# White Paper::

Xcor – THE NEXT GENERATION HUNTER TECHNOLOGY

185 Ainsley Drive \\ Syracuse, NY 13210 \\ 800.448.1655 \\ www.arcomdigital.com

arcom digital

## THE ARCOM DIGITAL HUNTER PLATFORM HAS PROVIDED SIGNIFICANT VALUE TO THE MANY OPERATORS WHO HAVE INSTALLED THE SYSTEM.

## Introduction

With many successes to date, the first generation of CPD Hunter has proven to be the ultimate tool in pinpointing CPD in an HFC network. Yet in order to further the advancement of the platform, various adjustments needed to be made to its infrastructure. This meant eliminating CPD Hunter's need for dedicated bandwidth for its radar signals. The next generation Hunter platform uses our proprietary technology — Xcor — to remove these limitations by using the analog and digital channels that already exist in the system as its probing signal. The result is a more efficient, more effective, and more precise state-of-the-art Predictive Maintenance tool.

## Successes to date

The Arcom Digital Hunter platform has provided significant value to the many operators who have installed the system. What makes this system so unique is its ability to serve as an effective Predictive Maintenance tool. Operationally, it has paid dividends because of its ability to quickly and efficiently find root cause sources of network impairments. For some operators, Hunter has re-shaped the entire plant maintenance methodology — and has allowed a major shift from Reactive maintenance to Predictive maintenance. What's more, it saves time and effort in finding and fixing problems — ultimately resulting in a better performing, more reliable facility. Other operators have experienced significant improvements in their ability to certify nodes, thereby increasing the speed at which advanced services can be implemented. The first generation CPD Hunter has proven to be extremely beneficial.

Hunter works by finding sources of Common Path Distortion (CPD) in a cable plant. CPD can be quite disruptive for cable operators, and it has been found that root causes of CPD sources are frequently also the root causes of noise and ingress issues. All agree that the types of problems that Hunter finds are real problems that need to be fixed. Devices that have been located include nodes with no seizure screws, amplifiers with completely loose hardline connectors, amplifiers and nodes partially filled with water, bent center conductors, cracked center conductors, faulty terminators, internally rusted taps, corroded F-connectors, etc. Many hundreds of devices have been found — all of which needed to be replaced, and all of which were causing or would have caused network problems.

Each CPD source is inherently a source of nonlinear distortion. We use this characteristic to our advantage, and use radar technology to tell exactly where in the system the problem is coming from. The radar portion of the system displays the time distance to the problem — and the database portion derived from electronic maps of the system tells the operator which device or devices are the corresponding time distance away. The technician then quickly, efficiently, and logically goes to the correct device and fixes the problem. Long gone are the times of spending weeks locating intermittent problems.

## The need for Xcor

The radar signals used in the first generation required 12.5 MHz of dedicated forward bandwidth. The only downside to the first Hunter product was the upstream bandwidth requirement. There are many systems that wanted to install Hunter and take advantage of the benefits it offered, but bandwidth constraints made it not feasible. As such, a different method that uses less bandwidth was needed. This was the driving force behind the development of Xcor — the next-generation radar technology now available in Hunter.

## The technology

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

In order to reduce or minimize the bandwidth requirement of the first implementation, a significant challenge was presented to find a suitable alternative probing signal. However, the answer was already there. Cable television networks obviously transmit signals, both analog and digital. It is these signals that Xcor uses as its radar probing signals, thereby satisfying the first of the three core elements. The use of these already existing video channels (which require zero additional forward bandwidth) is a huge improvement over the previous generation that required 12.5 MHz.

As the analog and digital channels propagate throughout the network, it's not until they come across source locations of nonlinear distortions (or CPD) that intermodulation products are generated. This, in addition to resultant noise problems, is why CPD is troublesome to CATV operators. 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. Additionally, a third order product will be generated between the QAM channels and analog channels. 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 is a representation of the second order intermodulation products from the digital QAM channels, and from the third order intermodulation products from the analog and digital channels. All of these signals are resident in the return path and as such are transmitted back to the headend. For efficiency purposes, Xcor selects a defined bandwidth of signals in which to monitor — as shown below, 10 MHz between 7 MHz and 17 MHz. This spectrum is simply a frequency range the system uses to passively observe; it is not dedicated and can be used for other purposes.

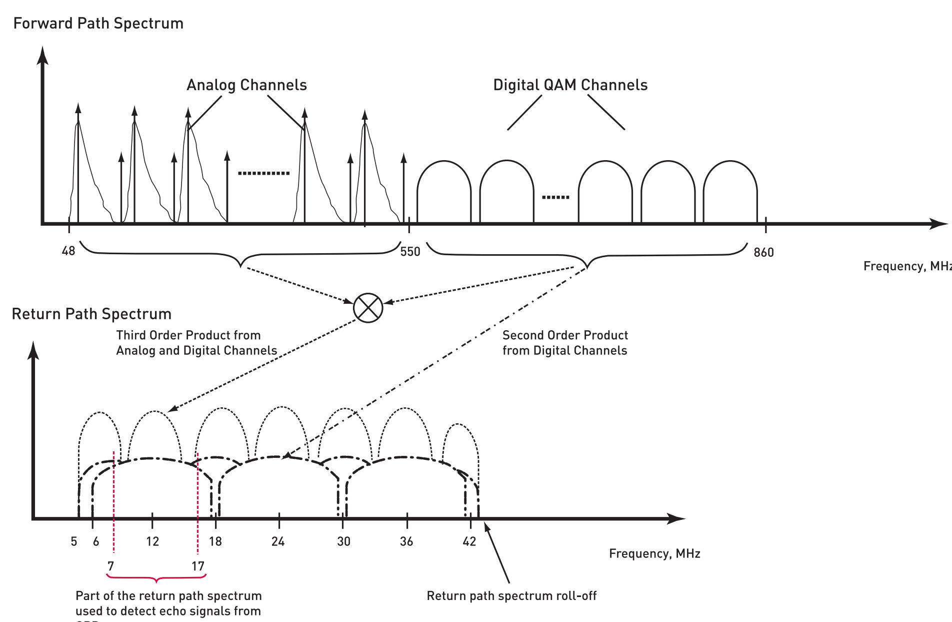


**Figure 1:**

Representation of the second order intermodulation products from the digital QAM channels

The last remaining required element is a relationship between the probing signal and the echo signal. Without this relationship, the echo is of no use and the system will not work. Xcor creates this relationship through a technique/function 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 second and third order 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, 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 was a CPD source at the headend, the T=0 echo is exactly how it would appear. It is also true that any 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 and represents the time distance to the source.

A rough block diagram of the entire Xcor radar system is shown in Figure 2.

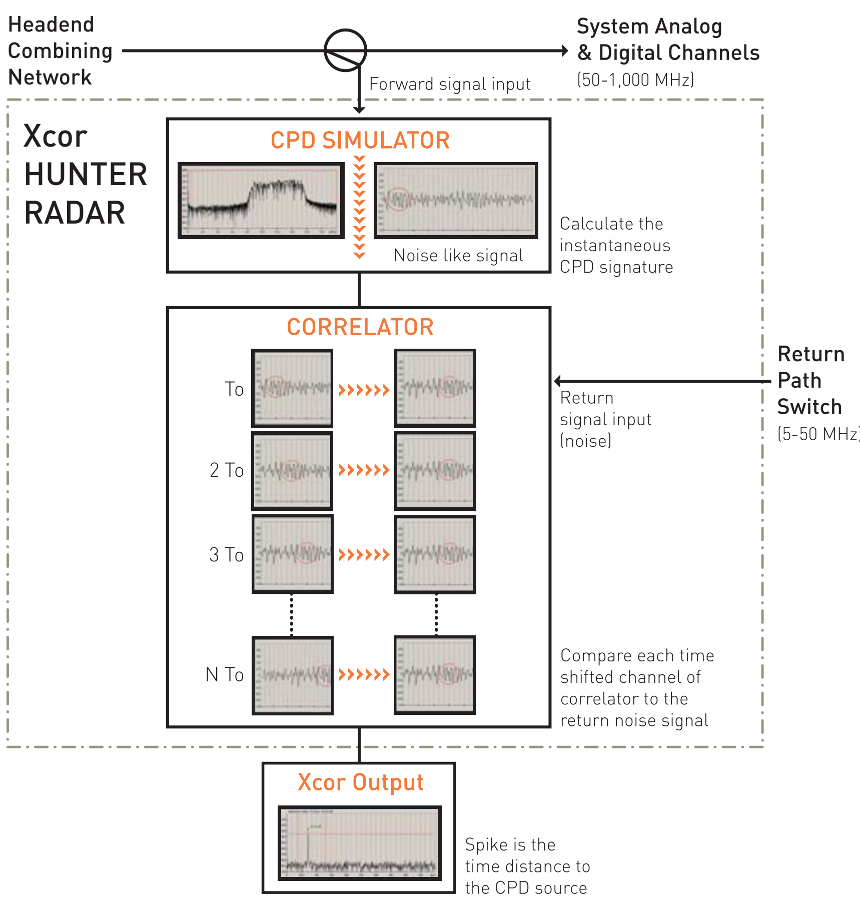


**Figure 2:** Diagram of the entire Xcor radar system

*Please reference Appendix A for a larger view.

Here the forward signals are input into the Xcor radar through a directional coupler. These signals then go through a CPD Simulator process in which all the relevant second and third order intermodulation products are calculated for the snapshot spectrum. Since only those products falling between 7 MHz and 17 MHz are of interest, these are the only ones used in subsequent calculations. The digitized output of the CPD Simulator is shown in Figure 3. While the signal appears as noise, it is clearly not. It is a non random signal having spectral components, the combination of which appear similar to noise. On the right side of the diagram the return inputs from the Hunter switches are fed into the Xcor radar. The digitized output of these signals is real noise from the system, although it has some special characteristics. Contained and hidden within this noise is a particular noise-like pattern identical to that from the CPD Simulator output, but shifted in time by some unknown amount. Figure 4 shows the output signal from the system return path.

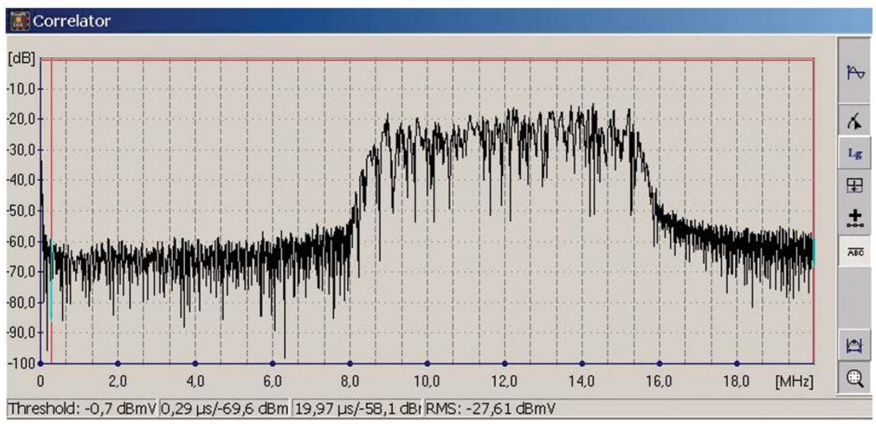


**Figure 3:**
Noise-like spectrum from CPD Simulator

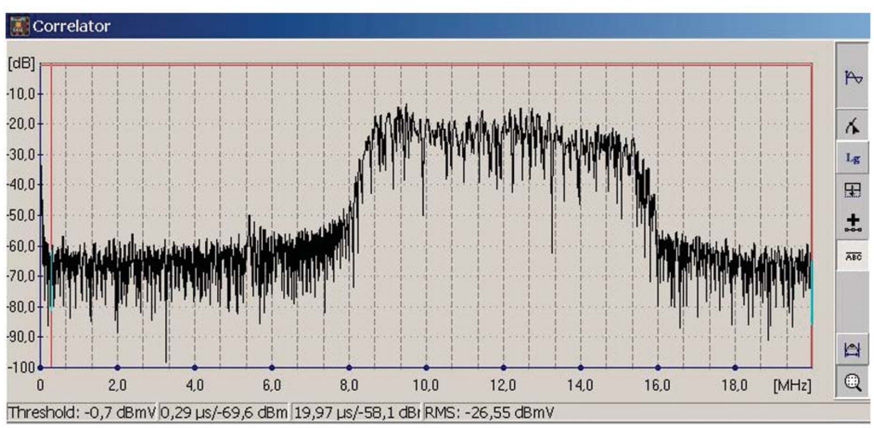


**Figure 4:**
Noise from system return

## Correlation Processing

A process called Cross Correlation is used to compare the two signals. This is a mathematical technique whereby two signals are statistically compared to see if they are identical. 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. Cross Correlation results are then stored. The CPD Simulator signal is again slightly time shifted and compared to the noise from the echo signal, and stored. This incremental time shift process continues for a few thousand iterations — enough so that delay from all of the RF portion of the plant can be taken into account. This technique is implemented in a parallel fashion so that the total process is performed simultaneously and only requires fractions of a second. The results of all 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 number that is of interest. This number represents the time delay to the CPD source. Also contained within the processed return signal is information on the relative strength or 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 -25.32dB.

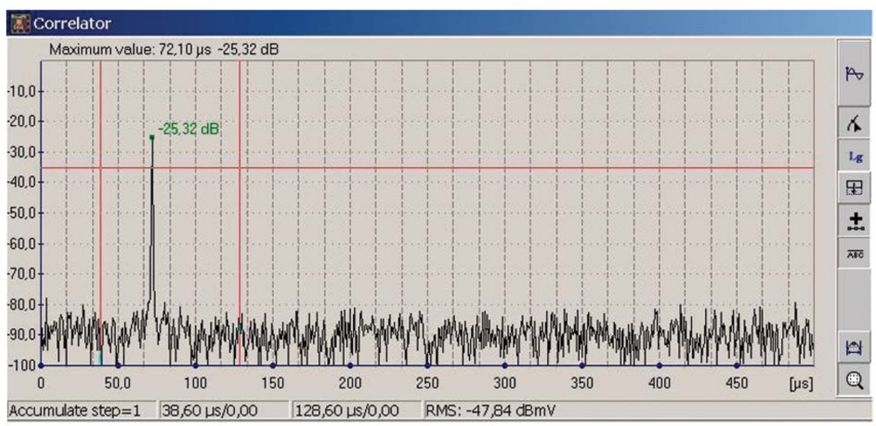


**Figure 5:**
Xcor results

## Results

The next-generation Xcor technology has been thoroughly field tested and performed flawlessly, just like its predecessor. Most importantly, it performed without utilizing any of the forward or return spectrum. It is now a passive radar system.

Looking again at Figure 5, it is obvious that the noise floor as seen using Xcor technology is well below and independent of the system noise floor. As such, CPD and root cause problems can be found at levels well below that which is distinguishable using any other available equipment. Traditional approaches using time-consuming and service disruptive hunting and pecking techniques only work on high-level CPD that is already network affecting. The technicians are looking for it because it is already causing a problem. With Hunter, even the lowest level CPD can be found. Furthermore, when systems go completely digital, it will be the only system that can locate CPD at any level. In an all-digital system, CPD will manifest itself as noise and will be indistinguishable from noise.

Hunter with Xcor technology allows for Predictive Maintenance which lets the operator fix problems before the device fails (before things stop working) and before customers call to complain. It is a tool that interrogates the network, listens to what the network says is wrong, and then finds where the problem is.

.01 It provides a technological approach to accurately and quickly identify and pinpoint root causes of network impairments.

.02 For the first time, a predictive maintenance tool is now available to the industry. Hunter identifies the problems prior to them becoming network affecting.

.03 The system will enable significant improvements in the efficiency and effectiveness of the technical and plant staff, thereby realizing significant operational savings.

.04 The early on identification and minimization of CPD related root-cause impairments will result in measurable improvements in the quality of service and the robustness of the plant.

# Appendix A

Diagram of the entire Xcor radar system