

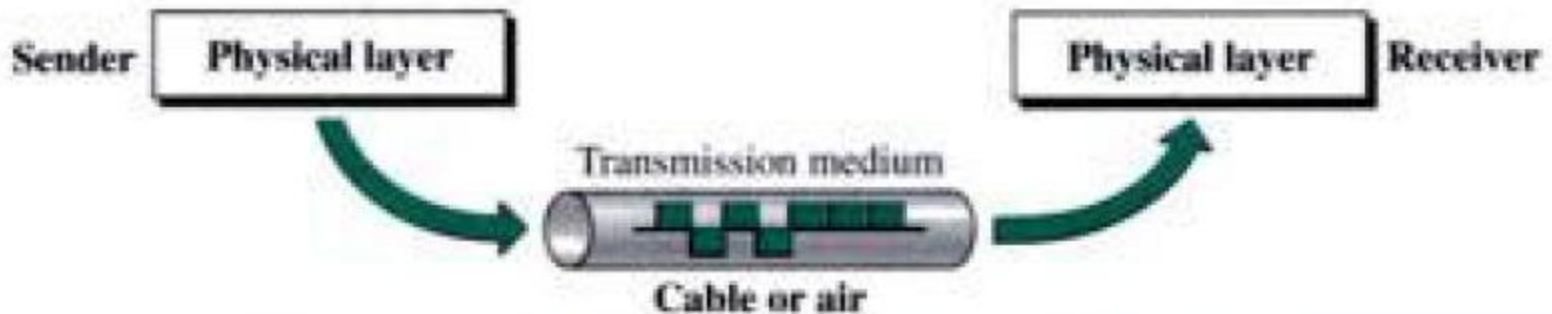
Computer Networks

Lecture -4-

Transmission Media

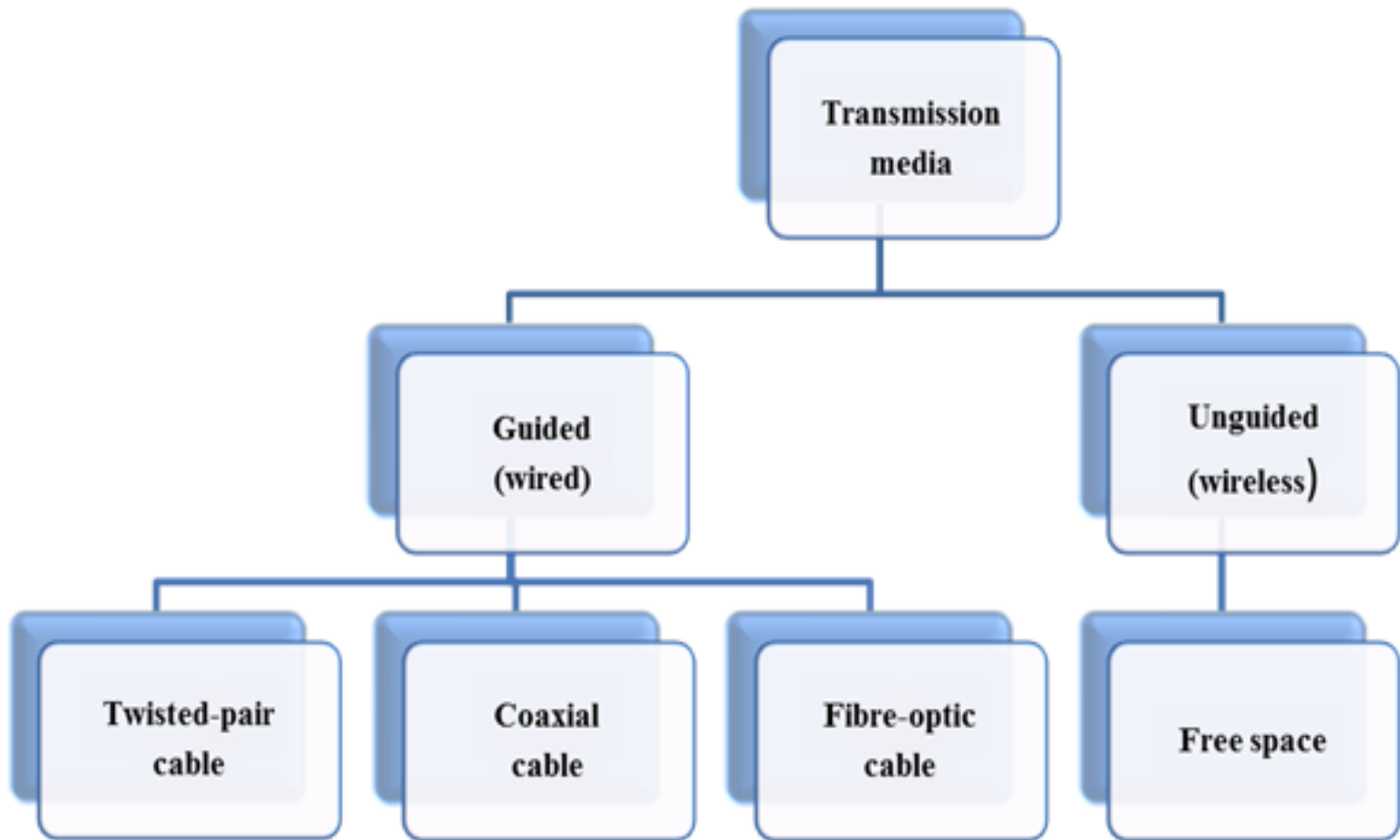
Dr. Methaq Talib

Transmission Media



A transmission medium can be broadly defined as anything that can carry information from a source to a destination.

Categories of Transmission Media



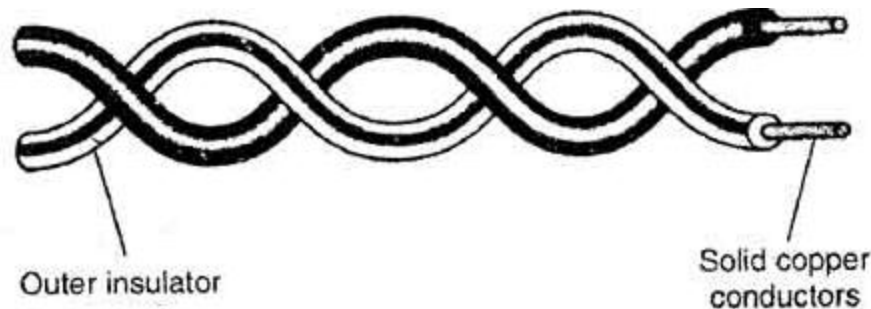
Each one has its own niche in terms of **bandwidth**, **delay**, **cost**, and **ease of installation** and **maintenance**.

Magnetic Media

- One of the most common ways to transport data from one computer to another is to write them onto **magnetic tape or removable media** (e.g., recordable DVDs), physically transport the tape or disks to the destination machine, and read them back in again.
- Although this method is not as sophisticated as using a geosynchronous communication satellite, it is often **more cost effective**, especially for applications in which high bandwidth or cost per bit transported is the key factor.
- **Bandwidth** of magnetic tape is **excellent**, but the **delay** is **poor**.

Twisted Pairs

- For many applications an **online connection is needed**. One of the oldest and still most common transmission media is **twisted pair**.
- A **twisted pair** consists of **two insulated copper wires**, typically about 1 mm thick. The wires are twisted together in a helical form.



One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference.

- The purpose of twisting the wires is to **reduce electrical interference** from similar pairs that may be close by.

Twisted Pairs

- The most common application of the twisted pair is the **telephone system** and **LANs**.
- Twisted pairs can run **several kilometers without amplification**, but for **longer distances** the signal becomes too attenuated and **repeaters are needed**.
- Twisted pairs can be used for transmitting either **analog or digital information**.
- The **bandwidth** depends on the thickness of the wire and the distance traveled, but several megabits/sec can be achieved for a few kilometers in many cases.
- Due to their **adequate performance, easy to install** and **low cost**, twisted pairs are widely used and are likely to remain so for years to come.

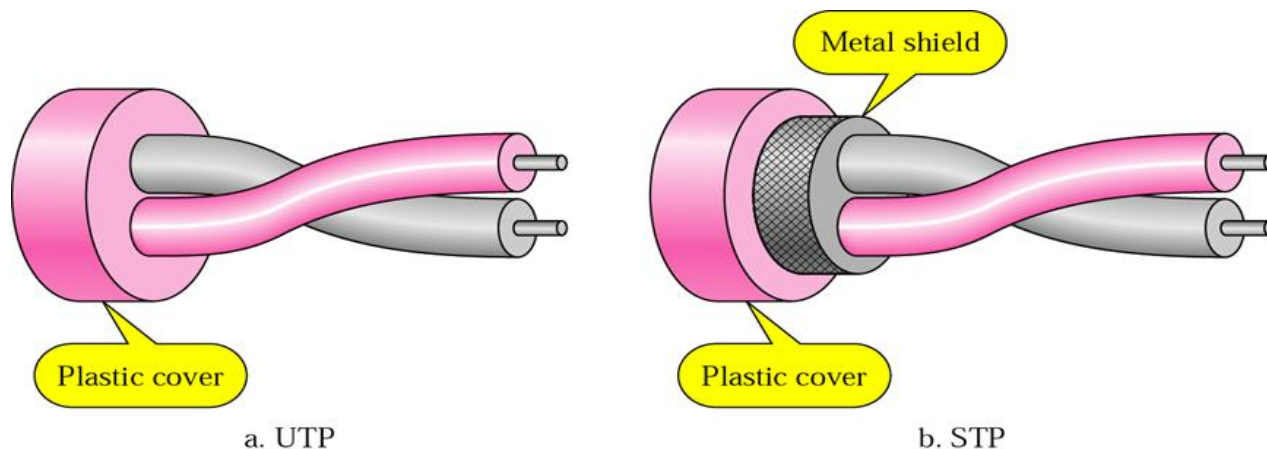
Twisted Pair - Transmission Characteristics

- Analog
 - Amplifiers every 5km to 6km
- Digital
 - repeater every 2km or 3km
- Limited distance
- Limited bandwidth (1MHz)
- Limited data rate (100MHz)
- Susceptible to interference and noise

Twisted Pairs

Twisted-pair cabling comes in several varieties.

- 1- Unshielded Twisted Pair (UTP):** they consist simply of wires and insulators.
- 2- Shielded Twisted Pair (STP):** have shielding on the individual twisted pairs, as well as around the entire cable (but inside the plastic protective sheath).
 - Shielding **reduces** the susceptibility to **external interference** and **crosstalk** with other nearby cables to meet demanding performance specifications.

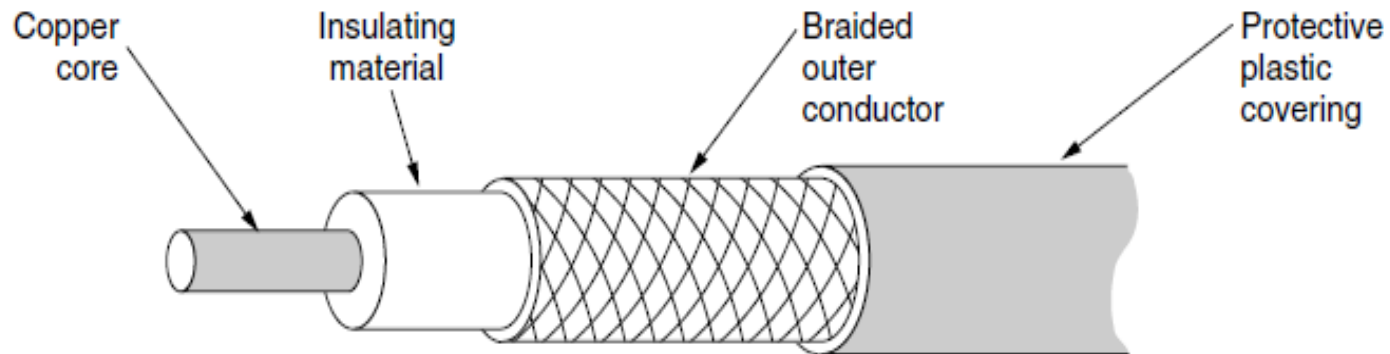


Unshielded and Shielded TP

- Unshielded Twisted Pair (UTP)
 - Ordinary telephone wire
 - Cheapest
 - Easiest to install
 - Suffers from external EM interference
- Shielded Twisted Pair (STP)
 - Metal braid or sheathing that reduces interference
 - More expensive
 - Harder to handle (thick, heavy)

Coaxial Cable

- A coaxial cable consists of a stiff **copper wire** as the **core**, surrounded by an **insulating material**. The insulator is encased by a **cylindrical conductor**, often as a closely woven braided mesh. The outer conductor is covered in a **protective plastic sheath**.



Coaxial Cable

- It has **better shielding** and **greater bandwidth** than **unshielded twisted pairs**, so it can **span longer distances** at higher speeds.
- **Two kinds of coaxial cable** are widely used.
 - ❑ One kind, **50-ohm cable**, is commonly used when it is intended for **digital transmission** from the start.
 - ❑ The other kind, **75-ohm cable**, is commonly used for **analog transmission** and cable television.

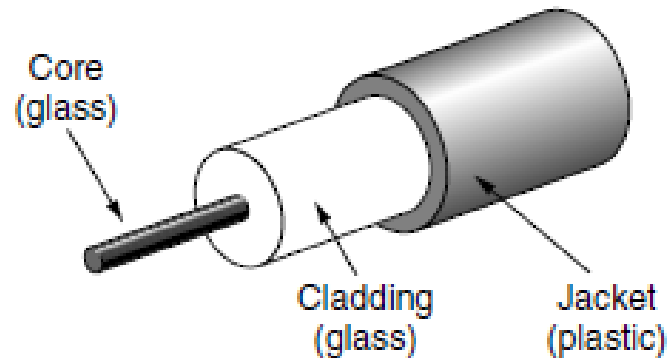
Coaxial Cable

Applications

- Coaxial cable was widely used in **analog telephone networks** where a single coaxial network could carry 10,000 voice signals.
- Later it was used in **digital telephone networks** where a single coaxial cable could carry digital data up to 600 Mbps.
- **Cable TV networks** also use coaxial cables.
- Another common application of coaxial cable is in traditional **Ethernet LANs**.

Fiber Optic Cables

- Fiber optic cables are similar to coax, except without the braid. Figure shows a **single fiber** viewed from the side. At the **center is the glass** core through which the **light propagates**.

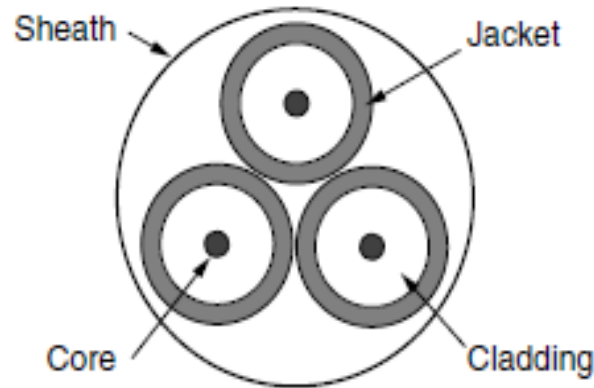


Side view of a single fiber

- In single-mode fibers, the core is **8 to 10** microns.

Fiber Optic Cables

- In **multimode fibers**, the core is typically **50 microns** in diameter, about the thickness of a human hair.

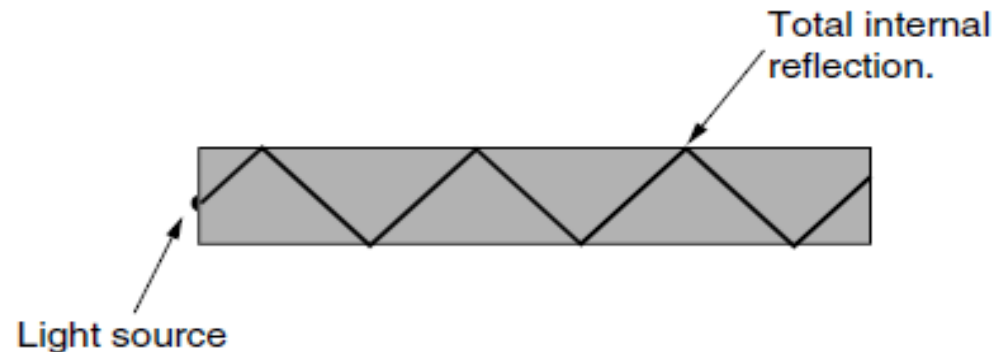


End view of a sheath with **three fibers.**

- The core is surrounded by a glass cladding with a lower index of refraction than the core, to keep all the light in the core. Next comes a thin plastic jacket to protect the cladding. Fibers are typically grouped in bundles, protected by an outer sheath.

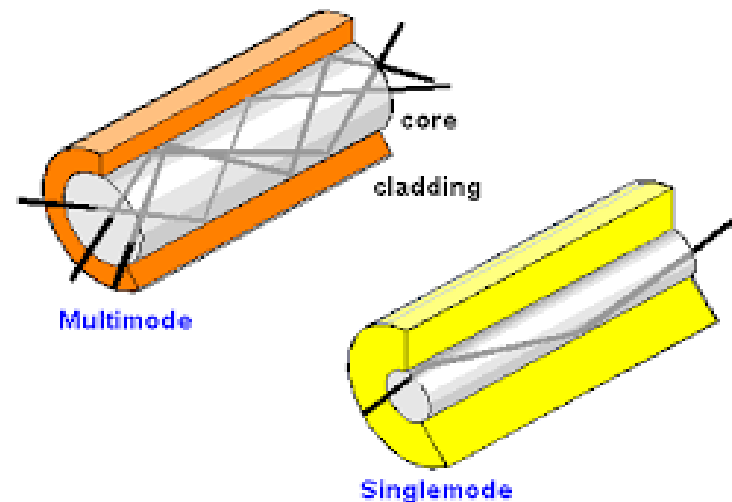
Fiber Optic Cables

- To understand optical fiber, we first need to explore several aspects of the nature of light. **Light travels in a straight line** as long as it is moving through a single uniform substance.
- Optical fibers use **reflection** to guide light through a channel



Fiber Optic Cables

- **Single Mode fiber** optic cable has a small diametral core that allows **only one mode of light** to propagate. This application is typically used in **long distance**.
- **Multimode fiber** optic cable has a large diametral core that allows **multiple modes of light** to propagate. This application is typically used for **short distance**.



Fiber Optic Cables

□ Advantages of Fiber optic cable are:

- high capacity (laser bandwidth),
- immune to interference (electromagnetic), and
- can go long distances (low attenuation).

□ Its disadvantages are:

- costly,
- difficult to join, and
- expensive to install and greater skill is required.

Comparison of Fiber Optics and Copper Wire

- **Fiber** has many advantages. It can handle much **higher bandwidths** than copper.
- **Fiber** also has the advantage of **not being affected by power surges, electromagnetic interference, or power failures.**
- Telephone companies like **fiber** for a different reason: it is **thin and lightweight.**
- **fibers** do **not leak light** and are **difficult to tap.** These properties give fiber **good security** against potential wiretappers.

Comparison of Fiber Optics and Copper Wire

- On the downside, fiber is a less familiar technology requiring skills not all engineers have.
- fibers can be damaged easily by being bent too much.
- Since optical transmission is inherently unidirectional, two-way communication requires either two fibers or two frequency bands on one fiber.
- Finally, fiber interfaces cost more than electrical interfaces.

Wireless Communication

- **advantages:**

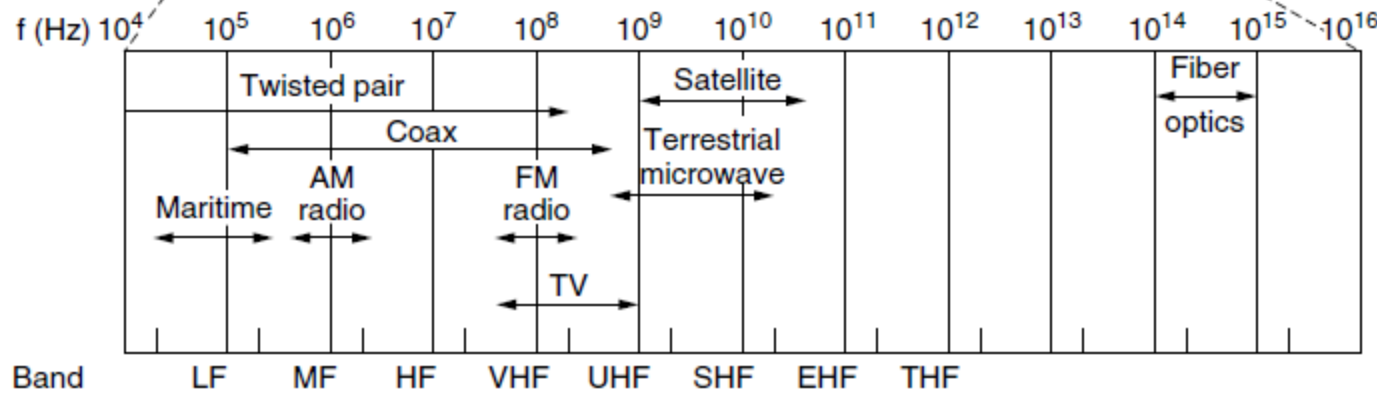
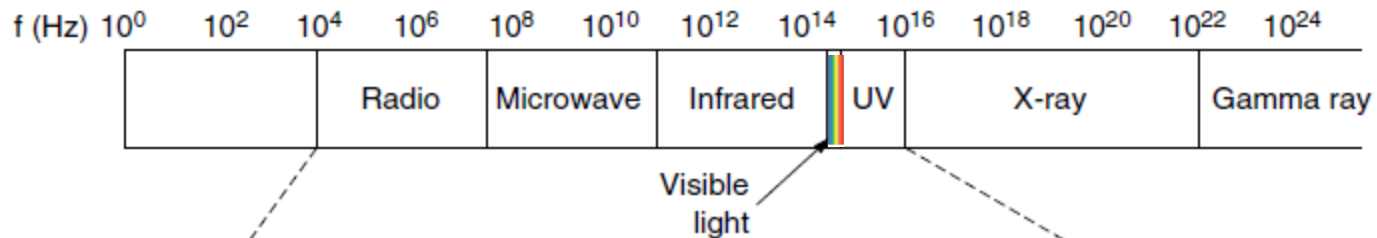
- mobility
- a wireless communication network is a solution in areas where cables are impossible to install (e.g. hazardous areas, long distances etc.)
- easier to maintain

- **disadvantages:**

- has security vulnerabilities
- high costs for setting the infrastructure
- unlike wired comm., wireless comm. is influenced by physical obstructions, climatic conditions, interference from other wireless devices

The Electromagnetic Spectrum

- When electrons move, they create electromagnetic waves that can propagate through space.



VLF = Very Low Frequency
 LF = Low Frequency
 MF = Medium Frequency
 HF = High Frequency
 VHF = Very High Frequency
 UHF = Ultra High Frequency
 SHF = Super High Frequency
 EHF = Extra High Frequency
 UV = Ultraviolet Light

Ranges of Bands

Band name	Frequency range
VLF (voice)	300 - 3000 Hz ($27 \cdot 10^2 \text{ Hz}$)
LF (Low)	3 - 30 kHz ($27 \cdot 10^3 \text{ Hz}$)
MF (Medium)	300- 3000 kHz ($27 \cdot 10^4 \text{ Hz}$)
HF (High)	3 - 30 MHz ($27 \cdot 10^5 \text{ Hz}$)
VHF (Very High)	30 - 300 MHz ($27 \cdot 10^6 \text{ Hz}$)
UHF (Ultra High)	300- 3000 MHz ($27 \cdot 10^7 \text{ Hz}$)
SHF (Super High)	3- 30 GHz ($27 \cdot 10^8 \text{ Hz}$)
EHF (Extremely High)	30- 300 GHz ($27 \cdot 10^9 \text{ Hz}$)

The Electromagnetic Spectrum

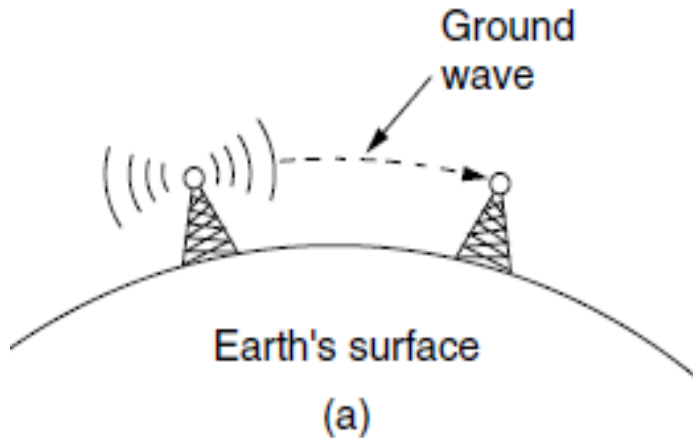
- The **radio, microwave, infrared,** and **visible light portions** of the spectrum can all be used for transmitting information by **modulating** the **amplitude, frequency,** or **phase** of the waves.
- **Ultraviolet light, X-rays,** and **gamma rays** would be even better, due to their higher frequencies, but they are hard to produce and modulate, do not propagate well through buildings, and are dangerous to living things.

Radio Transmission

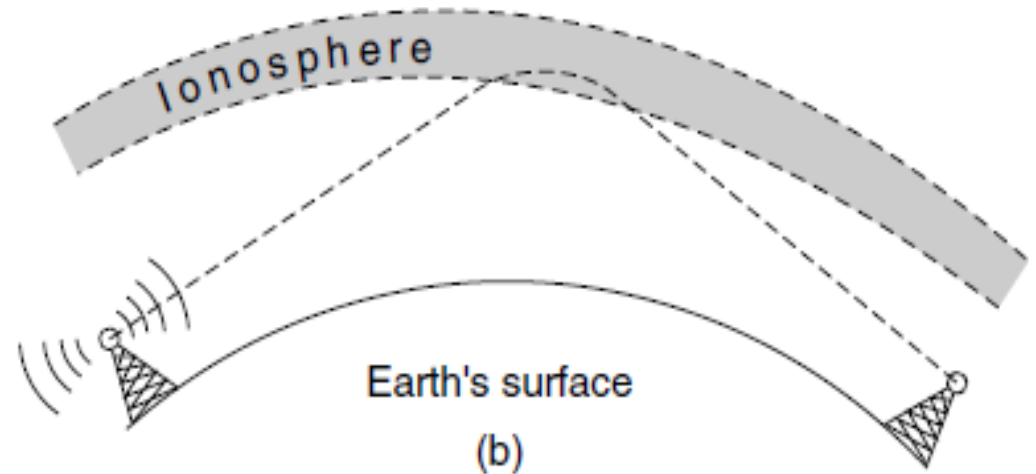
- Radio frequency (RF) waves are:
 - easy to generate,
 - can travel long distances,
 - and can penetrate buildings easily, so they are widely used for communication in both indoors and outdoors.

Radio waves also are omnidirectional, meaning that they travel in all directions from the source, so the transmitter and receiver do not have to be carefully aligned physically.

Radio propagation



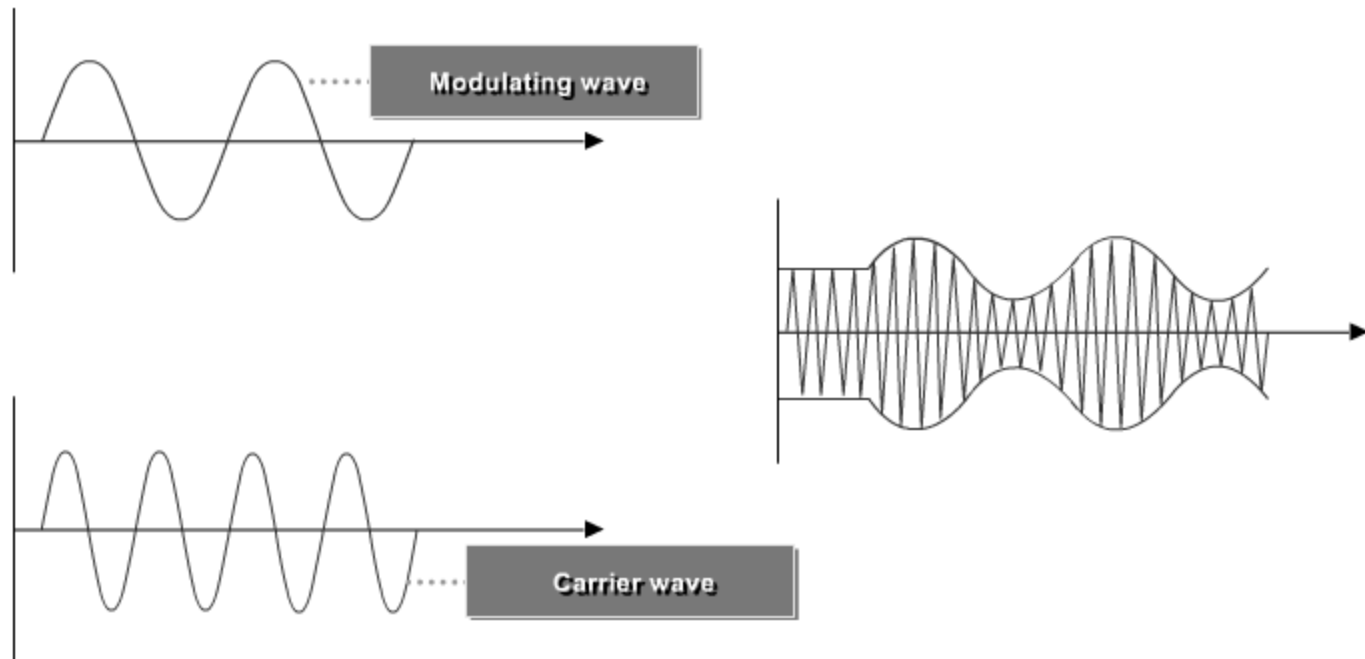
- In the VLF, LF, and MF bands, radio waves follow the ground.
- These waves can be detected for perhaps 1000 km at the lower frequencies.
- The **main problem** with using these bands for data communication is their low bandwidth.



- In the HF and VHF bands, the ground waves tend to be absorbed by the earth. The waves that reach the ionosphere, a layer of charged particles circling the earth at a height of 100 to 500 km, are refracted by it and sent back to earth.
- Under certain atmospheric conditions, the signals can bounce several times. Amateur radio operators (hams) use these bands to talk long distance. The military also communicate in the HF and VHF bands.

Modulation

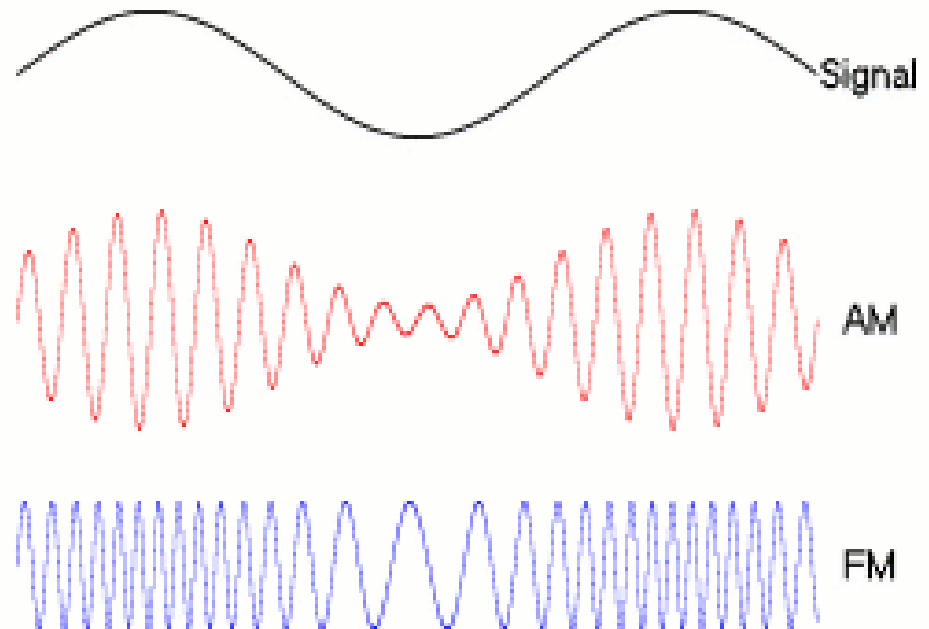
- modulation = adding information (e.g. voice) to a **carrier** electromagnetic (radio) signal



Modulation

The Modulation types are:

- Frequency Modulation (FM).
- Amplitude Modulation (AM).
- Phase Modulation (PM)



Microwave Transmission

- Above 100 MHz, the waves travel in nearly straight lines and can therefore be narrowly focused. Concentrating all the energy into a small **beam** by means of a parabolic antenna (like the familiar satellite TV dish) gives a much higher signal-to-noise ratio, but the transmitting and receiving antennas must be accurately aligned with each other.
- Microwaves travel in a straight line, so if the towers are too far apart, the earth will get in the way. Thus, repeaters are needed periodically. The higher the towers are, the farther apart they can be. The distance between repeaters goes up very roughly with the **square root** of the tower height. For **100-meter**-high towers, repeaters can be **80 km** apart.

Microwave Features

- Unlike radio waves at lower frequencies, microwaves **do not pass through buildings well**.
- Microwave communication is so **widely used** for long-distance telephone communication, mobile phones, television distribution.
- It has several **key advantages over fiber**. The main one is that **no right of way is needed to lay down cables**. By buying a small plot of ground every 50 km and putting a microwave tower on it, one can bypass the telephone system entirely.
- Microwave is also **relatively inexpensive**. Putting up two simple towers and putting antennas on each one may be cheaper than burying 50 km of fiber through a congested urban area or up over a mountain.
- Transmissions are **very susceptible to weather effects**, particularly rain.

Infrared Transmission

- infrared waves are widely used for **short-range communication**. The remote controls used for televisions use infrared communication.
- They are **relatively directional, cheap, and easy to build**.
- **Major drawback**: they do **not pass through solid objects**. In general, the waves behave more and more like light and less and less like radio.
- **Security** of infrared systems against eavesdropping is better than that of radio systems.
- No government license is needed to operate an infrared system, in contrast to radio systems, which must be licensed outside.