Is Your Spectrum Monitoring Tool Prepared For Modern Communication Technologies?

Berkeley Nucleonics Corporation

Radio Frequency (RF) spectrum is one of the most sought-after resources in the world. In the U.S., public spectrum auctions by the government generate billions of dollars for the right to utilize spectrum bands. The AWS-3 auction in January 2015 was the most successful auction to date, raising nearly $45 billion for 65 MHz of spectrum to be used for commercial wireless. This was a milestone in the Obama administration's goal of making 500 MHz of spectrum available for wireless broadband by 2020. Worldwide, spectrum auctions show a similar fervor. A fervor Berkeley Nucleonics continues to foster.

With new applications, technologies, and standards being developed and deployed, there is increasing value placed on monitoring the wireless spectrum by both public and private stakeholders. Those who own the rights to a portion of the spectrum actively attempt to protect and maximize the utility of their investment, while regulators strive to promote efficient use and minimize interference among users. What was once an engineering technician's duty has now very often become the dedicated responsibility of a multifunctional team.

In addition, governments worldwide are also recognizing the importance of monitoring and managing the electromagnetic spectrum and are exploring ways to make more effective use of the available spectrum. Reliable detection of signals with such disparate criteria can be a daunting task. Requirements for RF spectrum monitoring equipment include receivers with or enabling (1) wide instantaneous bandwidths (2) large dynamic range (3) narrow bandpass filters to discriminate the signal of interest from other signals on nearby frequencies (4) accurate transmitter location detection (5) meaningful frequency coverage to account for range of interest and (6) low receiver noise floor to detect low power signals.

Spectrum Monitoring In Today's Wireless Systems

The increasing sophistication and pervasiveness of modern communications technologies are largely driven by Internet adoption, wireless communications, the increased mobility offered by hand-held computing devices, and open-source software (e.g., Android OS). The decreased size, weight, and device power consumption, combined with corresponding increases in usable wireless communications capacity and the computing power available at low cost, have influenced science and technology trends significantly. This emergence and rapid growth of wireless technology is driving the requirement to use spectrum in more intelligent ways than before to avoid congestion on the physical layer. This makes the task of detecting such devices operating across the wireless spectrum challenging.

For instance, today's wireless systems can have:

- Low transmit power
- Wide system bandwidths (approaching 100 MHz)
- Complex digitally modulated waveforms
- Methods to utilize spectrum more efficiently; adapt to the electromagnetic environment such as:
  - Packet-based burst data transmission
  - Dynamic spectrum allocation
  - Aggregation of non-contiguous spectrum allocations.

Furthermore, today's wireless systems can co-exist with one another. Intelligent access mechanisms and design principles enable such systems to operate in "harsh" radio environments.

Key User Groups

There are three key user groups for spectrum monitoring: (1) commercial and public safety spectrum users, (2) spectrum regulators, and (3) security and defense agencies.

1. The spectrum users in the first group include cellular service providers, public safety radio, positive train control, wireless backhaul, satellite communications, and TV and radio broadcasters. Their objective in monitoring is to detect interference within specific frequencies and to measure how well they are using the coverage they have licensed.
2. Regulators monitor spectrum usage for enforcement purposes. They identify illegal and unlicensed radio and TV broadcasts and validate claims of interference made by spectrum users. They also look for spectrum occupancy and data utility rates in an effort to improve spectrum efficiency and make room for future users.
3. Security and defense agencies monitor the spectrum for espionage and counter-espionage purposes, as well as for the detection of signal intelligence. They use spectrum monitoring as a security precaution at military facilities, national borders, utility plants, airports, shipping docks, and other sensitive sites. They also monitor for illicit broadcasts from jails and prisons.

The growing needs for all three groups are the same: Monitor more frequently, in more geographical locations, and more cleverly by taking advantage of technological advances that can identify new legal and illegal uses of the spectrum.

Today's Spectrum Monitoring Requirements

Most spectrum monitoring users today need systems that can reliably identify and analyze signals that vary dynamically in amplitude or are agile in frequency, such as:

- weak signals masked by stronger ones
- signals masked by noise
- rare, short duration events produced by spread spectrum and frequency-hopping.

To keep pace with these market requirements, spectrum monitoring tools have had to change. Traditional tools like Swept Spectrum Analyzers (SAs) and Vector Signal Analyzers (VSAs) miss a lot of valuable information. The snapshots they provide of the signal in the frequency or modulation domains are often not detailed enough to confidently define the dynamic nature of modern RF signals.

Today's equipment needs to be able to capture every signal within a given bandwidth and to analyze them quickly and meaningfully so conclusions can be made with the same speed. Raw and processed data need to be marked with time, date, and geo-coordinates so they can be used for management decisions or enforcement. For practical and budgetary reasons, the new equipment must integrate with hardware and software that the user requires and is familiar with, and must be at a manageable price point.

Model RTSA7550 Spectrum Analyzer

Berkeley Nucleonics Real-Time Spectrum Analyzer Model RTSA7550 was built to satisfy the expanded needs of current spectrum monitoring. It is a PC-controlled device that has all the standard features of a spectrum analyzer such as frequency controls, marker functions, and multi-trace capacity, but it goes beyond to offer better performance and more features than comparably priced spectrum analyzers.

Capturing

The RTSA7550 can monitor what is known as a real-time bandwidth (RTBW) or Instantaneous Bandwidth (IBW) of up to 100 MHz in the frequency range of 9 kHz to 27 GHz. This range covers the frequency and bandwidth of most modern RF applications. This bandwidth allows the capture of modern waveforms such as 802.11ac and LTE-Advanced standards which occupy up to 80 MHz and 100 MHz, respectively. User-configurable capture control combined with fast, deep caching enables fast signal searches and sweeps.

"Real-time" means the analysis output keeps pace with the input signal in a given captured bandwidth so no signals are missed. This is extremely important to all customer groups since a complete set of data adds credence to any downstream analysis. A 100% probability of Intercept (POI) is as short as 25.5 µs, meaning a signal can be observed with absolute certainty in that time.

The unit has a highly optimizable, software-defined radio receiver which can capture the complex data packets associated with Wi-Fi and LTE. It offers a deep dynamic range of 100 dB when a narrow IBW is selected or 70 dB when a wide IBW is used. Real-time triggering allows selective capture of signals at defined frequencies, even when elusive and time-variant.

Analysis

Data analysis and readout occurs in real time, and the user can choose among displays. In addition to the standard spectrum graph, which plots Power vs Frequency, a user can move among the Spectrogram View, the Power Spectral Density Display, and the I/Q Plots. The different displays highlight different properties of spectrum activity.

The Spectrogram View adds the dimension of time, which allows easy recognition of the periodicity of a given signal. The Power Spectral Density Display, or Persistence Display, uses color to indicate how often a signal is present at a given power level. I/Q Plots show the changes in amplitude and phase of the sine waves of the RF signals and are useful for downstream integration with OEM high-speed digitizers.

Storage

The RTSA7550 features real-time recording and playback and has real-time memory storage size of 32 million samples, which means it can store a large block of continuous and contiguous data up to that memory limit. Fast local memory can be used for subsequent forwarding or streaming across the Ethernet.

Hardware Interfaces

Multiple RTSA7550 units can be synchronized by way of the 10 MHz input and output clock references, making it easy to coordinate a compound monitoring system. Data from the RTSA7550 can be transferred to a high-speed OEM digitizer and post-processing software tools via the analog I/Q output port. A 10/100/1000 Ethernet port on the unit allows for control and networking and supports unmanned, remote and/or distributed monitoring. Power input of +12V DC can be supplied through a standard electrical outlet or supplied through an automobile adaptor or external battery for mobile or remote usage. General Purpose Input/Output (GPIO) allows for external triggers and external modules such as antenna switches, down-converters, and GPS.

APIs and Programming Environments

The RTSA7550 can easily be integrated with new and existing applications. It has been built using industry-leading APIs/standards and open-source code for further analysis, automation, validation, and development. These programming environments include Python and PyRF development framework; NI LabVIEW®, MATLAB®, and C/C++ drivers; and DLL. Standard saved file formats are used including Standard Commands for Programmable Instruments (SCPI) and VITA-49 Radio Transport (VRT).

Value-Added.

The RTSA7550 has the performance of traditional high-end lab spectrum analyzers at a fraction of the cost, size, weight, and power consumption, and it is designed to be used in the lab, on the manufacturing floor, or out in the field. At less than 3 kg in weight, it is easy to move from place to place, and its 269 mm by 173 mm by 61 mm size takes up little space.

The unit is controlled by any PC with Windows OS 7 or greater. The system can be up and running in a short time by connecting the RTSA7550 to the PC through an Ethernet or Internet connection and installing the interface software on the PC. The user interface is intuitive and easy to operate.

Aligning User Needs to RTSA7550 Features

The chart below aligns the needs of the key users for spectrum monitoring with the features offered by RTSA7550. The RTSA7550 Spectrum Analyzer is a well-conceived monitoring system that provides exceptional value. It satisfies today’s growing need to monitor more effectively and continuously.

User Group	Need	RTSA7500 Feature
All Markets	Identify and analyze signals that vary in amplitude and are agile in frequency	Deep dynamic range, real-time capture
	Capture data continuously, no missing data	Real-time capture
	Monitor more frequently	Continuous operation is possible; real-time capture ensures all signals are detected
	Monitor in more locations	Networking capability through Ethernet port, fast local memory to stream data, small lightweight footprint for easy moving and minimal space requirement
	Monitor more cleverly to observe complex waveforms	Deep dynamic range of 100 dB when narrow RTBW selected, 70 dB when wide RTBW selected, wide RTBW of up to 100 MHz, variety of data displays to highlight different waveforms and patterns (Spectrogram view good for viewing time-variant signals.)
	Obtain group consensus after review of data; not all team members are technical	Variety of data displays to easily highlight different results
	Integrate with required hardware and software used in particular market	I/Q output port to transfer data to digitizer, Ethernet port for networking, unit built using industry-leading APIs/standards and open-source code for further analysis, automation, validation, and development
Spectrum Users	Detect interference in signal frequency used for commercial or public service	Real-time capture and analysis, wide RTBW of up to 100 MHz, deep dynamic range of 100 dB, multi-trace functionality, real-time triggering, 128 MB storage, variety of data displays
	Measure how well organization is using the coverage they have licensed	
Regulators	Scan for interference among users and enforce license compliance	
	Look for spectrum occupancy and data rate to manage spectrum efficiency and plan for the future	
	Validate claims of interference made by commercial and public entities	
Security and Defense	Spot espionage and counter-espionage, identify signal intelligence	
	Scan for broadcasts from places prohibited from broadcasting like jails and prisons	