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Antenna & Propagation

Introduction

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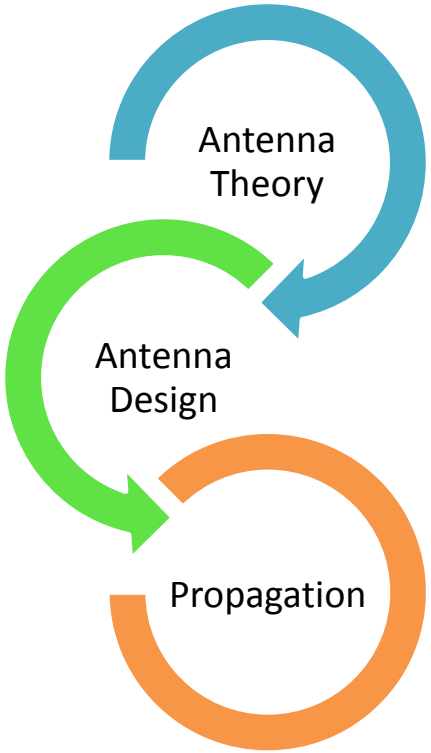
Syllabus Synopsis

In this course, the student will be exposed to the parameters of antenna such as radiation pattern, impedance, directivity, gain, polarization. Design principles to design various types of antenna are will be taught throughout the course. Students will be exposed to the techniques for estimating the propagation performance of a communication channel.

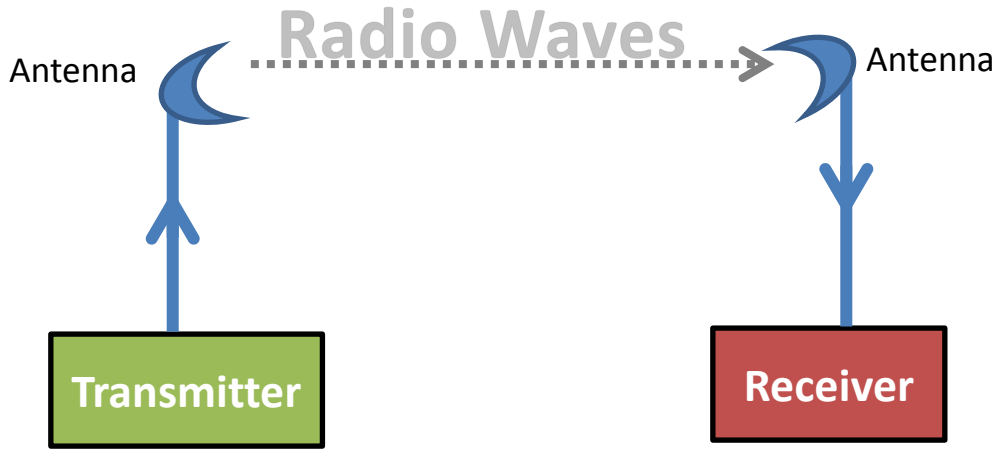


Course Outcome

At the end of this course student should be able to:

- ❑ Characterize the fundamentals of antenna operation and radio propagation.
- ❑ Design and evaluate various antennas to meet application requirements.
- ❑ Describe and analyze the characteristic of the atmospheric and surrounding effects on radio wave propagation.

Basic Communication Systems



- Wireless communication systems consist of:
  - ✓ Transmitter: converts the electrical signal into a signal
  - ✓ Antennas: radiates electromagnetic energy (radio waves) travel through the air
  - ✓ Receiver: accepts the transmitted message from the channel and converts it back
- In some cases, transmitter and receiver are on same device, that is called as transceivers.

Basic Knowledge of Antenna

- Every radio requires an antenna.
- Antennas come in all shapes and sizes. Shapes and sizes depend on the frequency the antenna is trying to receive.
- Ranges from long stiff wire (as in car radios) to large satellite dishes (as used by NASA).
- For satellites that are millions of miles away NASA uses antenna dishes that 200 feet wide.

Example of Antennas Image

Car Radio Antenna

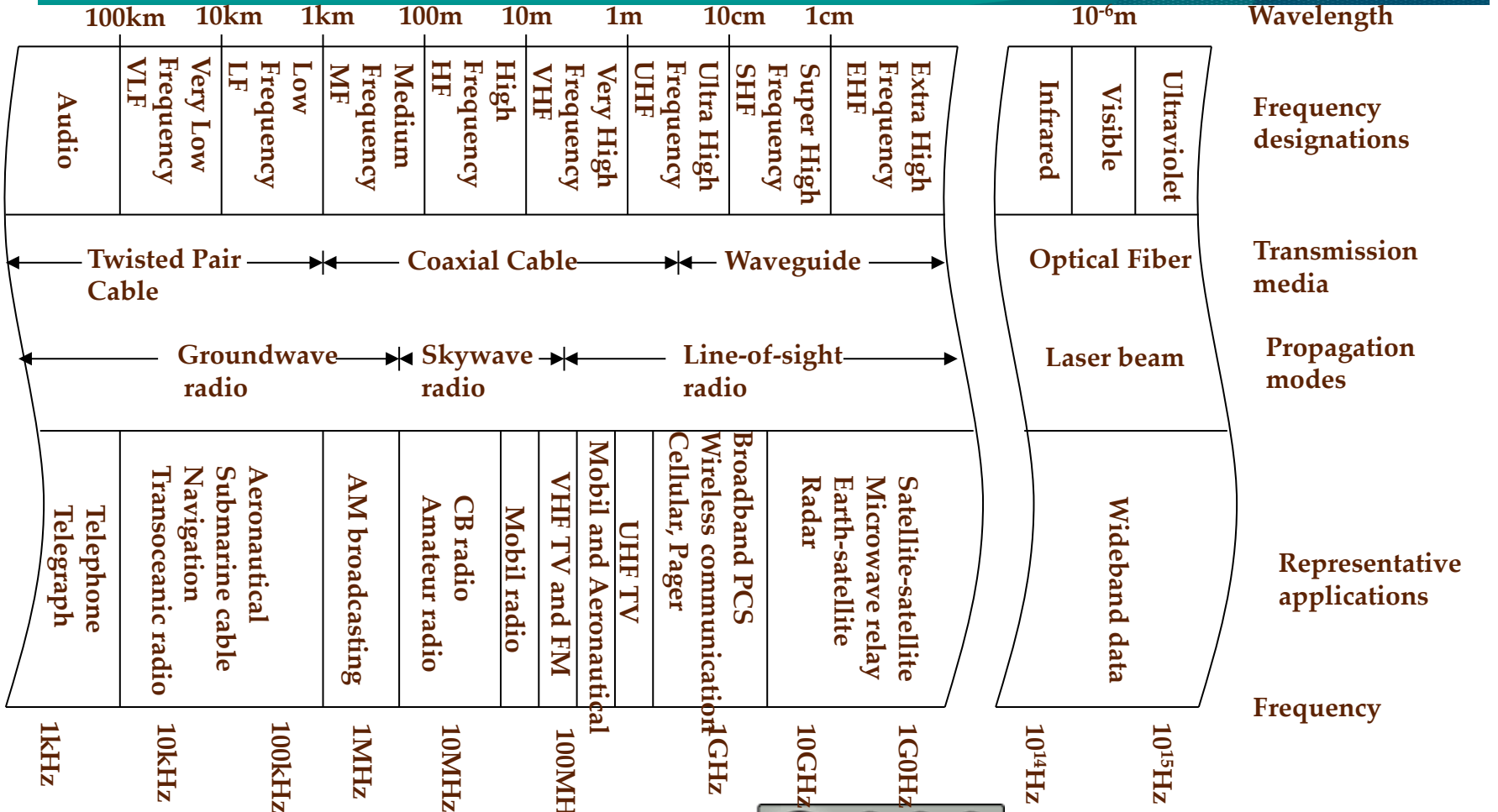
Source: https://commons.wikimedia.org

By: Mark Wagner

Satellite Dish Antenna

Source: pixabay.com

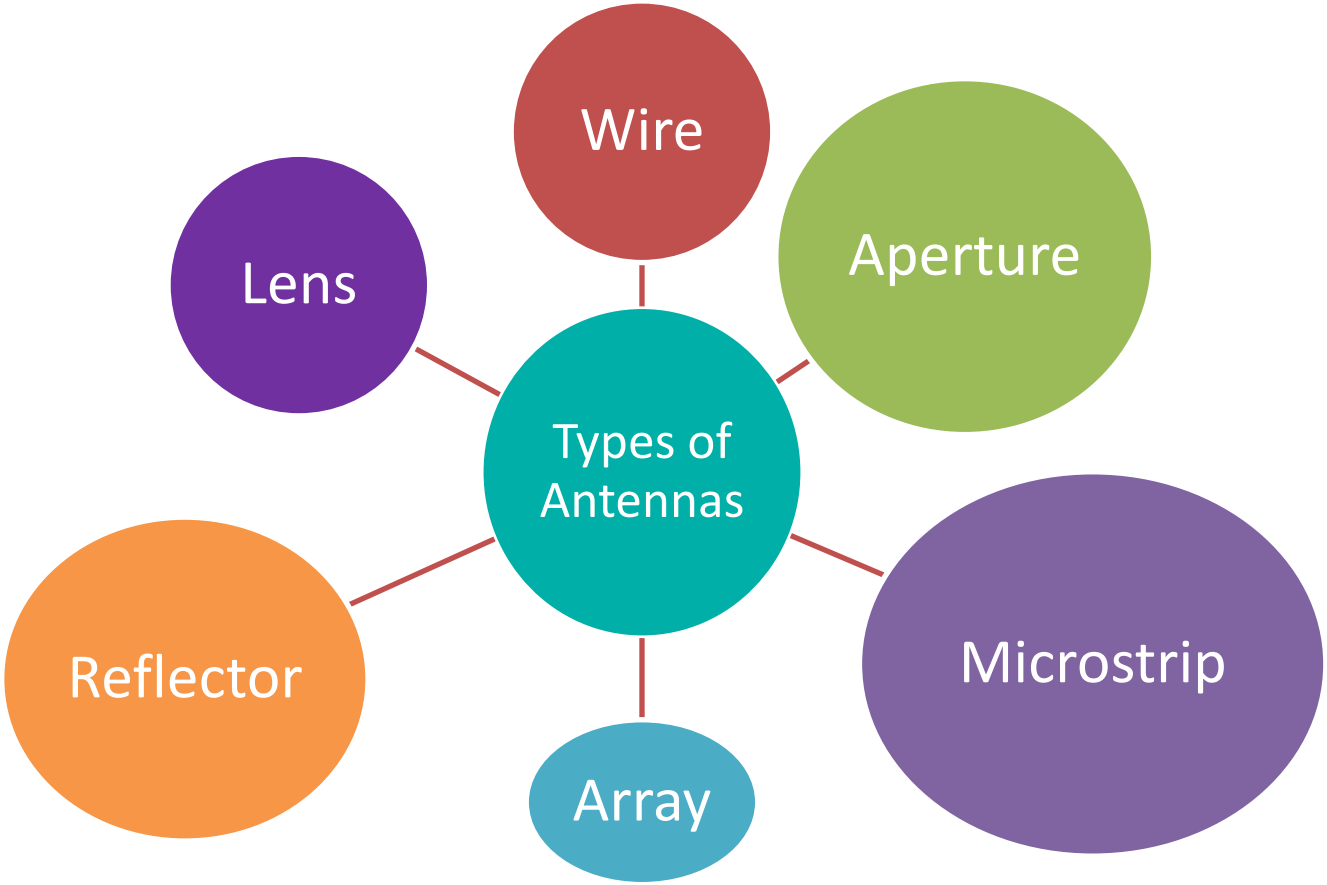
Frequency Spectrum



Radio Frequencies Band Names

Band Name	Abbr.	Frequency	Wavelength	Examples of Usage
Extremely Low Frequency	ELF	3-30 Hz	10-100 Mm	Military application
Super Low Frequency	SLF	30-300 Hz	1-10 Mm	Power lines
Ultra Low Frequency	ULF	0.3-3 kHz	0.1-1 Mm	Monitoring earthquake
Very Low Frequency	VLF	3-30 kHz	10-100 km	Submarines
Low Frequency	LF	30-300 kHz	1-10 km	Beacons
Medium Frequency	MF	0.3-3 MHz	0.1-1 km	AM broadcast
High Frequency	HF	3-30 MHz	10-100 m	Short-wave radio
Very High Frequency	VHF	30-300 MHz	1-10 m	FM and TV broadcast
Ultra High Frequency	UHF	0.3-3 GHz	0.1-1 m	TV, WiFi, mobile phones, GPS
Super High Frequency	SHF	3-30 GHz	10-100 mm	Radar, satellites, WLAN data
Extremely High Frequency	EHF	30-300 GHz	1-10 mm	Radar, automotive, data

Types of Antennas



Basic of Wave Propagation

- There is very important circumstance in the wireless communication, the physical environment over which radio waves travel.

- Radio waves can take many different paths to get from transmitter to receiver.

Propagation Techniques

A signal can be propagated in THREE (3) ways:

1. Ground-Wave Propagation

- Frequency < 2 MHz

2. Sky-Wave Propagation

- Frequency between 2 MHz and 30 MHz

3. Space-Wave (L.O.S)* Propagation

- Frequency > 30 MHz

*L.O.S = Line of Sight

Radio Wave & Transmission Environment

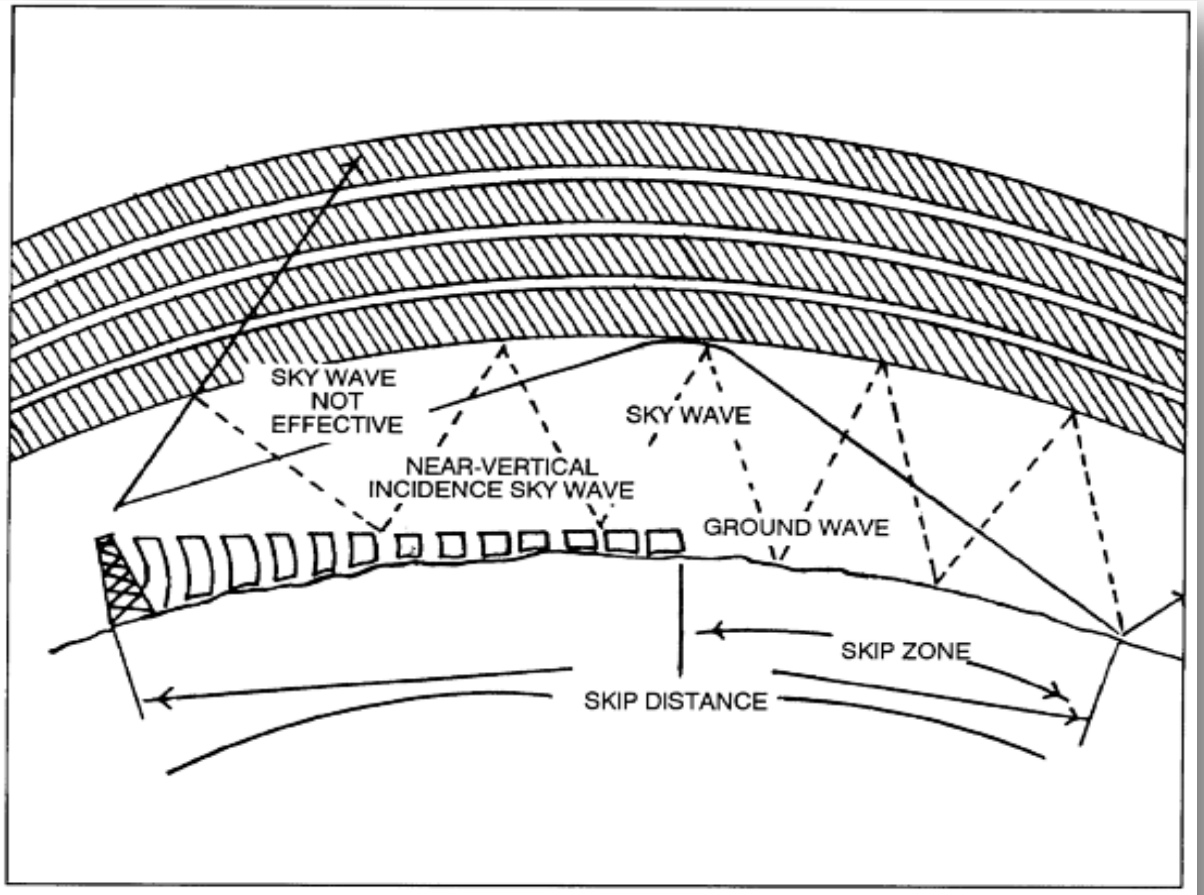
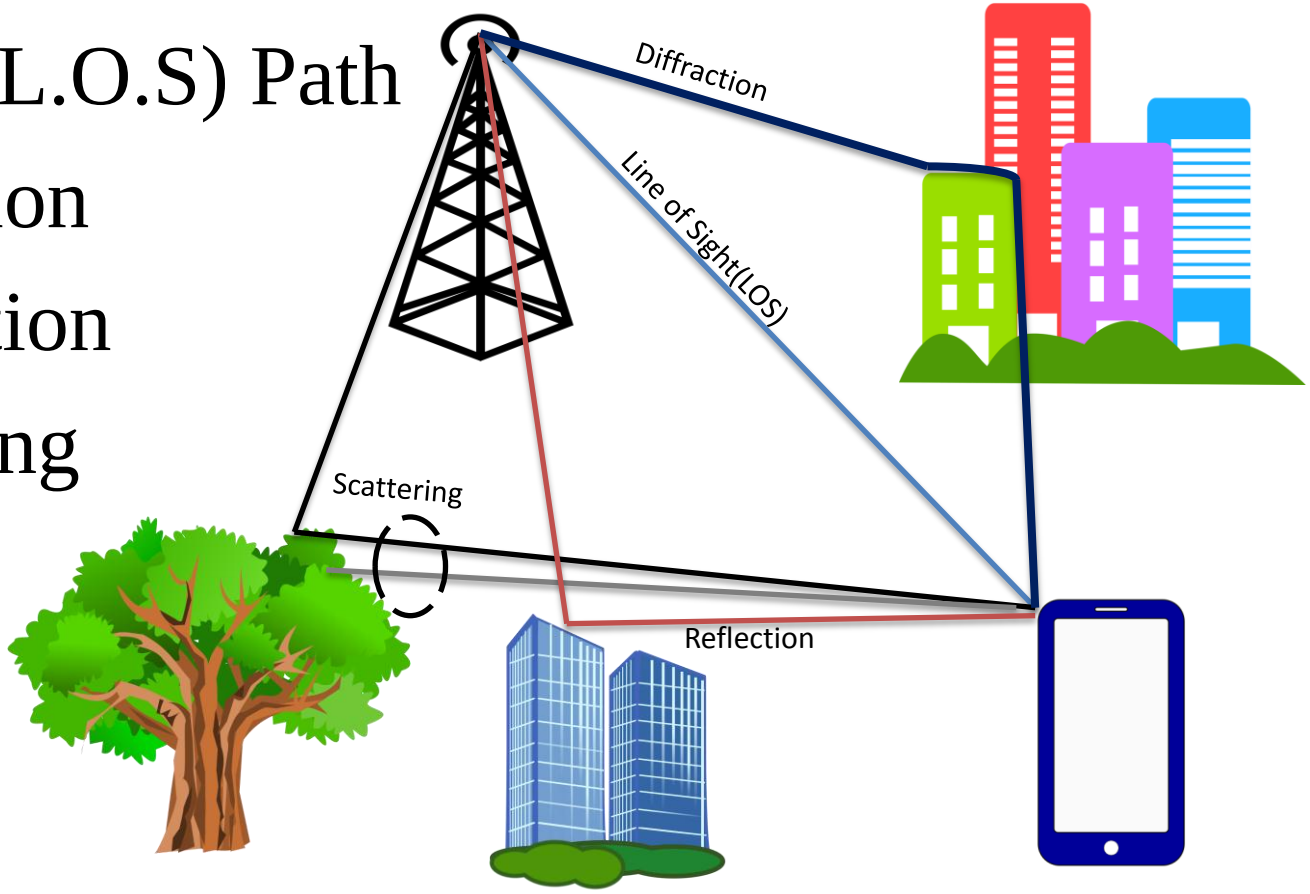


Figure D-4. HF skip zone and use of NVIS.

Source: http://www.globalsecurity.org
By U.S Army

Propagation Mechanism

- Direct (L.O.S) Path
- Reflection
- Diffraction
- Scattering



Challenges of Travelling Waves

- Essentially, the radio waves interact with the physical environment along each of these paths.

- There are typically (unless you are in free-space) many paths from the transmitter to the receiver.

- Challenges occurred in travelling :
  - ✓ Multipath
  - ✓ Fading
  - ✓ Distortion

Summary

1. Basic Antenna Operation:
   - ✓ Core component in radio system
   - ✓ Works in both transmitter /receiver
   - ✓ Design influenced heavily on operational frequency

2. Radio Propagation:
   - ✓ physical environment over which radio waves travel
   - ✓ Challenges – multipath, fading, distortion

References

[1] C.A. Balanis:"Antenna Theory: Analysis & Design", John Wiley & Sons, 2012.

[2] Stutzman and Thiele, *Antenna Theory and Design*, John Wiley, 2012.

[3] T. A. Milligan, "Modern Antenna Design" John Wiley, 2nd edition, 2005.

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