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Low-Power Wi-Fi for Industrial IoT Connectivity

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Wireless connectivity is driving the fourth industrial revolution, sometimes referred to as Industry 4.0, by transforming the industrial space and creating trillions of dollars in new market opportunities. Energy-efficient manufacturing, supply chains, and asset-intensive sites are now possible with Industrial IoT (IIoT) smart solutions, as they come to eliminate unplanned downtime, optimize operational processes, and maximize production yield. In this whitepaper, we'll explore how low-power Wi-Fi powers various IIoT applications in harsh conditions and challenging RF (radio frequency) environments.

More industries are seeing the benefits of bringing digital and physical technologies together with IIoT. Integrating wireless connectivity into new sites and retrofitting existing wired platforms presents new ways to automate, maximize operational efficiency, and enable new business models. Wireless technology plays a big role in helping factories rise to the challenges of meeting demand, scaling production, and maintaining satisfactory efficiency levels. Some of the industrial trends we see emphasize predictive maintenance, remote monitoring, and predictive analysis for real-time decision making. For example, innovations in industrial wearables are helping companies like 3M provide more convenient and comprehensive patient-centered care for medical professionals. And applications like fleet management and asset tracking are being completely reimagined thanks to innovations by companies like Trackunit and Milwaukee Tools.

With the cost and efficiency savings being realized across industries, it's simply a matter of time before most industrial organizations focus on connecting critical equipment, processes, and end-users. However, to fully unleash the value of IIoT, the underlying communication network must meet stringent requirements in terms of reliability, security, and resilience.

Wireless Connectivity for Industrial IoT Equipment and Systems

Wireless connectivity brings profound changes to industrial applications as we know them. Industries such as building automation, agriculture, healthcare, and more reap the benefits of real-time sensing data, automation, and remote control. The pros of widely adopting wireless across industries are extensive - from deeper insight into the condition of machinery to eliminating unplanned downtime and optimizing throughput. Yet, it all boils down to three fundamental benefits:

Fast Time-to-Market and Mobility	Cost Savings	Employee Safety
Extending wired networks in the industrial landscape implies great planning and cumbersome hardware installation. With wireless, enterprises are more agile in deploying new devices, avoiding design limitations. Sensors and edge devices are easier to add to facilities, whereas wires need to be installed or routed under floors, behind walls, and above ceilings.	Setting up a wireless network leads to substantial cost savings, as wired connections are more expensive due to the wire and labor costs. Moreover, if a wire fails, repairing or replacing it can be costly.	Remote monitoring and asset management becomes easier. Workers can navigate hazardous conditions that may typically require them to connect through wire. Eliminating the wires increases safety and improves efficiency.
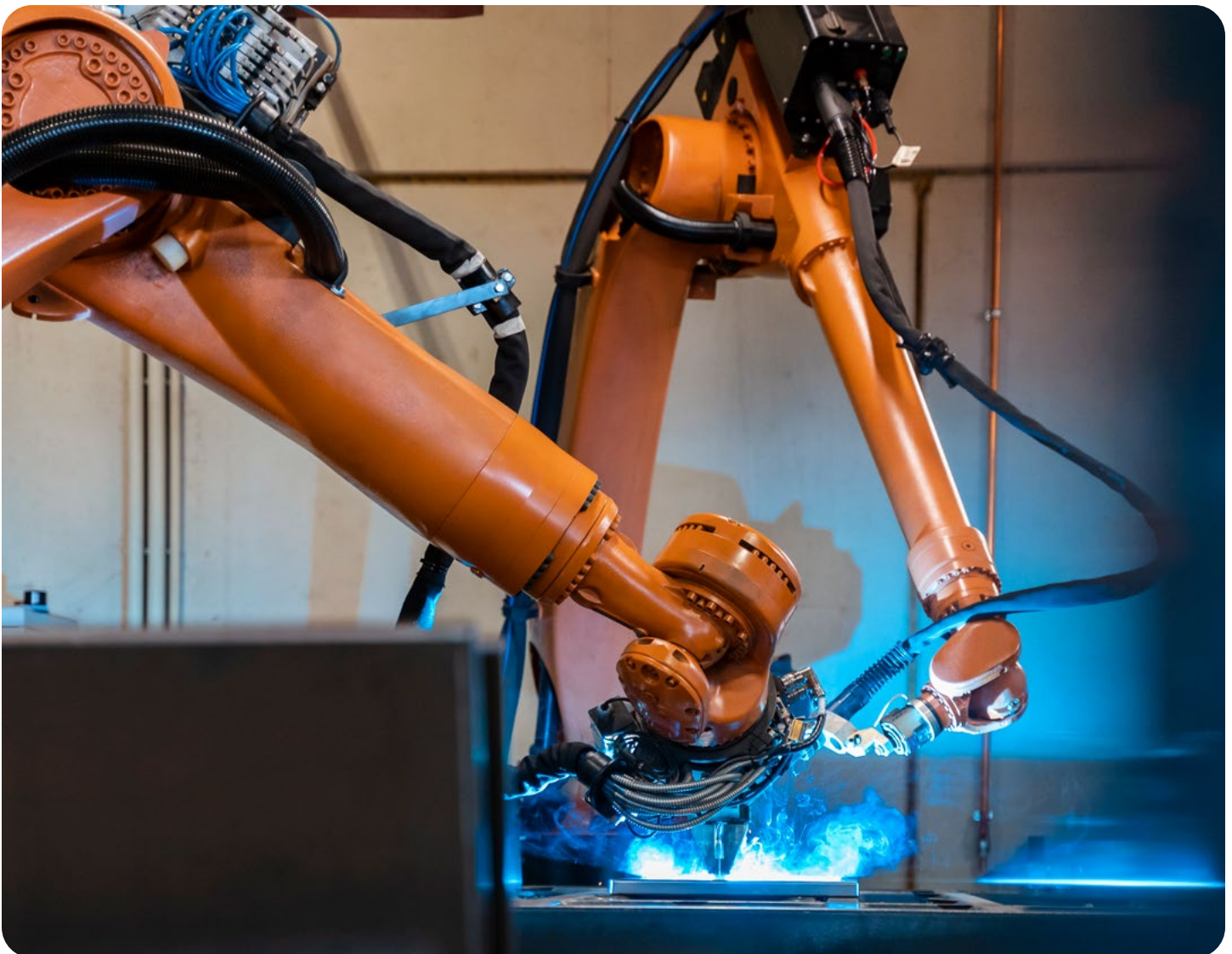
Wi-Fi, The Most Widespread Wireless Protocol

One of the greatest challenges when integrating wireless connectivity is determining which communication protocols to adopt and how to make these protocols work in harmony.

With its extensive installed base, Wi-Fi is a compelling protocol for IoT wireless applications. Along with the established infrastructure, here are four other key benefits of Wi-Fi:

- **Ubiquity, established infrastructure, and interoperability.** Wi-Fi is everywhere, and this familiarity has made it easy to use and connect. Thanks to its widespread availability, a lot of manufacturing and industrial applications utilize Wi-Fi. It's also interoperable with many device manufactures including Wi-Fi as a key protocol.

- **The cloud.** Remote monitoring through the cloud still tops the agenda for most enterprises. Cloud services become easy to deploy in a pre-existing Wi-Fi network.

- **The rise of AI/ML at the edge.** More companies are shifting to edge computing, running AI/ML algorithms closer to the device to reduce latency and scale processing. By placing decision making close to the device, it gives applications greater reliability and faster response time in taking preventive and predictive actions. This requires high bandwidth for the large amount of data transfer.

- **Over-the-Air (OTA) firmware updates and data transfers.** When transmitting larger pieces of data or performing firmware OTA updates, Wi-Fi is a good choice to carry large data quantities in a limited amount of time.

Low and Ultra Low-Power Wi-Fi, a Value Addition for Industrial IoT Applications

The industrial landscape can be a harsh one. Connected devices and sensors are often placed in remote locations, which raises logistical issues for both battery life and maintenance. Conventional Wi-Fi used in infrastructure devices (routers, mobile phones, gateways) is ill-suited because low-powered devices are the backbone of these systems and battery life is critical.

Low-power Wi-Fi on the other hand delivers low power consumption across transmit, receive, and sleep modes. This enhances battery life significantly for all end node devices and creates immense value for many industrial applications. Using low-power Wi-Fi becomes extremely favorable, as wireless devices running on battery power supply has become the first design choice for new remote monitoring applications. Low-power Wi-Fi can work in conjunction with Bluetooth/Bluetooth Low Energy (LE) for extending capabilities across local connections and clients.

Here is a rundown of Wi-Fi requirements when deploying low-power, low-cost IIoT applications:

- **Power consumption.** Battery powered end node devices require low power and traditional Wi-Fi is not suited for such applications. But Wi-Fi has good speed and bandwidth, which makes it advantageous to use in Industrial setups.

- **Wireless and networking stack integration.** It is important to simplify the IoT development process. Hence, wireless and networking stacks are expected to be integrated with the wireless solution.

- **Cloud connectivity.** Complete cloud connectivity with the major cloud providers is a key requirement.

- **Security.** Security from online and physical attacks are necessary in mission critical operations.

- **Cost and size constraints.** Cost and size are also a key factor in IoT, and it varies depending upon the use case.

Top IIoT Applications for Low-Power Wi-Fi

Applications	Industries/Areas Used	Low-Power Wi-Fi Use Case
Asset Tracker	Indoor Locations: Hospitals, Manufacturing, Chemical, Retail Outdoor locations: Parking Lots, Shipping Yards, Fleets, Logistics	• Real-time location monitoring within a confined area • Data transfer after the asset comes to facility
Smart Meter	Residential, Industrial, and Commercial	• Backbone for data to cloud • Access debug logs and monitor energy load profile
Clinical Medical	Patient Monitoring, Infusion Pump, Telehealth, Respiratory Therapy (CPAP)	• Data to internet and to cloud for access • Storage in patient portal and physician's portal
Point of Sale	Retail, Gas Stations	• Data collection of customers at server • Verify the payment backend
Garage Door Opener	Home Garages, Underground, and Collective Garages	• Easily connect to a home network with built-in Wi-Fi • Control via mobile and get real time alerts
HVAC	Building Automation, Hotels, Retail	• Remote connection, control, and monitoring via client
Body Worn Camera	Police Force, Law Enforcement Agency, Sports, and Adventure	• Audio and video capture, and transfer to cloud or server
Power Tools	Construction, Manufacturing	• Connect with a centralized station to transfer the data after work
Aftermarket Telematics	Automobiles, Trucks	• Create a Wi-Fi hotspot • Client access for diagnostics
Data Loggers/Wireless Sensors	Oil and Gas, Manufacturing, Automotive, Power Utilities, Healthcare, Food and Beverage, Logistics	• Monitoring and recording data remotely in facilities with Wi-Fi infrastructure
Industrial Wearables	Almost every industry that has a workforce	• Connect on client device for alerts and diagnostics • Centralized monitoring and collaboration

Wi-Fi 6 Will Boost Wireless Adoption in IIoT

Most of today's IIoT devices use 2.4 GHz Wi-Fi 4 due to its low power consumption, low cost, and longer range. But the spectrum is becoming crowded due to limited channels and because several other protocols such as Bluetooth Classic, Bluetooth LE, and Zigbee also use the same spectrum. This is where Wi-Fi 6 would make an impact.

Most routers and laptops already have Wi-Fi 6 capability and it's expected that IIoT end node devices featuring Wi-Fi 6 capability will begin picking up momentum in 2023.

Some of the main advantages and differentiation of Wi-Fi 6 in comparison to the previous generation include:

- **Larger Number of Coexisting Devices in a Dense Environment (OFDMA, MU-MIMO)**

  The biggest advantage of Wi-Fi 6 is that it can support many coexisting devices in a dense environment even in the 2.4 GHz spectrum due to OFDMA and MU-MIMO. This enables a large number of IIoT devices to coexist in the 2.4 GHz spectrum without having to move to 5 GHz or 6 GHz, which adds to the cost and power.

  Applications that will significantly benefit with from this newly introduced feature are the clinical medical, power tools, and industrial wearables.

- **Lower Power Consumption Due to Target Wake Time (TWT)**

  Target wake time is a newly introduced feature in Wi-Fi 6 and enables end devices to wake up at target times and look for data instead of periodic wake times. This reduces power consumption substantially, which is critically important for all battery-powered devices.

  This will make a difference for asset trackers, clinical medical, power tools, HVAC, industrial wearables, and body worn camera applications.

The Leader in Low-Power Wi-Fi Solutions for IIoT Applications

Wi-Fi will increasingly penetrate the Industrial market due to the rise in connected devices, the increasing data needs, and the need for a protocol that's interoperable with multiple devices. Silicon Labs offers IoT Wi-Fi 4 products today and we are the industry leader in low power Wi-Fi + Bluetooth/ Bluetooth LE and in small form-factor designs. Our products offer integrated wireless stacks, networking stacks, cloud connectivity, and best-in-class security for IoT. Our IoT Wi-Fi 6 products, which will include SoCs and modules, will be coming in 2023. For more about the potential we see for Wi-Fi, check out our whitepaper, The Future of Wi-Fi in Low-Power IoT Devices.

Explore our low-power Wi-Fi products.

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