

QUANTUM CONCEPT ANALYSIS

REPORT

I. Overall Summary

- **Total Matches Found:** 573
- **Unique Files with Matches:** 251
- **Unique Concepts Matched:** 117
- **Total Patterns Defined:** 24
- **Total Patterns Found:** 22
- **Average Similarity Score:** 0.8951

II. Match Type Breakdown

Match Type Counts

| match_type | count |
|------------|-------|
| name | 384 |
| summary | 189 |

Average Score by Match Type

| match_type | similarity_score |
|------------|------------------|
| name | 0.9927 |
| summary | 0.6967 |

III. Source Framework & Target Project Breakdown

Matches by Source Framework

| framework | count |
|-----------|-------|
| classiq | 344 |
| qiskit | 118 |
| pennylane | 111 |

Matches by Target Project

| project | count |
|---------------------------------|-------|
| classiq-library | 309 |
| Qualtran | 63 |
| amazon-braket-examples | 41 |
| Cirq | 22 |
| qiskit-machine-learning | 19 |
| Qrisp | 18 |
| amazon-braket-algorithm-library | 14 |
| qiskit-finance | 13 |
| catalyst | 10 |
| tensorcircuit | 9 |
| qiskit-algorithms | 8 |
| covalent | 7 |
| torchquantum | 7 |

| project | count |
|----------------------|-------|
| quimb | 7 |
| qibo | 5 |
| qiskit-nature | 4 |
| ProjectQ | 4 |
| guppylang | 3 |
| thewalrus | 2 |
| Perceval | 2 |
| qiskit-optimization | 2 |
| qiskit-addon-cutting | 1 |
| grove | 1 |
| ReCirq | 1 |
| OpenFermion | 1 |

IV. Cross-Framework Pattern Analysis

Table 4.1: Source Pattern Analysis (Where patterns originate)

| pattern | Total Matches | Source Frameworks |
|--------------------------------|------------------|-------------------------------|
| Basis Change | 161 | classiq, pennylane, qiskit |
| Quantum Phase Estimation (QPE) | 57 | classiq, pennylane |
| Domain Specific Application | 53 | classiq, pennylane |

| pattern | Total Matches | Source Frameworks |
|---|----------------------|----------------------------|
| Quantum Arithmetic | 43 | classiq, pennylane, qiskit |
| Circuit Construction Utility | 40 | classiq, pennylane, qiskit |
| Data Encoding | 37 | classiq, pennylane, qiskit |
| Amplitude Amplification | 26 | classiq |
| Initialization | 26 | classiq, pennylane, qiskit |
| Hamiltonian Simulation | 20 | classiq, pennylane, qiskit |
| Variational Quantum Algorithm (VQA) | 19 | classiq, pennylane, qiskit |
| Quantum Logical Operators | 13 | qiskit |
| Oracle | 13 | classiq, qiskit |
| Quantum Neural Network (QNN) | 11 | pennylane |
| Quantum Approximate Optimization Algorithm (QAOA) | 10 | classiq, pennylane, qiskit |
| Grover | 10 | classiq, pennylane, qiskit |
| Linear Combination of Unitaries | 7 | classiq |
| Dynamic Circuit | 6 | pennylane |
| SWAP Test | 6 | classiq |
| Creating Entanglement | 5 | classiq |

| pattern | Total Matches | Source Frameworks |
|---------------------------------------|--------------------------|------------------------------|
| Variational Quantum Eigensolver (VQE) | 5 | pennylane |
| Phase Shift | 4 | classiq, pennylane |
| Quantum Amplitude Estimation | 1 | classiq |

Table 4.2: Adoption Pattern Analysis (Where patterns are used)

| pattern | Project Coverage | Found In Projects |
|-------------------------------------|-----------------------------|---|
| Circuit Construction Utility | 11 | Cirq, OpenFermion, Perceval, Qualtran, ReCirq, amazon-braket-algorithm-library, amazon-braket-examples, classiq-library, covalent, qiskit-optimization, thewalrus |
| Variational Quantum Algorithm (VQA) | 8 | Perceval, amazon-braket-examples, classiq-library, covalent, qiskit-addon-cutting, qiskit-finance, qiskit-nature, torchquantum |
| Domain Specific Application | 8 | Qrisp, Qualtran, amazon-braket-algorithm-library, amazon-braket-examples, classiq-library, guppylang, qibo, qiskit-finance |
| Quantum Phase Estimation (QPE) | 8 | ProjectQ, Qrisp, Qualtran, amazon-braket-algorithm-library, amazon-braket-examples, classiq-library, guppylang, qiskit-finance |
| Basis Change | 8 | Cirq, Qrisp, Qualtran, amazon-braket-algorithm-library, amazon-braket-examples, catalyst, classiq-library, qibo |

| pattern | Project Coverage | Found In Projects |
|---|-------------------------|--|
| Quantum Arithmetic | 7 | Cirq, Qrisp, Qualtran, amazon-braket-examples, catalyst, classiq-library, qiskit-finance |
| Amplitude Amplification | 6 | Cirq, Qrisp, amazon-braket-examples, classiq-library, grove, qiskit-algorithms |
| Quantum Approximate Optimization Algorithm (QAOA) | 6 | ProjectQ, catalyst, classiq-library, qiskit-machine-learning, quimb, tensorcircuit |
| Data Encoding | 6 | Cirq, Qualtran, catalyst, classiq-library, covalent, qiskit-machine-learning |
| Grover | 5 | amazon-braket-algorithm-library, catalyst, classiq-library, qiskit-algorithms, qiskit-optimization |
| Quantum Neural Network (QNN) | 5 | Cirq, classiq-library, qiskit-machine-learning, quimb, tensorcircuit |
| Initialization | 5 | ProjectQ, Qualtran, amazon-braket-examples, classiq-library, covalent |
| Quantum Logical Operators | 3 | Qualtran, amazon-braket-examples, classiq-library |
| Oracle | 3 | Cirq, classiq-library, qiskit-algorithms |
| Dynamic Circuit | 3 | Cirq, classiq-library, quimb |
| Variational Quantum Eigensolver (VQE) | 3 | amazon-braket-examples, classiq-library, qiskit-nature |
| Phase Shift | 2 | catalyst, classiq-library |
| | 2 | classiq-library, qiskit-algorithms |

| pattern | Project Coverage | Found In Projects |
|---------------------------------|-------------------------|--------------------------|
| Hamiltonian Simulation | | |
| Quantum Amplitude Estimation | 1 | classiq-library |
| Linear Combination of Unitaries | 1 | classiq-library |
| SWAP Test | 1 | classiq-library |
| Creating Entanglement | 1 | classiq-library |

V. Quantum Pattern Analysis

Patterns by Match Count (Overall)

| pattern | count |
|--------------------------------|--------------|
| Basis Change | 161 |
| Quantum Phase Estimation (QPE) | 57 |
| Domain Specific Application | 53 |
| Quantum Arithmetic | 43 |
| Circuit Construction Utility | 40 |
| Data Encoding | 37 |
| Amplitude Amplification | 26 |
| Initialization | 26 |

| pattern | count |
|---|-------|
| Hamiltonian Simulation | 20 |
| Variational Quantum Algorithm (VQA) | 19 |
| Oracle | 13 |
| Quantum Logical Operators | 13 |
| Quantum Neural Network (QNN) | 11 |
| Grover | 10 |
| Quantum Approximate Optimization Algorithm (QAOA) | 10 |
| Linear Combination of Unitaries | 7 |
| Dynamic Circuit | 6 |
| SWAP Test | 6 |
| Variational Quantum Eigensolver (VQE) | 5 |
| Creating Entanglement | 5 |
| Phase Shift | 4 |
| Quantum Amplitude Estimation | 1 |

Average Score by Pattern

| pattern | similarity_score |
|------------------------------|------------------|
| Quantum Amplitude Estimation | 1 |
| Dynamic Circuit | 1 |
| Oracle | 0.994 |
| Hamiltonian Simulation | 0.9826 |
| Initialization | 0.9617 |

| pattern | similarity_score |
|---|-------------------------|
| Phase Shift | 0.9595 |
| Linear Combination of Unitaries | 0.9547 |
| SWAP Test | 0.9546 |
| Basis Change | 0.9434 |
| Variational Quantum Algorithm (VQA) | 0.9383 |
| Quantum Logical Operators | 0.9211 |
| Amplitude Amplification | 0.909 |
| Creating Entanglement | 0.8982 |
| Data Encoding | 0.8969 |
| Circuit Construction Utility | 0.893 |
| Grover | 0.8831 |
| Variational Quantum Eigensolver (VQE) | 0.8698 |
| Quantum Phase Estimation (QPE) | 0.822 |
| Quantum Arithmetic | 0.8082 |
| Quantum Approximate Optimization Algorithm (QAOA) | 0.8017 |
| Quantum Neural Network (QNN) | 0.7971 |
| Domain Specific Application | 0.7876 |

All Patterns within each Source Framework (Sorted by Frequency)

Classiq

| pattern | count |
|---|-------|
| Basis Change | 107 |
| Quantum Phase Estimation (QPE) | 56 |
| Domain Specific Application | 38 |
| Amplitude Amplification | 26 |
| Initialization | 18 |
| Circuit Construction Utility | 17 |
| Quantum Arithmetic | 17 |
| Hamiltonian Simulation | 15 |
| Data Encoding | 10 |
| Oracle | 9 |
| Linear Combination of Unitaries | 7 |
| Grover | 6 |
| SWAP Test | 6 |
| Creating Entanglement | 5 |
| Phase Shift | 3 |
| Variational Quantum Algorithm (VQA) | 2 |
| Quantum Amplitude Estimation | 1 |
| Quantum Approximate Optimization Algorithm (QAOA) | 1 |

Pennylane

| pattern | count |
|---|-------|
| Basis Change | 28 |
| Domain Specific Application | 15 |
| Data Encoding | 11 |
| Quantum Neural Network (QNN) | 11 |
| Variational Quantum Algorithm (VQA) | 10 |
| Quantum Arithmetic | 7 |
| Dynamic Circuit | 6 |
| Quantum Approximate Optimization Algorithm (QAOA) | 6 |
| Variational Quantum Eigensolver (VQE) | 5 |
| Hamiltonian Simulation | 4 |
| Circuit Construction Utility | 3 |
| Grover | 2 |
| Initialization | 1 |
| Phase Shift | 1 |
| Quantum Phase Estimation (QPE) | 1 |

Qiskit

| pattern | count |
|------------------------------|-------|
| Basis Change | 26 |
| Circuit Construction Utility | 20 |
| Quantum Arithmetic | 19 |

| pattern | count |
|---|-------|
| Data Encoding | 16 |
| Quantum Logical Operators | 13 |
| Initialization | 7 |
| Variational Quantum Algorithm (VQA) | 7 |
| Oracle | 4 |
| Quantum Approximate Optimization Algorithm (QAOA) | 3 |
| Grover | 2 |
| Hamiltonian Simulation | 1 |

VI. Top Matched Concepts

Top 20 Most Frequently Matched Concepts

| Framework | Concept | Matches |
|-----------|-----------------------|---------|
| Classiq | ...hadamard_transform | 52 |
| Classiq | ...qpe | 30 |
| Classiq | ...qft | 26 |
| Classiq | ...qpe_flexible | 26 |
| Qiskit | ...QFT | 24 |
| Pennylane | ...QFT | 21 |
| Classiq | ...qsvt | 19 |
| Classiq | ...apply_to_all | 16 |

| Framework | Concept | Matches |
|-----------|----------------------|---------|
| Classiq | ...suzuki_trotter | 15 |
| Qiskit | ...AND | 11 |
| Pennylane | ...QuantumMonteCarlo | 10 |
| Classiq | ...grover_operator | 9 |
| Qiskit | ...Permutation | 9 |
| Classiq | ...phase_oracle | 9 |
| Qiskit | ...zz_feature_map | 8 |
| Qiskit | ...z_feature_map | 8 |
| Pennylane | ...RandomLayers | 8 |
| Classiq | ...qft_no_swap | 8 |
| Pennylane | ...GQSP | 7 |
| Classiq | ...qct_qst_type2 | 7 |

VII. Unmatched Pattern Analysis

The following **2** patterns from the source files were **NOT found** in any project:

- Function Table
- Schmidt Decomposition