

INDUSTRY OVERVIEW

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INTRODUCTION OF WIRELESS COMMUNICATION INDUSTRY

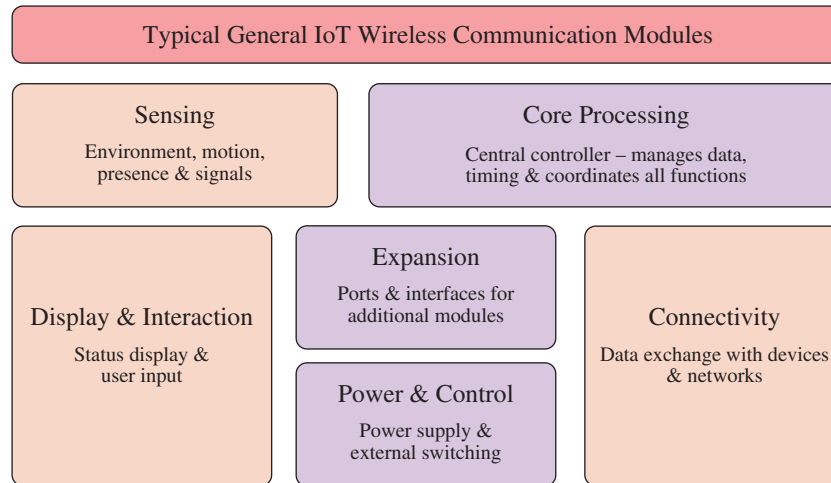
The wireless communication industry is a foundational pillar of modern connectivity, enabling seamless data exchange that underpins the rapid expansion of the Internet of Things. At its core are IoT Wireless Modules, integrated hardware units that provide wireless communication and connectivity across devices and systems. These modules encompass communication technologies such as Wi-Fi/Bluetooth, LoRa and other LPWAN, and cellular standards including GPRS, NB-IoT, and LTE-M, as well as positioning and sensing solutions including GPS/GNSS, UWB ranging, and radar, plus application-specific modules like offline voice-recognition SoMs, differentiated by power consumption, range, integration level, and deployment suitability. They are widely used in industrial manufacturing, smart agriculture, smart energy, consumer electronics, smart cities, metering, and public services, supporting flexible ODM/OEM models that accelerate product development and mass production. Within this landscape, Non-Cellular Modules operate independently of cellular networks using technologies such as Wi-Fi, Bluetooth, LoRa, Zigbee, UWB, and GPS/GNSS, offering low power consumption, cost-effectiveness, and suitability for short-to-medium range or localised applications in private networks. In contrast, Cellular Modules rely on public cellular networks including 2G, 3G, 4G LTE, 5G, NB-IoT, and eMTC, delivering reliable wide-area coverage, strong mobility support, global roaming, and SIM/eSIM functionality for long-distance, continuous, or remote connectivity in outdoor and mobile scenarios.

MARKET OVERVIEW OF GENERAL IoT WIRELESS COMMUNICATION MODULES

IoT wireless communication solutions comprise antennas and modules. Together, they are essential to the Internet of Things, serving as integrated hardware units that enable wireless communication and connectivity for various devices and systems. A wireless communication module solution provider typically integrates core components of the hardware including chips and antennas, and software layers including the software development kits (drivers & firmware, application layer API) – into a unified package. By consolidating these components into a single module-plus-SDK offering, the solution allows developers from underlying hardware complexity, provides a complete toolchain and ecosystem, and enables customers to focus on application-layer innovation, thereby significantly reducing development effort and accelerating time-to-market.

INDUSTRY OVERVIEW

The diagram presents a simplified functional architecture of a typical general IoT wireless communication modules. At the centre is the core processing unit, which acts as the central controller managing data, timing, and overall system coordination. Surrounding it are five key functional blocks: Sensing detects environmental conditions, motion, presence and remote signals; power & control supplies power and switches external devices; display & interaction shows status information and enables basic user input; connectivity supports data exchange with other devices and networks; and expansion provides interfaces for adding extra functions or connecting additional modules. Together, these blocks illustrate how an general IoT wireless communication modules integrates sensing, control, communication and expansion capabilities into a cohesive system.



Source: Frost & Sullivan

Non-cellular modules are general IoT wireless communication modules that operate independently of traditional cellular networks. These modules leverage alternative wireless technologies such as Wi-Fi, Bluetooth, LoRa, Zigbee, UWB, and GPS/GNSS to enable connectivity. They are characterised by low power consumption, cost-effectiveness, and suitability for short-to-medium range or localised applications, making them ideal for deployment in private networks and controlled environments.

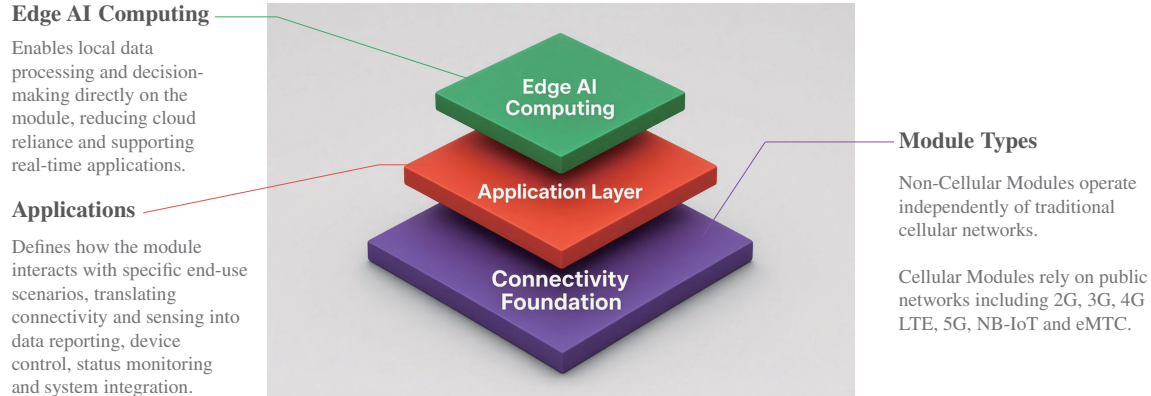
Cellular modules are general IoT wireless communication modules that rely on public cellular networks, including 2G, 3G, 4G LTE, 5G, NB-IoT, and eMTC technologies. They provide reliable wide-area coverage, strong mobility support, and global roaming capabilities, often incorporating SIM or eSIM functionality. These modules are particularly well-suited for applications requiring long-distance, continuous, or remote connectivity across outdoor and mobile scenarios. These wireless modules can be assembled individually or combined together depending on the application scenarios.

Sensing products, such as GPS/GNSS, UWB ranging, and radar provides application-specific functionalities, including offline voice-recognition SoMs. Across these families, key differentiators include power consumption, range, level of integration, and suitability for different deployment scenarios.

INDUSTRY OVERVIEW

Layered Functions of General IoT Wireless Communication Modules

From connectivity foundation to application capabilities



Source: Frost & Sullivan

The general IoT wireless communication modules can be assembled into PCBA and further integrated into IoT products for consumer and industrial applications. General IoT wireless communication modules are widely deployed in industrial manufacturing, smart agriculture, smart energy, consumer electronics, smart cities, metering, and public services. They support flexible ODM/OEM delivery models, allowing customers to accelerate product development and achieve efficient mass production.

Major Downstream Applications

Consumer electronics represent one of the largest and most relevant application areas for the Group’s general IoT wireless communication products and solutions. The rising penetration of smart homes and connected consumer devices has driven strong demand for wireless connectivity technologies that enable seamless data transmission, remote control, device interconnection and positioning, thereby enhancing user convenience and experience. Products in this segment typically prioritised compact size, low power consumption, cost efficiency and ease of integration.

Consumer electronics remain the primary application area. Solutions are also used in industrial, energy, commercial, and other emerging sectors, which typically require higher reliability, environmental adaptability, broader coverage, or more flexible deployment.

Value Chain Analysis

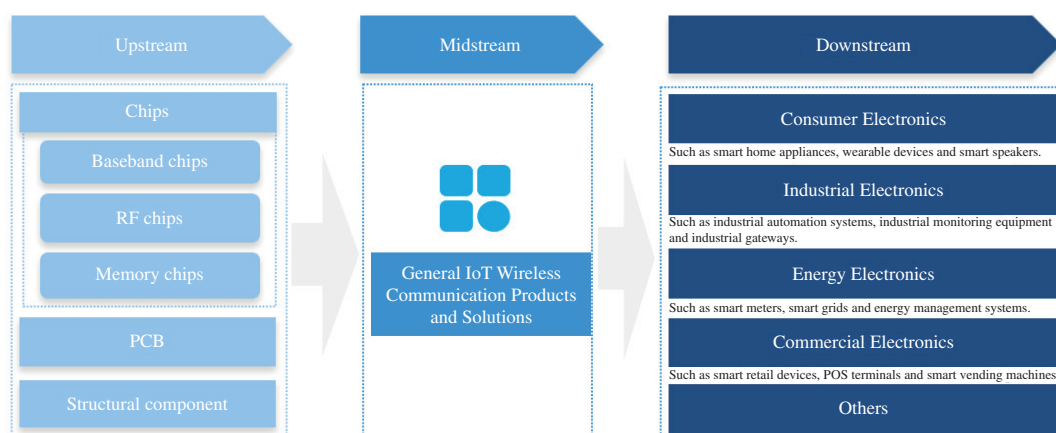
The general IoT wireless communication modules industry chain comprises three segments:

- (i) Upstream manufacturers and solution providers: Dominated by core components such as baseband chips and RF chips, primarily supplied by semiconductor manufacturers and fabless companies, as well as the PCB and substrate;
- (ii) Midstream manufacturers and solution providers: Design and transform upstream components into standardised modules and customised solutions for vertical customers to deploy at scale. Their main responsibilities include designing and integrating wireless SoCs, RF front-ends, PCBs, antennas and passive components into certified modules covering cellular, LPWAN, Wi-Fi/BLE and other technologies, as well as providing reference designs, SDKs and technical support to device OEMs and system integrators. Some midstream manufacturers further position themselves as “module + solution” providers by bundling hardware with firmware, cloud platforms, device management and application software.

INDUSTRY OVERVIEW

- (iii) Downstream manufacturers and solution providers: Connecting end-application scenarios including smart living, industrial and commercial IoT, smart infrastructure, and energy, agriculture and other emerging IoT applications.

Positioned in the midstream of the industry chain, general IoT wireless communication modules serve as the critical link between upstream components and downstream applications. They integrate key elements such as wireless communication chipsets, RF devices, antennas and memory into standardised products or customised solutions, delivering stable and high-performance wireless connectivity that enables downstream customers to rapidly deploy intelligent devices across various scenarios. As downstream demand for intelligence, customisation and system-level integration grows, midstream players are evolving beyond pure module supply into comprehensive solution providers. They create additional value through system integration, RF optimisation, firmware customisation, reference designs and cloud-based device management platforms. By combining hardware with software and technical support services, midstream manufacturers facilitate collaborative innovation between upstream suppliers and downstream users, accelerate application deployment and drive the large-scale implementation of IoT technologies.



Source: Frost & Sullivan

MARKET OVERVIEW OF WIRELESS COMMUNICATION TERMINAL ANTENNAS

Wireless communication terminal antennas refer to specialised antenna products and related components designed for IoT devices and other wireless communication terminals, primarily responsible for the efficient transmission and reception of wireless signals. Key product categories include built-in antennas, external antennas, combination antennas, and RF connection components, which cover a wide range of frequency bands, such as 2G/3G/4G/5G, Wi-Fi, Bluetooth, LoRa, and GNSS, and support various installation methods. These antennas are tightly integrated with wireless communication modules to deliver comprehensive RF solutions. By optimising antenna design, they significantly enhance signal stability, coverage range, transmission efficiency, and overall system reliability, while maintaining high compatibility and design flexibility. They are widely deployed in conjunction with wireless modules across diverse scenarios, including automotive communications, smart wearables, industrial equipment, smart cities, intelligent homes, and other IoT terminals requiring stable and high-performance wireless connectivity.

Value Chain Analysis

The wireless communication terminal antenna industry chain generally consists of upstream raw material and component suppliers, midstream wireless communication terminal antenna providers, and downstream application sectors. Midstream participants manufacture built-in

INDUSTRY OVERVIEW

antennas, external antennas, combination antennas and RF connection components, which are typically deployed in conjunction with wireless communication modules to support stable wireless connectivity. Major downstream applications include automotive communications, industrial IoT equipment, wearable devices, smart city infrastructure and other wireless-enabled IoT terminals.

Positioned in the midstream of the value chain, wireless communication terminal antenna providers transform upstream materials and components into antenna products covering multiple frequency bands and installation methods. Through antenna design, impedance matching, RF testing and performance optimisation, they enhance signal stability, transmission efficiency and coverage performance. Their products serve as critical components within wireless communication systems and enable reliable connectivity across diverse IoT applications.

As demand for wireless connectivity continues to increase across automotive, industrial IoT, wearable and smart city applications, customers are placing greater emphasis on compact design, multi-band compatibility and customised deployment requirements. As a result, wireless communication terminal antenna providers are evolving from standalone antenna manufacturers into providers of comprehensive RF solutions. In addition to antenna products and RF connection components, market participants increasingly offer RF design, testing and optimisation services, creating additional value through integrated full-stack RF solutions and strengthening their role within the wireless communication ecosystem.

The PRC General IoT Wireless Communication Modules Market Size

From 2021 to 2025, the PRC general IoT wireless communication modules market grew steadily from RMB10.7 billion to RMB13.6 billion at a CAGR of 6.2%. Cellular modules including 2G, 3G, 4G LTE, 5G, NB-IoT, and eMTC dominated the market, accounting for 69.1% of the total market in 2025, rising from RMB7.0 billion in 2021 to RMB9.4 billion in 2025 at a CAGR of 7.6%. This growth was driven primarily by large-scale deployments in smart metering, asset tracking, smart cities, and industrial applications, supported by government policies promoting NB-IoT, Cat.1 bis, and 5G infrastructure rollout. Non-cellular modules including Wi-Fi, Bluetooth, LoRa, Zigbee, UWB, and GPS/GNSS represented 30.9% of the total market in 2025, increasing from RMB3.7 billion in 2021 to RMB4.2 billion in 2025 at a CAGR of 3.2%. This segment was fueled by demand in localised scenarios such as smart homes, consumer electronics, and private industrial networks, benefiting from low power consumption and cost-effectiveness.

From 2026 to 2030, the market is projected to accelerate from RMB15.0 billion to RMB22.0 billion at a CAGR of 10.0%. Cellular modules are expected to grow from RMB10.5 billion in 2026 to RMB15.3 billion in 2030 at a CAGR of 9.9%. This expansion will be propelled by 5G RedCap commercialization, widespread Cat.1 bis adoption especially in electric two-wheelers and public utilities, smart city mandates, industrial IoT expansion, and automotive connectivity. Non-cellular modules are projected to grow from RMB4.5 billion to RMB6.7 billion at a CAGR of 10.5%, supported by AIoT integration in smart homes, agriculture, and short-to-medium range applications, though at a relatively slower pace due to competition from cellular wide-area solutions. The upward trends reflect policy-driven digital transformation, 5G and edge computing convergence, and cost reductions enabling broader adoption across manufacturing, energy, and public services.

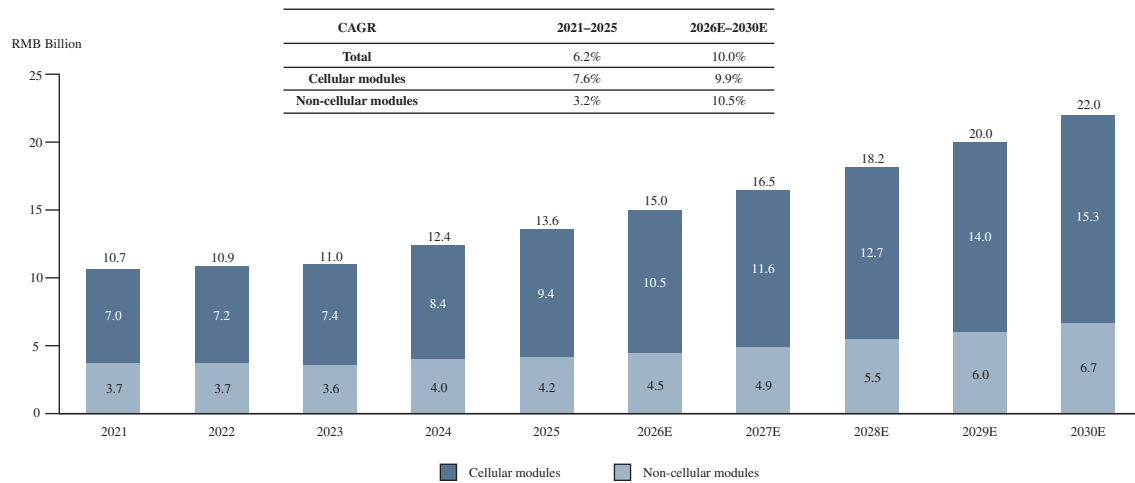
Industrial electronics was the largest segment throughout this period, growing from approximately RMB3.5 billion in 2021 to RMB4.6 billion in 2025 at a CAGR of 7.1%. This strong growth was primarily driven by national digital economy initiatives under the 14th Five-Year Plan, large-scale smart city and smart grid projects, and the acceleration of industrial automation and smart manufacturing. During 2021 to 2025, market growth was primarily driven by national digital economy initiatives under the 14th Five-Year Plan, along with large-scale smart city, smart grid, and industrial automation projects. Key demand came from widespread deployment of smart metering in utilities, the expansion of industrial IoT in manufacturing

INDUSTRY OVERVIEW

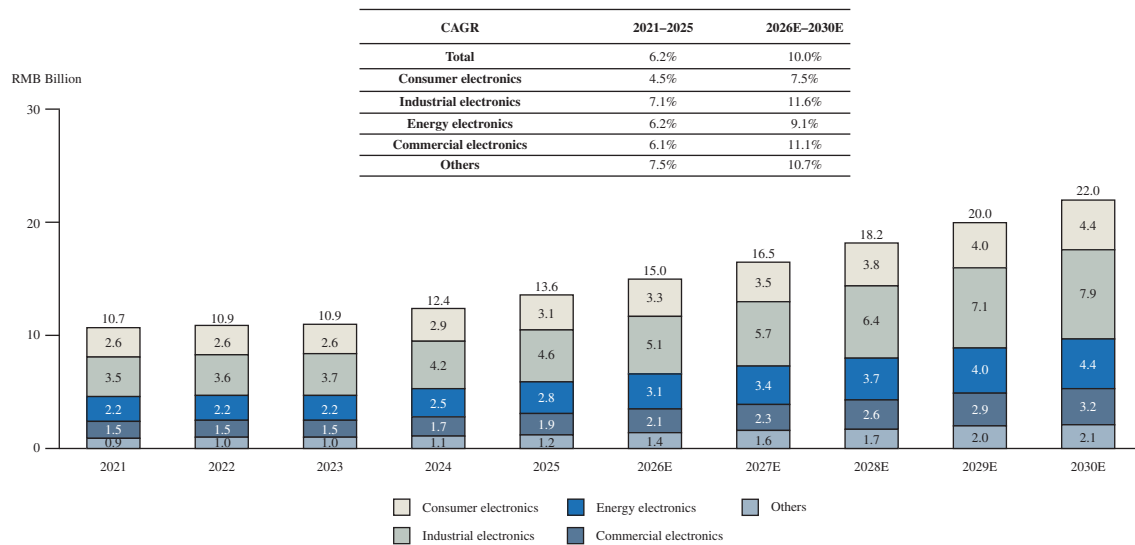
(including predictive maintenance, real-time monitoring, and production line automation), and increasing adoption of connected devices in commercial and logistics sectors, all supported by favourable government policies on mobile IoT and infrastructure upgrades.

Industrial electronics is expected to reach approximately RMB7.9 billion by 2030, followed by energy electronics and consumer electronics of RMB4.4 billion, commercial electronics of RMB3.2 billion, and Others of RMB2.1 billion. This faster growth will be propelled by deeper integration of edge computing, on-device AI, and advanced sensing technologies, as well as continued smart city development, private 5G networks, industry 4.0 initiatives, and large-scale applications in renewable energy, logistics, and intelligent manufacturing. Going forward, the PRC’s extensive standardised IoT deployments, robust policy support, and ongoing technological upgrades are enabling sustained market expansion that frequently surpasses global averages, with a clear shift toward higher-value, intelligent modules.

General IoT Wireless Communication Modules Market Size in The PRC (by categories), 2021–2030E, by Revenue



General IoT Wireless Communication Modules Market Size in The PRC (by Downstream Industries), 2021–2030E, by Revenue



Source: Frost & Sullivan

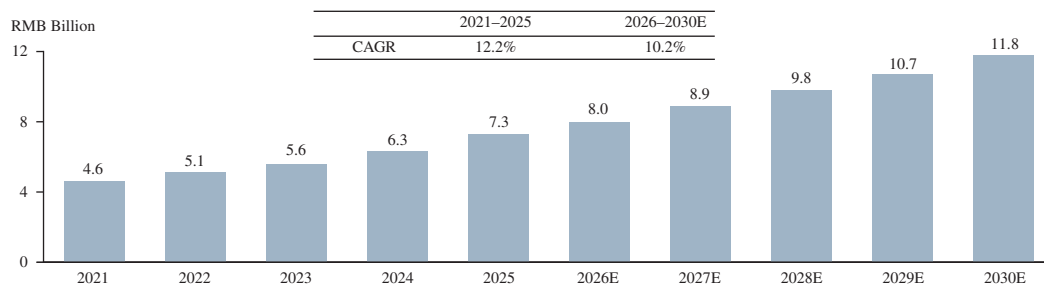
INDUSTRY OVERVIEW

The PRC Wireless Communication Terminal Antennas Market Size

From 2021 to 2025, the market for wireless communication terminal antennas in the PRC experienced steady and robust growth, expanding from RMB4.6 billion in 2021 to RMB7.3 billion in 2025 at a CAGR of 12.2%. This growth was primarily driven by the rapid deployment of 5G infrastructure, surging demand from consumer electronics, smart homes, and wearable devices, as well as the initial acceleration of intelligent connected vehicles. Increasing integration of antennas with IoT modules and the need for multi-frequency, high-performance solutions further supported market expansion during this period.

From 2026 to 2030, the wireless communication terminal antenna market in the PRC is projected to enter a phase of accelerated development, growing from RMB8.0 billion in 2026 to RMB11.8 billion by 2030 at a CAGR of 10.2%. This faster momentum will be fueled by the commercialization of 5G RedCap and 5G-A technologies, large-scale industrial IoT deployments, smart city initiatives, and deeper intelligence integration in automotive and industrial applications. The trend toward smarter, more integrated, and multi-scenario antenna solutions is expected to drive higher value-added growth and stronger demand across various IoT terminals.

The PRC Wireless Communication Terminal Antennas Market Size, 2021–2030E, by Revenue



Source: Frost & Sullivan

MARKET OVERVIEW OF IoT-RELATED PCBA SOLUTIONS

IoT-related PCBA solutions refer to the design, assembly, and integration of printed circuit board assemblies (“PCBA”) specifically tailored for IoT applications. These solutions involve mounting and interconnecting wireless communication modules, sensors, microcontrollers, power management units, and other application-specific components onto printed circuit boards to create fully functional, ready-to-install electronic assemblies.

Key characteristics include high integration of wireless connectivity, support for edge computing, low power consumption design, and compliance with IoT-specific performance and certification requirements. IoT-related PCBA solutions enable efficient mass production and accelerated time-to-market for various IoT terminals, such as smart home appliances, industrial sensors, smart metering devices, wearables, and logistics trackers.

They serve as a critical bridge between individual electronic components and complete IoT products, offering customised, reliable, and cost-effective hardware foundations for the rapidly expanding IoT ecosystem.

INDUSTRY OVERVIEW

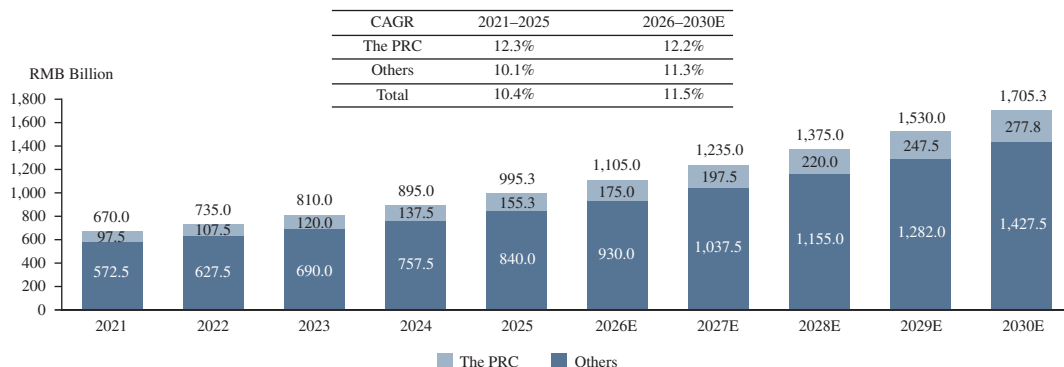
IoT-Related PCBA Solutions Market Size

From 2021 to 2025, the global IoT-related PCBA solutions market expanded steadily from approximately RMB670.0 billion to RMB995.3 billion. Growth during this period was primarily driven by the rapid adoption of smart home devices, expansion of industrial IoT deployments, and rising demand for connected consumer electronics, supported by the increasing integration of wireless modules and sensors into compact assemblies. From 2026 to 2030, the market is projected to accelerate from RMB1,105.0 billion to RMB 1,705.3 billion. This faster growth will be propelled by deeper AIoT integration, higher device complexity requiring advanced multi-layer and high-density assemblies, large-scale smart city and industrial automation projects, and continued expansion of smart home ecosystems worldwide.

The market for IoT-related PCBA solutions in China expanded steadily from approximately RMB97.5 billion to RMB155.3 billion, at a CAGR of 12.3%. This growth was primarily driven by the rapid adoption of smart home appliances, expansion of industrial IoT deployments, and increasing demand for smart metering and energy management systems. Rising consumer spending on intelligent home devices, government support for digital infrastructure, and the acceleration of industry 4.0 initiatives further boosted demand for integrated PCBA boards that combine wireless modules, sensors, and application-specific circuitry.

From 2026 to 2030, the market is projected to accelerate from RMB175.0 billion to RMB277.8 billion, with a CAGR of approximately 12.2%. This faster growth will be propelled by deeper integration of edge computing and on-device AI, widespread adoption of matter protocol in smart homes, continued smart city and industrial automation projects, and the expansion of renewable energy and logistics IoT applications. The shift toward higher-value, more complex IoT terminals requiring advanced PCBA solutions, along with ongoing policy support for digital transformation, will sustain strong momentum in this period.

Global IoT-Related PCBA Solutions Market Size, 2021–2030E, by Revenue



Source: Frost & Sullivan

IoT-Related PCBA Solutions for Smart Home Appliances Market Size

The global IoT-related PCBA solutions market for smart home appliances grew steadily from approximately RMB230.0 billion in 2021 to RMB380.0 billion in 2025. This expansion was mainly driven by rising consumer demand for connected devices such as smart speakers, lighting systems, security cameras and home hubs, supported by increasing disposable incomes and the early adoption of interoperable smart home ecosystems. From 2026 to 2030, the segment is expected to accelerate from RMB345.0 billion to RMB760.0 billion at a CAGR of 15.0%. Faster

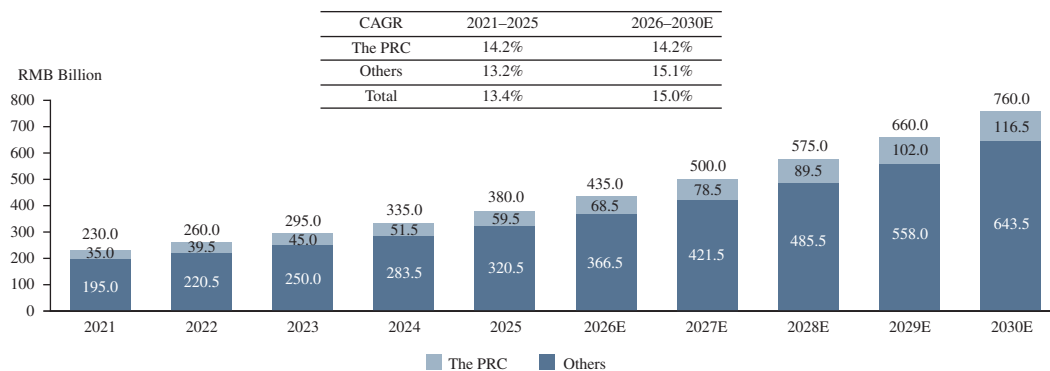
INDUSTRY OVERVIEW

growth will be propelled by the widespread adoption of the Matter protocol, deeper integration of AI and voice control, the trend toward whole-house intelligent systems, and continuous innovation in energy-efficient and multi-functional smart appliances.

The IoT-related PCBA solutions market for smart home appliances in China grew from approximately RMB35.0 billion in 2021 to RMB59.5 billion in 2025, at a CAGR of approximately 14.2%. This growth was mainly driven by rising consumer demand for intelligent home devices, increasing disposable income among urban households, and the popularisation of smart speakers, lighting, security systems, and home hubs. Supportive government policies promoting smart communities and the early adoption of connected appliances further accelerated market expansion during this period.

From 2026 to 2030, the segment is expected to accelerate from RMB68.5 billion to RMB116.5 billion, with a CAGR of approximately 14.2%. This faster growth will be propelled by the widespread adoption of the matter protocol for better interoperability, deeper integration of AI and voice control, the trend toward whole-house intelligent systems, and strong policy support for digital home ecosystems. Rising consumer preference for energy-efficient and health-oriented smart appliances, along with the development of new residential projects featuring pre-installed smart systems, will continue to drive robust demand in this period.

Global IoT-Related PCBA Solutions for Smart Home Appliances Market Size, 2021–2030E, by Revenue



Source: Frost & Sullivan

Market Drivers for General IoT Wireless Communication Modules

Supportive Government Policies and the Development of “New Quality Productive Forces”

China’s proactive national digital economy initiatives and sector-wide industrial upgrade programmes are serving as fundamental catalysts for the sustained growth of the general IoT wireless communication modules market. The State Council’s 2026 IoT action plan targets a core IoT industry value of over RMB3.5 trillion by 2028 and more than 10 billion IoT terminal connections, highlighting the scale of policy support behind device-side connectivity demand. The strategic emphasis on “New Quality Productive Forces” has accelerated the deployment of advanced digital infrastructure across public services, intelligent transportation, energy management, advanced manufacturing, and smart urban governance. These policies provide strong support through favourable spectrum allocation, subsidies for technology adoption, and regulatory frameworks that encourage the use of low-power wireless solutions.

INDUSTRY OVERVIEW

For non-cellular modules, the policy tailwind is particularly pronounced in private networks and localised deployments in smart cities and industrial parks, where Wi-Fi, Bluetooth, Zigbee and Sub-GHz/LoRa solutions are widely used in metering, sensing and control scenarios that do not require public cellular coverage but benefit from low power and low cost.

Explosive Growth in Downstream IoT Application Scenarios

The rapid proliferation of IoT deployments across key vertical industries continues to generate substantial demand for wireless communication modules. High-volume application areas such as smart metering, logistics tracking, video surveillance, connected vehicles, industrial gateways, and renewable energy systems are expanding at an accelerated pace.

For non-cellular modules, this growth is especially pronounced in consumer electronics, particularly smart home devices, smart agriculture, and new energy sectors. China’s smart home devices market reached an estimated RMB955.7 billion in 2025, with device shipments rising from 150 million units in 2018 to about 279 million units in 2025, dominated by categories such as smart appliances, lighting and home security that typically integrate Wi-Fi and Bluetooth modules. In agriculture and new energy, the extensive use of LoRa and Zigbee-based systems for smart irrigation, precision agriculture and remote monitoring, citing low power consumption, long range and cost effectiveness as key advantages.

Increasing Integration of AI and Edge Computing (AIoT)

The rapid advancement of artificial intelligence and its deepening convergence with IoT (AIoT) has become a major growth driver for the general IoT wireless communication modules market. The penetration of on-device AI in new IoT terminals rose from less than 10% in 2023 and is expected to reach 25 to 30% by 2026, driving demand for modules that combine wireless connectivity with local data processing, real-time analytics and intelligent decision-making capabilities. Non-Cellular Modules, particularly Wi-Fi and Bluetooth-based solutions, are well-positioned to benefit in privacy-sensitive and latency-sensitive applications such as smart homes, industrial automation, consumer electronics and intelligent buildings, where on-device processing and efficient local networking are essential. As enterprises and consumers increasingly require higher autonomy, privacy and responsiveness, the need for advanced modules supporting edge AI continues to accelerate and is expected to expand further through 2030 as AIoT transitions from pilot projects to large-scale commercial deployments.

Market Drivers for Wireless Communication Terminal Antennas

Strong Policy Support for 5G, IoT, and Digital Infrastructure Development

China’s robust national policy framework continues to provide powerful momentum for the wireless communication terminal antenna market to promote large-scale 5G commercialization, IoT infrastructure construction, and smart city development. These policies encourage widespread deployment of advanced wireless connectivity solutions across public services, intelligent transportation, industrial upgrading, energy management, and urban governance. In particular, supportive measures on spectrum allocation, technology innovation subsidies, and vertical industry application pilots have accelerated the adoption of high-performance terminal antennas. This policy environment benefits both Cellular and Non-cellular modules by driving demand for reliable, multi-frequency, and highly integrated antennas in applications such as smart metering, environmental monitoring, intelligent transportation, and industrial IoT networks.

INDUSTRY OVERVIEW

Rapid Expansion of Downstream IoT and Intelligent Device Applications

The explosive growth of IoT terminals, intelligent connected vehicles, smart homes, consumer electronics, and industrial automation is significantly boosting the demand for wireless communication terminal antennas. As non-cellular technologies such as Wi-Fi, Bluetooth, LoRa, and Zigbee proliferate in private networks and localised scenarios, there is increasing need for built-in, external, and combination antennas that deliver stable signal coverage, multi-frequency support, and compact designs. The rise of smart wearables, renewable energy systems, and industrial sensors further accelerates antenna requirements for enhanced performance and integration.

Technological Advancements and Higher Integration Requirements

Continuous innovation in antenna technology, including multi-band compatibility, smart antenna arrays, miniaturisation, and improved integration with wireless modules, is creating strong market momentum. The shift toward 5G RedCap, Wi-Fi 7, and AIoT applications demands more sophisticated terminal antennas capable of supporting higher data rates, lower latency, and better interference resistance. End customers increasingly require customised antenna solutions that deliver full-stack RF performance, driving demand for advanced design, simulation, and testing capabilities in the antenna segment.

Market Trends for General IoT Wireless Communication Modules

Accelerated Transition Toward 5G RedCap and Multi-Technology Integration

The general IoT wireless communication modules market in China is witnessing a clear trend toward deeper integration of multiple wireless technologies, with non-cellular modules playing an increasingly important role. Technologies such as Wi-Fi 6/7, Bluetooth, LoRa, and Zigbee are being widely adopted and combined with cellular modules to form hybrid connectivity solutions. This multi-technology approach allows for optimised performance in both wide-area and localised private networks, reflecting the industry’s shift toward more flexible and scenario-specific module designs.

Rapid Evolution Toward Intelligent and Edge-Computing Enabled Modules

General IoT wireless communication modules in China are evolving rapidly from basic connectivity components into highly integrated intelligent platforms. A prominent trend is the incorporation of edge computing capabilities, on-device AI processing, embedded processors, and advanced sensing functions into modules. This smart integration enables real-time data processing, OTA upgrades, and enhanced system autonomy, particularly in Non-cellular modules used for smart homes, industrial automation, and AIoT applications. As enterprises prioritise data privacy, low latency, and energy efficiency in private networks, demand for these intelligent non-cellular solutions is rising significantly. This trend is further reinforced by the growing platformization of modules, which now serve as critical nodes for device management and ecosystem collaboration.

Accelerated Product Innovation and Miniaturisation of General IoT Wireless Communication Modules

A prominent market trend in China’s IoT wireless modules industry is the continuous advancement toward higher functional complexity and miniaturisation to meet the evolving demands of downstream applications. As end-user devices become more sophisticated, particularly in wearable electronics, smart home appliances, and industrial sensors, there is rising demand for modules that integrate multiple functions such as wireless connectivity, edge computing, sensing, and power management within increasingly compact form factors. This trend is driving industry participants to strengthen their R&D capabilities, focusing on advanced

INDUSTRY OVERVIEW

antenna-module co-design, ultra-compact architectures, low-power optimization, and high-integration solutions. Such efforts enable the development of lightweight, high-performance modules that better address the growing requirements for space-constrained and multifunctional IoT terminals across various sectors.

Market Trends for Wireless Communication Terminal Antennas

Miniaturisation and High-Density Integration

There is a clear trend toward smaller, lighter, and more highly integrated antenna designs to meet the demands of compact IoT devices, smart wearables, and space-constrained applications. Manufacturers are increasingly embedding antennas directly into PCBA boards or developing ultra-thin, multi-layer structures that combine multiple frequency bands within limited physical space. This miniaturisation trend supports the growing need for sleek product designs while maintaining strong RF performance, particularly for non-cellular applications in consumer electronics and industrial sensors.

Growing Adoption of Smart and Adaptive Antenna Technologies

The market is shifting toward intelligent antenna solutions featuring beamforming, MIMO, and adaptive tuning capabilities. These smart antennas can dynamically optimise signal direction, reduce interference, and improve connection quality in complex environments. This trend is gaining momentum as 5G-A, Wi-Fi 7, and AIoT applications require higher data throughput and more reliable connectivity, driving innovation in software-defined and reconfigurable antenna systems for both industrial and consumer terminal devices.

Price Trends of Key Cost Components of General IoT Wireless Communication Modules

The key cost components of general IoT wireless communication modules mainly include chips, PCBs, crystal oscillators, shielding covers, resistors, capacitors, diodes, and transistors, flexible printed circuits and metal hardware components. Prices rose sharply in 2021 and 2022 amid the global semiconductor shortage and strong demand. Most categories corrected or stabilised lower in 2023 as inventories built and demand softened. From 2024 into 2025, trends diverged that mature-process chips remained relatively soft, while PCBs, specialty MLCCs, and copper-linked materials, such as shielding, FPCs and hardware, showed renewed upward pressure driven by rising raw material costs, AI/server demand, and tighter supply of key materials such as electronic cloth and high-end CCL.

Price Trends of Key Cost Components of General IoT wireless communication modules in the PRC, 2021–2025

2021=100	2021	2022	2023	2024	2025 (2021–2025)	CAGR
Chips (Baseband, RF, SoC, Memory – mature-process/IoT-relevant)	100.0	118.0	100.0	95.0	103.0	0.7%
PCBs (Printed Circuit Boards)	100.0	110.0	100.0	118.0	135.0	7.8%
Flexible Printed Circuits (FPCs)	100.0	110.0	100.0	113.0	123.0	5.3%
Capacitors (esp. MLCCs) & Resistors	100.0	118.0	98.0	108.0	128.0	6.4%
Diodes and Transistors	100.0	115.0	93.0	98.0	110.0	2.4%
Crystal Oscillators	100.0	107.0	98.0	102.0	104.0	1.0%
Shielding Covers & Metal Hardware Components	100.0	103.0	95.0	110.0	128.0	6.4%

Source: Frost & Sullivan

INDUSTRY OVERVIEW

Price Trends of Key Cost Components of Wireless Communication Terminal Antennas

Key raw materials for wireless communication terminal antennas mainly include copper, aluminium, engineering plastics, polyimide film, liquid crystal polymer, ceramic materials, connectors & plating materials. Prices rose broadly in 2021 and 2022 amid strong electronics demand and elevated commodity costs, corrected or stabilised in 2023, then diverged in 2024 and 2025. Copper and high-frequency materials showed renewed upward pressure, while standard engineering plastics faced continued downward pressure from domestic overcapacity. Polyimide film recovered moderately, and ceramic materials remained relatively stable.

Price Trends of Key Cost Components of Wireless Communication Terminal Antennas in the PRC, 2021–2025

2021=100	2021	2022	2023	2024	2025 (2021–2025)	CAGR
Copper	100.0	105.0	98.0	112.0	135.0	7.8%
Aluminium	100.0	102.0	95.0	105.0	115.0	3.6%
Engineering Plastics	100.0	108.0	95.0	90.0	88.0	-3.1%
Polyimide Film	100.0	110.0	105.0	108.0	115.0	3.6%
Liquid Crystal Polymer	100.0	115.0	110.0	112.0	118.0	4.2%
Ceramic Materials	100.0	105.0	100.0	103.0	108.0	1.9%
Connectors & Plating Materials	100.0	110.0	98.0	105.0	120.0	4.7%

Source: Frost & Sullivan

Market Challenges for General IoT Wireless Communication Modules

Rapid Technological Iteration and High R&D Investment Pressure

The general IoT wireless communication modules market faces continuous and rapid technological evolution driven by 5G RedCap, Wi-Fi 7, AIoT integration, and multi-frequency requirements. General IoT wireless communication modules manufacturers must constantly invest heavily in R&D, advanced simulation tools, and testing capabilities to develop smaller, higher-performance, and more integrated IoT wireless modules solutions.

Technological Standardisation, Supply Chain Vulnerabilities, and Security Concerns

The general IoT wireless communication modules market continues to encounter challenges related to fragmented technology standards, complex supply chain dependencies, and rising cybersecurity and data privacy requirements. Additionally, reliance on imported key components (such as high-end chips and RF materials) exposes the industry to supply chain disruptions and geopolitical risks. Heightened regulatory scrutiny on data security and network authentication further raises compliance costs and technical barriers for module developers and users.

INDUSTRY OVERVIEW

Market Challenges for Wireless Communication Terminal Antennas

Intensifying Market Competition and Downward Price Pressure

The wireless communication terminal antennas market in the PRC faces fierce competition from both domestic manufacturers and global players, resulting in significant pricing pressure and margin compression. With numerous local suppliers offering similar solutions for smartphones, consumer electronics, IoT devices, and automotive applications, product differentiation has become increasingly difficult, particularly in standard and mid-to-low-end antenna segments. This intense rivalry is forcing companies to continuously lower prices while increasing R&D investment in advanced technologies, such as 5G/mmWave, multi-band, and high-precision antennas, to maintain market share. These dynamics pose ongoing challenges to profitability and long-term sustainable growth, especially for mid- and small-sized antenna suppliers.

Rising Technical Barriers and Integration Complexity

The fast pace of technological advancement in 5G RedCap, Wi-Fi 7, AIoT, and multi-protocol integration presents considerable challenges for antenna manufacturers. There is continuous pressure to develop smaller, more efficient, multi-band, and smart antennas that can deliver superior signal stability and interference resistance while integrating seamlessly with wireless modules. This requires advanced simulation capabilities, and stringent testing, which creates high technical barriers, especially for smaller players in the market.

Market Drivers for IoT-related PCBA Solutions

Growing Requirement for Highly Customised and Integrated Assemblies

The expansion of non-cellular IoT applications is generating strong demand for PCBA solutions that seamlessly integrate wireless modules with other critical components such as sensors, power systems, and custom circuitry. As IoT device manufacturers aim to reduce design complexity and accelerate product development, professional PCBA providers are increasingly relied upon to deliver optimised, compact, and production-ready boards tailored for smart homes, industrial sensors, consumer electronics, and private network devices.

Continued Push for Supply Chain Localization and Manufacturing Efficiency

China’s ongoing efforts to strengthen domestic electronics supply chains and enhance cost competitiveness are significantly supporting the PCBA industry. In the Non-Cellular IoT segment, where price sensitivity and volume production are common, PCBA solutions help manufacturers achieve greater localization, shorter procurement cycles, and improved overall cost efficiency while upholding stringent quality and reliability standards.

Rising Need for Flexible and Scalable Manufacturing Capabilities

The diversification and rapid evolution of Non-Cellular IoT terminals require agile manufacturing support. PCBA solutions play a vital role by offering flexible high-mix production, rapid prototyping, and smooth scaling from pilot runs to mass manufacturing. This enables IoT companies to bring new products featuring advanced Wi-Fi, Bluetooth, LoRa, or Zigbee connectivity to market faster and respond effectively to shifting market demands in sectors such as intelligent buildings, wearables, and industrial automation.

INDUSTRY OVERVIEW

COMPETITIVE LANDSCAPE

The number of companies in the PRC that offer both wireless communication terminal antennas and general IoT wireless communication modules as core integrated solutions is relatively limited. The Group is one of the pioneers in the PRC in providing comprehensive general IoT wireless communication solutions that integrate both wireless communication terminal antennas and general IoT wireless communication modules. The number of specifications offered by the Group is significantly more diversified than those of other market participants in the general IoT wireless communication modules and wireless communication terminal antennas market in the PRC. In particular, the Group offers over 160 general IoT wireless communication solution models in the PRC, placing its portfolio above the industry average range of approximately 100 to 150 models. This scale exceeds the typical breadth of most market participants and approaches the coverage maintained by leading players, enabling broader technology and application coverage. As a result, the extensive model range constitutes a clear competitive edge, supporting stronger customer design-in capability and multi-scenario solution delivery relative to the majority of peers. As an general IoT wireless communication solutions provider offering both terminal antennas and general IoT wireless communication modules, the Group enjoys several strategic and operational advantages:

- **System-Level Optimization and Performance Enhancement:** By designing antennas and modules together, the Group can achieve improved overall system performance. This co-design approach is particularly valuable in complex or space-constrained applications such as smart home devices, wearables and industrial terminals.
- **One-Stop Solution Capability:** Customers benefit from a single supplier that can deliver both core connectivity components (modules) and antennas. This reduces coordination costs, shortens development cycles and simplifies supply chain management for downstream device manufacturers.
- **Stronger Customization and Application Fit:** Deep expertise across both product categories enables more precise customization. The Group can tailor antenna designs to specific module characteristics and application environments (e.g., smart home, pet care, entertainment devices or new energy systems), resulting in higher reliability and faster time-to-market for customers.
- **Higher Value Capture and Differentiation:** Offering integrated antenna-module solutions allows the Group to move beyond pure component supply and capture greater value through system-level solutions, technical support and long-term partnerships. This positions the Group more strongly against pure-play module or antenna competitors.
- **Enhanced R&D Synergies and Innovation Capability:** Cross-domain knowledge between antenna design and module development accelerates technological innovation, particularly in miniaturisation, multi-band support, low-power performance and AIoT integration. These synergies strengthen the Group’s ability to address evolving IoT application needs across consumer and industrial sectors.

The general IoT wireless communication modules market in the PRC is highly concentrated with the top five market participants accounting for the market share of 73.2%. Competition is driven by scale and cost advantages from large domestic demand and efficient supply chains, as well as product differentiation through intelligent modules with edge AI, automotive-grade solutions, customised firmware and integrated offerings. While price competition remains intense

INDUSTRY OVERVIEW

in standardised modules, higher-value customised and AIoT solutions provide better margins. Overall, the landscape is characterised by strong domestic dominance, ongoing consolidation among leading players, and a gradual shift from pure module supply toward integrated solutions.

Ranking in the PRC General IoT Wireless Communication Modules Market by Revenue, 2025

Ranking	Company	Revenue (RMB Million)	Market Share (%)
1	Company A	6,117.8	45.0%
2	Company B	1,508.4	11.1%
3	Company C	1,129.7	8.3%
4	Company D	680.6	5.0%
5	Company E	521.7	3.8%
	Others	3,641.8	26.8%
Total		13,600.0	100.0%

Source: Frost & Sullivan

Notes:

1. Company A is a global leading provider of IoT wireless communication modules and overall solutions. It offers a comprehensive portfolio of cellular, GNSS, short-range, and automotive modules, along with antennas and value-added services, serving industries such as automotive, industrial IoT, smart energy, and consumer electronics worldwide.
2. Company B is a global leading provider of wireless communication modules and AI solutions, and China’s first A+H dual-listed wireless module company. Founded in 1999, it focuses on cellular modules, smart modules, automotive-grade modules, and full-stack solutions that help industries transition from connectivity to intelligent applications.
3. Company C is a global leading provider of wireless communication modules and solutions, with a strong focus on smart modules and high-computing-power AI modules. Its products and solutions are widely applied in general IoT, intelligent connected vehicles (ICV), wireless broadband, and on-device AI scenarios.
4. Company D is a high-tech enterprise specialising in AIoT products and solutions centred on intelligent connectivity. Its main businesses include wireless communication modules, smart devices, communication equipment, and engineering services, serving telecom operators and various industry clients globally.
5. Company E is an IoT one-stop solutions provider engaged in the R&D, production, and sales of IoT modules and system solutions, as well as IC value-added distribution. It offers a wide range of wireless modules and serves smart metering, industrial, automotive, and other application fields.

The wireless communication terminal antennas market in the PRC is relatively fragmented and highly competitive with a mix of specialised antenna manufacturers and integrated solution providers. The top five market participants account for the market share of 43.4% in 2025. Competition focuses on technical performance, multi-band support, miniaturisation, signal stability and efficiency, cost control, customization capability, and the ability to provide full RF solutions that combine antennas with modules or PCBA. Price pressure is significant in standardised consumer and IoT antenna products, while higher-margin opportunities exist in customised, high-performance and automotive-grade solutions. Overall, the market is characterised by intense competition on technology and cost, with leading firms leveraging R&D

INDUSTRY OVERVIEW

strength, vertical integration and close relationships with module makers and device OEMs to maintain their positions.

Ranking in the PRC Wireless Communication Terminal Antennas Market by Revenue, 2025

Ranking	Company	Revenue (RMB Million)	Market Share (%)
1	Company F	1,050.0	14.4%
2	Company G	900.0	12.3%
3	Company A	600.0	8.2%
4	Company H	500.0	6.8%
5	Company I	125.0	1.7%
	Others	4,125.0	56.5%
Total		7,300.0	100.0%

Source: Frost & Sullivan

Notes:

1. Company F is a Chinese provider of wireless terminal antennas and modules, with products widely used in smartphones, automotive, AR/VR, satellite terminals, and other consumer and IoT devices. It also offers thermal management components, wire harnesses, and sensor modules.
2. Company G is a global leader in RF components and antennas, specialising in terminal antennas, wireless charging modules, connectors, and related precision components. Its products serve consumer electronics, automotive, satellite communication, and IoT applications worldwide.
3. Company H global manufacturer of precision components, connectors, cables, and system integration solutions for consumer electronics, automotive, and data centres. Antenna products form part of its broad portfolio of interconnect and electronic components supplied to leading international brands.
4. Company I is a Chinese communication antenna and RF products manufacturer, offering base station antennas, terminal antennas, microwave devices, and related components. Its products are mainly applied in mobile communication networks, microwave systems, and emerging scenarios such as low-altitude economy and satellite internet.

Entry Barriers

High Technical and R&D Thresholds

Entering the market requires deep expertise in RF engineering, electromagnetic simulation, antenna design, and wireless protocol integration. New entrants must invest heavily in advanced R&D capabilities, including professional simulation software, anechoic chambers, and extensive testing facilities for multi-frequency, high-performance products (such as 5G RedCap, Wi-Fi 7, and AIoT modules). The rapid pace of technological evolution further raises the bar, as companies need continuous innovation to meet stringent performance requirements in signal stability, power efficiency, and electromagnetic compatibility.

INDUSTRY OVERVIEW

Stringent Certification and Regulatory Compliance Requirements

The market is heavily regulated, demanding multiple mandatory certifications including SRRC, CCC, network access approvals from major operators, and industry-specific qualifications (e.g., IATF 16949 for automotive). The certification process is time-consuming, costly, and requires proven reliability and traceability in the supply chain. Foreign or new domestic players often face additional scrutiny, making regulatory compliance one of the most significant barriers to market entry.

Strong Established Customer Relationships and Economies of Scale

Leading companies have built long-term strategic partnerships with major downstream customers, including automotive OEMs, smart home brands, and industrial equipment manufacturers. New entrants face high switching costs for customers and must compete against incumbents' advantages in production scale, procurement bargaining power, and proven delivery reliability, making it difficult to secure sizable orders.

SOURCE OF INFORMATION

We engaged Frost & Sullivan, an independent market research and consulting company founded in 1961 with 40 offices and more than 2,000 industry consultants, market research analysts, technology analysts and economists globally, to conduct an analysis of, and to prepare a report on, the General IoT Wireless Communication Modules, Wireless Communication Terminal Antennas and IoT-related PCBA solutions market in the PRC in connection with the [REDACTED]. The report prepared by Frost & Sullivan for us is referred to in this document as the industry report. We agreed to pay Frost & Sullivan a fee of RMB440,000 which we believe reflects market rates for reports of this type.

RESEARCH METHODOLOGY

Frost & Sullivan's independent research consists of both primary research (in-depth interviews with leading industry participants and industry experts) and secondary research (reviewing company reports, independent research reports and data based on Frost & Sullivan's own research database). Projected data were obtained from historical data analysis plotted against macroeconomic data with reference to specific industry-related factors.

BASIS AND ASSUMPTIONS

In compiling and preparing the research, Frost & Sullivan assumed that the social, economic and political environments in the relevant markets are likely to remain stable in the forecast period. Except as otherwise noted, all of the data and forecasts contained in this section are derived from the industry report, various official government publications and other publications. We believe that the information has been derived from appropriate sources and we have taken reasonable care in extracting and reproducing such information.