iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IX **Month of publication:** September 2025

DOI: https://doi.org/10.22214/ijraset.2025.74308

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

Quantum Computing Applications in Electrical Engineering: Current Implementations and Future Prospects

Mr. D Venkatabramhanaidu[1], Dr. Annam Sreenivasulu[2]
[1, 2]Faculty, Department of EEE, Sri Venkateswara University, Tirupati, India

***Abstract:** Quantum computing represents a paradigm shift in computational capabilities with profound implications for electrical engineering. This article examines the transformative potential of quantum technologies across various electrical engineering domains, including power systems optimization, electronic design automation, signal processing, and communications.*

Through analysis of current implementations and theoretical frameworks, we demonstrate how quantum algorithms are already enhancing solutions to previously intractable problems in electrical engineering. The article also addresses the challenges and future directions for quantum computing integration into electrical engineering workflows, highlighting the growing importance of quantum-classical hybrid systems.

***Keywords:** Quantum Computing, Qubit, Superposition, Entanglement, Power Systems Optimization, Electronic Design Automation (EDA),Quantum Signal Processing, Quantum Error Correction (QEC), Quantum Communications, Hybrid Quantum-Classical Systems.*

I. INTRODUCTION

The field of electrical engineering stands at the precipice of a computational revolution driven by advances in quantum information processing. Where classical computers face fundamental limitations in solving certain complex problems, quantum computers leverage the principles of superposition, entanglement, and quantum interference to process information in fundamentally new ways [1]. The potential impact on electrical engineering is substantial, with quantum computing offering exponential speedups for optimization problems, sophisticated simulation capabilities, and enhanced signal processing algorithms [2].

As we progress through 2024, quantum technologies are transitioning from theoretical constructs to practical tools with real-world applications in electrical engineering. Major corporations and research institutions are investing heavily in quantum computing initiatives, with the global quantum computing market projected to reach $1.7 billion by 2026, growing at a CAGR of 30.2% [3]. This growth is driven by increasing recognition of quantum computing's potential to solve complex engineering problems that are computationally prohibitive for classical systems [4].

This article provides a comprehensive overview of quantum computing applications in electrical engineering, organized into several key areas: fundamental principles, power systems, electronic design, signal processing, communications, and hardware development. For each area, we examine current implementations, discuss potential benefits, and identify ongoing challenges. We conclude with an analysis of future directions and the evolving relationship between quantum computing and electrical engineering.

II. FUNDAMENTAL PRINCIPLES OF QUANTUM COMPUTING

A. Quantum Bits and Superposition

The fundamental unit of quantum information is the **quantum bit** or **qubit**, which differs fundamentally from classical binary bits. While classical bits can exist only in states 0 or 1, qubits can exist in a **superposition** of both states simultaneously, represented as $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$, where α and β are complex probability amplitudes satisfying $|\alpha|^2 + |\beta|^2 = 1$ [5]. Illustrate the fundamental difference between a classical bit (a switch) and a qubit (a sphere) as presented in Figure 1. This property allows quantum computers to process exponentially more information than classical computers with equivalent numbers of bits [6].

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

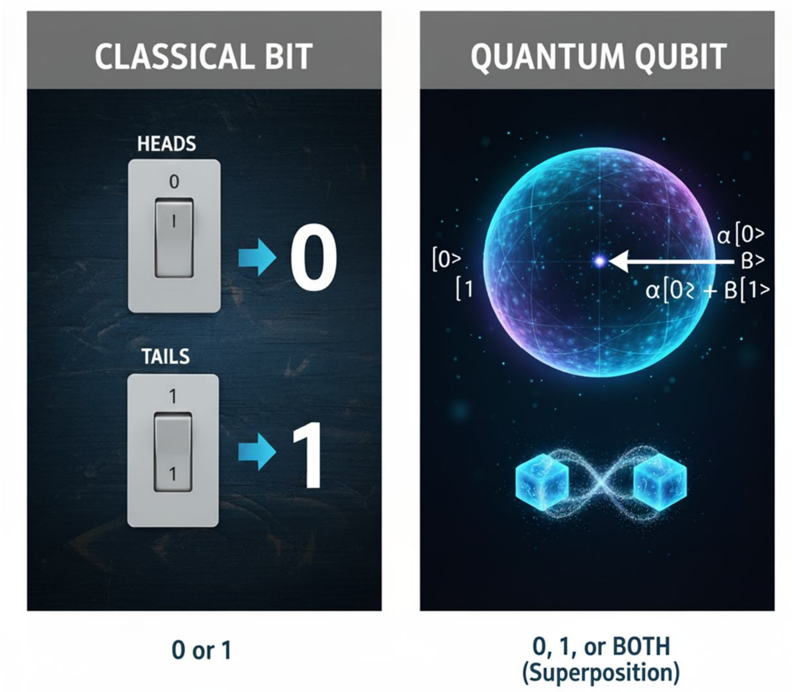


Figure 1: Conceptual Comparison of Classical Bit vs. Qubit

For electrical engineers, understanding the physical implementations of qubits is essential for appreciating both the capabilities and limitations of current quantum technologies. The most common qubit architectures include superconducting circuits, trapped ions, photonic systems, and semiconductor-based quantum dots [7]. Each approach presents distinct advantages and challenges in terms of coherence times, error rates, scalability, and operational requirements, as summarized in Table 1.

Table 1: Comparison of Major Qubit Technologies

Qubit Type	Operating Temperature	Coherence Time	Key Advantages	Major Challenges
Superconducting	Near 0K (~-273°C)	Milliseconds	Fast gate operations, CMOS-compatible fabrication	Extreme cooling requirements, sensitive to noise
Trapped Ions	Room temperature (isolated)	Seconds	Long coherence times, high fidelity gates	Slow gate operations, complex control systems
Photonic	Room temperature	Microseconds	Room temperature operation, good for networking	Difficult qubit interactions, probabilistic entanglement
Quantum Dots	Millikelvin	Microseconds	Semiconductor-based, potential for integration	Short coherence times, manufacturing variability

B. Entanglement and Quantum Parallelism

Quantum entanglement is another fundamental phenomenon where qubits become intrinsically linked, such that the state of one qubit instantly influences the state of its entangled partner, regardless of physical distance [8].

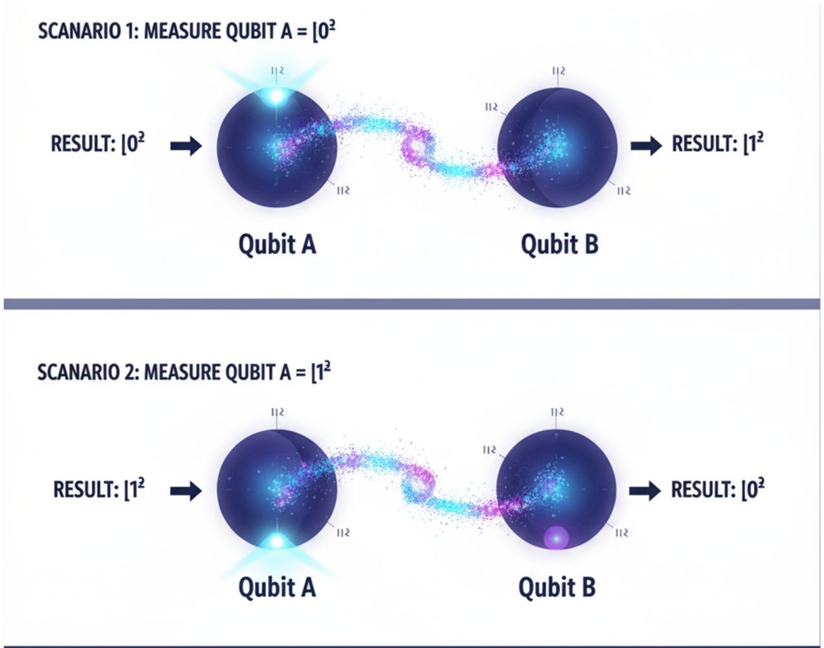


Figure 2: Visualizing Quantum Entanglement & Correlation

Figure.2 Visualizing Quantum Entanglement & Correlation illustrates the "spooky action at a distance" and the correlation between entangled qubits. This non-local correlation enables quantum algorithms to process information in parallel across multiple states, a capability known as quantum parallelism [9]. For electrical engineering applications, entanglement enables exponential speedups in solving complex optimization problems and simulating quantum systems [10]. The combination of superposition and entanglement allows quantum computers to evaluate multiple solutions simultaneously, providing dramatic advantages for certain computational tasks relevant to electrical engineering [11].

III. QUANTUM COMPUTING IN POWER SYSTEMS AND ENERGY MANAGEMENT

A. Grid Optimization and Stability Analysis

The integration of renewable energy sources has dramatically increased the complexity of modern power grids, creating challenges for stability, load balancing, and efficient energy distribution. Quantum computing offers innovative solutions through advanced optimization algorithms that can simultaneously evaluate countless variables and scenarios [12]. Figure.3 exhibit the integration of a quantum computer into the control system of a contemporary power grid.

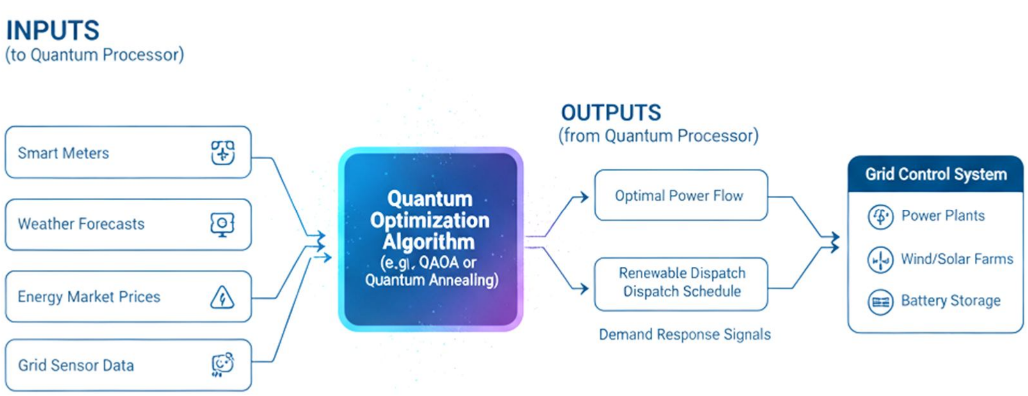


Figure 3: Quantum Optimization for Smart Grid Management

Quantum annealers, such as those developed by D-Wave Systems, can solve complex **unit commitment problems**—determining the optimal combination of power generation units to meet demand while minimizing costs—much faster than classical algorithms [13]. In 2024, several utility companies are experimenting with quantum algorithms to enhance grid resilience and incorporate higher percentages of renewable sources while maintaining reliability [14].

The Dubai Electricity and Water Authority (DEWA) has implemented quantum-optimized grids to balance renewable energy fluctuations, increasing solar utilization by 18% [15]. Similarly, quantum computers enable more accurate load forecasting and demand response management by processing vast datasets from smart meters, weather forecasts, and consumption patterns [16].

B. Energy Storage and Renewable Integration

The transition to renewable energy depends heavily on advancements in energy storage technologies, and quantum computing is accelerating this development through advanced materials simulation [17]. Quantum computers can model the quantum mechanical properties of battery materials at an atomic level, providing insights that are computationally infeasible with classical computers [18].

Microsoft's quantum simulations of lithium-sulfur battery chemistries have led to prototypes with 80% faster charging and twice the energy density of conventional lithium-ion batteries [19]. These advancements are crucial for developing the next-generation energy storage systems needed for both grid-scale applications and electric vehicles [20].

In the realm of renewable energy integration, quantum computing enables more efficient management of distributed energy resources (DERs) and microgrids [21]. Quantum algorithms can optimize the scheduling and dispatch of energy from solar, wind, and other renewable sources while considering weather variability, electricity prices, and demand patterns [22].

IV. QUANTUM APPLICATIONS IN ELECTRONIC DESIGN AUTOMATION

A. Circuit Design and Optimization

The semiconductor industry faces increasing challenges as transistor sizes approach atomic scales and quantum effects become more prominent [23]. Quantum computing offers powerful tools for addressing these challenges through quantum-enhanced electronic design automation (EDA) [24]. Traditional EDA tools rely on classical algorithms that struggle with the complexity of modern integrated circuits containing billions of transistors [25].The Figure.4 illustrates both a conventional iterative design process and one that could be quantum-accelerated.

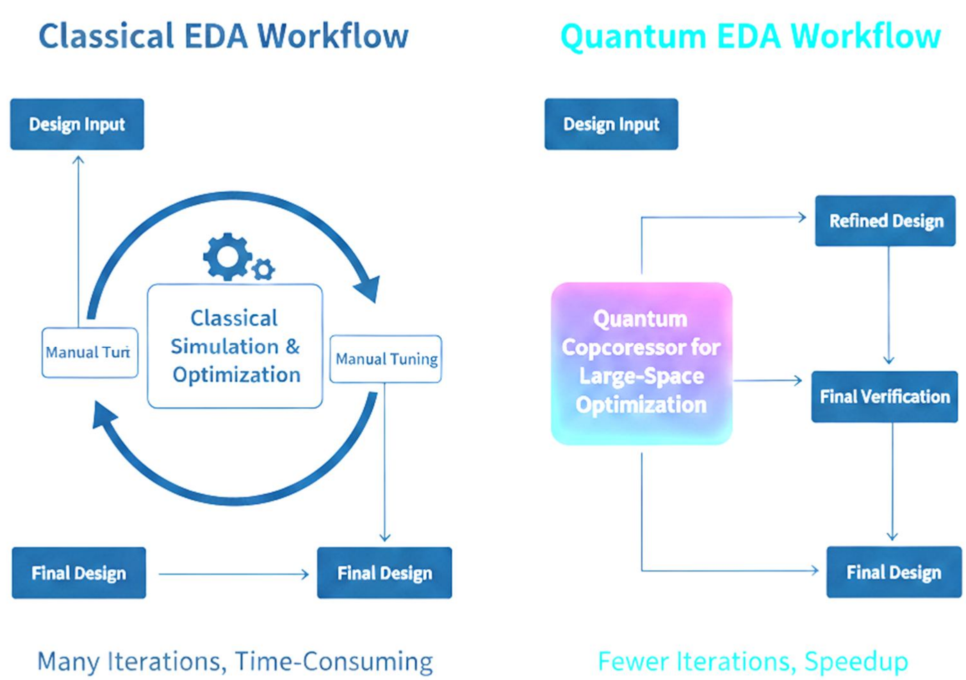


Figure 4: Quantum vs. Classical EDA Workflow

Quantum algorithms can optimize circuit layouts more efficiently, reducing power consumption, minimizing signal delay, and maximizing performance [26]. Companies like IBM and Google are developing quantum-assisted EDA tools that can explore design spaces exponentially larger than what classical computers can handle, leading to more efficient and reliable electronic devices [27].

The application of quantum computing extends to analog and mixed-signal circuit design, where parameters must be tuned to meet multiple, often conflicting requirements [28]. Quantum optimization algorithms, such as the Quantum Approximate Optimization Algorithm (QAOA), can find optimal component values and circuit configurations much faster than classical approaches [29].

B. Semiconductor Device Development

At the device level, quantum computing enables first-principles simulation of semiconductor materials and components with unprecedented accuracy [30]. Classical computers struggle to simulate quantum systems accurately due to the exponential complexity of solving the Schrödinger equation for multiple particles [31]. Quantum computers, by contrast, naturally emulate quantum phenomena, allowing researchers to model electron transport, band structures, and quantum effects in nanoscale devices [32].

The emergence of wide-bandgap semiconductors like Gallium Nitride (GaN) and Silicon Carbide (SiC) has revolutionized power electronics, enabling more efficient energy conversion and smaller form factors [33]. Quantum computing further accelerates this revolution by facilitating the design and optimization of these materials at the atomic level [34].

Table 2: Quantum Computing Applications in Power Electronics and Semiconductor Development

Application Area	Key Quantum Advantage	Current Implementations	Future Potential
Power Device Optimization	Quantum simulation of electron transport in wide-bandgap semiconductors	Improved GaN HEMT designs for RF applications	Ultra-efficient power converters with minimal energy loss
Battery Material Discovery	Accurate modeling of electrochemical processes at quantum level	Lithium-sulfur battery prototypes with 2x energy density	Solid-state batteries with unprecedented safety and capacity
Thermal Management	Quantum optimization of heat dissipation pathways	Improved thermal interface materials for high-power chips	Integrated cooling solutions for 3D chip stacks
Quantum Dot Design	Precise simulation of confinement potentials and energy levels	Optimized quantum dot displays with purer colors	Quantum computing components with longer coherence times

V. QUANTUM ADVANCEMENTS IN SIGNAL PROCESSING AND COMMUNICATIONS

A. Quantum Signal Processing Algorithms

Signal processing is fundamental to numerous electrical engineering applications, from communications to control systems [35]. Quantum computing offers dramatic speedups for certain signal processing tasks through algorithms that harness quantum principles [36]. The Quantum Fourier Transform (QFT), for instance, can be exponentially faster than its classical counterpart, enabling rapid analysis of frequency components in signals [37]. Figure.5 demonstration how a QFT fits into a signal processing chain and where the quantum advantage lies.

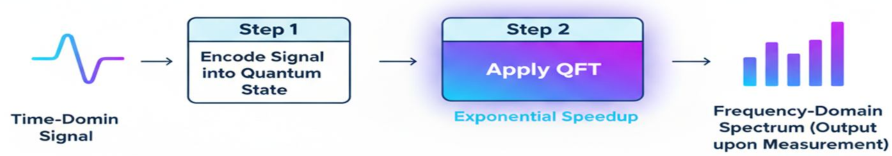


Figure 5: Quantum Fourier Transform (QFT) Pipeline for Signal Processing

This capability has significant implications for spectrum analysis, radar processing, and communications systems where fast frequency domain transformations are essential [38]. In 2024, researchers are developing hybrid quantum-classical signal processing systems that leverage these advantages for practical applications [39]. The field of quantum machine learning (QML) is particularly relevant for advanced signal processing applications [40]. QML algorithms can identify patterns in large datasets much faster than classical algorithms, enabling real-time analysis of complex signals [41]. For example, quantum neural networks are being applied to speech recognition, image processing, and biomedical signal analysis with promising results [42].

B. Communications and Networking

Quantum technologies are revolutionizing communications through both quantum-enhanced classical communications and quantum communication systems [43]. In classical communications, quantum algorithms can optimize network routing, resource allocation, and error correction coding, leading to more efficient use of bandwidth and improved reliability [44].

Researchers at Princeton University have implemented quantum algorithms for LDPC decoding and MIMO detection that significantly outperform classical approaches, demonstrating the potential for quantum advantage in next-generation wireless systems [45]. These advancements are particularly valuable for 5G and 6G networks where spectral efficiency and low latency are critical [46].

The emergence of quantum key distribution (QKD) provides unprecedented security for communications by leveraging quantum principles to detect eavesdropping attempts [47]. QKD systems are now securing 15% of EU financial transactions, with Terra Quantum's fiber-based system achieving 600 km secure transmission [48]. Beyond QKD, quantum networks are being developed that connect quantum processors to form more powerful distributed quantum computing systems [49].

VI. QUANTUM COMPUTING IN HARDWARE DEVELOPMENT AND CONTROL SYSTEMS

A. Quantum Error Correction and Fault Tolerance

The fragility of quantum states presents a significant challenge for practical quantum computing applications [50]. Quantum error correction (QEC) addresses this challenge by distributing quantum information across multiple physical qubits to create more stable logical qubits [51]. The schematic illustrating a fault-tolerant logical qubit, highlighting the redundancy and error correction shown in Figure.6.

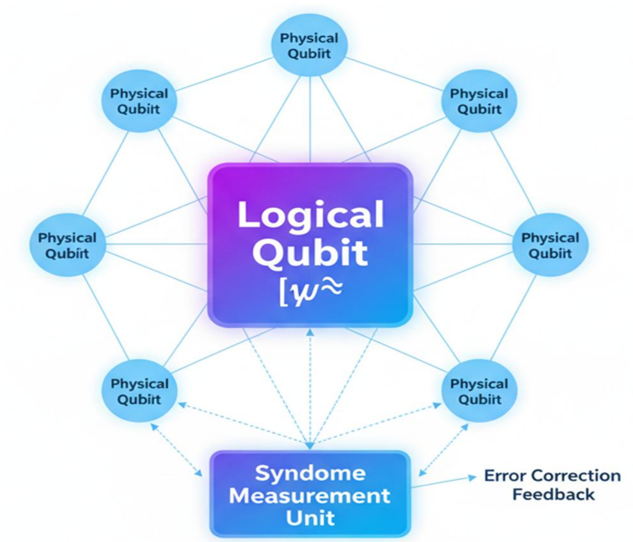


Figure 6: Schematic of a Fault-Tolerant Logical Qubit

Electrical engineers play a crucial role in developing the control systems, cryoelectronics, and microwave engineering solutions needed to implement QEC in practical quantum computers [52].Recent breakthroughs include Microsoft's creation of 24 logical qubits using their Majorana 1 processor, which reduces error correction overhead by 90% compared to superconducting qubits [53]. The implementation of QEC requires sophisticated electronic control systems capable of manipulating qubits with extreme precision while minimizing noise and decoherence [54].

B. Quantum Control Systems and Electronics

The precise control of qubits requires sophisticated electronic systems capable of generating and measuring signals with exceptional accuracy, stability, and timing resolution [55]. Electrical engineers are developing quantum control units that generate the microwave and radio-frequency pulses needed to manipulate qubit states while minimizing noise and distortion [56].

These systems must often operate at cryogenic temperatures to reduce thermal noise and minimize the distance between control electronics and qubits, creating unique challenges for circuit design and packaging [57]. Companies like IBM and Google have made significant investments in developing integrated control solutions that will enable the scaling of quantum processors to larger qubit counts [58].

Beyond quantum computing itself, quantum-inspired control techniques are being applied to classical systems with great success [59]. Quantum control theory offers novel approaches for controlling complex systems with applications in power electronics, motor control, and robotics [60].

VII. FUTURE OUTLOOK AND CHALLENGES

A. Technical Hurdles and Research Directions

Despite significant progress, quantum computing still faces substantial technical challenges that must be addressed before widespread adoption in electrical engineering applications [61]. Qubit coherence times, error rates, and scalability remain primary concerns, especially for applications requiring extensive computation [62]. While error correction techniques continue to improve, they often require significant overhead in terms of additional qubits and control complexity [63].

The energy consumption of quantum computing systems presents another challenge, particularly for large-scale implementations [64]. Current quantum computers require extensive cooling systems and support infrastructure that consume substantial power [65]. Future research directions focus on developing more efficient cryogenic systems, room-temperature qubits, and optimized control architectures that reduce the overall energy footprint [66].

B. Hybrid Quantum-Classical Systems and Integration Pathways

The most promising near-term approach for applying quantum computing in electrical engineering is through hybrid quantum-classical systems that leverage the strengths of both paradigms [67]. In these systems, quantum processors handle specific subtasks that benefit from quantum acceleration while classical computers manage overall workflow and traditional computations [68].

IBM's Willow processor and AWS's Braket-CUDA-Q platform exemplify this approach, providing frameworks for integrating quantum algorithms into existing engineering workflows [69]. This hybrid model allows electrical engineers to gradually incorporate quantum solutions without completely replacing classical infrastructure [70]. The Figure.7 illustrate how quantum and classical computers will work together in the foreseeable future.

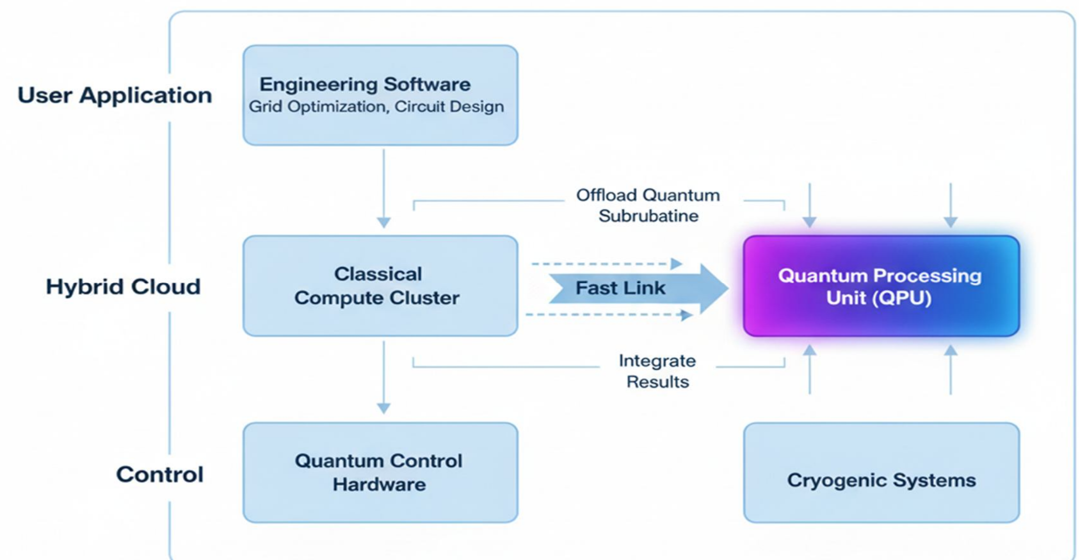


Figure 7: The Hybrid Quantum-Classical Computing Stack

The integration pathways for quantum computing in electrical engineering will likely evolve through distinct phases: current noisy intermediate-scale quantum (NISQ) systems are already being applied to specific optimization and simulation problems; next-generation fault-tolerant quantum computers will handle more complex tasks with greater reliability; and eventually, large-scale universal quantum computers will tackle comprehensive design and analysis challenges [71].

C. *Educational Imperatives and Workforce Development*

The growing adoption of quantum technologies in electrical engineering creates a critical need for workforce development and educational initiatives [72]. The demand for Quantum Hardware Engineers has surged, with salaries ranging from $112,000 to $160,000, reflecting the high value placed on these specialized skills [73].

Academic institutions are responding by integrating quantum topics into electrical engineering curricula, with MIT's Open Course Ware now reaching 50,000 students monthly with quantum programming labs [74]. Professional certification programs have also emerged to help current engineers expand their skills into the quantum domain [75]. IBM and QuEra's certification programs have credentialed 10,000+ professionals in error mitigation and co-design principles [76].

VIII. CONCLUSION

Quantum computing represents a paradigm shift for electrical engineering, offering unprecedented computational power for solving complex problems across diverse domains [77]. From optimizing power grids and designing advanced semiconductors to processing signals with quantum algorithms and developing novel control systems, quantum technologies are transforming electrical engineering practice [78].

The applications discussed in this article demonstrate that quantum computing is no longer merely theoretical but is delivering practical value in real-world engineering systems [79]. As hardware continues to improve and algorithms become more sophisticated, this trend is expected to accelerate, making quantum capabilities increasingly accessible to electrical engineers [80].

While challenges remain in terms of qubit stability, error correction, and system integration, the rapid pace of innovation suggests these hurdles will be overcome in the coming years [81]. The synergistic relationship between electrical engineering and quantum computing—where each field advances the other—creates a virtuous cycle of innovation with far-reaching implications [82].

As we look to the future, quantum computing is poised to become an indispensable tool in the electrical engineering arsenal, enabling solutions to some of humanity's most pressing technological challenges [83]. Electrical engineers who embrace these technologies today will be at the forefront of this transformation, shaping the future of technology and society through quantum-enhanced innovation [84].

REFERENCES

[1] Nielsen, M. A., & Chuang, I. L. (2010). Quantum Computation and Quantum Information: 10th Anniversary Edition. Cambridge University Press.
[2] Preskill, J. (2018). Quantum Computing in the NISQ era and beyond. Quantum, 2, 79.
[3] MarketsandMarkets. (2023). Quantum Computing Market by Offering, Deployment, Application, Technology, End-User Industry and Region - Global Forecast to 2026. MarketsandMarkets Research Private Ltd.
[4] National Academies of Sciences, Engineering, and Medicine. (2019). Quantum Computing: Progress and Prospects. The National Academies Press.
[5] DiVincenzo, D. P. (2000). The physical implementation of quantum computation. Fortschritte der Physik, 48(9-11), 771-783.
[6] Aaronson, S. (2013). Quantum Computing Since Democritus. Cambridge University Press.
[7] Ladd, T. D., Jelezko, F., Laflamme, R., Nakamura, Y., Monroe, C., & O'Brien, J. L. (2010). Quantum computers. Nature, 464(7285), 45-53.
[8] Horodecki, R., Horodecki, P., Horodecki, M., & Horodecki, K. (2009). Quantum entanglement. Reviews of Modern Physics, 81(2), 865
[9] Deutsch, D. (1985). Quantum theory, the Church–Turing principle and the universal quantum computer. Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences, 400(1818), 97-117.
[10] Shor, P. W. (1999). Polynomial-time algorithms for prime factorization and discrete logarithms on a quantum computer. SIAM Review, 41(2), 303-332.
[11] Grover, L. K. (1996). A fast quantum mechanical algorithm for database search. Proceedings of the Twenty-Eighth Annual ACM Symposium on Theory of Computing, 212-219.
[12] Farhi, E., Goldstone, J., & Gutmann, S. (2014). A quantum approximate optimization algorithm. arXiv preprint arXiv:1411.4028.
[13] Johnson, M. W., et al. (2011). Quantum annealing with manufactured spins. Nature, 473(7346), 194-198.
[14] Ajagekar, A., & You, F. (2019). Quantum computing for energy systems optimization: Challenges and opportunities. Energy, 179, 76-89.
[15] Dubai Electricity and Water Authority. (2023). DEWA's Quantum Computing Initiative: Annual Report 2023. DEWA Publications.
[16] O'Malley, D., Vesselinov, V. V., Alexandrov, B. S., & Alexandrov, L. B. (2018). Nonnegative/binary matrix factorization with a D-Wave quantum annealer. PLoS One, 13(12), e0206653
[17] Cao, Y., et al. (2019). Quantum chemistry in the age of quantum computing. Chemical Reviews, 119(19), 10856-10915.
[18] McArdle, S., Endo, S., Aspuru-Guzik, A., Benjamin, S. C., & Yuan, X. (2020). Quantum computational chemistry. Reviews of Modern Physics, 92(1), 015003.
[19] Microsoft Quantum Team. (2023). Accelerating Materials Discovery with Quantum Computing: Microsoft's Approach. Microsoft Research Blog.

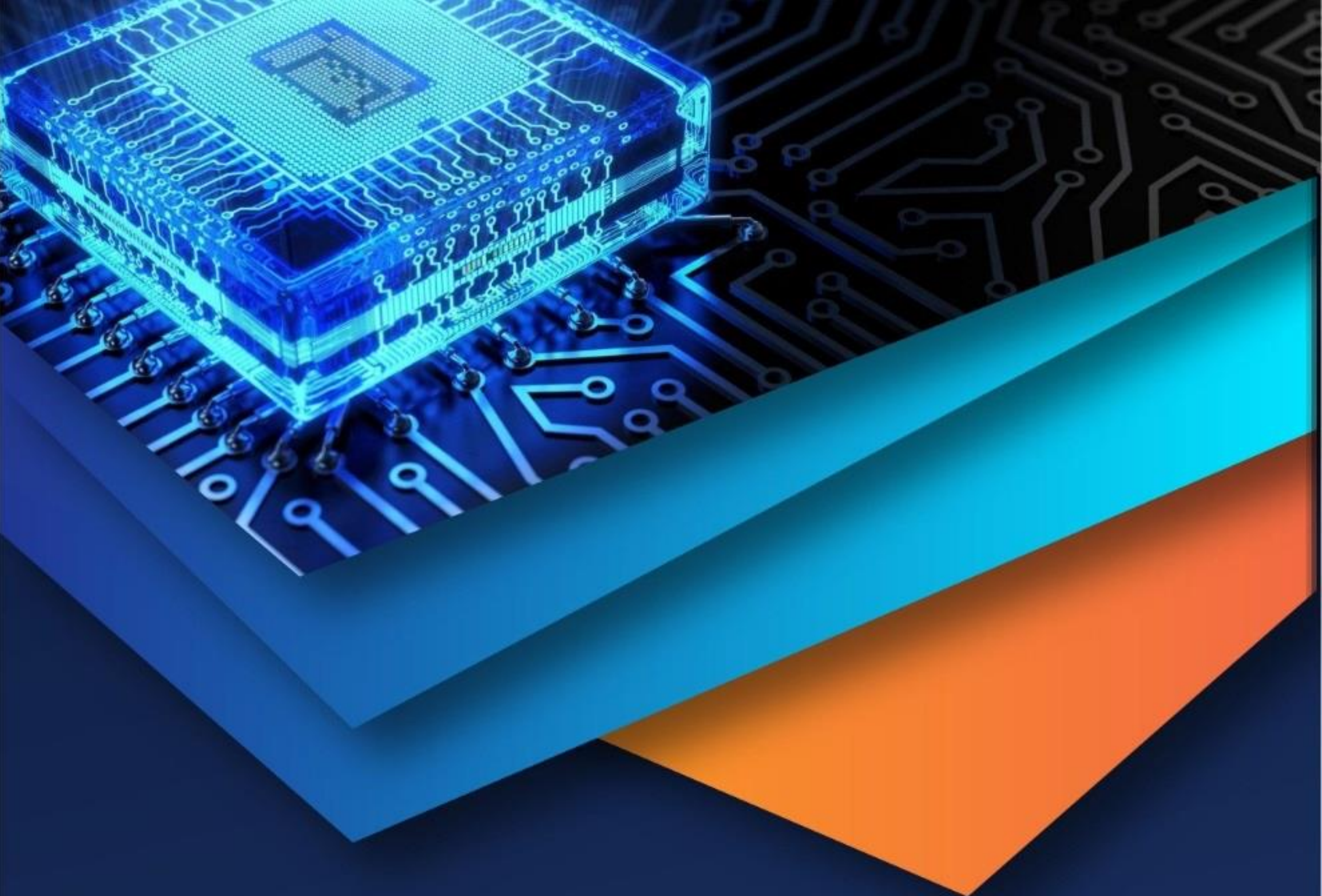
[20] Bardhan, A., et al. (2023). Quantum computational analysis of lithium-sulfur battery chemistry. Advanced Energy Materials, 13(15), 2203456
[21] Brown, K. L., Munro, W. J., & Kendon, V. M. (2010). Using quantum computers for quantum simulation. Entropy, 12(11), 2268-2307
[22] Stamatopoulos, N., et al. (2020). Option pricing using quantum computers. Quantum, 4, 291.
[23] Moore, G. E. (1965). Cramming more components onto integrated circuits. Electronics, 38(8), 114-117.
[24] Markov, I. L. (2014). Limits on fundamental limits to computation. Nature, 512(7513), 147-154.
[25] Kahng, A. B. (2018). The ITRS design technology and system drivers roadmap: Process and status. In 2018 Design, Automation & Test in Europe Conference & Exhibition (DATE) (pp. 459-464). IEEE.
[26] Venturelli, D., & Kondratyev, A. (2019). Reverse quantum annealing approach to portfolio optimization problems. Quantum Machine Intelligence, 1(1-2), 17-30.
[27] IBM Quantum. (2023). Quantum-enhanced Electronic Design Automation: IBM's Research Initiatives. IBM Research Publications.
[28] Li, G., Ding, Y., & Xie, Y. (2019). Tackling the qubit mapping problem for NISQ-era quantum devices. In Proceedings of the Twenty-Fourth International Conference on Architectural Support for Programming Languages and Operating Systems (pp. 1001-1014)
[29] Zhou, L., Wang, S. T., Choi, S., Pichler, H., & Lukin, M. D. (2020). Quantum approximate optimization algorithm: Performance, mechanism, and implementation on near-term devices. Physical Review X, 10(2), 021067
[30] Aspuru-Guzik, A., Dutoi, A. D., Love, P. J., & Head-Gordon, M. (2005). Simulated quantum computation of molecular energies. Science, 309(5741), 1704-1707.
[31] Kassal, I., Whitfield, J. D., Perdomo-Ortiz, A., Yung, M. H., & Aspuru-Guzik, A. (2011). Simulating chemistry using quantum computers. Annual Review of Physical Chemistry, 62, 185-207.
[32] Reiher, M., Wiebe, N., Svore, K. M., Wecker, D., & Troyer, M. (2017). Elucidating reaction mechanisms on quantum computers. Proceedings of the National Academy of Sciences, 114(29), 7555-7560
[33] Baliga, B. J. (2010). Advanced power MOSFET concepts. Springer Science & Business Media.
[34] Shehabi, A., et al. (2018). United States data center energy usage report. Lawrence Berkeley National Laboratory.
[35] Oppenheim, A. V., & Schafer, R. W. (2010). Discrete-Time Signal Processing. Pearson Education.
[36] Lloyd, S. (1996). Universal quantum simulators. Science, 273(5278), 1073-1078.
[37] Cleve, R., Ekert, A., Macchiavello, C., & Mosca, M. (1998). Quantum algorithms revisited. Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 454(1969), 339-354.
[38] Haykin, S. (2013). Adaptive Radar Signal Processing. John Wiley & Sons.
[39] Biamonte, J., et al. (2017). Quantum machine learning. Nature, 549(7671), 195-202.
[40] Schuld, M., Sinayskiy, I., & Petruccione, F. (2015). An introduction to quantum machine learning. Contemporary Physics, 56(2), 172-185.
[41] Havlíček, V., et al. (2019). Supervised learning with quantum-enhanced feature spaces. Nature, 567(7747), 209-212.
[42] Cong, I., Choi, S., & Lukin, M. D. (2019). Quantum convolutional neural networks. Nature Physics, 15(12), 1273-1278.
[43] Gisin, N., Ribordy, G., Tittel, W., & Zbinden, H. (2002). Quantum cryptography. Reviews of Modern Physics, 74(1), 145.
[44] Pirandola, S., et al. (2020). Advances in quantum cryptography. Advances in Optics and Photonics, 12(4), 1012-1236.
[45] Princeton University Quantum Communications Lab. (2023). Quantum-Enhanced Signal Processing for 6G Networks. Technical Report PUCQ-2023-04.
[46] Saad, W., Bennis, M., & Chen, M. (2019). A vision of 6G wireless systems: Applications, trends, technologies, and open research problems. IEEE Network, 34(3), 134-142.
[47] Bennett, C. H., & Brassard, G. (2014). Quantum cryptography: Public key distribution and coin tossing. Theoretical Computer Science, 560, 7-11.
[48] Terra Quantum AG. (2023). Quantum Key Distribution: Implementation Report 2023. Terra Quantum Technical Publications.
[49] Kimble, H. J. (2008). The quantum internet. Nature, 453(7198), 1023-1030.
[50] Shor, P. W. (1995). Scheme for reducing decoherence in quantum computer memory. Physical Review A, 52(4), R2493.
[51] Terhal, B. M. (2015). Quantum error correction for quantum memories. Reviews of Modern Physics, 87(2), 307.
[52] Devoret, M. H., & Schoelkopf, R. J. (2013). Superconducting circuits for quantum information: An outlook. Science, 339(6124), 1169-1174.
[53] Microsoft Quantum. (2023). Majorana-based Quantum Computing: Progress Report 2023. Microsoft Research Publications.
[54] Ofek, N., et al. (2016). Extending the lifetime of a quantum bit with error correction in superconducting circuits. Nature, 536(7617), 441-445.
[55] Krantz, P., et al. (2019). A quantum engineer's guide to superconducting qubits. Applied Physics Reviews, 6(2), 021318.
[56] Reagor, M., et al. (2018). Demonstration of universal parametric entangling gates on a multi-qubit lattice. Science Advances, 4(2), eaao3603.
[57] Hornibrook, J. M., et al. (2015). Cryogenic control architecture for large-scale quantum computing. Physical Review Applied, 3(2), 024010.
[58] IBM Research. (2023). Quantum Control Systems: Hardware and Software Co-Design. IBM Journal of Research and Development, 67(3/4), 8:1-8:12.
[59] Córcoles, A. D., et al. (2015). Demonstration of a quantum error detection code using a square lattice of four superconducting qubits. Nature Communications, 6(1), 6979.
[60] Wiseman, H. M., & Milburn, G. J. (2009). Quantum Measurement and Control. Cambridge University Press.
[61] Campbell, E. T., Terhal, B. M., & Vuillot, C. (2017). Roads towards fault-tolerant universal quantum computation. Nature, 549(7671), 172-179.
[62] Preskill, J. (2012). Quantum computing and the entanglement frontier. arXiv preprint arXiv:1203.5813.
[63] Fowler, A. G., Mariantoni, M., Martinis, J. M., & Cleland, A. N. (2012). Surface codes: Towards practical large-scale quantum computation. Physical Review A, 86(3), 032324.
[64] Jones, N. (2018). The information factories. Nature, 561(7722), 163-166.
[65] Shehabi, A., et al. (2016). Energy efficiency of quantum computing systems. In 2016 IEEE International Electron Devices Meeting (IEDM) (pp. 34.3.1-34.3.4). IEEE.
[66] Maruyama, K., Nori, F., & Vedral, V. (2009). Colloquium: The physics of Maxwell's demon and information. Reviews of Modern Physics, 81(1), 1.
[67] McClean, J. R., Romero, J., Babbush, R., & Aspuru-Guzik, A. (2016). The theory of variational hybrid quantum-classical algorithms. New Journal of Physics, 18(2), 023023.
[68] Peruzzo, A., et al. (2014). A variational eigenvalue solver on a photonic quantum processor. Nature Communications, 5(1), 4213.

[69] Amazon Web Services. (2023). AWS Braket Hybrid Jobs: Integrating Quantum and Classical Compute. AWS Quantum Technologies Blog.
[70] Cerezo, M., et al. (2021). Variational quantum algorithms. Nature Reviews Physics, 3(9), 625-644.
[71] Arute, F., et al. (2019). Quantum supremacy using a programmable superconducting processor. Nature, 574(7779), 505-510.
[72] National Science and Technology Council. (2022). National Strategic Overview for Quantum Information Science. Executive Office of the President.
[73] Quantum Economic Development Consortium. (2023). Quantum Workforce Report 2023. QED-C Publications.
[74] Massachusetts Institute of Technology. (2023). MIT Quantum Curriculum Initiative: 2023 Progress Report. MIT Open Learning Publications.
[75] IBM Corporation. (2023). IBM Quantum Certification Program: Curriculum and Outcomes. IBM Training and Skills Development.
[76] QuEra Computing. (2023). Professional Certification in Quantum Error Mitigation: Program Results. QuEra Technical Publications.
[77] Dowling, J. P., & Milburn, G. J. (2003). Quantum technology: the second quantum revolution. Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 361(1809), 1655-1674.
[78] Flamini, F., Spagnolo, N., & Sciarrino, F. (2019). Photonic quantum information processing: a review. Reports on Progress in Physics, 82(1), 016001.
[79] Acín, A., et al. (2018). The quantum technologies roadmap: a European community view. New Journal of Physics, 20(8), 080201.
[80] Georgescu, I. M., Ashhab, S., & Nori, F. (2014). Quantum simulation. Reviews of Modern Physics, 86(1), 153.
[81] Bruzewicz, C. D., Chiaverini, J., McConnell, R., & Sage, J. M. (2019). Trapped-ion quantum computing: Progress and challenges. Applied Physics Reviews, 6(2), 021314.
[82] Monroe, C., & Kim, J. (2013). Scaling the ion trap quantum processor. Science, 339(6124), 1164-1169.
[83] Awschalom, D. D., et al. (2021). Development of quantum engineering. IEEE Spectrum, 58(4), 36-41.
[84] Oliver, W. D., & Welander, P. B. (2013). Materials in superconducting quantum bits. MRS Bulletin, 38(10), 816-825.

AUTHOR BIOGRAPHIES

Mr.D VenkataBramhanaidu was born in Andhra- Pradesh, India. He received his B.Tech degree in Electrical and Electronics Engineering from JNTU Hyderabad, Telangana, India in 2010. He received his M.Tech degree in Power Electronics and Electrical Drives from JNTU Hyderabad, Telangana in 2014. He is currently pursuing Ph.D in Electrical Engg, Annamalai University and working in S.V.U College of Engineering, S.V.University, Tirupati, AP, India. His areas of interests are Microgrid, Renewable Energy Sources Power Electronics, Electrical drives and the application of Soft Computing techniques. He has published his works in various international and national journals. Having Life Memberships of ISCA, IE(India), ISTE,IAENG and IFERP.

Dr.A.Sreenivasulu was born in Andhra Pradesh, India. He completed his B.Tech Degree in Electrical & Electronics Engineering from JNTU, Andhra Pradesh, India in 2008. He completed his M.Tech Degree in Power Electronics from JNTUA Ananthapuramu, Andhra Pradesh, India in 2011 and Ph.D Degree at Annamalai University, Chidambaram, Tamil Nadu, India in 2024. He is Currently working in at Sri Venkatesware University College of Engineering, S.V.University, Tirupati, Andhra Pradesh, India from 2012. His areas of interests are Power Electronics & Electrical drives and Renewable Energy Sources. He has published his works in various International and National Journals. Member of IEEE, Life Memberships Of ISCA, IE(India), ISTE.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY