Seeing the Full Picture

Introducing Software-Defined Spectrum Analyzers

Why Traditional Hardware Based Spectrum Analyzers Are Ill-Suited to Today's Spectrum Monitoring Applications

thinkRF

Introduction

Wireless communications technology has become a vital component of today's information driven world. With so much reliance on it, it's easy to forget how different the spectrum environment looked only a few decades ago. This shift has also pushed spectrum monitoring requirements well beyond what was previously the norm. But though the use of the spectrum continued to evolve, the equipment used to monitor it remained largely the same. However, these traditional spectrum analyzers no longer meet the requirements for monitoring in today's complex, dense and diverse environments.

Fortunately for users, a new category of software-defined spectrum analyzers have been designed and built for these new realities. Based on a relatively thin layer of software-defined radio (SDR) hardware, these analyzers offer greater versatility, better performance, and increased capabilities over the traditional hardware based, lab and handheld, equipment. This gives users the ability to see the full picture at a lower cost and with greater versatility than alternatives on the market today, without compromising on performance.

This paper will explain how the use of the spectrum is evolving and how it has impacted spectrum monitoring applications such as Signal Intelligence/Electronic Intelligence (SIGINT/ELINT), Technical Surveillance Counter Measures (TSCM), and Regulatory Monitoring. It will then show why traditional hardware based spectrum analyzers are ill-suited for this new reality, and introduce how software-defined spectrum analyzers are changing the game for users. Finally, it will present three common use cases that demonstrate the advantages of leveraging software-defined radio technologies for spectrum monitoring applications.

The Rise of Wireless Communications

In the last few decades, technology has advanced at an incredible rate. Smartphones, tablets, wearables, the emerging Internet of Things (IoT), and other connected devices have changed the way we work, play, and communicate. Devices that were cutting edge less than 10 years ago are now considered to be completely obsolete. Of course, as these wireless devices continue to evolve and become more widespread, so to do the requirements for spectrum monitoring.

A recent Cisco report underscored this new reality. In 2015, there were an estimated 16.3 billion connected devices worldwide.[i] And as IoT and other advances become more widespread, this number will continue to rapidly increase. The same report estimated that there will be at least 26.2 billion connected devices in 2020, each drawing on an increasingly crowded spectrum.

Not only are there more devices, but each of these devices now transmit and receive more signals as well. A standard iPhone 7 alone can detect and transmit up to 9 different types of signals, ranging from 4G/LTE to Bluetooth and GPS. And this is only the beginning, as researchers are continuing to push the boundaries of high frequency and wideband signals for commercial uses. Recent 5G experiments have tested the viability of the 24, 28, 32 and 42 GHz bands, well above the traditional 6 GHz range for use by the year 2020.[ii]

All of these advances have led to an enormous amount of data being transmitted over fixed or mobile wireless networks. IBM estimates that we already create over 2.5 exabytes, or 2,500,000,000,000,000,000 bytes, worth of data every single day.[iii] And this increasingly drives the demand for wireless traffic such as video streaming or gaming, or mission critical data that requires high speeds and low latency. These requirements are further pushing the need for new wireless standards and technologies that can handle the demands of end users.

Importantly for spectrum monitoring users in SIGINT/ELINT, TSCM, and Regulatory Monitoring, this diverse signal environment continues to evolve at a rapid pace. Consider the differences between spectrum monitoring only a few decades ago, and the requirements today.

With so many changes to the wireless environment, and to the devices that rely on it, why does monitoring equipment still look nearly identical to what it did before? Why do monitoring users still lug around heavy benchtop units or compromise with underpowered handheld analyzers when the requirements have changed so drastically? And most importantly, is there a viable alternative that doesn't sacrifice performance or capabilities?

MONITORING IN THE PAST:	MONITORING TODAY:
Signal environment was simple and homogeneous	More complex and diverse signal environment
Fewer devices in the environment transmitting and receiving fewer signals	Widespread adoption of wireless devices, each transmitting and receiving a variety of signals
Less dense with limited interference challenges	Increased risk of interference, both inadvertent and malicious
Fewer changes in the wireless environment over time	Rapid pace of innovation with new standards, such as 5G, being studied and released regularly
Typically centralized monitoring applications conducted from a single location	Growing requirements for distributed, dispersed and in-place monitoring
Higher cost of deployment with fewer cost pressures for monitoring	Increased cost-pressures and decreasing cost of deployment

Why Haven't Traditional Spectrum Analyzers Kept Up?

Traditional hardware based spectrum analyzers, in this case, lab and benchtop units, are still considered the standard for spectrum monitoring applications. However, the viability and usefulness of this equipment is limited to a small number of scenarios as the world evolves around them.

To understand why this has happened, it's important to remember that hardware based analyzers were never designed for spectrum monitoring in the first place. Instead, they were intended for use in a research lab to study specific signals of interest. They rarely needed to be moved around, and would be used by researchers to conduct in-depth analysis on a particular waveform. As a result, they were built with extensive hardware capabilities and had built in processing, displays and dials. This made them bulky, unadaptable, and expensive, typically costing up to and over $100,000 per unit.

Though they were not optimized for monitoring, they were, for a time, the best option available. By offering higher frequency and bandwidth performance than other equipment available, they could satisfy the basic, centralized monitoring requirements of the day. But as monitoring evolved, the limitations became more pronounced.

With no reasonable way to upgrade the units, users were stuck with the functionality of the hardware components available to them. And since they were so expensive, the thought of replacing them was a risky decision. Plus, they were familiar and users were comfortable with them. As a result, they simply got used to the limitations, accepted them, and believed that there wasn't a better way.

The use of traditional spectrum analyzers for spectrum monitoring applications has reached a breaking point, as the limitations associated with this equipment has constricted their usefulness. So what alternatives exist, and what advantages do they provide over the current standard?

BENEFITS OF TRADITIONAL HARDWARE-BASED SPECTRUM ANALYZERS

- High frequency and bandwidth performance
- User familiarity with capabilities and functions
- Effective at in-depth analysis of known or specific signals of interest

LIMITATIONS OF TRADITIONAL HARDWARE-BASED SPECTRUM ANALYZERS

- Not designed for spectrum monitoring
- Large, heavy, and power hungry, resulting in a lack of portability
- Expensive, often costing over $100,000 per unit
- Lack of flexibility or versatility, leaving users stuck with built in hardware capabilities
- Difficult to upgrade or adapt over time, rendering them obsolete or ineffective
- Network capability not designed for remote or in-place monitoring applications

How Software-Defined Radio is Changing the Game

Software-defined radio is a class of radios that can be reprogrammed and reconfigured through software rather than hardware. Basically, it is taking some of what used to be done in dedicated hardware components, such as tuning, reception and demodulation, and moving them to software functions instead.

The combination of the advances in SDR technologies, computing and networking have led to a new class of software-defined spectrum analyzers which have been designed and built for complex spectrum monitoring applications from the ground up.

In a software-defined spectrum analyzer, the software runs over top of a thin, broad layer of hardware to provide greater flexibility and versatility. The hardware components tend to make up only the RF to IF to digital conversion. An inexpensive standard PC can then be connected to provide the necessary computing power for digital signal processing, signal analysis and other capabilities.

As a result, users are not limited to built-in performance capabilities. By connecting to any laptop, the analyzers can leverage advances in computing power and the decreasing cost of high performance processing. The software capabilities can then be adjusted to various environments, signals of interest, and applications.

DESIGNED AND BUILT FOR SPECTRUM MONITORING APPLICATIONS

In contrast to their traditional counterparts, software-defined spectrum analyzers have been designed and built for monitoring from the start. With fewer, and simpler, hardware components, the size, weight, and power consumption of these analyzers are greatly reduced. This compact form factor, combined with purpose built networkability, makes them extremely versatile for remote deployment in any location.

Another key difference from traditional hardware is that software-defined analyzers can be easily upgraded without replacing the equipment itself. As new standards are introduced in higher frequencies and wider bandwidths, these analyzers provide the flexibility to adapt and evolve at a lower cost, greatly extending the useful life of the equipment.

BENEFITS OF SOFTWARE-DEFINED SPECTRUM ANALYZERS

- Greater versatility to deploy and monitor in more environments
- Better frequency and bandwidth performance to detect complex waveforms and a wider variety of signals of interest in real-time
- Ability to upgrade without replacing hardware components to access additional capabilities and extend the useful life of the equipment
- PC-driven to leverage the high computing, versatility and low cost of any laptop
- Compact form-factor with reduced size, weight and power (SWaP) requirements
- Remote deployment for in-place monitoring applications

LIMITATIONS OF SOFTWARE-DEFINED SPECTRUM ANALYZERS

- Not designed for lab environments that require the advanced functions of dedicated hardware
- Lack of familiarity for users comfortable with their current equipment
- No built-in display

Use Cases and Examples

SIGNAL INTELLIGENCE/ ELECTRONIC INTELLIGENCE (SIGINT/ELINT)

SIGINT users are constantly monitoring the spectrum for known or unknown signals of interest. They need to detect traditional narrowband signals, intermittent and short-duration signals, and emerging wideband digital communications in a wide range of environments and deployment scenarios. As with any aerospace & defense equipment, SWaP and the ability to integrate into a larger system are important requirements. And due to the mission critical nature of the application and the emerging prevalence of electronic warfare, performance and reliability are also a must.

Software-defined spectrum analyzers provide the right mix of performance, versatility, adaptability, and compact form factor for SIGINT users. With increased frequency range and bandwidth performance, fast scan rates, and a high probability of intercept, these analyzers maximize signal detection. Wide instantaneous bandwidths, deep dynamic ranges, and the ability to work with leading third-party software provide users with a powerful analysis tool. And with network and triggering capabilities, they can be deployed remotely for continuous monitoring of the spectrum environment increasing the likelihood of detection.

TECHNICAL SURVEILLANCE COUNTER MEASURES (TSCM)

TSCM users face unique challenges because they are often unsure what type of signal they are looking for, or even whether a signal is actually present at all. Often, malicious actors use infrequent, low powered transmissions that may occur irregularly and outside of working hours. This makes it important to have the ability to do both in-place monitoring and traditional sweeps to detect hidden devices. With highly sensitive and confidential data on the line, a lot is riding on the ability of trained professionals to detect, find and remove illicit devices in a variety of complex environments.

One way to increase the likelihood of detection is to deploy a distributed, continuous monitoring solution that leverages the advantages of software-defined spectrum analyzers. With a compact, lightweight and portable form factor, TSCM professions can use a single consistent solution for both sweeping and in-place monitoring. The ability to continuously monitor outside of regular working hours, from a remote location, adds another tool for users to detect infrequent or low powered signals that would otherwise be missed.

REGULATORY MONITORING

As the use of wireless communication technologies becomes more widespread, new standards are rolled out, and the potential for both inadvertent and malicious interference grows, spectrum regulators in both monitoring stations and in the field require the right mix of both performance and portability that goes beyond the capabilities of traditional handheld units.

Networked, remote deployable, and portable software-defined spectrum analyzers, with the performance of traditional lab spectrum analyzers, provide increased frequency range and bandwidth coverage for monitoring in densely populated wireless environments. The versatility and flexibility provided by software gives users the ability to detect interference or other unlicensed signals at a lower cost, without sacrificing on the performance required for the latest standards.

i https://newsroom.cisco.com/press-release-content?type=press-release&articleId=1771211

ii http://www.fiercewireless.com/tech/verizon-tells-fcc-to-move-fast-28-ghz-and-37-40-ghz-bands-to-promote-5g

iii https://www-01.ibm.com/software/data/bigdata/what-is-big-data.html

Monitor. Detect. Analyze.

The software-defined ThinkRF R5500 Real-Time Spectrum Analyzer has been built for spectrum monitoring applications such as SIGINT/ELINT, TSCM, and Regulatory Monitoring. With up to 27 GHz frequency range and 100 MHz instantaneous bandwidth, the R5500 analyzer provides greater versatility, better performance, and additional capabilities over traditional hardware based spectrum analyzers. Monitor in more locations, detect complex waveforms, and analyze new technologies and standards with patented software-defined radio technologies and an extensive lineup of third party applications, APIs, and development environments.

Traditional spectrum analyzers have been used for years for spectrum monitoring applications such as SIGINT/ELINT, TSCM, and Regulatory Monitoring. But this was largely due to the fact that there were limited viable alternatives. However, the advances in SDR technologies have given way to a new class of software-defined spectrum analyzers that are designed and built for spectrum monitoring in complex environments. As the shortcomings of traditional equipment increasingly limit their effectiveness, software-defined spectrum analyzers allow users to see the full picture at a lower cost, smaller form factor, and increased versatility and adaptation.

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