The Quantum Computing Company™

QPU-Specific Physical Properties: Advantage2_prototype1.1

USER MANUAL

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Overview

This document describes the physical properties of a particular D-Wave QPU. It includes a summary of its physical properties and graphed data showing the anneal schedule and other details.

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1 About this Document

1.1 Intended Audience

This document is for users of the D-Wave quantum computer system who want to better understand and leverage the physical implementation of the quantum processing unit (QPU) architecture. It assumes that readers have a background in quantum annealing and are familiar with Ising problem formulations.

1.2 Scope

This document describes the physical properties of a particular calibrated QPU. It includes a summary of its physical properties and graphed data showing the anneal schedule and other details.

Note: The values provided in this document are the physical properties of a calibrated QPU. They are not product specifications.

1.3 Related Documentation

Use this document in conjunction with the following other documents:

- Getting Started with D-Wave Solvers—Introduces the D-Wave system.
- QPU Solver Datasheet—Defines terms, provides in-depth background information on the D-Wave QPU, the quantum annealing process, ICE effects, and timing.
- Solver Properties and Parameters Reference—Describes the solver properties and parameters that are passed to and from QPUs and other solvers via the Solver API.

2 QPU Properties

2.1 System Identification

All data presented in this document are specific to the **Advantage2_prototype1.1** solver, which is a small, experimental prototype of the next-generation Advantage system architecture.

2.2 Summary of Physical Properties

This table lists the physical properties of the calibrated QPU.

Table 2.1: QPU Physical Properties

Parameter	Value
Model	Advantage2 prototype
Graph size	Z4
Qubits	563
Couplers	4790
Qubit temperature (mK)[1]	13.9 ± 1.0
M_{AFM} (pH)[2]	0.582
Quantum critical point (GHz)	1.867
L_q (pH)[3]	142.920
C_q (fF)[4]	169.388
I_c (μA)[5]	4.083
Average single qubit thermal width (Ising units)	0.117
FM problem freezeout (scaled time)	0.015
Single qubit freezeout (scaled time)	0.619
Φ^i_{CCJJ} (Φ_0)[6]	-0.686
Φ^f_{CCJJ} (Φ_0)[7]	-0.766
Annealing time range (μs)	1.0 to 2000.0
Readout time range (μs)[8]	15.0 to 48.0
Programming time (μs)[9]	~ 5500
QPU delay time per sample (μs)	21.0
Readout error rate[10]	≤ 0.001

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[1] Some qubits in this QPU are affected by high-frequency photon flux and may have a higher temperature than what is reported here. For more information, see the discussion of high-energy photon flux in QPU Solver Datasheet.

[2] Maximum available mutual inductance achievable between pairs of flux qubit bodies.

[3] Qubit inductance.

[4] Qubit capacitance.

[5] Qubit critical current.

[6] Initial value of the external flux applied to qubit compound Josephson-junction structures at the start of an anneal (s=0).

[7] Final value at the end of an anneal (s=1).

[8] Typical readout times for reading between one qubit and the full QPU.

[9] Typical for problems run on this QPU. Actual problem programming times may vary slightly depending on

Note: In addition to the above list of physical properties, each QPU has a number of other properties defined in software that are accessible via the Solver API. For a global list of the solver properties for a QPU, and for a list of the permitted user parameters for each type of solver, see Solver Properties and Parameters. To retrieve the solver properties for a particular QPU, see the Ocean documentation for the syntax and examples.

2.3 Working Graph

The Advantage2 prototype QPU is based on a physical lattice of qubits and couplers known as *Zephyr*. For information, see the Zephyr Graph section in Getting Started with D-Wave Solvers.

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the nature of the problem.

[10] Error rate when reading the full system.

2.4 Annealing Schedule

The following equation shows the quantum Hamiltonian that governs the annealing process, where $\hat{\sigma}_{\mathrm{x,z}}^{(i)}$ are Pauli matrices operating on a qubit q_i and nonzero values of h_i and $J_{i,j}$ are limited to those available in the graph.

$$\mathcal{H}_{\mathrm{ising}} = -\frac{A(s)}{2}\left(\sum_i \hat{\sigma}_{\mathrm{x}}^{(i)}\right) + \frac{B(s)}{2}\left(\sum_i h_i \hat{\sigma}_{\mathrm{z}}^{(i)} + \sum_{i>j} J_{i,j} \hat{\sigma}_{\mathrm{z}}^{(i)} \hat{\sigma}_{\mathrm{z}}^{(j)}\right) \tag{2.1}$$

The annealing schedule for this QPU is shown in Figure 2.1.

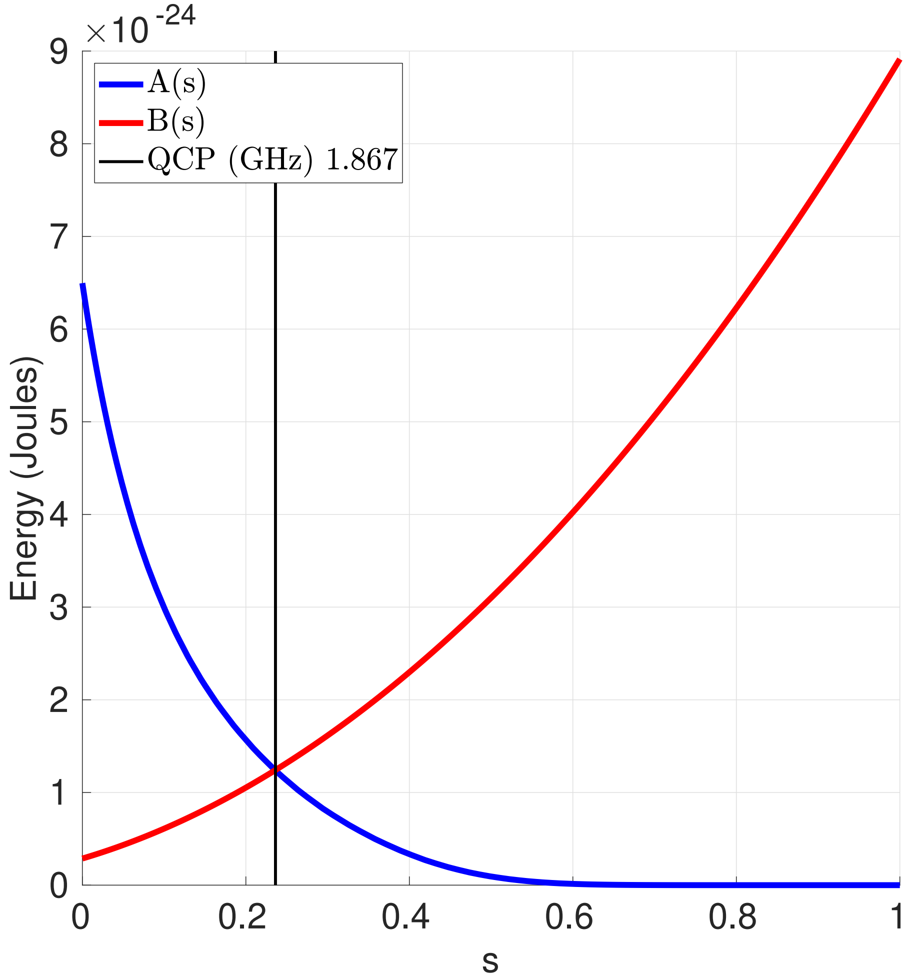

Figure 2.1: Annealing schedule for the QPU, showing energy changes as a function of scaled time.

2.5 DAC Quantization Effects

The on-QPU digital-analog converters (DACs) that provide the user-specified h and J values have a finite quantization step size. That step size depends on the value of the h and J applied because the response to the DAC output is nonlinear.

Figure 2.2 and Figure 2.3 show the effects of the DAC quantization step for the DACs controlling the h and J values, respectively, for this system.

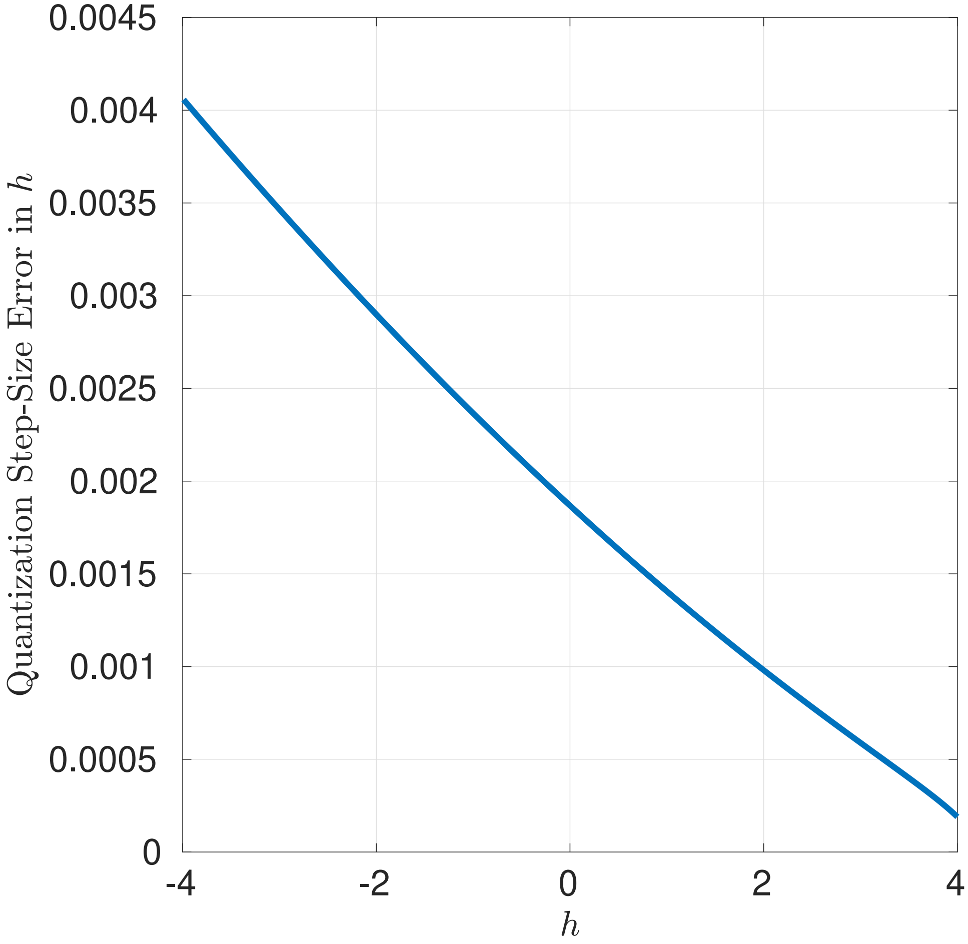

Figure 2.2: Typical quantization on the h DAC control.

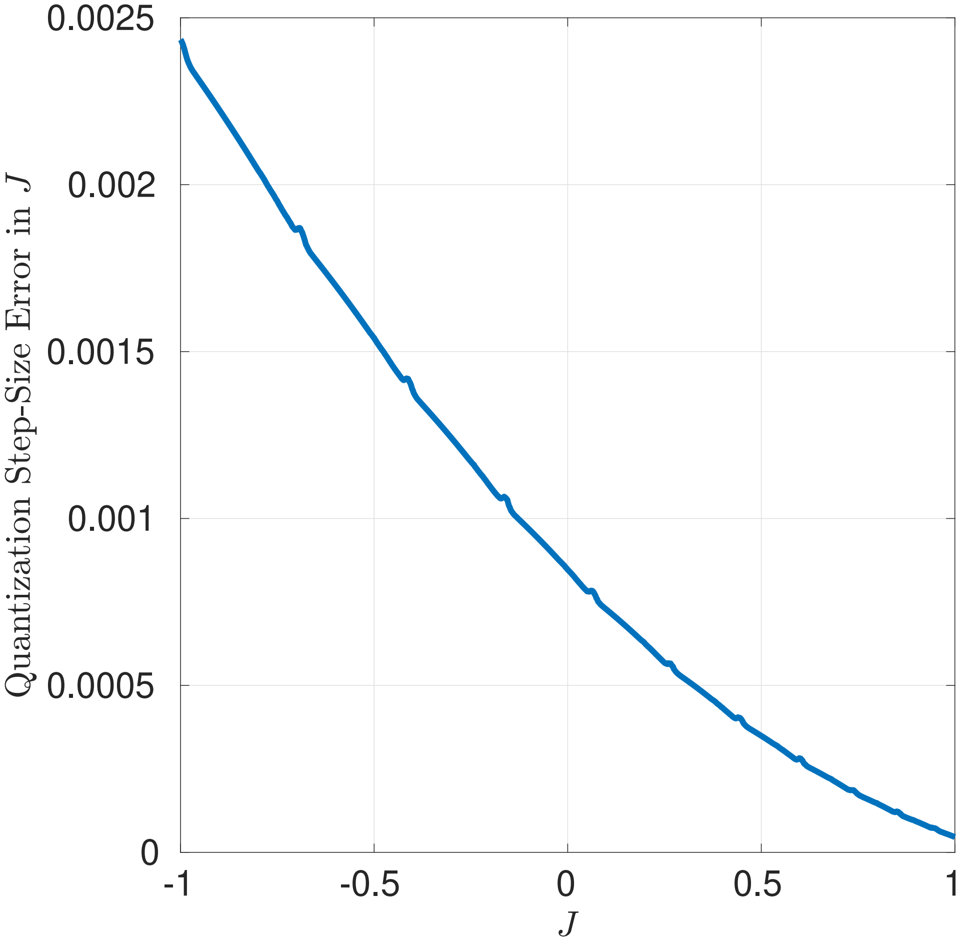

Figure 2.3: Typical quantization on the J DAC control.