Information Technology
Inside and Outside
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VI. Transmission and Storage Technology

15. Wire and Fiber Transmission Systems

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15. Wire and Fiber Transmission Systems

- Objectives:
  - about the **important distinctions** among **various types of wires and cables**, including shielded and unshielded twisted pair, and coaxial cable;
  - about the **interference rejection** and **transmission characteristics** of these **various wire and cable types**;
  - about the interference rejection and transmission characteristics of **fiber optic cable**; and
  - about **future advances in fiber transmission** leading to both higher speeds and greater transmission distances without amplification.

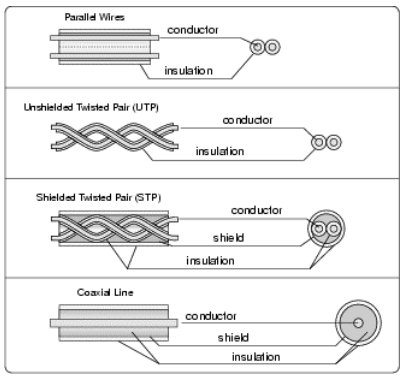
15.2 Wire as a Transmission Medium

- The wire-based transmission scheme
  - A **coaxial cable** (often called **coax** for short) has both a ``center'' conductor and a second ``shield'' conductor. These conductors are separated by some insulating material, such that the shield conductor entirely surrounds the center conductor.
  - The **unshielded twisted pair**(**TP** or often **UTP**) : the pair of wires may be held either parallel to each other by an appropriate stiff insulating material, or individually insulated and twisted around each other.
  - Finally, some arrangement of surrounding shield conductor may be placed around the resulting twisted pair to form a **shielded twisted pair** (**STP**). Implicit in this construction is that the physical arrangement of the shield conductor is not nearly as accurate as in the construction of coax.
  - All of the above wire-based transmission media are called **cables**, not just the coaxial cable.

15.2 Wire as a Transmission Medium(2)

- The wire-based transmission scheme

Figure 15.1: Four common types of transmission cable: parallel wires, UTP,STP, and coaxial.



15.2 Wire as a Transmission Medium(3)

- The wire-based transmission scheme

Table 15.1: The table shows costs of various cable types discussed in the text. Category 3 and 5 UTP are two grades of cable distinguished by the type of material used for insulator and the precision of the geometric relationship of the conductors.RG-58/U and RG-8/U are likewise smaller and larger diameter coaxial cables, respectively.

Cable Type	Cost Per Foot for Large Bulk Purchase
Parallel Pair (4 pair, 24 AWG)	$0.09
UTP Category 3 (4 pair, 24 AWG)	$0.15
UTP Category 5 (4 pair, 24 AWG)	$0.17
STP (2 pair, 24 AWG)	$0.20
Coax, RG-58/U (Thin Ether net)	$0.29
Coax, RG-8/U (Thick Ether net)	$1.12

15.2 Wire as a Transmission Medium(4)

- **15.2.1 Cable Characteristics**
- **loss of energy** and related reduction in the size of transmitted pulses
  → ***attenuation***
  - **the longer** the cable → **the greater the attenuation**
  - **The larger & more expensive cables → less attenuation and be more desirable**
  - **Table 15.2:**The table shows the attenuation of various cable types discussed in the text. These attenuations are given in deciBels (dB), a logarithmic measure. For example, 20 dB attenuation corresponds to a 10:1 reduction in signal level

Cable Type	Attenuation per 1000 Feet in dB at 100 MHz
UTP Category 3 (4 pair, 24 AWG)	56
STP (2 pair, 24 AWG)	37.5
Coax, RG-58/U (Thin Ether net)	60
Coax, RG-8/U (Thick Ethernet)	20

15.2 Wire as a Transmission Medium(5)

15.2.2 Why Some Cables Are Better than Others

15.2.3 Common Uses of the Various Cable Types

15.2.3.1 Parallel Conductor Cable Applications

- The **short distance** and **small bandwidth** of the signal

15.2.3.2 UTP Cable Applications

- ***local loop*** of the telephone company **under 18,000 feet** in length
- Applications: New kinds of special digital modems for ISDN and XDSL data services
  - **128 kbps (ISDN, bidirectional)** to **1.544 Mbps (HDSL in one direction)**
  - Rates as high as **52 Mbps (VDSL in one direction)** can be obtained if the length of the local loop is **below 3,280 feet**.
  - The **T1 signal** unidirectionally carries groups of 24 voice channels in a 1.544 Mbps digital format **over 6,000 foot distances** between regenerator circuits.
  - UTP is also found **in the walls (in spaces called plenums) throughout most buildings.**

15.2 Wire as a Transmission Medium(6)

15.2.3.2 UTP Cable Applications(2)

- Applications:
  - a cheap medium for the distribution of **medium-speed computer network** data connectivity
  - **10 Base-T Ethernet** in which UTP cable is used for distances up to **100 m(328 feet).**
  - A particularly high quality UTP is called **UTP-5**. This cable type has been used to support **100 Mbps Ethernet** transmissions **over distances of 100 m**.

15.2.3.3 STP Cable Applications

- Applications
  - some extent by telephone companies for moving **groups (96) of digitized telephone** conversations over distances of **6,000 feet between ``repeaters''**
  - **T2 connection** involves digital data transmission at speeds of **6.312 Mbps**.
  - High-quality STP has been applied by the telephone companies for transmission rates as high as **8.448 Mbps in Europe**.

15.2 Wire as a Transmission Medium(7)

15.2.3.4 Coaxial Cable Applications

- Applications
  - **long-distance**, **low-attenuation**, and **low-noise** transmission of information.
  - the transmission of a **hundred TV channels** into the home via CATV coaxial cable
  - a **bandwidth** of nearly **1 GHz** (that is, 1,000 MHz) into the home
  - the research and test deployment of **CATV-based Internet delivery systems**
  - the major delivery system for **10 and 100 Mbps**
    → being rapidly supplanted by UTP cable
  - **larger distances with higher-rate digital connections**
    → **140 Mbps** data signals between telephone switch buildings with a hop distance of up to **2 km (6,562 ft).**

15.3 Fiber -Optic Cable

- Guiding an E&M wave has an immense advantage over the use of wire-based wave guides
  - the surface of an **insulator**
  - two layers of glass or plastic (the **core** and **cladding** of the fiber) acts as an **ideal (no loss) mirror**

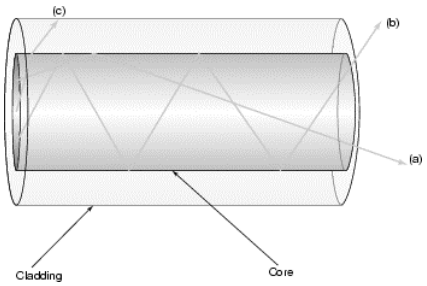


Figure 15.2: Side view of an optical fiber cable showing the paths of light rays that enter the face at different angles. Note how different the path lengths are of the two rays that are shown.

15.3 Fiber -Optic Cable(2)

- If an E&M wave strikes such a boundary at an angle **below the ``critical angle'' ➔** it undergoes **``total internal reflection.''**
- Other **benefits of fiber-optic cable** include:
  - The total confinement of the E&M wave means that surrounding materials do not increase the attenuation of the wave.
  - Because there are no free electrons as would be found in a conductor-based cable, no interference can be generated even by large surrounding magnetic fields.
  - Being an insulator, the fiber insulates the connected systems from each other. This is a major factor in cable systems in which atmospheric potentials and ground potentials can cause interfering and sometimes destructive currents to flow parasitic ally along communication cables.
  - For a given attenuation, a fiber cable is exceedingly lightweight and small in diameter. This means that many fibers may be placed in a cable where once only one wire-based cable may have been possible.

15.3 Fiber -Optic Cable(3)

15.3.1 Fiber Attenuation Characteristics

- **Low cost fiber-optic cable**
  - **Attenuations of less than 0.5 dB/1,000 ft**
  - **Bandwidths of hundreds of MHz**
  - Purchased **in 1999 for under $1.50/foot**
- **Higher cost fiber cables**
  - **0.03 dB/1,000 ft attenuations**
  - bandwidths in **excess of 1 Tbps**

15.3.2 Fiber Integral Optical Amplifiers

- By **adding** a small amount of ***Erbium*** additive **to a fiber**
  - The **fiber** itself into a **laser amplification** system
  - The **Erbium-doped fiber amplifier (EDFA)** is being incorporated in all of the **newest transoceanic cable** runs to interconnect the continents with **very high-speed**, **low-maintenance**, data service.

15.3 Fiber -Optic Cable(4)

15.3.2 Fiber Integral Optical Amplifiers(2)

- A **transoceanic cable** from the **United States** to **England** that uses EDFA technology was completed in **September of 1996**.
  - **four fibers** each providing **2.5 Gbps** of data service
    → **a total of 10 Gbps** of data.
  - Will bring **each fiber's bit rate** to **20 Gbps or greater**.

15.3.3 Solitons

- **Soliton**: a special packet of optical energy within such a cable that does **not ``disperse**." → **fantastic data rates over large distances**
- Nippon Telephone and Telegraph (NTT) of Japan, for example, has demonstrated soliton transmission of a **10 Gbps data stream over a distance of 50,000 km (over 30,000 miles).** Laboratory tests show that soliton technology may provide **data rates in excess of 1 Tbps** (10^{12} bps, or 1 million megabits per second) in the future over transcontinental and inter continental distances.

15.3 Fiber -Optic Cable(5)

15.3.4 How Fast Can Data Be Delivered to the Home?

- The theoretical and practical **maximum** for data transmission using the **normal telephone** connection is about **56 kbits/second**
- **ISDN** service: **128 kbps** bidirectional data services
- The higher-speed **XDSL** (various Digital Subscriber Loop) technologies: **number of Mbps**
- **CATV** equipment: **at least one Mbps** into homes
- **Fiber optic cable** → the possibility of new ``cable" being brought into **each of our homes**