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Quantum Computing Measurement & Control System

Market Research Report

June 2023

Methodology

Industry research: By conducting interviews with relevant companies, consumers, and industry experts, we aim to understand the demand, trends, and scale of the market.

Data analysis: By collecting, organizing, and analyzing market data, including market size, growth rate, pricing trends, consumer preferences, and more, we aim to understand the current status and development trends of the market.

Competitive analysis: By analyzing information such as competitor's products, prices, and market share, we aim to understand the competitive landscape in the market and our own strengths and weaknesses.

Technical analysis: By evaluating the technical requirements and development trends of the market, including the advantages and disadvantages of single photon detector technology characteristics, we aim to gain insights into the market's direction.

Regional analysis: By understanding factors such as local consumer demands and policy environments, we aim to identify regional differences in markets and potential for development.

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Introduction

The term quantum computing measurement and control system (QCMCS) refers to the hardware (and supporting software) system that connects a classical information system to a quantum bit (henceforth referred to as Qubit) system, it enables precise measurement and control of quantum states in quantum computer.

Different qubits possess distinct physical properties, necessitating specific methods for manipulation and measurement, superconducting qubits are measured using RF microwaves, ion trap qubits rely on lasers, photonic qubits use lasers and photodetectors, neutral atom qubits utilize precise optics or microwaves, and spin qubits rely on electron spin resonance techniques.

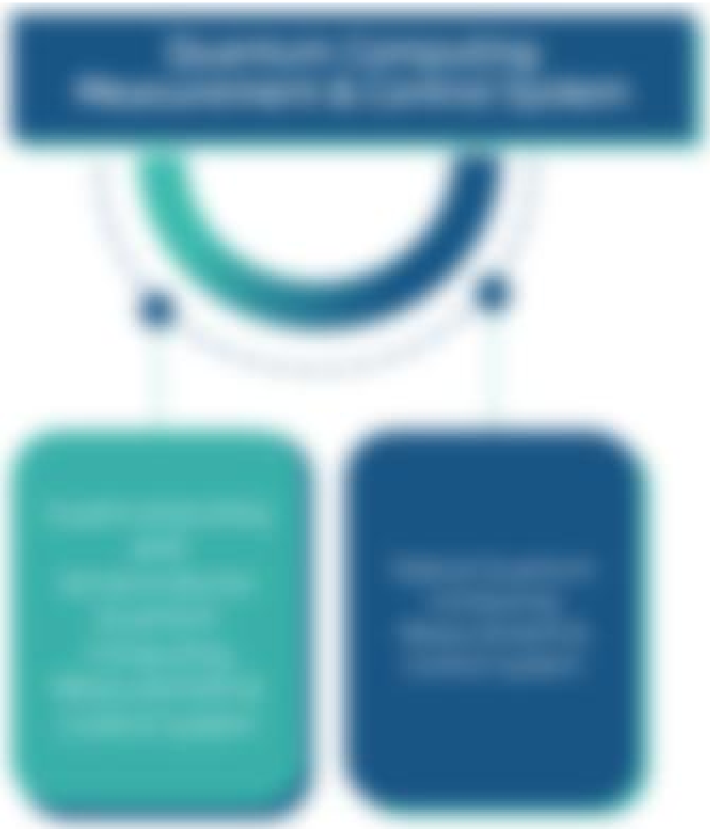
Given the advanced stage of superconducting quantum computing, its measurement and control system has emerged as a unique domain within the field of technology and equipment development. A typical Superconducting QCMCS generally includes:

- Signal generation devices, such as microwave signal generators. These are used to create the signals that operate the quantum bits.
- Signal processing devices, including Digital to Analog Converters (DACs) and Analog to Digital Converters (ADCs). These are responsible for handling measurement signals and readout signals.
- Signal amplifiers like low-noise amplifiers, which are tasked with amplifying the subtle readout signals.
- Control software, designed to command the hardware devices mentioned above and to process the resulting measurement data.

Categories of QCMCS

For the sake of classification and understanding of key components in the measurement and control systems, we categorize them into two types based on shared characteristics: Superconducting and Semiconductor Quantum Computing Measurement & Control Systems (SQCMCS) and Optical Quantum Computing Measurement & Control Systems (OQCMCS).

The main reason for classifying superconducting and semiconductor (silicon spin) as one category is that they both belong to quantum computing constructed by solid-state physical systems. Both systems use microwave pulses for operations and rely on radio frequency and microwave technology. The hardware equipment shares many common components. The other category is due to the commonalities of optical quantum computing, ion trap computing, and neutral atom computing, all of which are associated with optical devices.



Introduction

Different companies' products may use different names for this system, but they serve the same purpose, such as:

Source: Company website, ICV TAnK

The role of QCMCS

In a quantum computer, the measurement and control system serves a role similar to that of the input/output system and control unit in a classical computer. QCMCS is responsible for reading, controlling, and manipulating the qubits' state. It orchestrates the timing and synchronization of quantum operations and manages the flow of information between the qubits and other components of the system. QCMCS generates precise signals, such as microwave or laser pulses, to manipulate the qubits according to the desired quantum operations. It ensures the proper execution of quantum algorithms by controlling the interactions between the qubits.

QCMCS are vital for advancing quantum computing due to several key reasons.

Explanations of SQCMCS

The workflow of SQCMCS involves transmitting instructions from the classical computer to the measurement and control system, which then interfaces with the quantum chip, and the results are read back to the measurement and control system before being transmitted back to the classical computer.

[illegible]

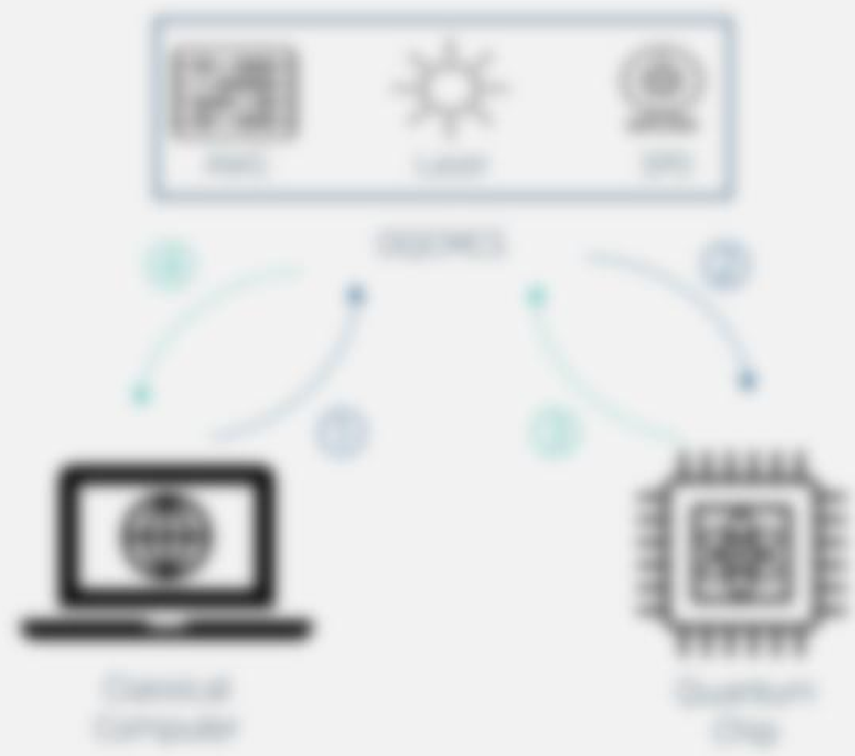
Additionally, both superconducting and semiconductor qubits operate at extremely low temperatures to maintain their quantum properties. This necessitates the use of cryostats to provide the required cooling environment. The measurement and control systems for both types of qubits are designed to operate within these cryostats to ensure precise control and measurement of quantum states.

Workflow of the SQCMCS

Explanations of OQCMCS

OQCMCS are suitable for trapped ion qubits, neutral atom qubits, and photonic qubits because these systems rely on the manipulation and measurement of light. This commonality allows for the development of a unified optical measurement and control system for multiple quantum architectures. These systems utilize laser pulses to perform precise quantum gate operations and readouts.

Workflow of the OQCMCS



Note: AWG: Arbitrary Waveform Generator； SPD: Single Photon Detector.

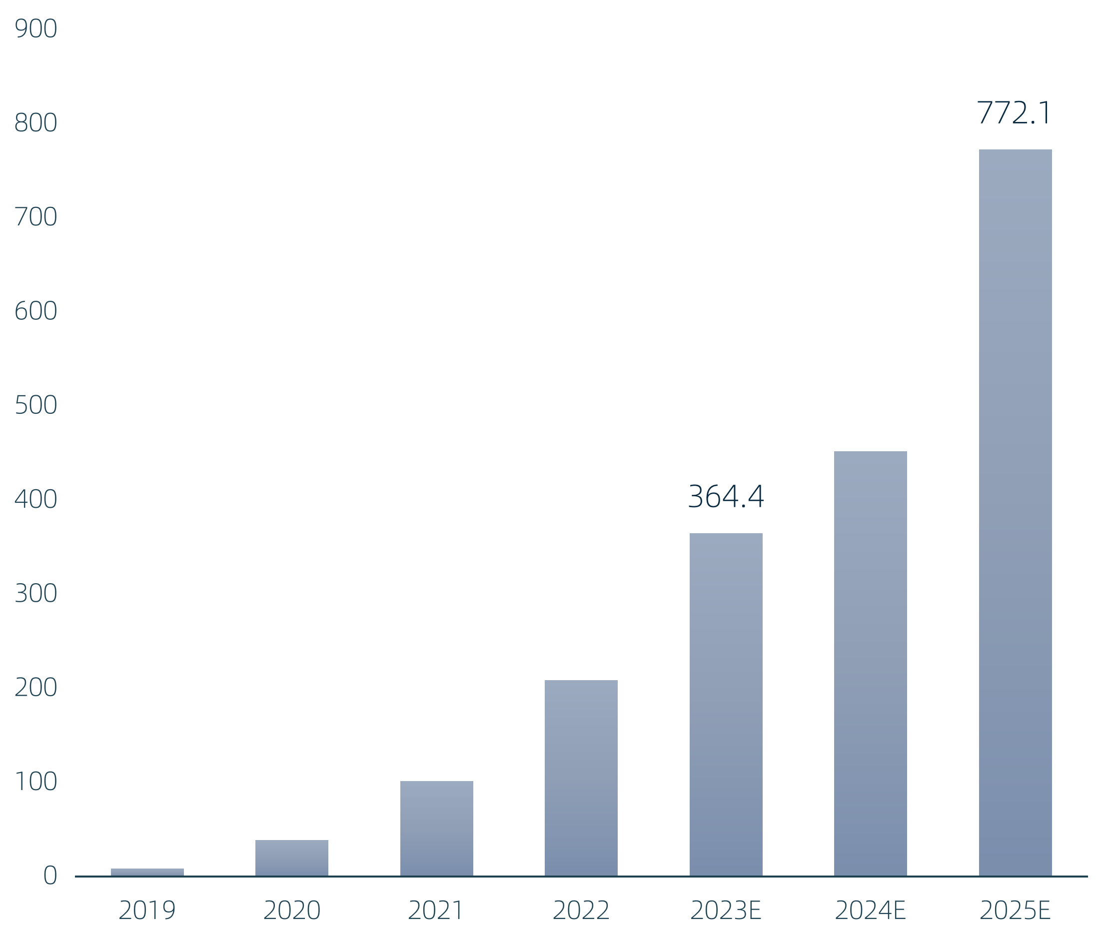
Typical Parameters of QC Measurement & Control System

Company Name	Model	Channel Number	Sampling Rate	Bandwidth	Noise
Keysight Technologies	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zurich Instruments	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ZWDX	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
QBLOX	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source： Company Website, ICV TAnK

Global Market Overview

Global QCMCS Market Size (in Million USD)



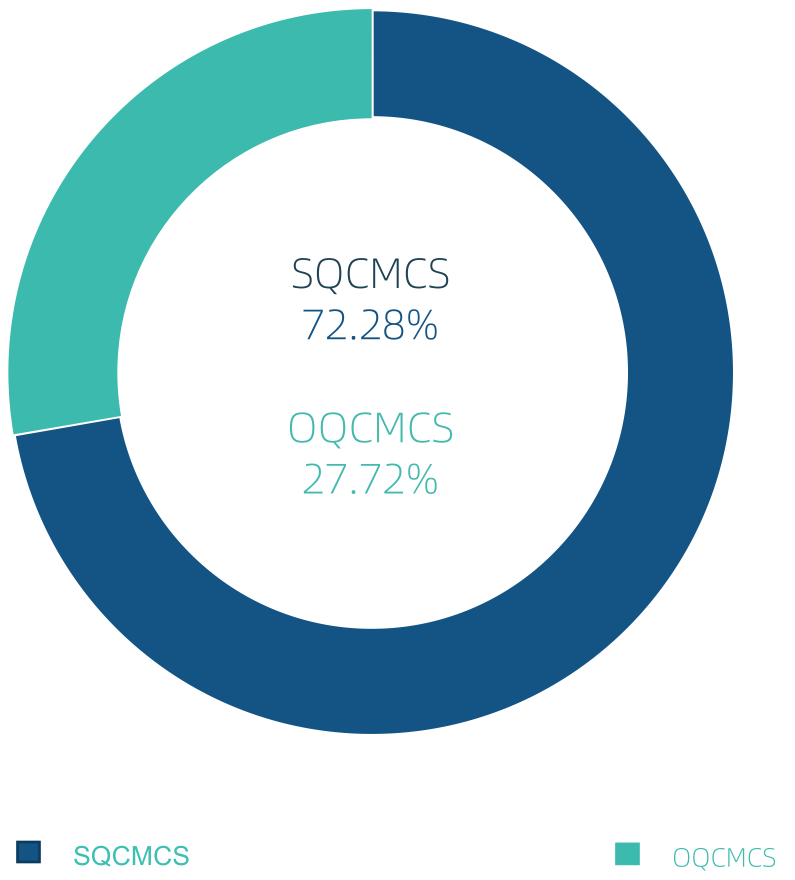
The future market growth of QCMCS is influenced by two key factors.

First, advancements in quantum computing technology drive the demand for sophisticated measurement and control systems. As quantum computing capabilities improve, there is a need for more precise and efficient tools to manipulate and measure quantum states.

Second, the increasing research and development activities in the field of quantum computing contribute to the growth of the QCMCS market. Ongoing R&D efforts focus on enhancing quantum computing performance, exploring new algorithms, and developing novel applications. These endeavors create a demand for advanced measurement and control systems that can support experimentation, testing, and characterization of quantum devices.

Segment Market by Type

Market Share by Type (2025E)

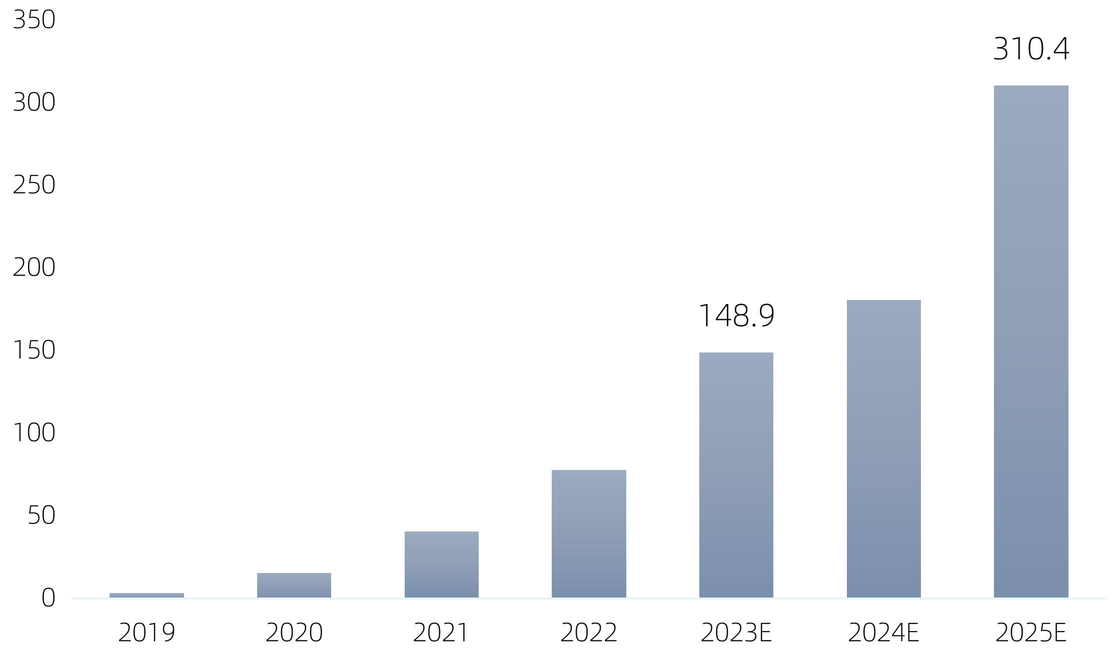


The market share forecast can be attributed to:

- Superconductors and semiconductors exhibit greater compatibility with existing manufacturing and integration technologies. This compatibility factor has greatly promoted the market demand for it in the quantum computing industry.
- From the perspective of commercial promotion, superconducting quantum computing and other technical routes have a relatively high overall technological maturity. Their developments in quantum systems have been extensively studied and improved, resulting in more powerful and reliable measurement and control systems. The established technological base of superconducting quantum computing enhances their market appeal and boosts the confidence of potential users.

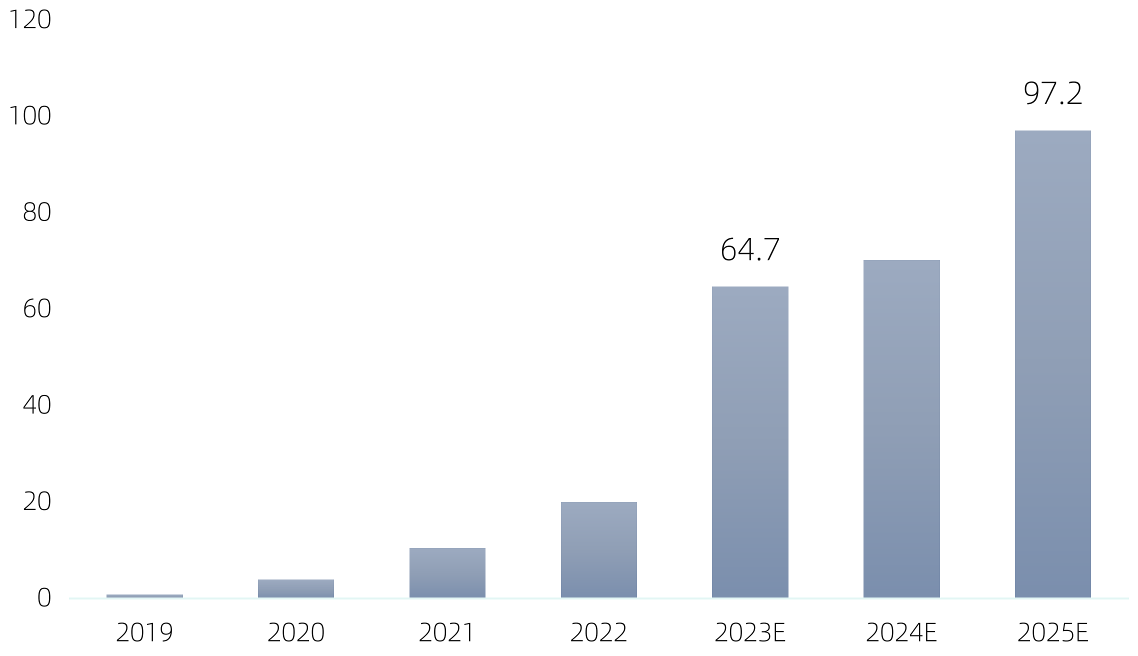
Segment Market by Region

Market Size Forecast - Europe (in Million USD)



The market of QC Measurement & Control System in Europe will worth $148.9 million in 2023, it is estimated to grow to $310.4 Million in 2025, resulting at a 4-year CAGR of 41.4%.

Market Size Forecast - North America (in Million USD)



The North America market will be the second largest segment, it will worth $64.7 million in 2023 and is estimated to increase to $97.2 Million in 2027, with a 4-year CAGR of 48.5%.

Timeline for the Establishment of QCMCS

Source： Company website, ICV TAnK

Global Vendors for Complete QCMCS

Supplier Profile

Supplier Profile

Supplier Profile

QBLOX

Qblox, a leading quantum computing company based in the Netherlands. They offer FPGA-based quantum controllers and low-noise amplifiers that are tailored to different types of qubits, including superconductors, ion traps, and neutral atoms. Qblox collaborates with prominent players in the quantum computing industry, including companies like QuTech, Quantum Delta NL, QphoX as well as prestigious research institutions.

MenloSystems

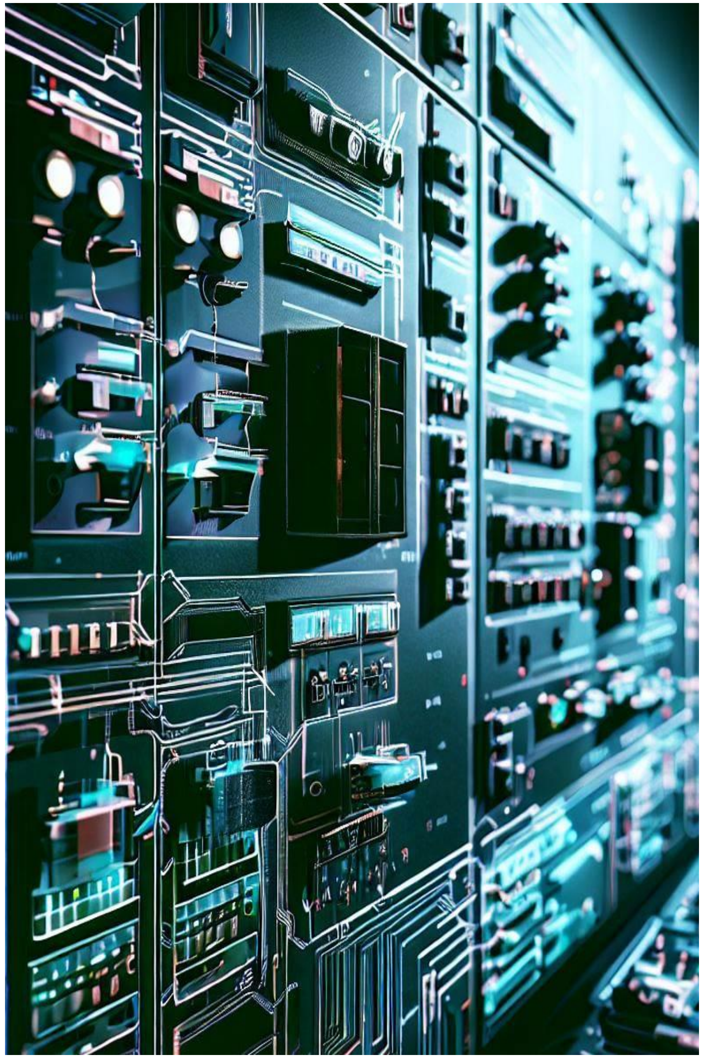
Menlo Systems, a German company, their QCMCS integrates cutting-edge optical frequency combs, ultra-stable lasers, and continuous wave lasers. This integration enables exceptional performance in terms of spectral purity, narrow linewidth, and high stability across the entire frequency comb spectrum. These features are crucial for coherent conversion to the radio frequency (RF) domain, a key requirement for precise manipulation and readout of quantum states. Their esteemed partners include companies such as IBM, as well as esteemed research institutions like ETH Zurich and University of Innsbruck.

Tektronix

Tektronix, a US technology company, has developed the AWG5200 Series. The AWG5200 Series also offers a high sample rate and memory depth, which enable the generation of complex and precise signals for quantum computing experiments. The AWG5200 Series supports various quantum computing platforms and architectures, such as superconducting, spin and trapped ion qubits. Tektronix has established cooperative relationships with many leading quantum computing researchers and organizations, such as IBM and Cold Quanta.

Development of QCMCS

The future of QCMCS is expected to witness significant advancements driven by several key factors.



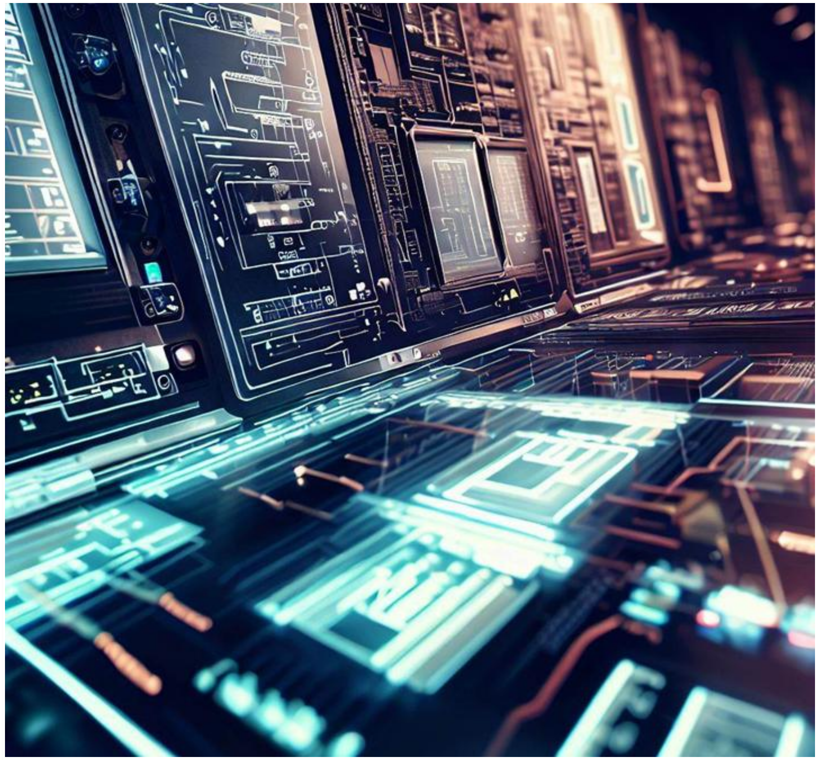
Determining Your Approach to Quantum Control System Development

Current QCMCS for QC R&D teams are either developed by their own internal team members, or externally collaborated (or procured).

Self-Developed	Co-developed or Outsourced
[illegible]	[illegible]
[illegible]	[illegible]

Advice for Quantum Computing R&D Teams

For teams about to enter research in quantum computing science, teaching or commercial applications, the choice between independently developed and procured a dedicated QCMCS depends on several factors.



Summary

- The field of QCMCS is experiencing significant growth and innovation, driven by advancements in

- One crucial aspect of QCMCS is their adaptability to different quantum computing architectures.

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Ordering Information

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Market Research Report

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