HF Radio Wave Propagation   Robert AK3Q 8-11-2013

▪ Understanding radio wave propagation can mean the difference between making or missing a contact to a particular part of the world.

– HF region spans 3 to 30 MHz.
– This includes the 80, 40, 30, 20, 17, 15, 12, and 10 meter bands.

■ Characteristics of HF radio propagation
– Propagation is possible over thousands of miles.
– It is highly variable. It has daily and seasonal variation, as well as a much longer 11 year cycle.

■ HF radio waves may travel by any of the following modes:
– Ground Wave
– Direct Wave (line-of-sight)
– Sky Wave

Ground Waves
▪ In the HF region, the ground is a poor conductor
▪ ground wave are quickly attenuated by ground losses. Some ground wave communication is possible on 80m, but at frequencies above 5 MHz, the ground wave is irrelevant.

Direct Waves
▪ Direct waves follow the line-of-sight path between transmitter and receiver.
▪ In essence they have to "see" each other

Sky Waves
▪ Sky waves leave the antenna in a straight line and are returned to the earth by the ionosphere. Communication is possible throughout much of the day to almost anywhere in the world via sky wave.

The Ionosphere
■ Created by ionization of the upper atmosphere by the sun.
■ Electrically active as a result of the ionization.
– Bends and attenuates HF radio waves
– Above 200 MHz, the ionosphere becomes completely transparent

▪ Consists of 4 highly ionized regions
– The D layer at a height of 38 – 55 mi
– The E layer at a height of 62 – 75 mi

– The F1 layer at a height of 125 –150 mi (winter) and 160 – 180 mi (summer)
– The F2 layer at a height of 150 – 180 mi (winter) and 240 – 260 mi (summer)

▪ The density of ionization is greatest in the F layers and least in the D layer
▪ Though created by solar radiation, it does not completely disappear shortly after sunset.
– The D and E layers disappear very quickly after sunset.
– The F1 and F2 layers do not disappear, but merge into a single F layer residing at a distance of 150 – 250 mi above the earth.
▪ Ions recombine much faster at lower altitudes.
▪ Recombination at altitudes of 200 mi is so slow that the F layer lasts until dawn.

The D-Layer
▪ Extends from 62-75 miles' altitude.
▪ Is created at sunrise, reaches maximum density at noon, and disappears by sunset.
▪ The D layer plays only a negative role in HF communications.
▪ It acts as an attenuator, absorbing the radio signals, rather than returning them to earth (this is why AM radio is short range).

The E layer
▪ Extends from 38 – 55 miles' altitude.
▪ Is created at sunrise, reaches maximum density at noon, and disappears by sunset.
▪ It can return lower HF frequencies to the Earth, resulting in daytime short skip on the lower HF bands.
▪ It has very little effect on higher frequency HF radio waves, other than to change slightly their direction of travel.

The F Layers
▪ The F1 layer extends from 125 –150 mi (winter)/180 mi (summer)
▪ The F2 layer extends from 150 – 180 mi (winter)/260 mi (summer)
▪ The F layers are primarily responsible for long-haul HF communications.
▪ The F layer carries almost all nighttime communications over intercontinental distances.

▪ Longer distances are covered by multiple hop propagation. When the refracted radio wave returns to earth, it is reflected back up towards the ionosphere, which begins another hop.

Daily Propagation Effects
▪ Shortly after sunrise, the D and E layers are formed and the F layer splits into two parts.
– The D layer acts as a selective absorber, attenuating low frequency signals, making frequencies below 5 or 6 MHz useless during the day for DX work.
– The E and F1 layers increase steadily in intensity from sunrise to noon and then decreases thereafter.
- The F2 layer is sufficiently ionized to HF radio waves and return them to earth.

■ During the daylight hours:
– 15, 12, and 10m for multi-hop DX.
– 40, 30, 20 and 17m, for short skip.
■ After dark
– 80, 40, 30 and 20m for DX.
– Noise levels on 80m can make working across continents very difficult.

Seasonal Propagation Effects
▪ During the winter months, the atmosphere is colder and denser.
▪ The ionosphere moves closer to the earth increasing the electron density.
▪ During the Northern Hemisphere winter, the earth makes its closest approach to the sun, which increases the intensity of the UV radiation striking the ionosphere.
- Electron density during the northern hemisphere winter can be 5 times greater than summer's.

Effects of Sunspots
▪ A sunspot is a cool region on the sun's surface that resembles a dark blemish on the sun.
▪ The number of sunspots observed on the sun's surface follows an 11 year cycle.
Sunspots have intense magnetic fields which increases the electron density in the earth's atmosphere.
■ During sunspot maxima, the highly ionized F2 layer acts like a mirror, refracting the higher HF frequencies (above 20 MHz) with almost no loss.
■ Contacts on the 15, 12 and 10m bands in excess of 10,000 miles can be made using 10 watts or less.
■ During short summer nights, the MUF can stay above 14 MHz. The 20 m band stays open to some point in the world around the clock.