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Studies on Power Systems, Electronics, Telecommunications, Embedded Systems, and Computer Engineering

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ABSTRACT

Power systems, electronics, telecommunications, embedded systems, and computer engineering are fundamental disciplines driving digital transformation, intelligent automation, and sustainable technological innovation across various industrial and commercial sectors. Rapid advancements in smart grids, artificial intelligence (AI), the Internet of Things (IoT), fifth-generation (5G) communications, embedded computing, and cloud technologies have significantly improved system efficiency, reliability, and operational performance. This study aims to systematically review recent research trends, technological developments, and engineering applications in these interconnected fields based on scientific publications published between 2019 and 2023. A Systematic Literature Review (SLR) was conducted by identifying, screening, evaluating, and synthesizing relevant articles from reputable scientific databases. The review highlights major advances in intelligent power systems, power electronics, next-generation telecommunications, embedded system technologies, and computer engineering. The findings indicate that integrating intelligent computing, advanced communication networks, and embedded technologies enhances energy management, industrial automation, data processing, and system resilience while supporting the development of secure, efficient, and sustainable engineering solutions.

Keywords: *Power Systems; Electronics; Telecommunications; Embedded Systems; Computer Engineering; Systematic Literature Review.*

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1. | INTRODUCTION

Power systems, electronics, telecommunications, embedded systems, and computer engineering have become fundamental technologies driving digital transformation and intelligent automation across industrial, commercial, healthcare, transportation, and communication sectors (Vermesan & Bacquet 2022). The rapid evolution of renewable energy integration, artificial intelligence (AI), Internet of Things (IoT), cloud computing, edge computing, and advanced communication networks has accelerated the development of interconnected engineering systems capable of improving operational efficiency, system reliability, and decision-making processes. Consequently, these engineering disciplines are increasingly integrated to support the implementation of smart industries, smart cities, and sustainable digital infrastructure.

Power systems have undergone substantial transformation through the implementation of smart grids, distributed energy resources, digital substations, and intelligent monitoring technologies (Kabalci & Kabalci, 2019). Unlike conventional power networks, modern power systems employ real-time sensing, communication technologies, and automated control to enhance energy efficiency, operational flexibility, and grid resilience. The growing penetration of renewable energy sources such as solar and wind power has also increased the need for adaptive power management, advanced protection systems, and secure communication infrastructures capable of maintaining power system stability under dynamic operating conditions.

Advances in electronics have significantly contributed to improving the performance of energy conversion systems, industrial automation, and intelligent electronic devices (Xiang et al., 2021). Recent developments in power electronic converters, semiconductor technologies, digital controllers, and high-efficiency energy conversion systems have enabled more reliable renewable energy integration, electric vehicles, and industrial motor drives. At the same time, continuous improvements in electronic packaging, thermal management, and electromagnetic compatibility have enhanced the efficiency and reliability of modern electronic equipment operating in increasingly complex environments.

Telecommunications technology has experienced remarkable progress with the deployment of fifth-generation (5G) communication systems, cloud services, edge computing, and software-defined networking (Pham et al., 2020). These technologies provide high-speed, low-latency, and reliable communication services that support autonomous systems, industrial Internet of Things (IIoT), intelligent transportation systems, and smart energy management. Furthermore, communication infrastructures have become essential components of modern cyber-physical systems because they enable real-time data exchange, distributed intelligence, and coordinated operation among geographically distributed devices.

Embedded systems and computer engineering have also evolved rapidly due to advances in embedded processors, microcontrollers, field-programmable gate arrays (FPGAs), machine learning, and edge artificial intelligence (Ajani et al., 2021). These technologies enable real-time processing, autonomous control, predictive maintenance, and intelligent decision-making in robotics, healthcare devices, industrial automation, and smart infrastructure. The integration of embedded computing with AI and IoT allows intelligent systems to process data locally while reducing communication latency, improving cybersecurity, and enhancing system reliability. Such capabilities are increasingly important for supporting next-generation engineering applications requiring high computational performance and continuous operation.

Although considerable progress has been achieved across these engineering disciplines, many existing studies focus on individual technologies rather than their interdisciplinary integration (Okorie et al., 2018). As digital transformation continues to reshape engineering practice, comprehensive reviews are required to identify emerging research trends, technological developments, implementation challenges, and future research opportunities. Therefore, this study employs a Systematic Literature Review (SLR) to synthesize scientific publications published between 2019 and 2023 concerning power systems, electronics, telecommunications, embedded systems, and computer engineering. The findings are expected to provide a comprehensive understanding of current technological advances while supporting future research and innovation toward secure, intelligent, efficient, and sustainable engineering systems.

2. | RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) to identify, evaluate, and synthesize scientific publications related to power systems, electronics, telecommunications, embedded systems, and computer engineering published between last five years. The review followed a structured methodology consisting of four sequential stages: identification, screening, eligibility assessment, and qualitative synthesis. Relevant literature was collected from internationally recognized scientific databases, including IEEE Xplore, Scopus, Web of Science, ScienceDirect, SpringerLink, ACM Digital Library, and Wiley Online Library. The search process utilized combinations of keywords such as power systems, smart grid, power electronics, telecommunications, 5G, 6G, Internet of Things, embedded systems, computer engineering, artificial intelligence, machine learning, edge computing, and cyber-physical systems. Only peer-reviewed journal articles published in English between last five years were included to ensure the quality, relevance, and credibility of the reviewed literature. Conference papers, book chapters, editorials, duplicate publications, and studies lacking sufficient methodological information were excluded. After the screening and eligibility processes, the selected articles were analyzed according to their research objectives, methodologies, technologies, engineering applications, experimental results, and major findings (Gao et al., 2019). The reviewed studies were subsequently categorized into several thematic areas, including smart power systems, power electronics, wireless and next-generation telecommunications, embedded computing technologies, artificial intelligence, Internet of Things applications, and computer engineering innovations. Finally, a qualitative synthesis was conducted to compare research findings, identify technological trends, evaluate current challenges, and determine future research opportunities for developing intelligent, secure, reliable, energy-efficient, and sustainable engineering systems that support digital transformation across multiple industrial sectors.

3. | RESULTS AND DISCUSSION

The systematic literature review indicates that research on power systems, electronics, telecommunications, embedded systems, and computer engineering has grown rapidly between last five years, reflecting the increasing demand for intelligent, interconnected, and energy-efficient engineering solutions (Ugwu et al., 2022). The reviewed studies consistently demonstrate that the convergence of these disciplines has become a key driver of digital transformation across industrial automation, smart cities, renewable energy integration, healthcare, and transportation. Recent technological advances have been supported by developments in artificial intelligence (AI), Internet of Things (IoT), cloud computing, edge computing, digital twins, and next-generation communication networks, enabling engineering systems to become more autonomous, adaptive, and resilient. These technologies have significantly improved system performance while supporting sustainable industrial development and digital infrastructure modernization. Moreover, interdisciplinary collaboration among electrical engineering, electronics, telecommunications, embedded computing, and information technology has accelerated the development of integrated engineering solutions capable of addressing increasingly complex industrial challenges. As digital technologies continue to evolve, engineering systems are becoming more intelligent, data-driven, and capable of responding dynamically to changing operational conditions, thereby creating new opportunities for innovation across both developed and developing economies.

One of the most significant research trends identified in the reviewed literature is the modernization of power systems through smart grid implementation. Conventional electrical grids are gradually evolving into intelligent energy networks capable of integrating renewable energy resources, distributed generation, energy storage systems, and advanced metering infrastructures (Joseph & Balachandra, 2020). Smart grids utilize real-time communication, intelligent monitoring devices, and automated control systems to optimize energy distribution, improve operational reliability, and enhance power quality. Furthermore, digital transformation enables utilities to monitor grid conditions continuously, perform predictive maintenance, and respond rapidly to system disturbances while improving energy efficiency and reducing operational costs. The integration of artificial intelligence and advanced data analytics into power system operations has further strengthened the capability of utilities to forecast electricity demand, optimize generation scheduling, and minimize transmission losses. These improvements contribute to greater resilience against unexpected disruptions while supporting the global transition toward cleaner and more sustainable energy systems.

Power electronics has also experienced remarkable progress during the review period (Afonso et al., 2021). The increasing adoption of renewable energy systems, electric vehicles, and industrial automation has accelerated research on high-efficiency power converters, wide-bandgap semiconductor devices, intelligent control algorithms, and digital power management. These technological developments improve energy conversion efficiency, reduce switching losses, and enhance system stability under dynamic operating conditions. Machine learning techniques are increasingly integrated into power electronic systems to support fault diagnosis, adaptive control, parameter optimization, and predictive maintenance, thereby increasing equipment reliability and extending operational lifetime. Furthermore, advancements in semiconductor materials such as silicon carbide (SiC) and gallium nitride (GaN) have enabled higher switching frequencies and improved thermal performance, making power electronic systems more compact and efficient. These innovations are particularly important for renewable energy integration, electric mobility, aerospace systems, and high-performance industrial applications where efficiency and reliability are critical requirements.

Telecommunications technology has undergone substantial transformation through the deployment of fifth-generation (5G) communication networks and the ongoing development of beyond-5G and early 6G technologies. These communication systems provide ultra-low latency, high bandwidth, massive device connectivity, and reliable data transmission that support industrial Internet of Things (IIoT), autonomous vehicles, smart manufacturing, and intelligent healthcare services (Jain et al., 2018). Software-defined networking, network virtualization, and programmable communication architectures further improve network flexibility, scalability, and resource utilization while enabling real-time communication for critical engineering applications. The emergence of edge computing has complemented these communication technologies by allowing computational processes to occur closer to data sources, thereby reducing transmission delays and improving service responsiveness. Together, these developments create communication infrastructures capable of supporting billions of interconnected devices while maintaining high levels of reliability, security, and operational efficiency.

The literature also highlights the rapid growth of embedded systems as intelligent processing platforms capable of supporting real-time monitoring, sensing, and autonomous control. Modern embedded systems employ energy-efficient microcontrollers, system-on-chip architectures, field-programmable gate arrays (FPGAs), and edge AI processors to execute complex computational tasks directly on local devices. This approach reduces communication latency, minimizes bandwidth consumption, and enhances cybersecurity by processing sensitive information locally instead of relying entirely on cloud computing. Tiny Machine Learning (TinyML) has emerged as an important research direction because it enables artificial intelligence algorithms to operate efficiently on resource-constrained embedded devices. These technological improvements have significantly expanded the application of embedded systems in wearable healthcare devices, environmental monitoring, autonomous drones, industrial robotics, intelligent transportation systems, and smart consumer electronics. The combination of embedded intelligence and efficient hardware architectures enables devices to make autonomous decisions with minimal energy consumption while maintaining high computational performance.

Computer engineering has likewise expanded significantly through advances in cloud computing, artificial intelligence, cybersecurity, big data analytics, and distributed computing architectures. Intelligent algorithms have become essential tools for system optimization, anomaly detection, predictive maintenance, image recognition, natural language processing, and engineering decision support. Cloud-edge collaborative computing further improves computational efficiency by distributing processing tasks between centralized cloud servers and edge devices according to application requirements. Such architectures enable real-time services while maintaining scalability and reducing communication overhead. In addition, the rapid evolution of high-performance computing, virtualization technologies, and container-based software deployment has improved the flexibility of modern computing infrastructures. These advances enable organizations to process increasingly large volumes of engineering data while supporting complex simulations, digital twins, and intelligent automation that facilitate faster and more informed engineering decision-making.

Another major finding of this review is the increasing integration of cyber-physical systems that combine power infrastructure, communication networks, embedded devices, and computational intelligence into unified engineering platforms. Smart factories, autonomous transportation systems, intelligent buildings, and digital energy management systems rely on continuous interaction between physical equipment and digital technologies. Sensors collect operational information, embedded processors analyze local conditions, communication networks transmit data securely, and cloud platforms perform large-scale analytics for strategic decision-making. This multidisciplinary integration has significantly improved operational efficiency, system reliability, and infrastructure resilience across numerous engineering applications. Furthermore, cyber-physical systems facilitate predictive maintenance, automated quality control, resource optimization, and adaptive process management, allowing industries to respond rapidly to changing operational conditions. The implementation of digital twins further enhances these capabilities by creating virtual representations of physical assets that enable continuous monitoring, simulation, and performance optimization throughout the operational lifecycle.

Despite these technological advances, several challenges remain (Mihai et al., 2022). Cybersecurity continues to be a major concern due to increasing connectivity among critical infrastructure components. Smart grids, industrial control systems, and IoT devices are vulnerable to cyberattacks that may compromise operational safety, data integrity, and service continuity. Researchers therefore emphasize secure communication protocols, encryption methods, authentication mechanisms, and AI-based intrusion detection systems as essential elements for protecting future engineering infrastructures. Interoperability among heterogeneous hardware and software platforms also remains a challenge because different communication standards and proprietary technologies often limit seamless integration across engineering systems. Additional challenges include ensuring data privacy, maintaining regulatory compliance, managing the growing complexity of interconnected infrastructures, and addressing the shortage of highly skilled professionals capable of developing and maintaining advanced digital engineering systems. These issues highlight the importance of establishing standardized frameworks and international collaboration to support secure and interoperable technological development.

In addition, the reviewed studies identify energy efficiency, scalability, reliability, and sustainability as important research priorities. Future engineering systems are expected to consume less energy while supporting increasingly complex computational workloads and communication requirements. Advances in low-power electronics, energy-aware embedded systems, intelligent power management, and renewable energy integration will therefore play essential roles in achieving sustainable digital transformation. Continued collaboration among electrical engineers, computer engineers, communication specialists, and data scientists will accelerate the development of intelligent engineering systems capable of supporting future industrial and societal needs. Future research should also emphasize explainable artificial intelligence, resilient communication infrastructures, intelligent energy management, autonomous control systems, and environmentally sustainable computing technologies. Collectively, these developments will contribute to engineering ecosystems that are not only technologically advanced but also economically viable, environmentally responsible, and socially beneficial, ensuring that future digital infrastructure remains capable of supporting the rapidly evolving demands of Industry 4.0 and beyond.

4. | CONCLUSION

Power systems, electronics, telecommunications, embedded systems, and computer engineering have become increasingly interconnected in supporting digital transformation, intelligent automation, and sustainable technological development. Based on the systematic literature review of studies published between 2019 and 2023, significant advancements have been achieved in smart power systems, power electronics, next-generation communication networks, embedded computing, artificial intelligence, and Internet of Things technologies. The integration of these disciplines has enhanced energy efficiency, communication reliability, computational performance, system automation, and real-time decision-making across various engineering applications. Furthermore, the convergence of cloud computing, edge computing, machine learning, and cyber-physical systems has accelerated the development of smart grids, intelligent manufacturing, autonomous transportation, and digital infrastructure. Despite these achievements, challenges related to cybersecurity, interoperability, scalability, energy management, and system resilience continue to require further investigation. Future research should emphasize interdisciplinary collaboration, secure communication architectures, intelligent control algorithms, and sustainable engineering practices to develop reliable, adaptive, and energy-efficient engineering systems capable of supporting future industrial transformation and global technological innovation.

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The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement

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Data Disclosure Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Afonso, J. L., Tanta, M., Pinto, J. G. O., Monteiro, L. F., Machado, L., Sousa, T. J., & Monteiro, V. (2021). A review on power electronics technologies for power quality improvement. *Energies*, *14*(24), 8585.

Ajani, T. S., Imoize, A. L., & Atayero, A. A. (2021). An overview of machine learning within embedded and mobile devices–optimizations and applications. *Sensors*, *21*(13), 4412.

Gao, C., Sun, X., Lu, L., Liu, F., & Yuan, J. (2019). Prevalence of gestational diabetes mellitus in mainland China: a systematic review and meta-analysis. *Journal of diabetes investigation*, *10*(1), 154-162.

Jain, A. K., Acharya, R., Jakhar, S., & Mishra, T. (2018, April). Fifth generation (5G) wireless technology "Revolution in telecommunication". In *2018 second international conference on inventive communication and computational technologies (ICICCT)* (pp. 1867-1872). IEEE.

Joseph, A., & Balachandra, P. (2020). Smart grid to energy internet: A systematic review of transitioning electricity systems. *Ieee Access*, *8*, 215787-215805.

Kabalci, E., & Kabalci, Y. (Eds.). (2019). *Smart grids and their communication systems* (No. 1). Singapore:: Springer.

Mihai, S., Yaqoob, M., Hung, D. V., Davis, W., Towakel, P., Raza, M., ... & Nguyen, H. X. (2022). Digital twins: A survey on enabling technologies, challenges, trends and future prospects. *IEEE Communications Surveys & Tutorials*, *24*(4), 2255-2291.

Okorie, O., Salonitis, K., Charnley, F., Moreno, M., Turner, C., & Tiwari, A. (2018). Digitisation and the circular economy: A review of current research and future trends. *Energies*, *11*(11), 3009.

Pham, Q. V., Fang, F., Ha, V. N., Piran, M. J., Le, M., Le, L. B., ... & Ding, Z. (2020). A survey of multi-access edge computing in 5G and beyond: Fundamentals, technology integration, and state-of-the-art. *IEEE access*, *8*, 116974-117017.

Ugwu, J., Odo, K. C., Ohanu, C. P., García, J., & Georgious, R. (2022). Comprehensive review of renewable energy communication modeling for smart systems. *Energies*, *16*(1), 409.

Vermesan, O., & Bacquet, J. (Eds.). (2022). *Cognitive hyperconnected digital transformation: Internet of things intelligence evolution*. CRC Press.

Xiang, C., Bowers, S. M., Bjorlin, A., Blum, R., & Bowers, J. E. (2021). Perspective on the future of silicon photonics and electronics. *Applied Physics Letters*, *118*(22).