

Designing with ultra-low-power Wi-Fi

5 Things you need to know to get started



INTRODUCTION

In the Internet of Things (IoT), devices and objects that were once autonomous are now connecting to each other, to the Internet, and in many cases, both. Many of these devices are battery powered and the more sophisticated and feature-rich the device, the more power it consumes. In this IoT world of battery powered devices, longevity and extended stay-on power is critical and expected.

For device makers, choosing the right low-power wireless technology is the core of the design and in many use cases, battery-friendly Wi-Fi is the best option.

1: The Highs and Lows of Wi-Fi

Wi-Fi provides reliable wireless connectivity for both low and high bandwidth applications. Historically known for the technology's complex radio scheme comprised of supporting various data rates, modulation techniques and range, Wi-Fi power consumption has been considered relatively high in comparison to other technologies, such as Bluetooth.

So, how can Wi-Fi be an option for battery operated devices that demand low-power consumption?

Telit has implemented system power saving schemes apart from the Wi-Fi IEEE 802.11 protocol defined schemes¹. These proprietary system power saving enhancements optimize low-power consumption and are compliant with the IEEE standards, ensuring interoperability with other devices in the network.

Most people are familiar with the standard Wi-Fi system current consumption typically used in laptops. Now, with the IEEE specification for low-power consumption and the proprietary ultra-low-power Wi-Fi solution from Telit, Wi-Fi can now be leveraged for applications that demand the benefits of Wi-Fi and low current.

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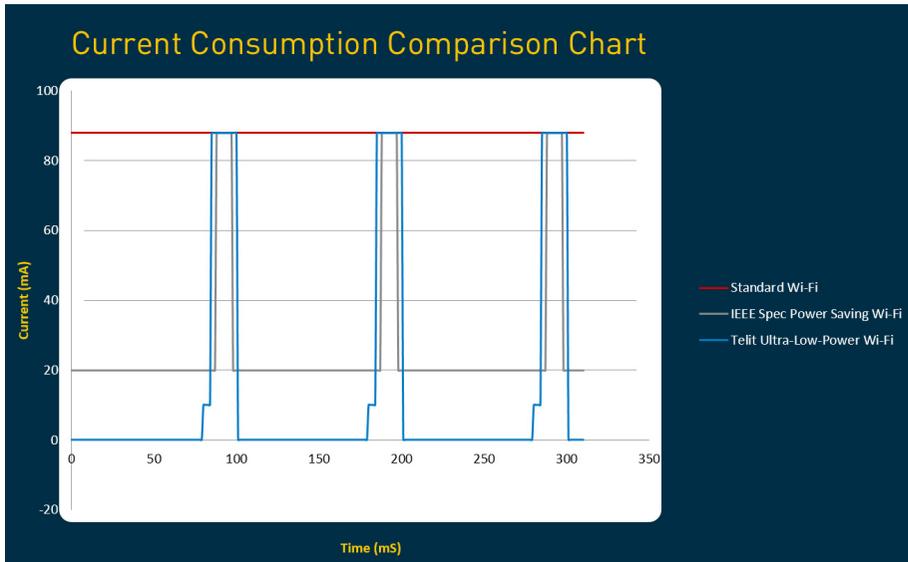


Figure 1 – Current Consumption Comparison

The graph elements shown in Figure 1 demonstrate the reception of beacon frames periodically every 100ms. The Telit System on Chip (SoC) (blue line) remains in ultra-low-power standby mode (2.4 – 8uA) by maintaining association with the access-point and secured connection with cloud. Notice the significant improvement with Telit’s technology.

Use Case: Data Collection over Wi-Fi

Consider a scenario in which the Wi-Fi device checks data availability from the cloud server every second (DTIM10). In this example, the ultra-low-power solution from Telit saves ~97% of the power compared to the power saving schemes defined by IEEE spec alone.

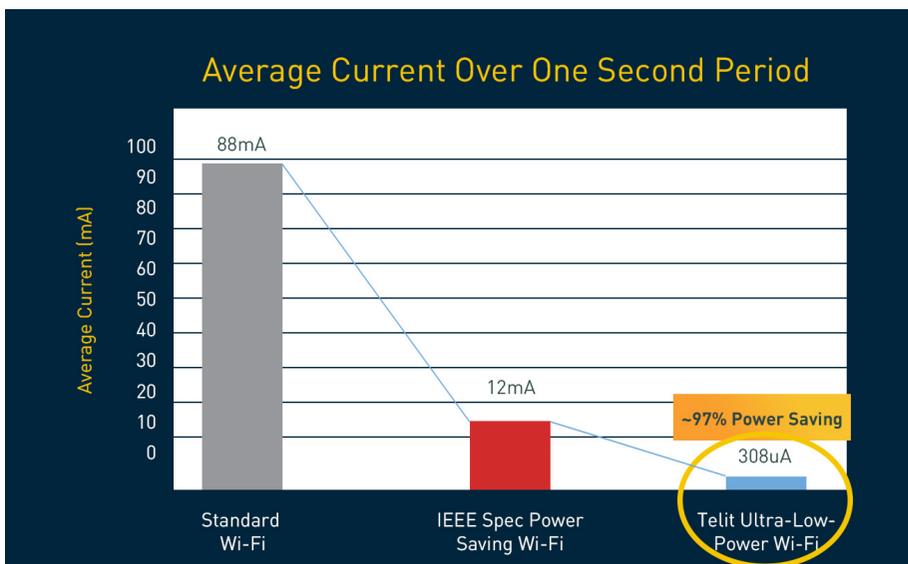


Figure 2 – Average Current Consumption per Second

With this advancement in Wi-Fi, millions of battery operated devices can benefit from Wi-Fi security while easily becoming “smart” and directly accessible from laptops, mobile phones, cloud etc. With ultra-low-power Wi-Fi, best in class security schemes such as HTTPS are built in. The IP, on which both internet and Wi-Fi is built upon, enables seamless, secure connectivity across devices anywhere in the globe, without any additional network infrastructure — unlike other competing technologies such as Bluetooth or ZigBee.



Figure 3 – You can use AA battery operated devices with ultra-low-power Wi-Fi

High data bandwidth Wi-Fi is not necessarily limited to applications such as video/audio streaming. There are a handful of scenarios in which high data bandwidth is preferred. Battery operated low bandwidth applications benefit from this feature including Over-The-Air firmware upgrades, provisioning, and other actions.

This unique combination of standard Wi-Fi capabilities with ultra-low-power enable IoT devices to operate on AA batteries which eliminates the need for a wired power connection while making rapid deployment possible.

2: Less is More

No other System on Chip (SoC) is designed to work the way the Telit ultra-low-power Wi-Fi does. Let's take an inside look at the technology.

Telit leads the industry in design and performance due to a unique combination of hardware and software:

- 1. A proprietary and highly integrated System on Chip (SoC) hardware architecture featuring dual embedded processor cores**
- 2. An efficient partitioning of embedded Wi-Fi System Software which runs on the SoC hardware platform**

Converging these two elements takes Wi-Fi ultra-low-power saving schemes to a game changing level.

3: Hardware – What to Look For

There is an intelligent base design behind the Telit dual-core SoC solution: one dedicated for Wi-Fi and the other for IoT applications. The combination offers a wide range of peripherals (I/O) to realize a complete IoT product without the help of an external MCU. For starters, the efficient integration of CPUs, memory, peripherals, MAC, PHY and particularly RF block in a single die significantly minimizes the need of external components (e.g. crystal) for a system design, thereby reducing the design complexity, BOM cost and cycle time.

It's all about the Gate

The most advanced feature and the differentiating factor of Telit SoC, is its capability to power gate (dynamically power up and power down) and clock gate (selectively providing the clock) each of the sub systems within the silicon, thereby saving a significant amount of power. These ultra-low-power modes include 'Deep-Sleep', 'Standby' and 'Hibernate', which consumes ~440uA (micro amperes), ~2.4-8uA (micro amperes) and ~260nA (nano amperes) respectively.

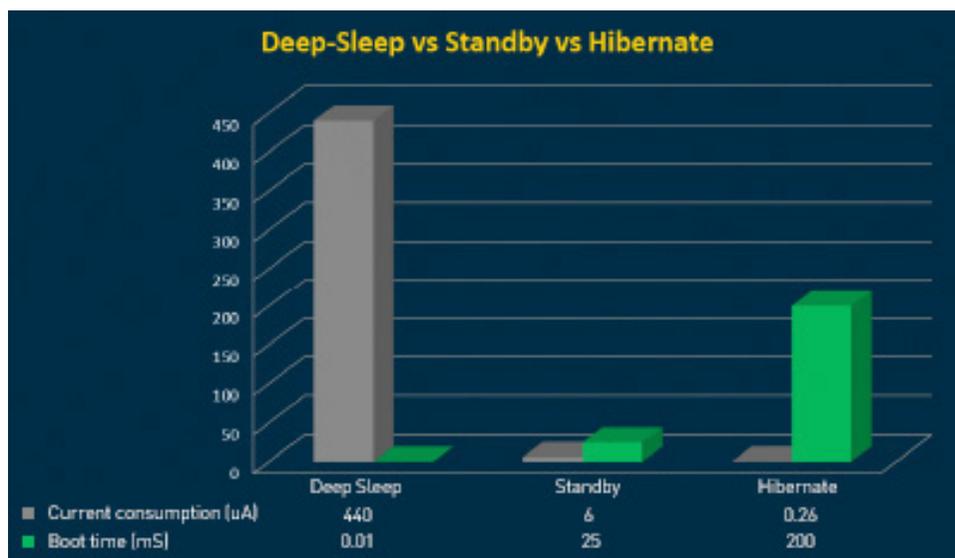


Figure 4 – Current consumption vs boot time with ultra-low-power modes.

Mode Comparison

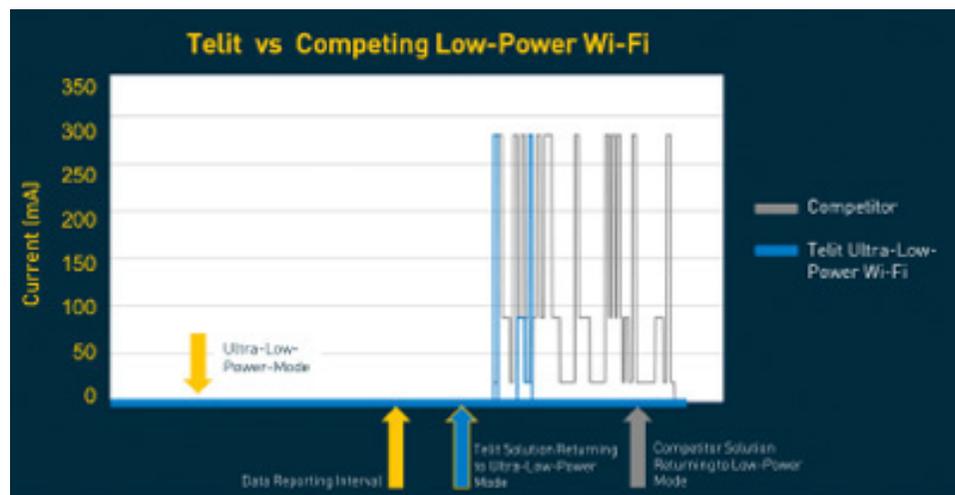
	Hibernate	Standby	Deep-Sleep
System current Consumption	260 nA	2.4-8 uA	440 mA
Connection to the access-point/router maintained?	No	Yes	Yes
Connection to the cloud server maintained?	No	Yes	Yes
Events to exit from this mode			
- Trigger from external sources (e.g. MCU, sensors, etc.)	Yes	Yes	Yes
- Trigger from internally pre-configured timer	No	Yes	Yes

Use Case: Temperature Sensor

A typical scenario of a temperature sensor uploading its status to the cloud server occurs every 5 minutes over a secured (HTTPS) tunnel.

The advanced capability of Telit's solution maintains association status with the access-point and secured communication (HTTPS) with the cloud server across Standby and Deep-Sleep modes. This enables IoT devices to reserve considerable battery capacity compared to competing solutions which typically don't support either of these. Hence, non-Telit devices regularly re-establish the association and secured connectivity to the cloud server at each data reporting interval which consumes a lot of power.

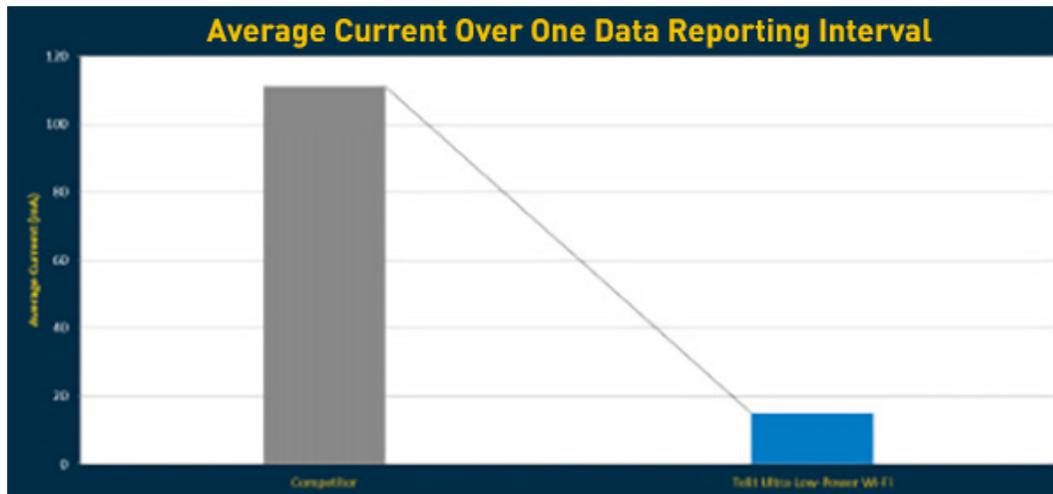
Notice the sequence of events detailed in Figure 5 below. Each data reporting interval between devices is shown as powered by Telit (blue) and competing solutions (gray).



Telit: Wake up, data exchange and return to ultra-low-power mode

Wake up, associate, acquire IP, cloud connect, data exchange, and then return to low-power mode

Figure 5 – Telit vs Other Low-Power Wi-Fi



5-minute data reporting intervals reveal about ~85% power savings with Telit devices.

Quick start-up for IoT products is essential, especially for time-sensitive use cases such as intrusion detection systems for security. With the Telit SoC, instant boot-up occurs because both CPUs are booting up simultaneously from low-power modes.

Use Case: Security System – Intrusion Detection

A system powered by Telit reports intrusion detection to the cloud within 25 ms of its occurrence over HTTPS. This is made possible by the synergy of its ultra-low-power standby mode (which consumes <2.4 to 8µA (micro amperes)) and advanced capabilities. These features include hardware cryptographic modules (separate for HTTPS and Wi-Fi) and execution of instructions by the CPU using the internal oscillator (RC).

4: Firmware – What to Look For

To ease the firmware development process, Telit developed a platform called embedded platform software (EPS), which absorbs all the complex low-power schemes within, exposing the simple APIs (application programming interface) to the IoT application developer. This alone cuts development time considerably.

The platform software complements the ultra-low-power silicon with its high-power optimized operating system, protocol stack, network services and security subsystem (popularly known as supplicant). It supports a wide range of IoT protocols from discovery of devices in local network (e.g. mDNS) to secure exchange of data with the cloud server (e.g. HTTPS, MQTT, TCP etc.). The security module in the platform software is best in class by supporting enterprise grade security with the local access point and offers end-to-end security with the cloud server over TLS/SSL (supporting up to 4K RSA certificates).

IoT cuts across varied industries and the Telit platform software abstracts all low-level Wi-Fi details from the application developer so that the developer is able to focus on solving real world issues rather than getting lost in the details of Wi-Fi and IP world. Similarly, platform software also supports industry specific protocols like RTSP/RTP for video streaming, Apple® Airplay and DLNA® for music, Apple HomeKit, etc.

To ease the firmware development cycle, the Telit platform software provides production-ready utility modules which can be easily integrated with customer IoT applications for various needs.

To name a few:

Power management module: Searches for opportunities to transition the system to the lowest possible power mode.

Framework: Loads only relevant code (in to the RAM) for execution, thereby saving significant time and resources.

Connection management module: Offloads customer software from the details of wireless communication.

The platform software includes pre-built libraries for OTA firmware upgrades and provisioning (i.e. configuration of access-point credentials to the device), making it a complete package for IoT application developers.

2 Flavors: Hosted vs Host-less

Telit provides two types of low-power system solutions: Host-ed and Host-less.

Hosted Solution: An IoT product, where an external MCU is controlling the Telit silicon.

Telit offers a standard firmware (named as S2W-Serial2WiFi), which parses and processes the 'AT' instructions (commands) given by the MCU through serial peripherals (UART/SPI/SDIO). This firmware could be customized online in the Telit support portal before downloading the pre-built binary.

Host-less Solution: An IoT product, which is completely engineered in the Telit silicon (without an external MCU).

Accelerate the firmware development process and demonstrate all low-power capabilities with the Telit 'close to production', 'cloud-integrated', low-power reference application, which demonstrates three very distinctive real world use-cases.

This allows developers to configure the parameters of these use cases (e.g. the frequency of temperature data updates to the cloud) through a web-based tool in the Telit portal for customized binary and quick evaluation (Figures 7 and 8).

Module Information
Module: G52011 M2/M3E v3.0 or later | Firmware: G5GPS v5.3.0 Pre-Beta2 | Application: TLS Low Power AEM (Hostless) | Build Output: Custom Package

SRAM SUMMARY	
APP CPU SRAM Total	512KB
APP CPU SRAM Available	0KB
WLAN CPU SRAM Total	512KB
WLAN CPU SRAM Available	0KB
RTC NVRAM Available	0KB



FLASH SUMMARY	
Internal Flash Total	4096KB
Internal Flash Available	3009KB
External Flash Total	None
External Flash Available	None

Product Info | **Connectivity Conf** | Provisioning Conf | System Configuration | Battery Life Calculator ▶

Application Description:

Does the product periodically update data to the server?
 Yes No
 Frequency of data upload: Minutes
 Data Type: Temperature/Light sensor data Pre-defined data/No sensor?
 Data Size: (Bytes)
 Data Format:

Does the product update asynchronous events to the server? ?
 Yes No
 Frequency of events: times per Day
 Data Size: (Bytes)

Does the product receive asynchronous data from Internet/Intranet?
 Yes No

Make informed decisions with the product life time estimator tool, which help developers determine the battery capacity needs of the product in development.

SDK Builder | Build History | About Tool | Release Notes

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◀ Connectivity Conf | Provisioning Conf | **System Configuration** | Battery Life Calculator | Summary

Calculate Battery life for Current Config:

Battery Life : 5.68 Years

Assumptions:

1. Re-associate with access-point every hour.
2. Re-negotiate IP with DHCP server every hour
3. Re-establish socket connection (HTTPS or UDP) with cloud server every hour
4. Cloud server doesn't tear down the socket connection (HTTPS or UDP)
5. Operating environment isn't accounted for battery life computation and is considered to be clean with no interference and hence no re-transmissions
6. Premises (indoor or outdoor) isn't accounted for battery life computation.
7. Range (distance between AP and device) isn't accounted for battery life computation

The use cases demonstrated by the reference application covers three board categories of devices:

1. IoT devices which report status to the cloud periodically (once every 5 minutes). Typical devices are (smoke/temperature/humidity sensors etc). Such a solution shall be able to provide 5+ years of battery life with 5 min cloud updating interval with 2*AA batteries worth 2000mAh.
2. IoT devices which report status to the cloud upon an event. Typical examples are intrusion detection sensors, occupancy sensors/motion sensors etc. Such a solution shall be able to provide 10+ years of battery life for 24 events per day with 2*AA batteries worth 2000mAh.
3. IoT devices which always need to be accessible from the cloud. Typical examples are video doorbells, security cameras, door locks etc. Such a solution is able to provide 6+ months of battery life for 24 queries from the cloud per day with a response time of 2 seconds, using 2*AA batteries worth 2000mAh.

5: The Power Specs that Really Matter

Why does Telit offer an elaborate evaluation test bench? Simply put, it's easy to misguide engineers by citing transmit and receive power numbers in a datasheet. What really matters is the average system power consumption, since typical battery powered IoT products spend a fair amount of time (~90+%) in low-power modes instead of radio (transmit or receive) operational modes.

The non-cellular dependent arm of IoT for many IoT scenarios is Wi-Fi. It is the ideal choice for a handful of reasons, including IP and security. Road blocks with Wi-Fi have placed developers in limbo as they look for solutions which extend the life cycle of battery operated devices. Telit makes ultra-low-power Wi-Fi possible for the IoT by offering industry-leading solutions with technical capabilities not found in the market. The proprietary combination of the company's SoC and EPS deliver power savings up to ~97% beyond the IEEE specification.

CONCLUSION

This advanced level of engineering intelligence cuts development time and resources enabling developers to harness the power of intelligent, high performance modules to reach their design goals. Telit ultra-low-power certified Wi-Fi modules deliver significant cost savings due to less time and investment on app development and external components.



Simplify and Accelerate
Your Development Time.
Stop piecing together a fragmented solution.

START NOW WITH A FREE EVALUATION KIT →

Sources:

(1) Power saving schemes of Wi-Fi is defined in 'IEEE 802.11-2012': Wireless-LAN MAC (Medium Access Control) and PHY (Physical Layer) specification from Institute of Electrical and Electronics Engineers (IEEE) standards committee (IEEE 802).

Note:

- Wi-Fi Alliance (a non-profit organization that promotes Wi-Fi technology) do offer 'WMM®-Power Save' certifications as part of its drive for interoperability and quality user experience.
- WMM®-Power Save' specification from Wi-Fi Alliance Technical committee is a subset of IEEE 802.11e amendment in IEEE-802.11 spec.