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White Paper

Preparing For AV Over IP

High quality AV is Ready for the LAN – Is Your Network?

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INTRODUCTION

There's little doubt that the Internet of Things (IoT) movement is a part of a larger shift towards higher standards of twisted pair and fibre cabling in the enterprise. Whether a desired business technology requires faster data speeds, higher PoE capabilities or simply more cable runs to end-devices, IoT is forcing aging cable plants to be updated. Yet, there's one technology that can be a true game changer that would almost certainly demand improvements in the plant. That market is to stream low-latency and ultra-high definition (UHD) audio and video over standard Ethernet switches. If the professional audio/visual market is poised to converge onto IP networks as many claim it is, you'd better be sure your IP network and cable plant are up to the task.

Unlike the convergence of analog and digital voice onto IP networks a few decades ago, UHD video remains isolated on separate AV networks with proprietary switching and cabling requirements. Thus, you're likely to find HDMI/DVI/SDI/VGA matrix switches sharing the same network closet space with Ethernet switches. Additionally, specialized cabling must be pulled wherever AV signaling and transport is required. Until recently, there was a logical reason for this segmentation: the Ethernet network simply couldn't handle the bandwidth and low-latency speeds that streaming UHD required. But all of that is changing thanks to dramatic price reductions of 10 gigabit Ethernet switching hardware and software.

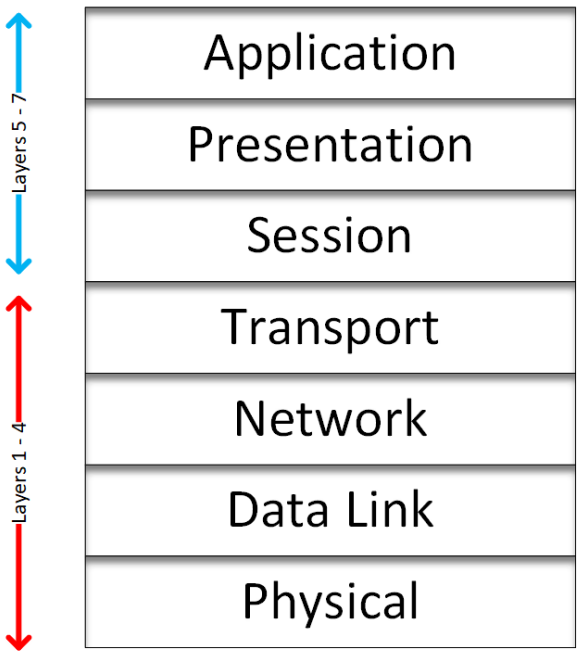
As businesses begin upgrading their enterprise LAN to handle multi-gigabit Ethernet speeds for other IoT projects, it also opens the door for the consolidation of bandwidth hungry UHD video onto Ethernet networks. In this paper, we will cover the emerging audio/video over IP (AVoIP) market space -- and how consolidating all video onto the campus LAN can create cost and administration benefits for businesses. We'll then move on to explain how high-bandwidth, low latency video creates new challenges as it relates to selecting the right cabling -- as well as testing of the cable plant for proper operation in a production environment. Lastly, we'll show examples of how cabling professionals can use the AEM TestPro CV100 multifunction tester to validate twisted pair and fibre optic cabling for AVoIP use.

WHAT EXACTLY IS AVOIP?

If your current job role focuses solely on IP network cabling, this may be the first time you've heard of AVoIP. That's because professional AV vendors have traditionally used their own, proprietary cabling and switching hardware and software. Packet-based switch hardware and cabling standards have all but been ignored. But as mentioned, the cost of multi-gigabit Ethernet has dropped considerably compared to AV matrix switch hardware. Because of this, the AV industry is realizing that the timing may finally be right to consolidate UHD AV services onto Ethernet-based IP-networks.

The generic term coined for transport of high-quality, low latency audio and video as well as signaling data over an IP network is Audio Video over IP -- or AVoIP for short. Within this AVoIP category, there are two standards-based alliances to familiarize yourself with. The first is the Software Defined Video over Ethernet (SDVoE) Alliance.

This group of professional AV and networking manufactures have collaborated to create a standards-based interface between IP-capable endpoints and the software that controls them. The Alliance was first formed in 2017 and has over 40 members including Sony, NETGEAR and Semtech. The SDVoE standards operate using the same 802.3 10 Gbps Ethernet standards at layers 1 to 4 of the OSI model. SDVoE also takes advantage of pre-existing Power over Ethernet (PoE) specifications including the latest 802.3bt Type 4 standard that can deliver up to 90 Watts to end devices.



OSI Model

Because Ethernet and PoE standards dictate data transport and power delivery specifications at layers 1 to 4 of the OSI model, SDVoE standards focus on the upper layers (5 to 7). The standard dictates cross-vendor interoperability to the AV world for the first time using open application programming interfaces (API). An AV manufacturer's differentiating features will therefore be focused on the unique hardware and software they create on top of SDVoE and Ethernet transport specifications.

A second group of AV manufacturers dabbling in the AVoIP space is the HDBaseT Alliance. This alliance was formed in 2010 and consists of over 200 members including LG, Samsung and Valens. While the HDBaseT Alliance has been around longer and consists of more industry members compared to SDVoE, the original HDBaseT standard is not based on convergence of AV onto IP-based networks. Instead, the purpose of HDBaseT was to develop AV matrix switches and protocols that could send UHD video and audio over twisted pair (Cat 5e or better) or fibre optic cabling. Separate switching hardware for IP data and AV would still be required – but a shared cable plant could be used for the first time. Thus, while HDBaseT does consolidate cabling, it's technically not considered AVoIP.

A second HDBaseT standard that is reportedly in development is called HDBaseT-IP. This is a true AVoIP standard that is very similar to SDVoE. It too allows for the transport of HD video over standard 10 Gbps Ethernet switches. That said, little is known about the status of this standard other than a few demonstrations of by HDBaseT Alliance members.

BENEFITS OF AVOIP FOR BUSINESSES

From a business perspective, deploying AVoIP can provide the following benefits:

1. AVoIP consolidates the transport of UHD video onto the same cable plant as all other IP data. This greatly simplifies cabling types and locations where connections should be run within and between buildings.

2. Because AVoIP operates using the same 10 Gbps Ethernet switches as all other networked devices use including PC's, servers, IoT devices and other network/infrastructure gear, there is no longer a need to purchase separate – and very expensive – AV matrix switches.

3. Consolidating both the cable plant and switching environment frees up data center and network closet space. Often, space is limited and a reduction in hardware can allow for the installation of new technologies. Also, a decrease in hardware and cabling translates into cooling and electricity savings.

4. Consolidation of AV onto the LAN can reduce the number of technology administrators required to manage both AV and IP networking resources

WHAT AVOIP MEANS FOR CABLE PLANTS

Just because AVoIP runs over standard twisted pair copper and single/multimode fibre and Ethernet switches doesn't mean you're automatically ready to support it. In fact, you'll quickly realize that some of the same challenges of running AVoIP services are also inherent in any other network challenge that requires multi-gigabit connectivity.

Once you move beyond 1000BASE-T Ethernet -- which has been the staple of enterprise networks for decades -- you'll find that higher-performance twisted pair cabling will usually be required. There are a few reasons for this. For one, higher-performance cable types use thicker gauge wiring and with tighter twists of the pairs. This allows data to be transported at higher frequencies. Higher frequencies mean better throughput. The trade off, however, is higher frequencies tend to create crosstalk/interference as wireless signals bleed out of the cabling and into neighboring pairs or cables in a bundle. This is where improvements in cable shielding/separation comes into play. Better quality cabling creates better signal separation using foil shielding techniques designed to reduce crosstalk when transporting data at higher speeds.

Multi-gigabit twisted pair cable validation tests can show you whether your cabling can run at higher speeds. That said, careful planning and testing must be done to fully verify this. Some lower quality cabling may end up passing validation tests – yet not perform well once put into production. The next section of this white paper will provide tips on how to best validate twisted pair cabling to ensure it will operate as expected in the real world.

A second benefit to thicker gauge twisted pair cabling has to do with heat dissipation. When running at higher bandwidths, as is the case with multi-gigabit Ethernet, the wires within the cable will reach higher temperatures. Additionally, consider the fact that many modern IoT devices – including many AVoIP endpoints – use Power over Ethernet (PoE) up to 90 Watts. Thus, the thicker copper gauged wires in Category 6A or higher cabling can better handle heat rise and ultimately protect the cabling, patch panels and connectors from premature failure.

There are some additional cable deployment requirements that installers must also be mindful of when using twisted pair cabling for AVoIP. One of them is a limitation on the number of connectors allowed between the video encoding and decoding devices. A maximum of 4 connector hops is recommended for any AVoIP data transport. The use of Modular Plug Terminated Links (MPTL) is a way to directly connect static devices without having to use two connector hops. Thus, while maximum connector options are more limited for AVoIP uses, there are ways to extend cabling within that framework using MPTL's when and where they make sense.

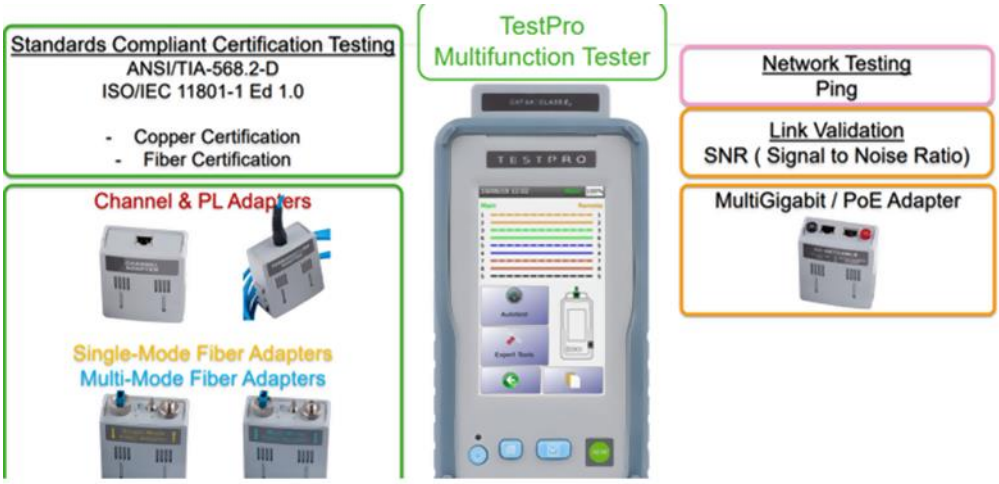
From a fibre perspective, AVoIP will operate the same as any other IP data traversing it. Single and multi-mode fibre is a great way to extend beyond the 100 meter twisted pair cable limitation when needed. That said, it's important to be sure that fibre is certified to operate at multi-gigabit speeds when upgrading fibre switch hardware form 1 Gbps to 10 Gbps or more.

USING THE TESTPRO TO CERTIFY AND VALIDATE CABLING FOR AVOIP DEPLOYMENTS

The following diagram can be used as a guide when certifying copper and fibre of various media types, standards, loss budgets and distances.

Media	Standard	Loss Budget / Max Distance
Copper	10/100/1G/2.5G/5G/10G BASE-T	Cat6A @ 100m
Fiber	10GBASE-SR	OM1 = 1.6dB @ 33m OM2 = 1.8dB @ 82m OM3 = 2.6dB @ 300m OM4 = 2.9dB @ 400m
	10GBASE-LRM	OM2 = 1.9dB @ 220m
	10GBASE-LR	OS2 = 6.2 @ 10km
	10GBASE-ER	OS2 = 10.9 @ 40km
	40GBASE-SR4	OM3 = 1.9dB @ 100m OM4 = 1.5dB @ 150m
	40GBASE-FR	OS1 = 4dB @ 2km
	40GBASE-LR4	OS2 = 6.7dB @ 10km

Because the TestPro CV100 is a multifunction tester with a modular adapter design, it can certify both copper and fibre using the same tool and when testing in channel, permanent link and MPTL configurations.

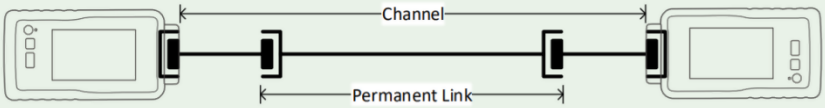
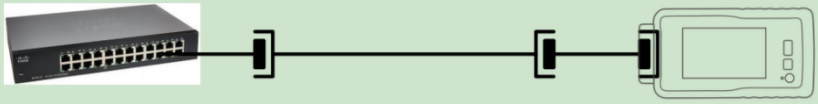


Important certification test parameters for multi-gigabit testing include:

- Length
- Delay
- DC loop resistance,
- Insertion loss (IL)
- Return loss (RL)
- Near-end crosstalk (NEXT)
- Power sum near-end crosstalk (PSNEXT)
- Attenuation to crosstalk radio, far-end (ACRF)
- Power sum attenuation to crosstalk radio, far-end (PSACRF)
- DC resistance unbalance
- Transverse conversation loss (TCL)
- Equal level transverse conversation loss (ELTCTL)

The two areas that are most likely to cause AVoIP issues due to an inferior grade of cabling will be near-end crosstalk (NEXT), PSNEXT and DC Resistance unbalance. Again, these tests are difficult to replicate in new cable plants. This may result in a passing certification test – but fail to operate properly in a production environment. Thus, Cat 6A or better cabling is preferred – and shielded cabling is ideal -- for AVoIP twisted pair runs.

The TestPro can also perform twisted pair link validation and PoE tests. These tests can be run between a main and a remote CV100 using either channel or permanent link adaptors. Additionally, PoE can be tested between an Ethernet switch with built-in PoE or with a switch and PoE injector or midspan as shown here:

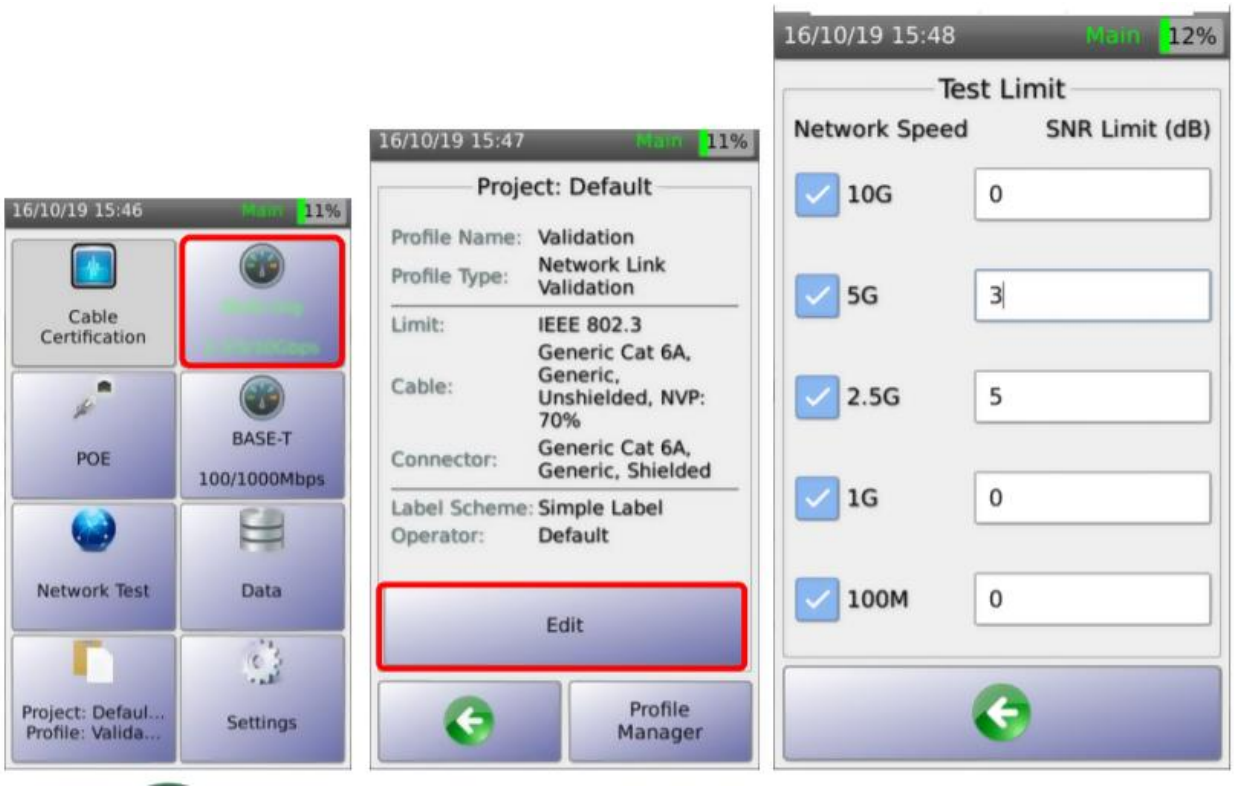
Link Validation	
Network Switch + PoE	
Network Switch + PoE Injector	

Link validation tests will show signal to noise ratios (SNR) in dB. However, if this is a new or unused cable plant, alien crosstalk will likely not show up in validation test results. Yet, when multiple cables in a bundle start transporting data, alien crosstalk will be noticeable at higher multi-gigabit speeds and when using cable types that are unshielded or are not the recommended Cat 6A or better standards. As seen in the following chart, category 5e and Cat6 will likely fail to perform at 10 Gbps speeds in production once alien crosstalk is observed:

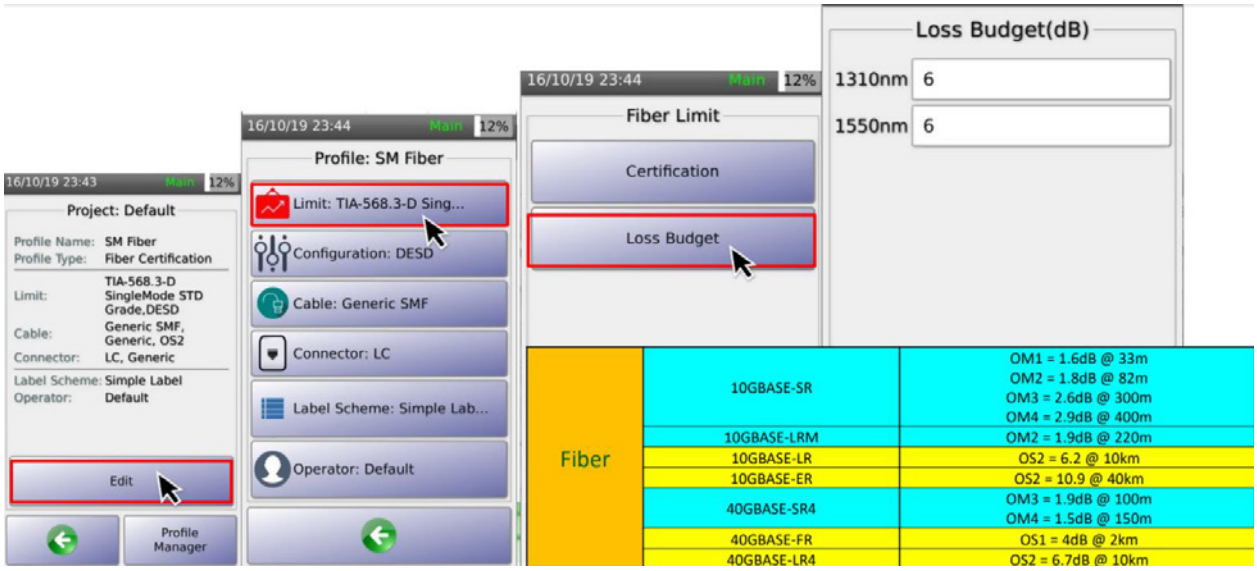
Certification Margin / Link Validation SNR

Cabling Type	Length (m)	Cat6A Certification Channel Margin			Link Validation (SNR in dB)		
		Insertion Loss	NEXT	Return Loss	2.5G	5G	10G
Cat5e UTP	50	1.5	1.8	7.8	9	6.9	X
	90	0.3	-4.4	5.8	8.2	3.7	X
Cat6 UTP	50	1.6	5.6	5.3	9.1	6.4	X
	90	0.5	6.6	4.6	10.4	3.5	X
Cat6A Shielded	50	1.6	9.3	8.3	10.9	7.8	4.3
	95	0.3	6.8	5.8	9.1	3.9	1.2
	100	0.1	9.4	6.2	10.1	3.7	0.6

Adjustments can be made to Multi-gigabit link validation test settings to program SNR limits for the various network speeds you're interested in. As you can see in the following TestPro screen captures, SNR limits can be individually modified for 100/1000 Mbps and 2.5, 5 and 10 Gbps multi-gigabit speeds.



From a fibre perspective, it's important to understand the following parameters prior to running certification tests. The first is to know what type of fibre you'll be testing. Multi-mode fibre ranges between OM1 to OM4. For single mode fibre, OS1 or OS2 are the most common. Next, you must know approximately how long the fibre run will be. Using this information, you will select the appropriate multi-gigabit Ethernet standard and corresponding fibre Ethernet interfaces to use. Lastly, based on the fibre type, Ethernet standard and distance, you can determine what the loss budget should be set to when using the TestPro. The following diagram lists common 10 and 40 Gbps fibre Ethernet standards along with fibre types, distances and loss budgets in decibels (dB). You can then configure the appropriate loss budget into the TestPro prior to running fibre certification tests as shown in the tool screen captures.



AVOIP – SIMILAR YET DIFFERENT ON THE LAN

While transporting UHD video using AVoIP standards is technically no different than any other multi-gigabit networked connection, the fact that it's steaming UDP data does highlight the need for cabling that meets stricter standards. While TCP data can be retransmitted, streaming UDP cannot. Thus, inferior or poorly installed cabling will be far more noticeable on runs transporting AVoIP. That's why it's going to be critical that you have the right tools and understanding on how to certify and validate twisted pair and fibre cabling once AVoIP converges onto your enterprise LAN.

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