



GameChanger Cable
Not the standard solution!



Ignoring The Limits: It's a GameChanger!

Once in a while, it pays to defy the standards. In today's world, cameras, WAPs and PoE+ edge devices are everywhere. Companies use cameras as a means to track merchandise, verify on site safety standards are being adhered to, protect themselves from litigious endeavors and enhance overall security of their business and campus environments.

The problem with outfitting many campuses with security is the fact that power does not necessarily exist at every location where a security device needs to exist. Power over Ethernet provides a means to send power to remote locations. The standards published distance for PoE applications is 100m, but that doesn't need to define the distance of your channels. Sometimes, it is advantageous to be able to extend the standards-based distance. A cable that can do that is aptly named "GameChanger."

A Word About Standards

For years, the standard distance for category cable has been 100m. Outside of Category 8, this is still true today. The limitation in the standards is based on a theoretical limit for transmissions based on the Ethernet protocol. Ethernet has various speeds and an allowable packet drop rate or bit error rate. Ethernet and IP are often confused as the same thing, however, TCP/IP is the protocol and Ethernet is the signaling which sets up the transmission over which the TCP/IP traffic is transmitted. The media [copper, WiFi or Fiber] all work with various forms of Ethernet to transmit TCP/IP. In fact, even cellular can transmit TCP/IP.

In order for any IEEE Ethernet standard to be written, there is first a call for interest to assure that the project will have support amongst those that write them. Then a study group is formed to investigate the technical feasibility and answer the 5 criteria required:

- 1) Is it technically feasible?
- 2) Will it serve a unique need?
- 3) Will I work with the other standards as needed (i.e. all Ethernet needs to work with all other Ethernet standards)
- 4) Is it economically feasible?
- 5) Will it have broad market appeal.

When this step is complete, the study group becomes a task force provided all of the 5 criteria are met. This group also liaises with TIA and ISO on the cabling portion of the standard. We know that not all manufacturers are on the same path when products start, and during the task force stage, there is a lot of voting to determine what final parameters for any standard will be in its final form. In order to achieve that, it is necessary to draw a line that both the electronics and the cable manufacturers can work towards.

At 100m for most copper-based communications, signal strength within the electronics is at an acceptable level and noise cancellation (and the resulting power) is kept to a minimum. It also provides a finite limit for other parameters so that active electronics manufacturers can begin working on the products to run over whatever medium is apropos.

For fiber, the length for applications changes based on speed and transceiver. Further, distances vary based on the mode of fiber. But as we know from fiber applications that meet or exceed the recommended length, some copper applications can also meet and exceed the 100m limit listed in the standards.

A Word About Power

For Power over Ethernet, the limits applied to a standards-based copper cable is limited by the Ethernet side, which, as stated, is 100m. However, we know that power signals can transmit longer distances than 100m on a given cable gauge. The distance is based on the resistance of the copper and the length of the copper and signal strength. In reality, the Ethernet limit has nothing to do with the power transmission except that the Ethernet switch is providing power.

There are two ways to transmit power over the copper pairs in PoE. The Power Sourcing Equipment can be the switch itself (Mode A -aka- Endspan), or a midspan (Mode B) injector can be used that breaks into the channel somewhere between the switch and end powered device. Mode A transmits power over the data pairs of 10/100BASE-T, Mode B delivers power on the non-data pairs at those same speeds. How the power is delivered (A or B) is a function of the PSE (switch or midspan).

With method B, injecting power and breaking into a channel some degradation is caused and therefore it will not provide the exact same performance as it would if the switch provides the power. This is also true for GameChanger.

The best means to provide power is always at the switch were possible, it does not introduce another point of failure and the power is provided on the data pairs with simultaneous transmission of both the Ethernet packets and DC power and fully supports 4 pair Type 4 (higher power) applications.

There are two main standards that govern the power transmitted over a 4-pair category cable. The original is 802.3af which was ratified in 2003 by IEEE and the second 802.3at published 2009. Higher power Type 4 (slated to publish in 2018) is 802.3bt. All provide parameters for the PSE (Power Sourcing Equipment) and the PD (Powered Device) at the end. The power delivery transmissions are defined by "type" with Type 4 being the highest power and Type 1 the original 802.3af standard from 2003. The difference between the two standards is the definition of the Ethernet link, the number of pairs used, and the amount of power delivered.

As the power is transmitted, some loss will occur. This loss is a matter of physics and will not change. Therefore the standards are written to address power at the source PSE and power available to the powered end device as shown in the table (right).

PoE Power Nomenclature	PoE	PoE+	4PPoE	Type 4
PoE Standard Designation	802.3af (802.3at Type 1)	802.3at (802.3 at Type 2)	802.3bt Type 3	802.3bt Type 4
Power available at Powered Device (PD)	12.95W	25.50W	51W	71W
Power at source (PSE)	15.40W	30.0W	60W	100W

A Word About Video Transmissions

Video transmissions can operate over a variety of platforms. Years ago, when transmission bandwidth was very low, video began using various forms of compression to assure that video could be watched without pixelation and losses that, unlike a data only packet, are visible and irritating byproducts of inadequate bandwidth. That said, video quality has gotten immensely better over time, and the higher performing video requires more bandwidth than in the past. For streaming, the lowest acceptable level of bandwidth is around 500 Kb/s. For today's 4k Ultra High Definition, 25Mb/s would be considered the minimum. 1080p which is acceptable for the majority of security transmissions requires 5-8 Mp/s, although Google® states that 4Mb/s is the minimum for YouTube® 1080p and 2.5Mb/s is the minimum required for 720p. Again, compression and other encoding algorithms will govern required bandwidth. The human mind fills in a lot of the "missing" details between frames and compression methods count on our minds and machines bridging the gap.

In the past, surveillance standardized on CCTV (Close Circuit Television). Parameters for CCTV vary from IP video as the media (copper or fiber) is different and the video equipment uses different encoding/decoding techniques to accomplish the transmission. Further, video cameras have different requirements. An inside camera that is motion activated will create bursty traffic, whereas an outside "always on" camera will create continuous streams of video. IP cameras are typically available in resolutions from VGA (.3 mega-pixels) to 29 mega-pixels for higher definition security needs. Higher definition resolutions available range from 720p to 2160p (4k).

Previous analog CCTV cameras used established broadcast formats like CIF (Common Intermediate Format), NTSC, PAL and SECAM. In order to have some standardization for IP video surveillance, in 2008, the Open Network Video Interface Forum (ONVIF) was founded along with the PSIA (Physical Interoperability Alliance) which assures mix and match ability between manufacturers. IP cameras have a wealth of features. The first centralized IP camera was introduced by Axis as the Axis Neteye200. There are many now. The IP cameras vary in form and functions. This relates not only to the resolution of the camera, but also the transmission and encryption functions of the cameras. Replacing a CCTV system can be problematic in an IP world. The biggest problem is the extended distances offered by CCTV over coax that, until now, have not been available over a 4 pair IP based system. One previous limitation being the 100m length mentioned previously.

IP cameras are different from analog cameras in that the signals are transmitted over IP and as such can be two-way communications accompanied by voice to allow the viewer at one end to speak to the someone at the end device. Another difference is that they can use wireless networks, and of course, operate over the various forms of PoE.

One other factor to consider in the transmission is frames per second (fps). NTSC (National Television Standards Committee) which is responsible for setting television and video standards for the US defines a composite video signal with a refresh rate of 29.97 FPS. PAL (Phase Alternating Line) dominant in Europe is 25 FPS. The final function of bandwidth requirements incorporates frames per second. In short, your Bit Rate = Frame Size * Frame Rate (fps). Transmissions speeds are also impacted by the type of compression used. In most surveillance applications, 30 fps are used with 1080p video with H.264 or MPEG 4 compression. H.264 was designed as a standard to provide good quality video at substantially lower bit rates than previous standards.

A Word About Distance

In a standards-based Ethernet world, 4 pair twisted copper cabling is limited to 100m based on acceptable Ethernet performance levels. Please note that this is the maximum distance for a transmission limited by the 802.3 Ethernet standard. However, distances can be (and are) exceeded by application based cabling.

In most buildings, there is a need to reach distances over 100m. This is true for many CCTV systems that upgrade to IP video. Also, think the camera in the corner, the cameras in the parking structure, or even locations that are within 100m as the crow flies, but not as the pathways run. There are a few ways to reach those areas using traditional Ethernet and powered methods. In order to reach those out of the way places, a few options exist.

Option 1) Install an additional IDF. Installation of a secure IDF requires identifying a location (which may take some space out of production/revenue generating functions). Install power to that location. Install pathways from this location to the outlying 100m location. Install an uplink switch port to add that location to the backbone. Add it to the security plan. A recent project estimated the cost of this IDF install to be \$38,000 US. But we can assume that this could easily be \$10,000. The room must be built (or enclosure installed), power must be supplied,

backbone cables must be installed, and backup power needs to be implemented, and it must be added to DR plans and tested.

Option 2) Install transceivers/media converters and carry the signal over mixed media. This requires power ports at both ends that may not exist. Adding the converters introduces two more points of failure to each link. The transceivers are roughly \$800 US each for a quality that you would want in a security system, plus the fiber in between. Conservatively, this adds roughly \$2,600 to each channel, plus ongoing power costs for powering the transceivers. Maintenance costs and backup power would be additional costs.

Option 3) Install repeaters in the channel which will be similar to the transceiver costs above with the exception that it will be copper only. Repeaters also add points of failure, must be secured, and most require some sort of power or inline repeaters will offer limited distance extension.

Option 4) Enter the patent pending, award winning GameChanger cable. The GameChanger cable was designed to support 1080p video and PoE+ over extended distances. The GameChanger cable fully supports 850' with PoE+ without repeaters at 10Mb/s and is UL verified to support 200m with PoE+ support at 100Mb/s and 1000Mb/s. The Category 6A version is shielded for additional benefits. These cables install and terminate like a traditional category cable, but with enhanced performance to allow these extended distances. MSRP on the cable is less than one transceiver in the above example. OSP is also available in shielded.

In fact, in a recent study completed for a major colocation facility, GameChanger saved \$2,006.60 for every single over length run. Across 120 cabling drops for extended distance cameras, the total savings was \$240,792 day one. This savings did not include additional power drops which would have been needed as those drops were considered outside of the scope of this project. Day two, 240 media converters were not needed resulting in the elimination of the out-of-scope power installation requirements and points of failure for each converter and additional areas that would need to be secured. With PoE+ being supported within the extended distances with GameChanger, there is not a need to add backup power to each converter either, which again, is a cost avoidance and immediate savings.

In determining the distance supported by GameChanger, the most critical factors are the

camera, encoding, frames, PSE for the PoE+ signal and the camera at the other end. While GameChanger has been tested in some configurations to support the full 1000' reel, with most cameras and switches 850' is easily realistic, and warrantied. By setting both the Power Sourcing Equipment and the camera to 10Mb/s, there is ample bandwidth for 1080p video at 30 fps which is common in surveillance applications.

For extra-long distances, cameras can attach to a switch that is uplinked to another switch. The backbone (uplink connection) over GameChanger is 650' at 1000Mb/s as shown in Figure 1. In fact, GameChanger supports a variety of Gb/s applications at 650'.

In another independent study completed by MSB Security Consulting, three options were evaluated to provide for 160 cameras at the building perimeter with most cameras more than 328' from the IDF. All options are materials assessments, exclusive of labor.

Option A with the GameChanger cable totaled \$22,305. Option B used UTP cable and PoE port extenders increasing the costs to \$104,525 and Option C used a combination copper and fiber cable with the copper used to provide power and the fiber used to carry signal. For this solution to work, the PoE Extenders in option B were needed and transceivers were needed to convert the digital signals to optical signals. The cost for this solution was \$126,170 with the media converters, but went down slightly to \$116,934 if fiber cameras were used, although it is necessary to point out that the fiber cameras would be more expensive than their copper counterparts. Note the comparison below.

Option A GameChanger	Option B Cat6 with Port Extenders	Option C With Extenders & Transceivers	Option C Without Transceivers
\$22,305	\$104,525	\$126,170	\$116,934

A Word About Bandwidth

There are various methods of calculating bandwidth for cameras. The factors involved include the hours of operation for the camera, resolution of the cameras, frames per second transmitted, streaming mode, and number of simultaneous transmissions. For small (8-10 camera) installations a simple 10 Mb/s is sufficient. For systems with more than 10 cameras, most manufacturers have calculators or recommendations

based on the camera resolution.

The encoding CODEC is generally inside the camera and the signals are encoded prior to transmission over the media to the respective server. Each type of encoding will consume different amounts of bandwidth. In fact, changing from MJPEG/MJPEG-4 to H.264 will drop bandwidth requirements by nearly 80%. However, the bandwidth required is a function of the camera and the other factors listed. Resolution is merely one factor.

It is also important to consider other network transmissions in your calculations. If your security network is autonomous from other networks, this will not be a factor. Many security systems have a variety of security cameras and methods for transmission. The GameChanger cable supports many bandwidth and camera configurations.

For assistance determining other bandwidth requirements, it is always best to work with your security integrator or discuss bandwidth requirements with your camera manufacturer(s). The GameChanger can support a multitude of encoding methods at extended lengths. To date, the cable has been tested over a variety of encoding methods with a variety of equipment including cameras, WAPs, switches, and other powered devices and each has shown a superior length advantage using GameChanger.

As stated, the encoding method will determine the bandwidth requirements. The switches should be designed to support the bandwidth needed. The cable is merely an extended length transport for power and signal even with 4K cameras.

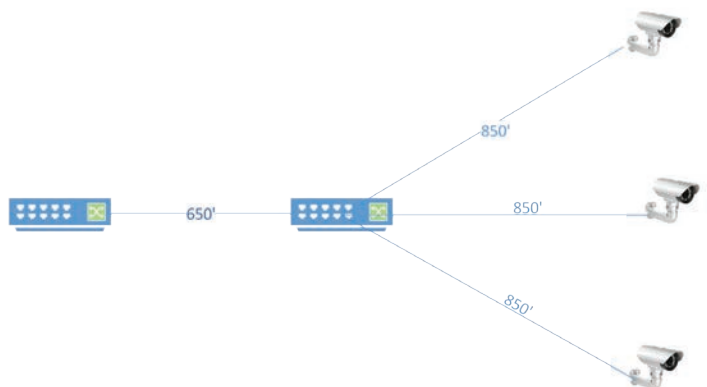


Figure 1. GameChanger can be used to pass PoE+ and 1 Gb/s 650 feet between the two switches and PoE+ and 10 Mbps



A Word About Testing

Testing extended distance channels in the past was limited to testing the pieces between active repeaters and transceivers and hoping that the sum of all parts would provide the desired final results. With GameChanger, you can test the full end to end channel as there is one extended distance channel. For a list of approved testers, visit the [GameChanger website](#). There you will find testers that can test the channel, and testers that can test for the application over the cable.

To test a permanent link or channel with a run of GameChanger cable, select the correct testing parameters with your testing device. As the channel will exceed TIA or ISO 100m limits, the test will be in the vendor section of your test device. For example, with the Fluke DSX series of testers you can select the "GameChanger 1Gb/s Channel" or "GameChanger 10Mb/s Channel" test limit from within their Vendor folder of test limits. For some testers that allow you to customize the channels, you may need to input the correct parameters. For more information on using your approved tester please contact sales@paigedatacom.com

To demonstrate the cable's performance with a switch and end device (i.e. camera, WAP, switch uplink , etc.) please note that a managed switch is recommended for distances over 200 meters. For these maximum distance scenarios, you may need to manually set your switch to 10Mb/s. Depending on your active equipment, the extended distance may otherwise cause the auto-negotiation between your switch and end device to timeout. For 200m and below, no changes are likely to be needed for your switch. For additional lengths with inline repeaters or transceivers, there will still be fewer components to test as the channel in between repeaters will be longer.

In Summation

Replacing CCTV systems does not require adding expensive electronics, additional power and points of failure. The Paige GameChanger cable is just that, a GameChanger for these and other security applications. By running all of your security cameras over the GameChanger system, not only do you have insurance against those runs outside of 100m, you will also have a robust cabling system providing extended distances with ROI on the first day of installation. The cable is striped for easy detection in a mixed use environment and is available in Riser, Plenum and OSP (Outside Plant) constructions.

For more information, reach out to Paige DataCom Solutions and let us show you how a surveillance system infrastructure built on Paige's award winning GameChanger can be a game changer in your environment. Paige's GameChanger is part of a full line of category copper, access control, security, fire, and fiber systems to support all of your data infrastructure needs.

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