



CAT5 UTP Copper is not yet dead!

Optical networks promise more bandwidth at cheaper prices. However, in the eyes of some, they also deliver over-capacity and debt. Over the longer term, will networks migrate inexorably to an all-optical architecture? Will optical fibre obsolete UTP cable once and for all?

To answer these questions the following is a review of the deployment of high-speed local area networks (HSLAN) and an explanation of how the introduction of category 5 cable has expanded and improved the data rate of UTP cable to counter the threat of optical fibre, and why the backbone office architecture to the desk top will remain copper and not transition to fibre.

Background

The purpose of a communication system is to transport a signal from point A to B with minimum attenuation, distortion and to counter interference while conveying the information in the shortest time possible. For years people have been intrigued by the use of light as a transmission medium to realise a cost-effective communication system. Optical fibre systems offer a number of distinct advantages over UTP cables. The most significant advantages of fibre are:

- 1) Lower transmission losses
- 2) Increased bandwidth
- 3) Lower weight, less bulky cables
- 4) Immunity to inductive interference
- 5) Transmission over longer distances

With such an arsenal of features and benefits how can category 5 UTP cable possibly compete? How can category 5 UTP remain the preferred transmission medium to connect both large and small offices to the Internet superhighway? By its very nature optical fibre looks to win hands down. However, a few missing pieces of the jigsaw puzzle must be considered:

Cost

Category 5 UTP cable provides adequate bandwidth to support multimedia applications to the desktop at a much lower cost than the equivalent fibre solution when comparing like for like new installations. Typically, as fibre and copper cable mature in the market, the cost of a fibre desktop port will stabilise at twice the price of a copper port.

Data Processing

Advances in integrated circuit silicon on chip data processing have helped to extend the bandwidth and data rate carrying capabilities of category 5 UTP cable.

Magnetic Interfaces

The ability of magnetic interfaces (transformers) overcome the inherently inferior data rate associated with using category 5 UTP cable.

To understand why category 5 UTP cable is the preferred solution, an explanation is needed as to how category 5 UTP cable is able to produce a low-cost system and how the data rate of category 5 UTP cable can be extended to keep pace with desktop multi-media applications used today and in the future, countering the benefits of deploying optical fibre technologies.

System Overview

Any LAN network consists of a central switch (hub) or router that links connecting nodes together. This network formation is commonly referred to as a “star topology” (Figure 1.0) and is commonly used today in Ethernet and HSLAN networks.

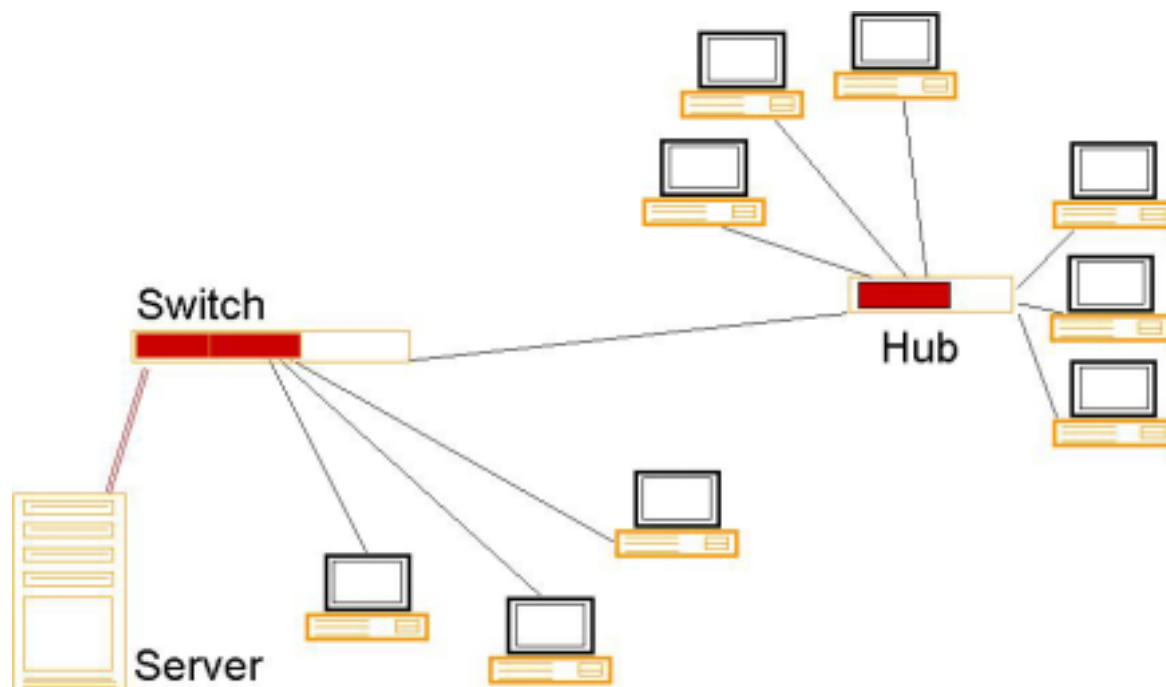


Figure 1.0 Typical LAN (Ethernet) Network Architecture

The success of Ethernet-based technologies is in part due to a common standard developed cooperatively by AT&T, Hewlett-Packard, IBM and other members of the IEEE802.11 standards committee. Success can also be attributed to the ability of the network to evolve with time, protecting customers' investments by using the same cabling system, topology, packet format and drivers existing within installed Ethernet networks. The mass deployment of Ethernet networks using category 5 UTP cable has allowed LAN networking systems to be readily upgraded from 10Mbps/s (10BaseT) to 100Mbps/s (HSLAN) or even higher still to 1000Mbps/s (Gigabit HSLAN). This has been accomplished without having to upgrade the backbone copper cable (UTP) infrastructure. The majority of office based architectures employ category 5 UTP cable to connect the switch or router to the desktop. The prevalence

of category 5 UTP cable allows system administrators to evolve the speed of the network over time. One set of hardware can be sold for 10BaseT, HSLAN and Gigabit HSLAN, offering significant savings and economy of scale. How is it possible, then, that an Ethernet network running at a mere 10Bbits/s using category 5 cable can offer a readily upgrade-able path to 1000Mbits/s?

Category 5 & 6 Cable

Over the past decade Ethernet networks systems have evolved from various media types:

Media Types (cable)	Network	Usable Range	Data Rate
Thick coax	10Base5	500M	10Mbits/s
Thin fibre coax	10Base2	200M	
Category 3 UTP*	10BaseT	100M	
Category 5 UTP*	10/100BaseT	100M	10 to 100Mbits/s
Category 5 & 6 UTP*	1000BaseT	100M	10 to 1000Mbits/s

*UTP: unshielded twisted pair

Table 1: Evolution of LAN Network Architectures

Until the development of category 3 & 5 cable, Ethernet systems suffered from two main drawbacks. First, the semi-rigid coaxial cables were difficult to install and use. Second, the available bandwidth was severely restricted at peak demand times since users could not operate independently of each other. The deployment of category 3 UTP cable in the early 1990s led to the development of a central switch that linked connecting nodes together (Figure 1.0). Category 3 UTP cable also paved the way for the mass deployment of category 5 UTP cable.

Since the mid 1990s, category 5 UTP cable became the dominant backbone architecture for Ethernet networks. It was simple to install and significantly reduced the cost of installation. The mass deployment of category 5 cable was driven by the need to connect large numbers of users. In such an environment, long cable lengths are not required. Category 5 UTP cable revolutionised the industry and allowed users, for the first time, to access speeds of up to 100Mbits/s.

Most network systems today are installed using Level V or Category 5 cable. While technically, *Category 5* and *Level V* are not the same, they are identical in practice. Both support up to 100Mbit/s data transmission, and their physical cable assembly requirements are the same. For the purpose of this article, both will be referred to as CAT5 unshielded twisted pair (UTP) cable. CAT 5 UTP contains four twisted pairs of wires (a total of eight wires). The pairs of wires in UTP cable are colour-coded by pairs to uniquely identify each pair at both ends of the cable (Figure 2.0). An RJ45 jack is frequently used to connect to both ends of the UTP cable. The RJ simply means "Registered Jack" and the "45" specifies the pin numbering scheme. The wiring scheme for CAT5 UTP cable is based on the original IEEE Specification for Ethernet 10BaseT requiring two twisted pairs be used for transmit (TX) and receive

(RX). One pair is connected to pins 1 and 2 (TX), and the second pair (RX) is connected to pins 3 and 6. Pins 4 and 5 are skipped! The remaining two pairs of wires (a total of four wires) are connected to the RJ45 jack but in practice are not used to carry data. The spare wires are used to help protect the TX and RX pairs from picking-up noise from the surrounding environment by using a resistor capacitor network to shunt noise picked up on the spare cables to ground. By utilising the unused bandwidth within the spare wires, it is possible to instantly upgrade the system from 100Mbps/s to 1000Mbps/s by sharing the data rate between all four pairs. Presto, there is now a 1000Mbps/s data rate for a fraction of the installation costs of optical fibre (Figure 2.0).

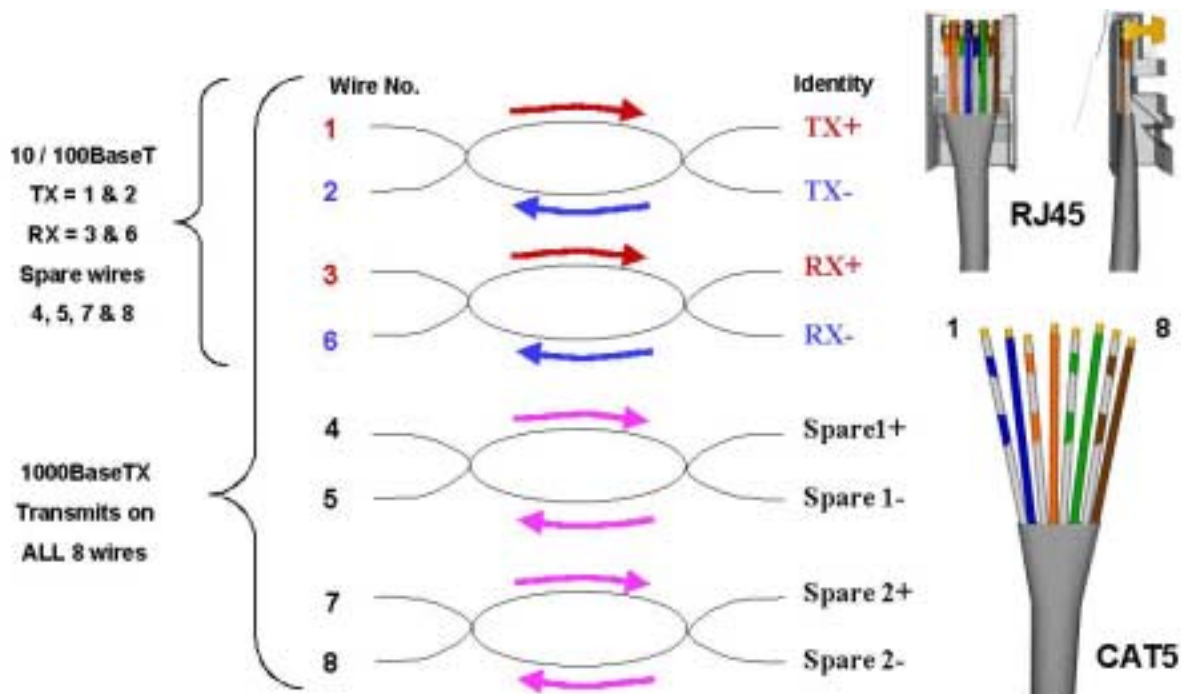


Figure 2.0: Overview of Category 5 Cable

Expanding the Need for CAT 5 UTP Cable

Clearly in the wide area network (WAN), optical fibre systems will prevail since its features and benefits align themselves to offer lower transmission losses, increased bandwidth and immunity to inductive interference. Whereas in the case of the last mile (to the desktop) copper-based technologies are dominant. An example of this outside the networking industry is the recent advances in the area of digital subscriber line (DSL), a copper-based system used to provide users with high-speed access to the Internet.

The need to compensate for the inefficiencies of UTP cable, to extend its operating range and improve its immunity to interference is a recurring problem for design engineers. In contrast to optical fibre, which has an attenuation response independent of modulation frequency, CAT 5 UTP cable frequency response varies proportionally with both modulation frequency and cable length. CAT 5 UTP cable also acts like an antenna, picking up and radiating radio-frequency interference (RFI), electromagnetic interference (EMI) or electromagnetic pulses (EMP).

Consequently, crosstalk, the coupling of information from one pair of copper wires to adjacent pairs is a major challenge for designers to resolve.

The deficiencies associated with CAT 5 UTP cable have been resolved at low cost by the design and use of magnetic components that suppress the ability of the system to pick up and radiate interference.. Magnetic components provide voltage isolation greater than 1500Vrms, and impedance matching to eliminate signal “echo echo echo.” They maximize power transfer into the cable and perform voltage step-up and step-down functions, improving cost and performance of the digital circuitry. An even more important function is that they reject common mode signal attenuation. For example, a simple series choke has the ability to remove unwanted common mode noise from the UTP cable. The choke creates high impedance to common mode noise signals ($+I_C$), at the same time presenting a low impedance path to the data rich differential signals ($+I_A$, $-I_B$) to pass through the choke (Figure 3.0).

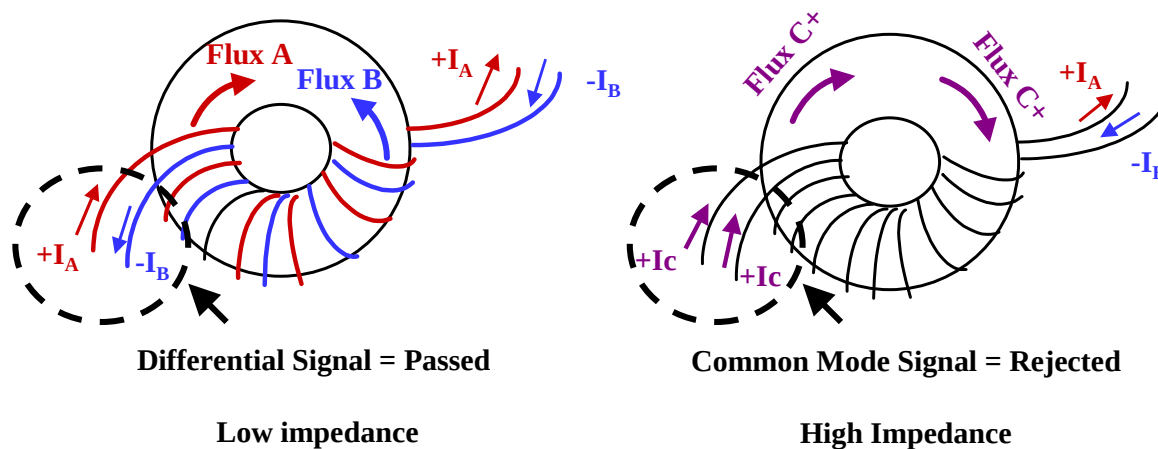


Figure 3.0 Simple In-Line Choke Rejecting Common Noise

Conclusion

The deployment of optical fibre networks will only help accelerate the need for traditional copper-based CAT 5 UTP cable. Mass distribution means that more and more computers need to be connected together. Companies will be forced to realise increased revenue from existing architectures, further creating a demand for both optical fibre- and existing copper-based cable systems. In new premises, copper will remain more economical to deploy, even when alongside new fibre installations. A good analogy to this is the paperless office. The explosion of low-cost high-speed desktop computer processing was supposed to lead to the paperless office by storing information electronically. One may argue that the expansion of desktop processing has created the opposite effect, creating the need to recycle paper. The same is true for copper and optical fibre, the further development of optical fibre based systems will further the drive for copper-based cable systems.