WHITE PAPER

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How Power over Ethernet (PoE) Will Impact Enterprise Networks and How To Support It In Premise Networks

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Introduction

According to the *Cisco Annual Internet Report (2018-2023)*[1], global M2M connections will grow 2.4-fold, from 6.1 billion in 2018 to 14.7 billion by 2023, and there will be 1.8 M2M connections for each member of the global population by 2023. Additionally, connected home applications, such as home automation, home security and video surveillance, connected white goods, and tracking applications, will represent 48 percent, or nearly half, of the total M2M connections by 2023.

For the network engineers responsible for designing and managing the enterprise and premise networks upon which these and countless other connections will depend, especially when it comes to ensuring availability and speed of these networks to business users, there are a number of technologies that should be considered when planning network upgrades.

This white paper, by Chatsworth Products (CPI), summarizes one such technology—Power over Ethernet (PoE)—and its impact on the physical premise network, while highlighting the most recent advancements in cable management and equipment storage that will help with network upgrades and ensure a smooth, reliable deployment of PoE-enabled systems that are poised to become instrumental in the fast-rising world of M2M connections highlighted above and beyond.

802.3bt: Enhanced Power over Ethernet (PoE++)

Power over Ethernet (PoE) was introduced in 2003. The basic concept is to deliver power over the network connection to end devices, eliminating the need for a separate power connection. Currently deployed PoE now delivers up to 60 Watts of power to equipment, with some newly emerging advances pushing that threshold even higher to 90-100 Watt systems, where all 4-pairs (8 conductors) carry power. With these new thresholds, PoE now easily powers Voice over Internet Protocol (VoIP) desk phones, wireless access points (APs) and basic security cameras.

Enhanced PoE++, IEEE 802.3bt-2018[2], creates two additional types, or power ranges, for 60 Watts and up to 100 Watts per connection, thus extending the possibilities to power other end devices such as high bandwidth APs, pan-tilt-zoom security cameras, access control systems and Internet of Things (IoT) sensors, and eventually large kiosk displays and computers as more PoE-enabled devices become available.

Wattage Requirements of Common Electronics

The following chart helps reveal the typical wattage requirements of a variety of existing and common household and office electronics. Keeping in mind the latest PoE wattage thresholds, it provides an idea of what kinds of devices are most likely to benefit from PoE-enabled capability.

Device/Appliance	Running Wattage
Night Light	1W
Hands-Free Speaker & Virtual Assistant	3W
Coffee Pot	1000W
Computer Monitor	25W
Laptop Computer	50W
Internet Router	5W
Table Fan	10W
LED 49" TV	85W
Printer (Ink Jet)	20W
Table Charger	10W
Cell Phone Charger	25W

Table 1 (below) lists some of the technical differences for the various network power standard amendments. Note that each progressive amendment introduces more power to the end device.

Comparison of IEEE 802.3 PoE Amendments				
IEEE Standard	**802.3af – 2003[1]**	**802.3at – 2009[1] "POE+"**	**802.3bt – 2018 "POE++"**	**802.3bt – 2018 "POE++"**
Type	Type 1	Type 2	Type 3	Type 4
Power/Port	15.4 W	30 W	60 W	90-100 W
Volts Source (Min.-Max.)	44 - 57 VDC	50 - 57 VDC	50 - 57 VDC	52 - 57 VDC
Volts Device (Min.-Max.)	37 - 57 VDC	42.5 - 57 VDC	42.5 - 57 VDC	41.1 - 57 VDC
Current (Max.)	350 mA	600 mA	600 mA /pair	960 mA /pair
Assured Power	12.95 W	25.50 W	51 W	71 W
Supported Cabling (min.)	Category 3	Category 5	Category 5	Category 5

Table 1: Comparison of IEEE 802.3 Amendments related to delivering Power over Ethernet.

Notes:

1. IEEE 802.3af-2003 and IEEE 802.3at – 2009 are incorporated into IEEE 802.3 – 2012 and IEEE 802.3 - 2015, which are not listed in the table above.
2. Several vendors are currently manufacturing switches that offer a power level similar to the 802.3bt Type 3 specification.
3. Table abbreviations: Watts (W); Volts Direct Current (VDC), milliamps (mA).

Deploying PoE requires a network switch or a separate in-line power injector to introduce power into the network connection. Network switches that support Type 1 and Type 2 PoE, may need to be upgraded to support higher power Type 3 and Type 4 PoE. The power supply in PoE switches is much higher wattage than power supplies for switches that do not support PoE, and consequently, the power connection to the switch is higher power.

Additionally, when PoE powers VoIP phones, an uninterruptable power supply (UPS) and battery backup are typically installed in line with the switch to maintain phone circuits during power outages. Higher power PoE will require a higher capacity UPS and batteries to maintain the same runtime. The switch, UPS and battery backup will also weigh more as compared to a non-PoE switch, which means the rack selected to support the IT equipment needs to be able to handle the additional weight.

PoE will transmit on existing Category 5e Unshielded Twisted Pair (UTP) cabling, but when using Type 4, you may need to adjust bundling size because of the additional heat from the higher power connection. PoE applications are covered in Article 725 of the 2020. National Electric Code[3] (NEC). Table 725.144 of the NEC provides guidance for bundle size based on the size of the conductor and temperature rating of the cable. For example, for an ambient air temperature of 86° Fahrenheit (30° Celsius), Category 5e UTP cable constructed of 24 American Wire Gauge (AWG) conductors and rated for 60°C would be limited to bundle sizes of 38 to 61 cables.

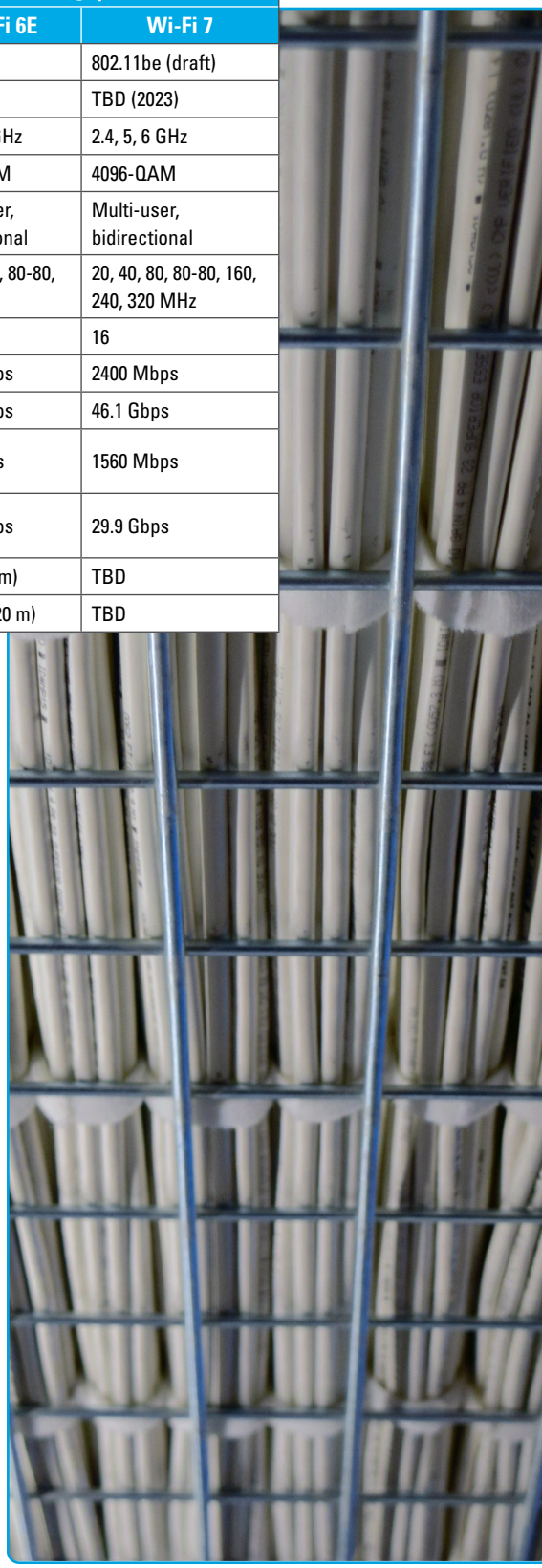
So, a bundle of 48 cables from a typical 2U patch panel would not need to be modified, but a larger bundle of 72 cables or 96 cables may need to be broken into smaller bundles. This means you may also need to space bundles in cable managers and pathways to maintain better airflow around bundles to remove heat.

Comparison of IEEE 802.11 Amendments – Increasing Wireless Networking (Wi-Fi) Throughput					
Wi-Fi Alliance Generation	**Wi-Fi 5**	**Wi-Fi 5**	**Wi-Fi 6**	**Wi-Fi 6E**	**Wi-Fi 7**
IEEE Standard	802.11ac "Wave 1"	802.11ac "Wave 2"	802.11ax	802.11ax	802.11be (draft)
Year Adopted	2013	2015	2019	2020	TBD (2023)
Band(s)	5 GHz	5 GHz	2.4, 5 GHz	2.4, 5, 6 GHz	2.4, 5, 6 GHz
Modulation (max.)	256-QAM	256-QAM	1024-QAM	1024-QAM	4096-QAM
MIMO	Single-user, downstream only	Multi-user, downstream only	Multi-user, bidirectional	Multi-user, bidirectional	Multi-user, bidirectional
Channel Widths	20, 40, 80 MHz	20, 40, 80, 80-80, 160 MHz	20, 40, 80, 80-80, 160 MHz	20, 40, 80, 80-80, 160 MHz	20, 40, 80, 80-80, 160, 240, 320 MHz
Spatial Streams (max.)	4	8	8	8	16
PHY rate (max./stream)	390 Mbps	780 Mbps	1200 Mbps	1200 Mbps	2400 Mbps
PHY rate (max. aggregate)	1560 Mbps	6240 Mbps	9608 Mbps	9608 Mbps	46.1 Gbps
Estimated Throughput (max. stream)	253 Mbps	507 Mbps	780 Mbps	780 Mbps	1560 Mbps
Estimated Throughput (max. aggregate)	1014 Mbps	4056 Mbps	6245 Mbps	6245 Mbps	29.9 Gbps
Range, Indoor (max.)	115 ft. (35 m)	115 ft. (35 m)	98 ft. (30 m)	98 ft. (30 m)	TBD
Range, Outdoor (max.)	345 ft. (105 m)	345 ft. (105 m)	390 ft. (120 m)	390 ft. (120 m)	TBD

Table 2: Comparison of the Impact of Amendments to the IEEE 802.11 Standard on Wireless LAN Networking (Wi-Fi) Throughput.

Notes:

1. 802.11ac "Wave 2" is a subset of the 802.11ac, published in 2013. However, vendors developed equipment in phases introducing MU-MIMO and 160 MHz channel width in commercial WAPs at the end of 2015. The distinction is important because "Wave 1" equipment is not forward compatible. Note that 802.11ac "Wave 1" and "Wave 2" amended IEEE 802.11-2012 and are now incorporated into IEEE 802.11-2016.
2. 802.11ax published in 2019. Huawei announced the first 802.11ax access point in December 2017, the AP7060DN, which uses 1024-QAM modulation. The 6 GHz wavelength was added in 2020 and APs that support this band first became available in late 2020.
3. 802.11be (Wi-Fi 7) is anticipated to publish in 2023. It introduces multiple updates that could quadruple throughput. 10 Gbps connections will be required to support this higher throughput.
4. PHY rate in Mbps based on the common 800 µs guard interval. Note that 802.11n and 802.11ac also support a 400 µs guard interval with slightly higher bandwidth. 802.11ax allows a 1600 µs and a 3200 µs guard interval with slightly shorter bandwidth. PHY rate is based on maximum modulation, channel width and spatial stream, so a device may support an IEEE standard but have lower bandwidth if it has a different specification or is configured differently.
5. Estimated throughput values assume 65 percent MAC efficiency (PHY rate) with highest MCS. Wi-Fi uses radio waves to transmit data, so location of the wireless access point (AP) relative to devices (users) and other site conditions can affect signal strength and throughput.
6. Table abbreviations: Gigahertz (GHz); quadrature amplitude modulation (QAM); megahertz (MHz), megabits per second (Mbps), gigabits per second (Gbps).



As it relates and impacts newly emerging PoE++ capabilities, the advantage of updating your wireless local area network (WLAN) is that 802.11ax provides faster Wi-Fi connections, can support more users/devices/connections per wireless AP and may have slightly better coverage depending on siting. These upgrades may allow you to eliminate wired networks for most network users and physical spaces.

Updating your WLAN will require replacement of APs because the hardware enables the faster connection speeds. Supporting your new high-bandwidth wireless network may require an update to your LAN switches and your structured cabling. IEEE802.11ac (Wi-Fi 5) APs are best supported with 5 Gigabit per second (Gbps) network connections. IEEE802.11ax (Wi-Fi 6) APs will require 10 Gbps network connections. This probably means an increase in your horizontal network from 1 Gbps connections to 10 Gbps and a corresponding upgrade in your backbone connections from 10 Gbps to 40 Gbps.

Consider a network switch that can deliver up to 10 Gbps to each AP, supports multigigabit switching per the IEEE 802.3bz-2016 amendment15 and has an integrated network controller. Multigigabit switching will allow the throughput speed to adjust dynamically between 1 Gbps, 2.5 Gbps, 5 Gbps and 10 Gbps depending on the access point requirements. A network controller, which can be software overlay or a separate hardware appliance, provides a single point for managing all of the access points in the network. If powering APs over the network, you will need a PoE switch. IEEE 802.11ac "Wave 2" APs draws approximately 30 Watts. Supporting the full capacity of IEEE 802.11ax APs will require more than 30 Watts, 60 Watt PoE power is recommended.

Additionally, the structured cabling may need upgrade, see Table 3 (below). A multigigabit switch will support network connections up to 5 Gbps over existing Category 5e UTP and Category 6 UTP network cabling. But for 10 Gbps, it is best to use Cat 6A UTP or better. Also, note that some APs support two network connections.

Comparison of Copper Cable Types and Maximum Supported Data Speed and Distance				
Cable Type	**Base Data Rate**	**Max. Data Speed**	**Max. Frequency**	**Max. Distance**
Category 5e UTP	1000 Base-T	5 Gbps	100 MHz	328 ft (100 m)
Category 6 UTP	1000 Base-T	5 Gbps 10 Gbps	250 MHz 250 MHz	328 ft (100 m) 164 ft (55 m)
Category 6A UTP	10G Base-T	10 Gbps	500 MHz	328 ft (100 m)
Category 8 F/UTP	25G Base-T 40G Base-T	25 Gbps 40 Gbps	2000 MHz	98 ft (30 m) 98 ft (30 m)

Table 3: Comparison of Copper Cable Types and Maximum Supported Data Speed and Distance for Connecting Wi-Fi Wireless Access Points to Your Network.

Notes:

1. Table abbreviations: Unshielded Twisted Pair (UTP); Foil or Shielded Twisted Pair (F/UTP); Gigabits per second (Gbps); Megahertz (MHz); feet (ft); meters (m).

How to Support PoE++ in the Premise Network

Advancements in Cable Management: Cable Runway and Cable Managers

Although the fundamentals of good cable management have not changed, the structural support components have improved significantly. Best practices dictate you should support cable to prevent sharp bends, twists and stretching. When making a vertical or horizontal transition, use a smooth 90-degree bend radius that is four-times the diameter of copper conductors and a minimum of 1 inch (25 mm) for fiber conductors.

New structured cabling installations should consider a 25 Gbps or 40 Gbps fiber or Category 8 F/UTP or U/UTP backbone and 10 Gbps Category 6A UTP or Category 8 F/UTP or U/UTP horizontal connections. However, existing Category 5e and Category 6 UTP horizontal cabling can support 5 Gbps network connections and PoE++ under certain conditions.

The new requirement is the need to use smaller bundles and more spacing between bundles to allow airflow around cables with higher power Type 4 POE applications. The alternative is loose fill, but similarly, you would still need to be able to control the potential buildup of heat where cable concentrates in pathways.

There are several advancements in cable management to address these concerns. First, you can easily and quickly align the transitions between vertical cable managers alongside equipment racks and overhead cable trays. Cable runway, or ladder rack, is now available with movable cross members. This lets you adjust the position of a cross member if it interferes with the transition of cables between the vertical manager and overhead pathway, as shown in Figure 1 below. You can place radius drops exactly where they need to be to path cable into the vertical manager. Additionally, easy-to-use tool-less pathway dividers allow you to maintain space between cable bundles within the pathway.

Figure 1: Advancements in cable pathway include cable runway (ladder rack) with adjustable cross members to quickly and easily correct alignment issues and tool-less pathway accessories to separate, guide and support cables. Photo shows CPI Adjustable Cable Runway, Tool-Less Radius Drop.

Second, enhanced vertical cable managers that include internal supports to space cable bundles improve airflow around cables for higher power PoE applications and improve troubleshooting by neatly organizing each bundle, as shown in Figure 2 below. If loose fill is your preference, use high-density cable managers originally developed for the data center to provide additional space within cable managers allowing more space around cables.

Use cable management to support cables and neatly organize and identify connections. Proper cable management helps maintain reliable network connections and helps technicians trace and update connections quickly. Cable management solutions have evolved from a simple trough to hold cable bundles to a mechanical system that adjusts to optimize cable support. Cable management systems like CPI's Adjustable Cable Runway, Motive® Cable Management and tool-less accessories provide advanced cable management solutions that are easy to use and adjust and provide precise support.

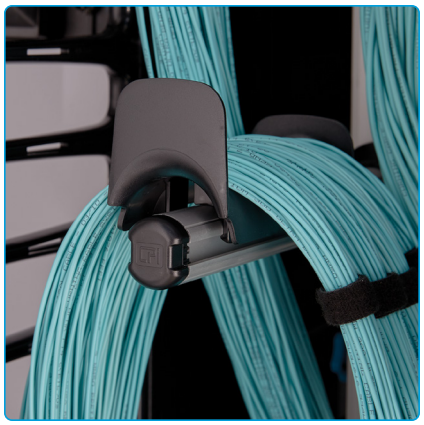


Figure 2: Advances in cable management include interior accessories that can support and separate smaller bundles of cables and adjust quickly to match cable support requirements. Photo shows CPI Motive Cable Management.

Advancements in Equipment Support: Equipment racks and cabinets

The standard premise network today includes a PoE switch with higher speed device connections. These switches are generally heavier than non-PoE switches and require a larger UPS or battery backup to provide longer runtimes with higher power end equipment. That may mean more heat exhausted from equipment. Bonding is more important with PoE switches and F/UTP, U/UTP, STP shielded cables. Physical security for equipment is another growing concern. You may need to place equipment in a shared location or retrofit an enclosure around existing equipment.

There are several advances in equipment support to address these concerns. First, wall-mount enclosures can provide security for network equipment in a shared space. Look for enclosures that are UL Listed under the NWIN category. This means they meet the ANSI/UL 2015, the standard for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure and Rack Systems16, which requires a load test and integrated bonding. In general, the loads supported by wall cabinets have increased to accommodate the heavier switches, UPS and battery backups that support high power PoE. The integrated bonding point makes connection to the telecommunications bonding bus bar easier so you can bond switches and patch panels.

Next, look for dual-swing enclosures, as shown in Figure 3. Dual-swing enclosures open at the front and rear to provide complete access to equipment and cabling. New types of cable openings and removable panels on enclosures allow the enclosures to be placed over existing wall-mounted equipment to retrofit physical security with minimal impact to existing network cabling. Fan technology has improved allowing quieter fans for cooling equipment, so enclosures can be placed in common areas such as conference rooms without adding disturbing background noise.

For retrofit applications, there are wall-mount cabinets with special knockouts that allow placement without replacing network connections. Equipment racks and cabinets like the CPI Universal Rack, Adjustable Rail QuadraRack and CUBE-iT® Wall-Mount Cabinet provide advanced equipment support solutions that are easy to use and provide precise support.

Figure 3: Advancements in equipment support include enclosures with increased load ratings for heavier equipment, front and rear access to equipment, retrofit features that allow installation over existing equipment and quieter fans that allow placement of enclosures and equipment in common areas. Photo shows CPI CUBE-iT® Wall-Mount Cabinet.

Summary of Network Changes

Table 4 (below) summarizes the impact of PoE++ to IT equipment and structured cabling and makes a recommendation for a CPI product solution discussed in this white paper. Use it as a basic guideline when considering a technology upgrade. Contact CPI for other product solutions.

Summary of PoE++ Impacts on the Enterprise Network				
Technology	**IT Equipment**	**Structured Cabling**	**Other Consideration**	**Product solution**
802.3bt POE++	Upgrade LAN switch to support IEEE 802.3bt Recommend combining requirements with 802.11 recommendations below	Recommend Category 6A UTP or Category 8 F/UTP or U/UTP in the horizontal If using existing CAT 5e or CAT 6 cabling, review heat buildup and adjust cable bundle sizes and pathway spacing if required	Upgrade UPS and battery backup to support longer runtime for higher wattage devices. May require higher power connection for switches or power injectors to supply additional wattage Review thermal requirements if switch is enclosed in cabinet or unventilated room Equipment cabinets may require a fan to increase airflow.	Universal Rack and Adjustable Rail QuadraRack, Motive Cable Management and Adjustable Cable Runway for LAN switch and cross connect in traditional equipment rooms CUBE-iT Wall-Mount Cabinet for LAN switch and cross connect in small network Zone Enclosures to secure wireless APs and endpoint network connections

Table 4: Summary of PoE++ Impacts to Enterprise Networks

Recommended Product Solutions

CUBE-iT® Wall-Mount Cabinet
Dual hinge wall-mount enclosure for class rooms, conference rooms and medium offices protects equipment while providing easy front and rear access for cabling.

ThinLine® II Wall-Mount Cabinet
Vertical mount enclosure uses minimal space in a small branch office. Supports a single switch and panel for network connections.

Universal Rack
Vertical mount for patch panels and fiber enclosures to maximize floorspace in traditional equipment rooms.

Adjustable Rail QuadraRack
Vertical mount for modular network switches in traditional equipment rooms

Motive® Cable Management
Attaches to the side of racks and creates an updated pathway to support and organize premise cable and patch cords

Adjustable Cable Runway
Updated ladder rack allows you to move rungs if they interfere with cable egress from overhead pathways

Zone Enclosures
Create secure spaces above drop ceilings for network connections and access points in the modern office.

RMR® Enclosures
Environmental and industrial enclosures provide outdoor protection from water and dirt.

Conclusion

There are a number of new networking technologies to consider for upgrades as you transition your premise network to support an ever increasing demand for bandwidth.

Don't forget to assess your physical network, your structured cabling, cable management practices and physical security as part of the process. Improved cable management products allow you to place supports exactly where they are required and easily separate cables to manage heat. New types of wall-mount enclosures create robust, secure spaces for your IT equipment and can easily retrofit over existing equipment or be placed in meeting rooms and other spaces where stronger network connections are required.

References

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[2] *IEEE Working Group WG802.3 – IEEE 802.3bt-2018 IEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs. Website:* https://standards.ieee.org/ieee/802.3bt/6749/.

[3] *National Fire Protection Association (NFPA). 2020. NFPA 70 National Electrical Code 2020. Article 725.144 Transmission of Power and Data.*

Contributors

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Michael Moore has more than 25 years of experience within the telecommunications industry. He has held various Product Management roles where he was responsible for developing, launching, and managing new innovative products within the Data Center, Airflow Management, and Information Technology market segments.

When Michael was with CPI prior, he held various roles from Technical Support Specialist, Applications Engineer, Associate Product Manager and Product Manager. As a Senior Product Manager for Open Architecture, he will be responsible for managing CPI's Cable Management, Cable Runway & Tray, Grounding & Bonding, Rack Systems, Wall-Mount Systems, Zone Cabling & Wireless Enclosures and Seismic Protection Systems product lines.

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Tom Cabral has worked in the telecom industry for 25 years and has been employed with CPI for 20 years, serving as a Regional Sales Manager, Field Applications Engineer and now Product Application Specialist.

Tom provides technical advice and design specifications on complex product applications and acts as a technical liaison with a high level of knowledge on product operation and performance. In addition to graduating Summa Cum Laude with a BS in Marketing and Business Communications from the University of Maryland, he is also RCDD certified.

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