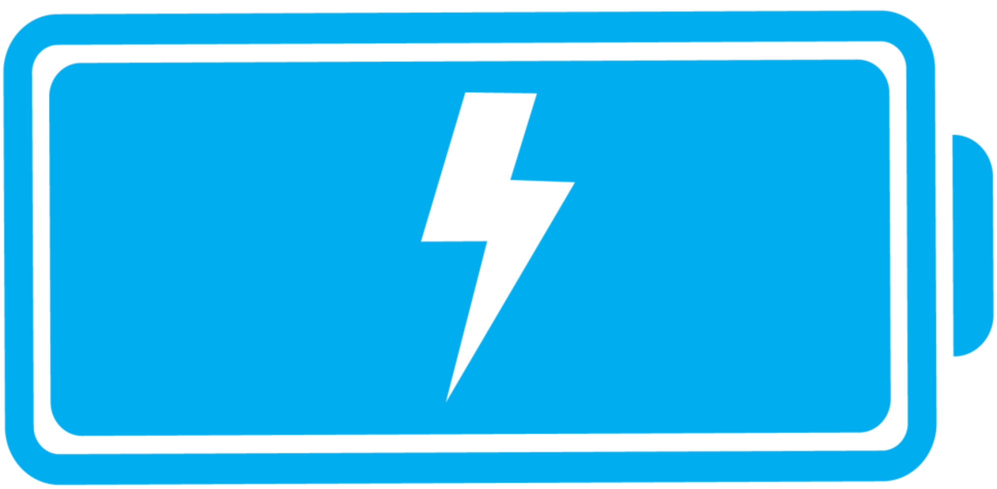
Testing IoT Devices: Battery Life

Application Note

Abstract:

With the IoT space rapidly growing into diverse areas like wearables, smart meters, fleet management, herd management etc., battery life is a key factor that can make or break your device and the solution you offer. Having a predictable battery life is imperative in ensuring a successful solution. This application note covers the latest additions in wireless technologies that enhance the battery as well as, effective ways to test and analyze the battery life consumption.



Application Note
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1 Introduction

Internet of things will soon, if not already, permeate to all industries and have influence in everyone's life. In general, smart devices sense and measure key parameters, connect to the internet and communicate with a central server. The smart devices at the edge of the network run on batteries that can last from few hours to multiple years, depending upon the use case.

Testing these smart devices throughout their entire lifecycle is essential before they go live on a network to ensure flawless performance and a great user experience. Many of these devices, regardless of being remote or local, are also battery powered. An un-reliable battery life with an erratic power consumption would lead to a frustrated end customer and would likely turn the user away from using the device. With the example of wearables, if a customer had to charge their device multiple times within the same day, each minute lost recharging the battery would likely decrease the user engagement by a considerable amount.

Furthermore, a suboptimal power consumption could also increase business operation costs like in the instance of associated battery replacement costs. If smart meters or asset tracking had suboptimal power consumption, support teams would be necessary, as they would have to send technical staff to remote areas to replace the batteries, thus increasing business costs.

Examining the power consumption patterns of a device under all possible use case scenarios is not only essential in making the development process faster, but ensuring its proper functionality in the field while minimizing risks.

2 Technology Overview

The software applications running on the IoT device strongly influences the battery consumption. Low power mode (or hibernating mode) saves power consumption and extends the battery life of the device. Timing and duration of data transmission also affect the battery consumption patterns.

A typical smart phone or tablet is loaded with Bluetooth, Wi-Fi, cellular and GPS technologies. Each device has different power consumption needs. In the idle mode, the device requires less amount of battery as it is sleeping. The battery consumption is much higher in the connected mode as the device is transmitting or receiving data. Multiple data-sessions (e.g. GPS for navigation and internet for playing songs) could also be running in parallel, draining out much more battery than usual. On the other hand, a simpler health tracking wearable may just have Bluetooth versus a sophisticated one with both Bluetooth and GPS tracking. Figure 1 lists some of the devices and their average battery life Fig 1.

Smart Phone	Wearable with GPS tracking ON	Smart Watch	Wearable with no GPS tracking	Smart Meters
<10 Hours	10 hours	1-2 days	5-7 days	10 years
				

Figure 1: Average battery life of various smart devices.

The cell coverage area and the optimal range between the smart device and access point are a couple of factors that drive the selection of technology for any IoT solution. This has a direct impact on the transmit power and battery life needs of the device. E.g., Smart meters in a remote location would be ideal candidates to be part of cellular networks, whereas printers, T.V., door locks etc. would be part of personal area networks.

The traditional technologies have undergone considerable changes to address the needs of IoT devices. Bluetooth Low Energy is the power efficient version of Bluetooth that is tailored primarily to IoT applications. BLE’s low energy needs makes it perfect for the devices that need to run for long period. This enables a wide range of connected devices to perform their functionality without the need of frequent battery replacements.

Similarly, 3GPP enhanced the LTE features to add “power saving mode” and “machine type communication” features in release 12 and 13 respectively. In addition to cost reduction measures, these features should provide significantly longer battery life of several years. Both non-cellular and cellular technologies have made improvements and optimizations to make the use cases for IoT devices possible.

2.1 Bluetooth

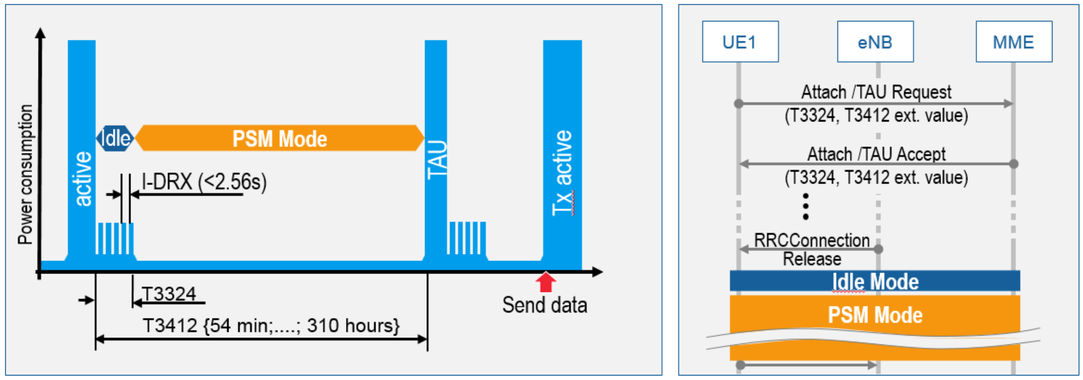
We have been using the traditional Bluetooth technology to pair earphones, speakers etc. with the smart phones for a while now. While the traditional Bluetooth technology moved in the direction to increase the data rates, the motivation for Bluetooth Low Energy (or BLE) is to achieve low cost and low power consumption. BLE uses the 2.45GHz band and is an important part of personal area networks.

The ultimate goal for BLE would be to support battery life of several years for devices that measure steps or sensors that detect harmful gases and measures temperature. Bluetooth Special Interest Group (SIG) realized the need of ultra-low power consumption and optimized the entire stack of BLE technology addressing the challenge of efficient use of battery. Bluetooth® 5 has features that provide IoT applications the benefits of low power consumption and increased range of Bluetooth connections by transmitting data multiple times. The latest specifications permits speeds up to 2 Mbit/s. Bluetooth® 5 also promises faster speed, larger broadcast message capacity, as well as improved interoperability and coexistence with other wireless technologies.

All of these features empower the developers to leverage the Bluetooth® 5 capabilities and come up with efficient connectionless solutions. This also raises the need to test these capabilities of the Bluetooth chipset and the entire IoT device. Bluetooth RF Test Suites, which comprises of transmission and receiver tests, provide the guidance to verify the Bluetooth features. Transmitter tests can be used to measure power, modulation and adjacent channel power (ACP). Receiver measurements can be used to determine the packet error rate and receiver sensitivity.

2.2 LTE (e) MTC

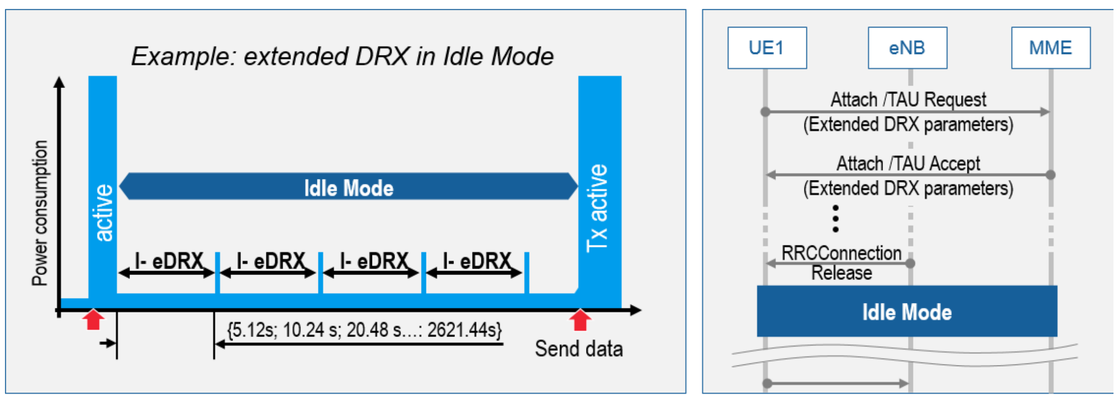
Taking into consideration the need of extended battery life for the devices that would be part of machine type communication, 3GPP added provisions for power saving mode in its release 12. The UE may move to a power saving mode to reduce its power consumption. This mode is similar to power-off but the UE remains registered to the network, with no need to re-attach or re-establish PDNs.



PSM Mode: UE remains registered with the network and there is **no need to re-attach or re-establish PDN connections** – saves power, but UE isn't reachable in PSM Mode

Figure 2: Power Saving Mode.

3GPP went a step ahead and added extended DRX in release 13. e-DRX has longer sleep cycles optimized for delay tolerance applications. Devices that have infrequent uplink data transfer (e.g. smart meters that would transmit data once a day), can save a lot of power and reduce the energy consumption significantly.



For devices with infrequently uplink data transmission, energy consumption can be reduced significantly by longer cycles for discontinuous reception (DRX).

Figure 3: Extended DRX.

3 Verification and Testing

A sub-optimal software code could heavily utilize the power and drain out the battery. Different apps running on a device need to be tested to understand the effect on battery consumption. Poor RF conditions (due to fading, degraded SNR, co-existence etc.) instigate retransmissions thereby increasing the power consumption. All of these scenarios and many more make battery life testing an imperative step in the design and verification phases of the product life cycle.

3.1 Test Solution

Testing may seem complicated and costly, however, test and measurement solutions from Rohde & Schwarz can provide you with solutions to validate and optimize your device in a controlled, emulated environment.

Emulating realistic network scenarios in a lab environment makes the test and validation phase convenient and cheaper. R&S CMW290 gives the flexibility to emulate LTE, WLAN or Bluetooth access points conveniently on your lab bench. Users can test various use cases including voice, video and data transfer.

Repeatable test scenarios ensures that ability to test the device under the same conditions and helps you optimize the battery consumption. By using R&S CMWrun software, you can create a wide range of test scenarios and plot the power consumption patterns of the device under test. Battery life measurements and tests are available as standard-specific CMWrun packages for WCDMA, LTE, WLAN, and Bluetooth technologies.

A broad and dynamic range of current makes the measurement a challenging affair. These measurements might vary from microamperes (sleep mode) to milliamperes (ON mode). R&S RT-ZVC gives you the capability to make high precision power analysis. Each power measurement group on the R&S RT-ZVC consists of a voltmeter and ampere meter with 18-bit A/D resolution and 5 M sample/s sampling rate. The built-in multiplier function available for each group ensures synchronous, sample-by-sample multiplication of current and voltage samples, at a rate of 5 M ample/s. An internal decimation unit accumulates the consumed power by averaging over 100, 1,000 or 10,000 samples. This ensures that even very short power consumption peaks are captured, while reducing the data transfer rate to a level a PC can handle.

R&S CMWrun estimates the battery life and displays all power group measurements, such as current, voltage and instantaneous power on the event graph.

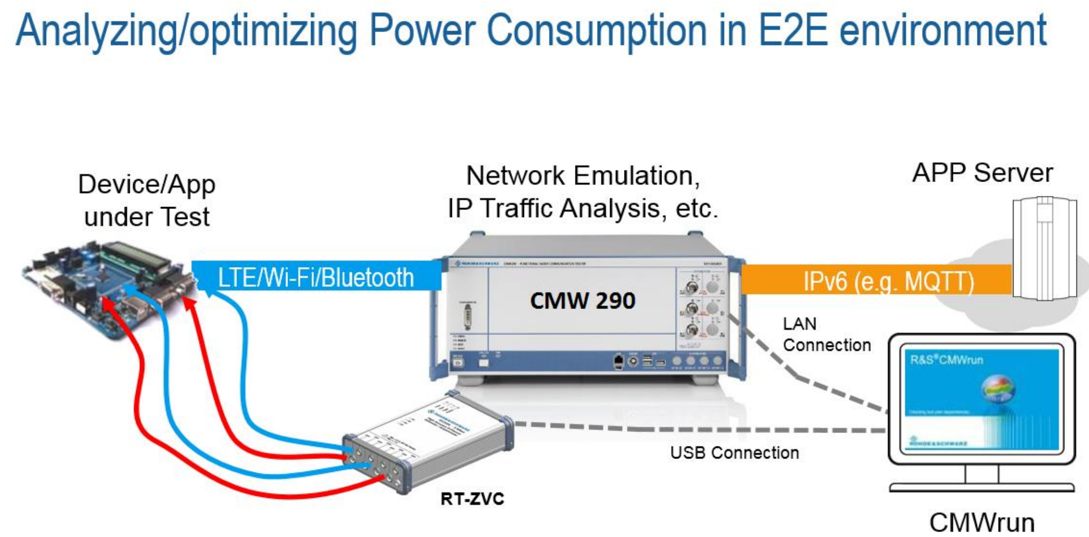


Figure 4: End to end setup to test battery life consumption.

Figure 4 shows an end-to-end setup to analyze power consumption, current drain and estimate battery life using R&S RT-ZVC multichannel power probe, R&S CMW290 network emulator and CMWrun software Fig. 4.

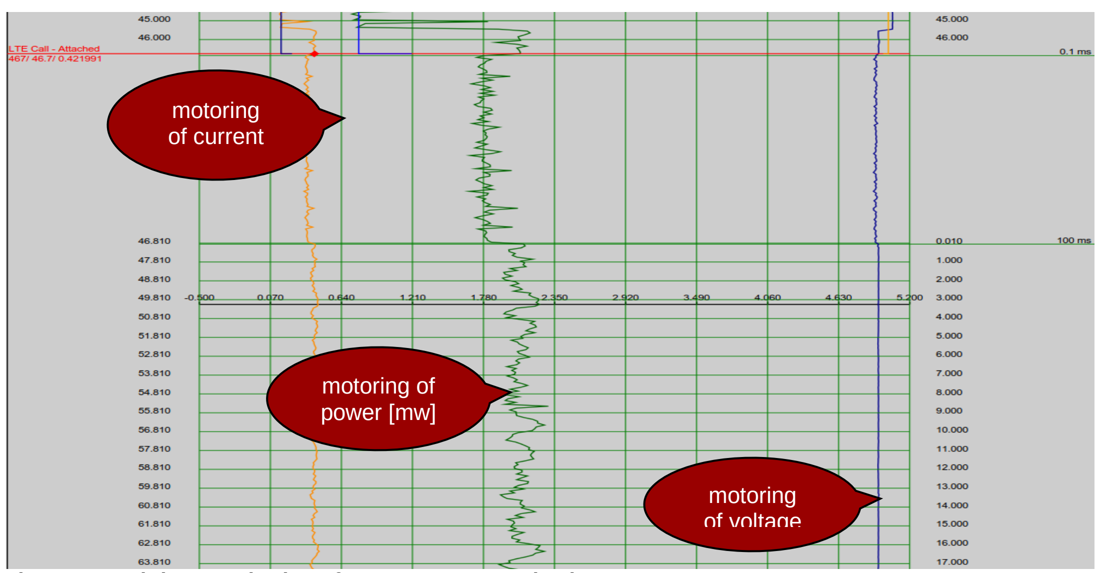
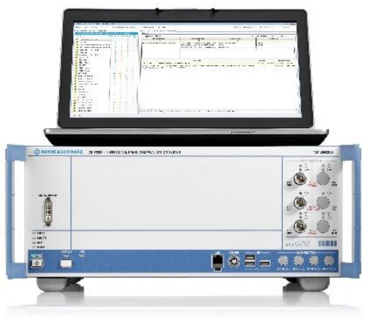


Figure 5: Real-time monitoring of power, current and voltage.

Figure 5 shows the plot of a real time monitoring of power, current and voltage measured using the RT-ZVC and plotted by CMWrun Fig. 5.

3.2 Product Information



R&S CMW290 functional radio communication tester is the cost effective compact version of R&S CMW500. It provides high quality, customized, automated test environment for functional tests. Power network emulation allows IoT/M2M system integrators to test module integration and custom IP applications.

R&S CMWrun software is a ready to use solution for configuring and remote controlling the test equipment to run throughput, battery life and coexistence tests. It provides full flexibility to configure parameters and limits and does not require any specific programming knowledge.

R&S RT-ZVC is a multi-channel power probe with high time resolution of 5 million samples per second. It provides a voltmeter/ampere meter with 18-bit resolution. The USB interface allows a plug and play flexibility to fetch data output using CMWrun. This is ideal for mobile phones, IoT chipsets, M2M modules and reference boards, etc. RT-ZVC offers up to two (with R&S®RT-ZVC02) or four (with R&S®RT-ZVC04) voltage and current channels.

4 Summary

The IoT ecosystem has an extensive range of devices, justifying the extensive use cases of battery consumption. IoT chipset manufacturers and M2M module manufacturers require considerable testing and validation to build a high quality product with a sustainable solution. Reducing the material required to make your IoT device is the best way to bring down the development cost. Batteries are one such material and if you can figure out the optimal power consumption requirements for your device, you can develop the battery to be as small as it needs to be.

A fully automated setup expedites product development and enables early detection of issues, thereby drastically reducing the cost and time to launch the product. Rohde & Schwarz's holistic test solutions can create repeatable test scenarios and can ensure superior performance and optimal battery life consumption of your IoT device.

For more information, please visit

https://www.rohde-schwarz.com/us

R&S®CMW290 Functional Radio Communication Tester

R&S®CMWrun Sequencer Software Tool

R&S RT-ZVCxx Multi-Channel Probe

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The electronics group is among the world market leaders in its established business fields. The company is headquartered in Munich, Germany. It also has regional headquarters in Singapore and Columbia, Maryland, USA, to manage its operations in these regions.

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Sustainable product design

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- Energy efficiency and low emissions
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