ZURICH INSTRUMENTS USES AMD FPGAs TO ADVANCE QUANTUM COMPUTING

CASE STUDY

AMD × Zurich Instruments

Quantum computing is one of the most powerful, yet mysterious, technologies of our time. It promises to solve problems that would take classical computers years, decades, or even centuries. But before quantum computers can change the world, they must first be controlled.

That's where Zürich Instruments comes in.

For the past decade, the Swiss-based company, now part of the test and measurement firm, Rohde & Schwarz, has been building sophisticated control systems that bridge the gap between quantum algorithms and physical qubits. At the heart of those systems are AMD FPGAs and adaptive SoCs.

"Quantum computing is much more powerful than classic computers for many of todays computing challenges," explained Dr. Flavio Heer, co-founder and CTO of Zürich Instruments. "Classical computers work with ones and zeros, but a quantum computer has two effects that make it special: The zeros and ones can be present at the same time (which we call a superposition), and the second is 'entanglement,' where all the qubits are entangled into a single computational force."

Because of superposition and entanglement, every qubit added to a system doubles its theoretical compute capacity. Add one qubit to a million-qubit system? You double its computational power. But there's a catch.

"We are very far away from that becoming a reality," Heer said. Today's most advanced researchers are working with around 100 qubits. Scaling to hundreds of thousands—or millions—will require advances not only in quantum hardware, but also in the classical electronics that control them.

Quantum Won't Replace Classical Computing

Contrary to science fiction visions of quantum laptops, Heer believes quantum computing will live alongside traditional architectures.

"Even over the next 50 years, it's not likely that quantum would be used as a standalone computer (as we know it today), but it will be able to do some computations so incredibly efficient that you'll want to give them to a quantum computer."

In the future, quantum systems will likely operate as part of hybrid, high-performance computing data centers, where workloads are intelligently assigned to

INDUSTRY
Quantum Computing

CHALLENGES
Quantum computing qubits often require operation in extreme conditions and precise control signals. They are fragile, short-lived, and difficult to measure accurately. Coordinating complex systems across many channels while maintaining precision and stability makes scaling quantum systems especially difficult.

SOLUTION
Zürich Instruments' QCCS leverages AMD Zynq™ UltraScale+™ RFSoCs and Versal adaptive SoCs to generate, capture, and decode ultra-clean RF signals with low latency.

RESULTS
By using AMD technology, Zürich Instruments has created a scalable, high-performance quantum control platform that reduces system complexity while enabling precise synchronization, fast feedback, and high-fidelity signal processing. This programmable foundation supports larger qubit systems and accelerates progress toward practical, large-scale quantum computing.

AMD TECHNOLOGY AT A GLANCE
AMD Versal™ Premium adaptive SoC;
AMD Zynq™ UltraScale+™ RFSoC
AMD Virtex™ UltraScale+™

CPUs, GPUs, or quantum processors depending on the task.

Early applications for quantum computing include modeling complex chemical molecules, financial forecasting, medical and scientific research, and security applications. In fact, Heer said that Shor's algorithm, when run on a quantum computer, could have the power to break RSA encryption. Many companies and countries are interested in quantum technology to protect future systems from nefarious actors.

"One of the key values of quantum computing is that problems that takes years or even decades to solve on today available hardware will be potentially solved in hours or days with quantum computing," Heer said.

CHALLENGE

Some quantum processors operate at temperatures near absolute zero, which is around 0 degrees Kelvin (approximately minus 460 degrees Fahrenheit). At these extreme conditions, atomic-level qubits can maintain their delicate quantum states.

But not everything with quantum computing happens at sub-zero temperatures. Zürich Instruments' Quantum Computing Control System (QCCS), which generates, routes, and reads the precise signals required to control qubits, operates at room temperature.

"Controlling even one qubit is very hard. They sometimes die faster than you can look at them," Heer explained.

Qubit control begins as engineers compile code across hundreds of channels. Signals are then sent through coaxial lines into a cryogenic chamber, where qubits are initialized, manipulated, entangled, and measured. In the end, the final physical states of each qubit (0 or 1) must be read out accurately.

"The cold temperature is tough to work with, and all the signals need to be very precise," Heer said.

SOLUTION

AMD technology plays a critical role by enabling precision at scale.

Zürich Instruments' QCCS relies on AMD's advanced programmable silicon to generate and capture ultra-clean radio frequency (RF) signals with extremely low latency.

"Today we are using an AMD Zynq™UltraScale+ RFSoC device on our quantum control platform," Heer said. "This device really solves test and measurement challenges by bringing RF into the FPGA."

By integrating high-speed ADCs and DACs directly into the programmable fabric, the RFSoC eliminates the need for complex external converter chains.

"Getting eight outputs and inputs in one chip really saves a lot of headache," Heer said.

The company also uses the AMD Virtex™ UltraScale+™ and AMD Versal™ Premium adaptive SoC as a central processing component in its Programmable Quantum System Controller (PQSC). Decoding algorithms can be efficiently implemented on the powerful FPGA core.

"The RFSoC is connected to qubit and is generating and reading signals," Heer explained. The Versal device brings RF signals together and decodes them, enabling tight synchronization and fast feedback. This integrated approach reduces design complexity and accelerates time to market, which is critical in a field where requirements change rapidly.

"The quantum model is very fast and requirements change on a weekly basis. It's tough to design in this environment," Heer said. "FPGAs are at the heart of any control system today, and, with integrated converters, the RFSoC solution is even better. You can save time to market by choosing such a platform and also reduce design complexity."

Pictured: *Zurich Instruments' Quantum Computing Control System. Photo courtesy of ETHZ-PSI Quantum Computing Hub.*

RESULT

"Today, the best people in the world are working with 100-qubit systems, but to broaden adoption, we'll have to scale by a factor of 1000X to get to hundreds of thousands or millions of qubits in a system, and that's many years away," Heer said.

Scaling quantum systems isn't just about better qubits. It also requires multi-channel synchronization, fast feedback for qubit reset and error correction, high-fidelity signal generation, and software automation.

Zürich Instruments addresses these challenges since many years and brought the first commercial quantum control system to the market. Today, the product portfolio of it's full-stack QCCS solution includes SHFQA+ Quantum Analyzers, SHFQC Qubit Controllers, SHFSG+ Signal Generators, HDAWG Arbitrary Waveform Generators, PQSC Programmable Quantum System Controllers, QHub Quantum System Hub, ZQCS Quantum Control System. LabOne Q is the open-source software platform, which provides a high-level Python interface for controlling the instruments and allows for experiment automation.

In the end, the company's goal is to reduce complexity, increase scalability, and bring practical quantum computing closer to reality.

Heer's journey reflects the spirit of the company itself. "I'm really excited to work in this field. It's very fascinating and rewarding," he said. "I'm a physicist by education and over the years, turned into an engineer. I see myself at the intersection of physics and engineering with an opportunity to solve some of the world's most complex challenges."

Quantum computing remains a riddle that is full of promise, but extraordinarily difficult to implement. Solving it requires not only breakthroughs in quantum hardware, but also precise, scalable, adaptive classical control systems. By leveraging AMD FPGAs and adaptive SoCs, Zürich Instruments is providing the programmable foundation that helps make quantum control practical today, and scalable for tomorrow.

ABOUT ZURICH INSTRUMENTS

Zurich Instruments is a test and measurement company headquartered in Zurich, Switzerland and is part of the Rohde & Schwarz family. The company makes cutting-edge instrumentation for scientists and technologists who work in advanced laboratories and are passionate about phenomena often difficult to measure. Our offering includes lock-in amplifiers, arbitrary waveform generators, impedance analyzers, phase-locked loops, digitizers, boxcar averagers, and quantum computing control systems. For more information, please visit http://zurichinstruments.com.

ABOUT AMD

For more than 50 years AMD has driven innovation in high-performance computing, graphics, and visualization technologies. Billions of people, leading Fortune 500 businesses, and cutting-edge scientific research institutions around the world rely on AMD technology daily to improve how they live, work and play. AMD employees are focused on building leadership high-performance and adaptive products that push the boundaries of what is possible. For more information about how AMD is enabling today and inspiring tomorrow, visit the AMD website (NASDAQ: AMD), LinkedIn, and X pages.

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