $\epsilon(t) \in \mathbb{R}, |\epsilon(t)| \leq 1 * 10^{-1}$GHz. The sampling rate of the AWG is 1.2 Gs/s with 14 bits. The bandwidth of the pulses should be less than $5 * 10^{-1}$GHz. We choose the duration of the pulse to be about 150ns.

2 Hamiltonian Parameter Robustness

We want to design pulses that are robust to variaitions in the hamiltonian parameter ω_q. We seek to find pulses that minimize the norm of the derivative of ω_q w.r.t the derivative of $\epsilon(t)$ w.r.t to the gate fidelity. We implement the universal gate set $\{R_x(\pi), R_x(\frac{\pi}{2}), R_y(\frac{\pi}{2}), T\}$ [Heeres et al.(2017)Heeres, Reinhold, Ofek, Frunzio, Jiang, Devoret, and Schoelkopf].

2.1 Spin Experiment 0

This experiment achieves the $R_x(\pi)$ gate

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix} \rightarrow \begin{pmatrix} 0 \\ -i \end{pmatrix}$$
$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \begin{pmatrix} -i \\ 0 \end{pmatrix}$$

2.2 Spin Experiment 1

This experiment achieves the $R_x(\frac{\pi}{2})$ gate

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\sqrt{2}}{2} \\ -i\frac{\sqrt{2}}{2} \end{pmatrix}$$
$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \begin{pmatrix} -i\frac{\sqrt{2}}{2} \\ \frac{\sqrt{2}}{2} \end{pmatrix}$$

2.3 Spin Experiment 2

This experiment achieves the $R_y(\frac{\pi}{2})$ gate

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\sqrt{2}}{2} \\ \frac{\sqrt{2}}{2} \end{pmatrix}$$

$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \begin{pmatrix} -\frac{\sqrt{2}}{2} \\ \frac{\sqrt{2}}{2} \end{pmatrix}$$

2.4 Spin Experiment 3

This experiment achieves the T gate

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix} \rightarrow \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \begin{pmatrix} 0 \\ \frac{\sqrt{2}}{2} + i\frac{\sqrt{2}}{2} \end{pmatrix}$$

References

[Heeres et al.(2017)Heeres, Reinhold, Ofek, Frunzio, Jiang, Devoret, and Schoelkopf] Reinier W Heeres, Philip Reinhold, Nissim Ofek, Luigi Frunzio, Liang Jiang, Michel H Devoret, and Robert J Schoelkopf. Implementing a universal gate set on a logical qubit encoded in an oscillator. *Nature communications*, 8(1):94, 2017.