Leveraging Wideband and Full Spectrum Receiver Capabilities to Develop and Utilize Software-based Tools for Remote Spectrum Analysis and Troubleshooting

K. Scott Helms
ZCorum
Jim Koutras
MaxLinear

Abstract

Spectrum analysis tools have been in use in the cable industry for troubleshooting and design purposes for a long time. Traditionally this meant buying and maintaining large numbers of meters, spectrum analyzers, and other specialized tools. This increased expenses and training time, and limited the number of people in any organization who could leverage spectrum analysis.

Today, using new software in conjunction with newer components in modems and set-top boxes, remote spectrum analysis is possible without purchasing specific test equipment. This allows spectrum captures to be performed from anywhere and the exact downstream characteristics in a customer premise can be seen and analyzed without having to drive to that location or the need to gain access to the in-home wiring.

NEW CAPABILITIES IN REMOTE SPECTRUM ANALYSIS

New DOCSIS 3.0 modems using wideband or Full-Spectrum Capture™ receivers have the ability to capture and report local (end-user) cable-plant spectra, providing Cable and Multi-System Operators (MSO) new freedom in remotely monitoring, managing, and troubleshooting their networks. Embedded remote spectrum monitoring and diagnostic data is delivered to a software application for performance analysis. This remote spectrum monitoring technology allows rapid capture of frequencies from 54 MHz to 1GHz using dedicated on-chip FFT hardware to transform time-sampled input signals to the frequency domain for subsequent user analysis and interpretation.

When the remote spectrum monitoring function executes, the tuner inside the cable modem receives the spectrum information and is commanded to fill an on-chip buffer with time-series data. Various windowing functions can be applied to time-series data on either side of the buffer to smooth discontinuities at the window boundaries (thus reducing spectral leakage) and an FFT is performed. The frequency-domain data read from the device are then interpolated as necessary to achieve the requested frequency step size and finally converted to units of dBuV.

This means that not only can we see the spectrum wherever we have a modem that employs wideband or Full-Spectrum Capture tuners; we can also look at multiple sources at the same time. This allows us to compare multiple devices in the same home to isolate an in-home problem or compare modems in the neighborhood to determine if impairments are specific to one drop or are more systemic.

In terms of data flow, the spectrum data from the receiver is sent to the DOCSIS 3.0 modem SoC or MPEG decoder SoC depending on the application. In the case of a DOCSIS modem or STB with an embedded DOCSIS modem, the data can be transferred to a CMTS/CCAP via a DOCSIS 3.0 MIB. In

the case of a STB without DOCSIS, standard protocols like TR69 and SNMP can be used to transmit the data to a headend/operations center.

BENEFITS OF REMOTE SPECTRUM ANALYSIS

There are significant benefits in developing or purchasing a remote spectrum analysis tool.

Reduce travel time.

Reducing the amount of time, especially travel time, needed to capture spectrum information at specific locations in the cable plant eliminates one of the major inconveniences of using traditional, equipment-based spectrum analysis tools. The burden of carrying spectrum analysis equipment to the location where you want to make the measurements will no longer be necessary.

Measuring levels in a combining plant can be relatively straight forward and quick, but in many cases we need to measure a forward path at specific locations. We generally have two choices in order to accomplish this. We can either drive the tools to that site or we can install probes ahead of time and hope that we have enough coverage so that we can use our probes for most forward path testing.

By leveraging wideband or Full-Spectrum Capture tuners in modems and set-top boxes, we basically turn all of our compatible Customer Premises Equipment (CPE) into probes for spectrum analysis without having to purchase dedicated hardware. We also eliminate the costs involved in deploying multiple dedicated probes.

Reduce the cost of spectrum analysis tools.

Reducing the costs associated with spectrum analysis tools also eliminates the need to replace dedicated hardware as DOCSIS technology changes. This is especially important as we look forward to DOCSIS 3.1. Today our spectrum analysis tools have to incorporate a large amount of custom circuits and electronic components in order to perform the capture of the spectrum data and present it in a usable format. This causes the costs of even basic meters to be hundreds of dollars while more advanced devices are substantially more expensive.

By leveraging the existing RF tuners and demodulators in our set top boxes and cable modems for spectrum analysis we can now move the display of that information to consumer grade tablets and smart phones. This lets us take advantage of the competition in consumer electronics, which greatly lowers the costs of the devices our technicians have to carry and reduces the number of separate devices they have to carry with them. Because we are now using the RF components already in our modems and set top boxes we no longer have to replace or upgrade meters to account for changes in DOCSIS protocols. As we deploy new modems and set tops in DOCSIS 3.1 we have the ability to leverage those devices as probes without having to purchase new hardware.

Increase the number of technicians who can leverage spectrum analysis.

By increasing the number of people who can effectively use spectrum analysis in troubleshooting, we can decrease training time for new technicians and leverage the comfort level that younger employees have with tablets and smart phones. This serves a two-fold purpose and is driven by two different factors. One of the issues for many MSOs is that the cost of spectrum analysis tools limits how many meters and analyzers are purchased, which of course limits the number of people who can use those tools at any one time.

The other challenge is that few new technicians are comfortable using a spectrum

analyzer and many don't use them effectively even when they have access to a meter or analyzer. Training time and costs, especially with contractors in the mix, frequently prevent good tools from being used to their full potential.

One of the advantages of moving the technician interface to tablets and smartphones and away from dedicated hardware is the level of comfort that most new technicians will have with the interface. These current interfaces are much more intuitive than most meters and will make it easier to use and incorporate more features to help the user identify problems.

PREREQUISITES BEFORE YOU BUILD

If your plan is to develop your own remote spectrum analysis tool, the following prerequisites need to be in place.

A method to handle modem communication (SNMP).

You can manage the modem SNMP communication as well as the communication to the spectrum client utilizing a custom-built centralized server that can run in the head-end or in a MSO's datacenter. The server handles discovering modems that support spectrum capture as well as authentication and authorization of clients that should be able to run spectrum analysis. The server can be available on the public Internet (our server supports TLS/SSL encryption) or behind a corporate firewall so that a VPN must be used to reach it. Spectrum data can also be sent to a device in the home network. For instance, a tablet running spectrum analysis software connected via Wi-Fi allows a technician to analyze the spectrum while troubleshooting in the home.

A method to discover modems that support docsIf3SpectrumAnalysis OIDs.

A method to poll through the modem pools looking for devices that correctly respond to a SNMP GET request on docsIf3CmSpectrumAnalysisCtrlCmdEnable OID (Object Identifier). Figure 3, on page 5 below, shows an example of a server-side admin panel that is displaying four modems in a lab test network that have responded to the SNMP GET request. This data can be refreshed as frequently as the MSO would like by allowing for a setting in the server's configuration file.

A client to display the information.

By implementing a client-server approach with the client being apps for iOS and Android, we're able to run them on standard tablet and smartphone platforms. This allows technicians to simply connect to the server from anywhere in the world and then request the server to run the spectrum analysis functions and relay the results to the client for display.

Applications utilizing the spectrum data can include but are not limited to:

- Channel Loading/Response
- Tilt Measurement
- Ingress Detection
- Remote Network Monitoring
- In-home Spectrum Analyzers

A client distribution method in place

The most popular sites for distribution and follow-on updates are the Google Play Store and iTunes App Store. This will also be where the client subscription is managed. One of the biggest challenges for anyone involved in software distribution is dealing with updates. Keeping software up to date on the various mobile platforms is even more difficult, which is why choosing to tie into the most popular app stores makes sense.

In addition to smart phone and tablet clients, offering desktop clients via the iTunes

market for Macs and the Windows Store for Windows 8 and later PCs will be beneficial for in-office use.

Modems in place that currently support docsIf3CmSpectrumAnalysis

Remote spectrum capture capability is supported on the hardware side by modems that utilize the Intel Puma 5 and 6 chipsets with MaxLinear wideband and Full-Spectrum Capture receivers such as the MxL261, MxL265 and MxL267.

Note: While the hardware may support wideband or Full-Spectrum Capture tuners, the firmware on the cable modem might require updating to a version that supports docsIf3SpectrumAnalysis OID.

EFFECTIVENESS OF REMOTE SPECTRUM ANALYSIS

In testing we found that remote spectrum analysis was usually more effective in detecting and responding to impairments than traditional approaches of debugging network problems. The ease of running an analysis made it an earlier part of the troubleshooting process. The ability to compare multiple sources of data at the same time greatly improved technicians' ability to discern between common problems and channel tilt, ingress, suck outs, and other distortions of the forward path (see Figures 1 and 2). Technicians' ease of use and quicker adoption will rely on developing user interfaces that allow them to quickly find RF issues.

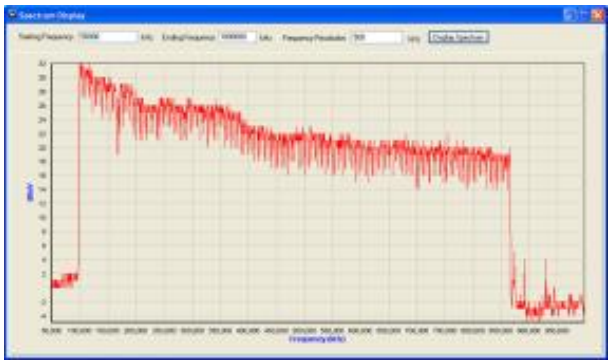

Figure 1 Course View - Channel Tilt

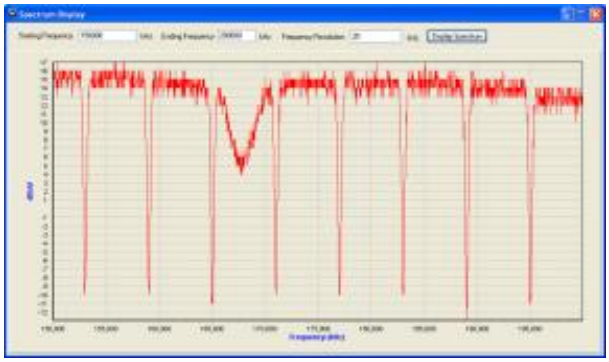

Figure 2 Zoomed View - Suck out

REMAINING CHALLENGES

The largest remaining challenge is deploying more modems in the field that have both the hardware and firmware to support remote spectrum monitoring through wideband or Full-Spectrum Capture tuners. Many tens of millions of existing modems already have the needed hardware but deploying the firmware upgrade to support docsIf3SpectrumAnalysis OIDs is an ongoing exercise.

As this technology is more widely adopted we expect that this problem will largely disappear with all of the major modem vendors pushing to get the firmware in place as rapidly as possible.

FUTURE APPLICATIONS

We have only scratched the surface of what's possible with remote spectrum monitoring and wideband or Full-Spectrum Capture receivers. We expect that future applications will be able to proactively detect problems on the forward path so that the tools can become more proactive in nature and we no longer have to wait for a customer in a neighborhood to tune to a specific channel, notice the impairment, and call to report it. We also expect to see Full-Spectrum Capture receivers implemented in other kinds of equipment including terrestrial and other technologies. Another area for future development is giving technicians more guidance about problems to shorten the troubleshooting process.

Figure 3 Example of a server-side admin panel

AUTHORS' CONTACT INFORMATION

Scott Helms, VP of Technology
ZCorum

4501 North Point Parkway, Suite 125
Alpharetta, GA. 30022
Tel 678-507-5000 Ext 5551
khelms@ZCorum.com
www.zcorum.com

Jim Koutras, Director of Product Marketing
MaxLinear

2051 Palomar Road, Suite 100
Carlsbad, CA 92011
Tel 760-517-1303
jkoutras@maxlinear.com
www.maxlinear.com