# Electronic engineering in intelligent communication systems

**Yoo-bin Park[1, a *], Charlie Evans[2, b], Guo Xiaopin[3, c],**

[1]Sejong University 209 Neungdong-ro, Gwangjin-gu, Seoul 05006, South Korea
[2]Elimo Engineering Ltd Unit B301, The Biscuit Factory, 100 Drummond Road, London SE16 4DG, United Kingdom
[3]Zhejiang Sci-Tech University 928 2nd Avenue, Xiasha Higher Education Park Qiantang District, Hangzhou, Zhejiang 310018, China
a.yoobin_395park@outlook.com,b.charlie_evan10212047@foxmail.com,c.xiaobin_0842@163.com
***Corresponding Author**

**Abstract:** With the rapid development of informatization and intelligentization, electronic engineering technology has become increasingly prominent in intelligent communication systems. Through optimized design in signal acquisition, transmission, processing, and network control, this technology has achieved high efficiency, stability, and intelligence in communication systems. Starting from the core content of electronic engineering technology, this paper analyzes its application mechanisms and key technologies in intelligent communication systems, and explores future development trends in combination with typical application scenarios. The results indicate that the deep integration of electronic engineering technology with frontier technologies such as artificial intelligence, Internet of Things, and big data is an important pathway for promoting the intelligent upgrading of communication systems.

**Keywords:** intelligent communication systems, electronic engineering technology, signal processing, hardware design, artificial intelligence

## 1. Introduction

Intelligent communication systems represent critical infrastructure in modern information society, and their performance directly affects data transmission efficiency and information security. As a core enabling technology for communication systems, electronic engineering technology plays a pivotal role in system hardware design, signal modulation and demodulation, data processing, and intelligent control. With the emergence of 5G/6G communications, edge computing, and AI algorithms, both the application scope and technical depth of electronic engineering technology in communication systems have expanded significantly. Therefore, systematic analysis of its applications is of great significance for promoting the efficient construction and technological innovation of intelligent communication systems.

## 2. Overview of electronic engineering technology

### 2.1. Basic connotation of electronic engineering technology

Electronic engineering technology is a comprehensive engineering discipline based on the principles of electronics, studying electronic components, signal processing circuits, and systems for information acquisition, transmission, and control. Its core mission is to achieve effective information transfer and intelligent control through the generation, modulation, amplification, transmission, and processing of electrical signals. As a foundational discipline supporting modern information society, electronic engineering technology encompasses a complete technical chain ranging from basic circuit theory to system-level integration design. At the technical level, it includes multiple branches such as analog and digital circuit design, embedded system development, signal and information processing, electromagnetic compatibility design, communication system design, sensing and detection technology, and intelligent control system integration.

https://doi.org/10.62852/csa/2026/264
Copyright (c) 2026 Cambridge Science Advance

### 2.2. Current status of technological development

Since the beginning of the 21st century, the rapid advancement of microelectronic manufacturing processes and the significant improvement in integrated circuit design capabilities have ushered in a new stage of development for electronic engineering technology. The long-term continuation of Moore's Law has driven continuous increases in chip integration density, while the maturation of nanoscale manufacturing technology has enabled exponential growth in the number of transistors accommodated on a single chip, thereby achieving qualitative leaps in performance, energy efficiency, and functional integration.

First, the trend toward system-level integration has become prominent. System-on-Chip (SoC) technology integrates processors, memory, communication interfaces, and sensing modules onto a single chip, substantially enhancing device miniaturization and energy efficiency ratios. This enables communication terminals, wearable devices, and others to implement complex computations and multi-functional coordination within limited space. Second, programmable hardware has been widely applied. Field-Programmable Gate Arrays (FPGAs) and Digital Signal Processors (DSPs) have become key hardware platforms in modern communication and signal processing systems. FPGAs provide efficient solutions for high-speed signal processing and algorithm verification through their flexible logic configuration capabilities, while DSPs specialize in real-time numerical computation, playing a central role in fields such as speech recognition, image processing, and radar signal analysis.

## 3. Electronic engineering in intelligent communication systems

### 3.1. Signal acquisition and processing technology

#### *3.1.1. Signal acquisition and processing technology*

In modern communication environments, information transmission faces increasingly complex channel conditions, including multipath fading, random noise, and nonlinear distortion. High-fidelity and high-robustness performance during signal acquisition, transmission, and reconstruction must be ensured through high-precision sampling and intelligent processing methods. High-speed analog-to-digital conversion (ADC) technology constitutes a critical component of signal acquisition. Combined with digital filtering and compression algorithms, it can effectively mitigate noise interference, reduce redundant information, and improve transmission efficiency and spectral utilization. In 5G/6G systems, the substantial increase in signal bandwidth imposes higher requirements on ADC sampling rates and signal-to-noise ratios, making new-generation hybrid sampling and adaptive quantization techniques a research priority.

#### *3.1.2. Spatial signal processing and intelligent algorithms*

In multiple-input multiple-output (MIMO) systems and beamforming architectures, electronic engineering achieves refined control of channel resources through spatial signal processing. MIMO technology significantly enhances spectral efficiency and reduces bit error rates through parallel transmission capabilities of multi-antenna arrays. Beamforming technology, through phase adjustment and signal superposition, concentrates energy in target directions, effectively suppressing spatial interference and energy leakage. This spatial-dimension-based signal processing improves the anti-interference capability of communication systems and provides technical support for massive user access and high-speed mobile communications. At the algorithmic level, the introduction of artificial intelligence has fundamentally transformed traditional signal processing paradigms. Convolutional neural networks can automatically extract time-frequency features of signals through end-to-end learning mechanisms, enabling adaptive equalization in complex channel environments. Recurrent neural networks and attention mechanisms can achieve predictive filtering and interference identification in dynamic channels. Through the self-learning characteristics of deep learning models, communication systems can effectively correct signal distortion and noise without requiring precise physical modeling. This paradigm shift from "model-driven" to "data-driven" approaches has propelled signal processing into an intelligent self-optimization stage.

https://doi.org/10.62852/csa/2026/264
Copyright (c) 2026 Cambridge Science Advance

### 3.2. Communication hardware design and integration technology

Communication hardware serves as the physical foundation of intelligent communication systems, and its design level plays a decisive role in the upper-limit performance of signal processing and transmission. Innovations and optimizations in electronic engineering technology at the hardware level enable communication devices to maintain stable operation at higher frequencies, larger bandwidths, and in more complex environments. As communication frequency bands extend into the millimeter-wave and terahertz domains, electronic components face escalating requirements for high-frequency characteristics, thermal dissipation performance, and power consumption control. Traditional silicon-based technologies have encountered bottlenecks, making wide-bandgap semiconductor materials and advanced packaging technologies critical breakthroughs.

In terms of devices, the widespread application of gallium nitride (GaN) and silicon carbide (SiC) materials has substantially elevated the performance limits of communication hardware. GaN devices feature high electron mobility, high breakdown electric field, and excellent thermal conductivity, enabling stable operation under high power density and high-frequency conditions. SiC materials, leveraging low on-resistance and high voltage withstand characteristics, demonstrate outstanding performance in radio frequency (RF) power amplifiers and high-efficiency power modules. These novel materials allow RF front-ends to achieve low loss, high linearity, and high output power in millimeter-wave communications, providing reliable assurance for high-speed communication links.

Hardware integration represents another critical direction for electronic engineering in intelligent communications. System-on-Chip (SoC) integrates communication processing, signal modulation, power control, and algorithmic computation modules within a single chip, substantially enhancing system integration density and computational efficiency while reducing power consumption and latency. RF System-in-Package (SiP) technology achieves integrated design of analog, digital, and RF circuits through three-dimensional stacking and multi-chip collaboration. SiP structures shorten signal paths, reduce interconnect inductance and parasitic effects, enabling more stable high-speed signal transmission, and provide new approaches for the design of portable and miniaturized communication devices.

### 3.3. Embedded control and real-time systems

Embedded control systems bear core responsibilities for data management, real-time response, and resource scheduling within intelligent communication architectures. Their primary characteristic is the tight integration of computation and control functions into communication nodes, enabling rapid perception of complex networks and adaptive regulation. In terms of architecture design, embedded systems are generally based on ARM architecture multi-core processors or RISC-V instruction set platforms, achieving low-latency response through hardware parallel computing and high-speed cache management. FPGA, as a flexible programmable hardware acceleration platform, can construct collaborative architectures with microcontrollers to support real-time implementation of critical communication functions such as channel estimation, modulation and demodulation, and power control. The introduction of hardware acceleration enhances system computational efficiency while reducing dependence on central servers, achieving intelligent autonomous control at the edge layer. In wireless communication nodes, embedded systems are responsible for channel measurement, resource allocation, and relay cooperation tasks. Through hardware-software co-design, systems can dynamically adjust power and bandwidth allocation based on channel feedback, achieving optimal distribution of communication loads and energy balance. In industrial IoT environments, embedded control platforms utilize real-time task scheduling algorithms to ensure synchronous communication among hundreds of terminal nodes, guaranteeing low latency and high reliability even under high-concurrency conditions. Optimization of embedded operating systems significantly improves the determinism and predictability of task execution. Modern RTOS can support multi-threaded communication protocol stacks, distributed task management, and adaptive scheduling strategies, enabling communication nodes to achieve efficient control despite limited resources. By combining self-learning algorithms with dynamic resource management mechanisms, embedded systems can autonomously determine task priorities and adjust power allocation, achieving true "intelligent control."

https://doi.org/10.62852/csa/2026/264
Copyright (c) 2026 Cambridge Science Advance

### 3.4. Integration of intelligent algorithms and electronic systems

The deep integration of electronic engineering and intelligent algorithms is driving communication systems from traditional rule-based control modes toward self-learning, self-optimizing intelligent architectures. This integration is manifested not only in algorithms enhancing electronic system capabilities but also in electronic structural design influencing the execution efficiency of intelligent algorithms. In the field of communication resource management, deep reinforcement learning-based algorithms can dynamically adjust power control and spectrum allocation strategies based on channel state information and network load feedback, achieving dual optimization of communication rate and energy efficiency. Through a "state-action-reward" cyclic learning mechanism, this algorithm continuously optimizes decision-making, enabling the system to maintain stable performance even under uncertain channel conditions. In network traffic prediction, support vector machines and multi-layer neural network models can perform fitting analysis on historical data to predict traffic variation trends, enabling advance bandwidth planning and congestion control. Relying on model self-learning mechanisms, the system can automatically adjust parameters when network structures change or external disturbances occur, achieving intelligent and proactive communication scheduling.

The combination of edge computing and distributed intelligence endows communication nodes with local learning and decision-making capabilities. By embedding lightweight machine learning models into electronic systems, edge devices can complete signal screening, anomaly detection, and data compression locally, achieving rapid response without relying on central servers. This "edge intelligence" model effectively reduces data transmission latency and energy consumption while enhancing overall network collaborative efficiency. Electronic system architectures are evolving toward reconfigurable computing platforms. By implementing algorithm hardware deployment on FPGAs, GPUs, and AI-dedicated accelerator chips, systems can automatically switch computing modes based on task types, achieving optimal performance under different business scenarios.

Table 1 LPWAN System Design Parameters and Metrics

| Indicator Category | Design Parameter | Performance Indicator | Implementation Effect |
|---|---|---|---|
| Circuit Structure | 4-layer high-density PCB with embedded RF shielding layer | EMI reduced by 35% | Improved system anti-noise performance |
| Power Management | Dynamic power regulation circuit and sleep mode design | Average power consumption ≤ 20 m W | Device battery life extended by 45% |
| Communication Performance | LoRa modulation + adaptive power control | Communication distance ≥ 15 km | Urban node coverage rate reaches 98% |
| Data Security | AES-128 hardware encryption module | Data packet loss rate < 0.1% | Significantly enhanced communication security |
| System Reliability | Redundant power supply and overcurrent protection design | Stable operation time > 10,000h | Improved system maintainability |

## 4. Case study of typical applications

### 4.1. Overview

Within the overall architecture of smart cities, intelligent communication systems undertake core tasks of urban information interconnection, resource scheduling, and data fusion. In recent years, with the deep integration of IoT, big data, and cloud computing, Low-Power Wide-Area Networks (LPWAN) have gradually become an important supporting technology for smart city communication systems. Characterized by low power consumption, long-distance transmission, and massive connectivity, LPWAN can effectively meet the dual requirements of communication stability and energy efficiency for distributed sensor nodes in urban perception systems.

https://doi.org/10.62852/csa/2026/264
Copyright (c) 2026 Cambridge Science Advance

### 4.2. Implementation plan

Perception Layer Design: Real-time monitoring of environmental and equipment status is achieved through the integration of high-sensitivity sensing chips and ultra-low-power microcontroller units. A System-on-Chip (SoC) architecture is adopted to integrate data acquisition, signal conditioning, and preliminary processing functions within a single chip, thereby reducing system power consumption and wiring complexity.

Transmission Layer Optimization: Under LPWAN protocols such as LoRa and NB-IoT, efficient signal transmission and enhanced anti-interference performance are achieved through radio frequency matching network design in electronic circuits. Adaptive modulation and coding algorithms combined with digital filtering techniques enable communication links to maintain stable connections in multipath and fading environments.

Application Layer Integration: An urban IoT information management system is constructed through data interaction between intelligent communication terminals and cloud platforms. Encryption modules and data verification circuits supported by electronic engineering technology ensure the security and integrity of information transmission.

### 4.3. Effectiveness analysis

Through implementation and application in smart city perception systems, LPWAN intelligent communication systems have demonstrated significant technical and social benefits.

## 5. Conclusion

In summary, electronic engineering technology serves as the key enabling foundation for achieving efficient, stable, and intelligent operation of intelligent communication systems. Through its applications in signal processing, system control, and network optimization, this technology has significantly enhanced the performance and reliability of communication systems. In the future, efforts should be intensified to further integrate electronic engineering with emerging technologies such as artificial intelligence, Internet of Things, and big data, so as to promote the comprehensive upgrading and industrialization of intelligent communication systems.

## 6. References


[1] Chen Hui. Application of electronic information engineering technology in communication intelligence [J]. Modern Industrial Economy and Informatization, 2023, 13(04): 119-121.

[2] Li Yonghong. Discussion on SDN-based intelligent communication power grid [J]. China Broadband, 2023, 19(04): 100-103.

[3] Zhang Keke. Construction ideas for internet-oriented intelligent communication billing system [J]. Information and Communications Technologies, 2023, 17(01): 71-77.

[4] Hu Zhilin. Analysis of development trends in high-efficiency intelligent communication power supply technology [J]. China New Telecommunications, 2023, 25(02): 16-18.

[5] Li Guanzhan, Jian Xiang Cheng. Research on the application of electronic information engineering technology in intelligent communication [J]. China New Telecommunications, 2022, 24(23): 10-12.

[6] Gao Hongwei, Liu Xiangnan, Zhang Haijun, Long Keping. Intelligent communication and sensing integration for 6G [J]. Journal of Communication University of China (Science and Technology), 2022, 29(03): 9-16.

[7] Li Liangxi. Application of electronic information engineering technology in communication intelligence [J]. Engineering Construction and Design, 2022(08): 98-100.

[8] Zheng Xiuyi. Research on the application of electronic information engineering technology in intelligent communication [J]. Electronic Components and Information Technology, 2022, 6(03): 109-110, 124.

[9] Zhang Ling, Ye Qi. Power intelligent communication power supply technology and its application [J]. Digital Technology and Application, 2022, 40(02): 105-107.

[10] Liu Yang, Dai Hao. Analysis of development strategies for electronic information engineering technology in communication intelligence [J]. Wireless Internet Technology, 2021, 18(21): 8-9.


https://doi.org/10.62852/csa/2026/264
Copyright (c) 2026 Cambridge Science Advance