QUECTEL

Build a smarter world

Wi-Fi 7 white paper

Wi-Fi in 2025: when is Wi-Fi 7 the answer?

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Contents

INTRODUCTION

Wi-Fi is a universally accepted, highly-familiar and cost-effective technology for connecting devices of all types wirelessly. The familiarity originates from users' adoption of the technology for PC, tablet and mobile device connectivity and Wi-Fi connectivity is ubiquitous in homes and workplaces across the globe. The ability to establish a network without service provider input and enable local connectivity at very low cost in comparison to cellular connectivity is a compelling attraction.

The technology's appeal has widened as Wi-Fi networks have become ubiquitous across city centers, industrial and enterprise campuses and sites such as hospitals, ports and entertainment venues. Innovations such as Wi-Fi 6 and 6E Wi-Fi 7 and Wi-Fi HaLow are expanding the applicability of Wi-Fi to use cases that need higher speeds, wider coverage and lower latency and positioning Wi-Fi as a compelling alternative to cellular connections.

Each of these new variants presents different incentives for the market to move beyond Wi-Fi 5. The transition to Wi-Fi 6/6E has been primarily driven by the need for higher efficiency, better performance in dense environments, and improved power management. Wi-Fi 6 and 6E promise better coverage, improved node density and lower power consumption.

Wi-Fi 7 also includes these benefits and adds better interference resiliency and, most importantly, low latency for applications such as augmented and virtual reality (AR/VR), industrial automation and cloud gaming. Wi-Fi 7 also introduces multi-link operation (MLO) and lower latency, a game-changing feature that allows devices to transmit and receive data across multiple frequency bands simultaneously. This significantly reduces network congestion and improves reliability, especially in environments with high interference.

In addition, enhancements in WPA3 security across Wi-Fi 6 and 7 ensure stronger encryption and protection against cyber threats, making these technologies a secure choice for enterprise and industrial applications. The advances introduced across Wi-Fi 6 and 7 ensure that Wi-Fi continues to meet the growing demand for seamless, high-speed connectivity in an increasingly digital world.

Unlike traditional Wi-Fi technologies, Wi-Fi HaLow adds a further dimension to the applicability of Wi-Fi. HaLow operates in the sub-1GHz spectrum band, offering extended range and better penetration through walls and obstacles. This makes it particularly suitable for IoT applications such as smart agriculture, industrial automation and smart cities, where low-power, long-range connectivity is essential. By enabling connectivity over distances of several kilometers, HaLow fills a crucial gap in the IoT ecosystem.

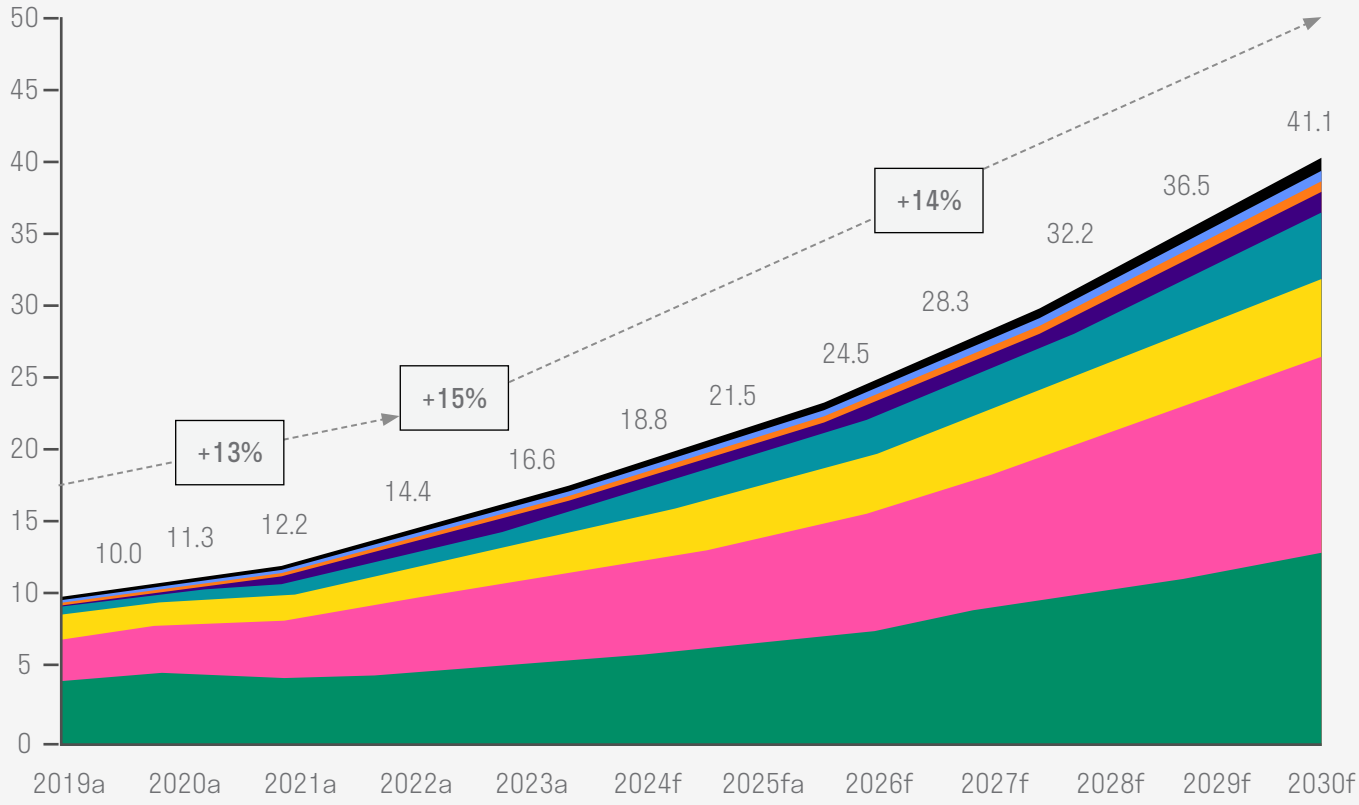
MARKET DEVELOPMENT

Throughout its history, Wi-Fi in all its forms has been used to connect an enormous range of applications thanks to its blend of performance, low cost and simplicity. The proof of its influence has been detailed by analyst firms. IoT Analytics, for example, has reported that Wi-Fi makes up 31% of all IoT connections.[1] The firm says that in 2023, three-quarters of Wi-Fi-enabled devices shipped worldwide were based on the latest Wi-Fi 6 and Wi-Fi 6E technologies, which promise faster and more reliable wireless connectivity than its predecessor, Wi-Fi 5.

The adoption of the latest Wi-Fi technology variants has made communication between IoT devices more efficient, leading to improved user experiences and overall performance. Wi-Fi technology is leading IoT connectivity in sectors such as smart homes, buildings and healthcare. In addition, Wi-Fi 7, which started to ship in 2024, is expected to contribute to 7% of IoT-based Wi-Fi shipments.

1 https://iot-analytics.com/number-connected-iot-devices/

FIGURE 1 Connected IoT devices forecast 2024–2030



CONNECTIVITY TYPE	CAGR 21-23	CAGR 23-30
Other	21%	17%
Wireless neighborhood area networks (WNAN)	15%	14%
Cellular 5G IoT	147%	62%
Wired IoT	4%	9%
LPWA	35%	21%
Cellular IoT (excl. 5G, LPWA)	21%	11%
Wireless local area networks (WLAN)	18%	14%
Wireless personal area networks (WPAN)	12%	13%

XX% =CAGR

Source: IoT Analytics

Although ABI Research has reported that the worldwide Wi-Fi market faced challenges in 2023 as it faced financial constraints, market saturation and implementation issues, the firm says markets are stabilizing and the arrival of Wi-Fi 7 and Standard Power 6GHz are set to reignite demand. The firm says these trends will drive an 8.0% compound annual growth rate (CAGR) for wireless LAN infrastructure shipments between 2023 and 2030, with total shipments jumping 71.3%.[2]

This is borne out in Counterpoint Research's projections for the Wi-Fi chipset market for which it expects revenue to increase by 12% year-on-year in 2025.[3] Wi-Fi 5 is expected to have retained its dominance in 2024 with a projected 56% market share, but the rapid rise of Wi-Fi 6, 6E and Wi-Fi 7 standards is underway. In 2024, Wi-Fi 6, 6E and 7 will collectively capture 29% of the market, which is expected to increase to 43% by 2025, the firm says. This transition mirrors the rapid shift from Wi-Fi 4 to Wi-Fi 5 and reflects the need for faster, more robust internet across multiple devices.

FIGURE 2 Specifications of key Wi-Fi standards

	Wi-Fi 5	Wi-Fi 6	Wi-Fi 6E	Wi-Fi 7
Launch year	2014	2019	2021	2024
IEEE standard	802.11ac	802.11ax		802.11be
Max data rate	6.9Gbps	9.6Gbps		46Gbps
Bands	5GHz	2.4/5GHz	6GHz	1-7.26GHz
Channel size	160MHZ			320MHz
Latency	Mid to high	Medium		Low
Distance	Short	Medium		Fair
Technology	40nm	28nm	14/16nm	6/7nm

Source: Counterpoint Wi-Fi Chipset Market Report

2 https://www.abiresearch.com/press/wi-fi-7-and-standard-power-6-ghz-to-boost-wi-fi-infrastructure-market-rebound-in-2024-with-123-year-on-year-shipment-growth
3 https://www.counterpointresearch.com/insight/post-insight-research-notes-blogs-wifi-chipset-market-projected-to-grow-12-yoy-in-2025

Wi-Fi 7 will enable significant innovation into the Wi-Fi ecosystem in 2024, says ABI Research, as the new standard introduces a series of enhancements that will significantly improve capacity and performance. Access to the 6GHz band will expand the available spectrum, addressing capacity challenges, and headline features such as multi-link operation (MLO) will enhance spectrum efficiency, helping to overcome interference issues in congested environments.

These new features will also allow Wi-Fi to serve new applications that the technology previously could not satisfy but challenges remain. Many regions still lack unlicensed 6GHz access, severely restricting the performance gains they can expect from the technology. In addition, the cost of Wi-Fi 7 is considerably higher than Wi-Fi 6, which may pose a barrier to adoption for low average selling price (ASP) markets, says the firm.

Counterpoint Research also acknowledges that Wi-Fi 7 is at an early stage of deployment but thinks the technology is set for broader adoption by late 2025 as infrastructure and technology support catch up. The firm says the need for Wi-Fi 7's enhanced capabilities will increase with AI gradually becoming a core component in PCs and flagship smartphones, pushing the demand for ultra-fast connections. The adoption of Wi-Fi 7 is likely to surpass that of previous Wi-Fi generations thanks to its critical role in providing next-generation connectivity for a wide range of applications, from edge AI to augmented and virtual reality (AR/VR) and IoT.

HIGH-VOLUME CONSUMER AND PROSUMER USE CASES

Wi-Fi's cost efficiency means it can be added to everything from smart speakers and cameras through to PCs, tablets and TVs. The smart speaker market, for example, is booming as users find the convenience of accessing intelligent virtual assistants via voice commands compelling.

Wi-Fi and Bluetooth connectivity offer seamless integration with other products and systems and this market is set to grow by US$50.8 billion in the period 2024-2028 according to Technavio.[4] The market will experience a CAGR of 34.28% during the period 2023-2028.

AT HOME WITH SMART CONNECTED DEVICES

Household appliances, smart meters and sports equipment all utilize variants of Wi-Fi. Wi-Fi dominates the smart home market with a share of 40% in 2024, reports PS Market Research.[5]

Research from the IoT analyst firm Berg Insight, the number of smart homes in Europe and North America reached 126.2 million in 2023.[6] By 2028, the firm estimates that about 83.8 million homes in North America will be smart, equal to 55% of all homes in the region.

The European market is still somewhat behind the North American, in terms of market penetration. The number of smart homes in Europe is forecast to reach about 101.2 million at the end of 2028, representing a market penetration of close to 42%. Wi-Fi is the essential enabler of smart home connectivity because it is typically already present in the home so it's simple for home-owners to add appliances, devices and products to their existing network.

4 https://www.prnewswire.com/news-releases/smart-speaker-market-projected-to-grow-by-usd-50-8-billion-from-2024-2028--driven-by-rising-unit-sales-and-ai-powered-market-evolutiontechnavio-302256624.html

5 https://www.psmarketresearch.com/market-analysis/smart-home-appliances-market

6 https://www.berginsight.com/close-to-50-percent-of-european-and-north-american-homes-will-be-smart-by-2028

SMART LAUNDRY, REFRIGERATION AND THERMOSTATS

One use case that has been an early adopter of Wi-Fi is washing machines. These have added value to consumer by enabling apps to set functions and control machine cycles and adoption is continuing to accelerate.

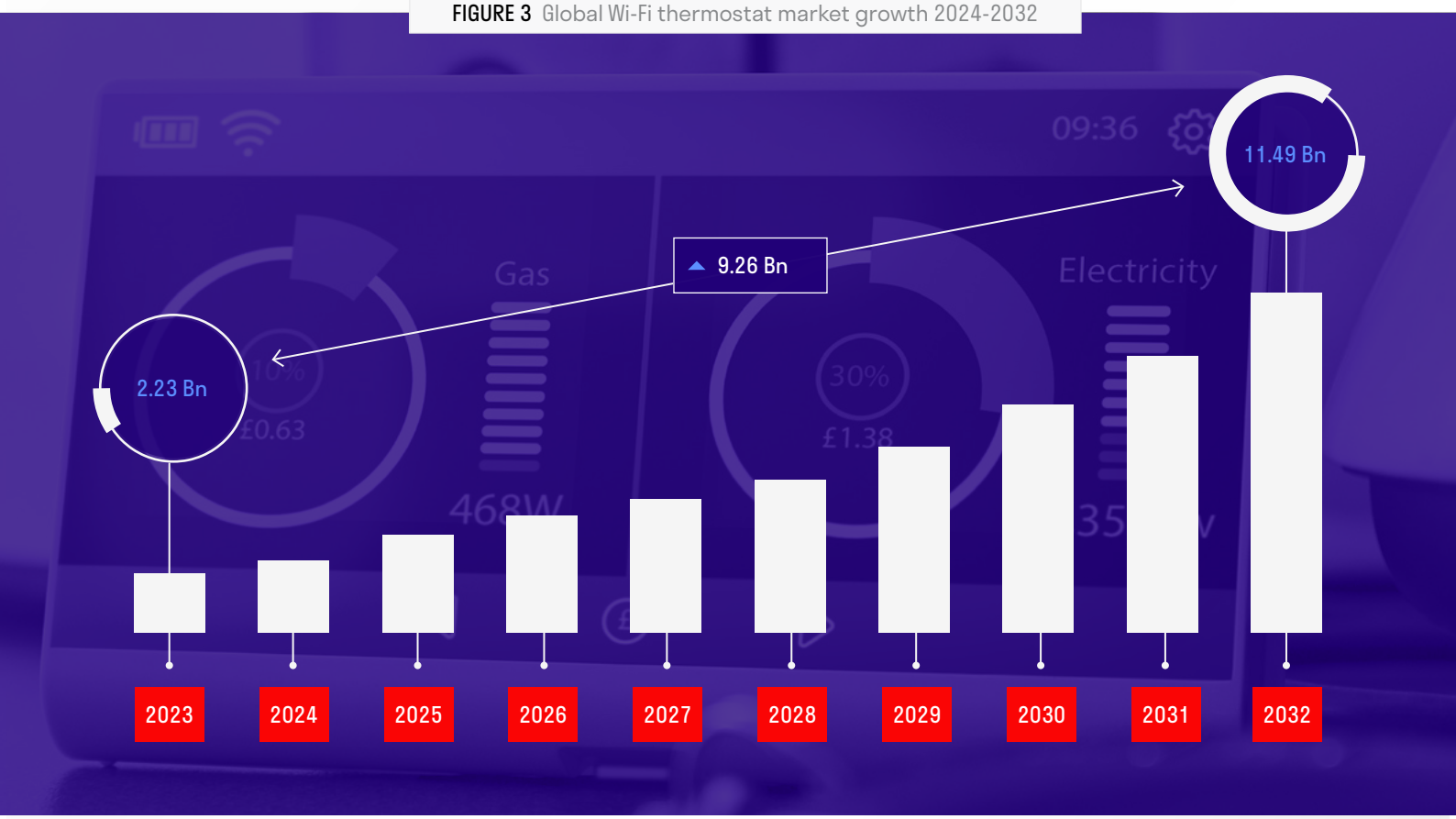
Technavio also reports that the smart washing machine market is set to grow by US$25.46 billion at a CAGR of 20.65% between 2023 and 2028.[7]

The market is experiencing significant growth as demand for energy-efficient appliances increases as consumers seek to reduce their utility bills and minimize their carbon footprint. The firm says integration of Wi-Fi connectivity is enabling users to remotely monitor and control their washing machines, as well as receive notifications and diagnostics.

Another home appliance category with significant headroom for growth is the smart refrigerator and freezer market. This was estimated by Grand View Research to be worth US$27.58 billion in 2024. The integration of smart technology into refrigerators is gaining massive momentum in the industry, the firm says, and smart refrigerators that are equipped with Wi-Fi connectivity, touchscreens and virtual assistants are enhancing the ownership experience of smart fridges and freezers.[8]

Wi-Fi is long-established as a means to connect thermostats and a recent study from Zion Market Research predicts the global market will grow in value from US$2.23 billion in 2023 to US$11.49 billion in 2032, at a CAGR or approximately 20%.[9]

FIGURE 3 Global Wi-Fi thermostat market growth 2024-2032

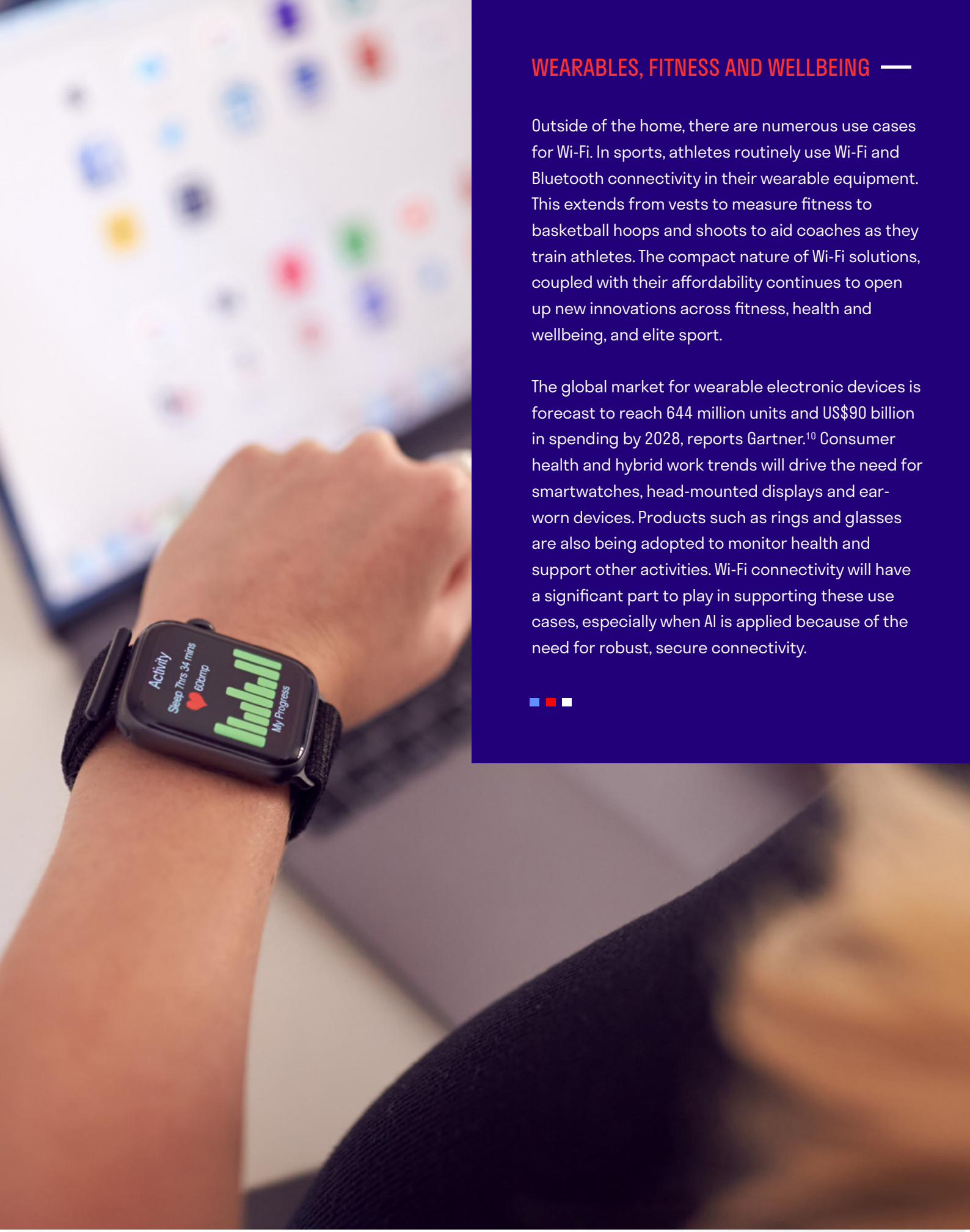


7 https://www.technavio.com/report/smart-washing-machine-market-analysis
8 https://www.grandviewresearch.com/industry-analysis/north-america-household-refrigerators-freezers-market-report
9 https://www.zionmarketresearch.com/report/wi-fi-thermostats-market

WEARABLES, FITNESS AND WELLBEING

Outside of the home, there are numerous use cases for Wi-Fi. In sports, athletes routinely use Wi-Fi and Bluetooth connectivity in their wearable equipment. This extends from vests to measure fitness to basketball hoops and shoots to aid coaches as they train athletes. The compact nature of Wi-Fi solutions, coupled with their affordability continues to open up new innovations across fitness, health and wellbeing, and elite sport.

The global market for wearable electronic devices is forecast to reach 644 million units and US$90 billion in spending by 2028, reports Gartner.[10] Consumer health and hybrid work trends will drive the need for smartwatches, head-mounted displays and ear-worn devices. Products such as rings and glasses are also being adopted to monitor health and support other activities. Wi-Fi connectivity will have a significant part to play in supporting these use cases, especially when AI is applied because of the need for robust, secure connectivity.



10 https://www.gartner.com/en/documents/5399863

SPECIALIZED INDUSTRIAL USE CASES

Wi-Fi provides a great way to cover a site with wireless connectivity and, with HaLow the area covered can be significantly expanded. As a secure, mature technology, enterprises utilize Wi-Fi to manage their campuses taking in building management, access control and connections in public areas. The technology is also adopted in industrial settings to support machines, robots, automated guided vehicles, monitoring and security use cases and worker protection.

BUILDING MANAGEMENT AND HVAC

In building management, Wi-Fi is used in air conditioning and HVAC and in support of meeting rooms, conferencing devices and, of course, tablets and PCs. While traditional HVAC systems have a binary function of on or off, smart HVAC systems offer many more features and condition the air based on multiple factors such as ambient temperature, occupancy, equipment scheduling and energy consumption. Smart HVAC goes far beyond basic cooling and heating functions by bridging the connected and unconnected through intelligent climate control.

This comprises temperature, air quality and humidity tracking and enables remote management, proactive, predictive maintenance and energy optimization.

Currently, reports ABI Research, more than 75% of HVAC systems are hard-wired but, as awareness grows, by 2030, adoption of wireless connected smart HVAC systems will reach over 55%.[11]

INDUSTRIAL USE CASES

Industrial environments utilize Wi-Fi because it robust, secure, wire-free and cost effective. Many machines can be run using Wi-Fi connectivity and AGVs, forklifts and other robots all utilize the technology.

Port and campus authorities, for example, use Wi-Fi for safety cameras, managing traffic flows, tracking vehicles and containers and operating worker safety applications. ABI Research also forecasts that these trends will rapidly expand annual global shipments of campus WLAN access points (APs), up from 22.2 million in 2024 to 41.8 million in 2030.[12]

11 https://www.abiresearch.com/press/commercial-hvac-system-shipments-valued-at-us354-billion-in-2030-driven-by-innovations-in-cooling-energy-efficiency-and-sustainability

12 https://www.abiresearch.com/press/rapid-growth-in-multiple-dwelling-units-education-and-large-public-venues

HOW QUECTEL HELPS

To reflect the broad applicability of Wi-Fi Quectel offers a comprehensive portfolio of Wi-Fi modules, addressing all Wi-Fi variants and covering a wide range of industry needs from high performance Wi-Fi 7 solutions to long-range Wi-Fi Halow modules so you can be sure to find a module that matches the needs of your use case that is secure, economically-optimized and robust. Notable products are listed in the Appendix 1 of this whitepaper.

The Quectel portfolio covers the latest innovations in Wi-Fi including Wi-Fi 6, Wi-Fi 7 and Wi-Fi HaLow modules. These also offer multiple connectivity technologies so you can select a module that combines Bluetooth and cellular connectivity with Wi-Fi to support devices that traverse sites and need to use various networks at different times and for different purposes.

In addition, Quectel offers Wi-Fi antennas that can be pre-integrated with modules, enabling faster, simpler development and accelerated time to market.

To accelerate time to market for developers and designers, Quectel offers a range of services from ODM to testing and certification, all designed to remove friction and accelerate market introduction for your Wi-Fi solutions.

CONCLUSION

Wi-Fi is a ubiquitous, mature, secure, familiar technology that continues to introduce new innovations that improve performance and keep the technology relevant. The enduring appeal of Wi-Fi is the result of its versatility, large community of developers and its cost efficiency. Able to support the connectivity needs of complex operations, Wi-Fi is well placed to support AI workloads and a growing number of use cases at both the high and low ends of the market.

Quectel recognizes the wide applicability of Wi-Fi to use cases from devices in users' pockets to equipment in factories, campuses and stadiums and therefore has developed a large portfolio of Wi-Fi modules and antennas to ensure there are options to suit every use case. We continue to innovate, developing new Wi-Fi modules to support smart applications at home, at work and in leisure venues. Wi-Fi truly is a fundamental enabling technology as we continue to build a smarter world.

APPENDIX 1

The modules

Quectel's strong portfolio of Wi-Fi solutions includes the latest Wi-Fi 6, 7 and HaLow modules. Notable products include:

WEARABLES, FITNESS AND WELLBEING

Quectel's FGS060N, FCS962N-LP, FC66E and the FCM363X provide high efficiency and improved performance in dense networks.

The Quectel FGS060N is a high-performance Wi-Fi 6, Bluetooth 5.2 and 802.15.4 module that supports a maximum data rate of 600.4Mbps. The odule measures 14.0 x 13.0 x 2.0mm and operates in a temperature range of -40°C to +85°C.

The Quectel FCS962N-LP supports Wi-Fi 6 in the 2.4GHz and 5GHz Wi-Fi bands and Bluetooth 5.4, Bluetooth LE audio and BLE long range. Maximum data rate is 143.4Mbps and the module has dimensions of 12.0 x 12.0 x 1.55mm. Able to operate in the -40°C to +85°C temperature range, the module is designe for IoT applications that seek improved network efficiency and can save energy.

The Quectel FC66E is a Wi-Fi 6E and Bluetooth 5.3 module that supports a maximum data rate of 3000Mbps. Measuring 19.9 x 18.0 x 2.1mm, the module operates in the -30°C to +75°C temperature range. The module supports 2x2 + 2x2 MIMO and is ideal for industrial consumer and automotive use cases.

FGS060N

Wi-Fi 6, BLE (Bluetooth 5.2) and 802.15.4 module

14.0 mm × 13.0 mm × 2.0 mm

FCS962N-LP

Wi-Fi 6 and Bluetooth 5.4 module

12.0 mm × 12.0 mm × 1.55 mm

25.5mm × 18.0mm × 3.16mm

FCM363X

Wi-Fi 6 and BLE 5.2 module

WI-FI 7

Quectel's FGE576Q and FME170Q-865 deliver ultra-fast network speeds, multi-link operation and optimized network efficiency.

The Quectel FGE576Q supports Wi-Fi 7 and Bluetooth 5.3 enabling dual-band simultaneous operation on 2.4GHz + 5GHz and 2.4GHz and 6GHz. The module offers a maximum data rate of 3.6Gbps and supports ultra-low latency for real-time response. Measuring 16.0 x 20.0 x 1.8mm, the product operates in the -20°C to +70°C temperature range and is ideal for cloud gaming, 8K audiovisual streaming, augment and virtual reality use cases, Industrial IoT and telemedicine.

The Quectel FME170Q-865 is an ultra-low latency Wi-Fi 7 and Bluetooth 5.4 module, offering a maximum data rate of 5.8Gbps. It supports simultaneous operation on 2.4GHz + 5GHz, 2.4GHZ + 6GHz, 5GHz + 5GHz and 5GHz + 6GHz bands. Measuring 22.0 x 30.0 x 2.20mm, the modules operates in the -10 °C to +65 °C temperature range.

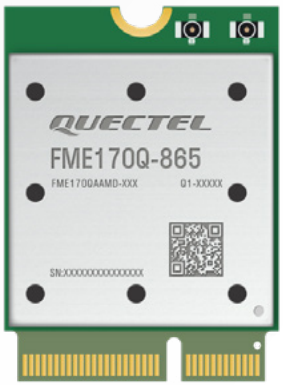
WI-FI HALOW

Quectel's FGH100M-H is ideal for long-range, low power IoT applications that require connectivity over kilometers. With a maximum data rate of 32.5Mbps, the module operates in the Sub-1GHz range, enabling users to control devices in a radius of 1km. With dimensions of 13.0 x 13.0 x 2.2mm, the module can enable simultaneous access for upt o 8,191 devices on the same Wi-Fi access point.

16.0 mm × 20.0 mm × 1.8 mm

FGE576Q

Wi-Fi 7 and Bluetooth 5.3 module



22.0 mm × 30.0 mm × 2.20 mm

FME170Q-865

Wi-Fi & Bluetooth

13.0 mm × 13.0 mm × 2.2 mm

FGH100M-H

Wi-Fi HaLow module

APPENDIX 2

The antennas

Quectel's strong portfolio of antennas includes the latest Wi-Fi 6, 7 and HaLow antennas. Notable products include:

WI-FI EMBEDDED ANTENNAS

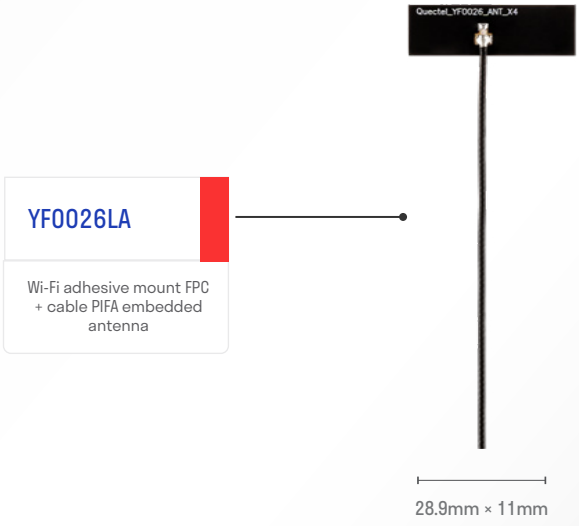
The Quectel YF0026AA is a Wi-Fi adhesive mount FPC and cable PIFA embedded antenna that operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges. With dimensions of 28.9 x 11mm, this antennas has the RF1.37 cable type and is both RoHS and REACH compliant. The antenna offers peak gain of 6.9dBi.

The Quectel YF0026LA offers the same frequency ranges and dimensions as the YF0026AA but with an RF1.13 cable type and peak gain of 5.2dBi.

The Quectel YFBC001WWA is another Wi-Fi adhesive mount FPC and cable PIFA embedded antenna that operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges. This antenna offers peak gain of 6.4dBi and has dimensions of 38 x 7mm. It is RoHS and REACH compliant and has the RF1.37 cable type.

SMT CHIP ANTENNA

The Quectel YFBC001WWA is a Wi-Fi SMT mount ceramic chip loop embedded antenna. It operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges and offers peak gain of 2.3dBi. With dimensions of 1.6 x 0.8 x 0.4mm, the antenna is both RoHS and REACH compliant.



WI-FI EXTERNAL ANTENNAS

The Quectel YEBT001W1AM is a Wi-Fi terminal mount rubber monopole external antenna with diemnsions of 135 x 15.6 x 13mm. The antenna operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges and offers peak gain of 4.1dBi. The antenna has an IP67 rating and is both RoHS and REACH compliant. Another option is the Quectel YEBT002W1AM which operates in the same frequency ranges and shares the same dimensions and peak gain as the YEBT002W1AM. This antennas is RoHS compliant.

The Quectel YEBA001L1AH is a Wi-Fi adhesive mount whip monopole external antenna. The antenna operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges and offers peak gain of 4.7dBi. With dimensions of 30mm radius x 83.2mm, the antenna features the RG174LL cable type, has IP67 rating and is RoHS and REACH compliant. The Quectel YEBM001L1AH has the same features as the YEBA001L1AH but offers a magnetic mount.

The Quectel YEBA000J1AM is a Wi-Fi adhesive mount low profile dipole external antenna. The antenna operates in the 2400-2500MHz, 5150-5850MHz and 5925-7125MHz frequency ranges and offers peak gain of 2.1dBi. With dimensionso f 60 x 16 x 6.3mm, the antenna has the RG174 cable type and is RoHS and REACH compliant.

YEBT001W1AM

Wi-Fi terminal mount rubber dipole external antenna

YEBA000J1AM

Wi-Fi/V2X adhesive mount low profile dipole external antenna

To find out more about any of our products, please contact:

↗ sales@quectel.com

↗ support@quectel.com

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