Understanding Extended Distance Network Transmission –White Paper

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Transmission is rapidly becoming the key component of video security network systems. As IP cameras, digital and network recorders improve in quality along with the advent of cloud storage the criteria for system performance will depend on how signals are transmitted between various points on the network with the least amount of information loss while maintaining the best possible quality.

Many such video network systems require point to point bidirectional communications to maintain their closed circuit "secure" aspect at distances greater than the Ethernet limit of one hundred meters. Current analog video systems transitioning to IP face the challenge and potential extra costs of installing additional UTP cabling and extra equipment while leaving existing coax useless.

All of these challenges can be solved by the use of extended distance UTP transmission and media conversion UTP to Coax and extended distance UTP solutions. However, networking standards and test methods applied to commonly smaller file size data transmission do not often work when applied to larger file video file frames transmitted at high speeds. Further the increasing need to power cameras and other devices using Power over Ethernet (PoE) adds additional considerations and stresses to network transmission. This necessitates a clear understanding of existing transmission methods, the need for improvements and testing requirements to validate claims.

Even top performing cameras and recorders can be rendered underperforming or useless by a transmission system's inability to handle data and power requirements.

Challenges Facing Video IP Security Networks

a. Limitation of network transmission at 100 meters/328 feet and the need to account for 5 meters at each side for a total of 10 meters is allocated for the connection so the result is 90 meters or less then 300 feet.

b. While distances can be regenerated it requires the use of network switch or other types of immediate equipment resulting in additional installation and cost considerations

2. The need to maintain the secure "closed circuit" aspect as Open Network-Closed Network-**CCTV** becomes **CCSN** (Closed Circuit Security Network).

In most installations control centers are usually located at distances greater than 100 meters. Casinos, larger industrial complexes, college campuses, and shopping centers which require parking lot surveillance are all examples of applications that require transmission distances of more than 100 meters.

The need for extended distance network is not always apparent. Many of us are familiar with the ability of plugging in an Ethernet cable or turning on WiFi and accessing information from all around the world. The simplification in this often makes us overlook the security aspects. CCTV is not limited by analog or IP signals, it is still required to be Closed Circuit. The best method to assure security is to limit access to its network and that requires that all connections remain with their own network with no potential, or limited outside access. Almost daily we read about the most secure networks, even government sites being hacked and information stolen or altered. We have these potentials any time a network or device on a network is exposed to the web.

The Potential is Great

There is general agreement that use of IP for video security applications is growing. While both analog and IP camera system sales are growing, IP is growing much faster and often at a higher rate when more complex systems are concerned. Over the next few years it is estimated that IP camera growth will outpace analog cameras by almost three to one with sales reaching almost 9 million units by 2015. It is reasonable to assume that not all of these connections will be restricted to 100 meters.

Looking at projections for encoder sales over the same period is also very telling. Sales are expected to increase, while the use of network recorders will double. All of these devices will require transmission paths.

Security products, especially cameras are a good investment. In the mid to late 1980's as video cameras transitioned from tube to chip images the last replacement component dependent upon age was removed. It is difficult to project the life span of a video security camera and many installations from that period are still active.

Current trends present a challenge to recording as the usage of digital and networking continue to grow. Gone are VHS time lapse recorders, Digital Video Recorders are morphing into Network Video Recorders and at some point they will be replacement by cloud networking. However the stable reliable CCD analog camera continues to work. In current economic environments the need to update is challenged by the greater costs of digital equipment compared to their analog ancestors. The largest cost consideration is rewiring. This can often exceed the cost of the equipment itself.

There are many projections as to the average per year sales of analog cameras. Conservatively if we just look back ten years when IP was in its infancy the figure would probably stand at ten million cameras per year world-wide. That would mean approximately one hundred million analog cameras at least are still functioning adding to this average growth of about a million and half encoders and there lies the potential that as network based IP digital systems continue their rapid growth current analog systems will have to find some method to convert.

Coax cable has its distance limitation which is often cited at about 1000 feet or 338 meters. These limitations were overcome by the use to Unshielded Twist Pair (UTP) transceivers. It is currently estimated that there are almost twelve million channels of analog cameras operating over UTP at distances up to 6,000 feet or 1818 meters in operation. Add to this several thousand channels of fiber that currently carry analog camera signals. It is difficult to estimate how many of these will covert to IP, but due to the transitions occurring in recording and storage technology, in time all will. Even at one percent per year over a million channels could be subject to this conversion.

Technology has proven that as time passes technology results in decreasing product costs. This was true of all aspects of analog systems and still is today with digital IP systems. All costs with the exception of one, labor. As equipment costs have decreased labor costs have increased, not just related in salaries, but health care, and more recently transportation. Decreasing cost for improved network cameras and recorders are quickly outweighed by the labor cost of replacing coax cable for UTP.

The solution then becomes to leave the existing transmission media either in the form of coax cable or UTP and use it for transmitting IP.

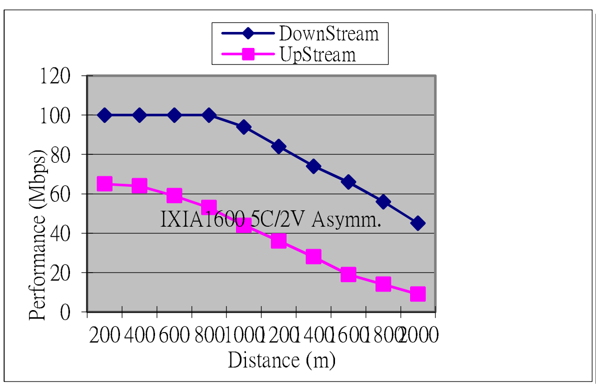
Extended Transmission: The need to understand.

As with any technology just looking at products specifications is often times not enough to make the right decision. An extension of IP does not solely involve just distances greater than 100 meters or the ability to carry signals over coax cable. More and more our security cameras are being powered over the cable by industry standards IEEE 802.3af and more recently a high power version known as 802.3at. Like Ethernet transmission, the ability to power devices using PoE is limited to 100 meters. The challenge in extending transmission is twofold, data and now data plus power. This increases the need to understand the technologies involved in extended transmission and the individual considerations in extending power and distance.

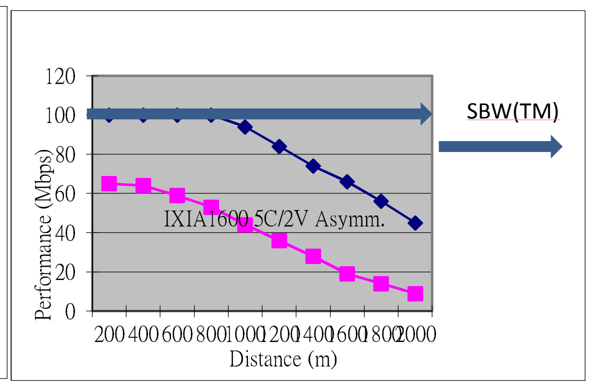
Like many technologies currently used in video security applications, extended distance transmission has its roots in consumer applications. Internet Service Providers (ISP) faced similar cable distance restrictions. This led to the development of Very High Speed Digital Subscriber line 2, or VDSL2 technology. Used for high speed internet connection to a home is fine, however when applied to video security applications there are several significant defects.

First is bandwidth. VDSL2 rapidly decreases with distance. A VDSL2 device rated to operate at 100Mbps may only do so for distances significantly shorter that what may appear on product specification sheet. Next are the differences between uplink and downlink. As VDSL2 was designed to primarily feed information in one direction, the focus is on downloading (remote site to source) and not uploading (source to site). The differences in bandwidth can be almost forty percent. The final consideration is power. VDSL2 requires using a lot of power as it must packetize and push the signal.

Figure 1: Differences in VSDL-2 and Symmetric Bandwidth



Typical VDSL-2 performance showing bandwidth drop-off with distance



VDSL-2 performance verses Vigitron with Symmetric bandwidth

A device indicating its Ethernet port is capable of transmitting 10Mbps/100Mbps is not an indication that its system actually does transmit 10Mbps/100Mbps of data. In most case several factors limit the amount of bandwidth a system can handle including differences between upload and downloads.

What do the limitations of VDSL2 mean to me?

Bandwidth and Packets

Understanding what the limitations of VDSL2 means everyday performance requires a little knowledge of how signals are transmitted over a network. First we have to consider the differences between port bandwidth and usable signal bandwidth. The port bandwidth is the one you most often see in product specifications. Typical ones are 10Mbps and 100Mbps. Mbps stands for megabits per second and is used as the reference for data transfer speed. Don't confuse this with the use of megabyte which is expresses as MB. Note the difference between the use of little b Mb and big B MB. **1 MBps (megabyte per second) = 8 mbps (megabits per second).** An IP signal is transmitted with several embedded signals that assist in directing the signal. These are known as overhead and take away from the amount of bandwidth available for the actual signal. While there are no standard specifics with regard to how much signal is lost to overheads, the more conservative you are the better. Error on the side of safety would have you allocating almost forty six percent (46%) to overhead leaving fifty four percent (54%) for actual signals.

The amount of available bandwidth is also related to the amount of information that can pass. Packets come in different sizes. The larger the packet the more information contain within it but the more difficult it is to transmit. Packet sizes are usually determined by the source information. A Request for Comments or RFC has been established defining the various packet sized used in network transmission. While RFCs are called requests, if the specification is accepted it does become a standards document. The RFC for network packet transmission is called RFC-2544. It includes packet sizes ranging from 64 bytes to 1514 bytes. As with any form of transmission the bigger the signal the more difficult and less signal is transmitted. The following are the difference between packet size and number of packets transmitted.

Size :Packet Size (bytes)	Ethernet: Number of Packets transmitted per (pps) second)
64	14880
128	8445
256	4528
512	2349
768	1586
1024	1197
1280	961
1518	812

As the size of the individual packet increases, the number of packets that can be transmitted is reduced

The difference between the number of packets transmitted for the smallest packet size and number of packets transmitted for the largest packet size is almost ninety five percent (95%) difference. Video cameras are generally in the 1518 packet size range while some large megapixel cameras generate packet sizes over 1518 and are referred to as "Jumbo Frames"

What product specifications don’t tell you about Bandwidth and Packets:

1. Most specifications express transmission in terms of the Ethernet port bandwidth.
    a. They don’t tell you the actual transmitted and received bandwidth.
    b. They don’t tell you how much bandwidth is lost.
    c. They often express the longest transmitted distance but omit the bandwidth available at that distance.
    d. They don’t tell you if the transmitted distance applies to PoE transmission or if a separate remote site power supply is required to provide power.
    e. Most specifications base their bandwidth and Packets per Second testing on 64bytes a figure that cannot be applied to video transmission, so performance is often misleading.
    f. Almost none will have proven test results for RFC-2544 conformity showing real world operating packet and bandwidth losses.
    g. Jumbo frames are not obtainable with VDSL2 so don’t expect to see this quoted in a specification.
    h. Some products indicate a maximum distance but don’t indicate what data rate can be achied at the maximum distance.

Power is key

The main point is maintaining bandwidth and avoiding losses is key in your system performance. As in the above example (Figure1) taken from actual product testing, by the time VDSL2 has reached the one thousand meter point (1000m) bandwidth has decreased almost twenty percent (20%). Add to this the difference between download and uploads resulting in an additional forty percent decrease and it is easy to see the problems these limitations have resulting in the number of cameras and megapixel camera sizes that can be transmitted using VDSL2. These losses are common to VDSL2 transmission.

More network switches are providing Power over Ethernet or PoE. This is often referred to as its IEEE standard of 802.3af. With increasing demands for power a new and more powerful PoE standard referred to as 802.3at has recently been introduced.

These standards result in compatibility between different manufacturer’s equipment. They also provide for some important safety features which protect both the equipment providing the power, call the Power Sourcing Equipment or PSE (switch) and the Power Device or PD (camera). The standards not only call out for different fixed classes of power found at the end of the a hundred meter (100m) cable run, but provide for communication between the PSE and PD in the form of preventing damage by minimum and maximum voltages.

Figure 2: PoE Class Chart

PoE Class Chart			
Class	Classification current [mA]	Power range [Watt]	Class description
0	0–4	0.44–12.94	Classification unimplemented
1	9–12	0.44–3.84	Very Low power
2	17–20	3.84–6.49	Low power
3	26–30	6.49–12.95	Mid power

Many types of extenders consume up to 6 watts or more from a 802.3af source with a end power of 12.95. This results in no available power for the cable. The result is external cost power supplies and associated power sources are required. Class one (very low power) and Class 2

VDSL-2 signal pushing requires using a great deal of power. Some devices required over six (6) watts just to power the device. As such a total of 12 watts is used up just in powering the transmitter and receiver. This must be taken from the source providing the PoE and reduces the available camera power. If class zero (0) and class three (3) require 12.94 watts to be available at the end of the 100 meter cable run and six watts is used just to power the device than the remaining power will only allow cameras and other Power devices operating at class one and two. Worse are some devices pushing power without regard to the specification safety features. Shorts and opens go undetected and can lead to damaged equipment. Finally this high power often requires the use of a site power supply, adding to cost and limiting installation when no additional power source is available at the site.

Power Complexities

Determining extended distance where power is concerned is a complex process dependent on several factors. The most important is that the extended system maintains the safety features established for 802.3af and 802.3at. These features are designed to provide the PSE and PD from damage from abnormal power conditions. This requires that the PSE and PD communicate with each other. This process starts with the PSE sends out a pulse to see if a standard PD is on line. The PD responses by reflecting a certain resistance that is much higher than the cable resistance. Once detection is achieved the PSE then detects the power class and finally power is sent to the PD turning it on. Current starts flowing and a load is applied to the system stabilizing the voltage at a value below which will result in the power being turn off. PD will not turn on. This is what will determine the distance limitation. It can be overcome, but sometimes at a very dangerous cost. Some approaches called “always on” will force feed voltage from an external power source. This approach removes all the safe guards as in the case of opens or shorts, the latter being the most damaging, as the flow cannot be turned off. In addition the forced voltage is fed without regard to PD classes. This means only one class of voltage is available and only at a specific cable distance. Any variation can be dangerous as either not enough power will be applied or too much potentially damaging the PD.

Keep in mind, power within a system is not constant. While shorts and opens are a matter of defects, temperature has an effect on PDs and the connections made to them. Resistance changes with temperature and as such can affect power supplied. For these reasons, while one manufacturer's product can boost of having the greatest distance, the cost in terms of product performance can limited high end operating temperature to +50C, but the internal heat buildup resulting from the use of high power supplies can account for an addition +10C, the result will reduce operating temperatures by that amount. This is an important consideration for extenders operating in high temperature environments such as the United States southwest and the Middle East.

Power supplies generate heat. The higher the power the higher the heat and the greater the opportunity that heat transmitted to the extender will result in a shorter product life span and less product reliability. This also impacts the environment an extender can operate within.

In summary VDSL2 transmission signal and power extenders present many significant challenges to video surveillance network systems and limited growth potentials for products that are demanding increased bandwidth and power. In common operation the need for localized power which also results in limited environmental performance will restrict their installation ability. Localize power cannot conform to operating temperature ranges of -40C to +75C. Many of these limitations are not clearly noted in products specifications sheet.

The solution For Power

With almost all network switches providing for some form of PoE, the best, most cost effective and reliable method to provide power to a camera site is to extend the range of power from the source to the site. This method called "Pass Through PoE" **(PTP™)** It eliminates the need for site power for the extender, allows the extender to operate at a wider temperature range and lowers installation associated costs for extra power supplies their method of power conforms to the safety prior by the IEEE 802.3 standards.

Figure 3: PoE System showing PTP™:

What the specifications don't tell you about PoE and extended distance transmission

With "Pass Through PoE(™)" Extenders and camera can be powered directly from a source PoE switch to eliminate the extra cost required for on-site remote power.

Most specifications will indicate the amount of power available at a stated distance, but will not indicate if

a. Some specifications will just state power over Ethernet without providing and end distance class or power figure.
b. Many specifications will not indicate that a separate power supply is required for operation even with an external PoE power source.
c. Many specifications will not indicate if their power is "always on" resulting in disabling IEEE 802.3 safety features.

d. Many specification will only indicate their devices provide PoE without stating they conform to IEEE 802.3 specifications.

e. Many specifications do not indicate ability to handle 802.3at.

Solving the Problems, Simplifying the Product.

Requirements for newer approaches to problem solving developed from increased system requirements. The growth of video security network IP systems required that transmission systems developed for a specific application assure peak performance will be maintained. Performance and the need to reduce installation calls through the use of pre-existing analog coax led Vigitron to the development of the Vi2300 UTP extension and Vi2400 Ethernet –coax media conversion extension product series.

The concept is the same in terms of extending Ethernet over UTP and Coax, however the technology and market approach represents a major change. Vigitron's technology uses a process known as **Symmetric Bandwidth (SBW™**) which maintains bandwidth consistency throughout the stated distances extending as far as five thousand feet. Bandwidth is maintained in both uploads and downloads resulting in a process of **Virtual Zero Packet Loss (VZPL™).** The need to re-packetize is also eliminated saving processing power and reducing signal noise.

The combination of **Symmetic Bandwidth (SBW™)** and Virtual Zero Packet Loss **(VZPL™**) results in compliance to RFC-2544 standards for TCP/IP transmissions to its upper limits of 1518 bytes and the product series ability to handle Jumbo Frames required for larger MegaPixel cameras and higher frame rate transmission.

Vigitron has carried these products steps beyond testing under RFC-2544 standards. The company is in the continuous process of certifying its transmission performance with leading camera manufacturers' highest pixel count cameras. This process assures cameras manufacturers and their customers of top level system performance that will not be downgraded by extended transmission limitations.

Vigitron's design accepts standard power inputs most commonly found in security applications. Models in the series can be powered by +12 Volts D.C., +24 Volts A.C. or directly from a PoE input. This latter feature allows more control and remote sites from a single PoE source and in turn maintains enough power to operate the remote site camera. This latter **Pass Through PoE (PTP™)** feature eliminates the need for remote site power reducing installation costs. It is accomplished using Vigitron's green Low Power Consumption (LPC™) design which lowers the unit's power requirement by eighty three percent (83%) compared to conventional methods resulting in the most available camera power and conforming to 802.3 af/at standards. By maintaining these standards, PSE and PD communication assures device protection in the event of power surges, under power conditions and shorts. In addition by requiring only approximately one watt of power, minimal internal heat is generated increasing extender reliability and helping in achieving a temperature operating range 0f -40C to +75C tested to NEMA-TS2 specifications.

The ability of the Vi2301 and Vi2401 using remote power over coax or UTP itself would not be enough to assure proper remote operation. Vigitron"s designs includes the ability to maintain harden performance under temperatures conditions from -40 C to +75C. Units are type tested using demanding NEMA-TS2 traffic environmental standards and result in the ability to operate under "Hardened" extended temperature environments (HRD™)

Reductions in power requirements and additional signal processing result in the ability of Vigitron systems to accomplish their extensions with only a pair of transceivers reducing the type of units to one. Further installation cost reductions and simplification are achieved my eliminating the need for power supplies and in many cases high cost power supplies necessary for PoE operation.

Another consideration is the type of wiring used. Throughout this paper we have labeled network cabling as UTP, or Unshielded Twisted Pair. As applications for network cameras grown many of them will be installed in outdoor environments which cannot use UTP. These installations require STP or Shield Twisted Pair, which provides not only environmental protection for the cable, but also additional grounding to protect equipment from damage in the event of lightning strikes. The cable characteristics of STP differ from that of UTP and in many cases result in shorter transmission distance. This is not the case with Vigitron's Vi2300 and Vi2400 which are designed to operate with both types of cabling.

The combination of wide temperature operation, ability to be powered by PoE which minimal power requirements and STP compatibility result in the Vi2300 and Vi2400 product the perfect solution for indoor and outdoor extended distance power and data transmission applications.

What makes Vigitron's approach to extended distance data and power transmission better?

MPC™ stands for MegaPixel Certified. The Symbol covers three areas. First is compliance to RFC2544 for TCP/IP packet loss transmission. Second is the ability to handle Jumbo frames ranging from 1518 to 9000 bytes

HRD™ stands for Hardened as applied to the ability to operate under extended temperature ranges from -40C to +75C.

VZPL™ stands for Vertical Zero Packet Loss maintaining the number of packets transmitted and received with vertically no loss of information.

LPC™ stands for low power consumption allowing for transceivers and cameras to be powered from a single PSE.

PTP ™ stands for Pass Through PoE allowing PSE to power Vigitron's Vi2300 an Vi2400 series as well as cameras and other devices without the need of external power supplies

EPTP ™ stands for Extended Pass Through PoE operating in the same manner as PTP™ with power handling capacity up to 60 watts.

SBW™ stands for Symmetric bandwidth resulting in same upload and down bandwidth with little loss over specified distances

As the saying goes, a fence is only as strong as its weakest link; a video security system is only as strong the quality its singles transmit on. Understanding the information contained and not contained in a manufacturer's product specification sheet is an important first step in achieving a reliable well performing system

Vi2301

Vi2308

Vi2316

Vi2804

Vi2401

Vi2408

Vi2416

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