ACCESS™

Communications Offers & Insights

Summer 2015

The Future of Broadband

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KGP Logistics

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INSIDE VIEW

Our industry is changing at an astounding pace. The demand for bandwidth from both consumers and enterprises is driving network transformation strategies focused on virtualization and the cloud. These advancements in technology increase the need for improvements in supply chain solutions. Simply having product available via local or regional distribution centers is no longer enough to meet the needs of carriers trying to rapidly upgrade their networks to meet the quality of service expectations of their customers.

As carriers invest in network upgrades that allow them to improve scalability and capacity while lowering network management costs, a need for unique and specific supply chain solutions at the network edge and in the last mile will become crucial. Micro Supply Chain solutions have emerged as a key method for improving efficiency and reducing costs associated with quality, availability and reliability. KGP is focused on developing and providing Micro Supply Chain solutions that are specific to the needs of each customer. By leveraging our broad capabilities, national distribution center network and value-add services, KGP is helping our customers develop solutions that address and mitigate the everyday challenges of building and maintaining wireline, wireline and cloud networks.

The relationships we have built with our customers and supplier partners allow us to forge a path in the current landscape with confidence. While showcasing strengths such as stability and flexibility prove invaluable as we move to the future, opportunities to engage multiple facets of our organization to provide unique solutions has become a key differentiator for KGP Logistics.

Marc Bolick

Vice President, Product Management and Marketing

KGP Logistics

Faster and More Efficient MDU Fiber Deployments

Kathy Terryll, TE Connectivity Product Manager

An estimated one-third of US residents live in multi-dwelling unit (MDU) properties, so these properties are prime targets for broadband service providers. Optical fiber is the chosen medium for future-proofing the network against higher and faster capacity requirements. But running fiber to every unit in an MDU facility comes with many challenges, including available space, power, fiber storage and aesthetics – not to mention the need for inexpensive, easy and fast deployments.

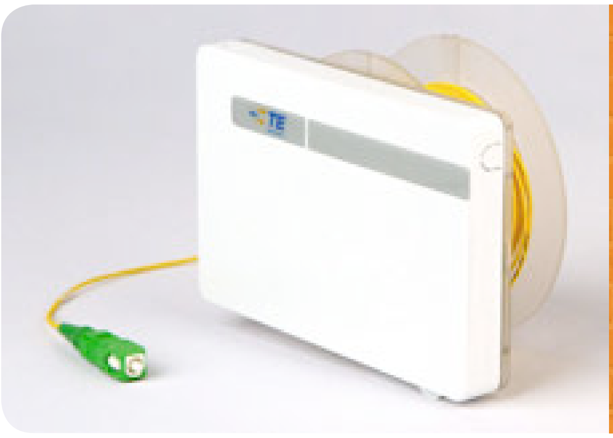
MDU fiber installations must deal with conduits and widely varying layouts that can require substantial time to both plan and conduct an FTTP installation. Rapid Fiber technology provides both qualitative and quantitative advantages over other methods. It's an inherently-flexible technique with benefits that carry across a wide range of constructions. Using the Rapid Fiber MDU system with appropriate hardware provides cost-effective bandwidth delivery to MDUs while reducing overall costs, planning time, complexity and manpower.

Rapid Fiber MDU system

The Rapid Fiber MDU system delivers fiber from the fiber distribution hub (FDH) through optical network terminals (ONTs) to the final termination point of each living unit. Connectivity is streamlined to enable faster installations that, in turn, will create a faster investment return to service providers. The capability of a Rapid Fiber distribution terminal (FDT) to store excess cable simplifies planning an MDU installation. After determining the length of horizontal runs, the height of each floor, and adding an error factor for additional bends or turns in the cable path, a planner can determine exactly how many FDTs are needed and each cable length the installation requires.

Using other methods requires either detailed analysis of the distances between each FDT and the FDH, or requires cutting cables to length on-site. Either technique poses the possibility of a "do-over" if the length is not correct. Also, with Rapid Fiber, the need to plan for slack storage is eliminated. The Rapid Fiber FDH is available with a parking lot feature, which eliminates the need for planning any connector parking, and the only splice required is connecting the feeder cable to the FDH. The spool on the Rapid FDT pays out exactly as much cable as is needed, and stores its own slack (up to 200 feet). The connector is simply cleaned and plugged in. Cable pulling can be accomplished with only one worker.

The significant advantage to a Rapid Fiber MDU system is installation speed. If the fiber network installers can be in and out of the building as quickly as the construction workers, it provides a huge incentive for the building owner to decide on FTTP architecture. There is minimal disruption to tenants in brownfield deployments and products have been designed to be unobtrusive and aesthetically pleasing.



MDU installation comparisons

To compare the Rapid Fiber MDU system to other installation methods, let's consider a large high-rise MDU with 23 floors and 15 units per floor. Using a stub-pull configuration method, a 432-fiber indoor FDH is located on the lower level with three 144-fiber stubs. FDTs reside on each floor that route 12 or 24 fibers down the FDH where they are typically spliced in. That's 432 splices between the FDH and FDTs alone, not to mention 345 individual drop cables from the FDTs to the ONTs that create a second splice point.

Another method, the loop-through configuration, would involve pulling several 72-fiber or larger distribution cables between the lower-level FDH and the FDTs on higher floors. On each floor, one of the cables is routed through the FDT where it is opened. Two of the 12-fiber ribbons are then opened to route 15 individual fibers to the splice tray in the FDT. In this example,

345 fibers would be spliced between the FDH and the FDTs with 345 individual drop cables running from the FDTs to the ONTs, creating another splice point as it is not possible to predict the exact length of each drop. Per-splice costs are also increased because the splicing technician spends additional time routing cables through the FDT and opening them.

With the Rapid Fiber MDU system, an FDT again resides on each floor, but an MPO connector is mounted on the stub of each. The fiber is deployed from each FDT to the indoor FDH, also with built-in 12-fiber MPO connectors. Each connection is easily plugged into the FDH from every floor. Installing fiber into an MDU is a simple matter of mounting the enclosures and making Rapid Fiber connections with the cables. Since distances vary from each FDT to the FDH, a built-in 500-foot fiber spool is designed on the FDT. Fiber cable is easily spooled out to the FDH and plugged in, while any extra cable remains on the spool. The box containing the spool is small—about 9 inches x 6 inches x 3.5 inches (height x width x depth) for 12 and 24 fibers – and can be locked down with a shroud to cover and protect the excess fiber. Finally, the Rapid Fiber faceplate allows the same fast connectivity between each living unit and the FDT.

Direct cost savings are substantial. In addition to saving on splice cost – which can be as high as $40 per splice when fully burdened with setup time, capital and maintenance costs, etc. – early installations of Rapid Fiber have shown a substantial reduction (as much as 10%) in labor time for non-splicing technicians as well.

In short, taking optical fiber into MDU environments is now faster, easier and more consumer friendly than ever before. Network equipment manufacturers have responded to the challenges of FTTP deployments with innovative and cost-effective solutions, such as the Rapid Fiber MDU system, that make it simpler and more cost-effective to deploy fiber to MDUs.

Contact KGP Logistics for more information about Multi-Dwelling Fiber Products from TE Connectivity

800-755-1950 | www.kgplogistics.com

TE connectivity

America's Wireless Infrastructure Deployment Agenda

ACCESS Interviews Jonathan Adelstein, President and CEO, PCIA – The Wireless Infrastructure Association

ACCESS: Consumer demand for wireless mobile data has increased 700x. What's the biggest challenge confronting the industry as it looks to meet the increasing consumer demand for data?

ADELSTEIN: The wireless infrastructure industry does indeed have terrific momentum. But we can't stay on this upward trajectory unless we continue to build more wireless facilities that will enhance broadband connectivity and wireless infrastructure as a whole. There's no doubt: we need to build new networks and upgrade our existing ones. Apportioning additional spectrum is not going to get the job done.

PCIA and other industry advocates have worked tirelessly to get certain regulations hindering wireless expansion changed. In one example of what's been accomplished, now, when you put a new antenna on an existing tower, or upgrade an old one, you don't have to get it zoned again. That means if you own a tower, you collect rent quicker. If your company helps install or upgrade that antenna, you can get your work done more quickly for your customer. If you manufacture the equipment, you sell it more quickly. If you're a carrier, your customers get better service faster. And all of these are important factors contributing to more robust wireless facilities across the nation.

The companies in the wireless industry have built and upgraded the world's greatest wireless broadband infrastructure right here in the United States. And wireless infrastructure companies are the ones who are going to keep it that way.

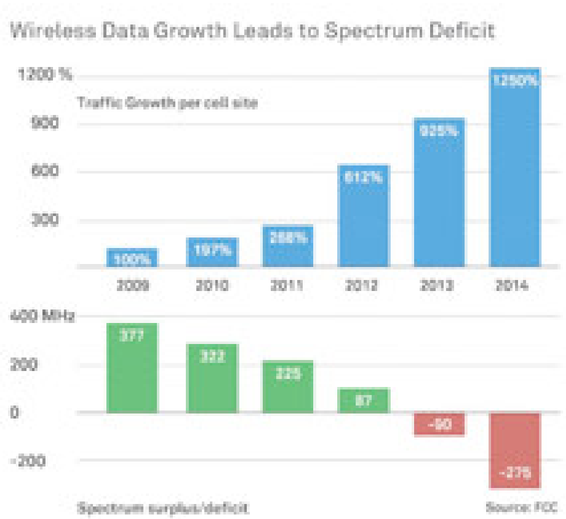
Jonathan Adelstein
President and CEO
PCIA – The Wireless
Infrastructure Association

ACCESS: Has the industry made headway in educating policymakers and elected officials about the need for new wireless infrastructure?

ADELSTEIN: We sure have – but the industry still has work to do. Federal, state, and local policymakers and regulators wield much authority over future deployment of wireless infrastructure. They need to understand the nexus between access to wireless mobile data and economic growth and job creations.

In Washington, we've achieved a bipartisan consensus for a pro-infrastructure agenda. The White House issued executive orders to promote wireless broadband deployment, with a real focus on Federal lands. Congress enacted our top priority to clear the way for siting and colocations. And the FCC followed with the strongest possible measures we requested all along the way. The FCC culminated its support with a final rule last October that gave us what we asked for: real shot clocks for municipalities to collocate or upgrade to 4G. If a locality ignores it, our siting request is automatically deemed approved.

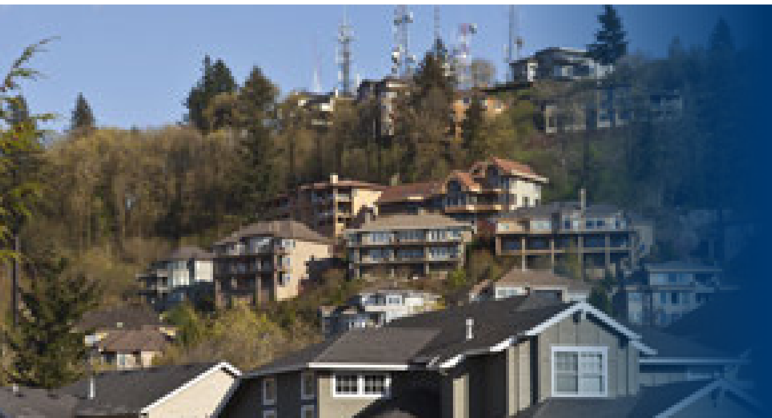
They also took major steps to streamline federal rules for deploying small cells and DAS, and are planning to do more. And more states are seeking new rules and policies to spur investment, from the heartland of Ohio to the coasts of Washington and California. Meanwhile, updates to provide greater access to rights-of-way are rolling out.



ACCESS: Tell us about the significance of the FCC's Infrastructure Order that was issued last fall.

ADELSTEIN: The FCC Order is an especially big win for our industry. Many unnecessary regulations have been eliminated. Others have been slimmed down. Still others are within striking distance! It didn't happen in a vacuum. PCIA worked with many members of the industry and our allies. For three-plus years, they worked hard and shared their time and expertise to shape that Order.

Now, at the direction of Commissioner Clyburn, who spoke at our recent Wireless Infrastructure Show, PCIA is working cooperatively with organizations that represent municipal voices to help implement those rules. We've developed an application checklist and model ordinance language and made them available to local officials around the country to help them comply. We're seeing that, properly enforced, the Order is facilitating even greater investment in our industry. So we're fighting to protect the FCC's Order by urging the courts uphold it.



"As networks get more complex, with more antennas closer to the end users, we need a workforce who knows what they're doing. They need to know the basics, and the specifics, of the RF environment in which they're building."

America's Wireless Infrastructure Deployment Agenda

ACCESS: Why has PCIA decided to re-launch its Innovation and Technology Council?

ADELSTEIN: It's because of the enormity of the deployment challenges that we face now and in the immediate future.

Led by industry visionary Jake MacLeod of Gray Beards Consulting, the Council will pave the way for even more improvements in 4G network deployment, all while we plan ahead for the needs of 5G networks. Jake is bringing together the leading lights of wireless infrastructure among our members to help navigate the technological landscape to deliver the infrastructure to meet the bandwidth demands of your customers.

And they're demanding a lot. Cisco, as you pointed out, predicts wireless data to grow sevenfold over the next five years. There's just three ways we can increase wireless data transmission: 1) spectrum; 2) new technological efficiencies; and 3), you guessed it, more infrastructure, by densifying the network.

> "We're not only creating jobs in the wireless industry -- we're creating jobs in virtually every other business in our economy, which increasingly rely on mobile broadband."

When it comes to spectrum, carriers just spent $41 billion for 65 MHz of prime new spectrum. Think about it: that's just 12 percent more than the roughly 550 MHz in commercial use today. And it won't be fully available for 3-5 years. So that's investing $41 billion for 12 percent more spectrum for capacity that won't be fully phased in for up to five years. What does that say about how much densification we're going to need to take care of the rest of the 700 percent of increased demand? Most analysts will tell you that it will take a lot of capex. Our job is to make sure that gets deployed as efficiently and effectively as possible.

ACCESS: How important is it for the industry to strengthen its job training programs to sustain projected job growth?

ADELSTEIN: It's hugely important. As networks get more complex, with more antennas closer to the end users, we need a workforce who knows what they're doing. They need to know the basics, and the specifics, of the RF environment in which they're building.

We're working with educational institutions, including Virginia State, Aiken Technical and Texas A&M, to pioneer model training programs that build on industry expertise and their training know-how. We're building up an apprenticeship program so workers can learn in the field through the federal Department of Labor's Telecommunications Industry Registered Apprenticeship, or TIRAP, which the FCC is also endorsed.

Wireless infrastructure is one of America's fastest-growing industries – and in my view the most economically critical. What should make you all proud is that we're not only creating jobs in the wireless industry -- we're creating jobs in virtually every other business in our economy, which increasingly rely on mobile broadband. A PCIA study found that investments in wireless infrastructure between 2013 and 2017 will create 1.2 million jobs and nearly $1.3 trillion in economic growth.

Titled "*Wireless Broadband Infrastructure: A Catalyst for GDP and Job Growth 2013-2017*," the report evaluates the economic and job-creation impacts generated by projected wireless infrastructure investments between $34 billion to $36 billion per year over the next five years. These investments will yield several other benefits:

- Between $863 billion and $1.2 trillion in cumulative economic development over the next five years, a 606 percent increase over the total amount the wireless industry will invest.
- A 2.2 percent increase in GDP by 2017.
- A direct impact of $85 billion to $87 billion of economic growth per year over the next five years, for up to a 0.5 percent improvement to GDP per year.
- The creation of over 28,000 jobs in 2017 and over 122,000 jobs in the next 5 years in the wireless infrastructure industry alone.

Source: http://www.pcia.com/pcia-press-releases/601-wireless-infrastructure-investment-will-generate-1-2-trillion-in-economic-activity-and-create-1-2-million-jobs

ACCESS: Are you concerned about the potential impact of the FCC's Net Neutrality rules on wireless infrastructure?

ADELSTEIN: Yes – we continue to carefully assess it. And our industry remains concerned about how the FCC's net neutrality rules will impact capital expenditures – and the jobs, economic growth, and technological development that come with them. If the United States reduces its wireless investment, it hurts the U.S. not only at home, but in the global marketplace.

Here's the bottom line: If we want to realize this promise, infrastructure builders need the capital to invest.

This is our message: Much more than our own needs are at stake. So we need regulators to help us, not stand in the way. We're in the right industry at the right time with the right technology. We're not just making profits. We're making history. How? By building networks that connect people and business in ways that were unimaginable just a few short years ago.

"The companies in the wireless industry have built and upgraded the world's greatest wireless broadband infrastructure right here in the United States."

PCIA

PCIA - The Wireless Infrastructure Association is the trade association representing the companies that make up the wireless telecommunications infrastructure industry. Our members include the carriers, infrastructure providers and professional services firms that own and manage more than 135,000 telecommunications facilities throughout the world.

Tags:
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#PCIA, #5G, #netneutrality,
www.pcia.com/, www.graybeardsconsult.com/ , www.tirap.org/,
www.fcc.gov/wireless-telecommunications-bureau

THE FOUNTAIN OF YOUTH FOR GIGABIT BROADBAND:

NG-PON2 Can Double the Life of Your Network

Kurt Raaflaub, Senior Manager, Strategic Solutions Marketing, ADTRAN

Make no mistake, if you offer a 1 Gbps symmetric broadband service you had better be able to deliver the goods. It's true that today's average broadband speed connection in the U.S. is still only about 10 Mbps and that average peak time usage per broadband user today hovers around 2 Mbps. The fact of the matter though, is that as Gigabit broadband service providers you answer to a higher power—the broadband speed test!

The almighty speed test is king and your network's credibility rests on supporting it. For now, most new Fiber-to-the-Home (FTTH) networks can handle this application, having the available access capacity to both support the full Gigabit per second burst, satisfying the network speed test, while still supporting many other peak time applications. The question is, what will happen in the coming years as "the need for speed" grows among countless users and inevitably taps out the network's ability to push that needle to 1 Gbps?

For a bit of background on tackling this question, let's first examine the current state of the Gigabit broadband landscape. Most of the broadband players in the Gigabit league today are using fiber-sharing GPON technology, rather than point-to-point Ethernet, for FTTH deployments. Point-to-point, sometimes referred to as Active Ethernet, supports a dedicated fiber port at the Central Office and therefore a full Gigabit of bandwidth for each user. GPON, on the other hand, follows a point-to-multipoint architecture, wherein the optical line terminal port is split to support a 2.5 Gbps per PON connection shared by 16 or 32 homes/businesses to download content (and a 1.25 Gbps shared pipe for uploading content). While point-to-point services deliver the certainty of a dedicated line, they remain a prohibitively expensive route to delivering Gigabit service on a large scale, hence most operators opt for the more cost-effective PON approach.

Nevertheless, if bandwidth utilization continues to grow at the approximately 40 percent annual rate we have seen in recent times, a 2.5 Gbps GPON port will eventually be unable to support a Gigabit speed test, perhaps in as little as 10 years. Moreover, an older FTTH network could run out of steam even earlier, maybe less than 5 years, if deployed on a less sophisticated GPON FTTH service delivery platform or if hungrier users like business customers consistently use speeds of over 100 Mbps.

The bottom line is we are approaching a limit on FTTH platform capacity comparable to a highway having extra lanes only part of the way between major interchanges. At some point a bottleneck on the 2.5 Gbps PON will result in an inability to on-ramp all traffic into the cloud at speeds promised. Many Gigabit service providers have already started to reduce their customer split per PON from 32 to 16 users to accommodate higher service rates. However, this will generally buy only a couple of more years at current growth rates before heavier user demands redline the FTTH GPON platform. So, what is a service provider to do?

The solution lies in next-generation 10 Gbps PON technology, namely NG-PON2, which at a minimum delivers four times more bandwidth than the current 2.5 Gbps per PON per wavelength.

The solution lies in next-generation 10 Gbps PON technology, namely NG-PON2, which at a minimum delivers four times more bandwidth than the current 2.5 Gbps per PON per wavelength. As this high-performance interface is rolled out in the coming years it can actually double the life expectancy of today's GPON networks, maintaining true Gigabit service for all subscribers.

ADTRAN is currently focused on demonstrating the value of its NG-PON2 architecture for operators in terms of both service agility and economic effectiveness. We have designed a single NG-PON2 system that meets the scale and flexibility needs of premium business and backhaul services, while also delivering on the price points needed for mass market residential applications. This technology uniquely makes NG-PON2 connections so cost effective it can support Gigabit Broadband services at under $100 per month, similar to today's GPON services.

ADTRAN's NG-PON2 solution truly offers service providers their first opportunity to scale and simultaneously support Gigabit service application growth for both residential FTTH customers and business adopters on a single, common access architecture.

CyberPower From PREMIER

New CyberShield® FTTx DC Battery Backup Power Supply Unit
Local Power Source with Battery Backup for Broadband and Telecom Applications.

The DTC36U12V FTTx DC power supply and battery backup is designed for desktop and mountable locations inside the home in contrast to traditional out-of-sight locations such as garages, basements, and utility closets. This makes the DTC36U12V unlike any model in the industry and its flexibility allows for reduced installation costs. The model allows providers to install the devices faster and in plain view, where they can be positioned with other utility devices such as phones, cable boxes and home electronics.

The DTC36U12V features an advanced LED and audible indicator system for simple interpretation of the unit's status. The improved battery maintenance and test algorithm accurately tests and maintains the battery for peak performance with minimal degradation and allows for the greatest utilization of the battery's capacity.

DTC36U12V Highlights

- FTTx Power Supply and Battery Backup Unit for desktop use
- Compact design saves installation space
- Visual indicators and audible alarm provide the unit status
- Emergency cold start function allows for "last gasp" availability
- Easy user-replaceable batteries
- Safe shutdown prior to any thermal damage

Local Powering Solution

- Cable telephone
- Wireless local loop
- VoIP & VoDSL
- Fiber to the home
- MTU/MDU
- SOHO network communication

Discontinued Model	Discontinued KGP Item #	New Replacement Model	New KGP Item #
DT30U12V-NA3	0000356280	DTC36U12V-NA3	0000436114
DT30U12V-NA3-G	0000364439	DTC36U12V-NA3-G	0000436115

The DTC36U12V model replaces the DT30U12V model (now discontinued)

For more information, visit www.dependonPREMIER.com or call 1.800.755.1950.

PREMIER®

Preformed Line Products is a Stable Presence in an Evolving Market

The market is going through yet another evolution. Gone are the days when a telephone company would only sell dial-tone to its customers and a cable TV operator would provide visual content. As technologies advance, services like High Definition Triple-Play in conjunction with Fiber to the Home are becoming all-in propositions from the Tier 3 Telco to the MSO with the national footprint.

Preformed Line Products Company (PLP) continues to support the evolving technological landscape and will continue to take risks from a financial and product development standpoint with one simple and inclusionary maxim spearheading their market strategy: "We are all connected."

Making connections leads to dramatic product development achievements. The deployment solutions the rural incumbent local exchange carriers require are not so different than the issues plaguing the likes of a large communication service provider, university campus, the US military, or a municipality deploying broadband services to its community. PLP supports all of them, albeit on a different scale, but effectively based on their mutual mandate, evolve or become extinct. At PLP, it is understood that when you build on something you'd better be sure you have a solid foundation.

With ground-breaking and innovative solutions like the line of COYOTE® Fiber Optic Products, and the THERMOLIGN® family of power transmission products, PLP has consistently pioneered modern advances in communications and power utility networks since 1947.

"Our customers count on us for reliable, high quality, innovative connectivity needs. They count on us to be creative, reliable, friendly and easy to do business with. Our customers count on us to be there when they need us," says Rob Ruhlman, Chairman, President and Chief Executive Officer at PLP.

Preformed Line Products delivers added value to its customers through their expertise and their unparalleled customer support. PLP's flexibility and global presence allow them to respond to customer's needs quickly and with precision. This strategy allows them to help their customers to meet their own business challenges head-on and achieve success.

COYOTE®
FIBER OPTICS

"The COYOTE® Fiber Optic line of products and the technology behind these important network devices are grabbing the attention of network design engineers and field personnel world-wide," says John Hofstetter, V.P. of Sales and Global Communications Markets at PLP. "Region by region, our teams are working hard to build on our experience and together we will continue to succeed in bringing broadband services to homes and enterprises around the world. A pipeline of new and exciting products is about to be released and we will be in a position to market next generation products that meet specific local requirements."

PLP continues to make advancements internally and externally. PLP's guiding principle is to provide training and support to their customers, like KGP, to insure KGP Logistics continues to be on the cutting edge of PLP's product offering and technical advancements to remain the leader in customer service and logistics management they have been recognized and decorated to be.

Preformed Line Products is regarded as a trailblazer when it comes to maintaining the highest quality product they can, and they do so by implementing tireless testing regiments. In fact, not only does PLP test products during the development stage in their research laboratory at their World Headquarters, they also test products at all their manufacturing facilities, to ensure their quality is never compromised. Quality begins at the receipt of materials when an incoming inspection is performed. This step ensures that PLP products start with high quality materials, supplied from certified, pre-approved vendors.

Today, PLP's lab is one of the largest test facilities of conductor and cable accessories for the power utilities industry as well as fiber connectivity devices for the communications industry. While many competitors have reduced or eliminated their test labs, Preformed Line Products recently expanded theirs 50%, to 23,000 square feet. PLP continues to be a leader in testing products to ensure they meet IEEE,CIGRE, IEC, ANSI, ASTM, Telcordia® and others industry standards.

Preformed Line Products was here yesterday, they are here today, and they will be here tomorrow to keep us all connected. Contact your local KGP Logistics Representative for additional information on PLP products.

PLP's lab is one of the largest test facilities of conductor and cable accessories for the power utilities industry as well as fiber connectivity devices for the communications industry

PIM Requirements Must Increase to Support Evolving DAS Systems

Luigi Tarlazzi
Product Line Manager, Distributed Coverage and Capacity Solutions

Several years ago passive intermodulation (PIM) was a virtually unknown performance metric in distributed antenna systems (DAS). Today it is recognized as one of the most critical requirements for optimum system performance. Hypersensitive antennas and radios, multiple frequency overlays, and more components in the RF path create an environment in which the margin for error regarding PIM continues to shrink[1]. Given the high susceptibility of current DAS systems, even small levels of PIM distortion can significantly impact network performance, as measured by upload speed.

Outdoor macro sites were the first deployment scenarios where the PIM issues had to be tackled. High power levels from the base transceiver station (BTS) ports and a more complex RF path to the antennas—including jumpers, filters and tower mounted amplifiers (TMAs)— contribute to generating PIM that can be very detrimental to the quality of wireless service. Due to the limited uplink (UL) transmit power of mobile terminals, the uplink receive sensitivity is a critical parameter to optimize in outdoor scenarios to allow a balanced downlink/uplink maximum path-loss. Best practices for macro site deployments have been defined over the past few years[1].

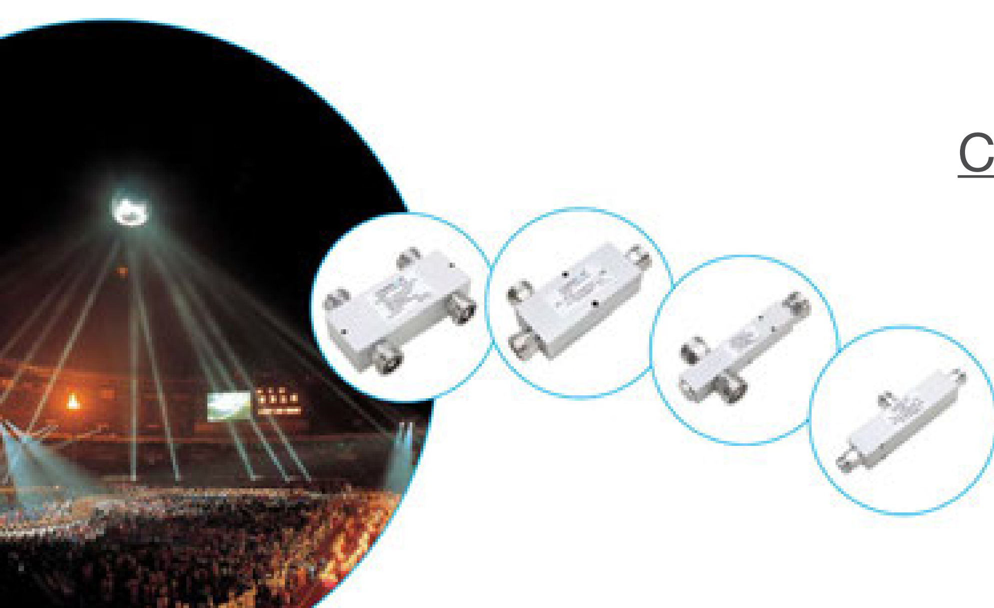
High and reliable data throughput values are even more important in DAS environments, such as stadiums, where there are many components in the RF path that can contribute to PIM generation. The minimum PIM specification for each and every component is improving continually. PIM specifications for RF components (splitters, couplers, etc.) and antennas have transitioned from –140 dBc to –150 dBc and now are moving to –153 dBc and –160 dBc[1]. With the passive components—such as splitters, hybrid couplers, and directional couplers—being placed closer to the signal sources in these systems, it is critical that the PIM specification for these devices is at the highest levels.

It should be noted that, at the DAS point of interface (POI), the PIM requirements are actually less stringent than at DAS remote unit ports coupled to a passive network. This is because DAS POIs typically feature filters that limit the frequency range of the generated PIM products. Moreover, BTS output ports are typically band-specific, so multiband carriers cannot mix together and generate PIM products falling in multiple UL bands. In this case, a –153 dBc PIM specification for POIs is typically sufficient to handle the input signals from macro BTS ports.

On the other hand, passive components used in RF signal distribution networks have wideband frequency support. Therefore, multiband and multicarrier signals from DAS remote unit output ports can mix together at every passive stage and generate a large variety of detrimental PIM products falling in multiple uplink bands. As such, PIM requirements for these passive components must be more stringent.

CommScope has introduced –160 dBc (i.e., –117 dBm IM power) passive components in the product portfolio to provide a solution for demanding DAS applications where PIM performance is critical. The following CommScope passive device families are offered with a PIM specification of –160 dBc:

- Power splitter
- Hybrid coupler
- Directional coupler
- Tapper



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To view the complete whitepaper online go to;
www.kgplogistics.com/prod_spotlight_commscope_whitepaper.html

[1] When measured with 2x20-Watt tones

PREMIER

Snap-In SC Single-Mode Fiber Module
For Indoor ONT Applications

The PREMIER snap-in SC single-mode fiber module provides connectivity for voice, data, networking and security applications in ONT applications, including Keystone style faceplates and housings. The ceramic sleeve provides for a sturdy and reliable alignment and connection.

Product Features

- Compatible with APC/UPC/SPC/PC connectors
- Jack module insert will snap into keystone style faceplates and housings
- Ceramic sleeve

PT-KJKSC-85

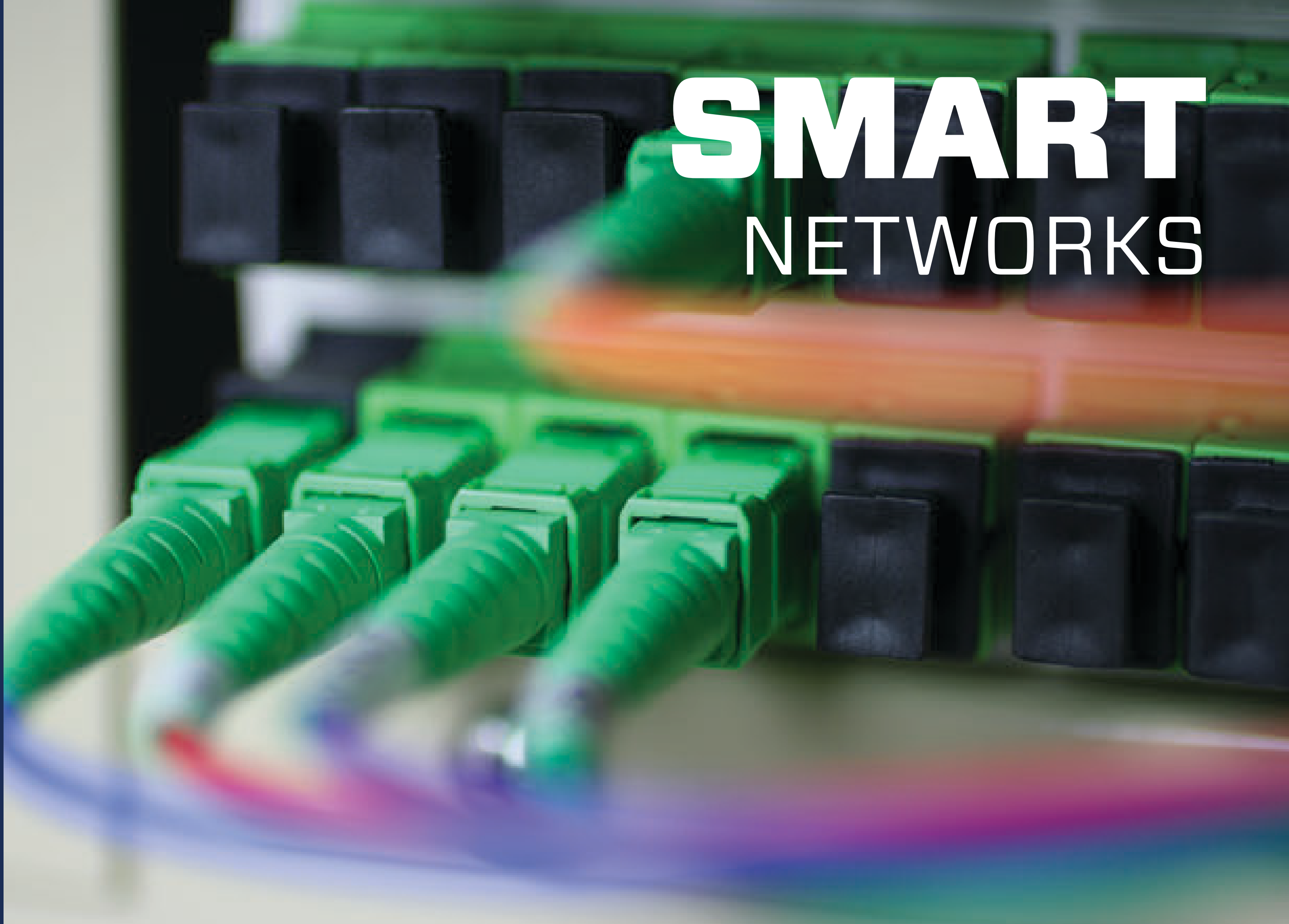
KGP Logistics Item #	Part #	Description
0000419425	PT-KJKSC-85	Snap-In SC Single-Mode Fiber Module in White. Compatible with APC/UPC/SPC/PC connectors. Jack Module Insert Will Snap Into Keystone Style Faceplates And Housings. Ceramic Sleeve.

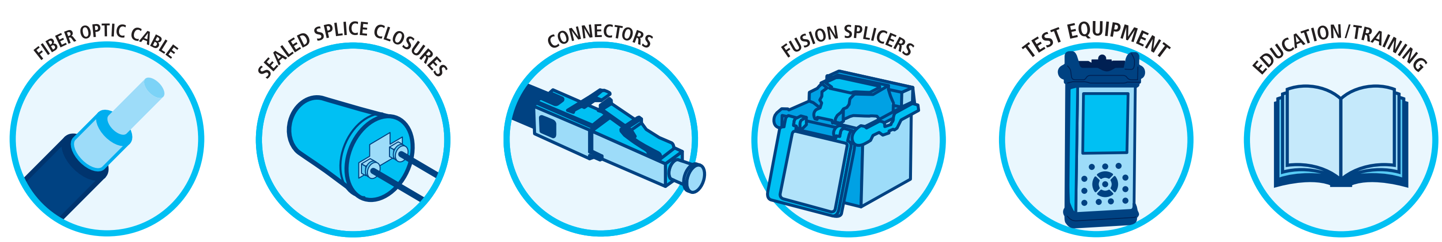
For more information, visit www.dependonPREMIER.com or call 1.800.755.1950.

Disaster Recovery

Recovering from a disaster requires the ability to act quickly and with confidence. Few can match the experience of KGP Logistics for determining the most efficient method to bring a business mired in various stages of emergency situations to an “Up and Running” status. Dedicated service teams will deploy the resources necessary to verify and ship inventory, arrange transportation and track shipments for delivery.

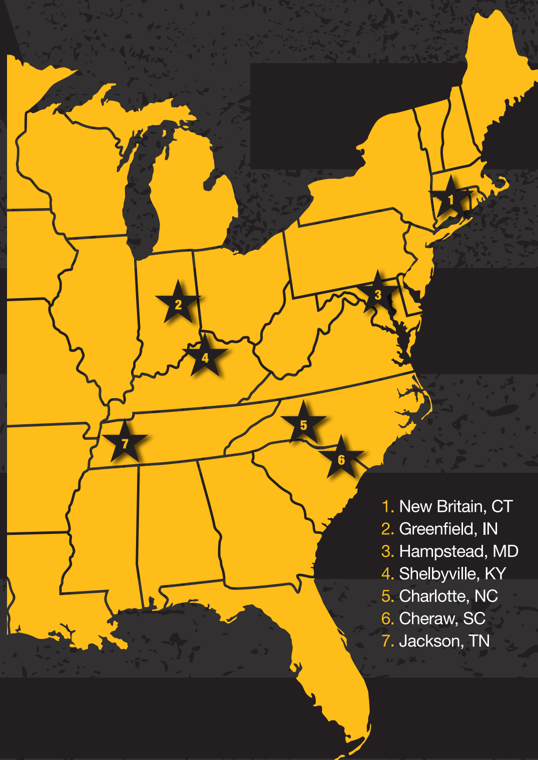
These services are available 24/7, 365 days a year through the KGP Logistics’ emergency support line at 800-755-1950.


SMART
NETWORKS


FIBER OPTIC CABLE
SEALED SPLICE CLOSURES
CONNECTORS
FUSION SPLICERS
TEST EQUIPMENT
EDUCATION/TRAINING

DEWALT IS A GLOBAL BRAND BORN RIGHT HERE IN AMERICA

7 US MANUFACTURING FACILITIES



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Communication Markets Division

3M™ Fiber Network Interface Devices

The compact 3M™ Network Interface Devices are exterior-mounted, weather-resistant enclosures that are typically attached to the side of a single family home.

3M™ Fibrlok™ Integrated Network Interface Device

The 3M™ Fibrlok™ Integrated NID includes one integrated 3M™ Fibrlok™ II Splice 2529 with one attached SC/APC pigtail prepared for the termination of a simplex singlemode fiber drop cable to the home. The 3M Fibrlok Splice and pigtail are pre-mounted in a protective splice tray with an integrated 3M Fibrlok Splice activation lever. The tray cover provides separation of the terminated drop cable from the home connection that is pulled into the enclosure and connected to the SC/APC adapter.

3M™ Fiber Network Interface Device

The 3M™ Fiber NID comes with a splice tray and one SC/APC adapter, enabling choice in connectivity within the enclosure.

Both NIDs have ample room for the slack storage of the home internal cable.

3M™ Fiber Network Interface Device

Specifications	
Application	Outside Plant Network, attached to building exterior, typically single family dwelling or duplex
Dimensions	170 × 240 × 80 mm (L x W x D) 6.7 × 9.4 × 3.2 in. (L x W x D)
Enclosure material	Thermoplastic
Enclosure material flammability	Meets UL 94 5VB (3M tested. Not UL listed)
Degree of protection	IP43 / IK06
Color	Light Gray
Slack storage capacity	Up to 35 ft. of up to 4.8 mm round cable

Note: This product is intended to be used with a non preterminated outside drop cable.

The cover of the enclosure is hinged on top, allowing the cover to fully open in tight spaces, as well as offer protection to internal components from inclement weather while working inside the box. The cover locks in two open positions, providing ready access for the technician. The hinged cover is secured with an integrated latching mechanism and permits the use of a tamper-evident security tag. Cables entering and exiting the enclosure are protected by rubber grommet entry ports.

The splice tray in both NIDs is capable of securing two 3M Fibrlok Splices or two fusion splice sleeves, two pigtails and two SC/APC adapters. A cover protects the drop cable fiber and splice, while access to the SC/APC adapter enables testing in both directions.

The 3M™ Network Interface Device 1724-ATF comes with an SC/APC adapter installed as well as a 3M™ Fibrlok™ Splice that can be easily actuated with the pre-installed lever.

Inside of the 3M™ Network Interface Device 1724-ATF

Inside of the 3M™ Network Interface Device 1724-AT

Ordering Information

Product Number	Description	3M ID	Min. Order
NID-FO-1724-ATF	3M™ Fibrlok™ Network Interface Device with one fiber splice tray with one 3M™ Fibrlok™ Splice and one SC/APC pigtail	80-6114-9788-6	18
NID-FO-1724-AT	3M™ Fiber Network Integrated Device with one fiber splice tray and one SC/APC adapter	80-6114-9787-8	18

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This product will be free from defects in material and manufacture for a period of 12 months from the time of purchase. **3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. Except where prohibited by law, 3M will not be liable for any loss or damage arising from this 3M product, whether direct, indirect, special, incidental or consequential regardless of the legal theory asserted.

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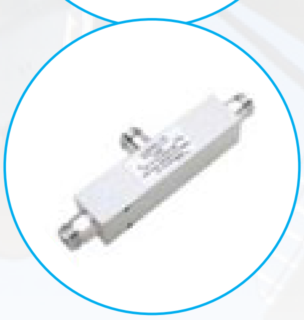

	700		AWS	
	f_{1L}	f_{1H}	F_{2L}	F_{2H}
Downlink (DL)	729	756	2110	2155
Uplink (UL)	699-716	777-787	1710	1755

Table 1: This shows the two U.S. bands supported by DAS in MHz.

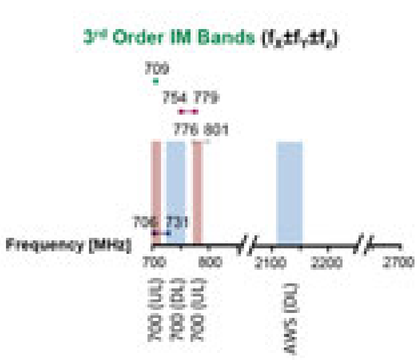

Figure 1: This illustrates third-order IM products with two U.S. bands and two wideband carriers per band (700 and AWS).

MAJOR PERFORMANCE THREATS IN HIGH TRAFFIC DAS INSTALLATIONS

There are a number of issues to consider when evaluating PIM requirements for the RF components in the passive distribution network of a multi-operator/multiband DAS installation:

1. The number of frequency bands and amount of spectrum used in each band are increasing, creating new and additional mixing products and generating wider bandwidths of PIM.
2. When multiple carriers on the same DAS infrastructure share a given band and are evenly spaced, the severity of the PIM products within the shared frequencies can multiply.
3. DAS systems are built using multiple cables and passive components in a cascaded architecture. The PIM performance is important for each element, but the passive components will be closer to the RF source—especially at high transmit (TX) power levels—and will have a greater influence on the overall PIM level produced.
4. PIM produced in the cabling and connector network may degrade over time and the importance to use high-PIM rated devices is critical for long-term operation of the system.

All the issues mentioned above represent major threats for the performance of DAS installations, which must support high data rates using large channel counts and multiple-in/multiple-out (MIMO) antenna schemes. This is an environment where PIM will have a tremendous impact on system performance, due to potential PIM creation through the multitude of channels and the need for minimum signal-to-interference noise ratio (SINR) for optimum MIMO performance.

In the following sections, the PIM requirements for passive components used in modern DAS installations are addressed in more detail and the driving needs for high-PIM rated devices are discussed.

PIM REQUIREMENTS FOR MULTIBAND DAS

Many DAS sites must support multiband configurations, where multiple bands share a common DAS infrastructure. Over the years, the number of bands to be accommodated has increased constantly. This, drastically increases the possibility that combinations of multiple carriers from different bands will fall in-band, generating intermodulation (IM) products. The 3rd Generation Partnership Project 3GPP has also discussed the impact of PIM on BTS receiver performance in “Multi-standard radio base station RF requirements for non-contiguous spectrum deployments” for both single- and multiband scenarios[2]. As long as a BTS transmits through one common DAS infrastructure for multiband scenarios, the PIM interference may cause receiver sensitivity degradation of another co-located BTS or its own BTS.

Over the next several years, more and more frequency bands and new technologies will need to be supported by DAS solutions. This will likely open the way to new frequency mixing and a higher probability of PIM generation. The figures to the left show the third-order IM products that are generated when multiple U.S. bands sharing a common DAS remote unit combine. Specifically, the data considers the interference generated by two bands and up to six bands. Each figure indicates the frequency intervals, representing the frequency range, where the interband third-order IM products occur. Even considering only the third-order IM products of type (e.g., 2fx+fy and 2fx-fy), several third-order IM bands—in some cases, even overlapping with each other—are generated as the carriers’ position within their respective bands shifts. The blue and red areas in each plot below indicate the downlink (DL) bands and show which calculated third-order IM bands fall in the uplink spectrum portions of the considered bands, respectively.

Figure 1 illustrates the third-order IM type ($f_x \pm f_y \pm f_z$) with two wideband carriers operating in both the 729–734 MHz and 751–756 MHz bands (700 MHz), and the 2110–2120 MHz and 2145–2155 MHz bands (AWS). This is one example of a single-operator DAS that must support a multiband and multicarrier configuration.

Even with only two bands, it is possible for overlapping PIM products to fall in the same 700 MHz UL band, causing harmful interference to the system. For applications involving wideband carriers such as LTE, even a single-operator DAS network can require the same or similar PIM performance as a multi-operator system.

Figures 2, 3 and 4 illustrate how PIM can affect a DAS network that must support from four to six U.S. bands.

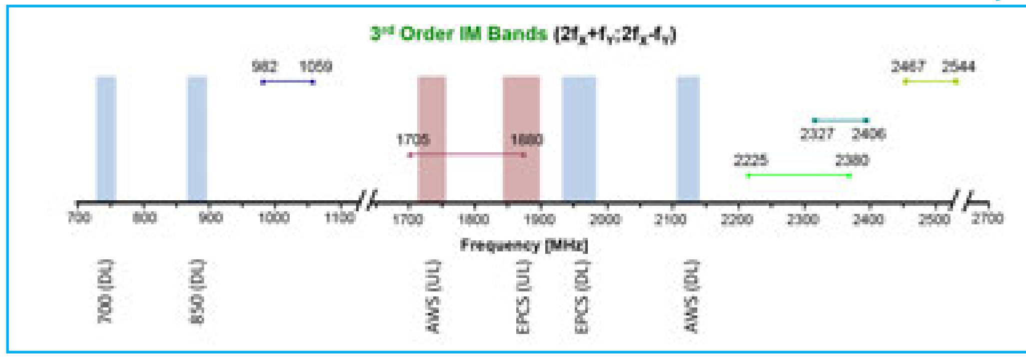

Figure 2: This illustrates third-order IM products with four U.S. bands (700, 850, EPCS and AWS).

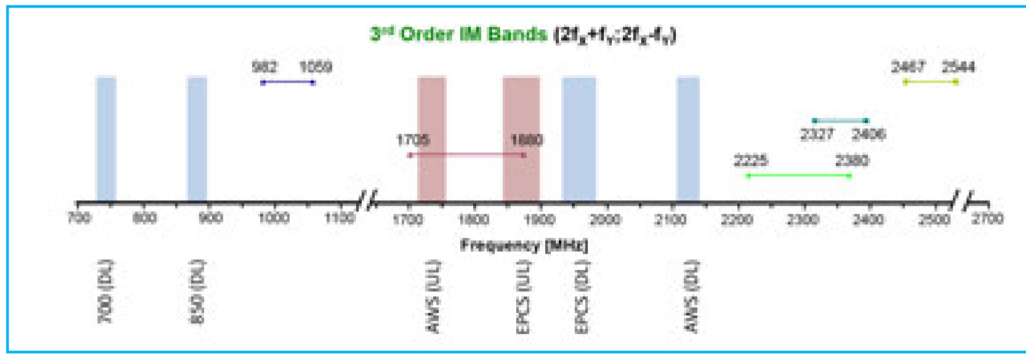

Figure 3: This illustrates third-order IM products with five U.S. bands (700, 850, EPCS, AWS and AWS-3).

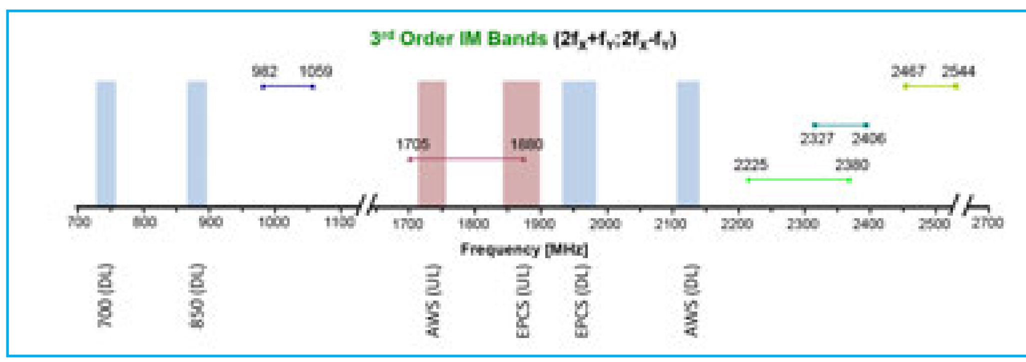

Figure 4: This illustrates third-order IM products with six U.S. bands (700, 850, EPCS, AWS, AWS-3, and WCS).

As can be seen, the number of UL bands affected by PIM products increases as a function of the number of bands supported. Moreover, some UL bands are impacted by more than one combination of DL bands. This entails that the resulting PIM product in these bands is given by the sum of each individual PIM product.

Once you factor in the additional third-order IM types (e.g., $f_x \pm f_y \pm f_z$) as well as higher IM orders (e.g., fifth and seventh), the mix of generated IM bands grows even larger. This is shown in Figure 5, in which another type of third-order IM is generated in the six-band configuration. As predicted, the number of UL bands impacted by PIM products becomes even larger.

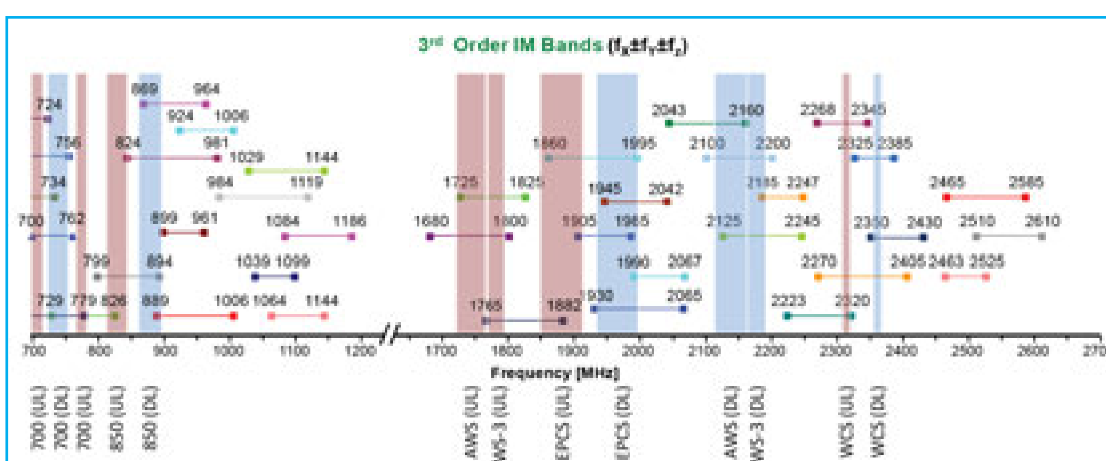

Figure 5: This illustrates third-order IM products ($f_x \pm f_y \pm f_z$) with six U.S. bands (700, 850, EPCS, AWS, AWS-3 and WCS).

For the European market, a DAS supporting five bands can be also considered.

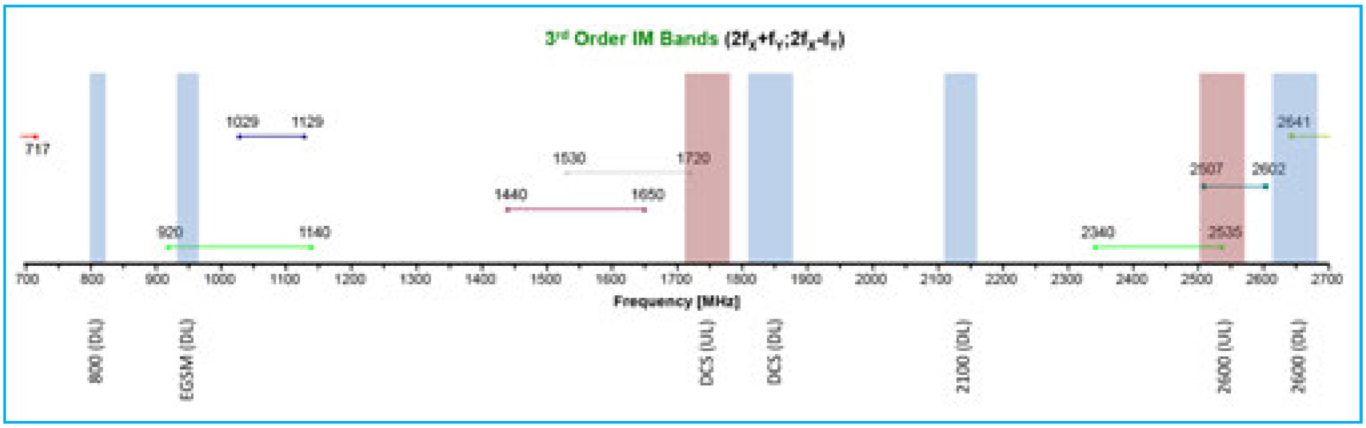

Figure 6: This illustrates third-order IM products (2fx±fy) with five EU bands (800, EGSM 900, DCS 1800, 2100 and 2600).

The more bands the infrastructure must support, the greater the potential for PIM. Moreover, it should be noted that these plots have been computed using only one type of third-order IM products ($2f_x+f_y$ and $2f_x-f_y$). The mix of generated IM bands would have been even larger if also considering additional third-order IM types (e.g., $f_x \pm f_y \pm f_z$) as well as higher IM orders (e.g., fifth and seventh). Figure 7 indicates the results when another type of third-order IM is generated in a five-band European network. As with the six-band U.S. system shown in Figure 5, the number of UL bands impacted by PIM products in the five-band European system becomes even larger.

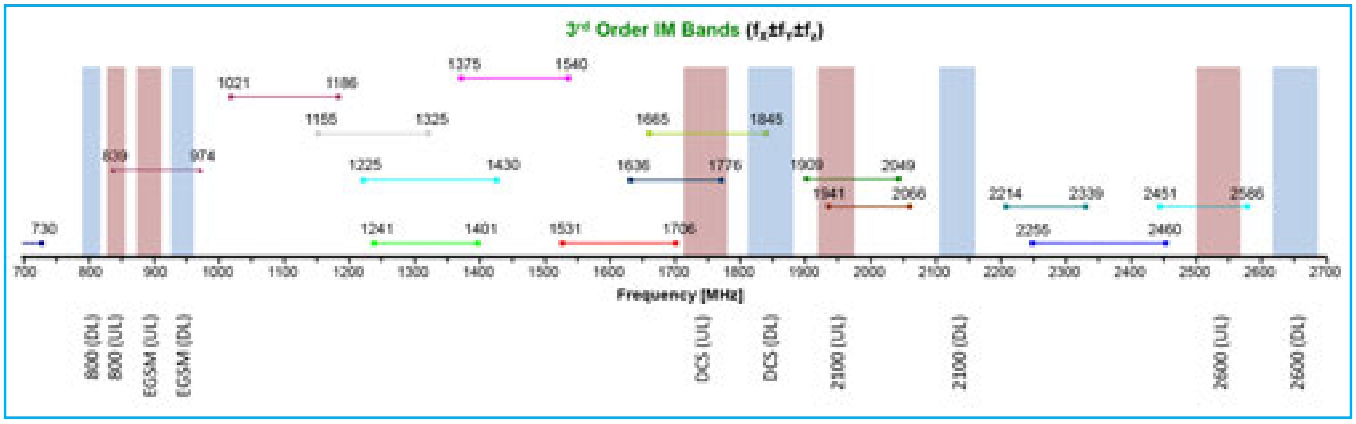

Figure 7: This illustrates third-order IM products ($2f_x \pm f_y \pm f_z$) with five EU bands (800, EGSM 900, DCS 1800, 2100 and 2600).

The bottom line is that, for any given PIM performance level, the more bands the DAS has to support, the better the PIM rating of the used passive devices needs to be.

Now let us consider the effect of a multicarrier DAS environment on PIM levels.

MULTIPLE CARRIERS INCREASE PIM REQUIREMENTS

In neutral host configurations, multiple channels can be allocated on the same band. Each operator may allocate one or more carriers for each band depending on its spectrum licenses. An example of this configuration is shown in Figure 8, where three evenly spaced carriers are allocated in the PCS band. The summation of third-order IM products within the same frequency is due to the combination of these evenly spaced carriers. The third-order IM products generated by the three evenly spaced, continuous-wave (CW) tones is calculated using the equations in Table 2. The pairs of intermodulation distortion (IMD) terms falling within the same frequencies are highlighted in red. It should be noted that the higher order PIM processes also contribute to the IM products at the frequencies of lower order products.

In this example the carriers operate within a 10 MHz bandwidth and are spaced 25 MHz apart in the PCS band. Note that the bandwidth for the third-order IM products triples compared to that of the fundamental carriers. This effect can be verified by comparing the 50 MHz frequency range of the CW tones (1985–1935 MHz) with the 150 MHz range occupied by the third-order IM products (2035–1885 MHz = 150 MHz). As a result, the chance increases even more that IM products generated by combinations of multiple modulated carriers will fall in-band.

Multicarrier signal	Third-order IM products
• F1 • F2=F1+Δf • F3=F1+2Δf	• (F1+F2-F3)=F1+F1+Δf-F1-2Δf=**F1-Δf** • (F1+F3-F2)=F1+F1+2Δf-F1-Δf=F1+Δf • (F2+F3-F1)=F1+Δf+F1+2Δf-F1=**F1+3Δf** • (2F1-F2)=2F1-F1-Δf=**F1-Δf** • (2F1-F3)=2F1-F1-2Δf=F1-2Δf • (2F2-F1)=2F1+2Δf-F1=F1+2Δf • (2F2-F3)=2F1+2Δf-F1-2Δf=F1 • (2F3-F1)=2F1+4Δf-F1=F1+4Δf • (2F3-F2)=2F1+4Δf-F1-Δf=**F1+3Δf**

Table 2: These equations calculate third-order IM products generated by three evenly spaced CW tones.

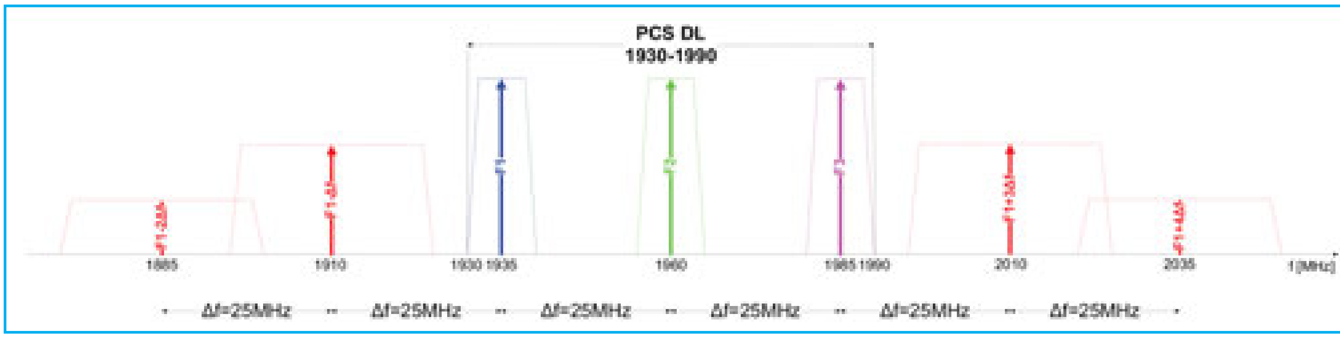

Figure 8: Three evenly spaced carriers are allocated in the PCS band.

Another way to analyze the PIM effects of multiple carriers on a shared DAS infrastructure is by using the concept of multicarrier backoff (MBO). MBO is a coefficient used to approximate the aggregate effect of multiple third-order IM products on the carrier-to-interference ratio (C/I), when the interference falls within the same frequency and the carriers are evenly spaced. In particular, the MBO takes into account the addition of third-order IM products when more than two carriers are present. The related formula is normalized to IM products created by two tones and can be expressed as:

C/ITotal = C/I2Tones - MBO = C/I2Tones - [6dB+10log(x)][3]

In this equation, X is a function of the number of tones considered. Table 4 below shows the MBO as a function of the number of evenly spaced carriers[3].

Using the data from Table 3, if the PIM rating of an RF component in a two-carrier 43 dBm

system is –153 dBc, then—in a five-carrier 43 dBm system—the PIM performance will drop to –140.5 dBc (–153 dBc + 12.5 dB). Therefore, the PIM performance of an RF component degrades as the number of carriers to be supported increases. In other words, for a targeted PIM performance level of a DAS installation, the more carriers per band the DAS has to support, the better the PIM rating of the passive devices needs to be.

Carriers	x	6 dB + 10 log (x)
2	0.25	0 dB
3	1	6 dB
4	2.3	9.6 dB
5	4.5	12.5 dB
6	7.5	14.8 dB
7	11.5	16.6 dB
8	15.5	17.9 dB
9	20	19.0 dB
10	26	20.1 dB
11	33	21.2 dB
12	40	22.0 dB
13	48	22.8 dB
14	57	23.6 dB
15	67	24.3 dB
16	77	24.9 dB
n>16	~(3/8) n2	6 dB + 10 log ((3/8) n2)

Table 3: Carrier and counting term calculations of MBO3

HIGH-POWER DAS PIM REQUIREMENTS

There's a growing trend toward substantially higher-power DAS deployments (e.g., 20 W and 40 W) in large venues and high-rise buildings. This is typically done to maintain DAS signal dominance over surrounding macro cells, especially on the upper floors. The strategy also enables TX power sharing between multiple carriers on the same DAS amplifier. Table 4 evaluates the impact of this trend on third-order PIM performance at various power levels. PIM rating and carrier power are calculated using the typical PIM power conversion factor of 2.5 dB/1 dB.

PIM Rating @2x43 dBm	-160 dBc	-153 dBc	-140.5 dBc
2x43 dBm	-117 dBm	-110 dBm	-97.5 dBm
2x42 dBm	-119.5 dBm	-112.5 dBm	-100 dBm
2x38 dBm	-129.5 dBm	-122.5 dBm	-110 dBm
2x32 dBm	-144.5 dBm	-137.5 dBm	-125 dBm
2x28 dBm	-154.5 dBm	-147.5 dBm	-135 dBm
2x20 dBm	-174.5 dBm	-167.5 dBm	-155 dBm

Table 4: This shows third-order PIM power levels vs. PIM rating and carrier power.

Table 5 illustrates how noise power changes as the power level increases. The reference noise power is for a remote DAS unit with an input calculated as –174 dBm/Hz+10*Log(BW)+NF. Bandwidth (BW) refers to the channel bandwidth and the noise figure (NF) refers to that of a single DAS remote unit.

DAS remote unit NF	Noise power @BW=5MHz	Noise power @BW=10MHz	Noise power @BW=15MHz	Noise power @BW=20MHz
6 dB	-101 dBm	-98 dBm	-96 dBm	-95 dBm

Table 5: Reference noise power level changes relative to different BW and NF.

It should be noted that PIM effects may be tolerated as long as the related noise introduced doesn't raise the UL reference noise power at the DAS remote unit input. Therefore, it is important to limit any rise in the UL noise—especially PIM—at the DAS remote unit input.

Let's now consider a typical passive network, illustrated in Figure 9, driven by a high-power DAS remote unit operating at 46 dBm per band.

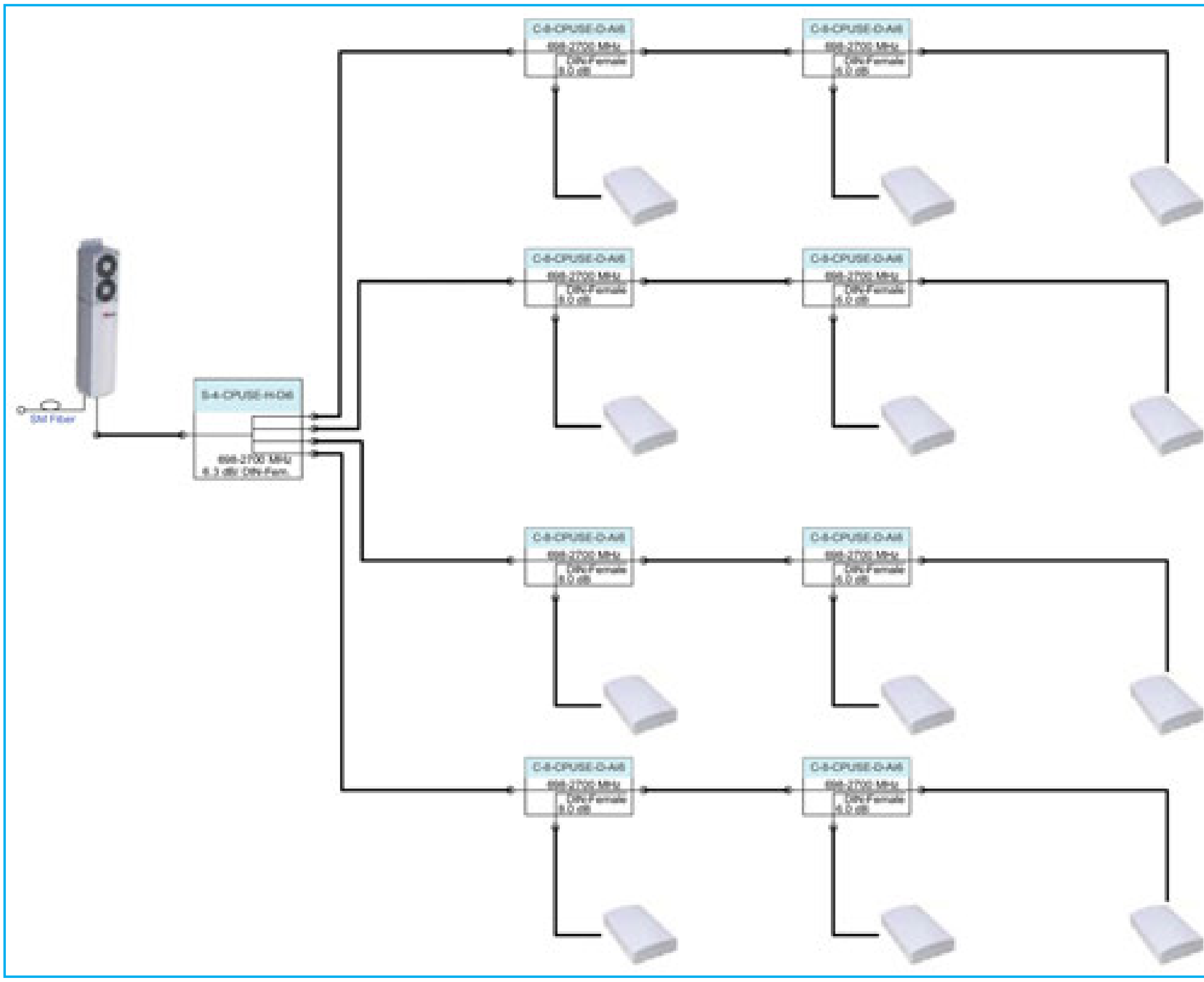

Figure 9: A typical passive network here is driven by a high-power DAS RU and passive network schematic.

Figure 10 shows the two passive stages from the network schematic highlighted in Figure 9. The four-way power splitter and the 8 dB directional coupler are connected to the panel antenna while a high-power DAS remote unit is coupled to the two RF passive stages and the antenna. Both passive devices have an assumed PIM rating of –160 dBc, whereas the antenna has a –153 dBc PIM rating. The computed total PIM power levels at the DAS remote unit input take into account the PIM generated by the entire passive chain.

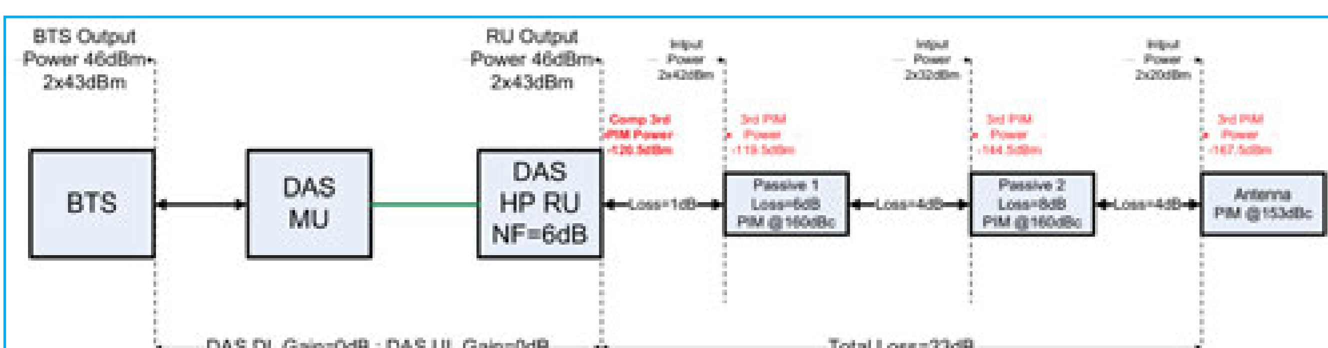

Figure 10: This shows the composite PIM power calculation @2x43 dBm carriers with two –160 dBc passive stages.*

From the scheme above it can be seen that the first passive stage plays the most critical role in the chain. As such it needs to have an excellent PIM rating. In this case the calculated composite third-order PIM power at the DAS remote unit input is –120.5 dBm, well below the reference noise power at the DAS remote unit (–101 dBm, 5 MHz BW, 6 dB NF).

* Only typical composite PIM values considered. PIM rating of RF jumpers assumed to be much better than other passives.

Figure 11 shows the same passive network configuration; the passive devices, however, have a –153 dBc PIM rating. The composite third-order PIM power is calculated at DAS remote unit input. In this case the composite third-order PIM power at the DAS remote unit input is –113.5 dBm, which is still below the reference noise power (–101 dBm for 5 MHz BW and 6 dB NF).

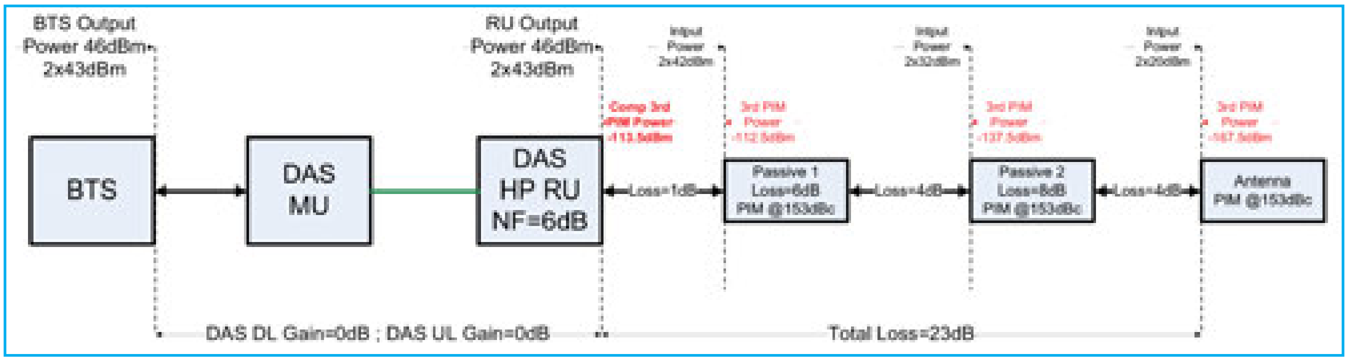

Figure 11: This shows the composite PIM power calculation @2x43 dBm carriers with two –153 dBc passive stages.*

Should this same DAS remote unit need to support three or more bands, the equivalent PIM performance for each passive component would drop significantly. The level of noise from the overlapping PIM products generated across multiple bands could easily approach the reference noise power at the DAS remote unit. Factor in multiple carriers operating at 43 dBm on different bands and the power levels from overlapping PIM products would increase 3 dB or more—to an estimated –110.5 dBm. It should be noted that even a PIM power as low as –110.5 dBm will translate into a 0.5 dB increase in noise power at the DAS remote unit ([–101 dBm] linear + [–110.5 dBm] linear = –100.5 dBm).

Figure 12 shows the identical scenario as Figure 11 but with five carriers instead of two. The passive devices are assumed to have a –153 dBc PIM rating and the output power of the DAS remote unit is 46 dBm. When the MBO from Table 4 is applied to this five-carrier scenario, the equivalent PIM performance will drop to –140.5 dBc (–153 dBc + 12.5 dB). The composite third-order PIM power is then calculated at the DAS remote unit input.

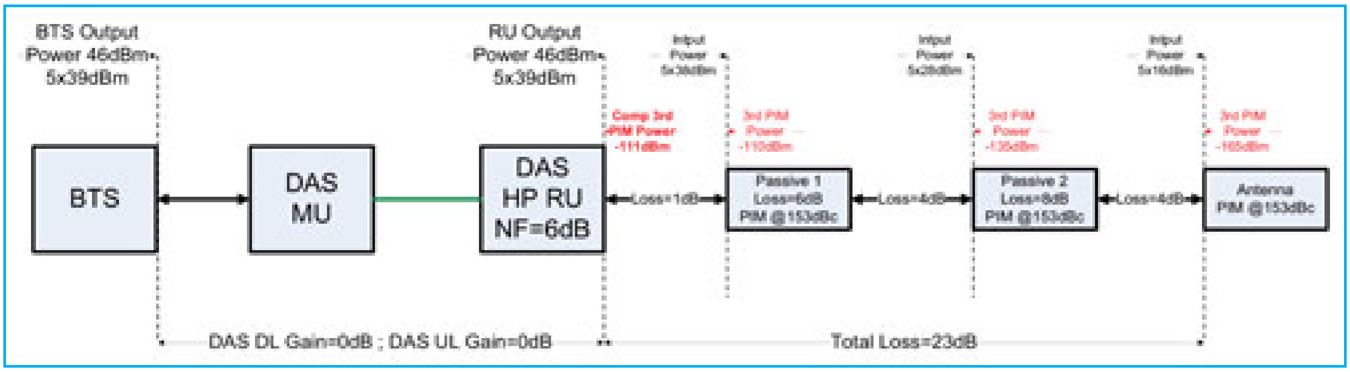

Figure 12: This shows the composite PIM power calculation @5x39 dBm carriers with two –153 dBc passive stages.*

It should be noted that, even in this case, the –111 dBm composite PIM power will translate into a 0.5 dB increase of noise power at the DAS remote unit ([–101 dBm] linear + [–111 dBm] linear = –100.5 dBm).

As demonstrated above, the combined effects of multiband and multicarrier application on PIM emphasizes the importance and urgency of deploying passive devices with extreme low-PIM performance. The need becomes even more dramatic when considering applications involving six bands (U.S.), as illustrated in Figures 4 and 5. In these cases, certain UL bands, like EPCS and AWS-3, may have as many as five overlapping PIM products. This becomes important as it can create an additional 7 dB of PIM products, exceeding the limit of today's –153 dBc PIM-rated components. To ensure sufficient PIM protection is achieved in these instances, CommScope recommends using passive devices with –160 dBc PIM rating or better.

EFFECTS OF AGING AND NEW BANDS ON PIM PERFORMANCE

RF devices used in passive networks are very susceptible to the effects of aging. RF connectors tend to loosen over time, exposing the network to dust, debris and water migration—common contributors to PIM. During installation, maintenance and repair, connectors can be easily damaged if over-torqued, further degrading PIM performance. Passive devices with modest PIM ratings can even accelerate the damage compared to those with better PIM ratings. Therefore, devices with excellent low-PIM performance become crucial for reliable long-term DAS performance. Using RF devices with a PIM rating of –160 dBc vs. –153 dBc provides a 7 dB margin against aging effects. This could translate to several additional years in lifespan of a DAS installation.

Low-PIM devices also provide more margins for upgrades to new bands deployed over the DAS. As highlighted in previous sections, every new band added to the DAS can generate a multitude of new PIM products in the uplink bands. Therefore, the lower the PIM rating of the devices used, the greater the capacity to add new bands without affecting overall DAS performance.

* Only typical composite PIM values considered. PIM rating of RF jumpers assumed to be much better than other passives.

LTE AND LTE-A CREATE ADDITIONAL PIM CHALLENGES

For wireless technologies like LTE, with a one-to-one frequency reuse, intercell interference is a key challenge. It's critical to minimize the UL transmission power of mobile devices at the cell edge in order to reduce interference in the adjacent cells. As the UL noise floor—as recognized by the BTS—increases, the mobile device boosts its UL transmission power to minimize SINR at the BTS receiver. As more interference is created, the cell begins to shrink due to the increasing noise at the receiver.

MIMO technology is part of the toolkit mobile operators are using to tackle the ever-increasing demand for mobile data capacity. It has been largely demonstrated that the multiplexing of independent data streams can be supported only in good RF channel conditions. That poses severe constraints on the coverage levels required as well as on the quality of the signal, given that the SINR has become a key performance indicator to optimize. Furthermore, LTE-Advanced supports MIMO schemes for the uplink path as well. As a result, the SINR requirements must be met even at the BTS receiver. In this context, it is even more critical to limit the uplink noise rise.

Carrier aggregation (CA) is another key feature introduced by LTE-Advanced. Wireless operators will combine different frequency bands in order to cope with their spectrum fragmentation. For a DAS installation, assuming both intra- and interband CA schemes with more and more DL component carriers aggregated to boost DL data rate, the number of possible multicarrier combinations can get extremely high—with a consequent higher probability for generated PIM products falling in uplink bands.

All the features above can make the impact of PIM issues on modern DAS systems targeted for LTE and LTE-Advanced technologies even more detrimental than for legacy networks.

DIFFERENCE BETWEEN CERTIFIED AND VERIFIABLE PIM PERFORMANCE

Quality is only as good as the data available to prove that the product meets or exceeds the stated specifications. This is even more critical for products that must meet very high performance requirements.

In the case of CommScope, for example, engineers employ 100 percent electrical testing of all passive products, as opposed to random testing of selected items. All test data is available to the customer via the company's website using a service called WebTrak®, an online, certified reporting system that allows customers to access performance testing results from multiple product groups.

The following information is made available for passive components through WebTrak® and can be accessed through a mobile device using cTrak™.

- PIM swept frequency plots
- VSWR swept frequency plots
- Insertion loss swept frequency plots
- Isolation swept frequency plots
- Coupling swept frequency plots

CONCLUSION

Today's current and emerging DAS solutions pose a variety of opportunities as well as difficult challenges for wireless operators and component OEMs. A key issue that will continue to affect network performance is PIM interference produced by passive devices. This paper has attempted to demonstrate how and why the evolving DAS environment is likely to generate higher and higher levels of performance-eroding PIM.

Specifically, multiband and multicarrier configurations, higher power settings and the effects of aging DAS infrastructures will have significant effects on PIM levels. Furthermore, the impact of PIM issues on modern DAS systems targeted for LTE and LTE-Advanced technologies can be even more detrimental than for legacy networks. In order to adequately protect their investment in DAS infrastructure over the long term, operators must begin to deploy network components that provide increasingly higher PIM margins. This involves transitioning from the current devices—PIM rated up to –153 dBc—to passive devices that are both certified and can be verified for PIM performance of –160 dBc. Going forward, these higher performing passive components with a PIM rating of –160 dBc will play a crucial role in the long-term success of high-end DAS solutions.

APPENDIX

	700[4]		850[4]		EPCS[4]	
	f_{1L}	f_{1H}	f_{2L}	f_{2H}	f_{3L}	f_{3H}
DL	729	756	869	894	1930	1995
UL	699-716	777-787	824	849	1850	1915
	AWS[4]		AWS-3[5]		WCS[6]	
	f_{4L}	f_{4H}	f_{5L}	f_{5H}	f_{6L}	f_{6H}
DL	2110	2155	2155	2180	2350	2360
UL	1710	1755	1755	1780	2305	2315

Table 6: These U.S. bands (in MHz) are supported by DAS.

	800[4]		EGSM 900[4]		DCS 1800[4]	
	f_{1L}	f_{1H}	f_{2L}	f_{2H}	f_{3L}	f_{3H}
DL	791	821	925	960	1805	1880
UL	832	862	880	915	1710	1785
	2100[4]		2600[5]			
	f_{4L}	f_{4H}	f_{5L}	f_{5H}		
DL	2110	2170	2620	2690		
UL	1920	1980	2500	2570		

Table 7: These EU bands (in MHz) are supported by DAS.

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REFERENCES

1 PIM Testing-Advanced wireless services emphasize the need for better PIM control; CommScope White Paper; 2014-02

2 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Passive Intermodulation (PIM) handling for Base Stations (BS) (Release 12); 2013-09

3 RF and Microwave Fiber-Optic Design Guide; Agere Systems Inc. Application Note, April 2001

4 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (Release 12); 2014-06

5 Auction of Advanced Wireless Services Licenses, Scheduled for November 13, 2014, Comment Sought on Competitive Bidding Procedures, for Auction 97; Federal Communications Commission; May 19, 2014

6 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; LTE in the US Wireless Communications Service (WCS) band (Release 12); 2013-07

AFL

Item No.	Vendor Item No.	Description
0000200812	8500-05-0001MZ	One Click Cleaner SC
0000207616	8500-10-0027MZ	Cletop Type A With Blue Tape
0000395401	DFS-00-04XU	Digital FiberScope Kit
0000404826	FAST-LC-SM-6	Fast Connect LC
0000397488	FOCIS-00-PK01	FOCIS-213P Wifi With Tablet
0000044696	OPM4-34-0900PR	Optical Power Meter
0000405892	S015530	AFL 12S Fusion Splicer Kit 2
0000415163	S015580	Fujikura 70S Fusion Splicer
0000397667	S015591	Fujikura 70S Fusion Splicer
0000406991	S015669	Ribbon Fusion Splicer FSM-70R
0000402687	S015670	Fusion Splicer Kit 70R
0000408219	S015671	Fujikura 70R Fusion Splcr Kit
0000436074	S015679	FSM-19S Splicer
0000407872	S015681	19S Fusion Splicer Kit
0000169794	VF12-00-0900PR	Visual Fault Identifier VFI2

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0000421518	C-10-CPUSE-N-Ai6	10DB Air Directional Coupler 698-2700 N Female
0000421519	C-13-CPUSE-N-Ai6	13DB Air Directional Coupler 698-2700 N Female
0000422048	C-15-CPUSE-N-Ai6	15DB Air Directional Coupler 698-2700 N Female
0000422049	C-20-CPUSE-N-AI6	20DB Air Directional Coupler 698-2700 N Female
0000422050	C-30-CPUSE-N-Ai6	30DB Air Directional Coupler 698-2700 N Female
0000368970	C-6-CPUSE-N	Directional Coupler 6 dB 698-2700 MHz N Female
0000422051	C-6-CPUSE-N-AI6	6DB Air Directional Coupler 698-2700 N Female
0000422052	C-8-CPUSE-N-Ai6	8DB Air Directional Coupler 698-2700 N Female
0000368957	CELLMAX-D-CPUSE	Directional Antenna 698-960/1710-2700 MHz
0000368958	CELLMAX-D-CPUSEi	Directional Antenna 698-960/1710-2700 MHz -140dBc
0000368961	CELLMAX-EXT-CPUSE	Outdoor Antenna 698-960/1710-2700 MHz -150dBc
0000368954	CELLMAX-O-CPUSE	Omni Antenna 698-960/1710-2700 MHz
0000368955	CELLMAX-O-CPUSEi	Omni Antenna 698-960/1710-2700 MHz -140dBc
0000368962	CMAX-DM30-CPUSEI	MIMO ANTENNA DIR 698-960/1710-2700MHZ
0000368963	CMAX-DM60-CPUSEi	MIMO ANTENNA DIR 698-960/1710-2700MHZ
0000422054	H-3-CPUSE-D-AI6	3DB Hybrid Couplers 698-2700Mhz DIN Female
0000369025	H-3-CPUSE-N-A	3 dB Hybrid Coupler 698-2700 MHz N Female
0000422055	H-3-CPUSE-N-Ai6	3DB Hybrid Couplers 698-2700Mhz N Female
0000422056	S-2-CPUSE-H-DI6	2-Way High Power Splitter 698-2700 DIN Female
0000368964	S-2-CPUSE-L-N	2-Way Low Power Splitter 698-2700 MHz N Female
0000368967	S-2-CPUSE-L-Ni	2-WAY LOW POWER SPLITTER 698-2700 N-150dBc
0000422058	S-3-CPUSE-H-DI6	3-Way High Power Splitter 698-2700 D Female
0000422059	S-3-CPUSE-H-NI6	3-Way High Power Splitter 698-2700 N Female
0000422060	S-3-CPUSE-L-N	3-Way Low Power Splitter 698-2700 N Female
0000368966	S-4-CPUSE-L-N	4-Way Low Power Splitter 698-2700 MHz N Female
0000368969	S-4-CPUSE-L-Ni	4-WAY LOW POWER SPLITTER 698-2700 N-150dBc
0000369034	T-10-NM	Termination 10 Watt Type N Male
0000369038	T-25-DM	Termination 25 Watt Type DIN Male
0000369031	T-2-DM	Termination 2 Watt Type DIN Male
0000369032	T-2-NM	Termination 2 Watt Type N Male

Comtrend

0000439773	WAP-PC1750W	AC1750 Wireless Access Point Dual Band High Power (560mW) Long Range High Sensitivity (-93dBm) w/ PoE

Corning - OptiSheath Multiport Terminal

0000220153	MOB-0244FD300FW-P	2 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount,300 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000380292	MOB-0244FD800FW-P	2 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 800 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000296586	MOB-0244TD050FW	2 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 50 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000369946	MOB-0244TD250FW-P	2 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 250 FT Stub of Toneable/Locateable Cable, Individually Packaged
0000298074	MOB-0244TD500FW	2 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 500 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000298075	MOB-0244TD750FW	2 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 750 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000220154	MOB-0444FD300FW-P	4 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 300 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged

Corning - OptiSheath Multiport Terminal, Continued

Item No.	Vendor Item No.	Description
0000220155	MOB-0444FD550FW-P	4 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 550 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000220156	MOB-0444FD700FW-P	4 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 700 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000293339	MOB-0444FD900FW-P	4 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 900 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000220157	MOB-0644FD300FW-P	6 Ports, 44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount,300 FT Stub of Dielectric Drop (Flat Drop) Cable, Individually Packaged
0000296589	MOB-0644TD050FW	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 50 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000151974	MOB-0644TD200FW	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 200 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000296585	MOB-0644TD250FW	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 250 FT Stub of Toneable/Locateable Cable, Bulk Packaging
0000220158	MOB-0644TD550FW-P	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 550 FT Stub of Toneable/Locateable Cable, Individually Packaged
0000220159	MOB-0644TD700FW-P	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 700 FT Stub of Toneable/Locateable Cable, Individually Packaged
0000355760	MOB-0644TD900FW-P	6 Ports,44 Single Mode SC APC Connectors, Wall/Pole/Pedestal Mount, 900 FT Stub of Toneable/Locateable Cable, Individually Packaged

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0000434049	80C00005AAA-A	Aastra 6863i Entry Level SIP Phone
0000434050	80C00002AAA-A	Aastra 6867i Mid Range SIP Phone Dual Port GigE
0000434051	80C00003AAA-A	Aastra 6869i Expandable SIP Desktop
0000434233	80C00001AAA-A	Aastra 6865i Mid Range GigE SIP Phone Dual Port

PLP

0000105077	8006944	6.5 X 17 Inch COYOTE Dome Closure With Buffer Tube/Loose Tube Organizer
0000252965	8006945	6.5 x 17 Inch COYOTE Dome Closure With Unitube/Ribbon Organizer
0000202201	80061055	9.5 X 28 Inch COYOTE Dome Closure With Buffer Tube Organizer
0000204576	80061056	9.5 X 28 Inch COYOTE Dome Closure With Unitube/Ribbon Organizer
0000366758	COY1-001	COYOTE ONE Dome With Buffer Tube Organizer
0000366759	COY1-002	COYOTE ONE Dome With Universal Organizer for Ribbon or Buffer Tube

PPC

0000010327	C8812	Kit Buried Srv Wire Klik-It 25
0000031635	709SC	CONNECTOR 709-SC DRY 106795222
0000139759	40-20003	CONNECTOR BOND EXP 10EA/BG10L
0000148375	HTCV2CLRFR	COVER H-TAP CLEAR
0000225034	TBT9105	SLEEVE REPAIR
0000372661	JPLUS6T36SE	Jumper, Plus, Rg6, Tri-Shield
0000377101	JPLUS6T72SE	Coax Jumper With Plus 72In
0000377108	JPLUS6T72WSE	Coax Jumper Tri 72In White
0000377110	JPLUS6T120WSE	Coax Jumper Tri 120In White
0000387209	DTDLH25	Locking Head
0000401528	FSNS6U	Univ F Type Nickle RG6/6 Quad
7122980318	KF81	CONNECTOR FEMLE SPLC F81 PRECI
7200010318	23-44444	CLAMP DROP WIRE B ALUM SHE
7209940318	31-10809	HOOK HOUSE P 4.5INL BX/200
7210350318	26-09010	CLAMP WIRE LASHING D F/1/4 TO
7210890318	30-01732	HOOK WIRE DROP (50/BOX)
7214330318	34-08875	Spacer Cable 3/4In 34-08875
7214640318	23-80262	CLIP(S)WIRESC6PR
7214760318	23-80370	CLAMP DROP WIRE 2PR LARGE BX/

PREMIER

0000436114	DTC36U12V-NA3	CyberPower FTTx DC Battery Backup Power Supply Unit
0000436115	DTC36U12V-NA3-G	CyberPower FTTx DC Battery Backup Power Supply Unit
0000419425	PT-KJKSC-85	Snap-In SC Single-Mode Fiber Module in White. Compatible with APC/UPC/SPC/PC connectors. Jack Module Insert Will Snap Into Keystone Style Faceplates And Housings. Ceramic Sleeve.

TE Connectivity

0000433837	FTAC-3G11000	TAC Handheld Tool Kit
0000433839	FTAC-21C	TAD Radius Limiter, Full Corner
0000433840	FTAC-22C	TAC Radius Limiter, Half Corner
0000433838	FTAC-1A0300C00000	TAC Fiber Spool 300 Ft Clear

3M

0000454268	NID-FO-1724-ATF	3M™ Fibrlok™ Network Interface Device with one fiber splice tray with one 3M™ Fibrlok™ Splice and one SC/APC pigtail
0000454269	NID-FO-1724-AT	3M™ Fiber Network Integrated Device with one fiber splice tray and one SC/APC pigtail

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