Computer Network(CSC 503)

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Lecture 9

2. Physical Layer

2.1 Introduction to Communication Electromagnetic Spectrum

2.2 Guided Transmission Media: Twisted pair, Coaxial, Fiber optics.

Functions of Physical layer

- Following are the various functions performed by the Physical layer

1. **Representation of Bits: Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.**

- We assume data in the form of text, numbers, graphical images, audio or video are stored in the computer memory as sequences of bits.
- You know computer is a digital Device so data is always in the form of binary (0,1)
- **Line Coding** converts a sequence of bits to a Digital Signal.
- At the sender Digital data are encoded into a Digital Signal. So at the receiver you need to decode the signal to retrieve the digital data.

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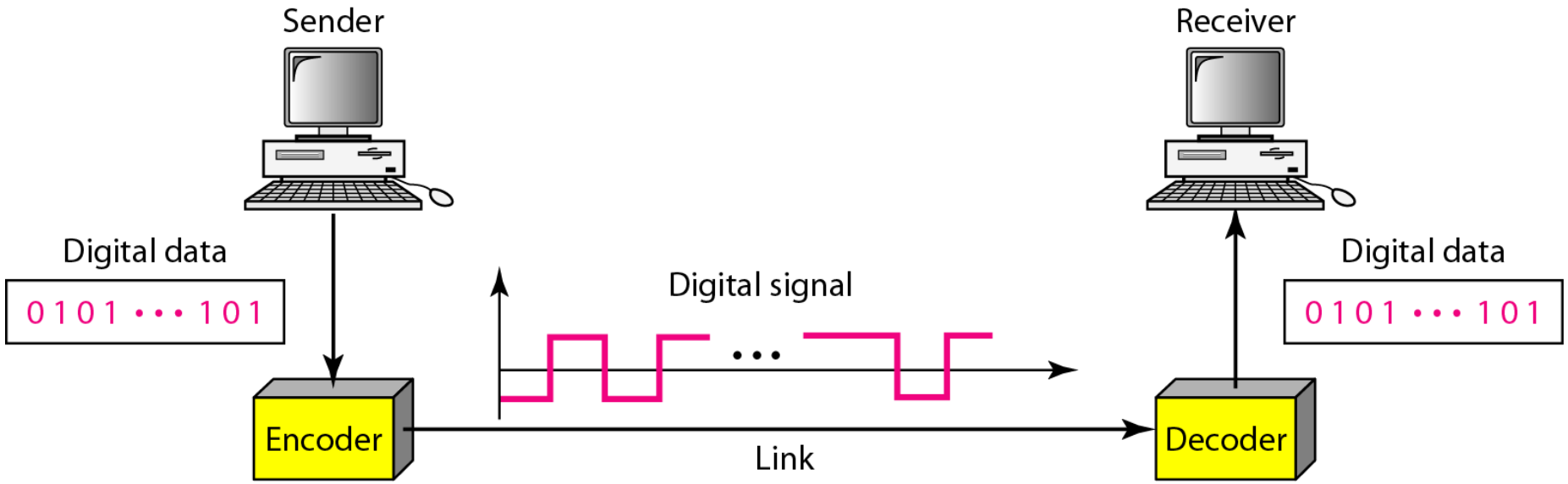
Sender
Receiver
Digital data
0 1 0 1 • • • 1 0 1
Digital signal
Digital data
0 1 0 1 • • • 1 0 1
Encoder
Link
Decoder

Contd..

Signal Element Versus Data Element

- In data communications, our goal is to send data elements.
- A data element is the smallest entity that can represent a piece of information: this is the bit.
- In digital data communications, a signal element carries data elements.
- A signal element is the shortest unit (time wise) of a digital signal.
- In other words, data elements are what we need to send: signal elements are what we can send.
- Data elements are being carried; signal elements are the carrier.

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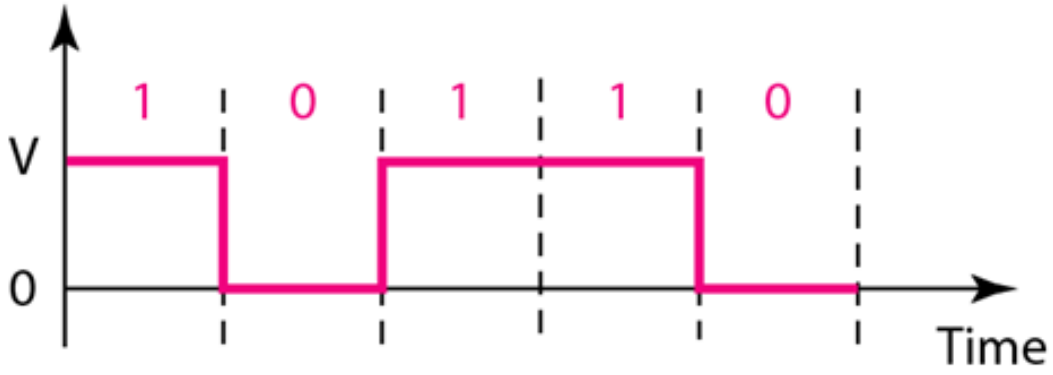
Line Coding schemes

1. Unipolar
2. Polar

1. Unipolar

All signal levels are on one side of the time axis – either above or below

Eg: Non return to zero (NRZ)



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2. Polar Coding

- The voltages are on both sides of the time axis.
- Types

  1. NRZ (Non return to zero)
     - NRZ - Level (NRZ-L) - positive voltage for one symbol and negative for the other
     - NRZ - Inversion (NRZ-I) - the change or lack of change in polarity determines the value of a symbol. E.g. a “1” symbol inverts the polarity a “0” does not.

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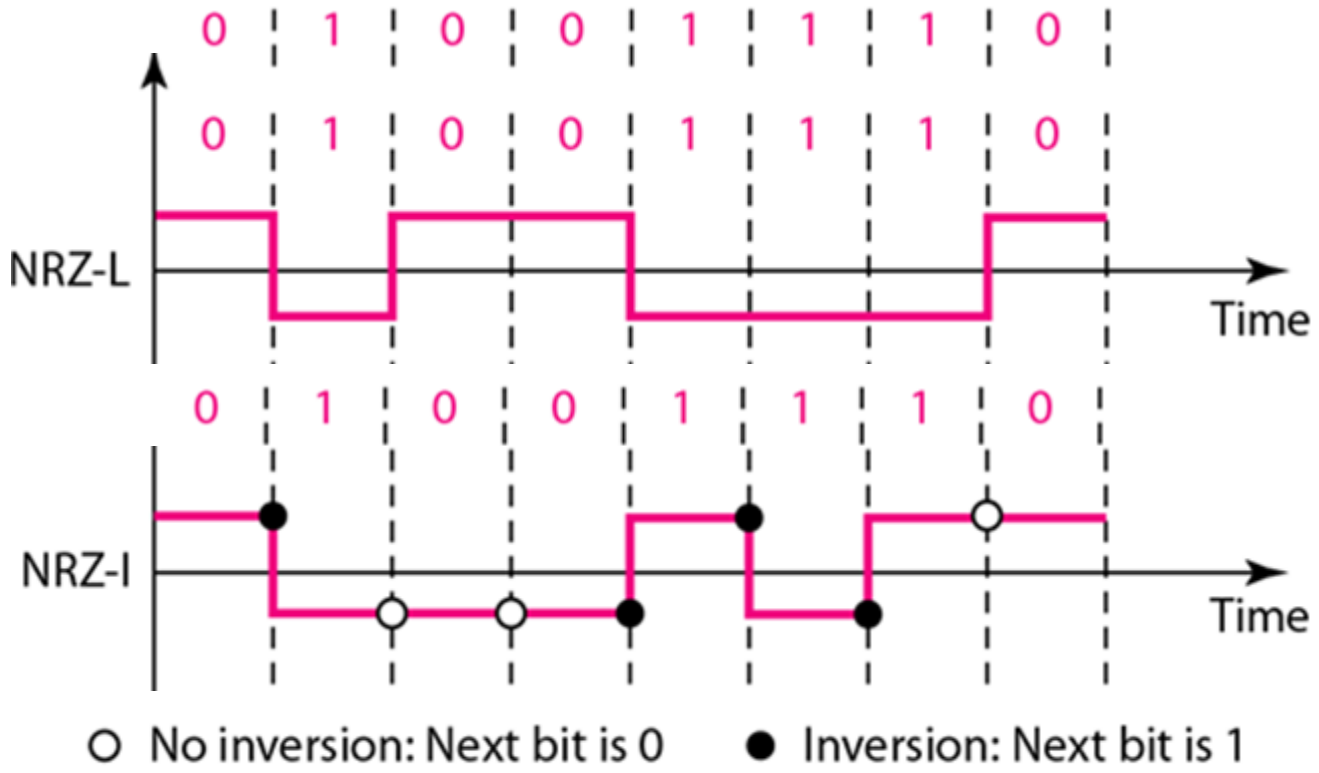

In NRZ-L the level of the voltage determines the value of the bit.
In NRZ-I the inversion or the lack of inversion

2. Return to zero (RZ)

- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.
- Each symbol has a transition in the middle. Either from high to zero or from low to zero.
- The signal returns to a resting state (called zero) during the second half of each bit.
- This scheme has more signal transitions (two per symbol) and therefore requires a wider bandwidth.

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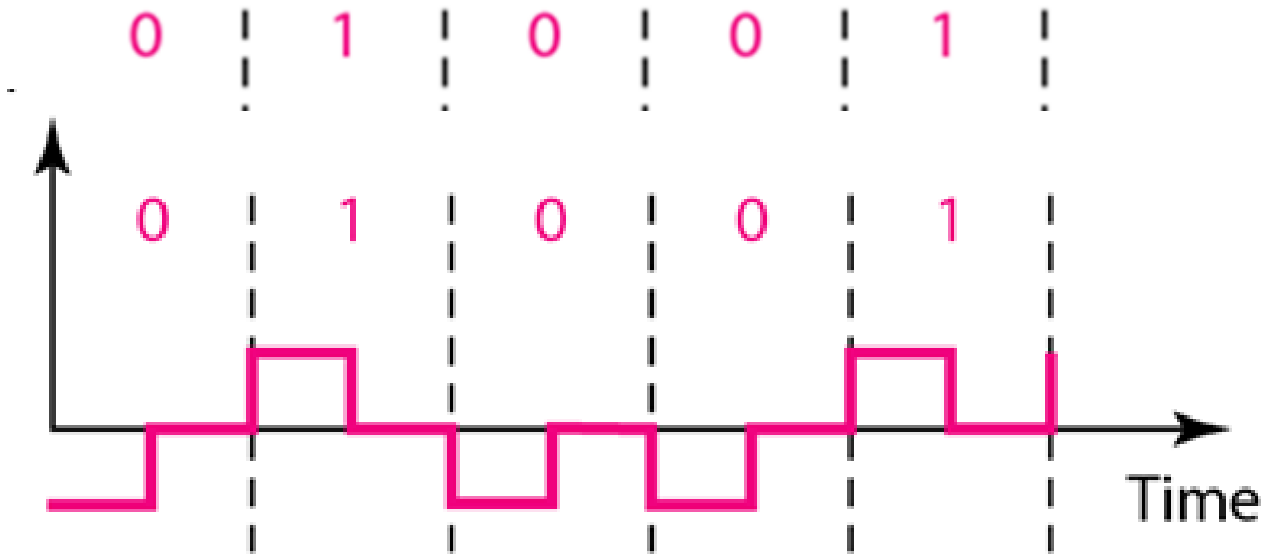
- Polar RZ



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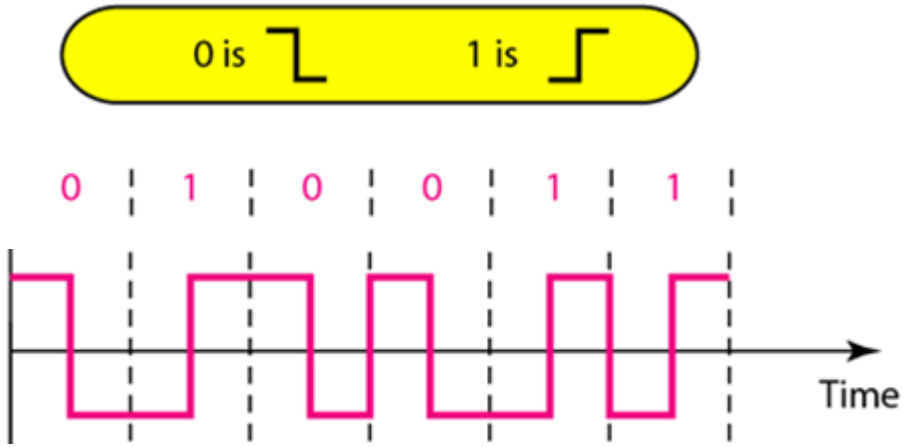
3. Manchester Encoding

- Every symbol has a level transition in the middle: from high to low or low to high. Uses only two voltage levels.



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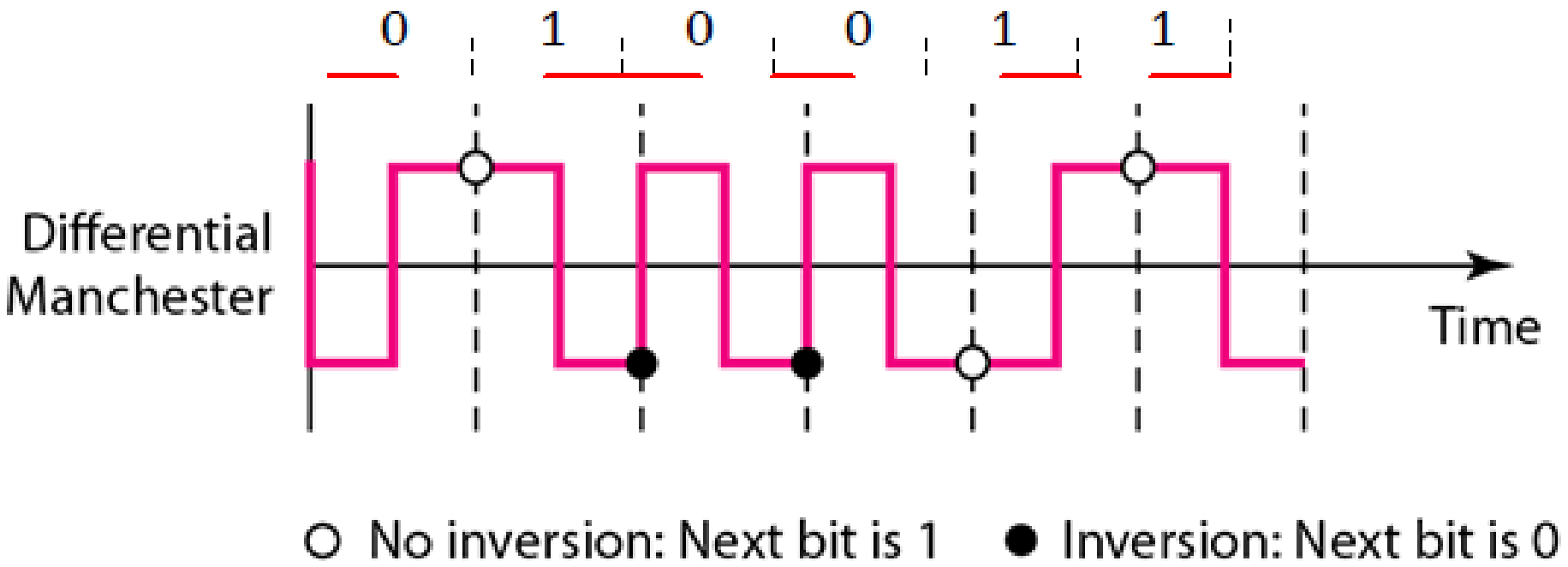
4. Differential Manchester Encoding

- Transition at start of a bit period represents zero
- No transition at start of a bit period represents one



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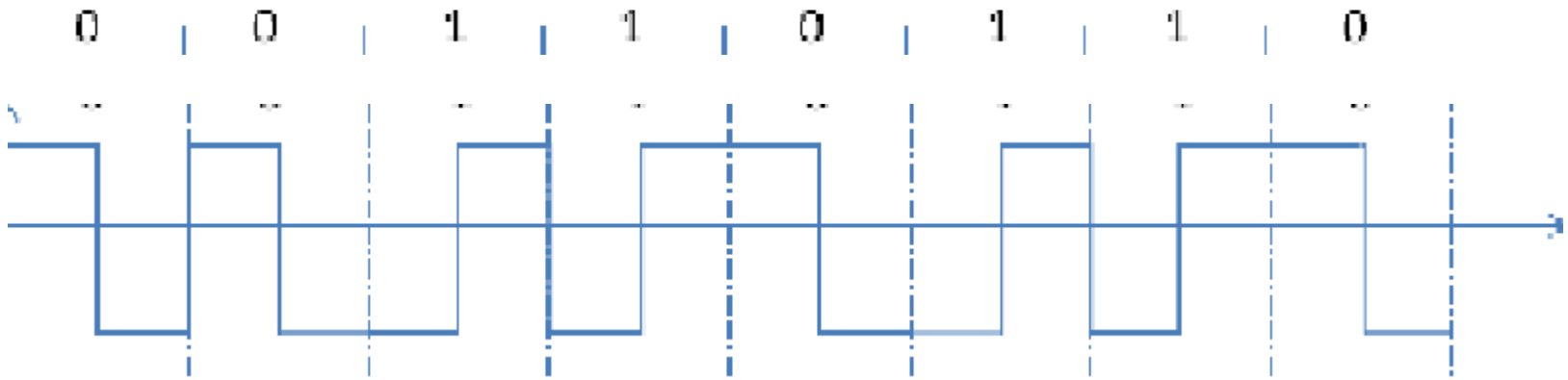
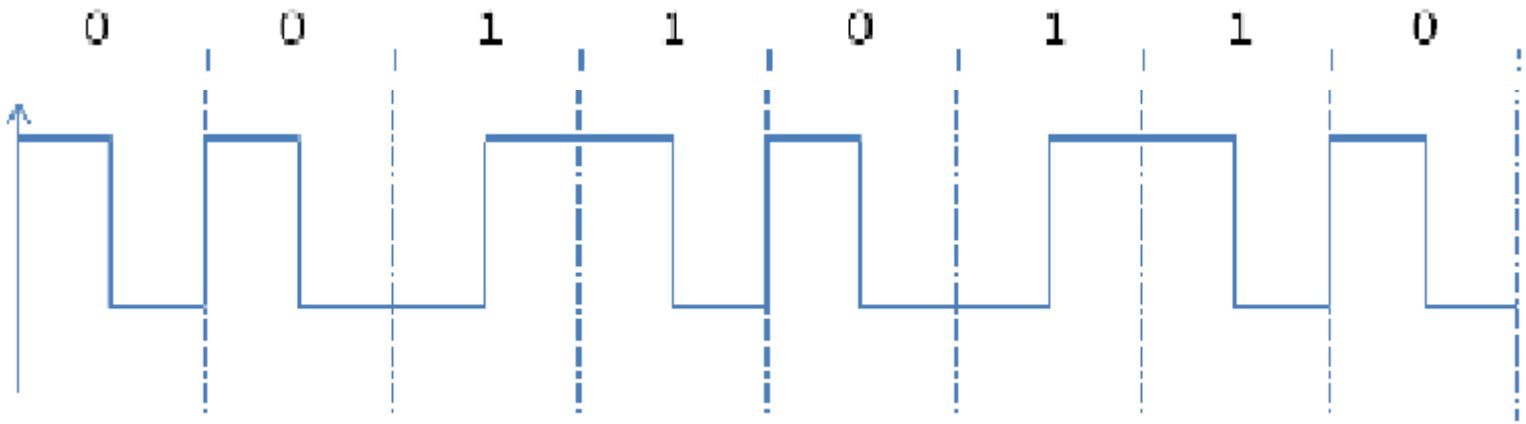
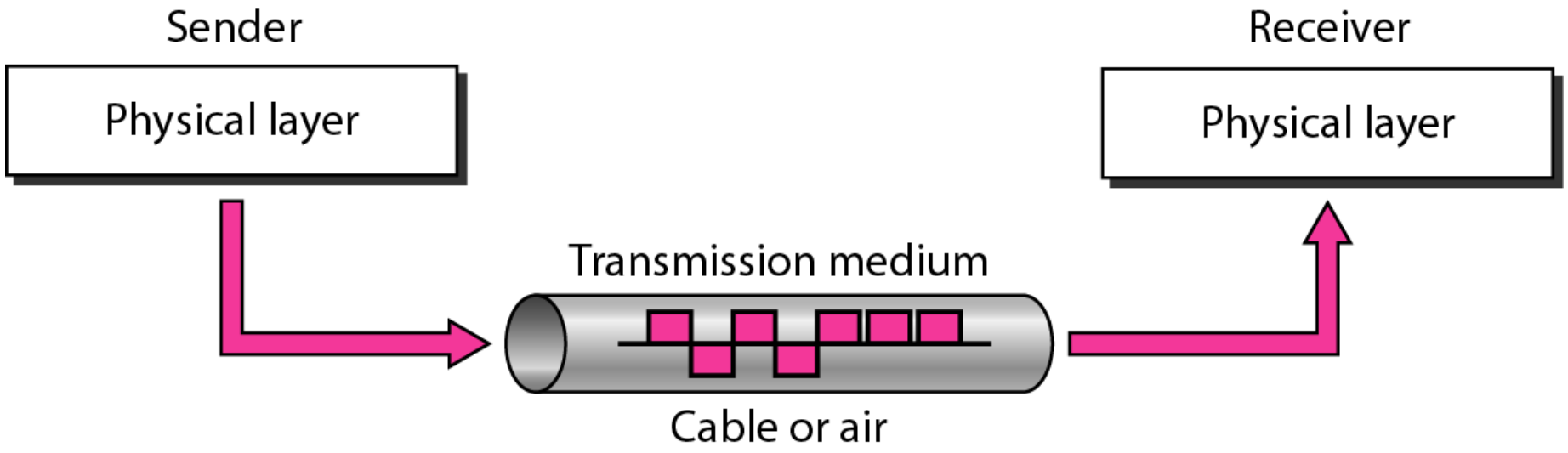
Manchester Encoding



Differential Manchester Encoding



Transmission medium



Introduction to Communication

Transmission Media

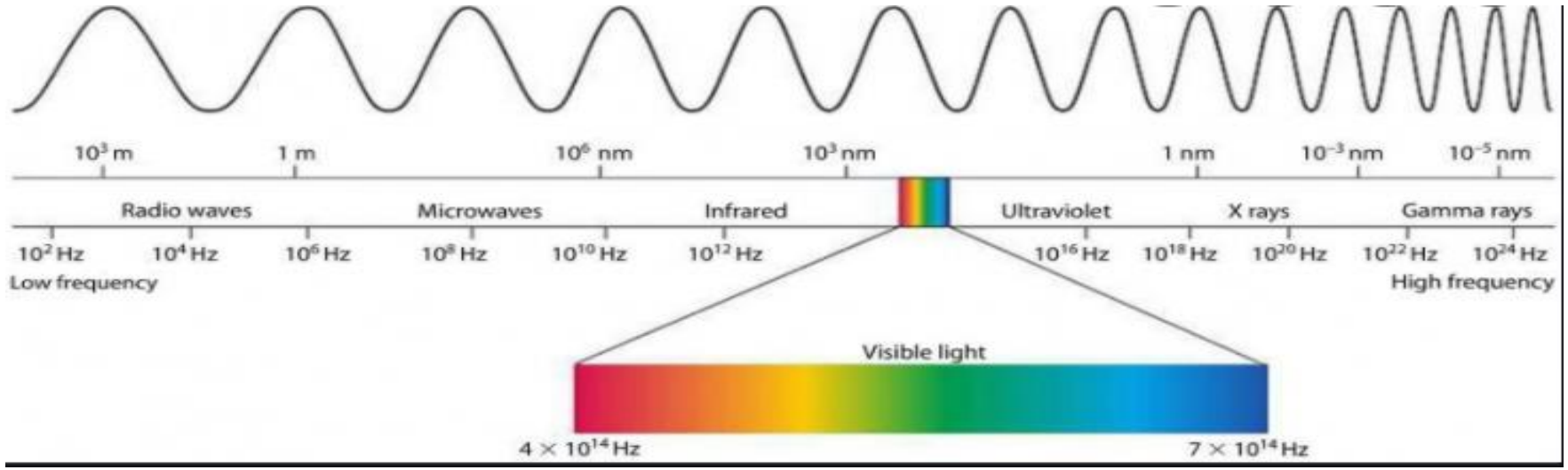
- **Transmission medium :** The physical path between transmitter and receiver.
- Communication of electromagnetic waves is *guided* or *unguided*.

  - ***Guided media*** :: waves are guided along a physical path (e.g, twisted pair, coaxial cable and optical fiber).

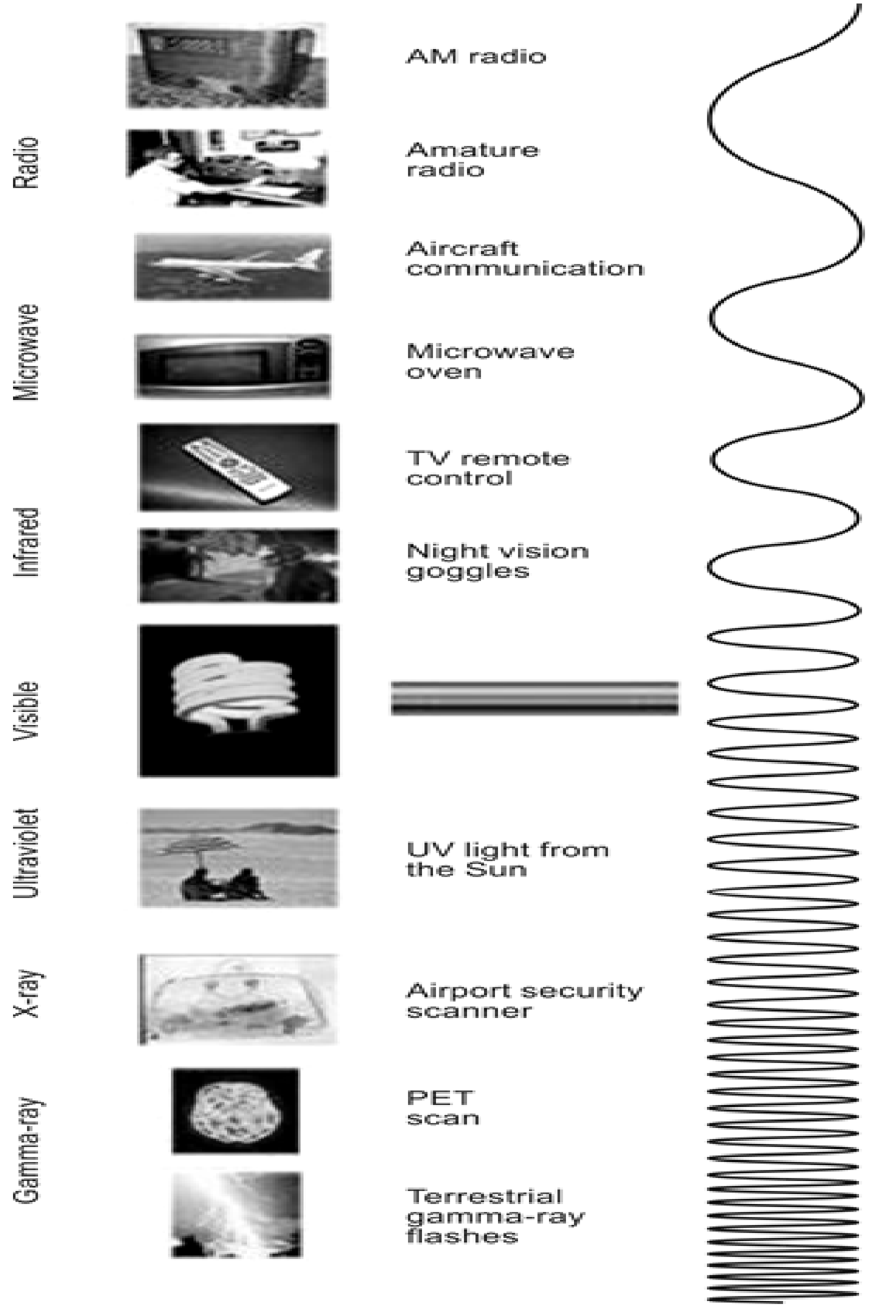
  - ***Unguided media***:: means for transmitting but not guiding electromagnetic waves (e.g., the atmosphere and outer space).

Electromagnetic Spectrum

- Electromagnetic spectrum, **the entire distribution of electromagnetic radiation according to frequency or wavelength**.

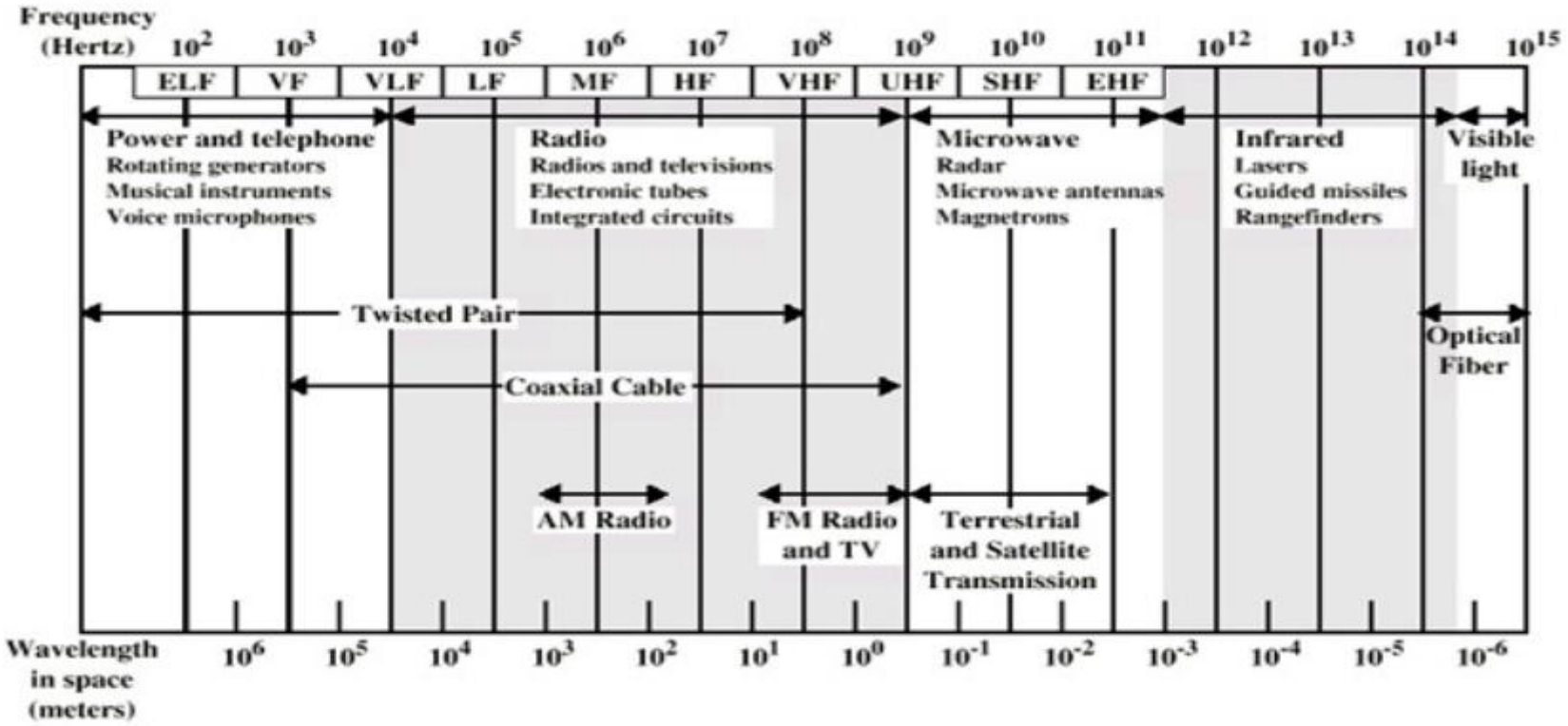


- The electromagnetic spectrum comprises the span of all electromagnetic radiation and consists of many subranges, commonly referred to as portions, such as visible light or ultraviolet radiation



- **Radio :** Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by stars and gases in space.
- **Microwave :** Microwave radiation will cook your popcorn in just a few minutes, but is also used by astronomers to learn about the structure of nearby galaxies.
- **Infrared :** Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the dust between stars.
- **Visible :** Our eyes detect visible light. Fireflies, light bulbs, and stars all emit visible light.
- **Ultraviolet :** Ultraviolet radiation is emitted by the Sun and are the reason skin tans and burns. "Hot" objects in space emit UV radiation as well.
- **X-ray :** A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag. Hot gases in the Universe also emit X-rays.
- **Gamma ray :** Doctors use gamma-ray imaging to see inside your body. The biggest gamma-ray generator of all is the Universe.

Electromagnetic Spectrum



ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

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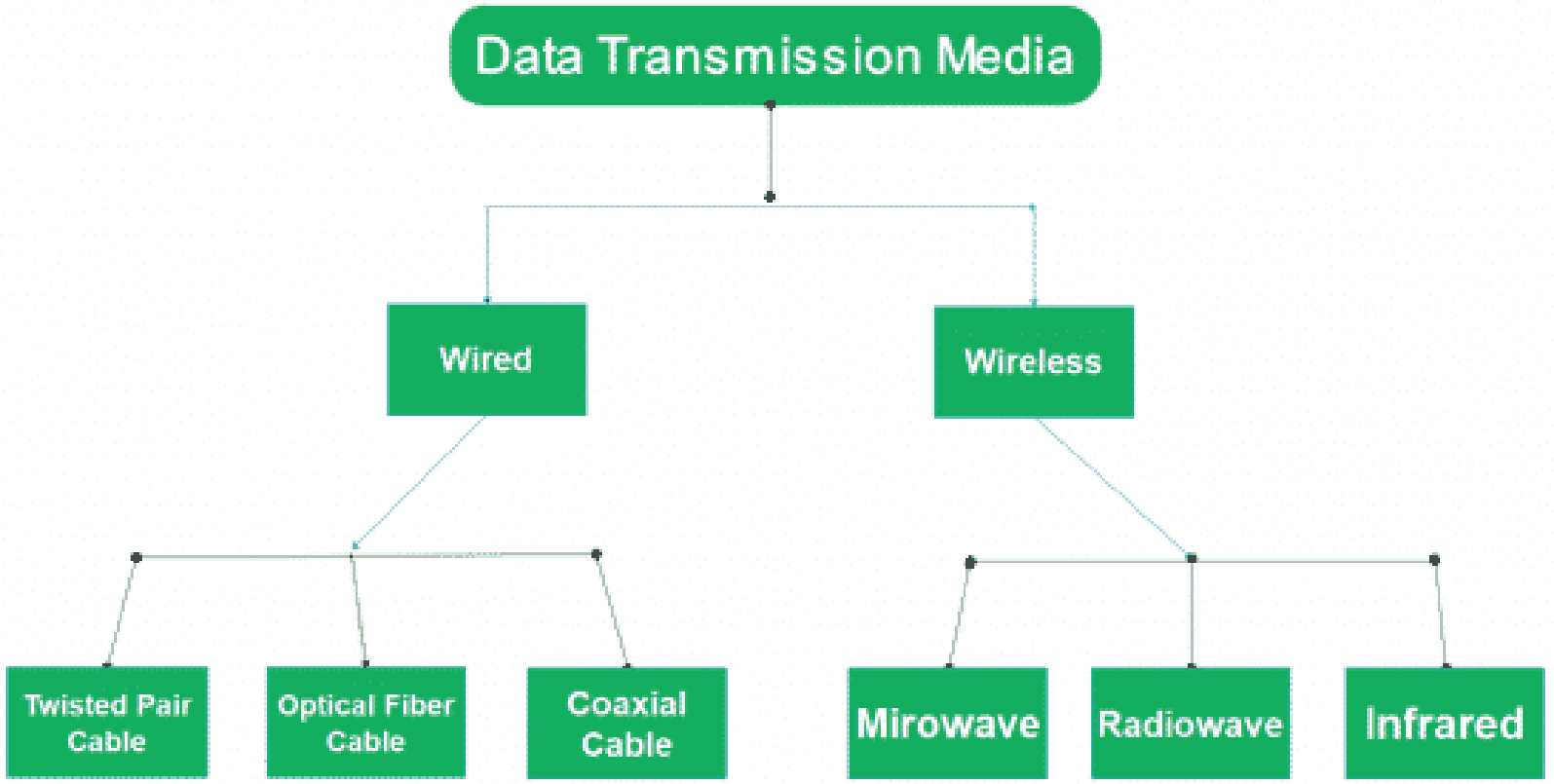
Frequency Band Name	Acronym	Frequency Range	Wavelength (Meters)
Extremely Low Frequency	ELF	3 to 30 Hz	10,000 to 100,000 km
Super Low Frequency	SLF	30 to 300 Hz	1,000 to 10,000 km
Ultra Low Frequency	ULF	300 to 3000 Hz	100 to 1,000 km
Very Low Frequency	VLF	3 to 30 kHz	10 to 100 km
Low Frequency	LF	30 to 300 kHz	1 to 10 km
Medium Frequency	MF	300 to 3000 kHz	100 to 1,000 m
High Frequency	HF	3 to 30 MHz	10 to 100 m
Very High Frequency	VHF	30 to 300 MHz	1 to 10 m
Ultra High Frequency	UHF	300 to 3000 MHz	10 to 100 cm
Super High Frequency	SHF	3 to 30 GHz	1 to 10 cm
Extremely High Frequency	EHF	30 to 300 GHz	1 to 10 mm

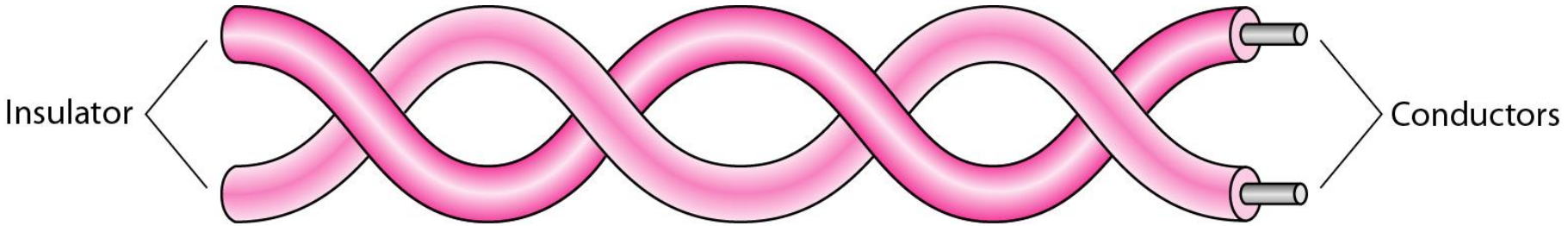
Factors for Selection of Transmission Media

1. Cost & Ease of installation
2. Type of cable
3. No of conductors/connectors
4. Noise Absorption
5. Bandwidth
6. Radiation
7. Durability
8. Attenuation
9. Flexibility
10. Reliability
11. Number of receivers
12. Transmission Rate

Classes of transmission media



Twisted-pair cable



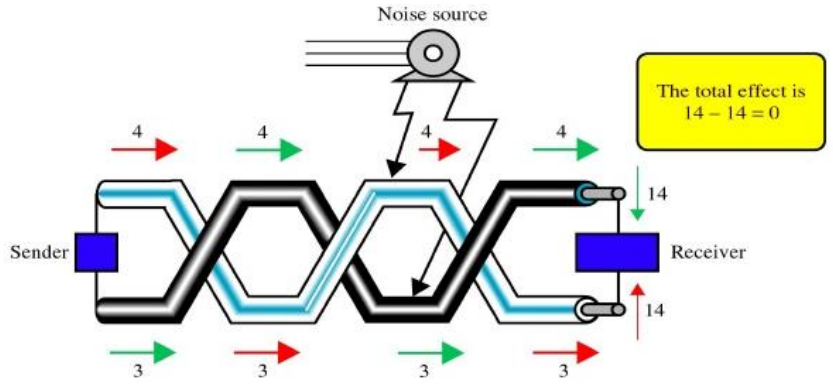
Some important points :

- Its frequency range is 0 to 3.5 kHz.
- Typical attenuation is 0.2 dB/Km @ 1kHz.
- Typical delay is 50 μs/km.

Repeater spacing is 2km.

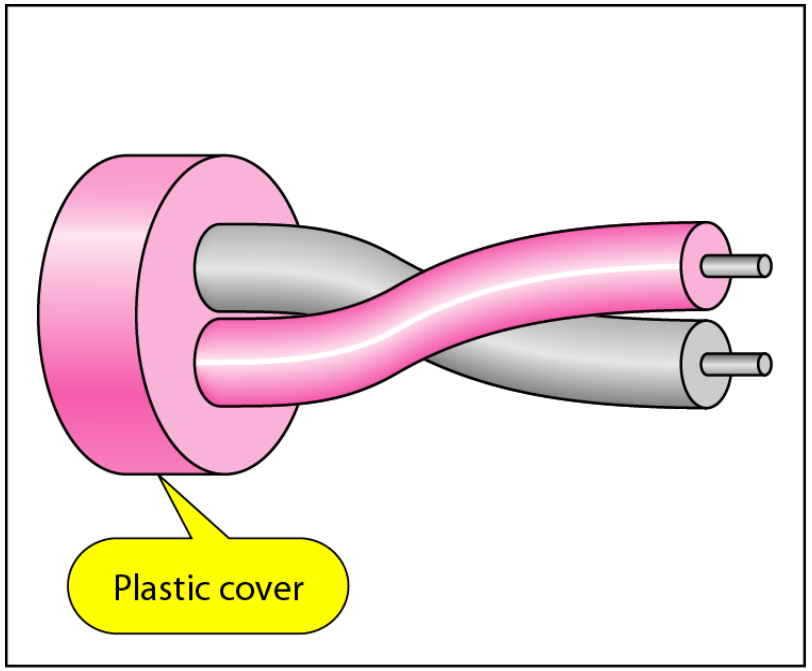
Twisted Pair

- Consists of 2 copper conductors each having it's own plastic insulation.
- Two wires are twisted around each other.
- One wire carries electrical signal and the other is the ground.
- Typically twisted pair is installed in building telephone wiring.
- Twisting is done to reduce the effect of noise on the pair. Each wire is closer to the noise source for half time and farther for the other half.

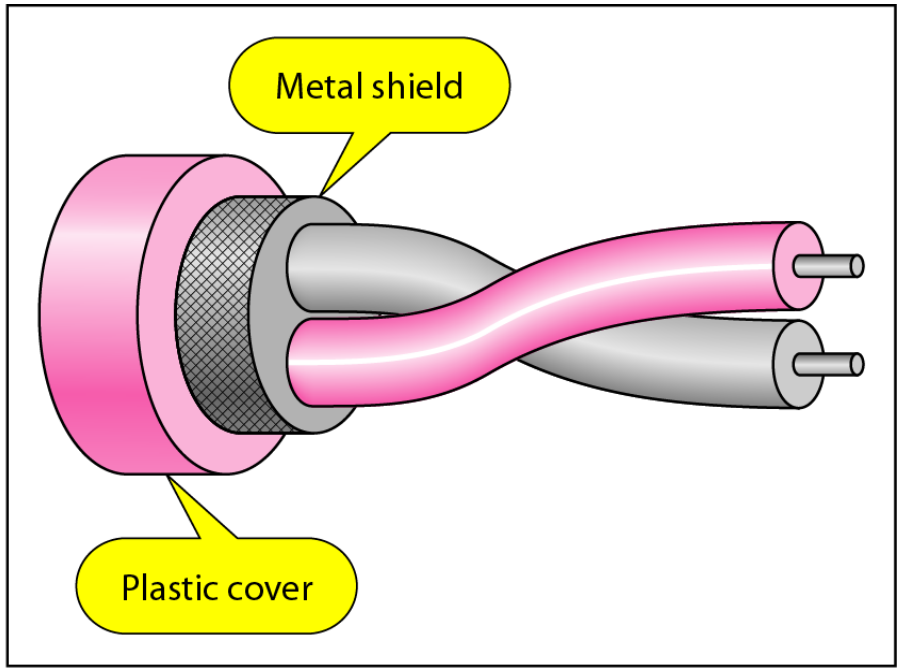


- Types: 1. Unshielded twisted pair
  2. Shielded twisted pair

UTP(Unshielded twisted pair) and STP (Shielded twisted pair) cables



a. UTP



b. STP

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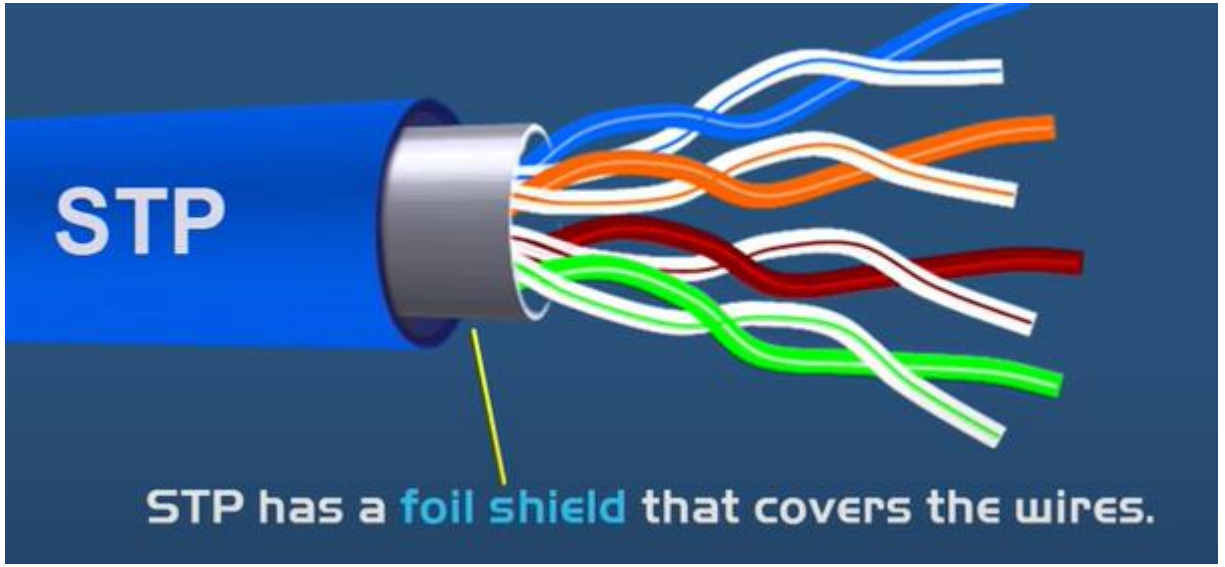
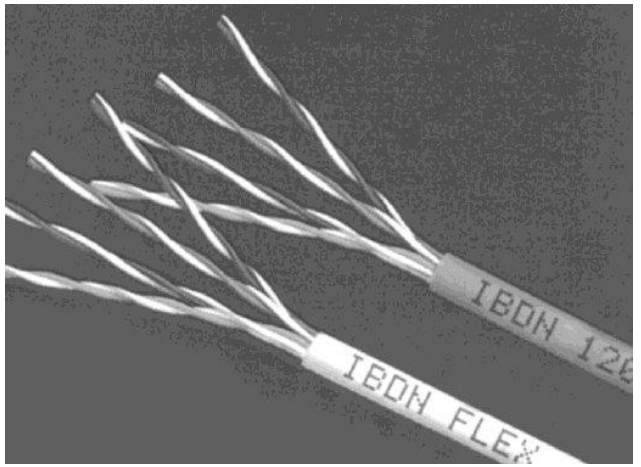


Unshielded Twisted Pair (UTP)

- Consists of 4 pairs (8 wires) of insulated copper wires typically about 1 mm thick.
- The wires are twisted together in a helical form.
- Flexible and cheap cable.
- CAT 3, CAT 4, CAT 5, Enhanced CAT 5 , CAT 6 and Cat 7.

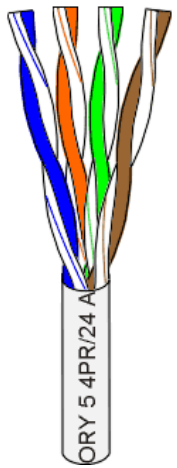


•UTP comes in several categories that are based on the number of twists in the wires, the diameter of the wires and the material used in the wires.

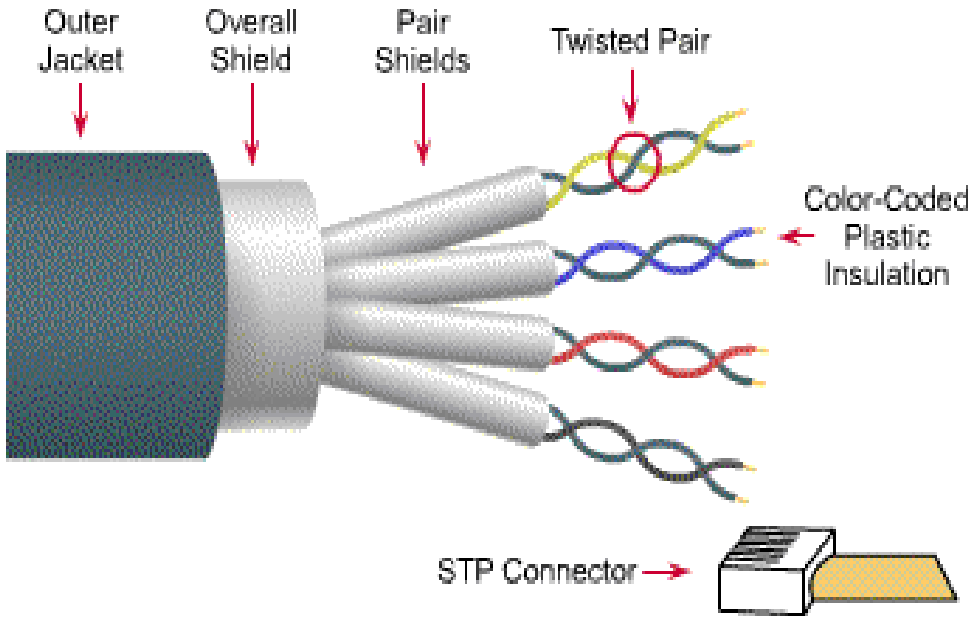
•Category 3 is the wiring used primarily for telephone connections.

•Category 4 and 5 currently the most common Ethernet cables used.

•Category 5e and 6 used in Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps)



Shielded Twisted Pair



- Speed and throughput: 10-100 Mbps
- Cost per node: Moderately expensive
- Media and connector size: Medium to Large
- Maximum cable length: 100m (short)

•STP cable has a metal foil or braided-mesh covering that enhances each pair of insulated conductors.

•The metal casing prevents the penetration of electromagnetic noise.

•Materials and manufacturing requirements make STP more expensive than UTP but less susceptible to noise

Categories of Twisted Pair

- EIA divides UTP into different category

Category	Speed	Use
1	1 Mbps	Voice Only (Telephone Wire)
2	4 Mbps	LocalTalk & Telephone (Rarely used)
3	16 Mbps	10BaseT Ethernet
4	20 Mbps	Token Ring (Rarely used)
5	100 Mbps (2 pair)	100BaseT Ethernet
	1000 Mbps (4 pair)	Gigabit Ethernet
5e	1,000 Mbps	Gigabit Ethernet
6	10,000 Mbps	Gigabit Ethernet

Example: 10Base T, 100base T, 1000 Base T

Category of TP → for Data communication