Computer Network

Unguided Media

- **Miciowave Transmission**

Above 100 MHz, the waves travel in straight lines and can thus be narrowly focused. Concentrating all the energy into a small beam using a parabolic antenna (like the satellite TV dish) gives a much higher signal to noise ratio, but the transmitting and receiving antennas must be accurately aligned with each other. Before the advent of fiber optics, these microwaves formed the heart of the long distance telephone transmission system. In order to overcome the problems of line-of-sight and power amplification of weak signals, microwave systems use repeaters at intervals of about 25 to 30 km in between the transmitting and receiving stations.

Unlike radio waves, at lower frequencies, microwaves do not pass through buildings well. In addition/ even though the beam may be well focused at the transmitter, there is still some divergence in space. Some waves may be reflected off low-lying atmospheric layers and may take slightly longer to arrive than direct waves. The delayed waves may arrive out of phase with the direct wave and thus cancel the signal. This effect is called multipath Fading. It is often a serious problem in microwave communication systems.

The first repeater is placed in line-of-sight of the transmitting station and the last repeater is placed in line-of-sight of the receiving station. Two consecutive repeaters are also placed in line-of-sight of each other. The data signals are received, amplified and re-transmitted by each of these stations. Since microwaves travel in a straight line, if the towers are too far apart, the earth curvature will get in the way. Consequently, repeaters are needed periodically. The higher the towers, the further 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 spaced 80 km apart.

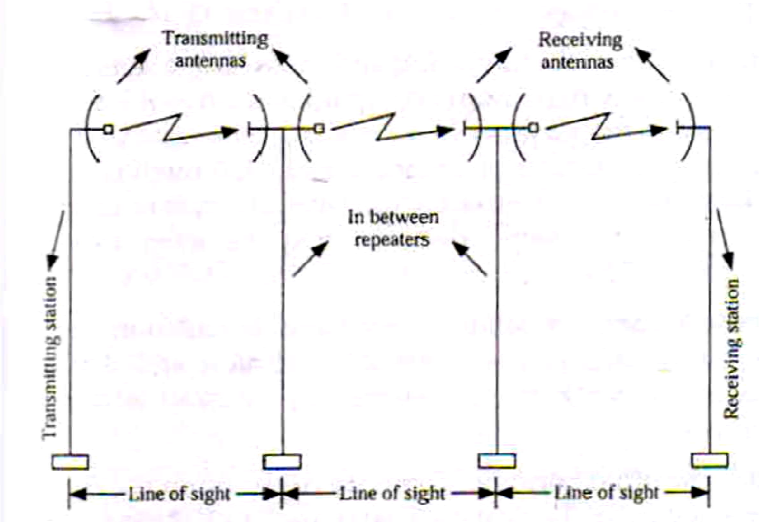


Illustration of microwave communication from one point to another

Characteristics of Microwave Communication

Microwave transmission depends on the weather and frequency. The frequency band of 10 GHz is in the routine use. Microwave communication is widely used for long-distance telephone communication, cellular telephones, television distribution and other uses resulting in a severe shortage of spectrum. The following are the characteristics of microwave communications:

i. Microwave is inexpensive as compared to fiber optics system. For example, placing up two simple towers and antennas on each side may be cheaper than burying 50 km of fiber through a congested area.

ii. Microwave systems permit data transmission rates of about 16 Giga bits per second (1 Giga = 10^9). At such high frequencies, microwave systems can carry 250,000 voice channels at the same time. They are mostly used to link big metropolitan cities which have heavy telephone traffic between them.

Types of Microwave Communication Systems

There are two types of microwave data communication systems. These are:

- **Terrestrial**
- **Satellite**

- **Terrestrial Microwave Systems**

Terrestrial microwave systems typically use directional parabolic antennas to send and receive signals in the lower Giga hertz range. The signals are highly focused and the physical path must be line-of-sight. Relay towers and repeaters are used to extend signals. Terrestrial microwave systems are used whenever cabling is cost-prohibitive, such as in hilly areas or crossing rivers, etc.

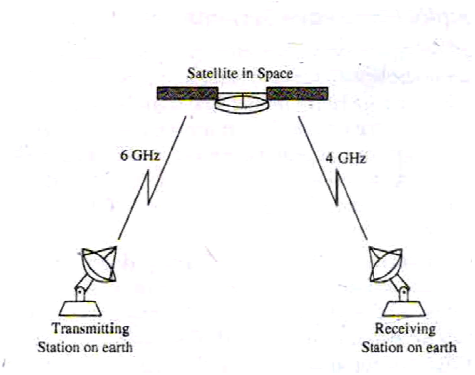
Because terrestrial microwave system does not use cables, microwave links often connect separate buildings where cabling would be too expensive, difficult to install or prohibited. For example, if two buildings are separated by a public road, you may not be able to get permission to install cable over or under the road. Microwave links would be a good choice in this type of situation.

Terrestrial microwave systems have the following characteristics:

- **Frequency range:** Most terrestrial microwave systems produce signals in the low Giga hertz range usually at 4 to 6 GHz and 21 to 23 GHz.
- **Cost:** Short-distance systems can be relatively inexpensive and they are effective in the range of hundreds of meters. Long-distance systems can be very expensive.
- **Installation:** Line-of-sight requirements for microwave systems can make installation difficult. Antennas must be carefully aligned. Also, because the transmission must be line-of-sight, suitable trans-receiver sites can be a problem.
- **Bandwidth capacity:** Capacity varies depending on the frequency used but, typically, data rates are from 1 to 10 Mbps.
- **Attenuation:** It is affected by frequency, signal strength, antenna size and atmospheric conditions. Normally, over short distances, attenuation is not significant. But, rain and fog can adversely affect higher frequency microwaves.
- **Electromagnetic Interference (EMI):** Microwave signals are vulnerable to EMI, jamming and eavesdropping. In ever dropping, outside agent can listen to the messages passing between the sender and the receiver. Microwave systems are also affected by atmospheric conditions.

❖ **Satellite Microwave Systems**

Satellite microwave systems transmit signals between directional parabolic antennas as shown in figure. Like terrestrial microwave systems, they use low gig a hertz frequencies and must be in line- of-sight. The main difference with satellite systems is that one antenna is on the satellite in geo-synchronous orbit about 36,000 kilometers (22,300 miles) above the equator. Thus, satellite microwave systems can reach the most remote places on earth and communicate with mobile devices.



A communication satellite is basically a microwave relay station placed precisely at 36,000 km above the equator where its orbit speed exactly matches the earth's rotation speed. Since a satellite is positioned in a geo-synchronous orbit (i.e. the orbit where the speed of the satellite matches the earth's rotation speed), then it appears to be stationary relative to earth and always stays over the same point with respect to earth. This allows a ground station to aim its antenna at a fixed point in the sky.

Satellite communication

In satellite communication, microwave signals at 6 GHz (read as Giga hertz = 109 Hz) are transmitted from a transmitter on earth to a satellite positioned in space. By the time this signal reaches the satellite, it becomes weak as it travels a distance of 36,000 km. The transponder in a satellite amplifies the weak signals and sends them back to the earth at a frequency of 4 GHz. These signals are received at a receiving station on the earth. It may be noted that the transmitting frequency is different from the receiving frequency of the satellite. This is done to avoid interference of the powerful re-transmitted signal with the weak incoming signal.

Satellite microwave systems have the following characteristics:

- **Frequency range:** Satellite links operate in the low Giga hertz range, typically 4-6 GHz and 11-14 GHz.
- **Cost:** The cost of building and launching a satellite is extremely high. Satellite communications are expensive; the cost of cable to cover the same distance may be even more expensive.
- **Installation:** Satellite microwave installation for orbiting satellites is extremely technical and difficult. The earth-based systems require exact adjustments.
- **Bandwidth capacity:** Capacity depends on the frequency used. Typical data rates are 1-to 10 Mbps.
- **Attenuation:** Attenuation depends on frequency power, antenna size and atmospheric conditions. Higher frequency microwaves are more affected by rain and fog.

Advantages and Limitations of Satellite Microwave Systems

The main advantage of satellite communication is that it is a single microwave relay station visible from any point of area on the earth. For example satellites used for national transmission are visible from all parts of the country. Thus, transmission and reception can occur between any two random chosen places in that area. Moreover, transmission and reception costs are independent of the distance between the two points. In addition, a transmitting station can receive back its own transmission and check whether the satellite

has transmitted the information correctly. If an error is detected, the data would be re-transmitted.

Band	Frequencies (GHz)	Downlink (GHz)	Uplink(GHz)	Problems
C	4/6	3.7-4.2	5.925-6.425	Terrestrial interference
Ku	11/4	11.7-12.2	14.0-14.5	Rain
Ka.	20/30	17.7-21.7	27.5-30.5	Rain; equipment cost

Exercise:

1: What is Microwave communication?
2: Write the characteristics of Microwave Communication.
2: How many types of Microwave Communication?
2: Compare Terrestrial and Satellite?