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Information Technology Systems Cabling:
Executive Overview

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This document provides an overview of the copper based physical media used for cabling in Information Technology physical Infrastructure and is intended for all audiences and knowledge levels.

The information superhighway consists of many types of roads for the information to travel on; this document focuses on the cabling typically used for the on-ramps from devices such as Desktop Computers, Printers and Network Cameras that provide access to the Network Infrastructure.

These copper cables typically used in the installation of the network infrastructure that connects the work area outlet (WAO) or jack at the user's desk to the Telecommunications Room (wiring closet) where connections are made with the network are referred to as horizontal cabling. This is due to the fact that these cables are typically run in the horizontal direction from the WAO to the TR. These cables consist of 4 unshielded, twisted pairs (**UTP**) of insulated 24 Gauge (typical), solid copper conductors under an overall jacket that are then terminated on insulation displacement (IDC) type hardware such as patch panels and connecting blocks in the Telecommunications Room (TR).

Unshielded Twisted Pair (**UTP**) copper cables are rated for their performance characteristics by the joint Telecommunications Industry Association (TIA) / Electronic Industries Alliance (EIA) standards, currently document series ANSI/TIA/EIA-568-C. These standards provide a minimum basis for uniform product selection, capacity measurement and promote interoperability between different manufacturer's products and systems. These are the nationally recognized standards for the United States through the American National Standards Institute (ANSI). Internationally, many countries use the ISO/IEC 11801 standards.

The TIA/EIA Cabling Standards in turn support the various application standards from organizations like the Institute of Electrical and Electronic Engineers (IEEE) 802.3 standards for Wired Ethernet Transport.

These ratings are referred to as performance categories or typically just categories. The higher the number, the better the performance level. These performance values are determined by electrical properties as well as by comparison of measured values to parameters defined in the TIA/EIA-568-C series of documents. Currently the following ratings are in place that apply to the cables used for the information technology cabling infrastructure in contemporary networks.

- Category 3 — Used for 10BASE-T (Ethernet) and traditional Voice applications (non IP)
- Category 5e — Ethernet, Fast Ethernet and basic Gigabit Ethernet. (10,100 and 1000BASE-T)
- Category 6 — all the above plus enhanced Gigabit, Power over Ethernet and Multi-Media Apps
- Category 6A — (Augmented Category 6) 10 Gigabit Ethernet (10GBASE-T)

ISO 11801 identifies cabling system performance parameters using alpha Class designations vs. the US performance categories and these ISO standards are used in many European countries.

Some basic details that are important to note about network cabling and signal transmission:

Ethernet (10Base-T) and Fast Ethernet (100Base-T) utilize two of the four pairs available to transmit and receive signals. Gigabit Ethernet (Gbe or 1000Base-T) and 10 Gigabit Ethernet (10GBASE-T) utilize all four pairs for signal transmission. Power over Ethernet (PoE and PoE+, IEEE 802.3af and 802.3at respectively) also require all four pairs to operate.

All of these standards compliant performance categories share some common design and application parameters including a maximum length for the Permanent Link (Jack to Patch Panel) of 90 Meters (295 ft.) and The Channel (Permanent Link with Patch Cords added in on both ends) of 100 Meters (328 Feet). These performance Categories and hardware and are required to be backwards compatible with each

other, all using the 8 Pin 8 Conductor (8P8C) Modular Connector as a physical interface (commonly referred to as an RJ-45)
Key measurements/values for cabling systems translate into Bandwidth and Headroom; these can best be described as follows:

Bandwidth is the total information carrying capacity of the system and is measured in Megahertz (Mhz.) or millions of cycles per second, this translates into lanes on a highway, and more bandwidth equals more lanes. The information sent over this highway is typically some type of packetized information (data) and this is measured in Megabits per second (Mbps) = data rate. Depending on the type of encoding and compression used by the network electronics (Network Interface Cards or NIC's, Switches, etc.) the data rate may be higher than the frequency. The Bits may be thought of as vehicles using the highway, some are contained in small packets, and some are in large packets depending on the application.

Headroom or Margin is additional signal carrying capacity beyond the standards specified baseline (minimum) values. This can be thought of as breakdown lanes/shoulders on the highway. This is a calculated value determined by comparing the signal level and cross talk between pairs on the cable and is measured in decibels. In audio terms, this may be thought of as signal to noise ratio.

Headroom is significant in several ways, most notably in that it provides a performance safety margin for installation variables such as cables being too close to lighting fixtures (a possible source of noise), bend-radius problems caused by obstacles in the cable pathways and temperature variations to name but a few problems that can occur in real-world network cabling system installations. Headroom also provides additional capacity in a system for future growth and emerging applications.

The previously noted performance categories have the following bandwidth specifications:

- Category 3 16 Megahertz
- Category 5e 100 Megahertz
- Category 6 250 Megahertz
- Category 6A 500 Megahertz.

Some confusion in terms and ratings exists due largely to an earlier classification of Category 5 that was obsoleted with the "B" series revision to the 568 standards. Category 5 or "CAT5" is still used in many instances to refer generically to the UTP Cable used for LAN or IT Network Cabling. Category 5 cable was also specified to the same 100Mhz bandwidth as the current Category 5e and was intended to support the simultaneous operation of all four pairs in a cable as was anticipated for what was at the time the still being developed Gigabit Ethernet but the original Category 5 had only a limited number of parameters defined to meet this objective.

As equipment to operate Gigabit Ethernet became commercially available, it was found that Category 5 cable was not robust enough in many instances to support this technology and changes to the parameters for testing were required to more closely measure the dynamics of 4 powered pairs of cable operating simultaneously and the overall effect this had on performance. These are seen as the "Power Sum" parameters that distinguish the newly recognized Category 5e (e for enhanced) cable from its now obsolete predecessor "Cat5". Category 5e is now the minimally acceptable cable that is recognized to support Gigabit Ethernet.

Category 6 cable is specified to 200 MHz (with a positive ACR value) and measured to 250 MHz. This not only provides support for Gigabit Ethernet but additional capacity and margin, resulting in many cases in much lower bit error rates (BER) in signal transmission when compared to a Category 5e system.

Category 6A (Augmented Category 6) with a bandwidth of 500 MHz is currently the highest performance rating for copper cabling in North America and is well suited to high bandwidth Data Center and Imaging applications and in general where future provisioning is a significant consideration.

10 Gigabit Ethernet requires the use of Augmented Category 6 (Category 6A) Cable to operate a full 90 Meter Link. Legacy Category 6 Cable *may* support limited distance deployments of 10 Gigabit Ethernet but is handled on a per requirement basis as defined in TSB 155. Category 5e and Category 3 are not listed for use with 10 Gigabit Ethernet Applications.

When designing a cabling infrastructure, the designer is concerned with many factors including consideration for support not only of current but future and evolving applications and technologies as well as to ensure the lifecycle of the installed cabling will support multiple generations of IT equipment and the associated refresh cycles (typically every 2-3 years). This helps to minimize or eliminate disruptive changes to the cabling and the associated maintenance, relocation and service changes that may be required in the very dynamic world of Information Technology and the applications so many businesses depend upon for profitable and efficient operation.

Many applications present additional demands on the Cabling Infrastructure and the Network Itself, some of these are devices that use Power over Ethernet (PoE) where in addition to signal transmission the Network Cables also carry power for devices such as IP Telephones, Wireless Access Points, IP Security Cameras and Radio Frequency (RF) Bar Code Readers. This requires a more robust cable and introduces considerations for the Ampacity (current carrying capability) of the cable and hardware and the associated thermal loads and attenuation (signal loss) that the PoE Equipment and Transport generates.

Bit Error Rate (BER) and the overall Quality of Service (QoS) are other major considerations in selecting the bandwidth and throughput requirements for the installed cabling. VoIP, Video Surveillance and A-V applications such as Digital Signage, HDMI Displays and IP based KVM applications require a higher degree of reliable transmission performance, which is in turn dependent upon a high quality, well installed and properly tested cabling system.

Video applications typically operate at higher frequencies than Ethernet/IP applications and the use of the highest performing cable possible will help to ensure these needs can be well met without jitter, latency and Image skew problems that can significantly affect image quality and the user experience.

In addition to the published and nationally recognized ANSI/TIA/EIA standards, there are some private labeling and testing programs in the marketplace as well as some highly visible manufacturers marketing and advertising campaigns. Many of these programs and campaigns introduce performance claims based on such terms as “anticipated”, “characterized” or “estimated values” that may or may not represent actual performance values. Testing in some of these programs may be done in a closed environment or under conditions that do not reflect the realities of actual field installations and operating conditions.

As in any business making decision, it is important that we deal with factual, validated information from sources that are independent from the products or services being evaluated and tested, Any system evaluation and selection strategy should incorporate a standards based approach.

One additional item that must be considered as a critical component in a working system are the patch cords used to connect user equipment to the system at the work areas as well as the user cabling to the network in the telecommunications rooms. The overall system rating is determined by the weakest link and any deviation in the performance category rating of any of the components in the channel will result in a reduction of the rating and the introduction of a potential bottleneck.

For instance, if category 6 cable, jacks and patch panels are installed and category 5 or 5e patch cords are utilized, the entire rating will now drop to category 5e or less. This is significant as many times the patch or equipment cords are not specified or part of a basic installation and are added after the cabling when the network is cut-over or placed into operation. Therefore, a long-term strategy should include what is referred to as a Channel tested configuration.

This channel test includes all cabling system components, including patch cords that, in addition to being tested at the factory have also been included in the testing of the completed installation. These patch cords can then be covered by the warrantee on the installed cabling system as well.

As the breakdown lanes and wide shoulders of a well-constructed highway provide space, capacity and a margin of safety at rush hour and in times of additional stresses such as accidents and enforcement activities, so too can a well-designed cabling system.

As in a modern highway system where the capacity, safety and operation of a system design must be balanced with available funding, so too does the Information Technology infrastructure need to address current and anticipated future requirements versus installation costs as well as other “soft” factors such as disruption to the workplace by installation and maintenance activities and the loss of productivity as a result of network downtime and construction activities.

There is a significant movement towards converging the corporate/institutional infrastructure where the traditional, separate telephone (voice) and network (computer) cabling systems are being merged into a single transport system (Voice over Internet Protocol or VoIP) that uses common network electronics (switches, routers, security and WAN access devices). From a cost standpoint for both hardware and personnel, this is a significant aspect of any long-term technology strategy. This converged infrastructure can however place additional demand on the cable plant and network for bandwidth and reliability.

It is the intent of good cabling system design in conjunction with the standards that are in place to provide a system that meets the current needs of the customer for both capacity and performance, but to also allow for future growth and support for emerging applications and technologies. In short the cable plant should be able to support numerous generations of Information technology equipment including computers, network hardware and transmission methods.

Cable plant work, be it moves, adds and changes, renovation, maintenance or installation can be expensive and disruptive to the work environment so a key consideration is to balance the benefits of the additional initial cost for a Category 6A or Category 6 system versus those for a Category 5e system. New technologies and bandwidth demands such as voice over Internet protocol (VoIP), video security, access control, facility automation, video conferencing, imaging applications (such as MRI) and CAD as well as many industrial automation systems are all transitioning to the corporate network. The cabling system must be able to accommodate these needs and maintain a high degree of reliability and care should be exercised in the proper selection of the components utilized.

Reputable distributors in the supply chain offer an extensive selection of standards compliant products from industry leading manufacturers and have resources in place to ensure quality control and product traceability back to point of manufacture to ensure the cable you receive is genuine and conforms to all appropriate codes, standards and ratings.

The use of a professional engineering firm to aid in the all aspects of a project needs and application analysis (development), design, deployment and documentation can be a key factor in the success of any project and the Skyline Group would be happy to have our team discuss you next project with you!

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This document is intended to present a summary of pertinent information for those involved in the various aspects of telecommunications and network infrastructure administration, support and installation. For additional details and information relative to the areas discussed in this document or for assistance in selecting an appropriate solution that has been independently verified for performance may be obtained by contacting us at the Skyline Group or through the following web sites.

The Skyline Group	www.tsgma.com
TIA Standards Information	www.tiaonline.org
Ethernet Standards (Institute of Electrical and Electronics Engineers)	www.ieee.org
ISO Standards (outside the US and Canada)	www.iso.ch
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