Real-Time Analysis of Ultra-Wide Band Signals

A case study of RIGOL's RSA5000 Series Real-Time Spectrum Analyzer at Indago, a medical technologies company, testing Ultra-Wide Band signals

Introduction to Ultra-Wide band Signals

Ultra-Wide band (UWB) signals utilize wide bandwidth, usually more than 500 MHz, at low power. These signals have some advantages over typical narrow band signals. One important element is that the bandwidth can be simultaneously used by other signal types since the power levels are low and these signals should not interfere with narrow band signals. In 2002, the FCC defined the max power density for UWB signals in the 3.1 GHz to 10.6 GHz range as less than -41.3 dBm/MHz[1]. This makes UWB useful in crowded bandwidth environments where low power output, spectrum sharing, and short range communication are important, such as in a hospital setting. The usage of wide bandwidth pulses at specific time intervals makes these signals relatively immune to multipath fading effects. This is valuable in many sensor applications working in a shared bandwidth.

Real-Time Spectrum Analysis of UWB Signals

RIGOL's RSA Family of real-time spectrum analyzers make it possible to visualize the spectrum of RF signals in different ways. Traditional spectrum plots are augmented with views that add the dimension of time including spectrogram charts as well as density or probability charts and power over time. With the ability to observe wider bandwidth sections simultaneously, to capture shorter duration pulse events, and to visualize time the RSA family analyzers are a great instrument for analyzing ultra-wide band transmissions. Real-Time analysis adds three capabilities which traditional analyzers lack that are well suited to Ultra-wide band signal characterization. First, the 100% Probability of Intercept (POI) of just 7.45 microseconds guarantees the capture of short duration pulses. Since the timing of these pulses is usually more important than the absolute power the seamless capture enables visualization of many pulses even shorter. Additionally, the density display shows this wideband pulse activity over time and can be used in conjunction with the spectrogram for slower pulse sequences. For faster pulse sequences, the Power vs Time display gives you a visual of the power over time with resolution below 10 microseconds for very fast pulse sequences. This makes it easy to capture time modulated sequences for further analysis.

[1] https://en.wikipedia.org/wiki/Ultra-wideband

Figure 1: Indago's test setup for on-site measurements

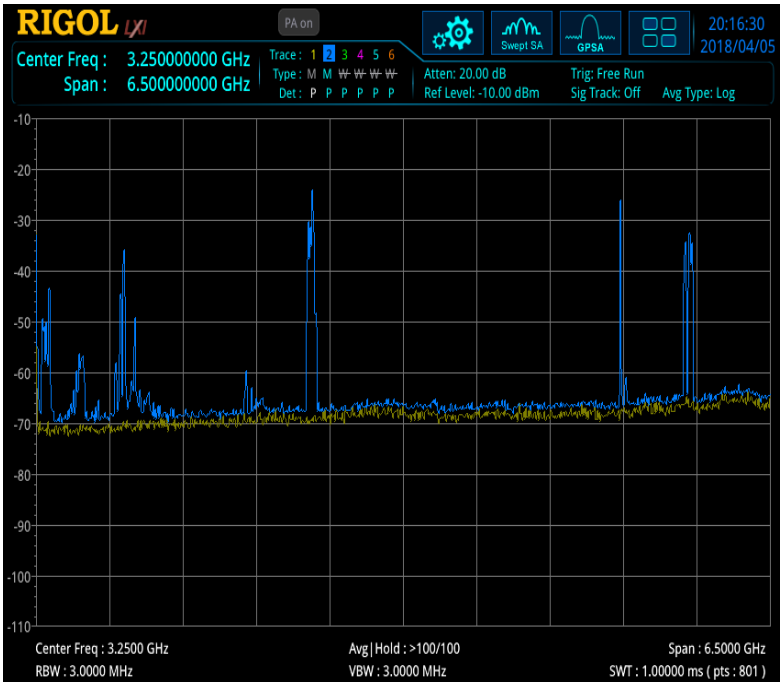

Figure 2: Background measurements

RF Test goals at Indago

Summary from Indago's Co-Founder and Lead Engineer:

*(Indago's test setup shown in **Figure 1**)*

The Engineering team at Indago had two goals to for the RIGOL RSA5065. 1, to have a snapshot of what an operating room's RF environment looks like, and 2, to capture a UWB signal during operation of a UWB transceiver.

Our team was able to accomplish the first goal with ease by connecting a UWB antenna to the RSA and setting the RSA analyzer to a full spectrum-width of 0 - 6.5GHz. This allowed us to visualize and identify the bands utilized by current devices. Additionally, our Engineers were able to plainly see changes to the RF environment when 'noisy' devices such as shavers and ablation devices were switched on and off or brought within proximity of the UWB antenna.

The second goal was achieved when we activated a secondary UWB transceiver. An initial observation was that the UWB signal was almost impossible to observe over the full spectrum, as it is at such a low power relative to other devices in the room. Once we zoomed in and isolated our signal on the RSA, the team was able to clearly see the activation of the UWB signal and the handshake between the transceivers. Subsequently, we initiated a data transfer over the UWB connection and were pleasantly surprised that the RSA5065 was sensitive enough to pick up the change in the signal. We proceeded to switch to the Power vs. Time mode and could clearly see the difference between sending a signal and a standby connection.

The RIGOL RSA5065 was a perfect choice for the tasks we wanted to accomplish. It allowed us to see and record the data that we needed in a clear and user friendly way.

Testing Challenges of UWB Signals

As the use of ultra-wide band grows into new applications driven by the Internet of Things the need to test, verify, and debug these types of signals is being faced by more engineers with less RF experience. Because of their wide bandwidth and relatively low power density it can be difficult to capture and analyze these signals with a traditional analyzer.

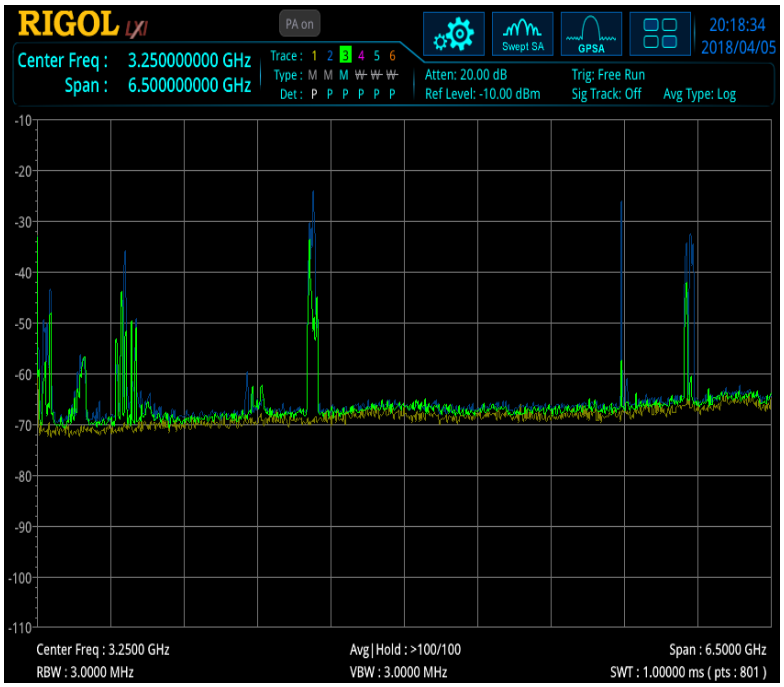

Figure 3: Active UWB Signal

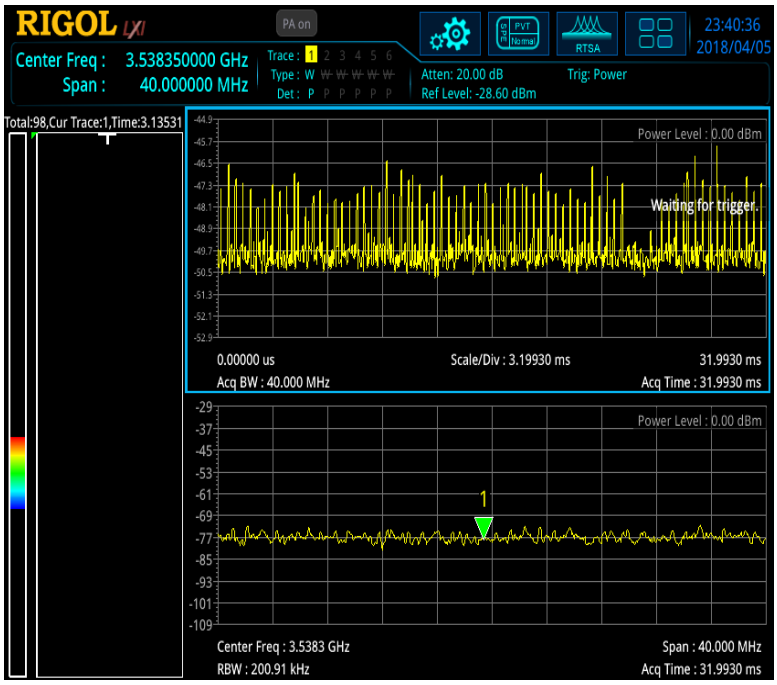

Figure 4: Real-Time Power vs Time visualization of a UWB channel

The following examples and results are from live, in field testing conducted by engineers at Indago using the RSA5065 to analyze UWB transceivers they are developing for medical applications. Part of their test requirement is to monitor how the UWB signal interacts with other signals in the environment. To understand this they first used the RSA5065 to sweep the full spectrum for RF sources.

In **Figure 2 & 3**, the yellow trace is a baseline with no antenna and the blue trace is a background measurement with an antenna. In **Figure 2** the green trace is added when the UWB signal is active. This UWB signal goes from about 3.1 to 4.8 GHz. While WiFi signals at 2.4 and 5 GHz are clearly visible along with a variety of equipment operating in the lower ISM bands, the UWB signal is virtually undetectable with these settings. The combination of short duration pulses and low power density makes these signals uniquely difficult to capture and analyze in swept mode.

In **Figure 4**, we can see this pulse activity in the power vs. time display. Here we can see a low duty cycle pulse at about 400 us rep rate (approximately 8 pulses per 3.2 ms division). We can also see on the spectrum below that there is no definable power spike in the spectrum display. The UWB signal is outputting power across the spectrum at low power density. The power vs time chart has an even wider capture bandwidth than the 40 MHz in the spectrum display making it a great method for capturing and analyzing this type of pulse activity. With these settings, the real-time analyzer has a 100% Probability of Intercept (POI) of just 7.45 us. Furthermore, the data capture with these settings is seamless. That means that while pulse events shorter than 7.45 us will not always be measured accurately in power they will be detected. As long as the power level is sufficiently above the noise floor they will be displayed. With seamless data capture the RSA never misses a pulse event from the UWB transmitter.

Conclusions

Ultra-wide band signals use a low power density, wide bandwidth signal to transmit data within a spectrum often occupied by a number of narrowband transmissions. Capturing these signals with a traditional spectrum analyzer can be difficult. Utilizing high performance, real-time analysis including power vs. time displays simplifies analysis and debugging of these signals. The ability to investigate and visualize pulse timing from microseconds to seconds is important to characterizing and debugging modern ultra-wide band implementations.

Investigating, characterizing, and debugging UWB signals requires capabilities beyond that of a traditional spectrum analyzer. A Real-Time Spectrum Analyzer with short 100% POI, seamless capture, and the ability to visualize the dimension of time like RIGOL's RSA family simplifies capture and analysis of ultra-wide band signals in many applications.

From Indago's Lead Engineer:

The RIGOL RSA5065 was a perfect choice for the tasks we wanted to accomplish. It allowed us to see and record the data that we needed in a clear and user friendly way.

Special Thanks

RIGOL would like to thank the team at Indago for working with us on this case study and providing comments, suggestions, data, and screenshots that we could share publicly. If you'd like to learn more about Indago and the technology they are developing contact them directly:

Indago

5000 Euclid Avenue, Suite 206

Cleveland, OH 44103

216.930.5679

indago.io

Our thanks in particular to the team we worked with directly. They include:

Ilya Malinskiy

Co-Founder and Lead Engineer

Laimis Belzinskas

Biomedical Engineer

Patrick Politio

Director, Regulatory and Compliance

Find more information on RIGOL and our Real-Time Spectrum Analyzers online

Explore the Power of Real-Time Spectrum Analysis

RSA3000 Family Information page

RSA5000 Family Information page

For more information on our real-time spectrum analyzers or other products please go to rigolna.com, contact us directly at **help@rigol.com** or call us toll free at **877-4-RIGOL-1**.

RIGOL Technologies USA

8140 SW Nimbus Ave
Beaverton, OR 97008
877.474.4651
www.rigolna.com