Technician License Course
Chapter 4

Lesson Plan Module 8 – Propagation

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Radio Wave Propagation: Getting from Point A to Point B

- Radio waves *propagate* in many ways depending on…
  - Frequency of the wave
  - Characteristics of the environment
- We will discuss three basic ways:
  - Line of sight
  - Ground wave
  - Sky wave

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Line-of-Sight

- Radio energy can travel in a straight line from a transmitting antenna to a receiving antenna – called the *direct path*
  - There is some attenuation of the signal as the radio wave travels due to spreading out
- This is the primary propagation mode for VHF and UHF signals.

Ground Wave

- At lower HF frequencies radio waves can follow the Earth's surface as they travel.
- These waves will travel beyond the range of line-of-sight.
- Range of a few hundred miles on bands used by amateurs.

Reflect, Refract, Diffract

- Radio waves are reflected by any conductive surface
  - Ground, water, buildings
- *Refraction* or bending occurs when waves encounter a medium having a different speed of light, such as water or an electrical feed line.

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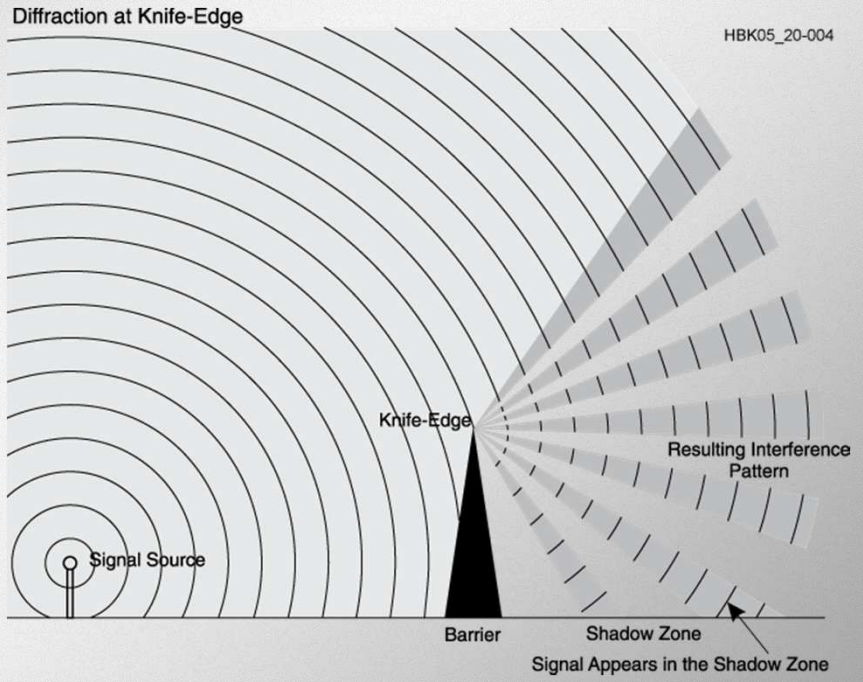
Reflect, Refract, Diffract

- *Diffraction* occurs when a wave encounters a sharp edge (*knife-edge propagation)* or corner



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VHF and UHF Propagation

- Range is slightly better than visual line of sight due to gradual refraction (bending), creating the *radio horizon*.
- UHF signals penetrate buildings better than HF/VHF because of the shorter wavelength.
- Buildings may block line of sight, but reflected and diffracted waves can get around obstructions.
- *Multi-path* results from reflected signals arriving at the receiver by different paths and interfering with each other.
  - *Picket-fencing* is the rapid fluttering sound of multi-path from a moving transmitter

“Tropo” - Tropospheric Propagation

- The troposphere is the lower levels of the atmosphere – to about 30 miles high
- Radio waves can be reflected or *scattered* by clouds, rain, and density variations in the troposphere – range up to about 300 miles
- Temperature inversions and weather fronts can form *ducts* that trap and conduct VHF and UHF radio waves for hundreds of miles

The Ionosphere

- A region from 30 to 260 miles above the surface of the Earth
- Atmosphere thin enough for atoms to be ionized by solar ultraviolet radiation
- Ions are electrically conductive

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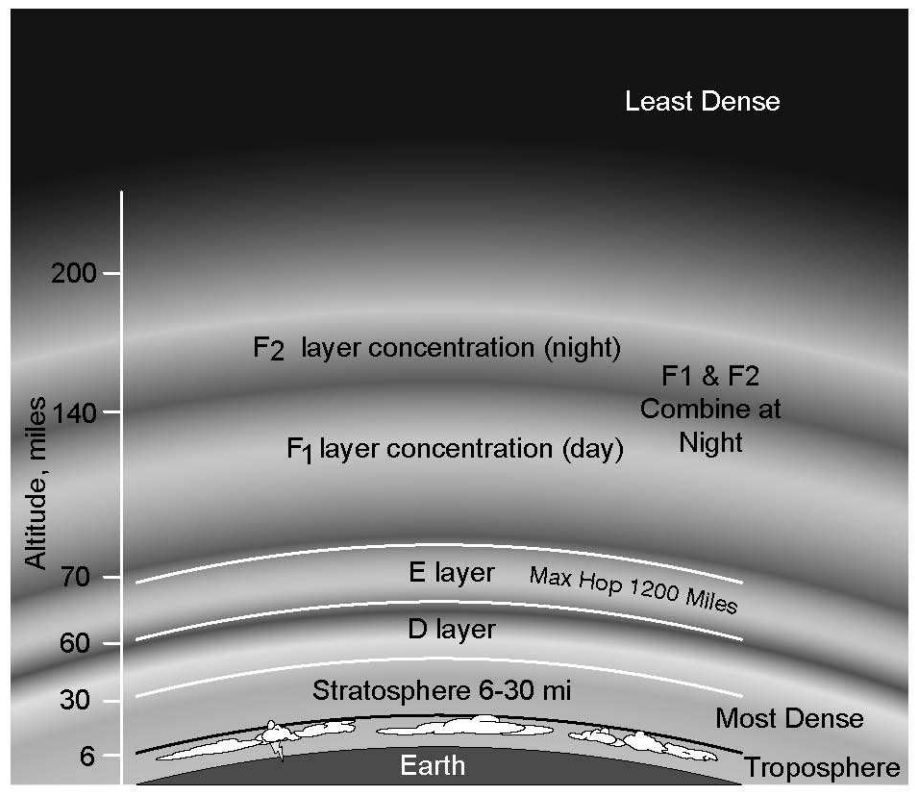
Ionospheric Levels

- Because of varying density, the ionosphere forms layers with different amounts of ionization
- Ionization varies with solar illumination (hour to hour) and intensity of solar radiation
- Higher ionization refracts or bends radio waves more strongly



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Sunspot Cycle

- The level of ionization depends on the intensity of radiation from the Sun.
- Radiation from the Sun varies with the number of sunspots on the Sun's surface.
  - High number of sunspots results in high levels of ionizing radiation emitted from the Sun.
- Sunspot activity follows an 11-year cycle.

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The Ionosphere – An RF Mirror

- The ionosphere can refract (bend) radio waves back to Earth – acts like reflection
- Most refraction of amateur frequencies occurs in the F layer

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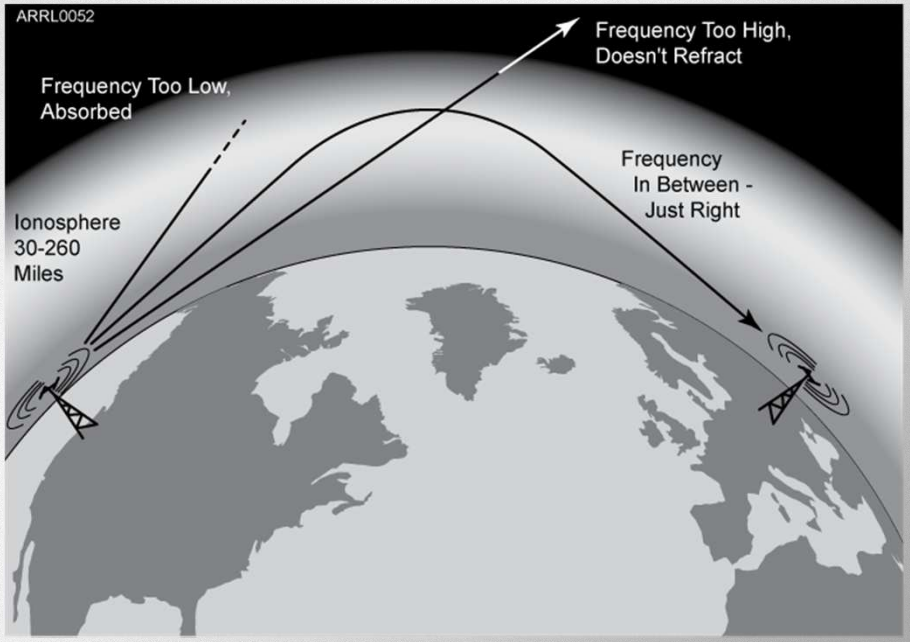
The Ionosphere – An RF Mirror

- Reflection depends on frequency and angle of incidence.
- Too high a frequency or angle and the waves are lost to space.



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The Ionosphere – An RF Mirror

- Sky-wave or skip propagation is responsible for most over-the-horizon propagation on HF and low VHF (10 and 6 meters) during peaks of the sunspot cycle.
- Skip is very rare on the 144 MHz and higher UHF bands.
- Each ground-to-sky-to-ground trip is called a *hop*.

The Ionosphere – An RF Mirror

- Signals can take many paths through the ionosphere.
- Randomly combining at the receiving antenna, signals can partially cancel, creating irregular fading as the ionosphere changes.
  - The resulting echo and flutter distort speech and CW.
  - Fading causes data errors for digital signals.

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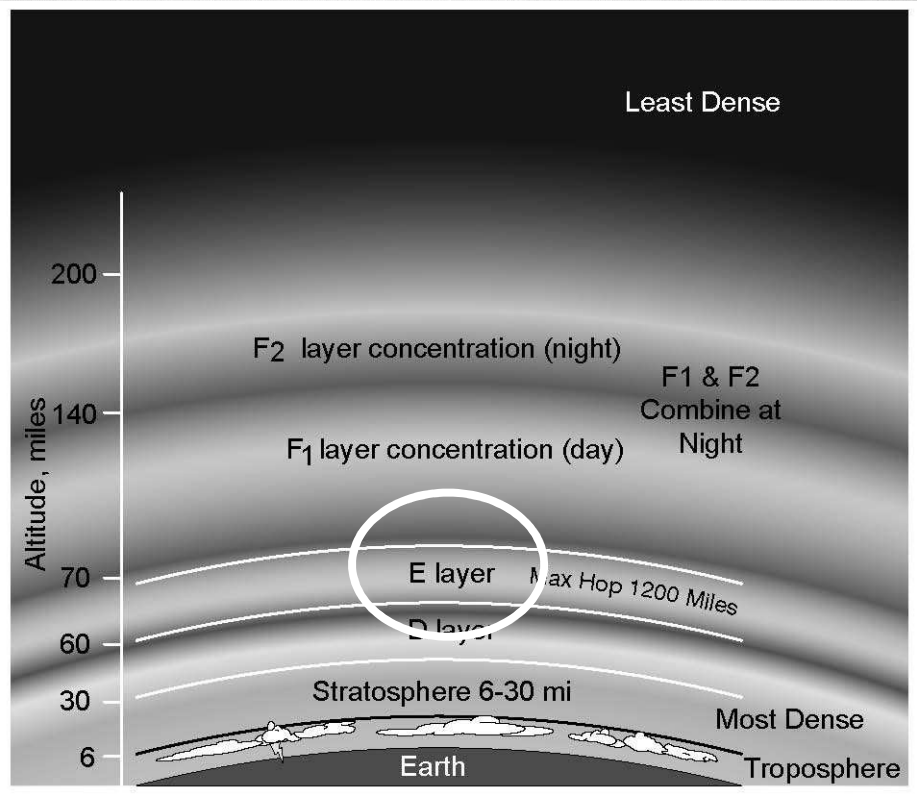
Sporadic E (Es) and Aurora

- Highly ionized patches of the E layer can reflect HF and VHF signals – best on 10, 6, and 2 meters.
- Aurora near the north and south poles can also reflect VHF and UHF waves with a distinctive distorted sound.



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Meteor Scatter

- Thousands of meteors enter the Earth's atmosphere every day – most quite small.
- Meteors leave trails of highly ionized gas that last for several seconds.
- Trails can reflect radio waves – called *meteor scatter.* The best band for this is 6 meters.
- Mostly in the E layer, meteor scatter and sporadic E supports contacts up to about 1500 miles.

Practice Questions

What should you do if another operator reports that your station's 2 meter signals were strong just a moment ago, but now they are weak or distorted?

A. Change the batteries in your radio to a different type

B. Turn on the CTCSS tone

C. Ask the other operator to adjust his squelch control

D. Try moving a few feet, as random reflections may be causing multi-path distortion

T3A01 HRLM (4-2)

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T3A01 HRLM (4-2)

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Why are UHF signals often more effective from inside buildings than VHF signals?

A. VHF signals lose power faster over distance

B. The shorter wavelength allows them to more easily penetrate the structure of buildings

C. This is incorrect; VHF works better than UHF inside buildings

D. UHF antennas are more efficient than VHF antennas

T3A02 HRLM (4-2)

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T3A02 HRLM (4-2)

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What term is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting?

A. Flip-flopping
B. Picket fencing
C. Frequency shifting
D. Pulsing

T3A06 HRLM (4-2)

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T3A06 HRLM (4-2)

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Which of the following is a likely cause of irregular fading of signals received by ionospheric reflection?

A. Frequency shift due to Faraday rotation

B. Interference from thunderstorms

C. Random combining of signals arriving via different paths

D. Intermodulation distortion

T3A08 HRLM (4-2)

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T3A08 HRLM (4-2)

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What may occur if data signals propagate over multiple paths?

A. Transmission rates can be increased by a factor equal to the number of separate paths observed

B. Transmission rates must be decreased by a factor equal to the number of separate paths observed

C. No significant changes will occur if the signals are transmitting using FM

D. Error rates are likely to increase

T3A10 HRLM (4-2)

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T3A10 HRLM (4-2)

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Which part of the atmosphere enables the propagation of radio signals around the world?

A. The stratosphere

B. The troposphere

C. The ionosphere

D. The magnetosphere

T3A11 HRLM (4-3)

ARRL The national association for AMATEUR RADIO

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T3A11 HRLM (4-3)

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Why are direct (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?

A. They are too weak to go very far

B. FCC regulations prohibit them from going more than 50 miles

C. UHF signals are usually not reflected by the ionosphere

D. They collide with trees and shrubbery and fade out

T3C01 HRLM (4-3)

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T3C01 HRLM (4-3)

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Which of the following might be happening when VHF signals are being received from long distances?

A. Signals are being reflected from outer space

B. Signals are arriving by sub-surface ducting

C. Signals are being reflected by lightning storms in your area

D. Signals are being refracted from a sporadic E layer

T3C02 HRLM (4-4)

ARRL The national association for AMATEUR RADIO

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T3C02 HRLM (4-4)

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What is a characteristic of VHF signals received via auroral reflection?

A. Signals from distances of 10,000 or more miles are common

B. The signals exhibit rapid fluctuations of strength and often sound distorted

C. These types of signals occur only during winter nighttime hours

D. These types of signals are generally strongest when your antenna is aimed west

T3C03 HRLM (4-4)

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T3C03 HRLM (4-4)

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Which of the following propagation types is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands?

A. Backscatter

B. Sporadic E

C. D layer absorption

D. Gray-line propagation

T3C04 HRLM (4-4)

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Which of the following propagation types is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands?

A. Backscatter

B. Sporadic E

C. D layer absorption

D. Gray-line propagation

T3C04 HRLM (4-4)

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Which of the following might cause radio signals to be heard despite obstructions between the transmitting and receiving stations?

A. Knife-edge propagation
B. Faraday rotation
C. Quantum tunneling
D. Doppler shift

T3C05 HRLM (4-1)

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Which of the following might cause radio signals to be heard despite obstructions between the transmitting and receiving stations?

A. Knife-edge propagation

B. Faraday rotation

C. Quantum tunneling

D. Doppler shift

T3C05 HRLM (4-1)

What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

A. Tropospheric scatter

B. D layer refraction

C. F2 layer refraction

D. Faraday rotation

T3C06 HRLM (4-2)

ARRL The national association for AMATEUR RADIO

What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

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C. F2 layer refraction

D. Faraday rotation

T3C06 HRLM (4-2)

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What band is best suited for communicating via meteor scatter?

A. 10 meters

B. 6 meters

C. 2 meters

D. 70 cm

T3C07 HRLM (4-4)

What band is best suited for communicating via meteor scatter?

A. 10 meters

B. 6 meters

C. 2 meters

D. 70 cm

T3C07 HRLM (4-4)

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What causes tropospheric ducting?

A. Discharges of lightning during electrical storms

B. Sunspots and solar flares

C. Updrafts from hurricanes and tornadoes

D. Temperature inversions in the atmosphere

T3C08 HRLM (4-2)

ARRL The national association for AMATEUR RADIO

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C. Updrafts from hurricanes and tornadoes

D. Temperature inversions in the atmosphere

T3C08 HRLM (4-2)

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What is generally the best time for long-distance 10 meter band propagation via the F layer?

A. From dawn to shortly after sunset during periods of high sunspot activity

B. From shortly after sunset to dawn during periods of high sunspot activity

C. From dawn to shortly after sunset during periods of low sunspot activity

D. From shortly after sunset to dawn during periods of low sunspot activity

T3C09 HRLM (4-4)

ARRL The national association for AMATEUR RADIO

What is generally the best time for long-distance 10 meter band propagation via the F layer?

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B. From shortly after sunset to dawn during periods of high sunspot activity

C. From dawn to shortly after sunset during periods of low sunspot activity

D. From shortly after sunset to dawn during periods of low sunspot activity

T3C09 HRLM (4-4)

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What is the radio horizon?

A. The distance over which two stations can communicate by direct path

B. The distance from the ground to a horizontally mounted antenna

C. The farthest point you can see when standing at the base of your antenna tower

D. The shortest distance between two points on the Earth's surface

T3C10 HRLM (4-1)

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T3C10 HRLM (4-1)

Why do VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations?

A. Radio signals move somewhat faster than the speed of light

B. Radio waves are not blocked by dust particles

C. The Earth seems less curved to radio waves than to light

D. Radio waves are blocked by dust particles

T3C11 HRLM (4-1)

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T3C11 HRLM (4-1)

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Which of the following bands may provide long distance communications during the peak of the sunspot cycle?

A. Six or ten meters

B. 23 centimeters

C. 70 centimeters or 1.25 meters

D. All of these choices are correct

T3C12 HRLM (4-4)

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T3C12 HRLM (4-4)

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