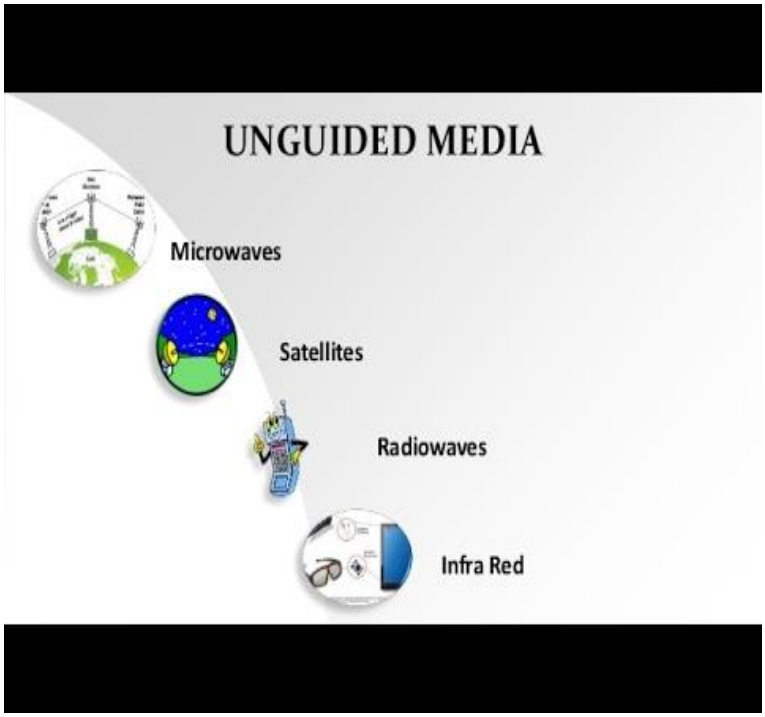
UNGUIDED MEDIA: WIRELESS

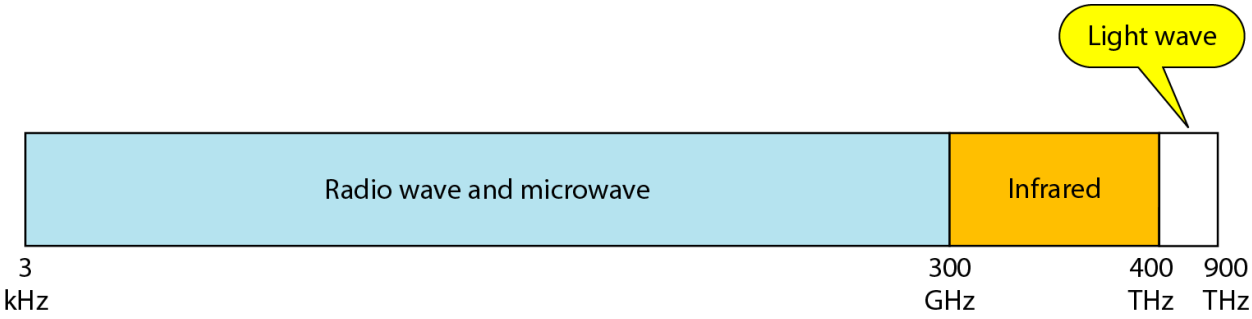
Unguided media transport electromagnetic waves without using a physical conductor, for unguided media, transmission and reception are achieved by means of an antenna. For transmission, the antenna radiates electromagnetic energy into the medium (usually air), and for reception, the antenna picks up electromagnetic waves from the surrounding medium. This type of communication is often referred to as wireless communication.

There are basically two types of configurations for wireless transmission: directional and omnidirectional. For the directional configuration, the transmitting antenna puts out a focused electromagnetic beam; the transmitting and receiving antennas must therefore be carefully aligned. In the omnidirectional case, the transmitted signal spreads out in all directions and can be received by many antennas. In general, the higher the frequency of a signal, the more it is possible to focus it into a directional beam.

- Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.



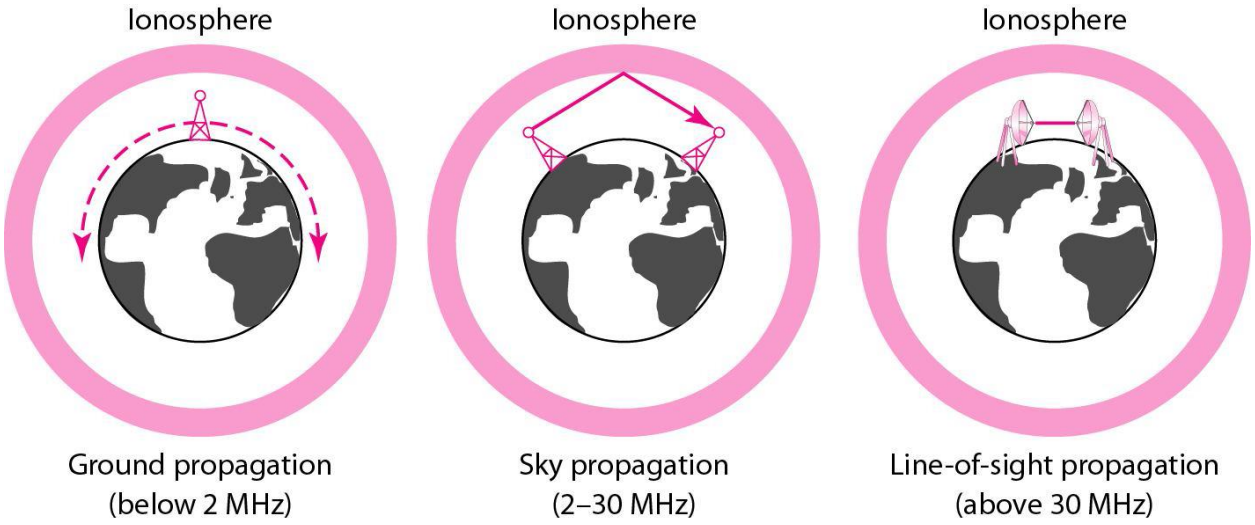
The figure below shows the part of the electromagnetic spectrum, ranging from 3 kHz to 900 THz, used for wireless communication.



Electromagnetic spectrum for wireless communication

- Unguided signals can travel from the source to destination in several ways:

ground propagation, sky propagation, and line-of-sight propagation, as shown in figure below:



- **In ground propagation**, radio waves travel through the lowest portion of the atmosphere, hugging the earth. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet. Distance depends on the amount of power in the signal: The greater the power, the greater the distance.
- **In sky propagation,** higher-frequency radio waves radiate upward into the ionosphere (the layer of atmosphere where particles exist as ions) where they are reflected back to earth. This type of transmission allows for greater distances with lower output power.
- **In line-of-sight propagation**, very high-frequency signals are transmitted in straight lines directly from antenna to antenna. Antennas must be directional, facing each other, Line-of-sight propagation is tricky because radio transmissions cannot be completely focused.

The section of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges, called bands. These bands are rated from very low frequency (VLF) to extremely high frequency (EHF). Table lists these bands, their ranges, and propagation methods.

Band	*Range*	*Propagation*
VLF (very low frequency)	3–30 kHz	Ground
LF (low frequency)	30–300 kHz	Ground
MF (middle frequency)	300 kHz–3 MHz	Sky
HF (high frequency)	3–30 MHz	Sky
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight
SHF (superhigh frequency)	3–30 GHz	Line-of-sight
EHF (extremely high frequency)	30–300 GHz	Line-of-sight

We can divide wireless transmission into three broad groups: radio waves, microwaves, and infrared waves. See Figure below:

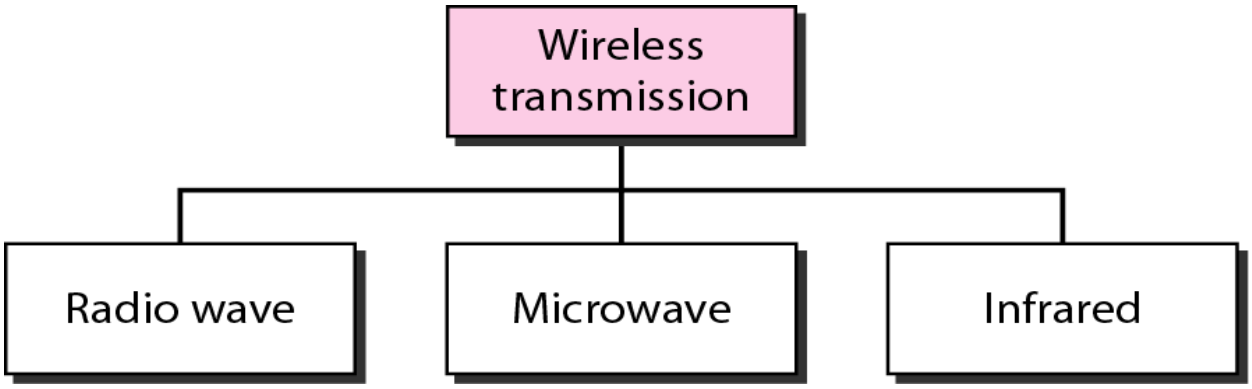


Figure show Wireless transmission waves

1. Radio Waves

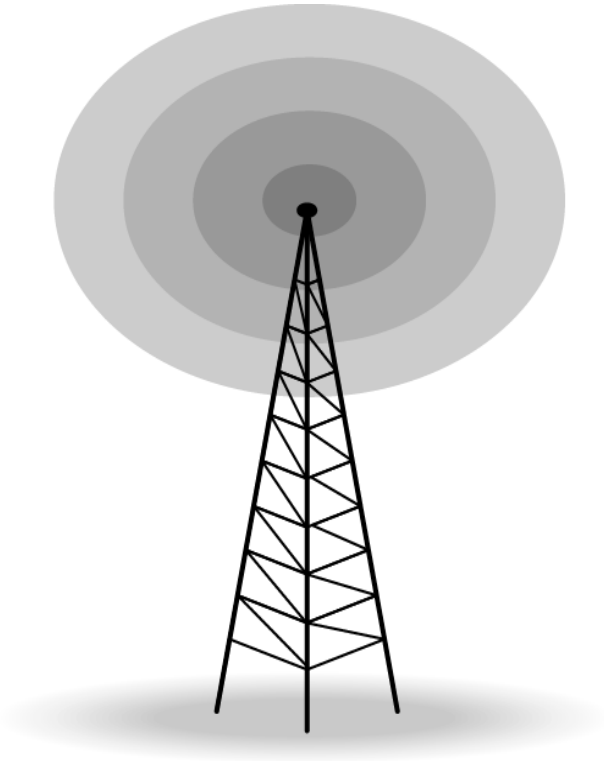
Although there is no clear limit distinction between radio waves and microwaves, electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves; waves ranging in frequencies between 1 and 300 GHz are called microwaves. However, the behavior of the waves, rather than the frequencies, is a better criterion for classification.

Radio waves, for the most part, are **omnidirectional**. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna sends waves that can be received by any receiving antenna. The omnidirectional property has a disadvantage, too.

The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band. Radio waves, particularly those waves that propagate in the sky mode, can travel long distances. This makes radio waves a good candidate for long-distance broadcasting such as AM radio (AM radio ranges from 535 to 1705 kHz). Radio waves, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, for example, an AM radio can receive signals inside a building. It is a disadvantage because we cannot isolate a communication to just inside or outside a building. The radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band. Using any part of the band requires permission from the authorities.

- **Omnidirectional Antenna**

Radio waves use omnidirectional antennas that send out signals in all directions. Based on the wavelength, strength, and the purpose of transmission, we can have several types of antennas. Figure below shows an omnidirectional antenna:



App1ications

The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. AM and FM radio (FM radio band goes from 88 to 108 MHz), television, and maritime radio are examples of multicasting.

2. Microwaves

Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are **unidirectional**. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

- **The following describes some characteristics of microwave propagation:**

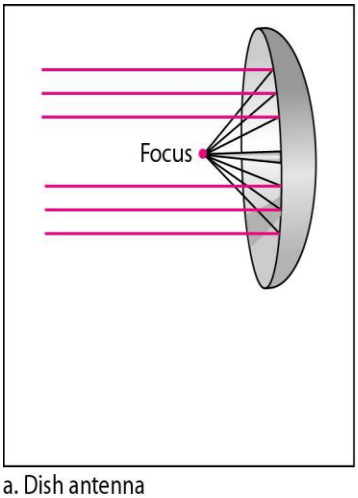
1. Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall. The curvature of the earth as well as other blocking obstacles does not allow two short towers to communicate by using microwaves. Repeaters are often needed for long-distance communication.
2. Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.
3. The microwave band is relatively wide, almost 299 GHz, and hence it provides a higher data rate rather than data rate provided by radio wave band.
4. Use of certain portions of the band requires permission from authorities.

Unidirectional Antenna

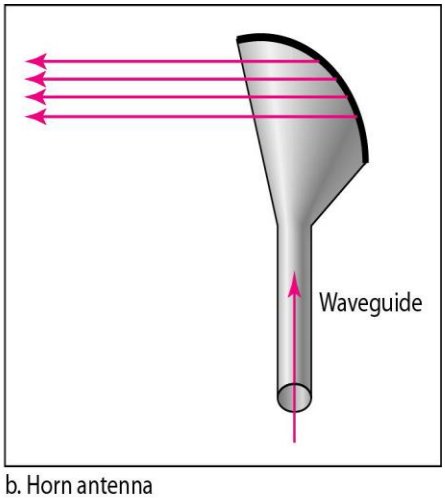
Microwaves need unidirectional antennas that send out signals in one direction. Two types of antennas are used for microwave communications: the parabolic dish and the horn see figure below:

Applications

Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communication is needed between the sender and the receiver. The cellular phones, and wireless LANs are examples of the applications that use the microwave signals.



a. Dish antenna



b. Horn antenna

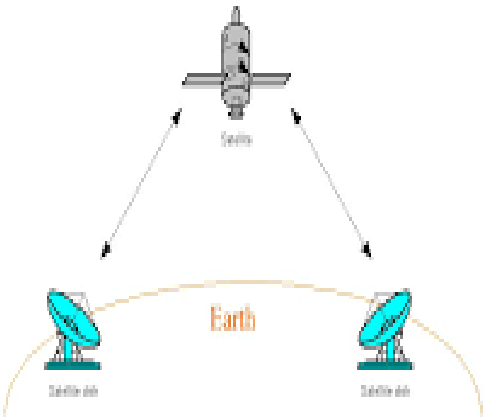
2.1 Satellite Microwave

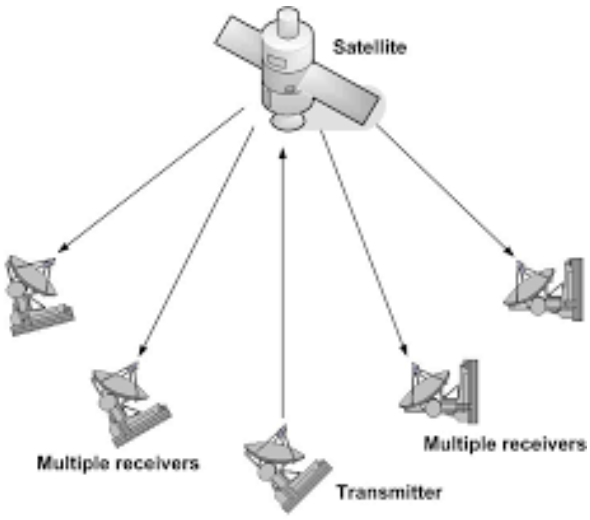
A communication satellite is, in effect, a microwave relay station. It is used to link two or more ground-based microwave transmitter/receivers, known as earth stations, or ground stations. **The** satellite receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink). A single orbiting satellite will operate on a number of frequency bands, called transponder channels, or simply transponders. Figure below depicts, in a general way, two common configurations for satellite communication. In the first, the satellite is being used to provide a point-to-point link between two distant ground-based antennas. In the second, the satellite provides communications between one ground-based transmitter and a number of ground-based receivers.

To remain stationary, the satellite must have a period of rotation equal to the earth's period of rotation. The communication satellite is a technological revolution as important as fiber optics. Among the most important applications for satellites are:

- Television distribution
- Long-distance telephone transmission
- Private business networks

Point-to-Point Link via Satellite Microwave





(b) Broadcast link via satellite microwave

The optimum frequency range for satellite transmission is 1 to 10 GHz. Below 1 GHz, there is significant noise from natural sources, including galactic, solar, and atmospheric noise, and human-made interference from various electronic devices. Above 10 GHz, the signal is severely attenuated by atmospheric absorption and precipitation.

2.2 Terrestrial Microwave

The antenna is fixed rigidly and focuses a narrow beam to achieve line-of-sight transmission to the receiving antenna. To achieve long-distance transmission, a series of microwave relay towers is used; point-to-point microwave links are strung together over the desired distance.

The primary use for terrestrial microwave systems is in long-haul telecommunications service, as an alternative to coaxial cable or optical fiber. The microwave facility requires far fewer amplifiers or repeaters than coaxial cable over the same distance, but requires line-of-sight transmission.

3. Infrared (IR)

Infrared waves, with frequencies from 300 GHz to 400 THz can be used for short- range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room.

When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

Applications

The infrared band, almost 400 THz, has an excellent potential for data transmission. Such a wide bandwidth can be used to transmit digital data with a very high data rate. The Infrared Data Association (IrDA), an association for use of infrared waves, has established standards for using these signals for communication between devices such as keyboards, mice, PCs, and printers.

For example, some manufacturers provide a special port called the IrDA port that allows a wireless keyboard to communicate with a PC. Infrared signals defined by IrDA transmit through **line of sight.**

4. Lightwave transmission:

Unguided optical signaling has been in use for centuries, it offers

1. very high bandwidth.
2. very low cost.
3. It is also relatively easy to install.

A disadvantage is that laser beams cannot penetrate rain or thick fog, but they normally work well on sunny days. Heat from the sun during the daytime causes convection currents to rise up from the roof of the building, this turbulent air, diverts the beam and make it dance around the detector.