4 Tips to Optimize IoT Device Battery Life

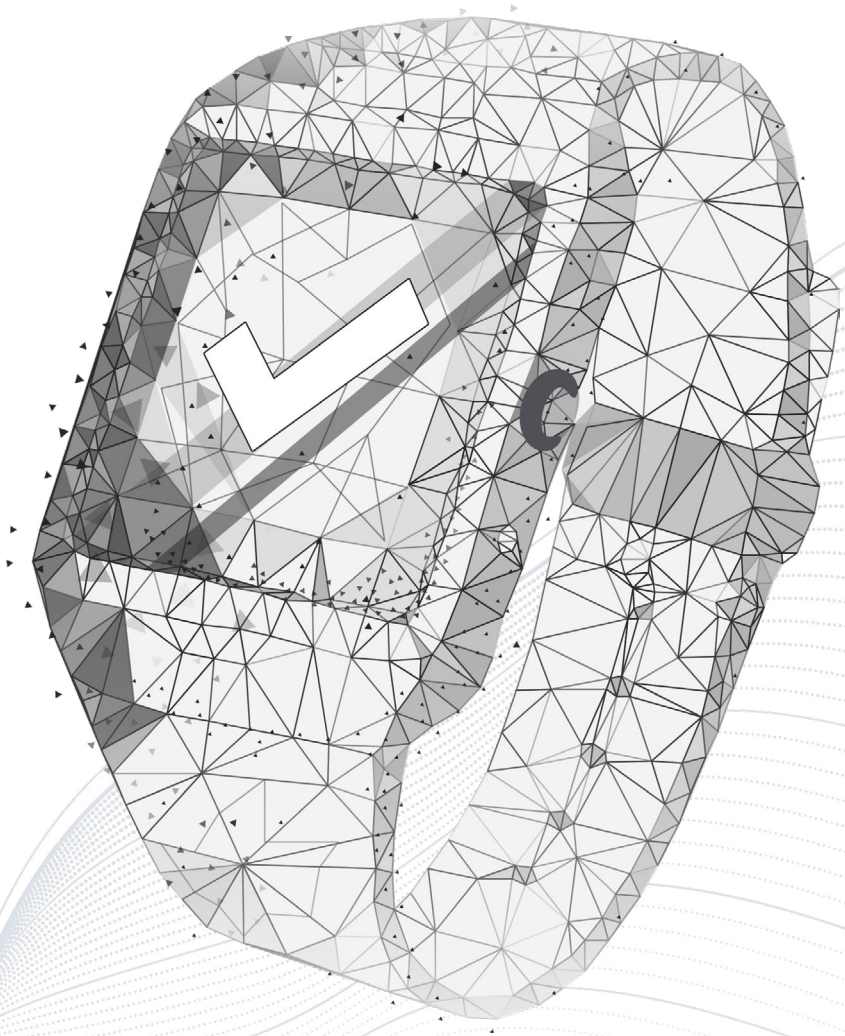
KEYSIGHT TECHNOLOGIES

Battery Life Is IoT Device Life

Battery life is one of the most important considerations for IoT devices. It's easy to understand why. Consumers often expect long battery life for their applications and devices. Smart agriculture and industrial sensors, for example, must work for long periods of time between charges—often 10+ years. For wearable medical devices such as pacemakers, where device life can mean the difference between actual life or death, battery failure is not an option.

Long battery life is a huge differentiator in consumer buying decisions. Devices with unexpectedly short battery life can damage a company's brand, lead to decreased sales, and even cause a costly recall that destroys a company's economic viability. And while batteries are cheap, replacing them is not. Replacing batteries often costs more than the cost of the entire IoT device.

Explore this eBook to discover the steps you can take today to optimize the battery life in your IoT devices.



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TIP 1

Test Devices Correctly in the Lab

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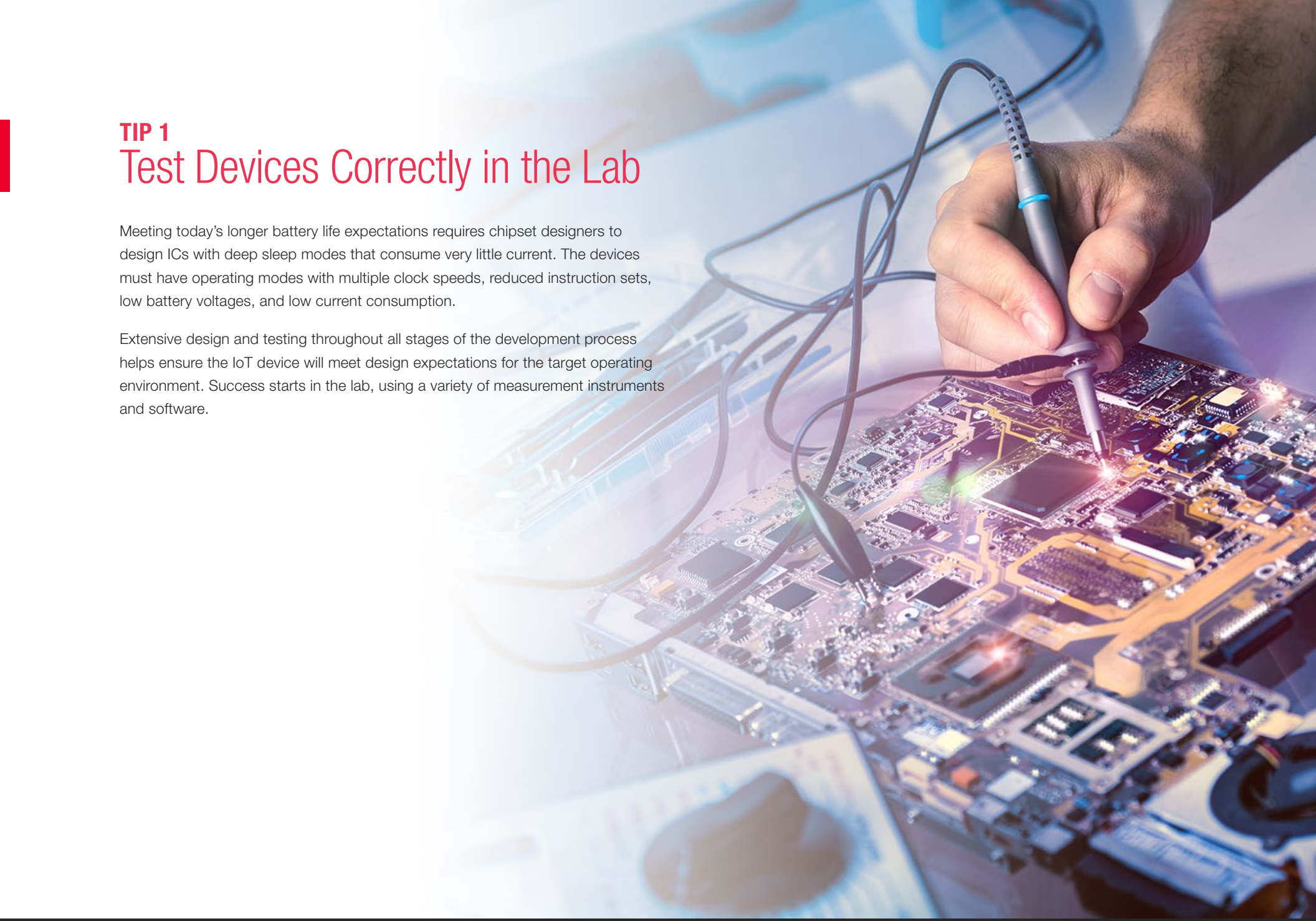
Test Devices Correctly in the Lab

Meeting today's longer battery life expectations requires chipset designers to design ICs with deep sleep modes that consume very little current. The devices must have operating modes with multiple clock speeds, reduced instruction sets, low battery voltages, and low current consumption.

Extensive design and testing throughout all stages of the development process helps ensure the IoT device will meet design expectations for the target operating environment. Success starts in the lab, using a variety of measurement instruments and software.



Measure Current with Sufficient Dynamic Range and Precision

To maximize battery life, IoT devices generally spend the majority of their time in standby or sleep mode, activating only at brief intervals to send or receive data. In active mode, an IoT device may draw up to hundreds of milliamperes, while in sleep mode, the device will draw only microamperes or nanoamperes.

To prevent unnecessary current drain, careful characterization of your device's dynamic current consumption is critical. You must be able to measure low currents accurately, and switch to high current measurements quickly. With the right measurements, current drain provides a window for gaining deeper insight you can use to optimize your battery's run time.

Recommendation

Use a measurement instrument with dual ranges or seamless ranging to avoid errors due to range changing. Make sure it can accurately measure over a wide dynamic range and handle a 1,000,000:1 ratio between minimum and maximum current levels.

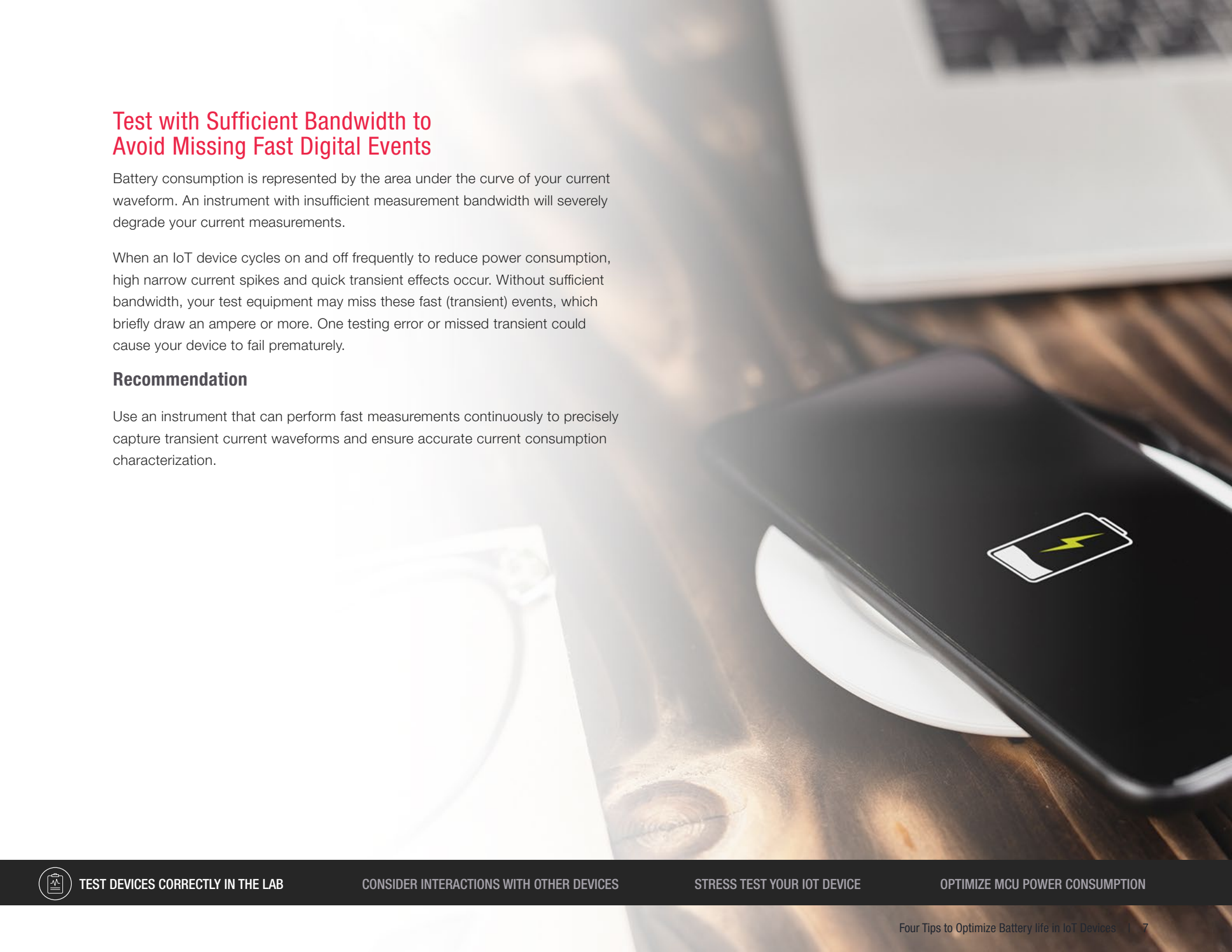
Test with Sufficient Bandwidth to Avoid Missing Fast Digital Events

Battery consumption is represented by the area under the curve of your current waveform. An instrument with insufficient measurement bandwidth will severely degrade your current measurements.

When an IoT device cycles on and off frequently to reduce power consumption, high narrow current spikes and quick transient effects occur. Without sufficient bandwidth, your test equipment may miss these fast (transient) events, which briefly draw an ampere or more. One testing error or missed transient could cause your device to fail prematurely.

Recommendation

Use an instrument that can perform fast measurements continuously to precisely capture transient current waveforms and ensure accurate current consumption characterization.

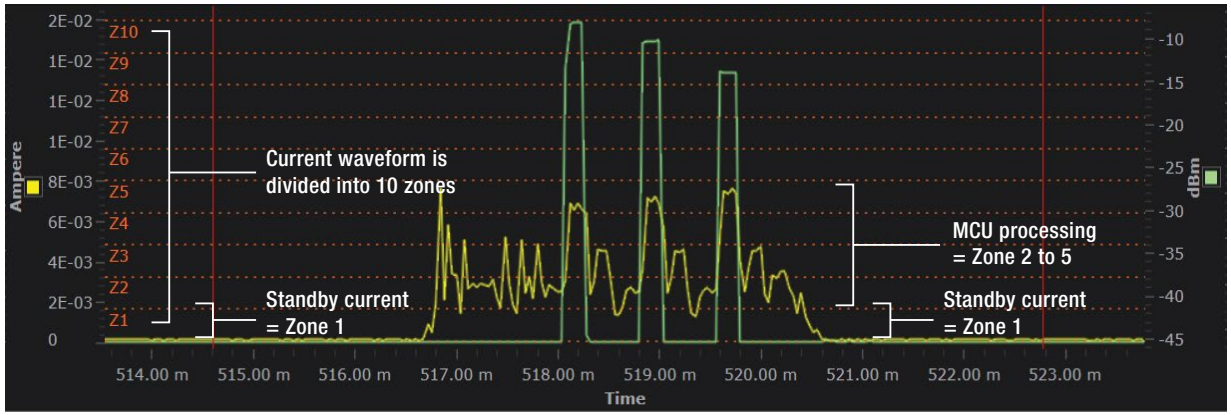


Consider The Effect of Your Firmware Choices and Updates

Long battery life depends on both hardware and firmware design. Firmware programmers require appropriate tools to measure the effects of their programming decisions. If these decisions are not well understood, battery life may be adversely impacted.

Recommendation

Use software that can provide you information on how often your device operates at various current levels. Use a tool capable of dividing your current waveform into segments and displaying detailed statistics for each segment, including charge consumed. Finally, consider using a measurement instrument with digital I/O lines that will allow you to trigger and stop measurements based on events within your device.



RF or DC event analysis with Keysight's KS833A1A/KS833A1B event-based power analysis software

Correlate Charge Consumption with RF Events

Understanding how an IoT device spends its charge when operating in real-world conditions is critical to optimizing battery life. Correlating the device's current consumption to a specific RF event makes it easier to identify which subsystems or events to optimize.

Recommendation

Perform event-based power analysis using a measurement instrument and software that allows you to capture RF and/or sub-circuit events from your IoT device. Then, synchronously match the captured events to the device's current waveform. This process enables you to easily identify the subsystems or events requiring optimization to extend the battery life of your device.

Synchronous correlation between the RF power (waveform in green) and current consumption (waveform in yellow)

Synchronous correlation between the LED supply voltage (waveform in blue) and current consumption (waveform in yellow)

Event-based power analysis with Keysight's X8712A IoT Device Battery Life Optimization Solution

TIP 2

Consider Interactions with Other Devices

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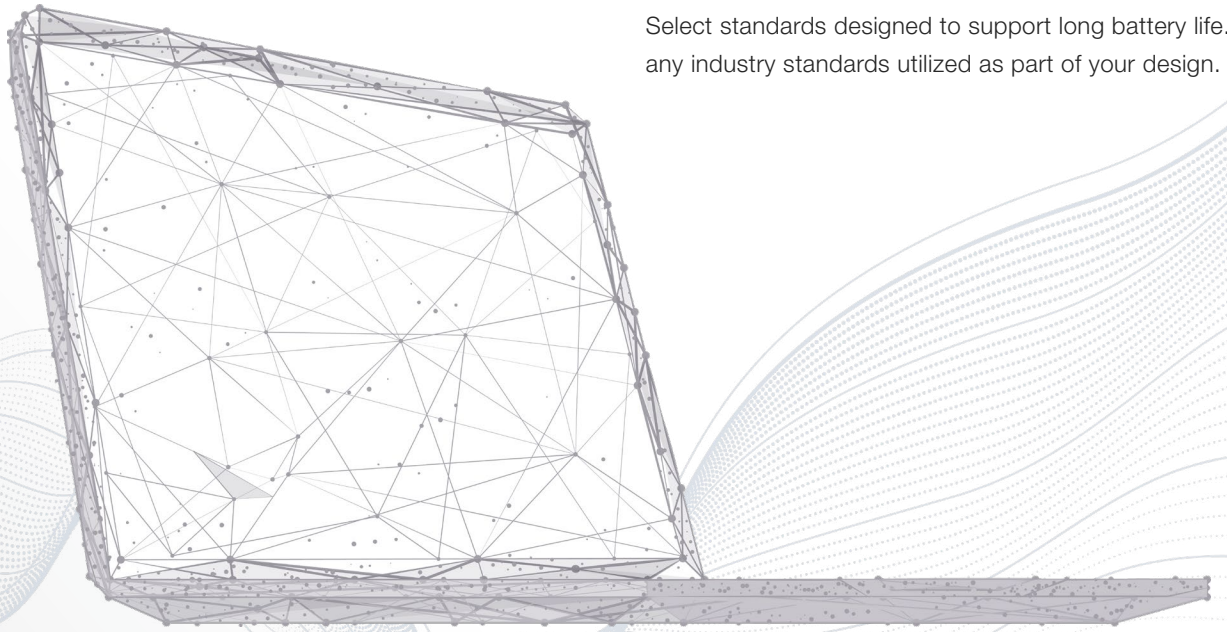
When wireless technologies share similar frequency bands, co-channel and adjacent channel interference can occur, resulting in dropped network connections and failed transmissions. In response, the IoT device continually attempts to reconnect to the network or to retransmit data—both of which can excessively drain a device's battery. The best way to avoid this situation is to consider how your device will interact with other devices in its environment and to design for sharing spectrum to avoid collisions and repeat transmissions.



Comply with Relevant Standards

The standards developed by many regulatory and standards bodies impact your product design. Some are even intended to offer longer battery life. Failure to comply with these standards increases end user risk, potentially impacting your company's brand and driving up costs when recalls or fines are imposed.

Recommendation

Select standards designed to support long battery life. Verify compliance to any industry standards utilized as part of your design.

Don’t Infringe on Your Neighbor’s Bandwidth

IoT devices often use different wireless communications protocols while operating over the same spectrum. Multi-radio interference can negatively impact battery life. In environments with many interferers, getting a signal from an IoT device through requires more power, which impacts the device’s transmission efficiency and reduces its battery life.

Recommendation

Ensure your device’s performance won’t be threatened by spectrum hogging competitors with these steps:

- Comply with FCC requirements
- Ensure your device’s transmission frequency accuracy is as tight as reasonably possible
- Avoid unnecessarily powerful transmissions
- Ensure your device only transmits when it has useful data

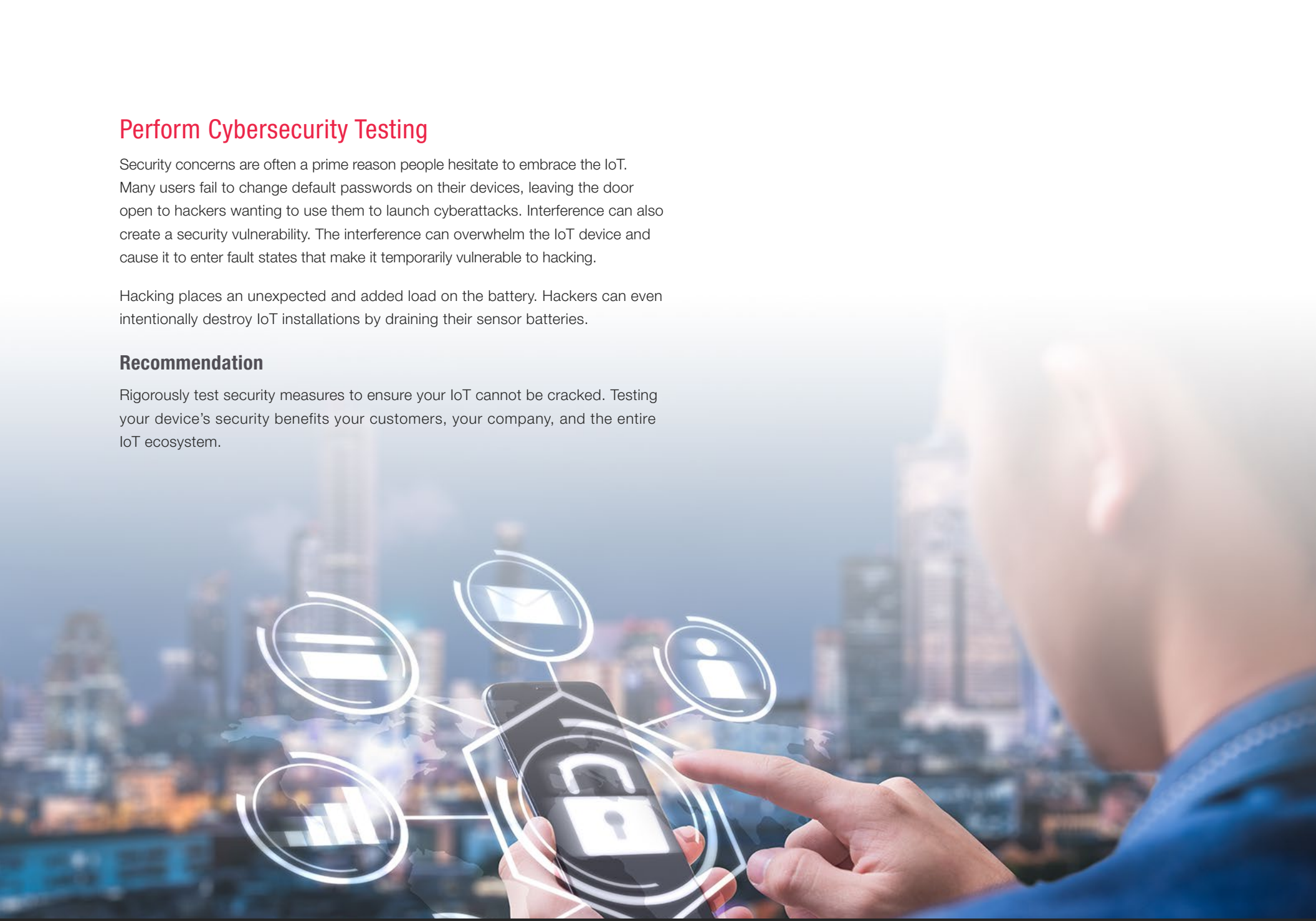
Perform Cybersecurity Testing

Security concerns are often a prime reason people hesitate to embrace the IoT. Many users fail to change default passwords on their devices, leaving the door open to hackers wanting to use them to launch cyberattacks. Interference can also create a security vulnerability. The interference can overwhelm the IoT device and cause it to enter fault states that make it temporarily vulnerable to hacking.

Hacking places an unexpected and added load on the battery. Hackers can even intentionally destroy IoT installations by draining their sensor batteries.

Recommendation

Rigorously test security measures to ensure your IoT cannot be cracked. Testing your device's security benefits your customers, your company, and the entire IoT ecosystem.



TIP 3

Stress Test Your IoT Device

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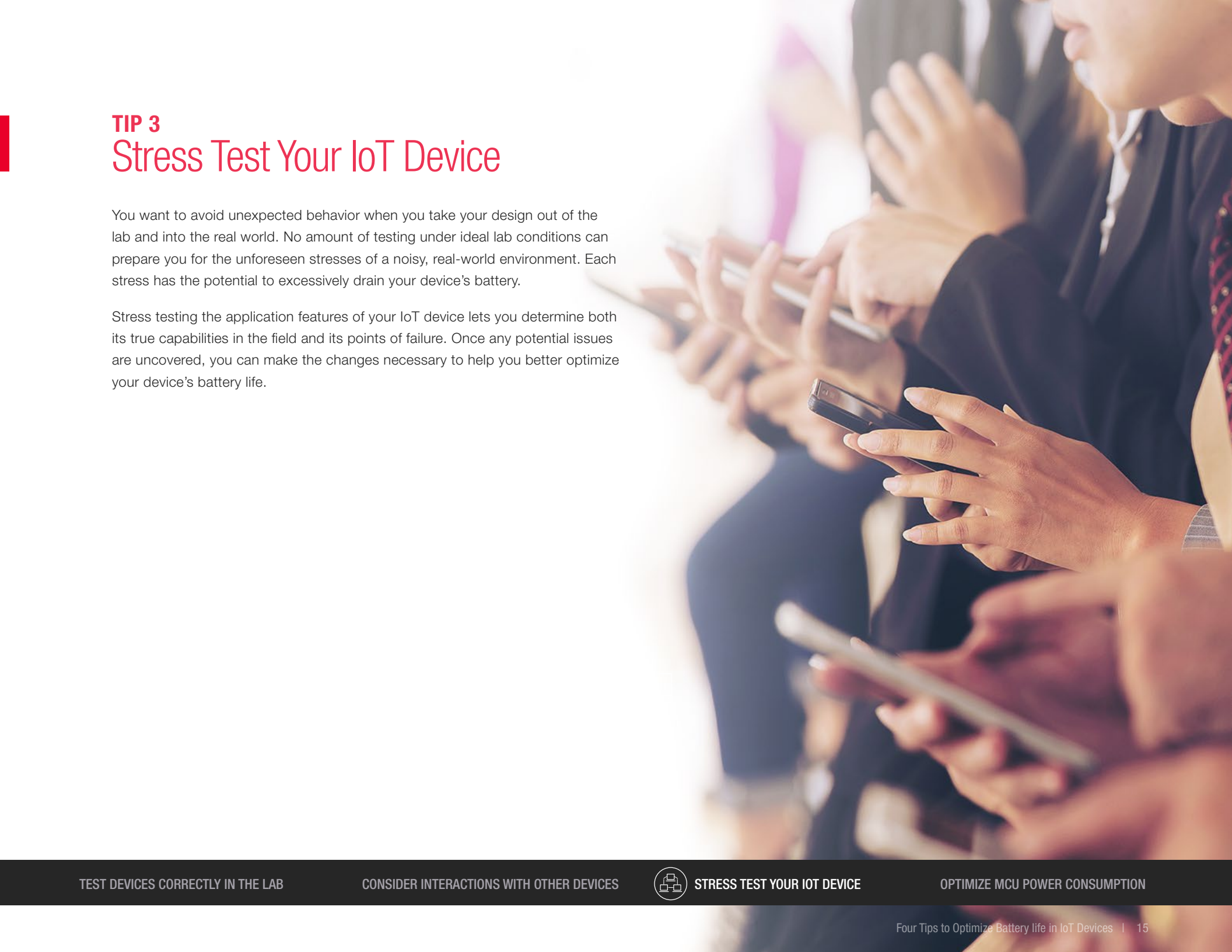
You want to avoid unexpected behavior when you take your design out of the lab and into the real world. No amount of testing under ideal lab conditions can prepare you for the unforeseen stresses of a noisy, real-world environment. Each stress has the potential to excessively drain your device's battery.

Stress testing the application features of your IoT device lets you determine both its true capabilities in the field and its points of failure. Once any potential issues are uncovered, you can make the changes necessary to help you better optimize your device's battery life.

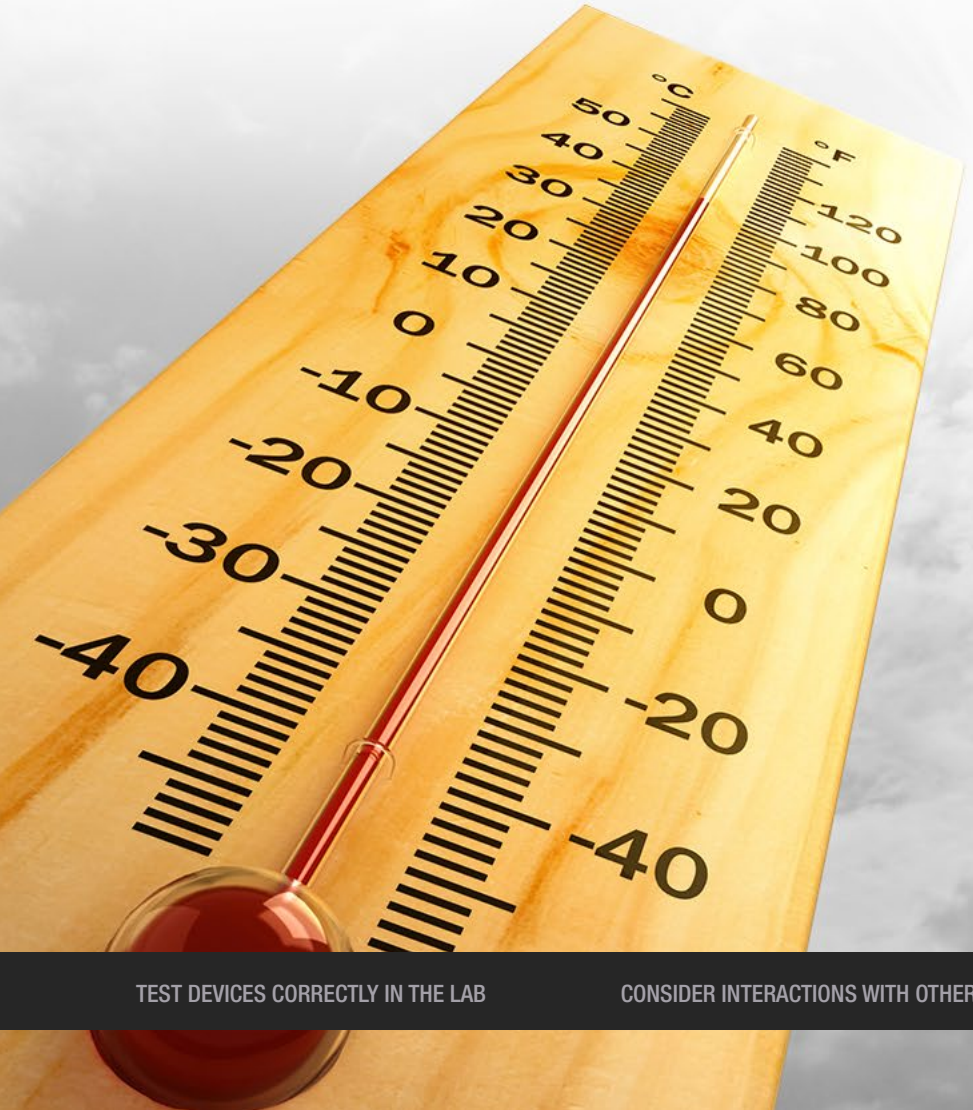


Test Under Extreme Environmental Conditions

Battery life varies with temperature and humidity. Heat kills a battery quickly. If the battery is stressed with frequent discharge, service life can drop dramatically.

Recommendation

Accurately measure power consumption across the range of temperature, humidity, and other conditions it will experience, during operation as well as during shipping and storage.



Test Coexistence with Other Wireless Standards

Different wireless standards and applications share the same frequency bands. Standards-based traffic, intensive use of unlicensed or shared spectrum, and high-density device deployments can all cause unavoidable interference, negatively impacting battery life.

Recommendation

Perform coexistence testing on your IoT device to ensure it is robust and will work all the time, every time, with consistent and predictable battery performance.

READ NOW

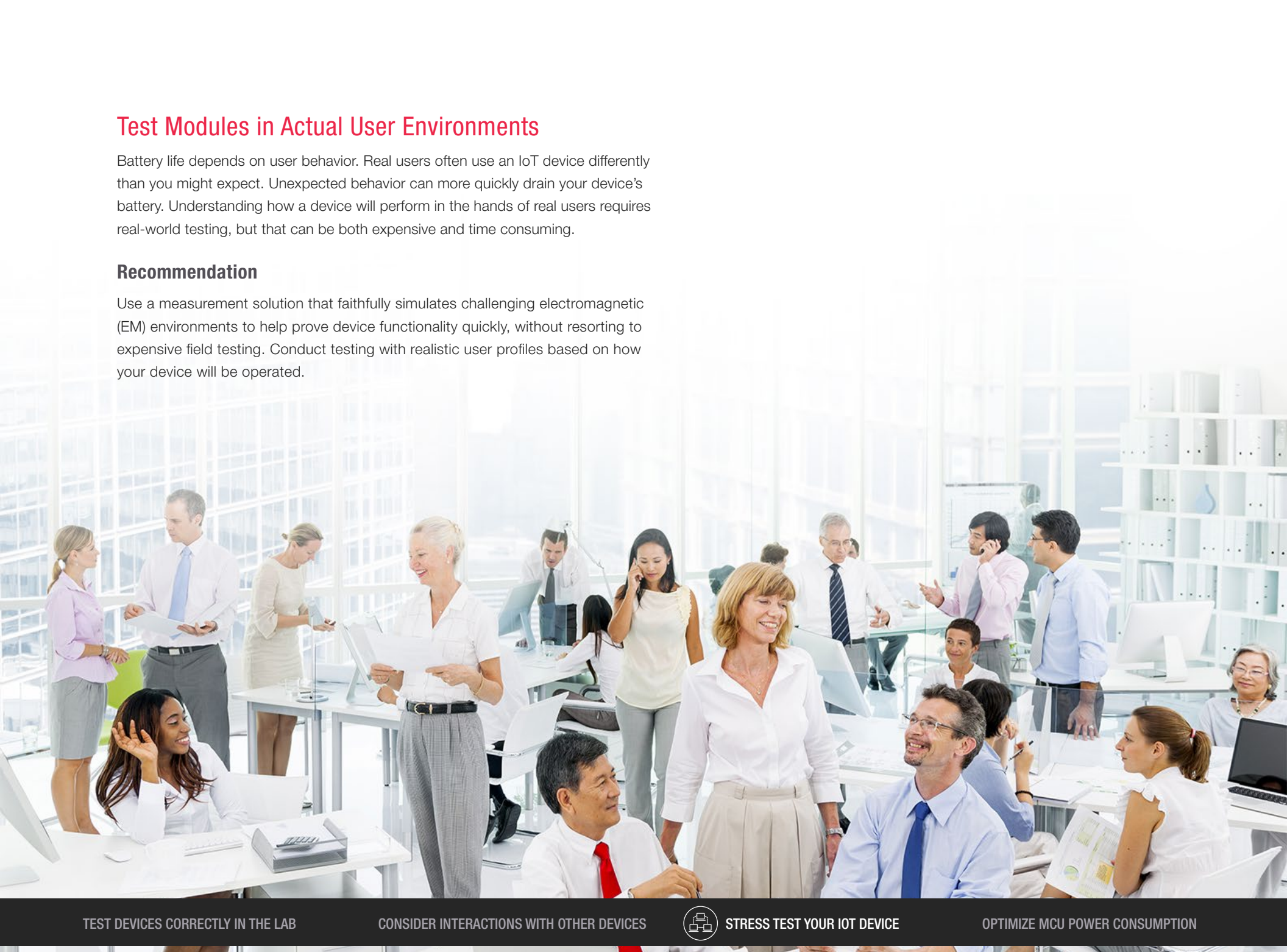
For more information on coexistence testing, check out the eBook: How to Ensure IoT Devices Work in Their Intended Environment

Test Modules in Actual User Environments

Battery life depends on user behavior. Real users often use an IoT device differently than you might expect. Unexpected behavior can more quickly drain your device's battery. Understanding how a device will perform in the hands of real users requires real-world testing, but that can be both expensive and time consuming.

Recommendation

Use a measurement solution that faithfully simulates challenging electromagnetic (EM) environments to help prove device functionality quickly, without resorting to expensive field testing. Conduct testing with realistic user profiles based on how your device will be operated.



Test in Difficult Electromagnetic Environments

An IoT device working perfectly on your bench may fail in the field due to a congested EM environment, among other factors. Attempting to squeeze large numbers of users onto a limited band of licensed spectrum creates co-channel and adjacent channel interference. Many interferers result in reduced transmission efficiency and reduced battery life.

Recommendation

Test for co-channel and adjacent channel interference rejection. Also, test for immunity from hostile and inadvertent interferers, including EM fields produced by heavy industrial equipment and even common appliances, like microwave ovens.

TIP 4

Optimize MCU Power Consumption

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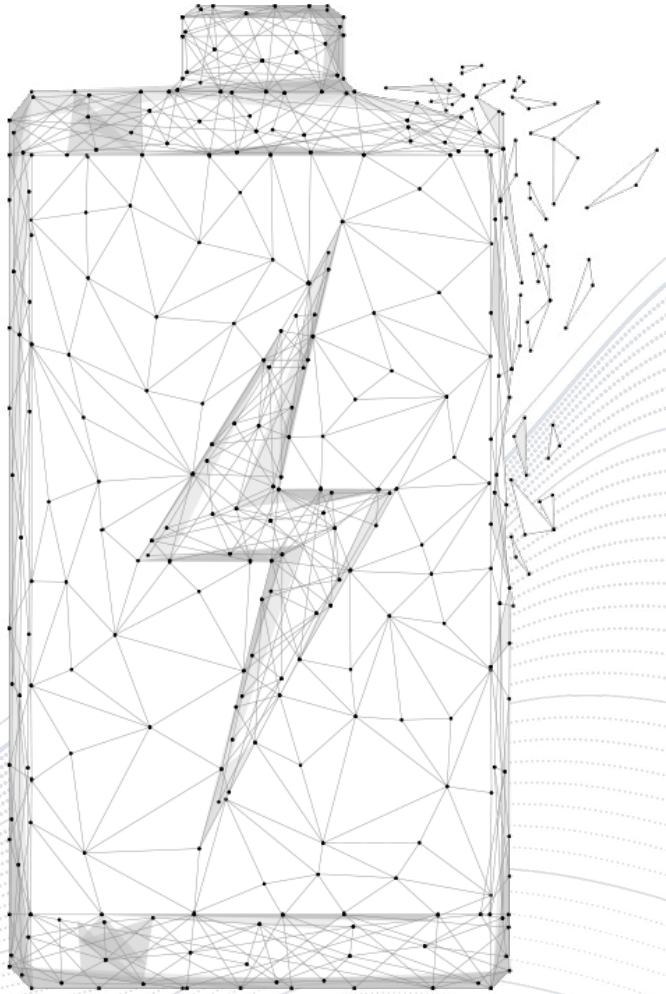
As a device designer, you want to select an energy efficient microcontroller unit (MCU). You should carefully configure and program your device's MCU to optimize the battery lifetime, and test to confirm your design and code.



Choose Your MCU Options Wisely

Every MCU has options. Your choices greatly influence your device's current consumption.

Recommendation

Choose options that minimize current consumption:

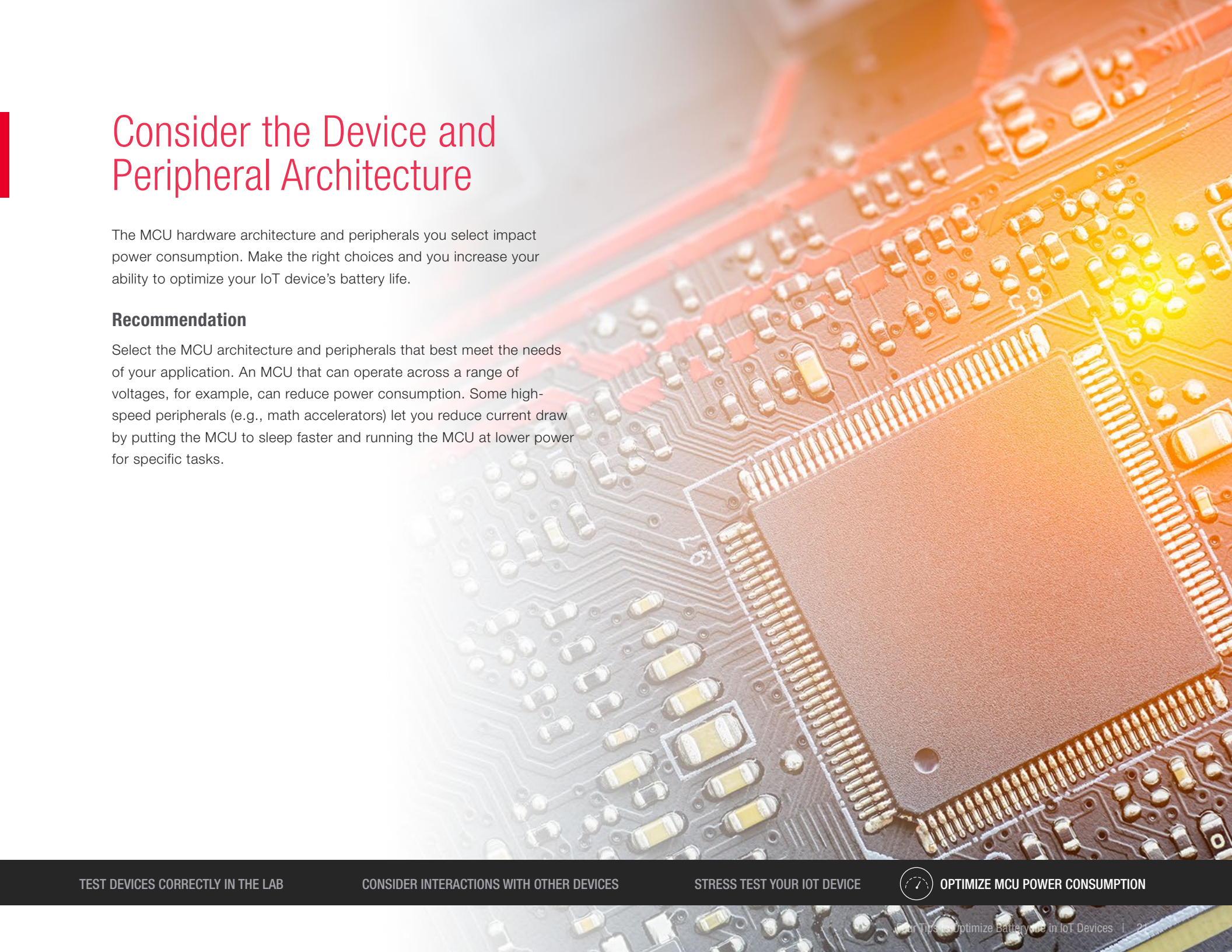
- Increase the amount of time your device spends in low-power sleep states
- Where possible, disable power to unused RAM
- Choose memory technology that minimizes battery power draw and still provides acceptable application performance
- Select an MCU with different speeds and types of timers and clocks to give you many ways to adjust battery drain

Consider the Device and Peripheral Architecture

The MCU hardware architecture and peripherals you select impact power consumption. Make the right choices and you increase your ability to optimize your IoT device's battery life.

Recommendation

Select the MCU architecture and peripherals that best meet the needs of your application. An MCU that can operate across a range of voltages, for example, can reduce power consumption. Some high-speed peripherals (e.g., math accelerators) let you reduce current draw by putting the MCU to sleep faster and running the MCU at lower power for specific tasks.



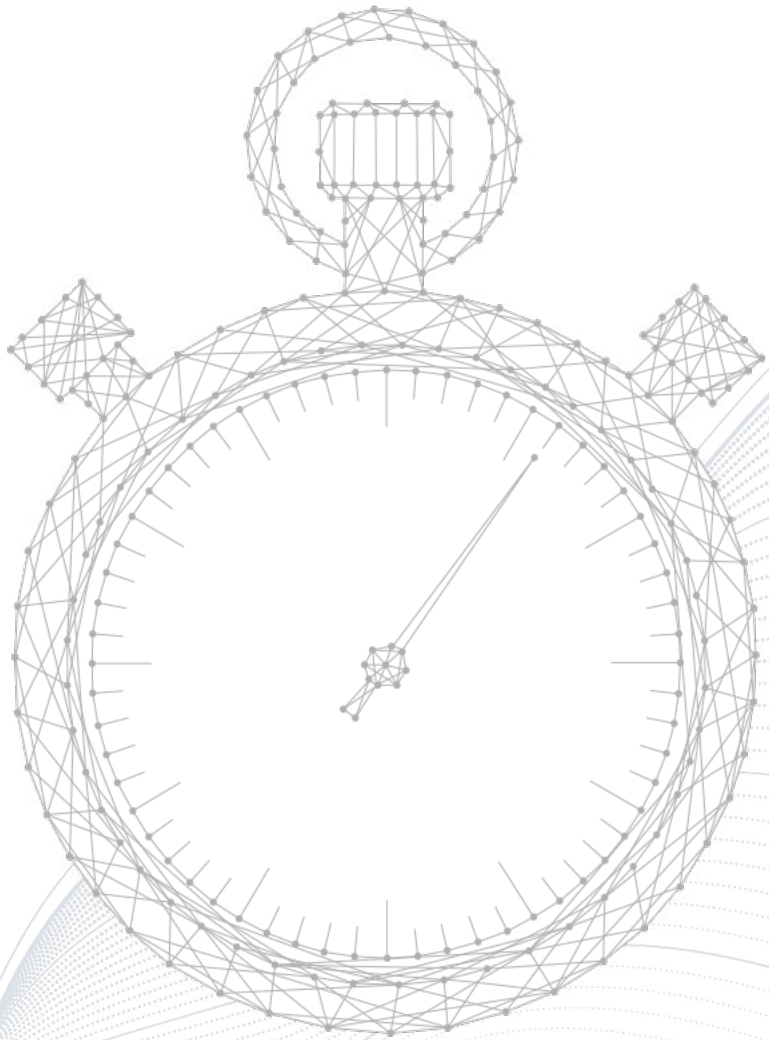
Write Firmware to Optimize MCU Clock Speed

Your first firmware design effort should be to write firmware that optimizes MCU clock speed. Because MCU current consumption is typically specified in µA/MHz, a slowly-clocked processor consumes less current than one with a fast clock. For code segments where the processor is largely idle, a slow MCU clock actually saves current.

Recommendation

Design your program to minimize clock cycles during IoT device operation and return the MCU to sleep as soon as possible. Ensure that sensors and other peripherals are on only when needed. Remember to allow for sensor power-on stabilization time to avoid inaccurate measurements.

You can also optimize MCU clock speed using standard best practices like setting constants outside of loops, avoiding unnecessary variables, declaring variables to be volatile only when necessary, and unrolling small loops. Additionally, adjust the frequency at which the MCU turns on the device's radio to transmit data, and optimize the radio's retry strategy.



Automated Current Profiles Are Your Friend

Firmware gives you many settings to adjust, and many programming options. All those choices make it extremely difficult to know whether your change reduces or increases current consumption.

Recommendation

Run a current profile before and after you make a change to gain greater insight into the impact of that change. Using a tool that includes both sleep and active states in the profile, and a wide dynamic range that can handle a 1,000,000:1 ratio between minimum and maximum current levels, is ideal.

SUMMARY

Optimized Battery Life Requires Rigorous Design and Test

Optimized battery life gives device manufacturers a distinct and marketable competitive advantage. Many different techniques—like those discussed in this eBook—can and must be used to realize an optimal outcome. This can only happen if extensive design and testing are utilized throughout all stages of the development process.

By capturing and analyzing battery performance data early in design and throughout the development process, the costly and time-consuming rework required to fix problems late in the development cycle can be avoided. Plus, the deep insight enabled by accurate battery life testing offers you the greatest chance of exploring new ways to extend and optimize your IoT device's battery life.

For information on how Keysight's solutions can help you optimize the battery life of your IoT device, explore the following links:

IoT Device Testing

Battery Life IS IoT Device Life

Battery Drain Analysis for Low Power IoT Devices

TEST DEVICES CORRECTLY IN THE LAB | CONSIDER INTERACTIONS WITH OTHER DEVICES | STRESS TEST YOUR IOT DEVICE | OPTIMIZE MCU POWER CONSUMPTION

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