Keysight Technologies
LoRaWAN Test Challenges

Application Brief

Long Range | Low Power | Scalable | Low Cost

KEYSIGHT TECHNOLOGIES

LoRaWAN is a fast-growing, relatively new radio technology for long range wireless radio networks from the LoRa Alliance. The LoRa technology has powerful capabilities that make it very attractive for many IoT device applications, and those powerful capabilities present significant test requirements to ensure that LoRaWAN devices deliver on the technology's promise for a decade or more.

Overview

LoRaWAN is a bidirectional, end-to-end encrypted protocol that operates using Chirp Spread Spectrum (CSS) modulation in sub-GHz regional ISM and lightly licensed bands. The LoRa Alliance is an open, non-profit organization comprising more than 500 members, including IBM, Cisco, Orange, Renesas, Semtech, Arduino, Microchip, ST Microelectronics, and ARM. This broad industry support means that the technology is supported worldwide, and there are already more than 350 ongoing trials and deployments.

Key Features

The LoRaWAN technology promises long range communications of 25 to 50 km (15 to 30 miles) outdoors, with very good indoor penetration for applications in buildings, basements, and parking garages. Client devices generally run at low data rates, and they often include low cost sensors and have battery lives exceeding 10 years – in some cases up to 20 years.

LoRaWAN is a scalable technology that supports both private and public use models with relatively low infrastructure compared to other solutions such as cellular technology. It includes reference hardware and reference designs, some of which include open source software. It also includes an optional geolocation estimation feature that does not rely on the global positioning system (GPS). Geolocation without GPS is significant, as GPS circuitry can lead to significant battery drain. The LoRaWAN geolocation feature is not nearly as precise as GPS; it is based on a differentiated arrival time algorithm that can resolve location down to the nearest city block.

Low Power

LoRaWAN has two key features that contribute to the long end node battery life that is often key to the LoRaWAN value proposition. First, LoRaWAN's use of CSS allows it to operate up to 25 dB below the power levels of interfering signals while still being recovered by gateways. Second, LoRaWAN uses an adaptive data rate algorithm that adjusts the end node's data rate based on its distance from the gateway to optimize the time on air.

Test Objectives

Because much of the value proposition for LoRaWAN is based on its sophisticated radio technology and the long battery life of its devices, it is critically important to test the devices thoroughly in R&D, validation, and manufacturing test. Low cost end devices makes LoRaWAN popular in applications with large numbers of sensors. The cost of installing the sensors may well exceed the cost of the sensors themselves, and customers may demand long warranty periods to ensure the success of their application over time. A firmware flaw or hardware defect in the end device that leads to excess battery charge consumption can destroy a project's economic viability.

Therefore, it is vital to ensure that a LoRaWAN device meets the following test objectives:

- Compliance with relevant RF regulations
- RF transmission capabilities
- RF reception capabilities
- Exceptional battery life

Compliance with Relevant RF Regulations

Every radio must comply with various governmental regulations, and in the U.S., LoRaWAN's use of CSS means that it must comply with FCC Part 15.247, which applies to frequency hopped and spread spectrum transmissions by unlicensed radios. You must test LoRaWAN devices in digital modulation mode, spread spectrum mode, and a hybrid mode that uses aspects of both digital modulation and spread spectrum. As a supplier and promoter of LoRaWAN hardware, Semtech provides application notes to help designers and manufacturers comply with FCC regulations.

RF Transmission Capabilities

A device's transmission quality is important to ensuring long battery life. If a data packet is not received, it must be retransmitted, and that drains the batteries of both the receiving and transmitting devices. All that is necessary is a relatively simple setup that uses software to stimulate the device under test (DUT) with specific test sequences and a signal analyzer to measure and analyze the signal transmitted by the DUT. The signal analyzer could be a standalone X-series signal analyzer like the Keysight N9020B MXA Signal Analyzer (Figure 1), or it could be a signal analyzer in a PXI format. In addition, you may choose to enhance the signal analyzer with software that can make modulation quality measurements.

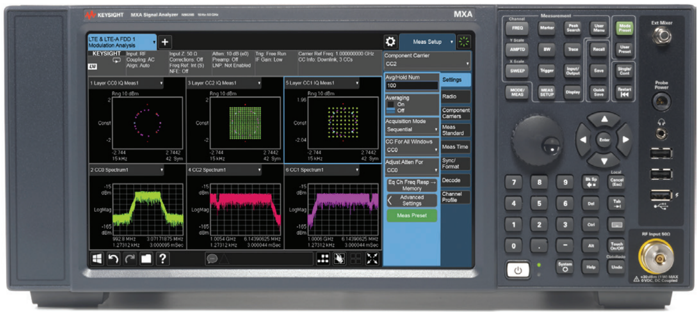

Figure 1. Keysight N9020B MXA Signal Analyzer

Some of the key transmission tests for LoRaWAN under FCC part 15.247 are:

- Emission output power ≤ 30 dBm
- 6-dB bandwidth > 500 kHz in digital modulation mode
- Conducted power spectral density ≤ 8 dBm in any 3-kHz band
- 20-dB bandwidth ≤ 500 kHz for a frequency hopped channel
- Tx spurious emissions power ≤ -43 dBm from 10 MHz to tenth harmonic of the Tx frequency
- Tx modulation characteristic in FSK mode, based on frequency deviation and carrier frequency tolerance

RF Reception Capabilities

Because LoRaWAN uses low power signals, it is important to verify that the receiver's sensitivity is set correctly and that the receiving device properly demodulates the signal and filters out all interference, including co-channel and adjacent-channel interference. To do this, use Keysight's Signal Studio software to control a signal generator and produce a LoRaWAN signal. Again, this can be either a standalone device like the Keysight N5182B MXG Vector Signal Generator (Figure 2) or a PXI module. In either case, the signal is attenuated to a very low power level and transmitted to a LoRaWAN device, where it is received. This LoRaWAN device under test (DUT) will typically be running with test software supplied by Semtech that works with the repeating arbitrary waveform from the signal generator as a stimulus and counts packets received correctly or in error.

Figure 2. Keysight N5182B MXG Vector Signal Generator

For LoRaWAN, it is critical to test receiver sensitivity at various spread factors and to ensure that sensitivity levels do not have to increase by more than 3 dB in the presence of an interference signal.

Measuring Battery Drain on DC Power Analyzer

Because long battery life is such a key part of the business case for many LoRaWAN applications, it is critical to have accurate and precise current consumption measurements. Furthermore, it is important to know how much charge is consumed by each of the various operations of your LoRaWAN device, so that you can make intelligent tradeoffs as you are writing your device firmware.

A LoRaWAN end device will likely have current that varies by several orders of magnitude between low power states (sleep, idle, hibernate, and so on) and operating modes (receiving, transmitting, or processing). Therefore, it is important to be able to measure across a wide dynamic range without the glitching associated with range changes. For example, if the highest operating current of your device or a component on your device is 250,000 times as high as the lowest hibernate mode, you need 18 bits of analog-digital converter (ADC) resolution just to cover the dynamic range. If you need 1% precision, you need an additional 7 bits, for a total of 25 bits.

Most instruments cannot come close to covering this sort of application requirement on a single measurement range, so it is best to look for an instrument with seamless ranging, such as the Keysight N6705C DC Power Analyzer (Figure 3) with a Keysight N6781A or N6785A Source-Measure Unit (SMU). The seamless ranging on the N6705C provides the equivalent of 28 bits of dynamic range without the glitching associated with range changes.

Figure 3. Keysight N6705C DC Power Analyzer

You can use the N6705C with Keysight 14585A Control and Analysis software to produce the complementary cumulative distribution function (CCDF, shown in Figure 4). The CCDF is useful for analyzing current consumption on LoRaWAN devices. The CCDF provides a clear XY graph that shows you how often your LoRaWAN device operates at various current levels.

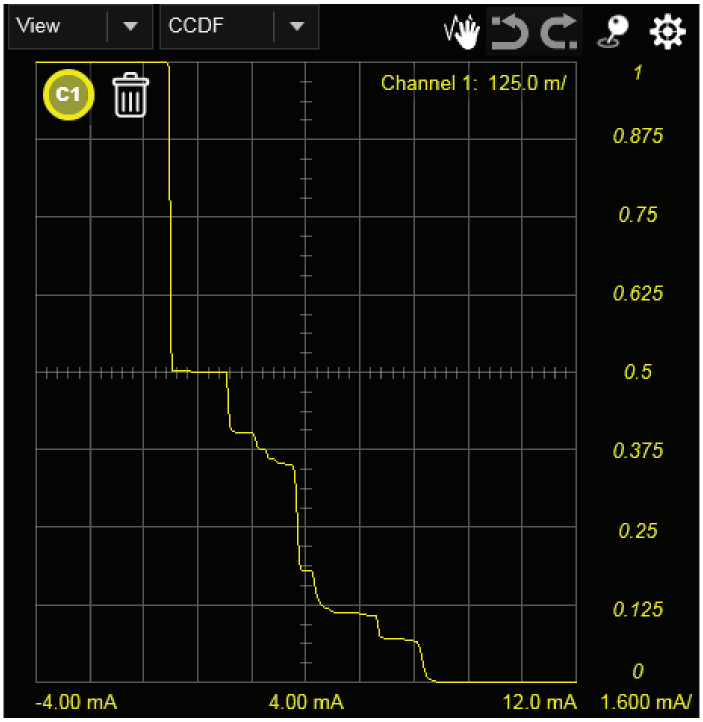

Figure 4. Complementary Cumulative Distribution Function (CCDF)

Measuring Battery Drain on Device Current Waveform Analyzer

The Keysight CX3300 Series Device Current Waveform Analyzer (Figure 5) is another useful instrument for measuring battery drain on LoRaWAN devices. It can measure current down to 100 pA at bandwidths up to 140 MHz. The high bandwidth makes the device current waveform analyzer ideal for capturing fast pulses.

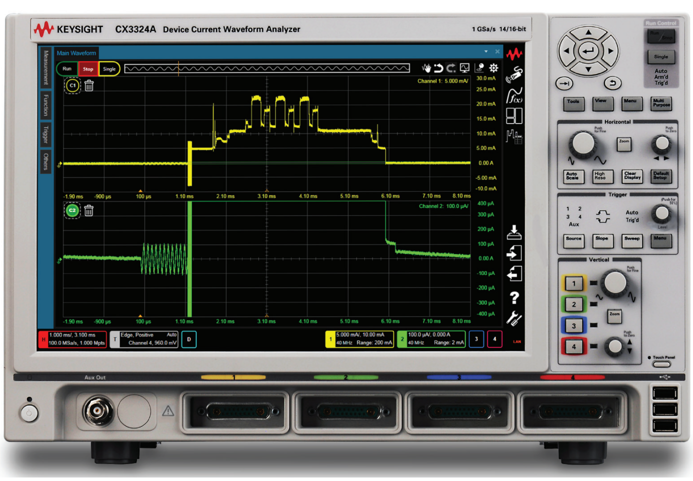

Figure 5. Keysight CX3324A Device Current Waveform Analyzer

In addition to being able to display a CCDF, the device current waveform analyzer has an automatic current profiler (Figure 6). This tool automatically divides a current waveform into segments based on current levels and calculates a variety of statistics for each segment. You can also add, delete, and move segment markers to get custom measurements and statistics beyond those that are provided automatically.

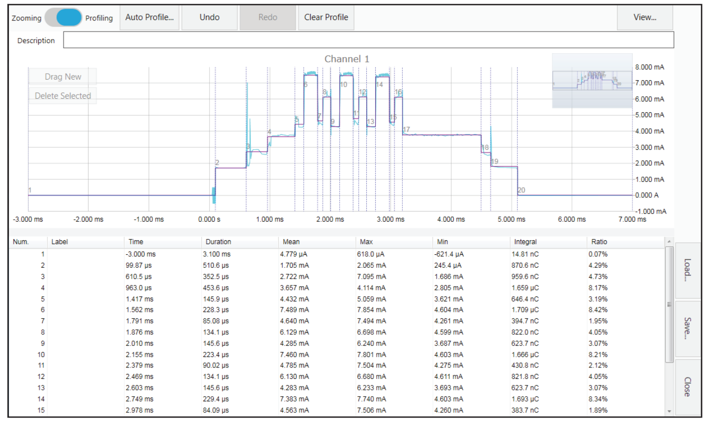

Figure 6. Automatic Current Profile

Summary

LoRaWAN is a sophisticated low power wide area network (LPWAN) technology that trades off low data rates for strong interference immunity, long distance coverage, and long battery life. To ensure the economic success of your LoRaWAN application, you must rigorously test the LoRaWAN devices to ensure that their transmission and receiving characteristics comply with FCC Part 15.247 and that their battery life meets customer expectations of a decade or more. For further information, see the application note on FCC Part 15.247 measurements at www.semtech.com/images/datasheet/an1200.26.pdf and the web page with information on low power wide area networks at www.keysight.com/find/lpwa.

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