Technician Licensing Class
"T3"

Presented by
Renton Emergency
Communication Service

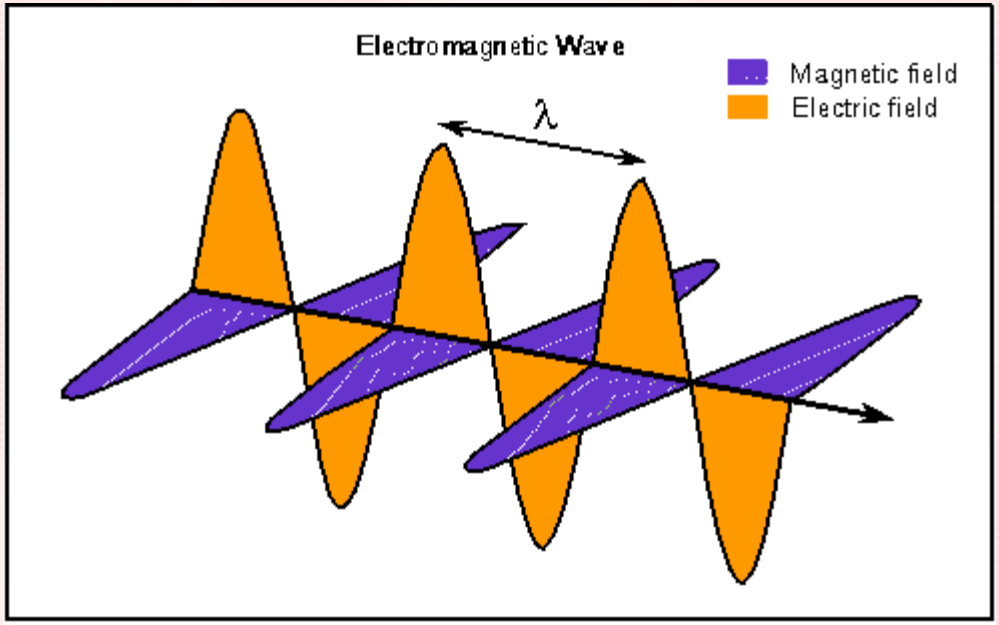
July 1, 2010

Amateur Radio Technician Class
Element 2 Course Presentation

- **ELEMENT 2 SUB-ELEMENTS**
  - **T1 – FCC Rules & Responsibilities**
  - **T2 – Operating Procedures**
  - **T3 – Radio Wave Properties**
  - **T4 – Station Setup & Operation**
  - **T5 – Electrical Principles**
  - **T6 – Electrical Components**
  - **T7 – Station Equipment & Troubleshooting**
  - **T8 – Operating Modes**
  - **T9 – Antennas & Feedlines**
  - **T0 – Electrical and RF Safety**

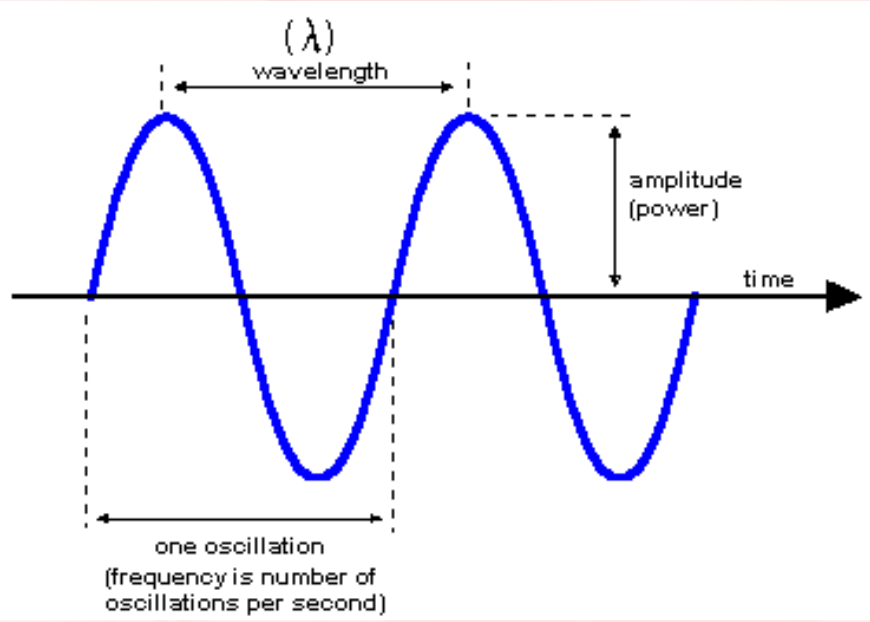
Radio Wave Characteristics

- **Electromagnetic** is the type of wave that carries radio signals between transmitting and receiving stations. (T3A07)
- As the name would imply, an electromagnetic wave has an electric component and a magnetic component.
- The two components of a radio wave are **electric and magnetic fields**. (T3B03)



Radio Wave Characteristics

- One important parameter of a radio wave is its frequency.
- **Frequency** is the term that describes the number of times per second that an alternating current (or radio wave) reverses direction (or polarity). (T3B02)



- Another important parameter of a radio wave is its wavelength.
- **Wavelength** is the name for the distance a radio wave travels during one complete cycle. (T3B01)
- **The wavelength gets shorter as the frequency increases**. (T3B05)

Radio Wave Characteristics

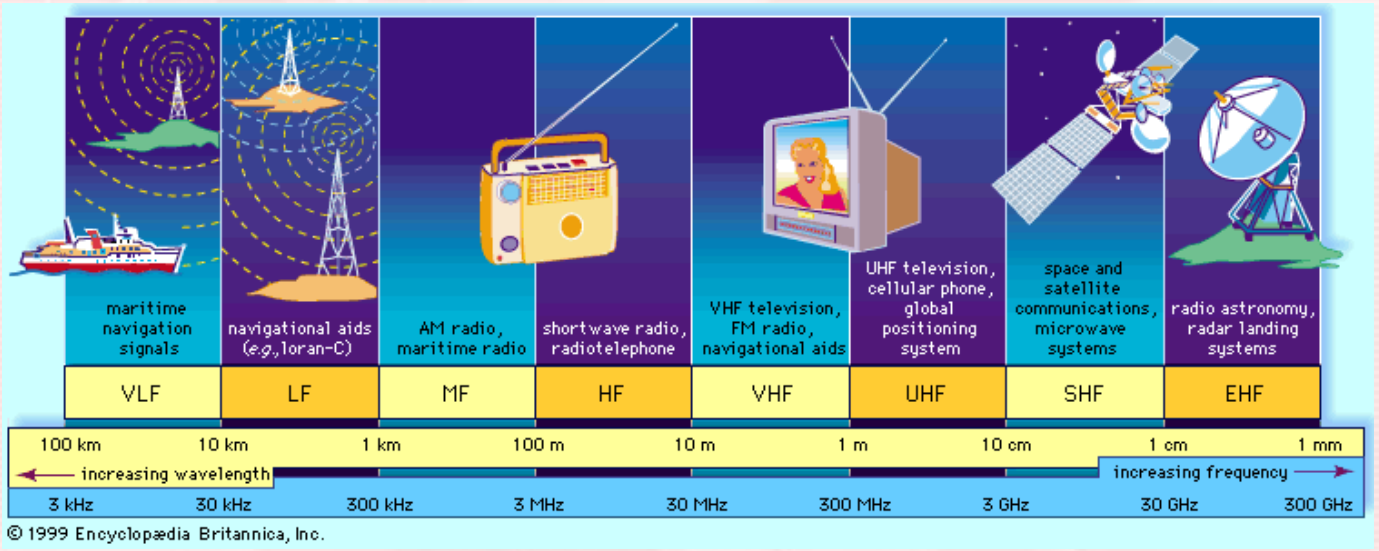
- A radio wave travels **at the speed of light** through free space. (T3B11)
- Because the speed of light is about 300,000,000 meters per second, the approximate velocity of a radio wave as it travels through free space is **300,000,000 meters per second**. (T3B04)
- The formula for converting frequency to wavelength in meters is **wavelength in meters equals 300 divided by frequency in megahertz**. (T3B06)

$$\lambda(Meters) = \frac{300}{f(MHz)}$$

- **The approximate wavelength** of radio waves is often used to identify the different frequency bands. (T3B07).
- For example, when we refer to the 2 meter band, we are referring to the amateur radio band that spans 144 MHz to 148 MHz. A radio wave with a frequency of 148 MHz, would have a wavelength of 2.02 meters.

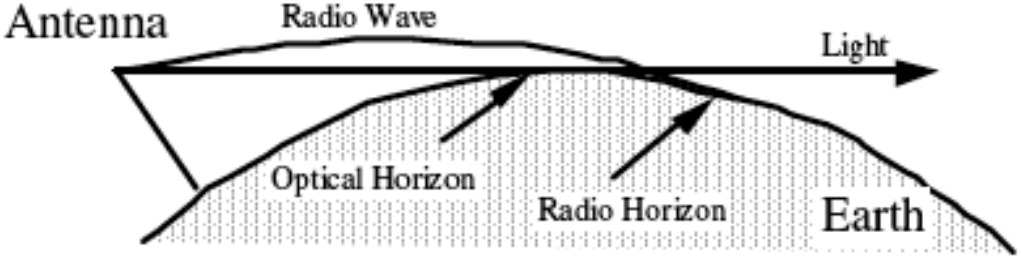
Radio Wave Characteristics

- For convenience, we split the entire range of radio frequencies into sub-ranges, including high frequency (HF), very high frequency (VHF), and ultra-high frequency (UHF).
- The frequency range **3 to 30 MHz** is referred to as **HF**. (T3B10)
- The frequency limits of the **VHF** spectrum are **30 to 300 MHz**. (T3B08)
- The frequency limits of the **UHF** spectrum are **300 to 3000 MHz**.(T3B09)



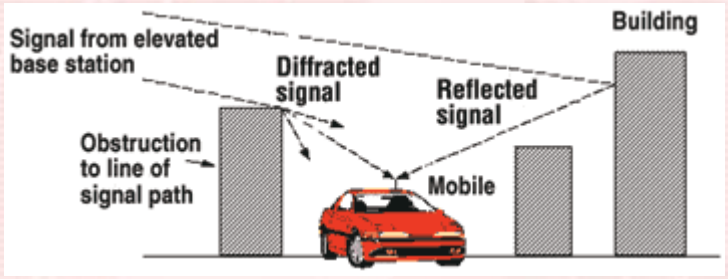
Radio Wave Characteristics

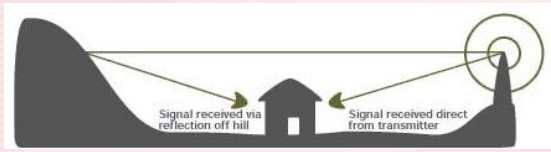
- Communications at VHF and UHF frequencies are generally "line of sight" communications. That is to say that normally they travel in a straight line from the transmitter to the receiver.
- The maximum distance for line-of-sight communications is called the **radio horizon.**
- The radio horizon is **the distance at which radio signals between two points are effectively blocked by the curvature of the Earth**. (T3C10)
- Because **the Earth seems less curved to radio waves than to light,** VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations, meaning that the radio horizon is somewhat farther than the visual horizon. (T3C11)

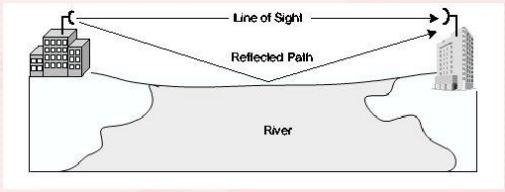


Radio Wave Characteristics

- One problem often encountered when using VHF and UHF frequencies is **multi-path distortion**. Multi-path distortion occurs when your signals arrive at a receiving station via two or more paths. Since the signals take different paths, they may be out of phase and cancel one another.
- If another operator reports that your station's 2 meter signals were strong just a moment ago, but now they are weak or distorted, **try moving a few feet, as random reflections may be causing multi-path distortion**. (T3A01)
- Multi-path distortion affects both voice and digital transmissions. **Error rates are likely to increase** if VHF or UHF data signals propagate over multiple paths. (T3A10)

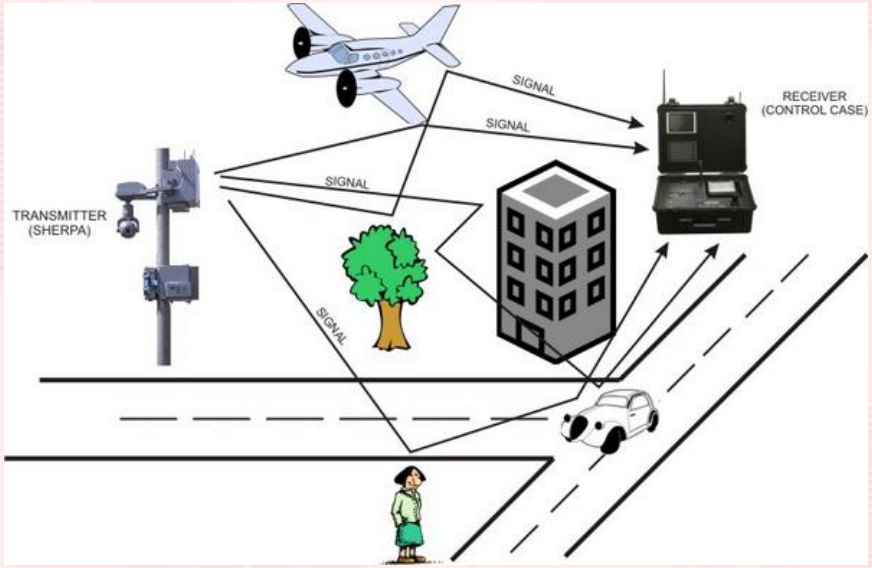






Radio Wave Characteristics

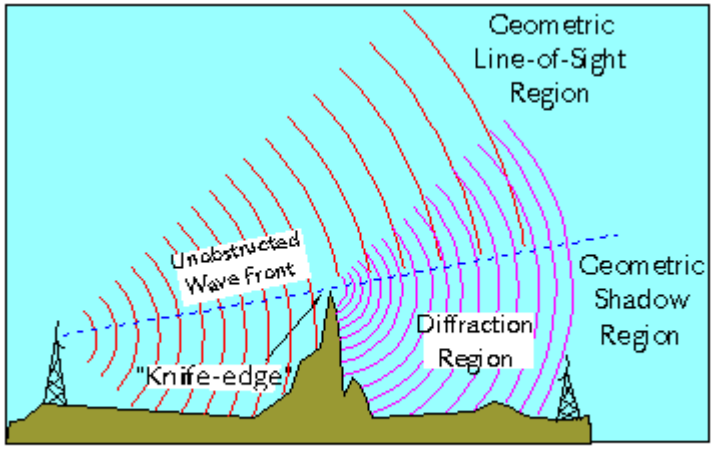
- When using a repeater, you may find yourself in a place where a direct path to the repeater is not possible. If you find yourself in this situation, you could try using a directional antenna.
- When using a directional antenna, **try to find a path that reflects signals to the repeater** if buildings or obstructions are blocking the direct line of sight path to a distant repeater. (T3A05)



Radio Wave Characteristics

- If you try to use a hand-held transceiver inside a building to communicate with someone, you might want to choose to operate in a UHF band.
- The reason for this is that UHF signals are often more effective from inside buildings than VHF signals because **the shorter wavelength allows them to more easily penetrate the structure of buildings**. (T3A02)

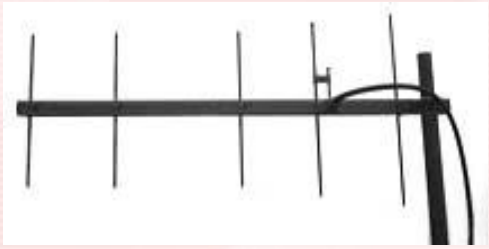
- Another interesting phenomenon is "knife-edge" propagation.
- Knife-edge propagation is the term used to describe when **signals are partially refracted around solid objects exhibiting sharp edges**. (T3C05)
- You might be able to use this phenomenon to get your signal around a building in an urban setting.



knife-edge effect

Radio Wave Characteristics

- Antenna polarization is also important at VHF and UHF frequencies.
- **Signals could be significantly weaker** if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization. (T3A04)
- When using a repeater, vertical polarization is most often used. So, when using a hand-held transceiver, make sure to hold it so that your antenna is vertically oriented.



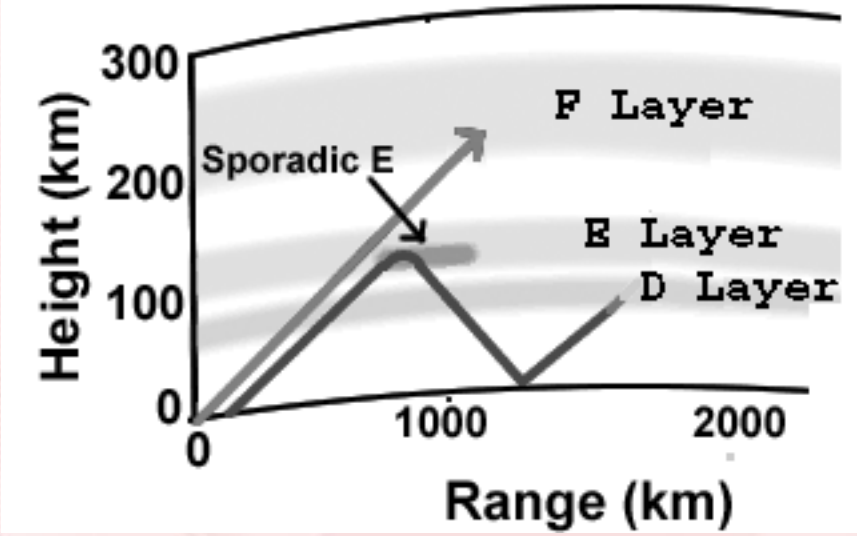
- On the other hand, **horizontal** antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands. (T3A03)

Radio Wave Characteristics

- Mobile operation has its own unique challenges as your transmitter location is constantly changing. This means that the signal at the receiving station constantly changes as well.
- **Picket fencing** is the term commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting. (T3A06)

Radio Wave Propagation

- The reason "direct" (not via a repeater) UHF signals are rarely heard from stations outside your local coverage area is that **UHF signals are usually not reflected by the ionosphere**. (T3C01)
- Even though VHF communications are most often line-of-sight, there are times when it's possible to communicate over long distances.
- Sometimes, VHF signals will bounce off the E layer of the ionosphere. When VHF signals are being received from long distances, what might be happening is that **signals are being refracted from a sporadic E layer**. (T3C02)
- **Sporadic E** propagation is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands. (T3C04)



Radio Wave Propagation

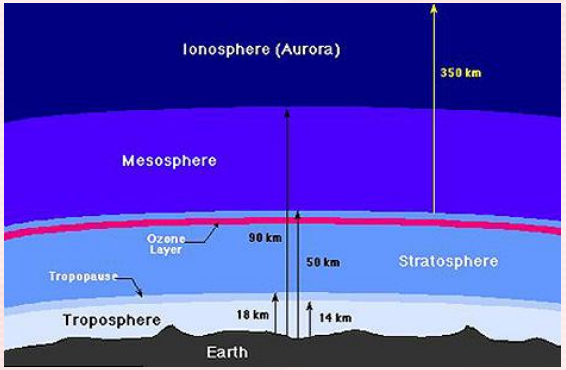
- Other interesting propagation phenomena at VHF frequencies include auroral reflection, meteor scatter, tropospheric scatter, and tropospheric ducting.
- Bouncing signals off the earth's aurora is very interesting. A characteristic of VHF signals received via auroral reflection is that **the signals exhibit rapid fluctuations of strength and often sound distorted**. (T3C03)

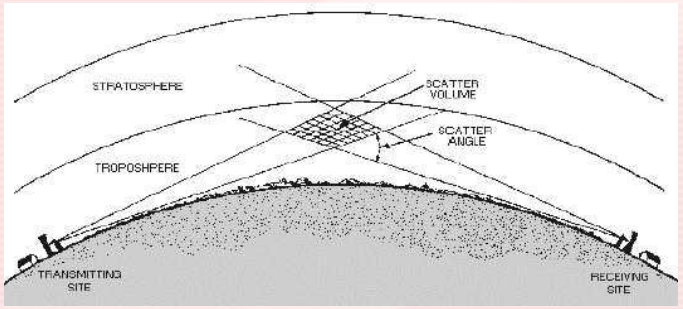
Radio Wave Propagation

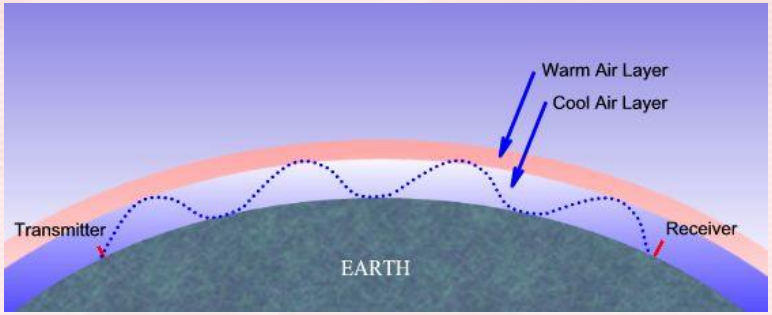
- Some hams also bounce signals off meteor showers. This propagation mode is called **meteor scatter**.
- **6 meters** is the band best suited to communicating via meteor scatter. (T3C07)

Radio Wave Propagation

- The troposphere is the lowest region of the atmosphere, extending from the earth's surface to a height of about 6–10 km.
- **Tropospheric scatter** is the mode responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis. (T3C06)
- **Tropospheric ducting** can also propagate VHF signals for many hundreds of miles.
- **Temperature inversions in the atmosphere** causes "tropospheric ducting." (T3C08)

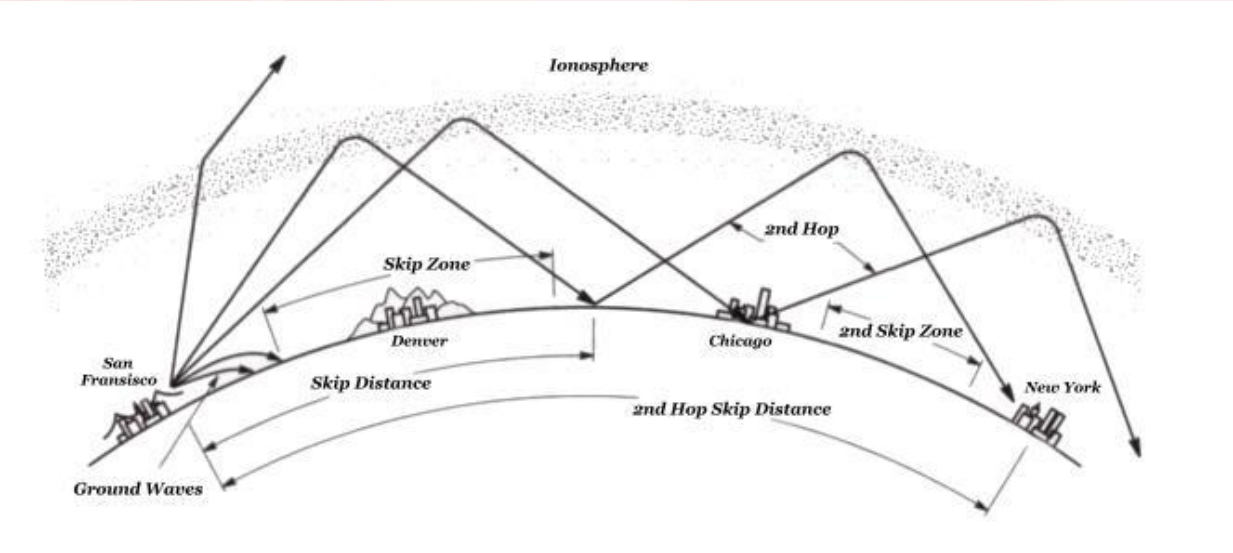






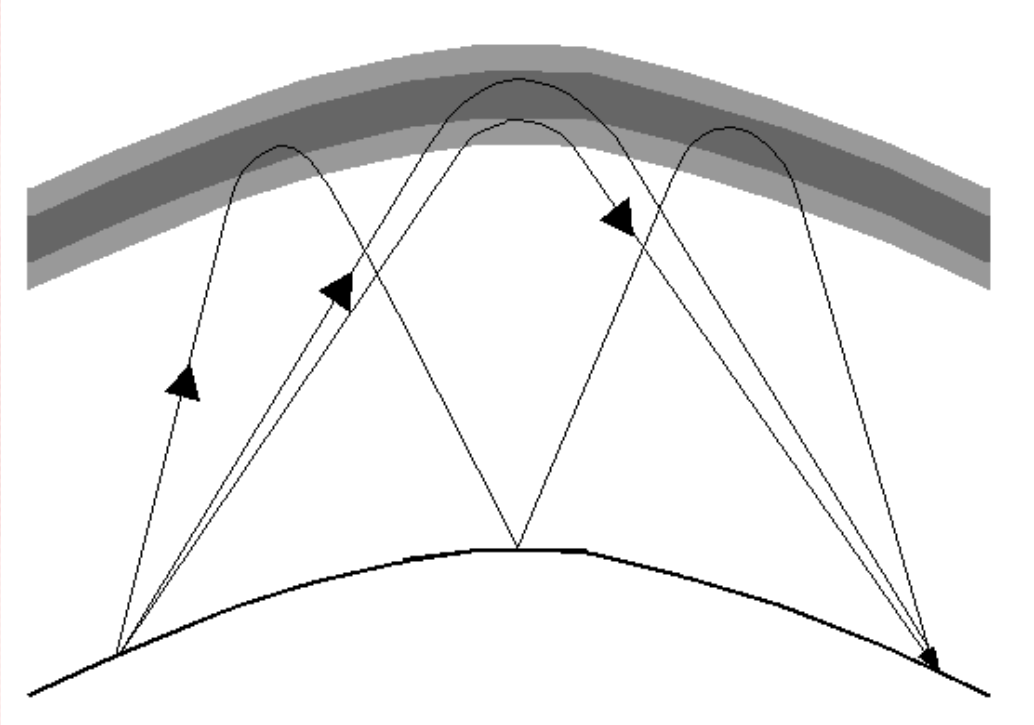
Radio Wave Propagation

- For more reliable long-distance communications, amateurs use the HF frequencies. The reason for this is that HF signals bounce off the ionosphere. The ionosphere contains a high concentration of ions and free electrons and is able to reflect radio waves. It extends from about 50 to 600 miles above the earth's surface.
- **The ionosphere** is the part of the atmosphere that enables the propagation of radio signals around the world. (T3A11)



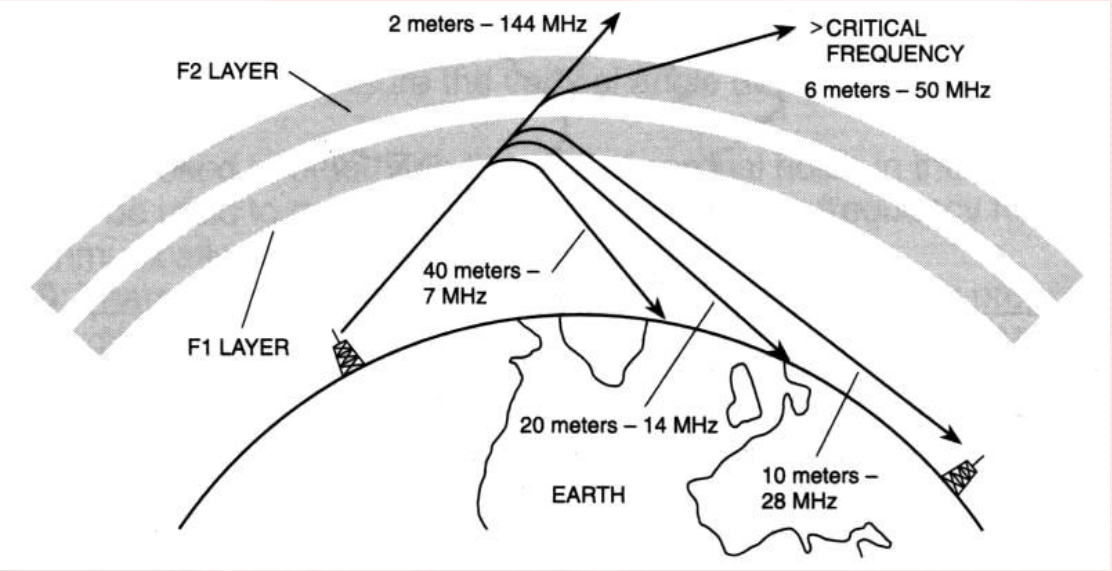
Radio Wave Propagation

- A common phenomenon of HF signal propagation is fading.
- The cause of irregular fading of signals from distant stations during times of generally good reception is **random combining of signals arriving via different path lengths**. (T3A08)



Radio Wave Propagation

- Unlike VHF/UHF communications, polarization is not quite so important. This is because signals "skip" off the ionosphere.
- One common effect of "skip" reflections between the Earth and the ionosphere is that **the polarization of the original signal is randomized**. (T3A09)
- Because of the way that the ionosphere changes throughout the day, propagation is best on the higher frequency bands, such as 10m, 15m and 20m, during the day while propagation is best on the lower frequency bands (160m, 80m, 40m) at night.
- Consequently, the best time for long distance 10 meter band propagation is **during daylight hours**. (T3C09)



Element 2 Technician Class Question Pool

T3 - Radio Wave Properties

Valid July 1, 2010

Through

June 30, 2014

T3A01 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

T3A02 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

T3A03 What antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands?

A. Horizontal
B. Vertical
C. Right-hand circular
D. Left-hand circular

T3A04 What can happen if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?

A. The modulation sidebands might become inverted
B. Signals have an echo effect on voices
C. Signals could be significantly weaker
D. Nothing significant will happen

T3A05 When using a directional antenna, how might your station be able to access a distant repeater if buildings or obstructions are blocking the direct line of sight path?

A. Change from vertical to horizontal polarization

B. Try the long path

C. Try to find a path that reflects signals to the repeater

D. Increase the antenna SWR

T3A06

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

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

T3A07 What type of wave carries radio signals between transmitting and receiving stations?

A. Magnetostrictive
B. Surface acoustic
C. Electrostatic
D. Electromagnetic

T3A08 What is the cause of irregular fading of signals from distant stations during times of generally good reception?

A. Absorption of signals by the "D" layer of the ionosphere

B. Absorption of signals by the "E" layer of the ionosphere

C. Random combining of signals arriving via different path lengths

D. Intermodulation distortion in the local receiver

T3A09 Which of the following is a common effect of "skip" reflections between the Earth and the ionosphere?

A. The polarization of the original signal is randomized

B. The sidebands become reversed at each reflection

C. The apparent frequency of the received signal is shifted by a random amount

D. Signals at frequencies above 30 MHz become stronger with each reflection

T3A10 What may occur if VHF or UHF 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

D. Error rates are likely to increase

T3A11 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

T3B01 What is the name for the distance a radio wave travels during one complete cycle?

A. Wavelength
B. Wave speed
C. Waveform
D. Wave spread

T3B02 What term describes the number of times per second that an alternating current reverses direction?

A. Pulse rate
B. Wavelength
C. Frequency
D. Pulse rate

T3B03 What are the two components of a radio wave?

A. AC and DC
B. Voltage and current
C. Electric and magnetic fields
D. Ionizing and non-ionizing radiation

T3B04 How fast does a radio wave travel through free space?

A. At the speed of light
B. At the speed of sound
C. Its speed is inversely proportional to its wavelength
D. Its speed increases as the frequency increases

T3B05 How does the wavelength of a radio wave relate to its frequency?

A. The wavelength gets longer as the frequency increases

B. The wavelength gets shorter as the frequency increases

C. There is no relationship between wavelength and frequency

D. The wavelength depends on the bandwidth of the signal

T3B06 What is the formula for converting frequency to wavelength in meters?

A. Wavelength in meters equals frequency in hertz multiplied by 300

B. Wavelength in meters equals frequency in hertz divided by 300

C. Wavelength in meters equals 300 divided by frequency in megahertz

D. Wavelength in meters equals frequency in megahertz divided by 300

T3B07 What property of radio waves is often used to identify the different frequency bands?

A. The voltage standing wave ratio of waves
B. The time it takes for waves to travel one mile
C. The magnetic intensity of waves
D. The approximate wavelength

T3B08 What are the frequency limits of the VHF spectrum?

A. 300 to 3000 MHz
B. 300 to 3000 kHz
C. 30 to 300 MHz
D. 30 to 300 kHz

T3B09 What are the frequency limits of the UHF spectrum?

A. 300 to 3000 MHz

B. 300 to 3000 kHz

C. 30 to 300 MHz

D. 30 to 300 kHz

T3B10 What frequency range is referred to as HF?

A. 300 to 3000 MHz
B. 30 to 300 MHz
C. 3 to 30 MHz
D. 300 to 3000 kHz

T3B11 What is the approximate velocity of a radio wave as it travels through free space?

A. 3000 kilometers per second

B. 300,000,000 meters per second

C. 300,000 miles per hour

D. 186,000 miles per hour

T3C01 Why are "direct" (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?

A. UHF signals are usually not reflected by the ionosphere

B. They are too weak to go very far

C. They collide with trees and shrubbery and fade out

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

T3C02 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

T3C03 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 to the south (for stations in the Northern Hemisphere)

T3C04 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. Gray-line propagation
B. D layer absorption
C. Sporadic-E
D. Backscatter

T3C05 What is meant by the term "knife-edge" propagation?

A. Signals are reflected back toward the originating station at acute angles

B. Signals are sliced into several discrete beams and arrive via different paths

C. Signals are partially refracted around solid objects exhibiting sharp edges

D. Signals propagated close to the band edge exhibiting a sharp cutoff

T3C06 What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

A. D layer refraction
B. Tropospheric scatter
C. F2 layer refraction
D. Faraday rotation

T3C07 What band is best suited to communicating via meteor scatter?

A. 70 cm
B. 2 meters
C. 6 meters
D. 10 meters

T3C08 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

T3C09 What is generally the best time for long-distance 10 meter band propagation?

A. During nighttime hours
B. During daylight hours
C. When there are coronal mass ejections
D. Whenever the solar flux is low

T3C10 What is the radio horizon?

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

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

C. The distance at which radio signals between two points are effectively blocked by the curvature of the Earth

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

T3C11 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

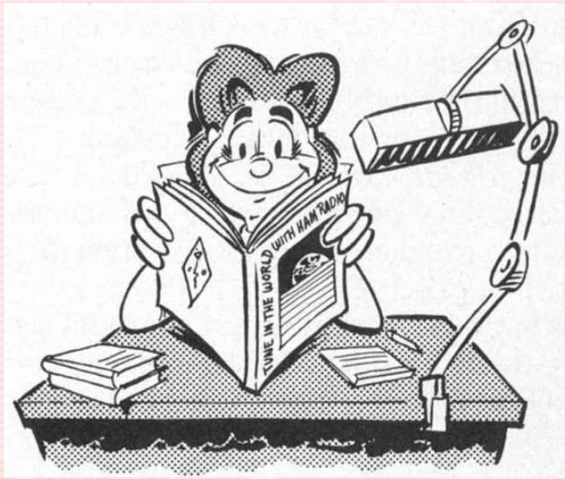
B. Radio waves are not blocked by dust particles

C. Radio waves are blocked by dust particles

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

Element 2 Technician Class

Study for next time….



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