

## EXPERIMENT 1

### Aim

Study the different types of physical layer wired and wireless connections.

### The OSI Model [1]

The Open Systems Interconnection (OSI) model describes seven layers that computer systems use to communicate over a network. It was the first standard model for network communications, adopted by all major computer and telecommunication companies in the early 1980s.

### Physical Layer [2]

The lowest layer of the OSI reference model is the physical layer. It is responsible for the actual physical connection between the devices. The physical layer contains information in the form of bits. It is responsible for transmitting individual bits from one node to the next. When receiving data, this layer will get the signal received and convert it into 0s and 1s and send them to the Data Link layer, which will put the frame back together.

The functions of the physical layer are :

1. **Bit synchronization:** The physical layer provides the synchronization of the bits by providing a clock. This clock controls both sender and receiver thus providing synchronization at bit level.
2. **Bit rate control:** The Physical layer also defines the transmission rate i.e. the number of bits sent per second.
3. **Physical topologies:** Physical layer specifies the way in which the different devices/nodes are arranged in a network i.e. bus, star or mesh topology.
4. **Transmission mode:** Physical layer also defines the way in which the data flows between the two connected devices. The various transmission modes possible are: Simplex, half-duplex and full-duplex.

7	Application Layer	Human-computer interaction layer, where applications can access the network services
6	Presentation Layer	Ensures that data is in a usable format and is where data encryption occurs
5	Session Layer	Maintains connections and is responsible for controlling ports and sessions
4	Transport Layer	Transmits data using transmission protocols including TCP and UDP
3	Network Layer	Decides which physical path the data will take
2	Data Link Layer	Defines the format of data on the network
1	Physical Layer	Transmits raw bit stream over the physical medium

## Wired Connections (Guided media) [3]

### 1) Twisted pair

Twisted pair is a physical media made up of a pair of cables twisted with each other. A twisted pair cable is cheap as compared to other transmission media. Installation of the twisted pair cable is easy, and it is a lightweight cable. The frequency range for twisted pair cable is from 0 to 3.5KHz. It can either be a shielded or unshielded twisted pair.

#### Unshielded Twisted Pair Cable

It consists of two insulating copper wires (1mm thick). The wires are twisted together in a helical form to reduce electrical interference from a similar pair. Identification is the reason behind colored plastic insulation. It has high-speed capacity. Bandwidth is low when compared with Coaxial Cable. It provides less protection from interference.

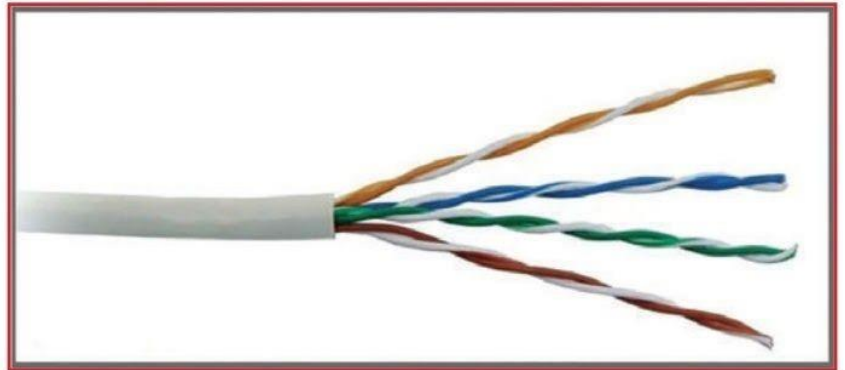


Figure 14.9 Unshielded Twisted Pair Cable

#### Scalability

Higher grades of UTP are used in LAN technologies like Ethernet.

#### Shielded Twisted Pair Cable

This cable has a metal foil or braided-mesh. Electromagnetic noise penetration is prevented by a metal casing. Shielding also eliminates crosstalk. It is faster than unshielded and coaxial cable.

#### Advantages

- It can be used for Analog or Digital transmission
- It increases the signaling rate.
- It eliminates crosstalk.

#### Disadvantages

- It is difficult to manufacture

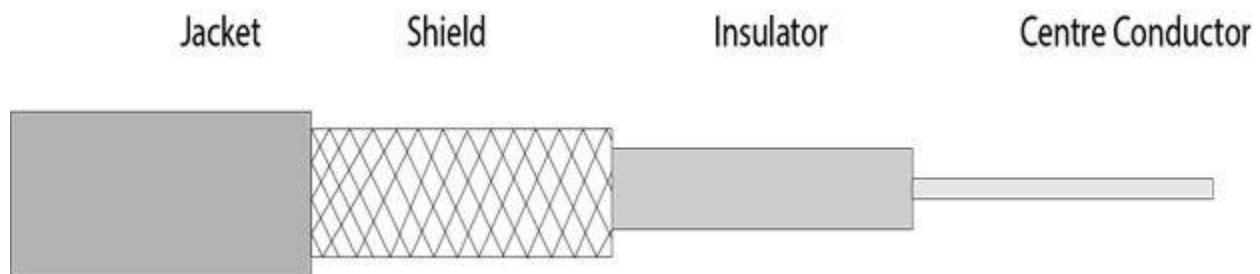


Figure 14.10 Shielded Twisted Pair

### 2) Coaxial Cable

- Coaxial cable is a very commonly used transmission media, for example, TV wire is usually a coaxial cable.

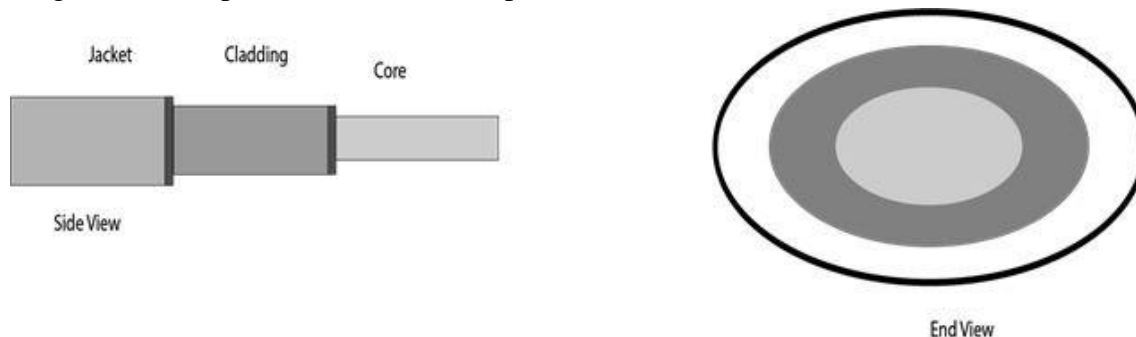
- The name of the cable is coaxial as it contains two conductors parallel to each other.
- It has a higher frequency as compared to Twisted pair cable.
- The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh. The middle core is made up of a non-conductive cover that separates the inner conductor from the outer conductor.
- The middle core is responsible for the data transferring whereas the copper mesh prevents EMI(Electromagnetic interference).
- The most common coaxial standards are:
  - 50-Ohm RG-7 or RG-11: used with thick Ethernet.
  - 50-Ohm RG-58: used with thin Ethernet
  - 75-Ohm RG-59: used with cable television
  - 93-Ohm RG-62: used with ARCNET.



### 3) Fiber Optic

- Fiber optic cable is a cable that uses electrical signals for communication.
- Fiber optic is a cable that holds the optical fibers coated in plastic that are used to send the data by pulses of light.
- The plastic coating protects the optical fibers from heat, cold, electromagnetic interference from other types of wiring.
- Fiber optics provide faster data transmission than copper wires.

Diagrammatic representation of fiber optic cable:



#### Scalability

Used in CAN networks.

### Ethernet [4]

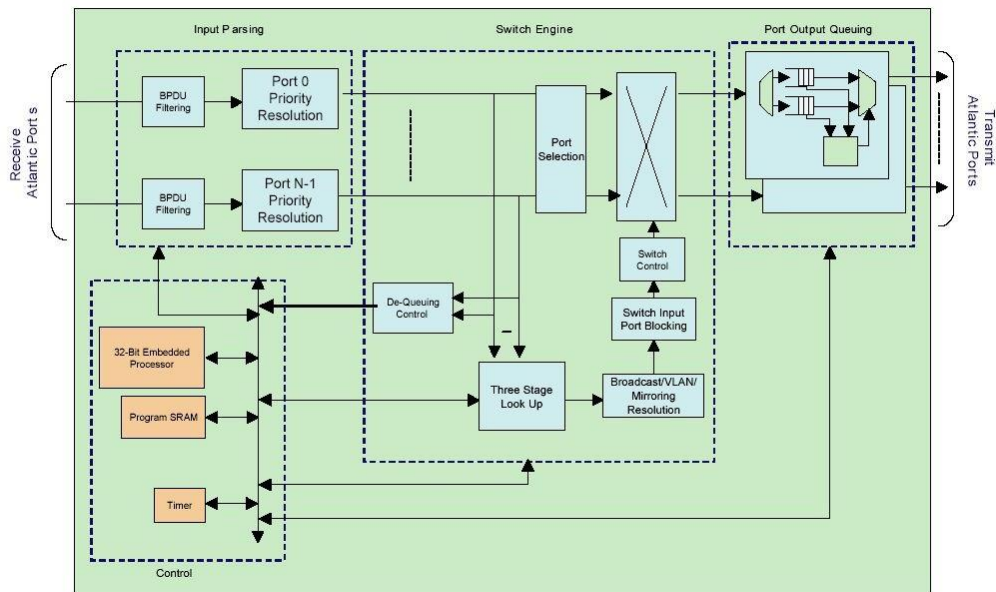
Ethernet is the traditional technology for connecting devices in a wired local area network (LAN) or wide area network (WAN), enabling them to communicate with each other via a protocol -- a

set of rules or common network language. Ethernet describes how network devices can format and transmit data so other devices on the same local or campus area network segment can recognize, receive and process the information. An Ethernet cable is the physical, encased wiring over which the data travels.

Connected devices accessing a geographically localized network with a cable -- that is, with a wired rather than wireless connection -- likely use Ethernet. From businesses to gamers, diverse end users depend on the benefits of Ethernet connectivity, which include reliability and security.

#### Schematic View

Figure 1: Ethernet Layer 2 Switch Block Diagram



#### Specifications :

- Range: Over deployed multi-mode cabling ethernet supports ranges of between 240m and 300 m with 400/500 MHz·km modal bandwidth. It also supports 10 km over single-mode fiber.
- Modulation: Ethernet uses biphase modulation to transmit data bits, this is accomplished by using a Manchester encoded bit-stream. Ethernet does not use IQ modulation because it is not bandwidth limited by the FCC.

#### Scalability :

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN), metropolitan area networks (MAN), and wide area networks(WAN). Ethernet is currently the most widely used technology in enterprise networking. Unfortunately, it is widely acknowledged that Ethernet does not have the scalability to meet the emerging networking needs of large enterprises. Ethernet does not scale well to large networks.

## USB [5]

Short for **universal serial bus**, **USB** is a plug and play interface that allows a computer to communicate with peripheral and other devices. USB-connected devices cover a broad range; anything from keyboards and mice, to music players and flash drives. For more information on these devices, see our USB devices section.

The diagram illustrates the internal circuitry of a USB to RS-485 module. Key components and connections include:

- USB Type B Connector (AU-91007R):** Provides VCC (pin 1), D+ (pin 3), D- (pin 2), and GND (pin 4/5/6).
- POWER LED-GREEN:** Connected to VCC (pin 1) and GND.
- 12.000 MHz Crystal Oscillator:** Connected to pins 1 and 2 of the CDC232 chip, with 22pF capacitors to ground.
- CDC232 Chip:** A central IC with multiple pins for power, ground, crystal, and RS-485 communication.
  - Power/Ground:** VCC (pin 14), GND (pins 18, 19, 20, 21).
  - Crystal:** Pins 1 and 2.
  - RS-485:** Pins 23 (P0A/ADC0), 24 (P0B/ADC1), 25 (P0C/ADC2), 26 (P0D/ADC3), 27 (P0E/ADC4/SCA), 28 (P0F/ADC5/CL), 29 (P0G/RESET), 30 (P0H/INT0), 31 (P0I/INT1), 32 (P0J/INT2), 33 (P0K/INT3), 34 (P0L/INT4), 35 (P0M/INT5), 36 (P0N/INT6), 37 (P0O/INT7), 38 (P0P/INT8), 39 (P0Q/INT9), 40 (P0R/INT10), 41 (P0S/INT11), 42 (P0T/INT12), 43 (P0U/INT13), 44 (P0V/INT14), 45 (P0W/INT15), 46 (P0X/INT16), 47 (P0Y/INT17), 48 (P0Z/INT18), 49 (P0AA/INT19), 50 (P0AB/INT20), 51 (P0AC/INT21), 52 (P0AD/INT22), 53 (P0AE/INT23), 54 (P0AF/INT24), 55 (P0AG/INT25), 56 (P0AH/INT26), 57 (P0AI/INT27), 58 (P0AJ/INT28), 59 (P0AK/INT29), 60 (P0AL/INT30), 61 (P0AM/INT31), 62 (P0AN/INT32), 63 (P0AO/INT33), 64 (P0AP/INT34), 65 (P0AQ/INT35), 66 (P0AR/INT36), 67 (P0AS/INT37), 68 (P0AT/INT38), 69 (P0AU/INT39), 70 (P0AV/INT40), 71 (P0AW/INT41), 72 (P0AX/INT42), 73 (P0AY/INT43), 74 (P0AZ/INT44), 75 (P0BA/INT45), 76 (P0BB/INT46), 77 (P0BC/INT47), 78 (P0BD/INT48), 79 (P0BE/INT49), 80 (P0BF/INT50), 81 (P0BG/INT51), 82 (P0BH/INT52), 83 (P0BI/INT53), 84 (P0BJ/INT54), 85 (P0BK/INT55), 86 (P0BL/INT56), 87 (P0BM/INT57), 88 (P0BN/INT58), 89 (P0BO/INT59), 90 (P0BP/INT60), 91 (P0BQ/INT61), 92 (P0BR/INT62), 93 (P0BS/INT63), 94 (P0BT/INT64), 95 (P0BU/INT65), 96 (P0BV/INT66), 97 (P0BW/INT67), 98 (P0BX/INT68), 99 (P0BY/INT69), 100 (P0BZ/INT70).
- RS-485 Interface:** Connected to a terminal block J1 (CON1-H4) via 470 ohm and 10k resistors.

- **Range:**
  - The USB 1.1 standard specifies that a standard cable can have a maximum length of 5 meters (16 ft 5 in) with devices operating at full speed (12 Mbit/s), and a maximum length of 3 meters (9 ft 10 in) with devices operating at low speed (1.5 Mbit/s).
  - USB 2.0 provides for a maximum cable length of 5 meters (16 ft 5 in) for devices running at high speed (480 Mbit/s).
  - The USB 3.0 standard does not directly specify a maximum cable length, requiring only that all cables meet an electrical specification: for copper cabling with AWG 26 wires, the maximum practical length is 3 meters (9 ft 10 in).
- **Modulation :**
  - At the input, the device communicates via MIDI and USB protocols. At the output is tension. Its value is managing by pulse-width modulation.
  - Pulse-width modulation (PWM) is used for controlling the amplitude of digital signals in order to control devices and applications requiring power or electricity. It essentially controls the amount of power, from the perspective of the voltage component, that is given to a device by cycling the on-and-off phases of a digital signal quickly and varying the width of the "on" phase or duty cycle.

USBs are used mostly in Wired Personal Area Networks(WPAN).

Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light. Electromagnetic waves from frequencies between 3 kHz and 1 GHz. Radio waves are omnidirectional (propagated in all directions). They can penetrate walls. They are useful for multicasting (one to many). Mostly used for wide area networks and mobile cellular phones.



## Microwaves

Microwaves are a form of electromagnetic radiation with wavelengths ranging from about one meter to one millimeter. Electromagnetic waves from frequencies between 1 GHz and 300 GHz are called microwaves. Microwaves are unidirectional (sending and receiving antennas need to be aligned). Its propagation is line-of-sight (the sending and receiving antennas need to be properly aligned with each other.) Very high-frequency microwaves cannot penetrate walls. They are useful for unicasting (one to one). Mostly used for Cellular phones, Satellite networks, and Wireless LAN.

## Infrared

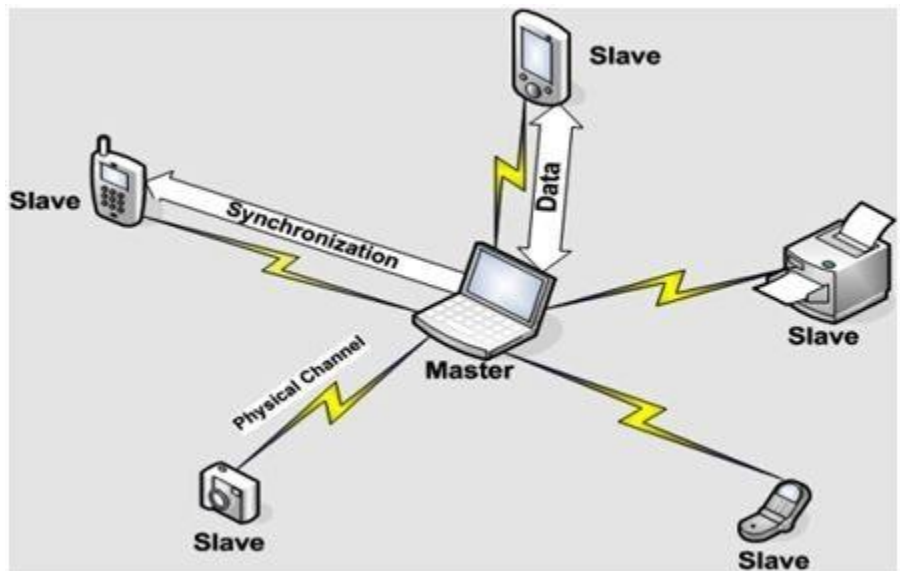
Infrared radiation (IR), is electromagnetic radiation (EMR) with longer wavelengths than those of visible light, and invisible to the human eye. Electromagnetic waves from frequencies between 300 GHz to 400 THz is called Infrared. Infrared waves are used for short-distance communication having high frequencies. They cannot penetrate walls. Infrared Data Association (IrDA) is used for communication between devices such as PCs, keyboards, mice, and printers. IrDA port allows wireless keyboard to communicate with a computer.

## Bluetooth [7]

A Bluetooth technology is a high speed low powered wireless technology link that is designed to connect phones or other portable equipment together. It is a specification (IEEE 802.15.1) for the use of low power radio communications to link phones, computers and other network devices over short distance without wires. Wireless signals transmitted with Bluetooth cover short distances, typically up to 30 feet (10 meters).

It is achieved by embedded low cost transceivers into the devices. It supports on the

frequency band of 2.45GHz and can support upto 721KBps along with three voice channels. This frequency band has been set aside by international agreement for the use of industrial, scientific and medical devices (ISM).rd-compatible with 1.0 devices.



### Specifications:

**Range:** The Bluetooth Core Specification mandates a range of not less than 10 meters (33 ft), but there is no upper limit on the actual range.

**Modulation**

- Originally, Gaussian frequency-shift keying (GFSK) modulation was the only modulation scheme available.
- Since the introduction of Bluetooth 2.0+EDR,  $\pi/4$ -DQPSK (differential quadrature phase-shift keying) and 8-DPSK modulation may also be used between compatible devices.

○ Devices functioning with GFSK are said to be operating in basic rate (BR) mode where an instantaneous bit rate of 1 Mbit/s is possible. The term Enhanced Data Rate (EDR) is used to describe  $\pi/4$ -DPSK and 8-DPSK schemes, each giving 2 and 3 Mbit/s respectively.

Bluetooth Scalability :

- The primary constraining factor in the scalability of a system that uses any wireless communications technology concerns the fact that radio is a shared resource with a finite capacity.
- Bluetooth has been developed to facilitate wireless personal area networks (PANs), in which the networks of different handheld computing terminals and mobile terminals can communicate and exchange data - even on the move or when there is no line-of-sight between the terminals.

## Cellular network [8]

Cellular network is an underlying technology for mobile phones, personal communication systems, wireless networking etc. The technology is developed for mobile radio telephone to replace high power transmitter/receiver systems. Cellular networks use lower power, shorter range and more transmitters for data transmission.

### Specifications

#### Range

A cellular network is used by the mobile phone operator to achieve both coverage and capacity for their subscribers. In cities, each cell site may have a range of up to approximately 1/2 mile (0.80 km), while in rural areas, the range could be as much as 5 miles (8.0 km).

## WIFI [9]

Wi-Fi is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smartphones and wearables), and other equipment (printers and video cameras) to interface with the Internet. It allows these devices--and many more--to exchange information with one another, creating a network.

Internet connectivity occurs through a wireless router. When you access Wi-Fi, you are connecting to a wireless router that allows your Wi-Fi-compatible devices to interface with the Internet.

### Specifications

#### Range

- A wireless network's range can vary wildly depending on the type of network. A standard home network using one wireless router can serve a single-family dwelling, but often not much more.
- Business networks with grids of access points can serve large office buildings, and wireless hotspots spanning several square miles have been built in some cities.
- A general rule of thumb in home networking says that Wi-Fi routers operating on the 2.4 GHz band can reach up to 150 feet indoors and 300 feet outdoors. Older 802.11a routers that ran on 5 GHz bands reached approximately one-third of these distances.
- Newer 802.11n and 802.11ac routers that operate on both 2.4 GHz and 5 GHz bands reach greater distances.

## Modulation

WiFi systems use two primary radio transmission techniques:

- 802.11b ( $\leq 11$  Mbps) – The 802.11b radio link uses a direct sequence spread spectrum technique called complementary code keying (CCK).

The bitstream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK).

## Wi-Fi Scalability :

- Compared to cell phones and similar technology, Wi-Fi transmitters are low power devices. In general, the maximum amount of power that a Wi-Fi device can transmit is limited by local regulations, such as FCC Part 15 in the US. Equivalent isotropically radiated power (EIRP) in the European Union is limited to 20 dBm (100 mW).
- To reach requirements for wireless LAN applications, Wi-Fi has higher power consumption compared to some other standards designed to support wireless personal area network (PAN) applications. For

## Zigbee [10]

Zigbee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless IoT networks. The Zigbee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz.

The 802.15.4 specification upon which the Zigbee stack operates gained ratification by the Institute of Electrical and Electronics Engineers (IEEE) in 2003. The specification is a packet-based radio protocol intended for low-cost, battery-operated devices. The protocol allows devices to communicate in a variety of network topologies and can have battery life lasting several years.

## Conclusion

I learned about the Physical layer, the types of Wired and wireless connections.

I also learnt about the technologies, specifications and schematic view of connections.

## References

OSI Model [1]

What is OSI Model | 7 Layers Explained

Physical layer Introduction and functions [2]

[https://www.geeksforgeeks.org/layers-of-osi-model/#:~:text=Physical%20Layer%20\(Layer%201\)%20%3A,one%20node%20to%20the%20next.](https://www.geeksforgeeks.org/layers-of-osi-model/#:~:text=Physical%20Layer%20(Layer%201)%20%3A,one%20node%20to%20the%20next.)

Transmission media

DCN - Physical Layer Introduction

Guided Media [3]

Guided Transmission Media - javatpoint

Wired Technologies and its types

Ethernet [4]

<https://searchnetworking.techtarget.com/definition/Ethernet>

[http://ecee.colorado.edu/~liue/teaching/comm\\_standards/ethernet/ethernet.html](http://ecee.colorado.edu/~liue/teaching/comm_standards/ethernet/ethernet.html)



USB [5]

What is USB (Universal Serial Bus)?

Unguided Media [6]

UnGuided/Wireless Transmission Media in Computer Network

Bluetooth [7]

Bluetooth Basics - How Bluetooth Works: Applications and Advantages

Cellular network [8]

Cellular Wireless Networks

WIFI [9]

What Is Wi-Fi? - Definition and Types

ZigBee [10]

<https://www.digi.com/solutions/by-technology/zigbee-wireless-standard#:~:text=Zigbee%20is%20a%20wireless%20technology,900%20MHz%20and%20868%20MHz.>