Patenting the Quantum Future – Practical Tips Based on PTAB Decisions

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The number of patents for quantum computing inventions is rapidly increasing as the industry increasingly moves towards greater commercialization. Patenting quantum computing inventions raises several recurring legal issues, many of which mirror issues with patents involving software and algorithms generally. However, the issues are sharpened by the field's heavy reliance on math and physics. Companies that rush to file patent applications in this space often overlook some of these critical issues.

To develop valuable quantum patents, applicants must ensure they can recite patent eligible subject matter. The claims must be drafted with sufficient care to ensure the Examiner does not interpret the claims as an abstract idea. The patentability of quantum algorithms follows the same fundamental criteria as classical software patents, but with unique quantum-specific considerations. An algorithm per se (e.g., a purely abstract mathematical method) is not patentable. However, when tied to specific technical implementations that yield tangible technical effects, quantum algorithms can receive patent protection. For example, if a quantum algorithm improves the functioning of a quantum computer or achieves a specific practical outcome (e.g., enhanced cryptographic security or more efficient drug discovery simulations) it may qualify for patent protection. The specification must contain sufficient details explaining not just what the invention does, but how it does it. Also, the specification must have sufficient detail to enable the full scope of the claim. Other details and some practical tips are provided below.

Status of Quantum Patent Filings

The number of quantum computing patents is rapidly growing. Quantum/AI-based patents are one area of notable growth. The average annual growth rate of quantum-related patents issued since 2019 has been about 40-50%. A recent MIT Quantum Index Report" Report (*MIT Report*) indicates that quantum related patent filings have increased 5x from 2014 to 2024. Over 5,000 such patents were filed in 2023 alone. This increased 13% in 2024.

According to the *MIT Report*, two-dozen manufacturers commercially offer more than 40 quantum processing units (QPUs), which are the processing hardware for a quantum computer. This is a step in the right direction of commercialization of quantum technology, but QPUs can't yet meet the requirements for running large-scale commercial applications. But this will change. And as a result, quantum patents will become even more important.

As the *MIT Report* concludes:

> As quantum technologies transition from the lab to the marketplace, patents and other forms of Intellectual Property (IP) are becoming increasingly important strategic assets in the race for quantum leadership. As well as serving as key indicators of general innovation activity, the growth in volume of quantum-related patent filings reflects both the maturing of research efforts and the intensifying competition among companies, institutions, and nations.

The following are some examples of quantum technology that are being patented:

Quantum Error Correction	**Quantum Communications and Networking**
Quantum Sensors	**Qubit Systems (e.g., Different Physical Implementations of Qubits)**
Quantum Cryptography	**Hybrid Classical-Quantum Systems**
Qubit Fabrication Processes	**Quantum Artificial Intelligence**

Key Patentability Considerations

1. Patent Eligible Subject Matter – Section 101 Rejections

As with all patent applications, it is important to ensure quantum applications comply with the patent eligible subject matter requirements under Section 101. To qualify as patent-eligible subject matter, the claim must not be directed to a "judicial exception" (i.e., abstract ideas, laws of nature or natural phenomena, including products of nature) unless the claim as a whole includes additional limitations amounting to significantly more than the exception.

Many quantum inventions are expressed as or based on algorithms or mathematical transformations on qubits. As patent practitioners in the computer arts well know, a patent claim merely covering algorithms or mathematical operations, without more, is typically considered an "abstract idea" and, therefore, not patent-eligible subject matter. Merely adding claim language invoking use of a computer or quantum computer to perform the operations does not, by itself, render the claim eligible subject matter. However, just because an algorithm or mathematical equation is required to complete the claimed method or system does not doom the claims to abstraction.

A claim may recite a mathematical formula, law of nature or other abstract idea, and still be patent eligible. To be so, the claim must recite something "significantly more" than the abstract idea. While a quantum algorithm on its own may not be patentable, tying the algorithm to a concrete technical implementation implemented on hardware may be. This is buttressed if it produces a technical effect. Also, if the claim as a whole integrates the abstract idea into a practical application, then the claim may be subject matter eligible. One way of showing that the claim integrates an abstract idea into a practical application is showing that the claimed invention "improves the functioning of a computer or improves another technology or technical field." Claiming the algorithm as part of a "practical application" can also render the claim patent eligible. The best option depends on the nature of the invention.

2. Enablement and Written Description – Section 112

Section 112 requires that the specification include a written description of the invention, including the manner and process of making and using it, in clear and concise terms to enable skilled persons to make and use the invention without undue experimentation.

The specification must conclude with one or more claims that distinctly and particularly point out the subject matter regarded as the invention. This includes drafting the application with sufficient details explaining not just what the invention does, but how it does it. To satisfy the written description requirement, the specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention at the time of filing.

One of the key issues to consider with quantum inventions is whether the inventor possessed the full scope of the invention recited in the claims. If not, the Patent Examiner will reject the application for failure to enable the full breadth of that claim. Problems of this nature often arise when claim language is generic or functional, or both. For example, generic claim language in the original disclosure may not satisfy the written description requirement if it fails to support the full scope of a genus claimed. The level of detail required to satisfy the written description requirement varies depending on the nature and scope of the claims and on the complexity and predictability of the relevant technology.

Quantum inventions often sit at the cutting edge of physics, so Patent Examiners often question whether the application enables a person skilled in the art to practice the invention without undue experimentation. Applicants must disclose enough details about the quantum invention, including necessary implementation details, to show they have actually reduced the invention to practice or at least fully possessed it, not just proposed a speculative idea.

3. Sample Quantum-Related PTAB Decisions

Several recent Patent Trial and Appeal Board (PTAB) decisions give guidance on how quantum and hybrid-quantum inventions can be found patent-eligible under Section101 and comply with Section 112. They show that well-drafted quantum applications that clearly explain and claim the invention (e.g., whether hybrid methods, error mitigation, or hardware-software interplay) can overcome these rejections.

(1) *Ex parte Yudong Cao* (Appeal No. 2024-002159; App. No. 16/591,239; TC 2100)

The claims were directed to a hybrid quantum-classical (HQC) computer system to solve a linear system of equations by breaking down a problem into smaller pieces and then combining the outputs to form a complete solution. The claims recited an HQC workflow that iteratively trains circuit parameters and controls qubits to prepare and measure a parameterized quantum state used to estimate and optimize an objective function for a linear system (Ax=b).

Section 101 Patent Eligibility – the PTAB held that the claims were patent eligible because they integrated the recited abstract idea (mathematical relationships) into a practical application (enabling noisy quantum computers, which have limited circuit depth, to practically solve linear systems) via a technology improvement. The PTAB rejected the Examiner's characterization that controlling qubits on a quantum computer to prepare a quantum state was a mere data gathering step. The PTAB credited the specification's framing of the invention as improving the ability of noisy, limited-depth quantum computers to practically solve linear systems using an HQC approach.

Section 112 Written Description – the PTAB held that the written description requirement was satisfied because the originally filed claims recited the disputed "objective function" limitation and the specification described that limitation and provided implementation examples. The "objective function" was the numerical target that the HQC computer system tries to minimize so that doing so becomes equivalent to solving the linear system (Ax=b).

The PTAB also overturned the Examiner's rejection that the written description was insufficient because the specification disclosed only two species of objective functions and was otherwise silent as to other objective functions within the claimed genus. The PTAB noted that the Examiner's "genus/species" discussion was misplaced regarding the written description rejection as it relates more to enablement (which was not the basis for the rejection).[1]

(2) *Ex parte Osama Nayfeh* (Appeal No. 2023-000069; App. No. 16/513,387; TC 2800)

The claims recited to a quantum/solid-state device architecture involving a "semiconductor vacancy qubit structure" and a "superconductor quantum memory nanowire," including limitations directed to coupling these structures and using the resulting hybrid device as an interface for computing or quantum-entangled networking.

On a rehearing, the PTAB affirmed the rejection that a claim may be properly rejected for lack of enablement where the specification does not teach how to make and use the full scope of the claimed invention regardless of whether some embodiments within the scope may be enabled. The PTAB found that the claimed "semiconductor vacancy qubit structure" covers all vacancies of a semiconductor and all vacancies in a semiconductor usable as a qubit. It determined that this far exceeds what is known in the art, and the quantity of experimentation necessary to reproduce the claimed invention is undue. The PTAB found the Examiner's findings were supported by meaningful analysis and Appellant identified only "two specific examples" as being disclosed by the Specification: "a vacancy in diamond semiconductor forming a qubit or a vacancy in silicon carbide semiconductor forming a qubit." This is a classic example of a claim to a genus where the inventor failed to provide sufficient detail to show they possessed the full scope of the invention recited in the claims and what the claim covered exceeded what was known in the art.

However, the PTAB reversed the § 112(b) indefiniteness rejection of the claimed "semiconductor vacancy qubit structure" because the record did not establish that a person of ordinary skill would find the disputed term unclear. It found that the word "semiconductor" would be understood only as referring to the material (semiconductor) in which the vacancy is present and credited the Applicant's argument that "nitrogen-vacancy center" is a term of art, illustrating that this style of defect-based terminology is commonly understood and not ambiguous. Accordingly, because "semiconductor" plainly identifies the host material containing the vacancy, consistent with how skilled artisans understand term-of-art defect names like "nitrogen-vacancy center," the claim term conveys reasonably certain meaning and is not indefinite under § 112(b).

Parsing through the technical details of this argument, what this comes down to is working with a skilled patent attorney who knows when a term is well known and clear to a person of ordinary skill and when more detail and explanation is necessary.

[1] *Note*: it appears the Examiner may have asserted the wrong type of rejection. It is not clear how the PTAB would have ruled had the Examiner asserted the correct grounds of rejection.

(3) *Ex parte Aaron Baughman* (Appeal No. 2023-002850; App No. 16/204,784; TC 2100)

The invention related to selecting layers from a number of external deep learning models;

forming and training a core deep learning model; training, by the computing device, the core deep learning model; and synchronizing layers in the core deep learning model with the layers from the plurality of external deep learning models using quantum entanglement.

The Examiner rejected the claims under: i) 35 U.S.C. § 112(b) as being indefinite for failing to particularly point out and distinctly claim the invention; ii) § 112(a) as failing to comply with the written description requirement; and iii) § 112(a) as failing to comply with the enablement requirement. The PTAB partially overturned the indefiniteness rejection but affirmed the written description and enablement rejections.

On indefiniteness, the PTAB found the Examiner erred in asserting that the claim missed an essential step because it failed to claim that the synchronizing step uses quantum entanglement even though every mention of synchronizing in the Specification discusses using quantum entanglement. The PTAB agreed with Appellant that the Specification identifies that it is optional.

The PTAB affirmed the rejection of another claim as indefinite because the term “synchronizing . . . using entanglement” is unclear “as there could potentially be nonquantum types of entanglement (which appears outside of the scope defined in the specification).

The PTAB affirmed the *enablement* rejection of claims that recited synchronizing layers in the core deep learning model with layers from external deep learning models using quantum entanglement because this was not described in the specification in such a manner to enable the skilled artisan to make or use the invention without undue experimentation. The Examiner asserted that there was no description of any specific starting material or of any conditions under which quantum entanglement of deep learning layers could be carried out. The Examiner further stated: (i) the application of quantum entanglement as claimed would further require a quantum-base physical hardware design to be coupled to classical computational hardware and software, requiring non-trivial programming on which the specification provides absolutely no direction or guidance; (ii) because of the numerous ways to design/implement such a complex quantum system, this creates undue experimentation; (iii) Applicant provides no guidance and direction in the specification as to how to make this complex quantum system; (iv) it is questionable how one of ordinary skill in the art can implement quantum entanglement for potentially large sets of data describing layers between the external deep learning models and the core deep learning model as quantum entanglement itself appears non-trivial; and (v) one method of using quantum entanglement involves the use of qubits but, based on the knowledge in the art, it is questionable how the large number of parameters involved in synchronizing layers as disclosed by the Specification can be performed.

On *written description*, the PTAB affirmed the rejection for failing to comply with the written description requirement because the claims recited limitations directed to synchronizing layers in the core deep learning model with layers from external deep learning models using quantum entanglement but this was not described in the Specification in such a manner to demonstrate that the inventors had possession of the claimed invention. It found the specification merely identifies the *result* of synchronizing using quantum entanglement but as discussed with respect to the enablement rejection, does not demonstrate *how* to achieve that result.[2] It also found the Examiner presented evidence to demonstrate the skilled artisan would not recognize how to achieve that result. The PTAB agreed that the use of quantum entanglement is not trivial, that the specification does not have a technical disclosure of how to achieve quantum entanglement or how it is implemented. It was not sufficient that the applicant argued that the concept of entanglement is understood.

[2] “The test for the sufficiency of the written description ‘is whether the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.’” *Vasudevan Software, Inc. v. MicroStrategy, Inc.*, 782 F.3d 671, 682 (Fed. Cir. 2015) (quoting *Ariad Pharm., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010) (*en banc*)). The Federal Circuit emphasized that “[t]he written description requirement is not met if the specification merely describes a ‘desired result.’” *Vasudevan*, 782 F.3d at 682 (quoting *Ariad*, 598 F.3d at 1349). Thus, the Federal Circuit stated that “[t]he more telling question is whether the specification shows possession by the inventor of how [the claimed function] is achieved.” *Vasudevan*, 782 F.3d at 683.

(4) *Ex parte Matthew Hastings* (Appeal No. 2023-003447; App No. 16/286,337; TC 2800)

This case addresses the interesting issue of "after-arising technology" (i.e., when the claims cover later-discovered types of computers that the specification does not enable).

The claims relate to operating a quantum computing device to perform a first phase estimation technique on a set of one or more qubits; evolving one or more qubits from a first state to a second state; performing a second phase estimation technique on the qubits; evaluating results of the second phase estimation technique relative to an error criteria; and determining that a solution to a combinatorial optimization problem provided by the qubits in the second state is acceptable or not acceptable based on the evaluation of the results of the second phase estimation.

The PTAB reversed the rejection under 35 U.S.C. § 112(a) as lacking enablement. The Examiner asserted that the claims encompass a "fault-tolerant quantum computer" but that as of the filing date, the time to create a large fault-tolerant quantum computer was more than a decade away. The Examiner concluded that because one of ordinary skill would not be able to make and use a fault tolerant quantum computer, the applicant failed to enable the full scope of the claimed invention.

The PTAB agreed with the Appellant that the law does not expect an application to disclose knowledge invented or developed after the filing date as such disclosure would be impossible (citing *Chiron Corp. v. Genentech, Inc.,* 363 F.3d 1247, 1254 (Fed. Cir. 2004). It further noted to say that Appellant should have disclosed the fault-tolerant quantum computer, which on the record did not exist as of the filing date, and whose future existence was purely speculative, would be to impose an impossible burden on inventors and thus on the patent system" (citing *In re Hogan 559 F.2d 595, 606 (CCPA 1977)).*

This highlights a scenario where a broad claim can be enabled based on what is known at the time if filing, even if it turns out broad enough to cover later developed technology.

(5) *Ex parte Yili Zhang* (Appeal No. 2025-000614; App. No. 17/651,277; TC 3600)

The claims were directed to a "quantum rating framework" for calculating risk by (i) receiving deterministic factor values, (ii) generating stochastic "quantum values" for each factor over an evolution interval using N-qubit quantum circuits (each qubit representing a risk level), (iii) combining those values into an intermediate quantum risk value, (iv) modifying it using classical parameters, and (v) outputting a final stochastic quantum risk value.

Section 101 Patent Eligibility Rejection Affirmed – the PTAB held the claims patent-ineligible because determining a credit risk rating/calculating risk was deemed an abstract idea, and Appellant did not show that the claim limitations integrated that idea into a practical application.[3]

It noted that the generic use of quantum-computing technology to an abstract idea (calculating risk) is not patent eligible where there is no technology improvement. Generally, subject matter eligibility is resolved by asking does this claimed invention improve computer technology or merely use computer technology. The PTAB agreed with the Examiner that the claims use generic quantum computing as a tool to perform the risk calculation, but do not improve quantum computing technology itself despite improving the speed and complexity of the risk analysis. In particular, the PTAB credited the specification's description that quantum computers can process exponentially large information in polynomial time, and concluded the asserted benefits (e.g., analyzing more factors) flowed from that *general capability* rather than from any claimed *improvement to quantum computing*.

This is a clear example of an abstract idea not being patentable just because it is implemented using generic quantum computing, without more.

[3] The PTAB agreed claim 1 recites an abstract idea as "an abstract method of organizing human activity – namely, the fundamental economic practice of determining a credit risk rating," and rejected the argument that "human involvement" must be explicitly recited.

(6) *Ex parte Alexei Ashikhmin* (Appeal No. 2017-006572; App. No. 13/912,876; TC 2100)

The claims related to quantum error processing, specifically an apparatus for measuring syndromes (i.e., error measurements) of quantum redundancy-coded states that may have degraded for correction.

Section 101 Patent Eligibility Reversed – the PTAB reversed the Examiner's § 101 rejection of the claims, rejecting the characterization that the claims were merely directed to the abstract idea of "generating abstract mathematical quantities called syndromes" implemented by nothing more than a generic computational unit.

The PTAB emphasized that independent claim 9, on its face, recited a machine/apparatus and recited it in a way to provide utility in the field of quantum processing by using various registers, a quantum circuit, detectors configured to measure physical qubit states and syndrome bits. Quantum processing using quantum bits or "qubits" and measuring physical states and syndromes associated therewith, may be esoteric technology, but this does not make the claimed invention abstract or lacking in utility, particularly when the claim is viewed as a whole. Put another way, even if quantum processing and syndrome measurement are specialized or esoteric, that alone does not render the invention abstract or non-useful under § 101 when the claims recite specific hardware configured for a specific technical quantum measurement task.

This is a clear example of a claim arguably including an abstract idea still being patentable because it recites specific hardware configured for a technical quantum measurement task and not just using quantum computing generally.

4. Practical Considerations

Each invention is unique and must be assessed individually. Despite the examples above being fact and technology intensive, the following are some practical considerations that can be gleaned from these cases and general legal principles:

- Preparing and obtaining valuable quantum patents requires working with a patent attorney who understands the technology and how the principles of patent law apply
- Meeting the legal requirements of the specification and claims requires understanding what is well known and what requires a more detailed explanation
- Quantum claims must either avoid reciting an abstract idea or must contain significantly more than the abstract idea – e.g., either a technical implementation or integration into a practical application
- The specification should include a clear written description of the invention and both what the invention is and how it works
- If the claims include generic or functional recitations, ensure the specification enables the full scope of the genus
- Monitoring evolving case law (e.g., PTO guidance and PTAB decisions on quantum-related inventions) is essential.

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