Schuster Lab - Autumn 2019 Report

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1 Simulation Parameters

1.1 Spin System

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

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

$\omega_q = 1 * 10^{-2}$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

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

2.2 Spin Experiment 1

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

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

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

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

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

2.5 Spin Experiment 4,5,6, pi_corpse

These experiments were intended to build a CORPSE $R_x(\pi)$ pulse following this Ken Brown paper [Merrill and Brown(2014)].

2.6 Spin Experiment 7

This experiment is the same as experiment 0 with the added constraint of zero integration.

3 Amplitude Robustness

3.1 Cavity Experiment 0

0 to 2 in the cavity following [Heeres et al.(2017)Heeres, Reinhold, Ofek, Frunzio, Jiang, Devoret, and Scho

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.

[Merrill and Brown(2014)] J True Merrill and Kenneth R Brown. Progress in compensating pulse sequences for quantum computation. *Quantum Information and Computation for Chemistry*, pages 241–294, 2014.