ADVANCED TECHNOLOGY

XCOR – TODAY'S APPROACH TO DETECTING COMMON PATH DISTORTION

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ADVANCED TECHNOLOGY

A NEED FOR CHANGE

Cable networks are trending further and further towards all–or majority–digital content. This trend has changed the way CPD appears to the technician. The days of troubleshooting high level CPD with a spectrum analyzer by looking for recurring 6 or 8MHz peaks are gone – CPD in today's network manifests simply as an elevated return path noise floor, making it impossible to differentiate CPD from noise and ingress. For field technicians, the only possible way to troubleshoot CPD has been to pull pads and disrupt the network in an attempt to track direction– not a sustainable practice in today's competitive market. Arcom Digital's Xcor technology has solved this issue by changing the way cable operators can monitor and troubleshoot Common Path Distortion (CPD) in the HFC network. Xcor is the ONLY technology that can accurately identify and track down CPD and other nonlinear distortion. It is available as part of an integrated and unique return path monitoring system called Hunter, or in standalone field test equipment in the Quiver series of meters. Operationally, Xcor has paid dividends because of its ability to quickly find the cause of network impairments. For some operators, Hunter has re-shaped the entire plant maintenance methodology, allowing a major shift from Reactive maintenance to Predictive maintenance. It saves time and effort, provides clear visibility to impairments that were previously difficult or impossible to identify, and results in a better performing, more reliable plant.

CPD can be quite disruptive for cable operators, and it has been found that the root causes of CPD sources are frequently the same root causes of noise and ingress issues. Issues that have been discovered with Hunter include nodes with missing seizure screws, amplifiers with loose hardline connectors, waterlogged amplifiers and nodes, faulty or overloaded amps, faulty terminators, internally rusted taps, corroded F-connectors, etc., etc. Thousands of devices have been found – all of which needed to be replaced, and all of which were causing or would have caused network problems.

Every CPD source is inherently a source of nonlinear distortion. We use this characteristic to our advantage. Our radar technology determines exactly where in the system the distortion is coming from. The radar portion of the system provides the time distance to the problem. The technician is able to quickly, efficiently, and logically go to the offending device and fix the problem. The days of spending weeks locating intermittent problems are gone.

/ THE TECHNOLOGY

For a radar system to operate within an HFC system three core elements are required: a transmission of a probing signal in which energy is propagated towards a target, an echo signal that will travel back through the network to a receiver, and a relationship between the probing and echo signal for ranging and detection processing.

Xcor utilizes the existing forward QAM channels as the radar probing signal. As the channels propagate through the network and as they come across source locations of CPD, intermodulation products are generated. For any two QAM channels, a second order intermodulation product will be generated at the difference between the two signals whenever they travel through a source of CPD. These intermodulation products that travel through the return network back to the radar receiver are the echo signals used by the system – they are the second of the three required elements mentioned above.

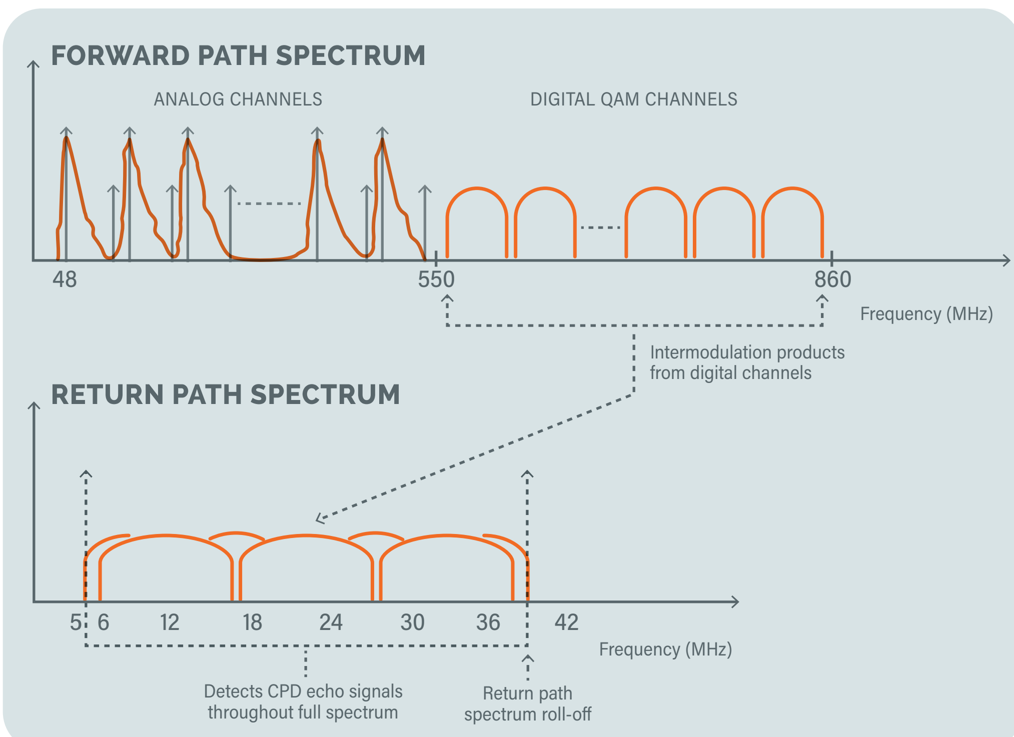

FIGURE 1

Figure 1 is a representation of the second order intermodulation products created from the digital QAM channels propagating a CPD source (a nonlinear junction or corrosion cell).

The last remaining required element is a relationship between the probing signal and the echo signal. Xcor creates this relationship through a technique that Arcom Digital has called a CPD Simulator. All the forward signals in the network are fed to the CPD Simulator. A snapshot is then taken of the spectrum at a specific moment in time. The CPD Simulator then calculates what the instantaneous intermodulation products would look like given the input spectrum. This calculated signal can be thought of as the T=0 echo. If CPD occurred at the headend or field connection point, these are the intermodulation products that would be generated. This process establishes a relationship between the probing signal and the echo, which satisfies the third and last required element of the radar system. All that remains is the signal processing for detection and ranging.

As was mentioned, if there is a CPD source at the headend, it will match the T=0 echo exactly. Furthermore, CPD occurring in the HFC network generated from the same signal as used in the CPD Simulator snapshot will appear identical to the T=0 echo, except that it will be shifted in time. The remaining task is the process that finds what this time shift is. The echo is compared with the signal from the CPD Simulator in order to determine this time delay in which the two signals are identical – which represents the time distance to the source.

A rough block diagram of the entire Xcor radar system is shown in Figure 2, and is essentially the same for either the headend or the field meter implementation.

The Forward signals are input into the Xcor radar through a directional coupler, or by a network connection when using the Quiver field meter. These signals then go through a CPD Simulator process in which intermodulation products are created from filtered forward QAM channels.The digitized output of the CPD Simulator appears as noise – however it is not noise because it was generated in a certain fashion and is not random.

On the right side of the diagram, the return inputs from the Hunter switches (or just a return path test point connection in the case of the Quiver) are fed into the Xcor radar. The digitized output of these return signals is real noise from the system – although it has some special characteristics. Hidden within this noise is a particular noise-like pattern, which is identical to that from the CPD Simulator but shifted in time by some unknown amount. Figures 3 and 4 show the output signals from the CPD Simulator and the return path.

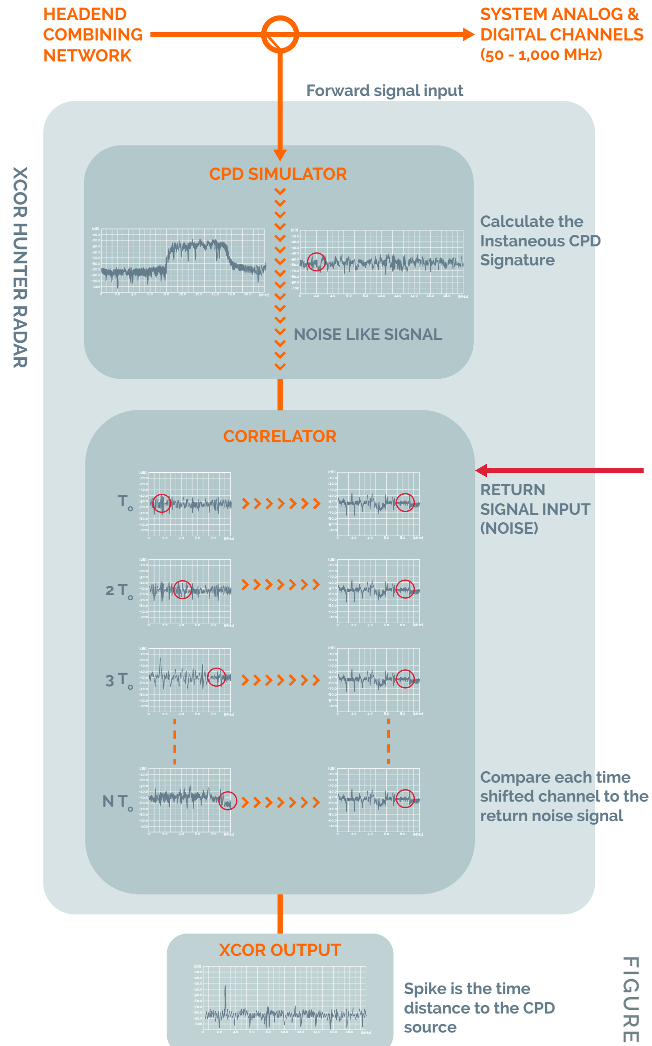

FIGURE 2

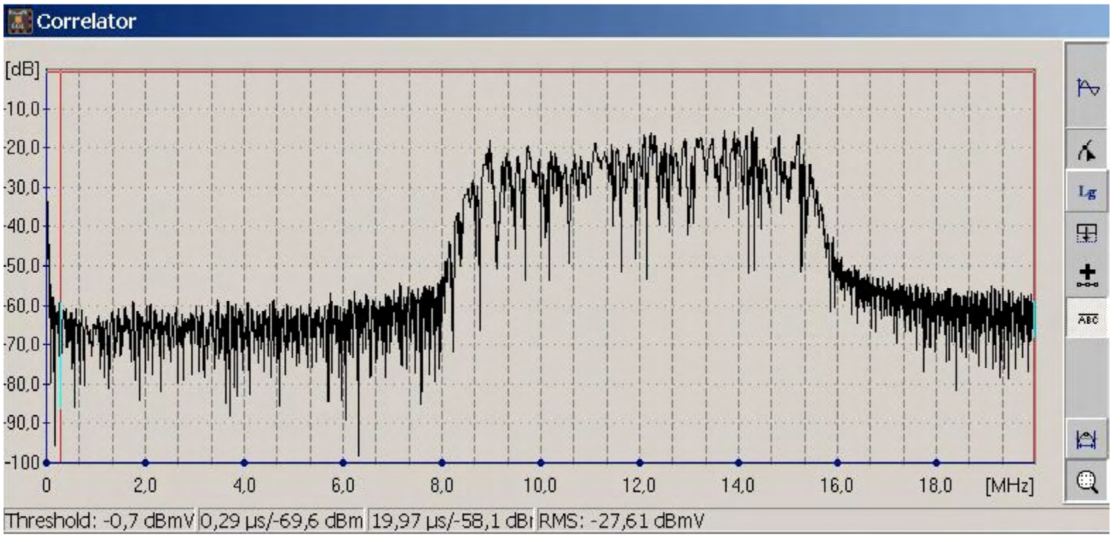

FIGURE 3
NOISE-LIKE SPECTRUM FROM
CPD SIMULATOR

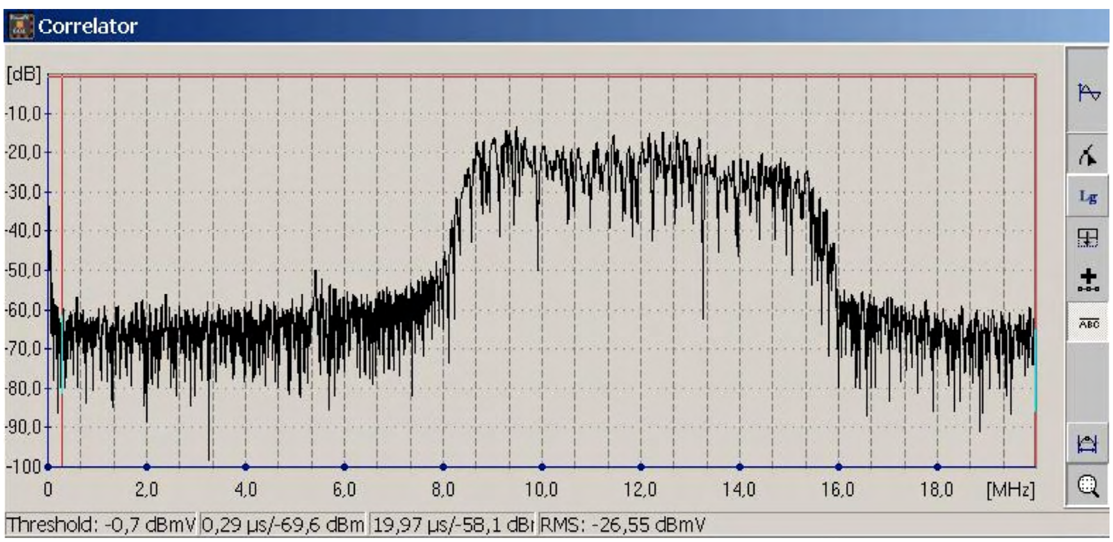

FIGURE 4
NOISE FROM SYSTEM RETURN

CORRELATION PROCESSING

Next, a Cross Correlation process is used to compare the two signals. Cross Correlation is a mathematical technique whereby two signals are statistically compared to see if they match. The time domain response of the noise-like signal from the CPD Simulator is first shifted by a small amount in time (20 nanoseconds) and then compared with the time domain response of the noise from the return path. The Cross Correlation results are then stored, and the CPD Simulator signal is time shifted again and re-compared to the noise from the echo signal. These results are also stored. This incremental time shift process continues for a few thousand iterations – enough times for the delay from the entire RF portion of the plant to be taken into account. This technique is implemented in parallel, allowing the entire process to be performed simultaneously and within fractions of a second. The net result of these signal comparisons form a response called a Correlation function. When this Correlation function is at a maximum, the two signals are considered identical. The cumulative time delay that corresponds to the maximum of the Correlation function is the key number – represents the time delay to the CPD source. Also contained within the processed return signal is information on the relative strength and severity of the CPD source. Figure 5 shows the output Xcor response of a real CPD source. The spike shown in Figure 5 shows the source at 72.1μs with a level of -25.32dBmV.

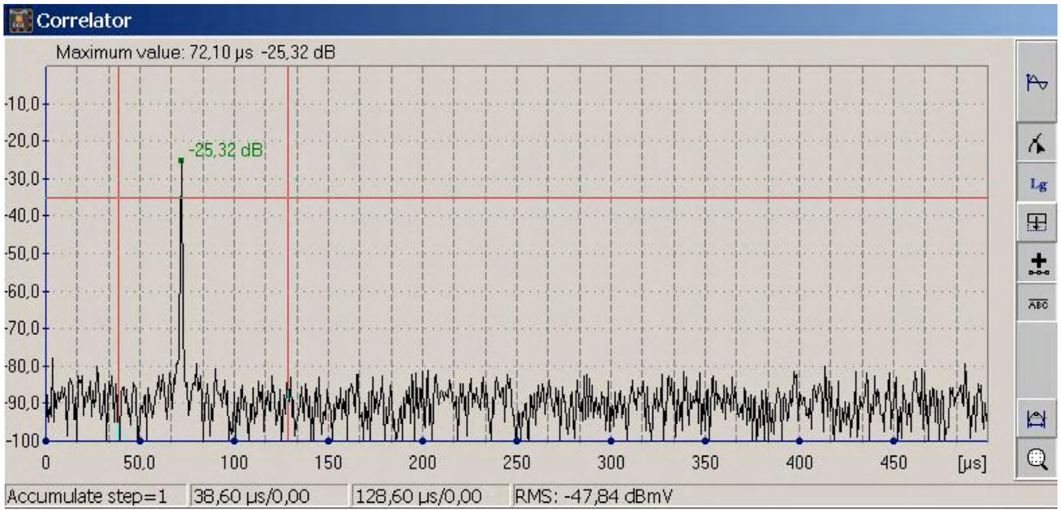

FIGURE 5
XCOR RESULTS - HEADEND VIEW

An example of the correlator results for the Quiver implementation are shown in Figure 6 – with amplitude of CPD at –30dBmV and a delay of 1.00 µs.

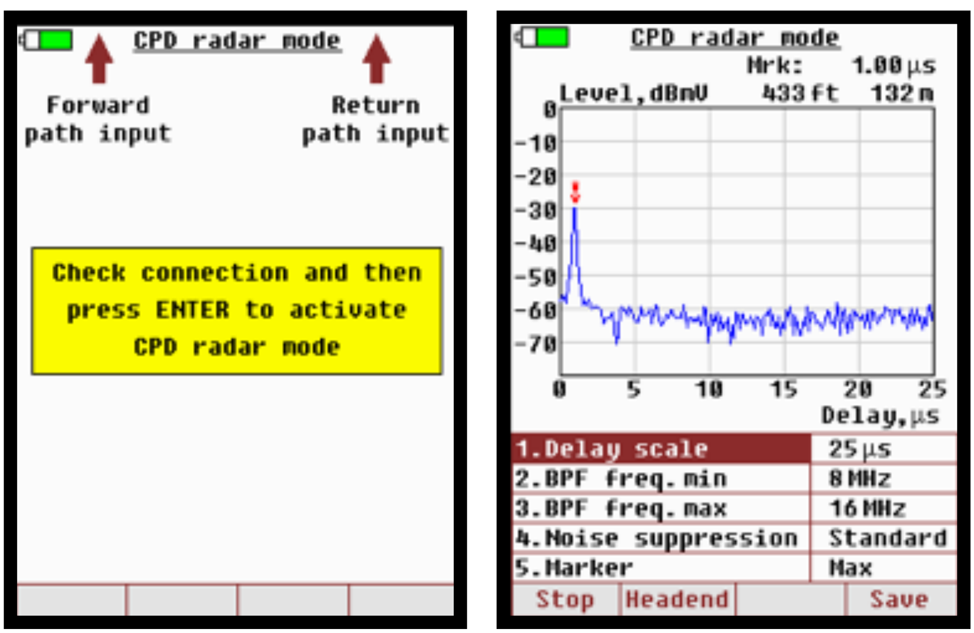

FIGURE 6
XCOR RESULTS - QUIVER VIEW

PREDICTIVE ELEMENTS

Figures 7 and 8 illustrate an example of how CPD is detected by Xcor while the RTN spectrum is absolutely clean with the CNR upstream at a level of >35dB. Following these images, Figures 9 and 10 illustrate how Hunter records and displays how a small level of CPD may increase during a short period of time – impacting service at the RTN. The top part of the screen shows the correlator results and displays CPD events with a corresponding amplitude and delay. The bottom portion of the screen shows the return path spectrum and provides a weighted CNR calculation of all the return carriers, to be used for prioritizing repair. The first screen capture in Figure 9 shows an example of CPD that is not yet network affecting. The second screen shot shows the same source only two hours later, when the CPD level increased by 26dB to the point that it became network affecting and deteriorated the return channel CNR.

These two images provide a great illustration of the predictive capability of Xcor. With CPD and the associated corrosion and network deficiency, the only certainty is that it will continue to deteriorate itself over time. With the clear visibility provided by Xcor, you can fix the impairment before it becomes network affecting. This ability makes Xcor truly a game-changer in how the modern network can be maintained.

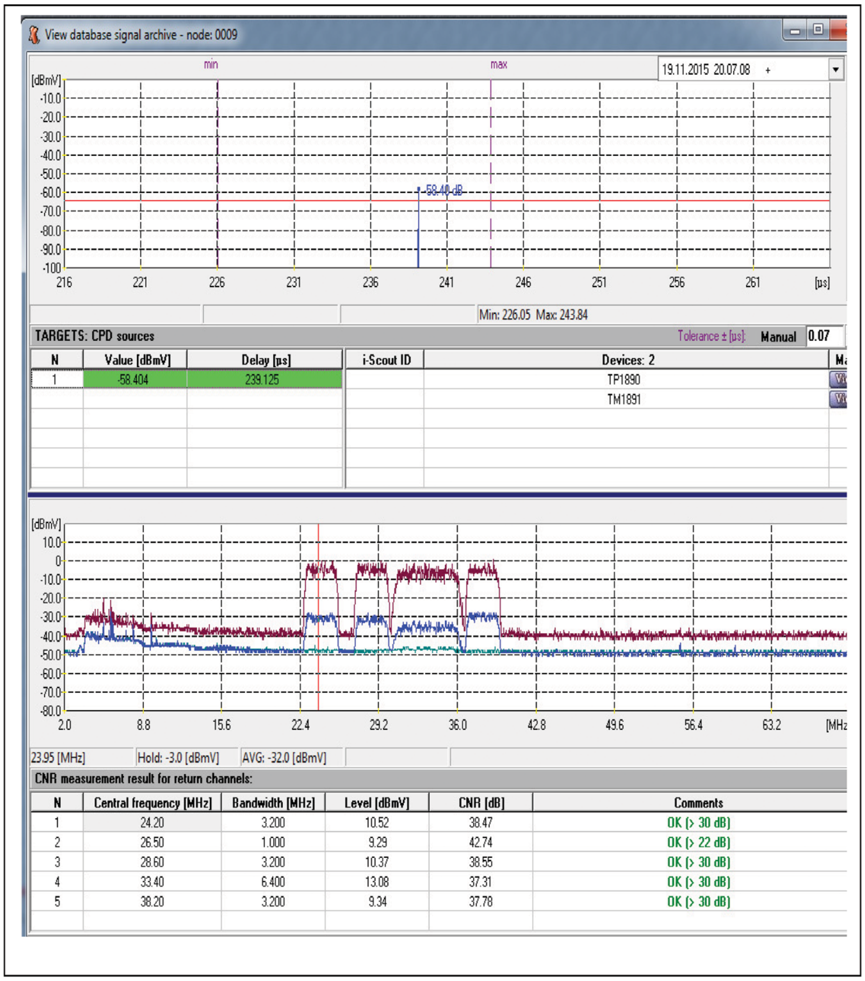

FIGURE 7

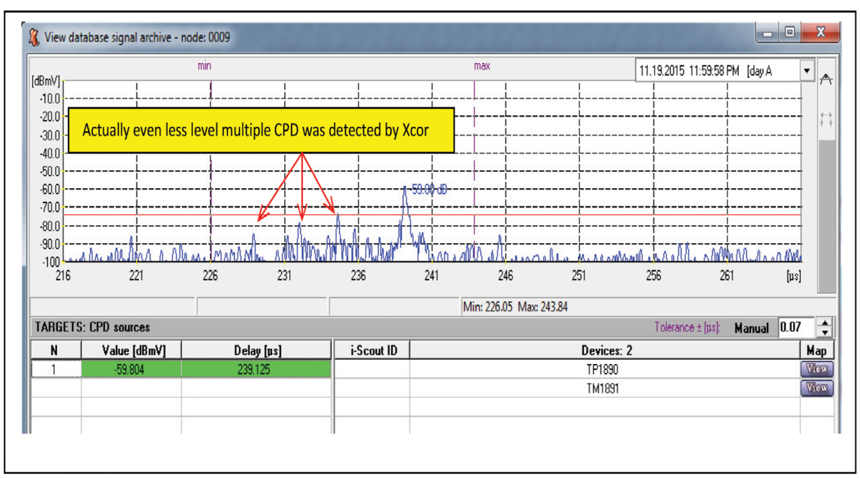

FIGURE 8

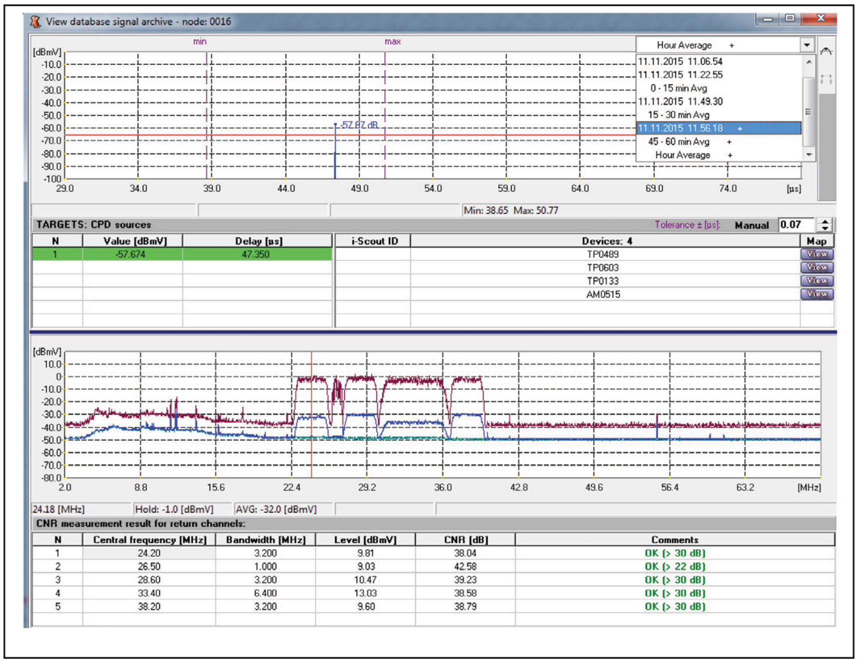

FIGURE 9

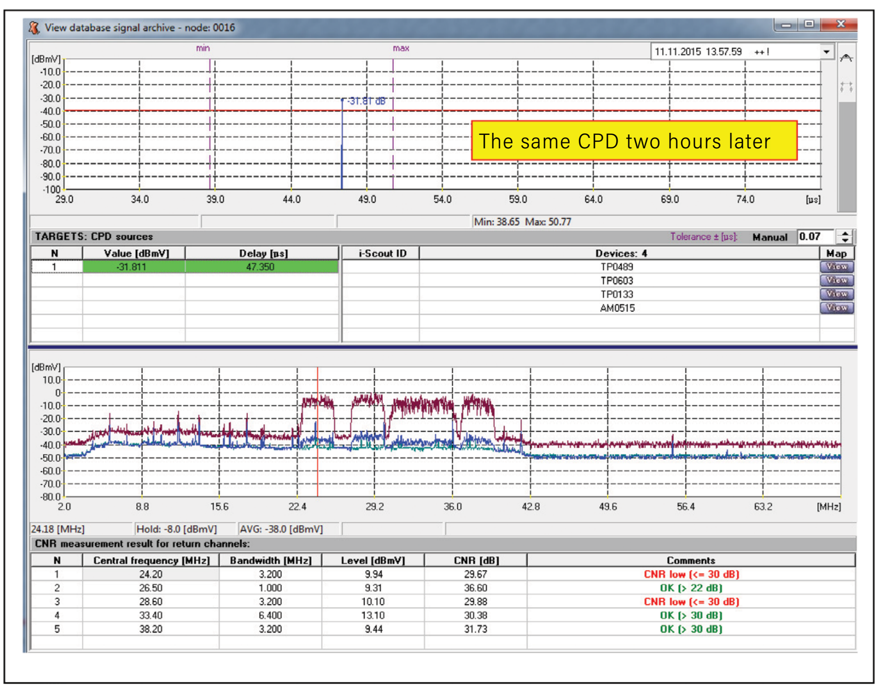

FIGURE 10

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