Technician License Course

KE6HEC February 11, 2021

Chapter 4 Part 1

Technician License Course

Chapter 4

Propagation

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

Radio Wave Propagation

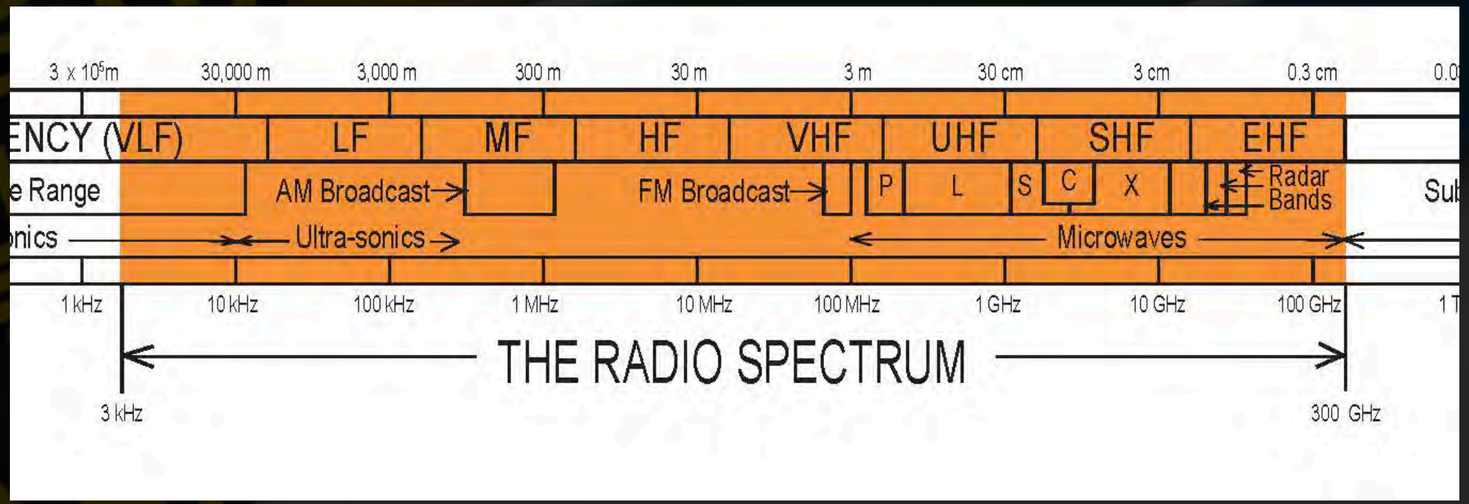
Ground Wave

Ground Wave/
Sky wave

Sky Wave

Sky Wave/
Line of Sight

Line of
Sight



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

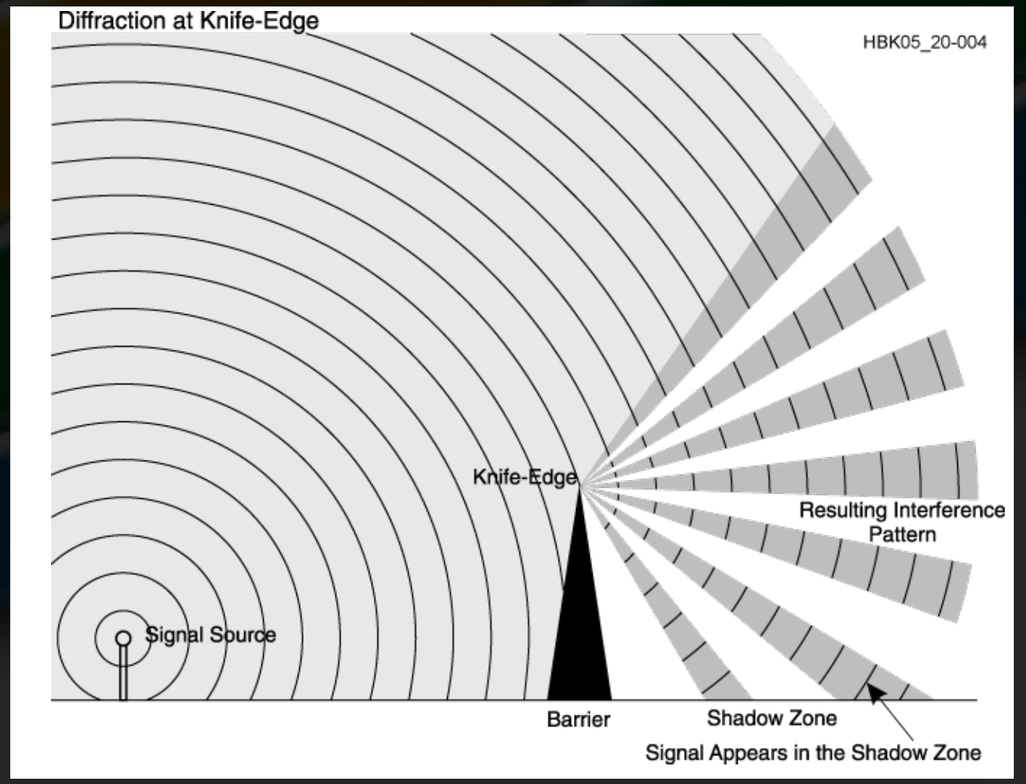
- At lower HF frequencies radio waves can follow the Earth’s surface as they travel.
- These waves will travel beyond the range of line-of-sight.
- Range of a few hundred miles on bands used by amateurs.

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.

Diffraction

- *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.

VHF and UHF Propagation

- *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

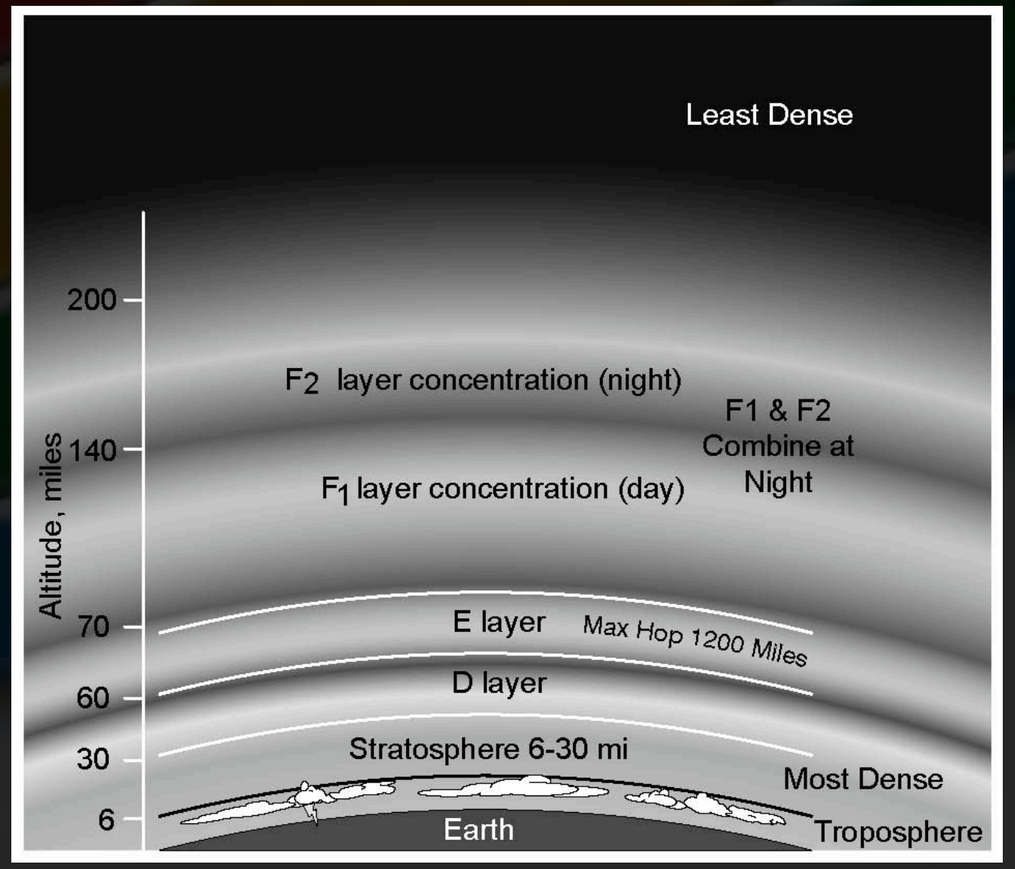
- The troposphere is the lower levels of the atmosphere – to about 30 miles high
- Radio waves can be reflected or *scattered* by clouds, rain, and density variations in the troposphere – range up to about 300 miles
- Temperature inversions and weather fronts can form *ducts* that trap and conduct VHF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

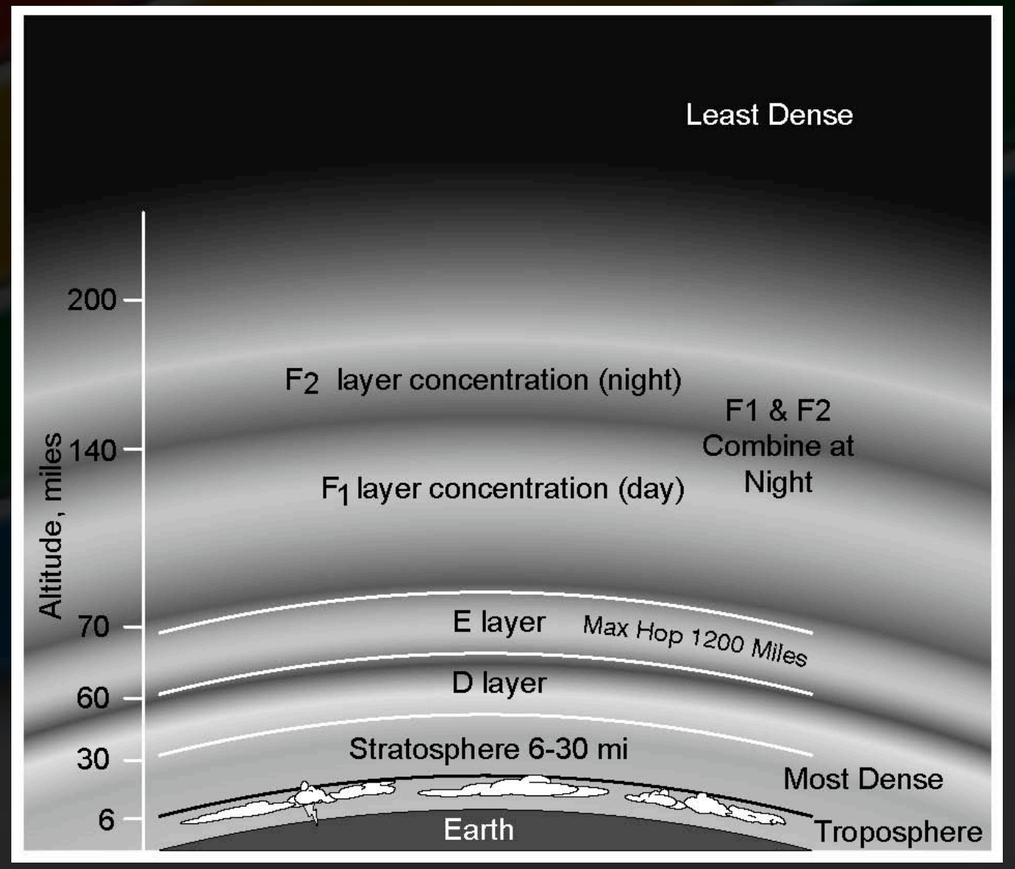
Ionospheric Levels

- 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



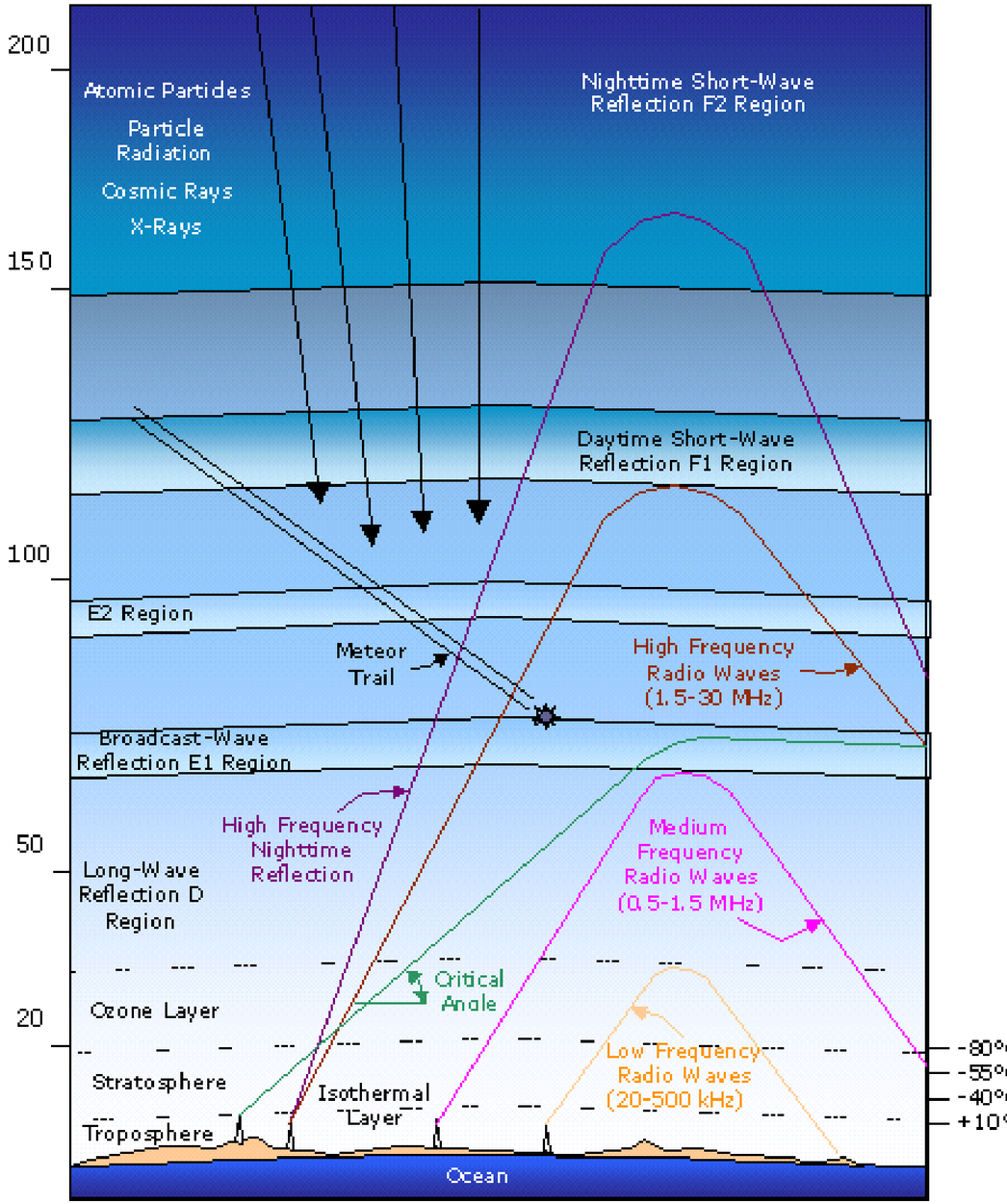
Ionospheric Levels

- Higher ionization refracts or bends radio waves more strongly



Ionospheric Levels

Altitude in miles



Sunspot Cycle

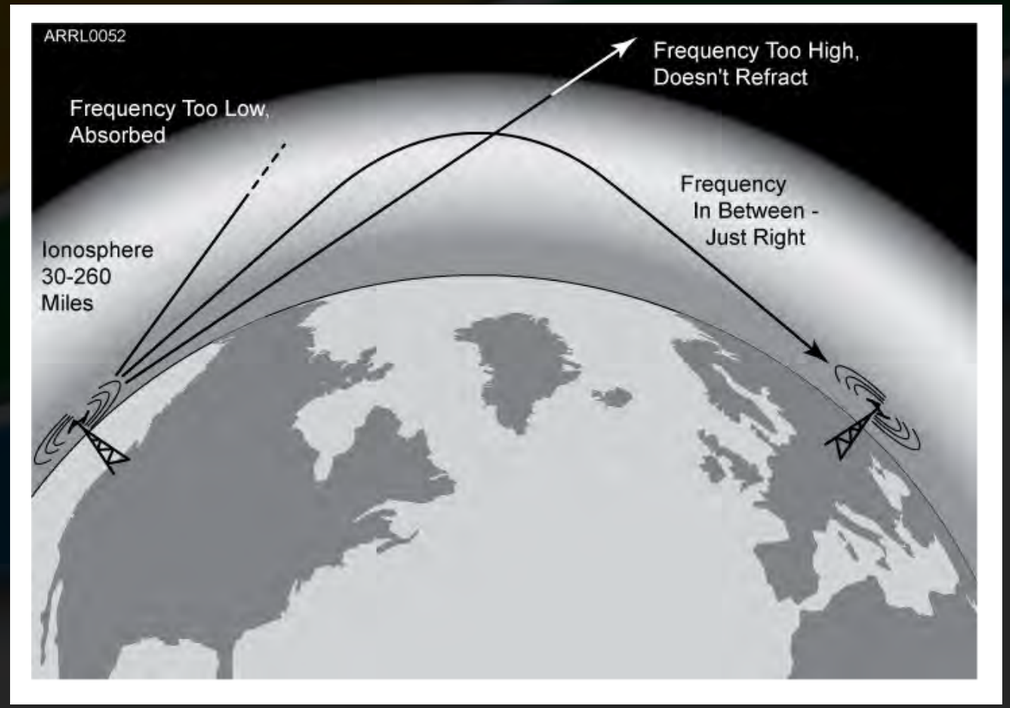
- The level of ionization depends on the intensity of radiation from the Sun.
- Radiation from the Sun varies with the number of sunspots on the Sun's surface.
  - –High number of sunspots results in high levels of ionizing radiation emitted from the Sun.
- Sunspot activity follows an 11-year cycle.

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.

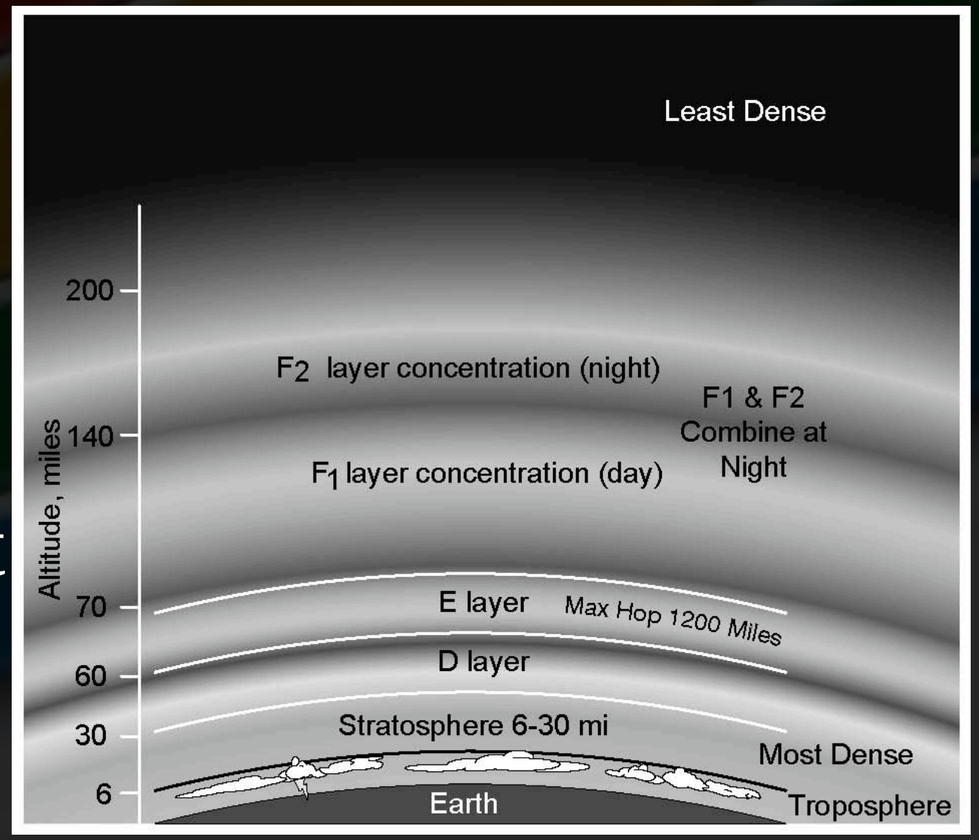


The Ionosphere – An RF Mirror

- 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.

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Chapter 4

Antenna Fundamentals

The Antenna System

- **Antenna**: Transforms current into radio waves (transmit) and vice versa (receive).
- **Feed line**: Connects your station to the antenna.
- **Test and matching equipment**: Allows you to monitor and optimize antenna system performance.

The Antenna (Some Vocabulary)

- **Element**: The conducting part or parts of an antenna designed to radiate or receive radio waves.
- **Driven element**: The element supplied directly with power from the transmitter.
- **Array**: An antenna with more than one element.

The Antenna (Some Vocabulary)

- **Parasitic element**: Elements not connected directly to a feed line.
- **Resonant**: An antenna is resonant when its feed point impedance has zero reactance.
- **Feed point**: Where the transmitted energy enters the antenna.
- **Radiation**: *NOT* radioactivity! An antenna emitting electromagnetic waves.

Electromagnetic Waves

- Radio waves are electromagnetic waves
  - Electric and magnetic fields at right angles to each other, oscillating at the wave's frequency
  - Spread out into space from the antenna
  - Created by ac current
  - Wave and current have the same frequency

Wave Polarization

- Orientation of the wave's electric field component with respect to the surface of the Earth
  - *Vertical* or *horizontal* – determined by elements
  - Can be *circular* if the orientation twists as the wave spreads through space
  - Combinations of polarization are called *elliptical* polarization

Cross-Polarization

- Antenna and wave polarization must match for maximum reception.
  - **Cross-polarized**: antenna elements and the wave's electric field at right angles
  - Can reduce reception by a factor of 100
- For elliptically polarized waves (such as HF sky-wave) any antenna will respond at least partially.

The Decibel (dB)

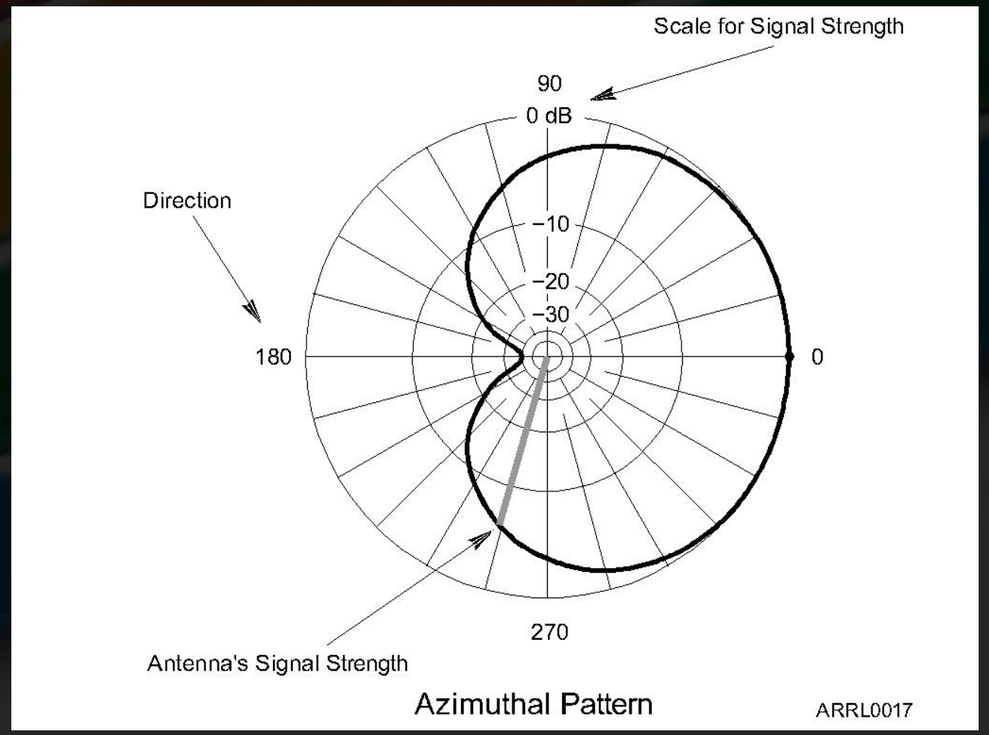
- A ratio expressed as an power of 10 to make large numbers easier to work with.
  - dB = 10 log (power ratio)
  - dB = 20 log (voltage ratio)
- Positive values in dB indicate ratios > 1 and negative values of dB are for ratios < 1.
- Antenna gain is discussed in terms of dB.

The Antenna (Some Vocabulary)

- **Gain**: Apparent increase in power in a particular direction by focusing radiation in that direction. Measured in decibels (dB).
- **Isotropic**: Equal radiation in all directions.
- **Omnidirectional**: No preferred horizontal direction.
- **Directional**: Antenna that focuses radiation in specific directions.

Antenna Radiation Patterns

- Radiation patterns are a way of visualizing antenna performance.
- The further the line is from the center of the graph, the stronger the signal at that point.
- Graph calibrated in dB.



Radiation Pattern Vocabulary

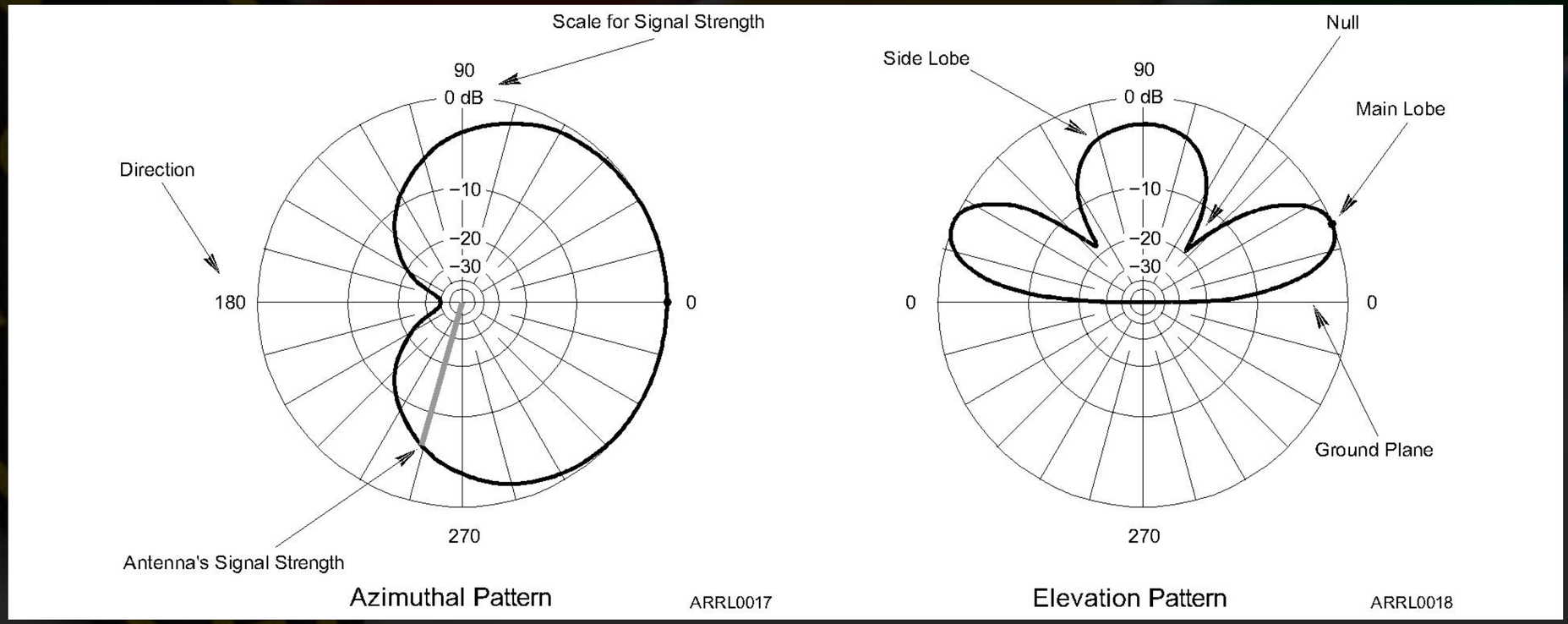
- **Nulls**: Directions of minimum gain
- **Lobes**: Regions between nulls
- **Main lobe**: Lobe with highest gain
- **Side lobe**: Any lobe other than the main lobe
- **Forward gain**: Gain in the direction assigned as forward

Radiation Pattern Vocabulary

- **Azimuth pattern**: Radiation pattern showing gain in all horizontal directions around the antenna.
- **Elevation pattern**: Radiation pattern showing gain at all vertical angles from the antenna.
  - Often restricted to angles above horizontal

Azimuth Pattern

Elevation Pattern



Radiation Pattern Vocabulary

- **Front-to-back ratio**: Ratio of forward gain to gain in the opposite direction.
- **Front-to-side ratio**: Ratio of forward gain to gain at right angles to the forward direction.

Practice Questions

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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?

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?

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

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

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

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

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

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

Picket fencing

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

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

Random combining of signals arriving via different paths

What may occur if data signals propagate over multiple paths?

What may occur if data signals propagate over multiple paths?

Error rates are likely to increase

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

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

The ionosphere

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

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

UHF signals are usually not reflected by the ionosphere

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

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

Signals are being refracted from a sporadic E layer

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

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

The signals exhibit rapid fluctuations of strength and often sound distorted

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?

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?

Sporadic E

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

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

Knife-edge propagation

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

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

Tropospheric scatter

What band is best suited for communicating via meteor scatter?

What band is best suited for communicating via meteor scatter?

6 meters

What causes tropospheric ducting?

What causes tropospheric ducting?

Temperature inversions in the atmosphere

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

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

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

What is the radio horizon?

What is the radio horizon?

The distance over which two stations can communicate by direct path

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

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

The Earth seems less curved to radio waves than to light

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

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

Six or ten meters

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?

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?

Signals could be significantly weaker

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

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

Electromagnetic

What is a common effect of "skip" reflections between the Earth and the ionosphere?

What is a common effect of "skip" reflections between the Earth and the ionosphere?

The polarization of the original signal is randomized

What property of a radio wave is used to describe its polarization?

What property of a radio wave is used to describe its polarization?

The orientation of the electric field

What are the two components of a radio wave?

What are the two components of a radio wave?

Electric and magnetic fields

What is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts?

What is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts?

3 dB

What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts?

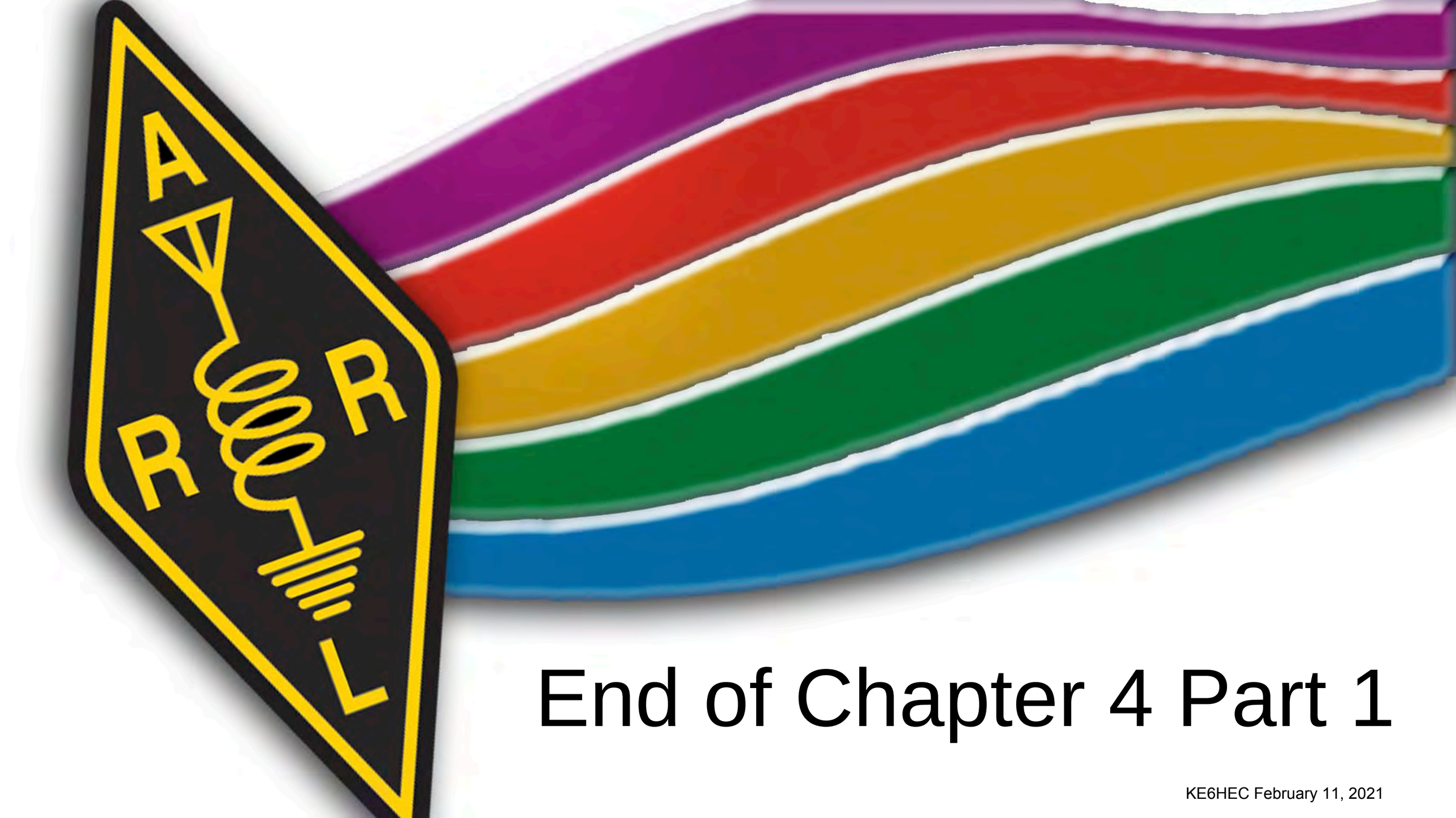
What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts?

-6 dB

What is the approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts?

What is the approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts?

10 dB



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