Part B - RF Propagation Basics

Western Colorado Amateur Radio Club

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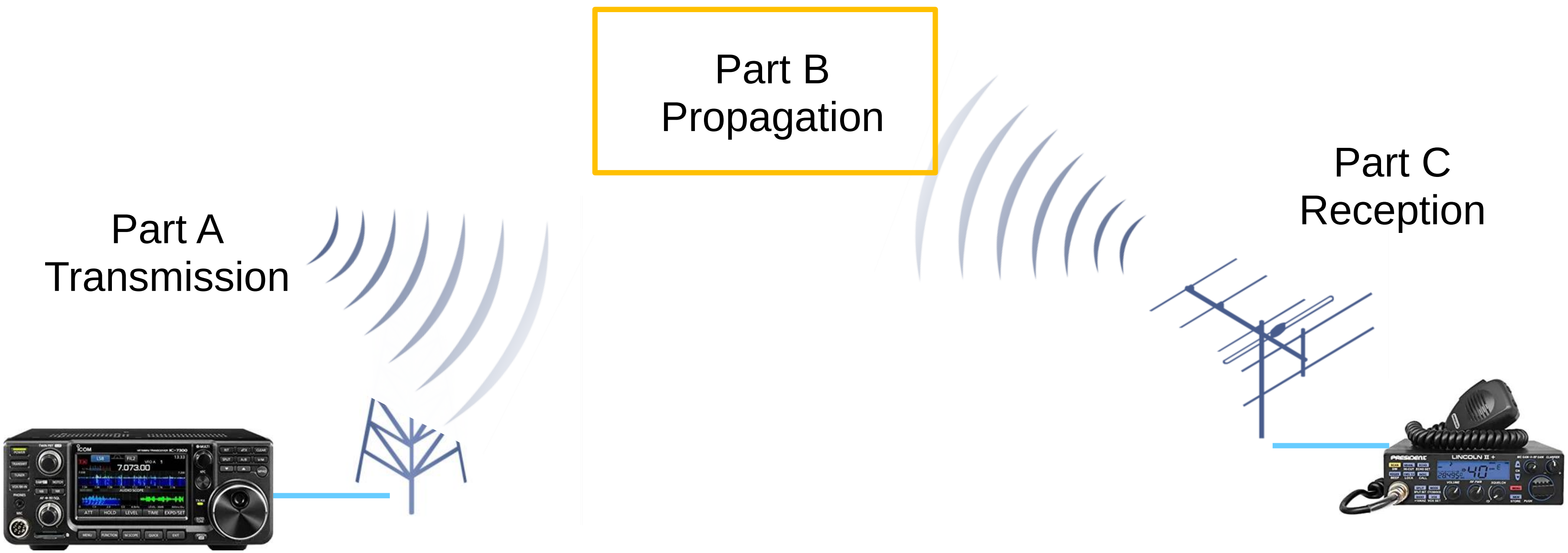
Communication Link

- Communication Link is broken into 3 parts
  - Transmission, Propagation, Reception
- Transmission is where damage to equipment is done



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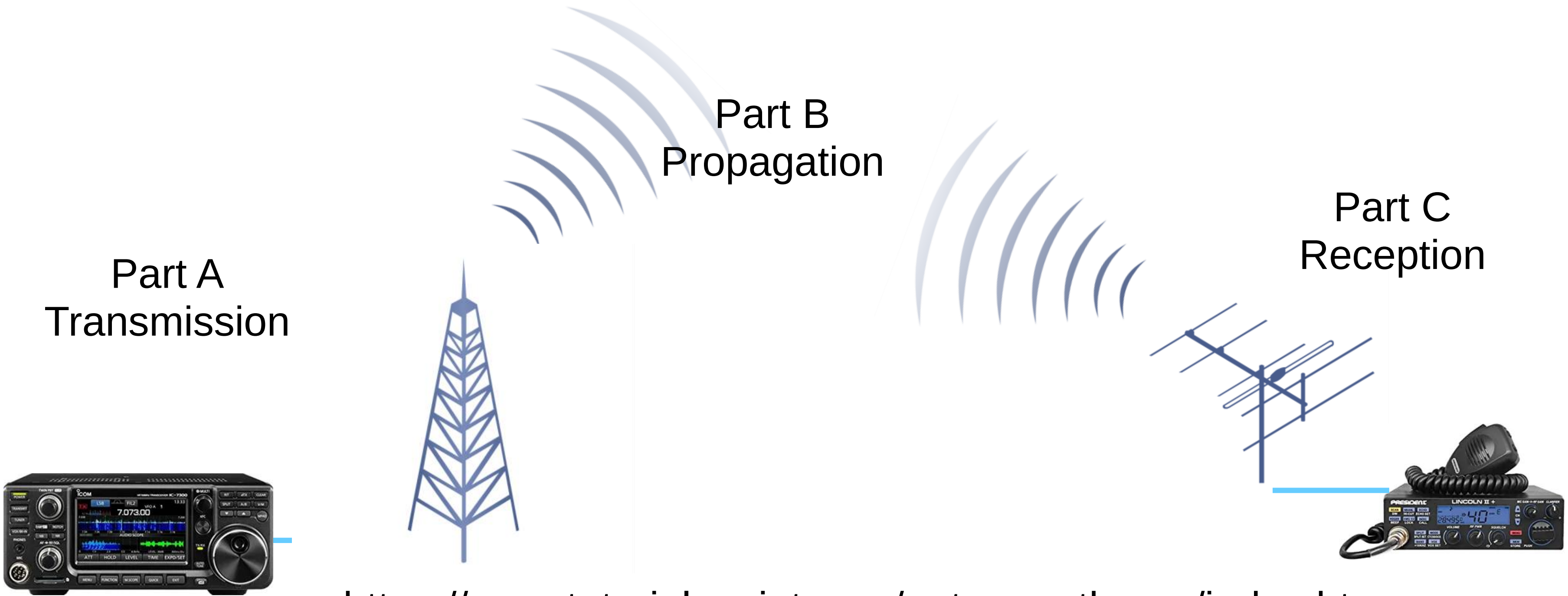
  - Sensitivity

Radio Propagation Defined

- Radio propagation is the behavior of radio waves as they travel, or are propagated, from one point to another in vacuum, or into various parts of the atmosphere.

Communication Link

- Line of Sight (LOS) is easy (fewer dominate factors)
- Distance Transmitting (DX) is more complex



https://www.tutorialspoint.com/antenna_theory/index.htm

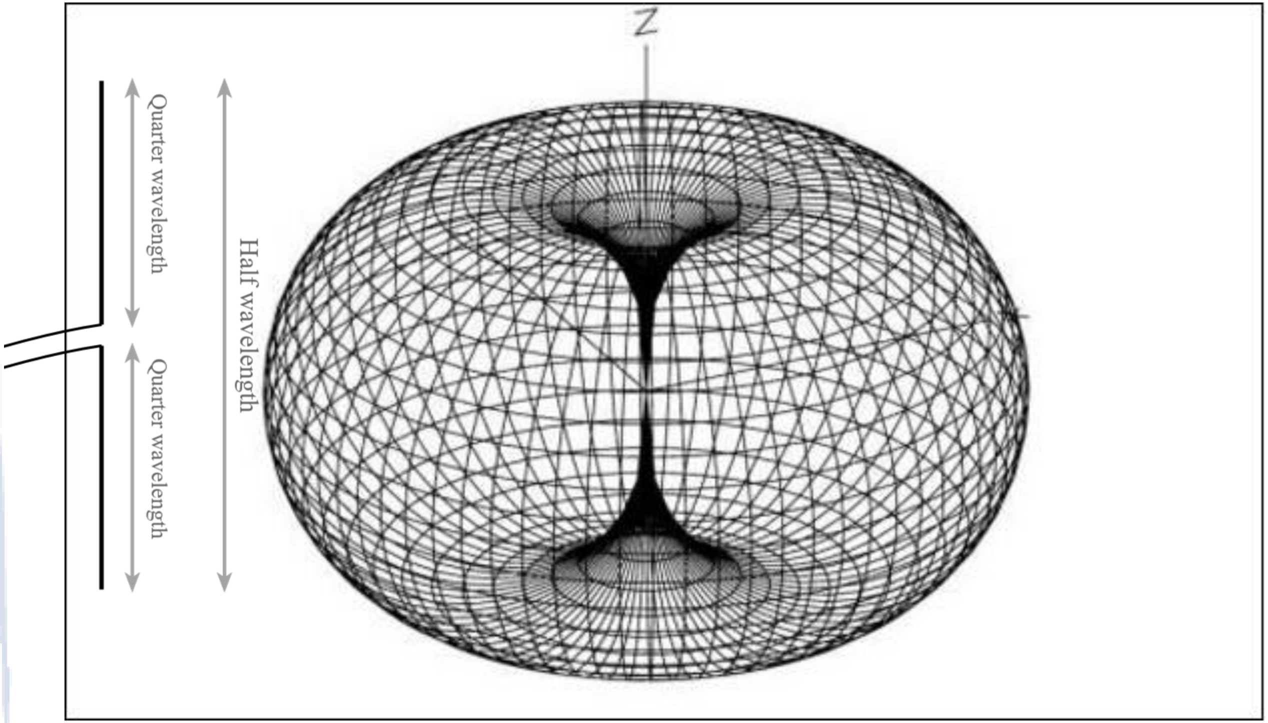
Transmission Link

- Factors
  - Power Transmitted
  - Power Received
  - Receiver Sensitivity
    - Noise Figure (NF)
    - Signal to Noise Ratio (SNR)
- If you hear them, but they not hear you
  - Them using more TX power than you
  - Your RX sensitivity better than theirs

Antenna

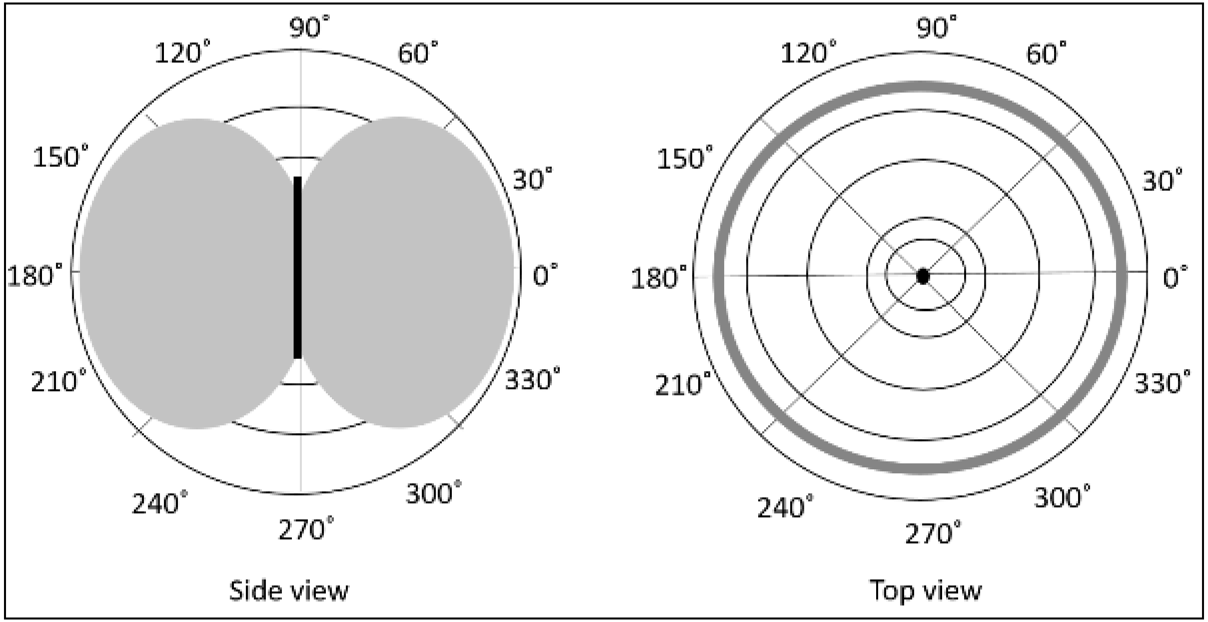
- How do Antennas get measured
  - Half-wave Dipole – Used as the reference with a perfect radiation pattern
  - dBi, an antenna radiation in a direction compared to a Dipole

3D representation of Dipole



- Notice
  - No Energy is directed at the ends
  - Maximum energy is directed perpendicular to the antenna

Shape of Radiated Energy



- Notice
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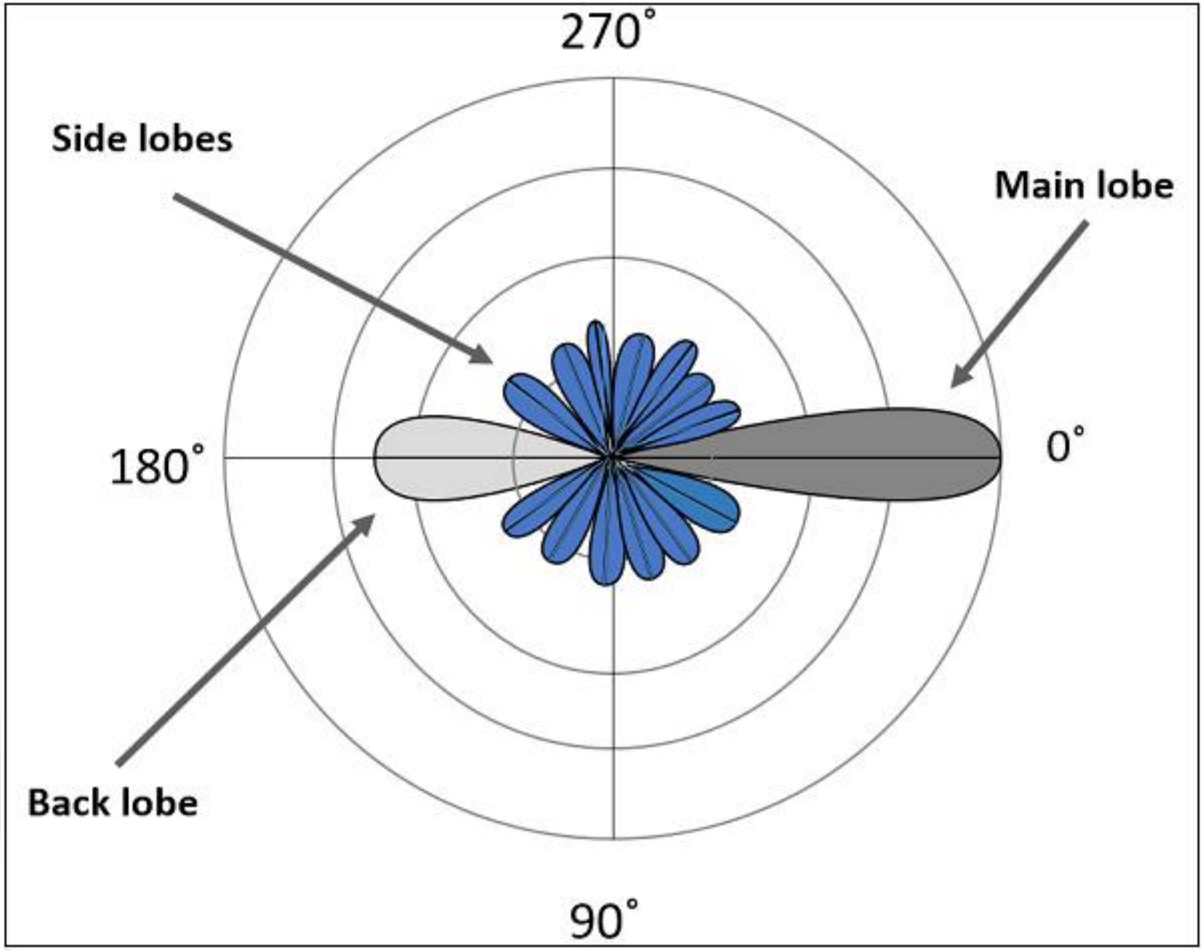
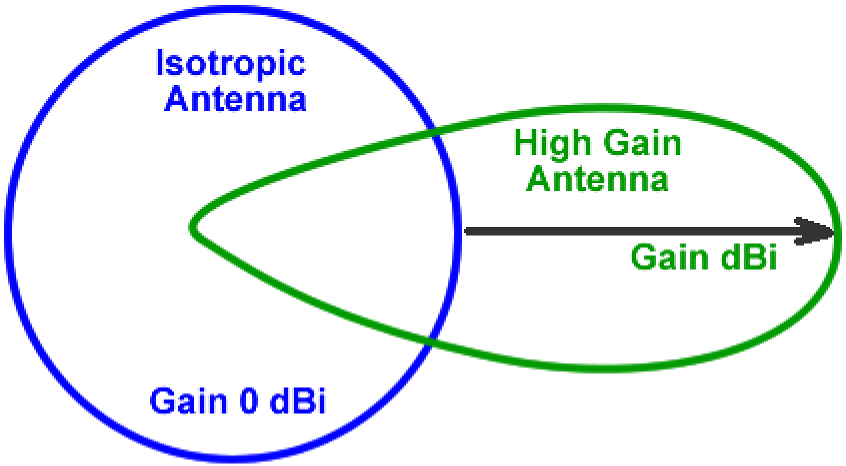
Radiation Pattern of Real Antennas



- Antennas are typically specified by their main lobe gain (dBi)

Measuring a Directional Antenna



- Remember
  - Antenna Gain (dBi) is referenced to an imaginary Isotropic Dipole

Bouncing RF off the Atmosphere

- HF (3-30 MHz) bounce of the E, F1 and F2 Layer
- Attenuation of the D layer

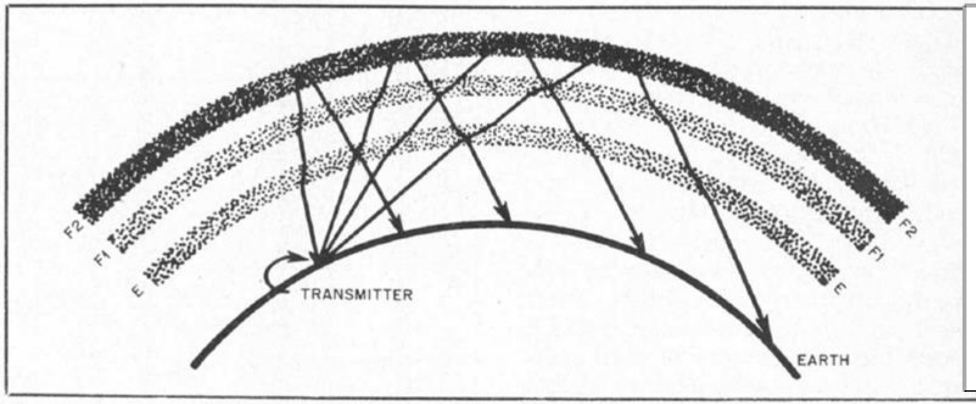
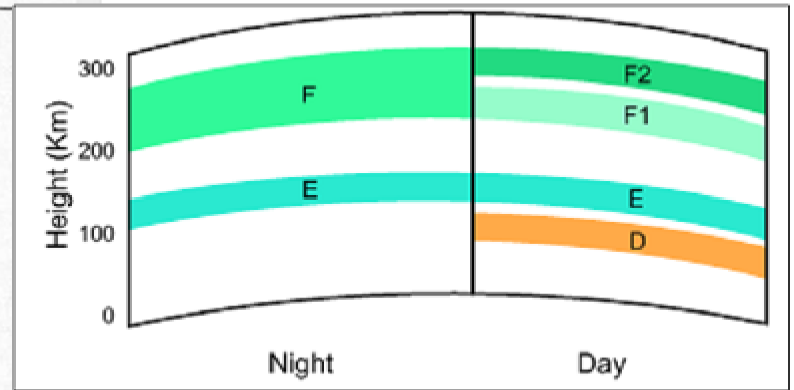


Fig. 3 — Typical daytime wave propagation at high frequency as compared to the ionospheric layers. The F2 layer is the most useful for long-range communications. The E layer is excellent for short-range skip communications at the high end of the HF spectrum and the lower part of the VHF spectrum.



- It's a Fuzzy World
  - No real selection, but rather all happen at once
  - Some more dominant than others
  - Environmental conditions with frequency dominate

How Energy Bounces

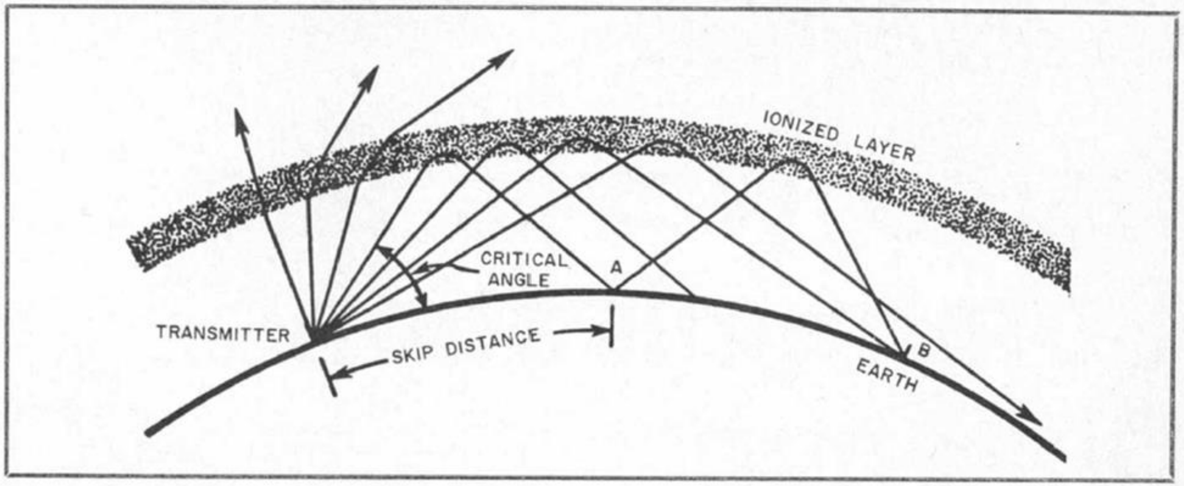


Fig. 2 — Radio signals as they are affected by the ionosphere. Some waves penetrate the ionosphere or are absorbed, while others are refracted earthward from these ionized layers (see text). Points A and B on the earth's surface in this drawing illustrate multihop skip.

- Primary Lobe
  - Vertical
  - Angled
  - Horizontal
- Skip Distances
- Multi-bounce

Antenna Pattern

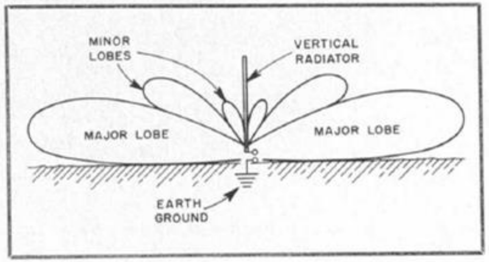


Fig. 4 — Illustration of various radiation angles versus major and minor lobes for a vertical antenna. Minor lobes occur also with most horizontal wire and beam antennas. All of these lobes are useful, depending on band conditions at a given instant and with regard to the desired communication distance (see text).

Table 1
Suggested DX Bands

Band (MHz)	*Typical Distance (Day)*	*Typical Distance (Night)*
1.8 (160 meters)	0-50 miles	0-3000 miles
3.5 (80 meters)	0-100 miles	0-3000 miles
7.0 (40 meters)	0-1000 miles	0-3000 miles
10.1 (30 meters)	0-2000 miles	0-4000 miles
14.0 (20 meters)	0-4000 miles	0-100 miles
21.0 (15 meters)	0-4000 miles	0-100 miles
28.0 (10 meters)	0-5000 miles	0-100 miles

These distances versus time of day are based on either daylight or total darkness. Average band conditions are assumed. The actual distance worked will depend on the antenna used, the amount of transmitter power and the condition of a band at a given moment. The mileage may be greater or less than stated above. Single-hop communications are assumed here. Multihop skip will provide worldwide communications under ideal band conditions.

- Each type of Antenna has its own pattern
- Range is based upon projecting energy toward your target
- Omni vs Directional

Why DX Radio at night?

- Atmospheric Attenuation (power at Receiver)
- Noise
  - Sun (Thermal)
  - Interferers – Noisy (motors) appliances
  - Other Transmissions (Radio Stations, TV, other)
  - Not the primary signal, but inter-modulation products
- Signal to Noise (SNR)
  - Receiver Sensitivity

Antenna Polarization

- Common Polarizations
  - Vertical
  - Horizontal
  - Circular (clockwise or Counterclockwise)
- Best energy transfer occurs if TX and RX antennas are the same polarization (often you only have control of your own antennas!)

Energy Transmitted vs Energy Received

- Energy in nature (Energy is logarithmic)
  - Atmospheric loss (attenuation) is dB per distance (ft, km, mile)
  - Atmospheric loss is variable based on air conditions (density)
  - Non directionality, signal is distributed by antenna (not columnated)
  - Bouncing (buildings, but also layers)
  - Noise (principally thermal)

RF Propagation Basics

Questions?