



# QPU-Specific Physical Properties: Advantage2\_prototype2.5

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## 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.

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

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## 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\_prototype2.5** solver, which is an experimental prototype of D-Wave's next-generation QPU.

### 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	Z6
Qubits	1216
Couplers	10808
Qubit temperature (mK) <sup>1</sup>	16.5 ± 1.0
$M_{AFM}$ (pH) <sup>2</sup>	0.443
Quantum critical point (GHz)	2.014
$L_q$ (pH) <sup>3</sup>	106.617
$C_q$ (fF) <sup>4</sup>	207.188
$I_c$ ( $\mu A$ ) <sup>5</sup>	4.570
Average single qubit thermal width (Ising units)	0.117
FM problem freezeout (scaled time)	0.009
Single qubit freezeout (scaled time)	0.605
$\Phi_{CCJJ}^i$ ( $\Phi_0$ ) <sup>6</sup>	-0.726
$\Phi_{CCJJ}^f$ ( $\Phi_0$ ) <sup>7</sup>	-0.819
Readout time range ( $\mu s$ ) <sup>8</sup>	17.0 to 87.0
Programming time ( $\mu s$ ) <sup>9</sup>	~ 18200
QPU delay time per sample ( $\mu s$ )	20.5
Readout error rate <sup>10</sup>	≤ 0.001

<sup>1</sup> 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](#).

<sup>2</sup> Maximum available mutual inductance achievable between pairs of flux qubit bodies.

<sup>3</sup> Qubit inductance.

<sup>4</sup> Qubit capacitance.

<sup>5</sup> Qubit critical current.

<sup>6</sup> Initial value of the external flux applied to qubit compound Josephson-junction structures at the start of an anneal ( $s=0$ ).

<sup>7</sup> Final value at the end of an anneal ( $s=1$ ).

<sup>8</sup> Typical readout times for reading between one qubit and the full QPU.

<sup>9</sup> Typical for problems run on this QPU. Actual problem programming times may vary slightly depending on the nature of the problem.

<sup>10</sup> Error rate when reading the full system.

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**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.

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## 2.3 Working Graph

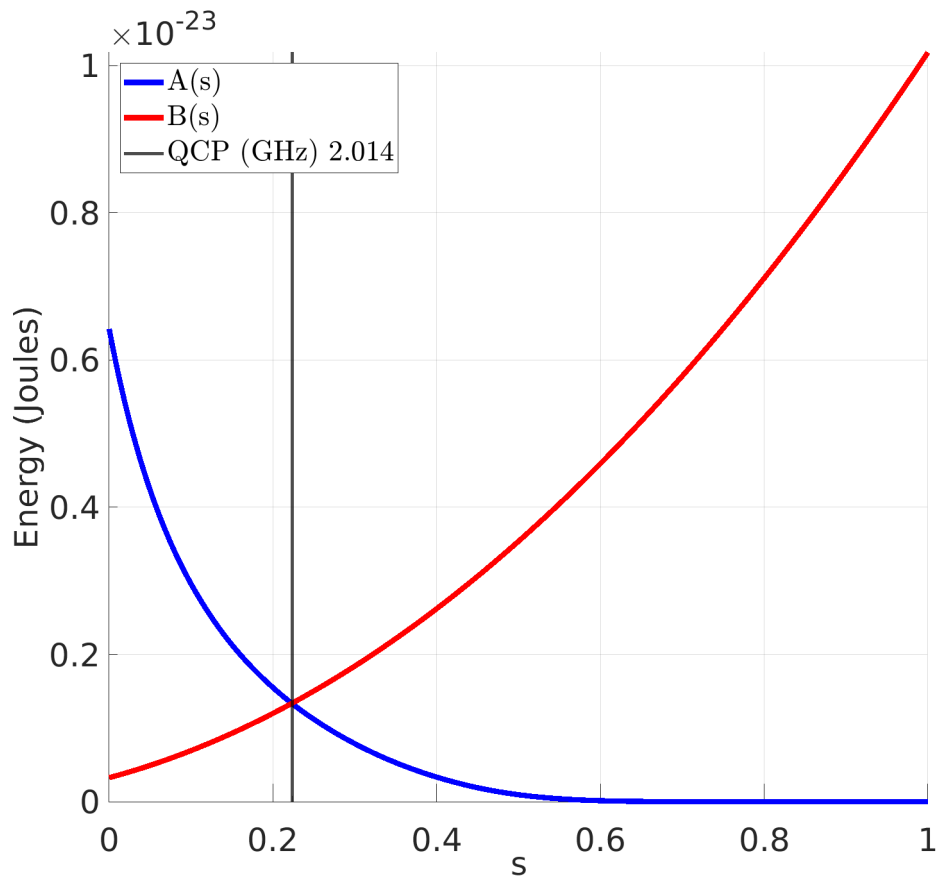
The Advantage2 prototype QPU is based on a physical lattice of qubits and couplers known as *Zephyr*. For information, see the [Zephyr Graph](#) section in [Getting Started with D-Wave Solvers](#).

## 2.4 Annealing Schedule

The following equation shows the quantum Hamiltonian that governs the annealing process, where  $\hat{\sigma}_{x,z}^{(i)}$  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.

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

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



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