Meet the Novera™ QPU

A 9-qubit quantum processor unit (QPU) based on Rigetti's latest architecture featuring tunable couplers and a square lattice.

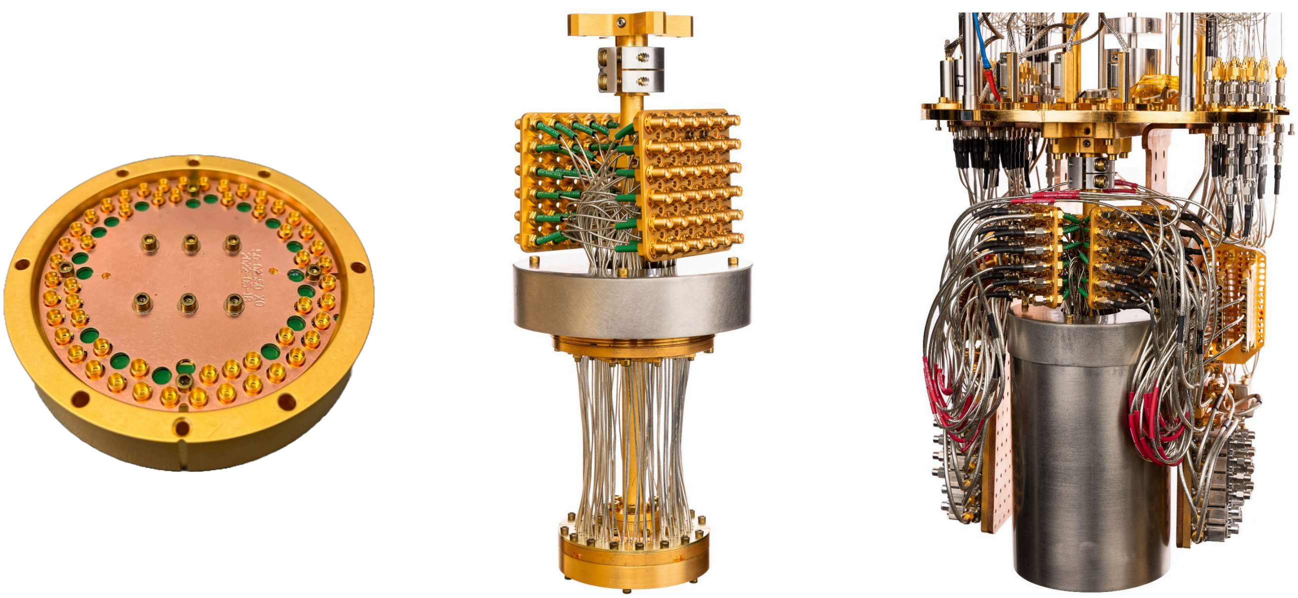
Broad Downstream Applications

The Novera QPU can be integrated with various systems with broad downstream applications. This hardware solution is ideal for:

- government programs focussed on domestic quantum technologies supply chain and workforce;
- labs engaged in quantum computing research;
- quantum R&D and professional services companies looking to enhance their offering.

Hardware included with the Novera QPU

1. A puck, embedding a 9-qubit chip.
2. A tower, which holds the puck, wrapped in a cylindrical shield.
3. A payload bracket, attached to the top end of the tower to host I/O lines and electronics.



(left) Top view of the puck with the 9-qubit chip embedded. (middle) Tower: the puck is suspended at the bottom, while the payload bracket is attached to the top. (right) Real-life set-up of a shielded Novera tower installed at the bottom of a mixing chamber with I/O lines, filters and amplifier.

Use cases

First use-case: Computing, system design, and integration

The Novera QPU implements universal gate-based quantum computing: it integrates with either Rigetti's components or any suitable third-party's to deliver a full-fledged small-scale quantum computer.

A quantum computer powered by the Novera QPU enables quantum software and algorithm researchers to prototype and test:

- **Hybrid quantum algorithms.** Quantum machine learning models that sample parameterised quantum circuits widely apply to the financial services industry, with early adopters focusing on recession forecasting and sample discrimination**.** Simulating simple molecules and bulk materials is another apt use of noisy, intermediate-scale QPUs, with notable proposals for demonstrating the early utility of quantum computing.

- **Characterisation, calibration, and error mitigation.** Today's hardware is not fault-tolerant, and noise affects its operations. Understanding and mitigating noise effects is paramount. Rigetti 9-qubit QPU offers an off-the-shelf testbed for designing and calibrating gate pulses, characterizing noise models, and testing quantum error mitigation methods on realistic applications.

- **Quantum error correction (QEC) experiments.** Rigetti 9-qubit QPU's square qubit lattice lends itself to early experiments with the surface code, particularly with some of its subroutines, such as syndrome extraction and measurement of stabilizers.

Second use-case: Full-stack development

Developing quantum computing components and integrating them together is highly non-trivial and critical to producing higher-quality full-stack systems. Leveraging the Novera QPU, organizations looking to develop components of the quantum computing stack can accelerate their efforts. Areas of significant interest are:

- **Control electronics and software**. Quantum control systems play a crucial role in developing high-performance quantum computers, and Rigetti has experienced this firsthand with its proprietary control electronics and software interfaces. Companies such as Riverlane, Quantum Machines and open-source initiatives such as Fermilab's QICK, have already started to invest and make technical progress on control systems.

- **QEC decoders.** Fault tolerance is rightfully seen by many as the ultimate goal for quantum computers, but that will not come without challenges. Even QEC codes tailored for particular architectures have high overheads, which could overshadow known algorithmic benefits. Hardware dedicated to QEC decoding could increase performance and reduce such limitations.

Third use-case: Quantum technologies

Controllable quantum systems are a central component of various quantum technologies. A high-quality QPU is pivotal for the experimental development of:

- **Transducers[1] and optical connectors for quantum networking**. Experimenting with coherent communication between localised quantum systems is essential for quantum key distribution and enabling quantum error correction via networked QPUs. Rigetti's 9-qubit QPU offers a testbed for developing and integrating next-generation transducers converting microwave impulses for on-chip interactions to optical frequency, more suitable for longer-range signal transmission.

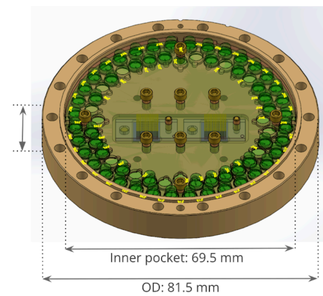
- **Randomness amplification and certification**. Verifying the correct functioning of a quantum computer while maintaining limited trust in third parties, such as hardware manufacturers or infrastructure providers, is a challenge with practical cybersecurity implications. Rigetti's 9-qubit QPU allows experimenting with protocols for entropy amplification and production of random bit sequences from quantum measurements.

[1] Some degree of customisation may be required depending on the project specifics.

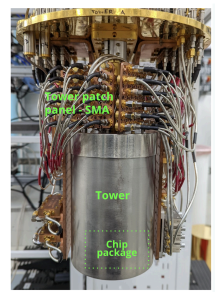
Product sheet

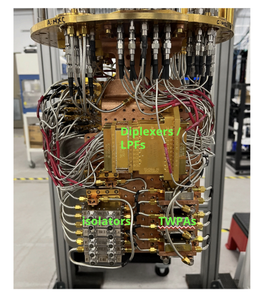
The Novera QPU is a small-scale version of our state-of-the-art deployed systems. It consists of all hardware below the mixing chamber plate (MXC) of a dilution refrigerator needed for quantum computing with nine superconducting qubits. The system is compatible with dilution refrigerators with an MXC flange diameter of 290 mm (or greater) and cooling power of 14 μW (or greater) at 20 mK.

QPU Components



- **Puck.** Contains both 9-qubit and 5-qubit quantum integrated circuit (QuIC) chips, along with interposers and a PCB to route signals to SMPM connectors at the puck periphery.
- **Tower**. Hangs from the mixing chamber plate and connects coaxial cables between the puck and the SMA patch panel.
- **Shields**. Surround the tower to isolate the puck from infrared radiation and stray magnetic fields.
- **Payload brackets.** Installed around the tower with mounted signal conditioning devices, including ferrite isolators, diplexers, filters, and optional quantum-limited amplifiers.

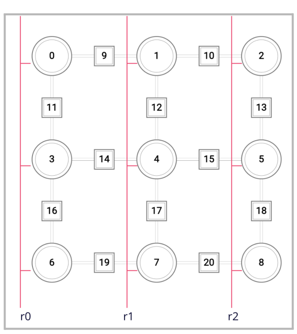


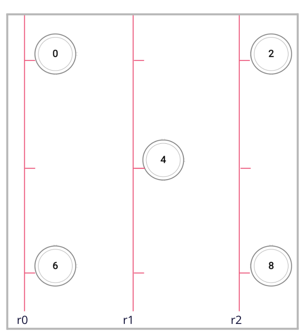


Quantum Integrated Circuit Details

The 9-qubit QuIC chip contains a 3x3 square array of tunable transmons. Between each adjacent pair of qubits is a tunable coupler for mediating fast two-qubit operations. Each column of three qubits shares a readout line. Operating this chip requires 9 microwave drive signals, 21 flux signals, 3 readout inputs, and 3 readout outputs.

The system contains a separate, independently addressable 5-qubit chip with no tunable couplers or qubit-qubit coupling. Its operation requires 5 microwave drive signals, 5 flux signals, 3 readout inputs, and 3 readout outputs.





Device Frequency Bands
Readout: 7-8 GHz
Qubit XY: 4-5 GHz
Flux: DC for static bias, <1 GHz for RF or fast DC pulses
TWPA Pump: 6.3-6.8 GHz

Not included

Dilution refrigerator, wiring/filtering/amplification between mixing chamber plate and room temperature, control hardware and software.

