Kenneth Vito Zichi

3018 Moyer Road
Williamston, MI 48895-9566

The ABC's of Propagation

As children, a lot of us thought of radio as a "magic" box. Just by turning a switch, voices and music from across the city, or state, would come drifting into our room. By the time most of us discover shortwave, we've outgrown the idea that supernatural forces were at work in our radios. Still, we remain awestruck at the idea that someone in Australia or South Africa could whisper into a microphone and we could hear it half a world away.

This decidedly non-supernatural method by which radio waves travel from point "A" to point "B" is called *propagation*. It is a concept basic to all radio communications. And despite popular myth, you do not need a Ph.D in physics to understand it.

Radio is a form of "electromagnetic radiation." That is a fancy way of saying that radio waves have both electrical and magnetic properties. If they are energetic enough, they can leave the confines of a conductor and travel freely through the air, a vacuum (like outer space), or other similar media. In this way, radio waves act much like light, which is another form of electromagnetic radiation, albeit higher in frequency than radio. In fact, light provides a very good analogy for explaining how radio waves propagate.

Types of Propagation

Like light, radio waves can propagate (travel) in several different ways. We've sketched out some of the most common types of propagation, how they work and on what band(s) you're likely to encounter them.

GROUND WAVE

The most common and reliable way for radio waves to travel is called "ground wave." This is a form of propagation that is common to *all* radio bands from VLF (Very Low Frequency) to radar. Simply put, when a radio wave travels directly from the transmitting antenna to the receiving antenna without bending, reflecting, or otherwise being diverted, it is traveling by ground wave.

Using the light analogy, imagine a lighthouse shining in the distance. So long as there is nothing between you and the light -- and you are not so far away that the curvature of the earth would place the lighthouse below the horizon -- you can see it. (See figure one, wave A).

You can increase the distance you can see the lighthouse by elevating either yourself (a receiver) or the light (a transmitter), but once these variables are fixed, there is a finite distance at which the light will be visible because of the earth's curvature.

Reception distance is therefore limited when using this form of propagation. However, this limitation is offset by the fact that groundwave reception is very reliable. Some examples of transmissions using ground wave reception are local AM and FM broadcasters, police communications and CB radio.

IONOSPHERIC ("Skip")

Another very common form of propagation is ionospheric propagation, which is also known as "skip" or "skywave." This common phenomenon of long distance communications on frequencies between .5 and 30 MHz is the result of the bending of radio waves in the earth's *ionosphere*.

The ionosphere is several regions of charged oxygen (and other gases) located some 60 and 200 miles above the ground. These layers have a number of unique properties, not the least is their ability to *refract* radio waves that enter it back toward the earth's surface.

To use the light analogy again, it is as if someone placed a huge mirror in the sky, and radio waves, which would ordinarily shoot off into space, are re-directed back to the earth's surface. (See figure one, wave B.)

Actually, this analogy is not quite correct since the ionosphere *refracts* radio waves and a mirror *reflects* light. At any rate, if a radio wave of the right frequency enters the ionosphere, it will be bent back to earth. The result is reception of the signal hundreds of miles away from the

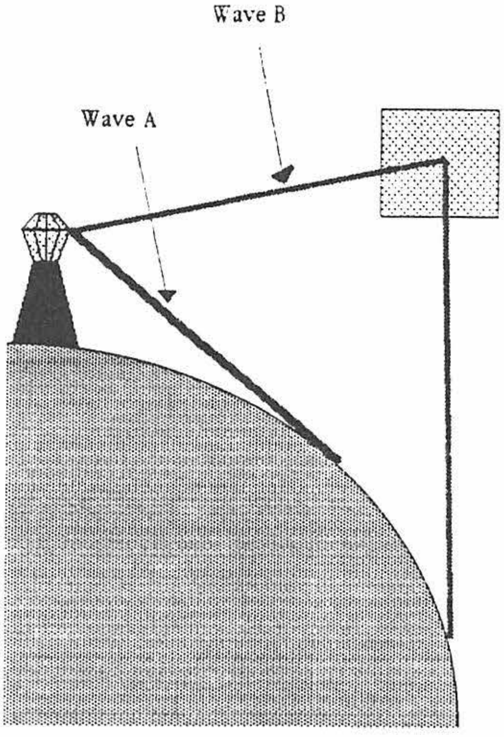

Figure One

Like the light from this lighthouse, radio waves travel only in straight lines. As a result of the curvature of the Earth, they can therefore only travel a finite distance (Wave "A").

Reception past the horizon can take place, but only if the radio waves are refracted or reflected off some surface, akin to someone in space holding amirror to allow you to see the lighthouse, as illustrated by wave "B."

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transmitter and well beyond the range possible by ground wave propagation.

Unfortunately, the ionosphere is also capable of absorbing or blocking reception of radio waves. Depending on the density of the ionosphere at a given time, the angle of the wave entering the ionosphere, and the frequency of the wave, long distance reception will be either enhanced or destroyed.

Too, the gap between where ground wave reception ends and the spot where the skywave signal hits the earth is also an area of non-reception. It is called the *skip zone* and the phenomenon is illustrated in figure two, with "S" denoting the skip zone.

Depending on the time of day and solar conditions (solar radiation is one of the major factors that cause gases in the upper atmosphere to ionize and form the ionosphere), different layers of ionized gas of varying intensity will be formed. Each layer affects radio waves slightly differently.

Lower frequency shortwave signals (eg. 2 through 9 MHz) will be absorbed if they pass through the ionosphere at low angles during the daylight hours. During this part of the day, there are more layers to the ionosphere and these layers are thicker. Thus, during the day, low frequencies do not propagate as well as higher frequencies (eg 11 through 25 MHz). Similarly, at night, the ionosphere is thinner and the low frequency waves are refracted without being absorbed. Then, the higher frequencies pass freely into space.

MULTI HOPS

Radio signals making the journey from transmitter to ionosphere to earth are said to have completed a "one hop" circuit. However, this is not necessarily the end of the trip. That same signal can be reflected from the earth, back up to the ionosphere once again, and down to earth, this time even further from the transmitter. If conditions are just right, a signal can go all the way around the world and double back on itself.

The "multi-hop" circuits do increase distances dramatically, but are less than single hops since they are subject to the uncertainties of the ionosphere more than once.

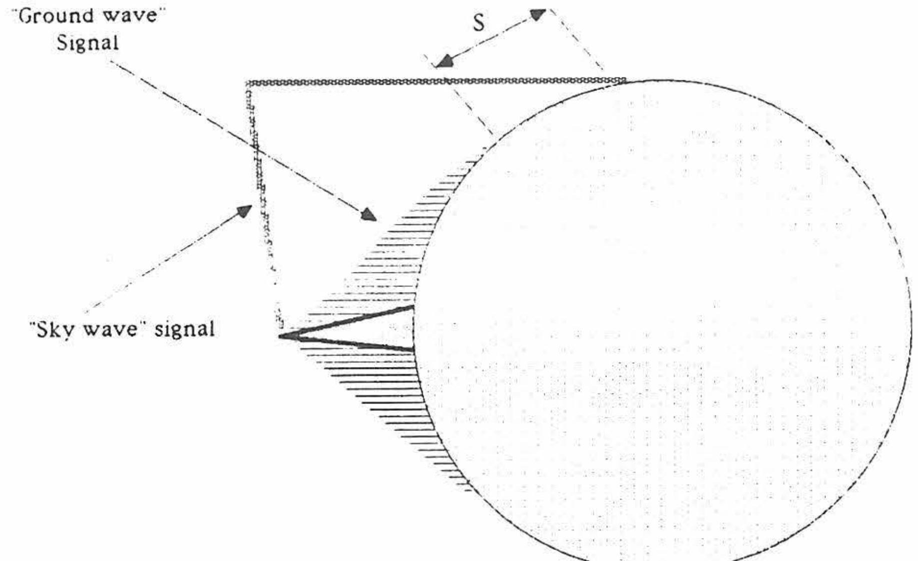

Figure Two

"S" = the "skip zone": the area between ground wave and sky wave propagation where reception of radio signals is difficult at best.

Drawing is not to scale! Actual distances for ground wave reception on the Earth would be about 300 km depending on effective height of transmitter and receiver antennae, not 1/4 of the planet's surface as indicated here!

EXOTIC STUFF

Lastly, there are numerous, less common ways that a radio wave can get from point A to point B.

One of these is called *sporadic E.* If it is sufficiently charged, the "E Layer" of the ionosphere is capable of refracting relatively high frequency radio waves. Occasionally, there will be "pockets" of highly charged particles within the E layer which allows for unusual reception.

This so called "sporadic E reception" is just that: sporadic. It is fairly common around local dusk and can boost reception of FM and TV signals well beyond their intended range. Sporadic E is also most common during the late spring and early summer in temperate latitudes but it is possible at any time of the year.

Moonbounce is a form of reception that's fascinating but rarely used now that man-made satellites populate the skies over planet earth. Pioneered by radio amateurs, it is a form of propagation in which signals are intentionally reflected off the moon's surface and back to earth.

Tropospheric Ducting is most common at relatively high frequencies and affects transmissions heard on FM, TV and scanners. It results when radio waves follow patterns of high and low pressure in the atmosphere (much the way weather patterns do). It allows for reception of signals slightly beyond the range you might otherwise expect.

Lastly, *Meteor Scatter* is probably one of the most unusual forms of propagation. Here, radio waves are bounced off the ionized trails of meteors. Like sporadic E reception, this results from a region of the atmosphere becomming supercharged, and thus refracting higher frequencies than normal back to earth. Reception of VHF signals using metero scatter can be very brief -- lasting in the order of seconds.

In short, there are a plethora of exotic reception techniques, but the ones outlined in the first part of this article are the ones you are most likely to run into, and should aid you in planning your listening to best enjoy the hobby. ■