

# Technician License Course

## Chapter 4

### Lesson Plan Module 8 – Propagation



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AMATEUR RADIO*

# 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



# 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

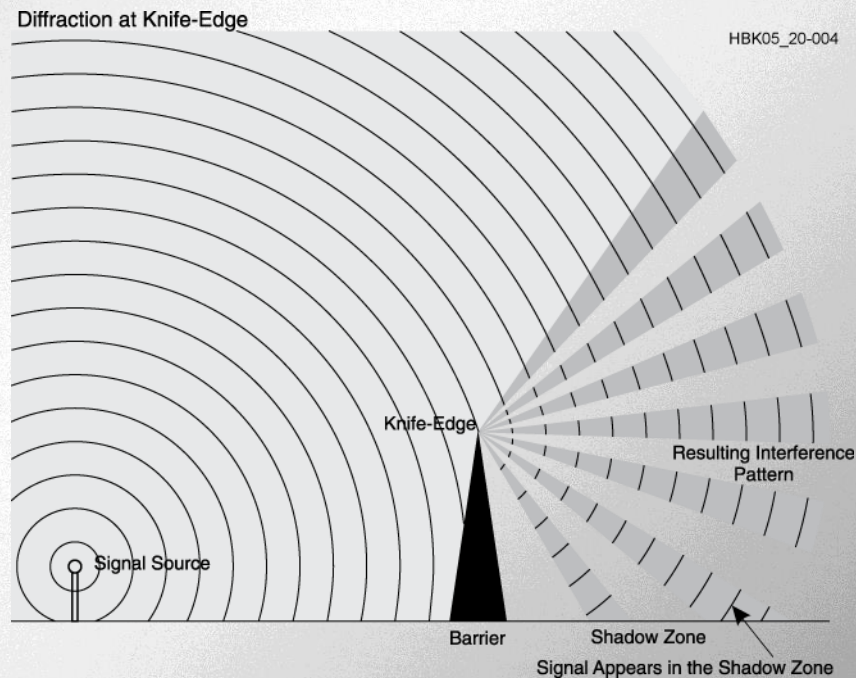
- At lower HF frequencies radio waves can follow the Earth's surface as they travel.
- These waves will travel beyond the range of line-of-sight.
- Range of a few hundred miles on bands used by amateurs.

# 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.

# Reflect, Refract, Diffract

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



# VHF and UHF Propagation

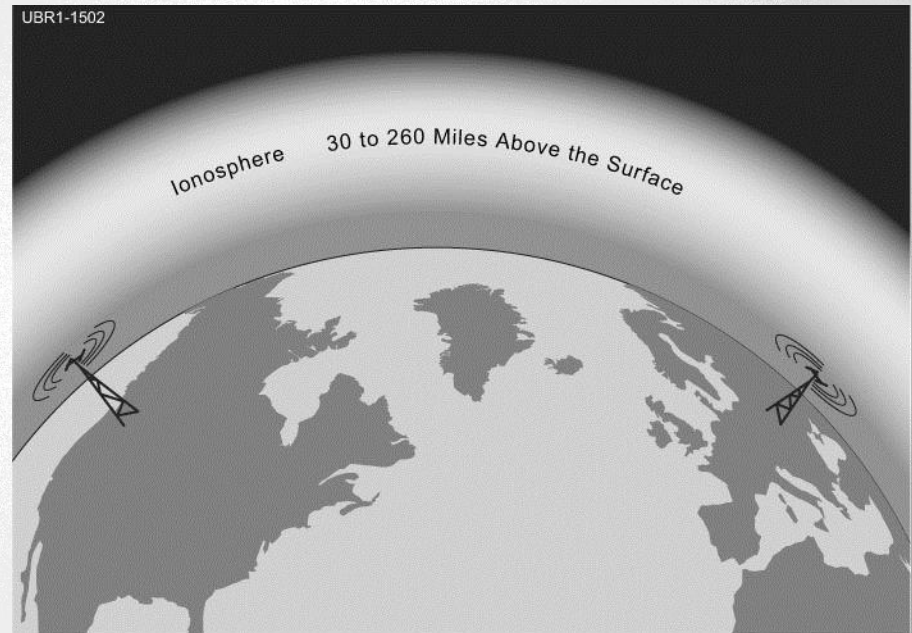
- Range is slightly better than visual line of sight due to gradual refraction (bending), creating the *radio horizon*.
- UHF signals penetrate buildings better than HF/VHF because of the shorter wavelength.
- Buildings may block line of sight, but reflected and diffracted waves can get around obstructions.
- *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

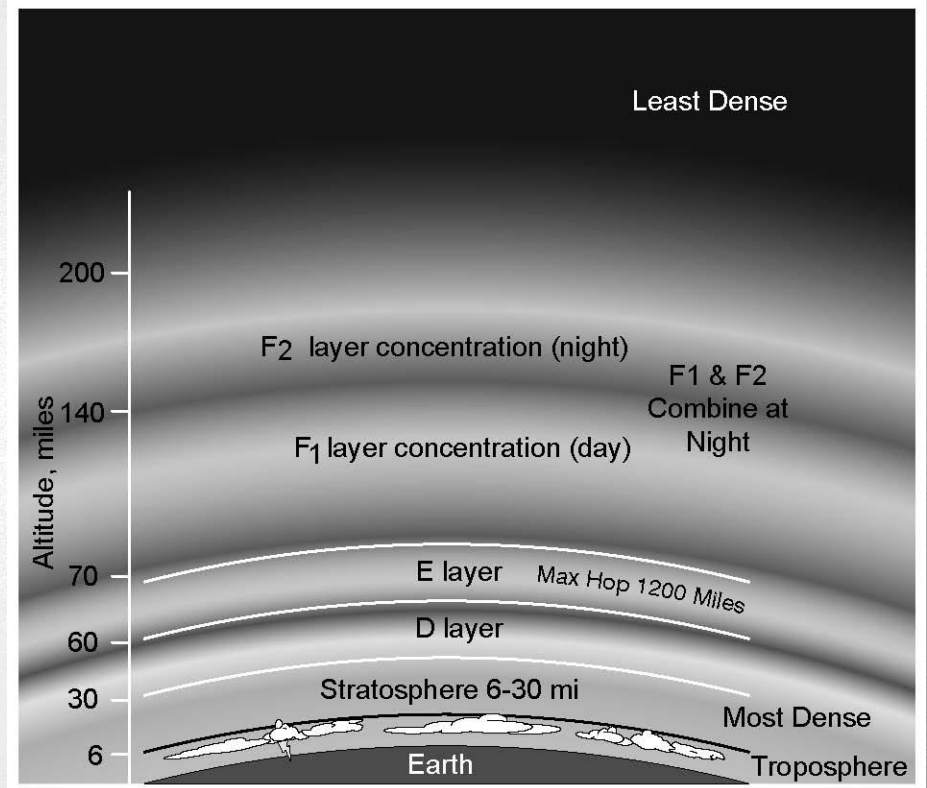
# The Ionosphere

- 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



# 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

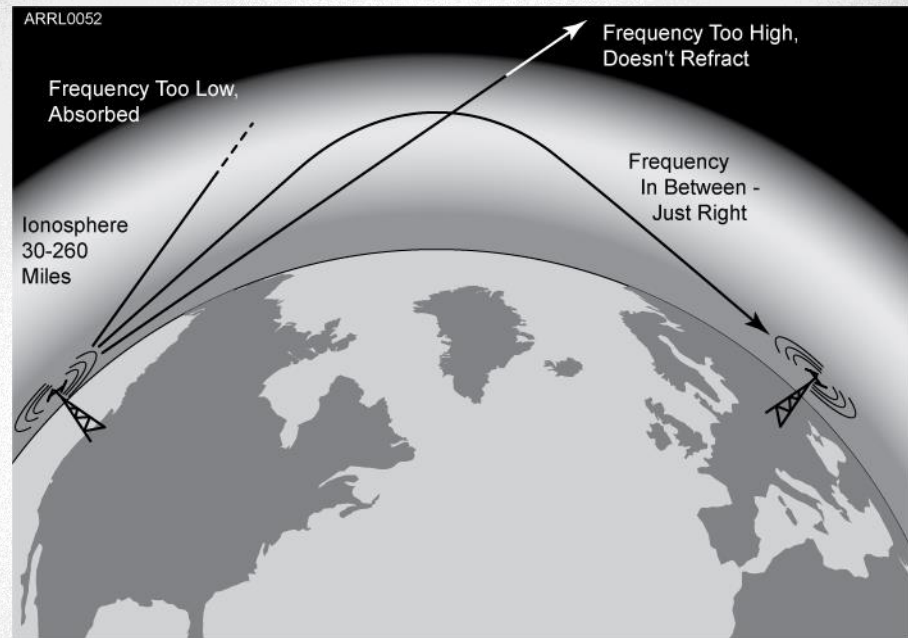
- The level of ionization depends on the intensity of radiation from the Sun.
- Radiation from the Sun varies with the number of sunspots on the Sun's surface.
  - High number of sunspots results in high levels of ionizing radiation emitted from the Sun.
- Sunspot activity follows an 11-year cycle.

# 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

# 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*.



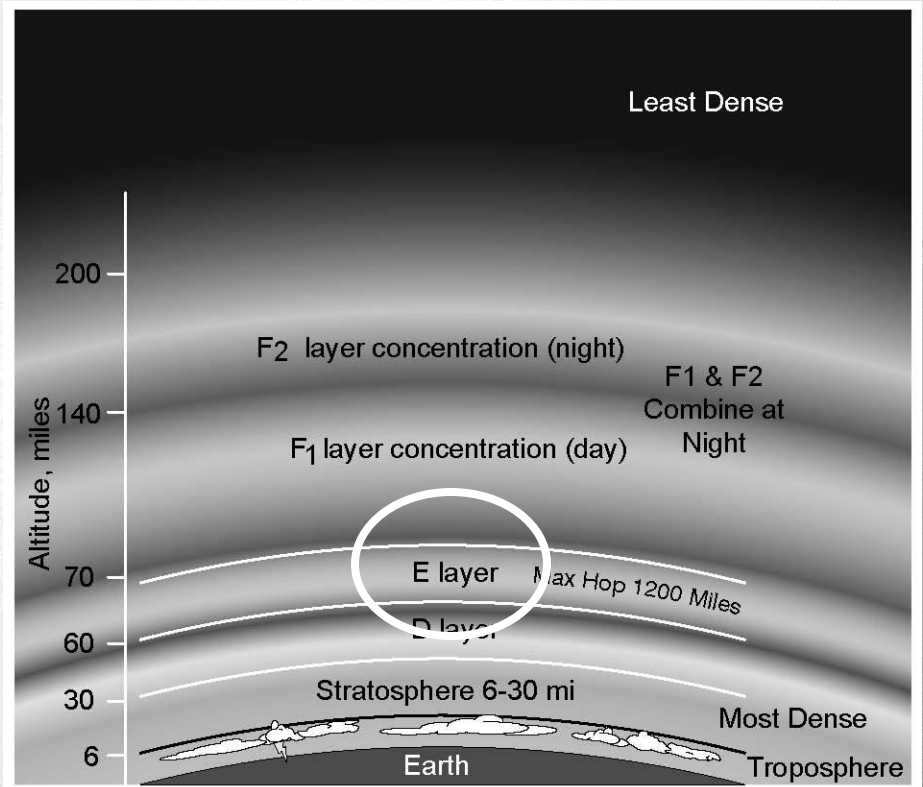
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# The Ionosphere – An RF Mirror

- 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.

# 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.



# 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)



# 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)

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)



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)



# 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)

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)



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T3A11 HRLM (4-3)



# 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)



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)



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T3C02 HRLM (4-4)



# 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)



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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T3C04 HRLM (4-4)



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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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)



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T3C06 HRLM (4-2)



# 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**
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T3C07 HRLM (4-4)



# 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)

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T3C08 HRLM (4-2)

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)



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T3C09 HRLM (4-4)



# 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)



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)

