Summerland Amateur Radio Club

Foundation Module 4

for the AMC Foundation & Practical Syllabus V10

Propagation

Syllabus Assessment Objectives

6.1	Recall that radio waves travel in straight lines, unless diffracted, reflected or refracted.
6.2	Recall that radio waves get weaker with distance as they propagate from the antenna.
6.3	Recall that [the] communication range at VHF/UHF is dependent on antenna height, a clear path, transmitter power and receiver sensitivity.
6.4	Recall that VHF and UHF signals are obstructed by hills and large structures.
6.5	Recall that unusual atmospheric conditions may at times provide extended range.
6.6	Recall using supplied reference material, that the ionosphere comprises layers of ionised gas at varying heights above ground.
6.7	Recall that ionospheric propagation is dependent on time of day, season, frequency and solar activity.
6.8	Recall that long-distance HF communication relies on propagation by ionospheric refraction.

Resources

CARS Foundation PowerPoint slides Propagation – download here - http://www.g0mwt.org.uk/training/courses/foundation.htm

WIA Foundation Manual Chapter 4

Australian Space Weather Forecasting Centre
https://www.sws.bom.gov.au/HF_Systems

Module Content

When travelling in 'free space', radio waves, like all electromagnetic radiation, travel in straight lines. (free space means a vacuum with no obstructions).

In free space, the strength of a radio wave reduces in proportion to the square of the distance from the source. This called the 'Inverse square law'. Think of the heat from a campfire – twice the distance back means a quarter of the heat.

So how is it possible for radio waves to travel ('propagate') well beyond the line of sight and even to the other side of the planet? This can occur by the wave being affected by *Reflection, Refraction or Diffraction.*

Reflection

Everyone is familiar with reflection of light, which requires a polished surface or a mirror, but the longer wavelengths of radio waves can be reflected by the ground, the ocean and objects such as buildings.

Refraction

Propagation by HF signals can occur over great distances by refraction in the ionosphere. This is the uppermost layer of the earth's atmosphere. Solar radiation causes this layer to be 'ionized', with lots of electrically charged atoms (ions) and free electrons.

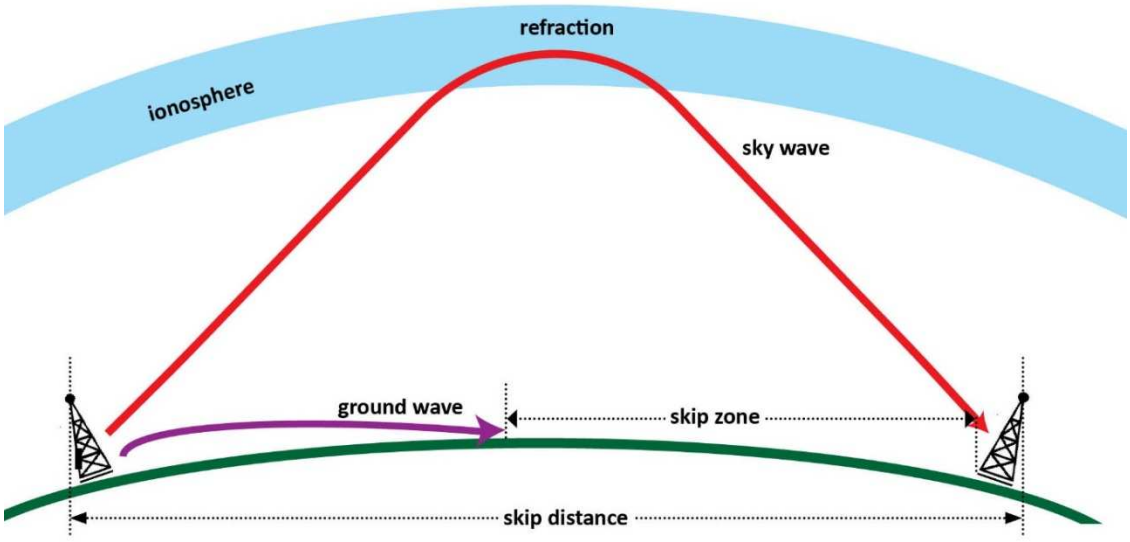
A high frequency radio wave entering the ionosphere can be gradually bent (refracted) and be returned to earth a great distance from the transmitting station. This is often called the 'sky wave' or 'skip'.

Ionospheric propagation is highly variable, and is dependent on the amount and distribution of ionisation in the ionosphere, and this varies with the time of day, the season, the frequency of the signals and the degree of solar activity.

On medium wave and HF frequencies, signals can also travel beyond line of sight by 'ground wave' propagation, where the waves travel close to the ground to the receiving station, eventually becoming too weak to detect.

The 'skip zone', as shown in the diagram, is an area between the end of ground wave propagation and the point where the refracted 'sky waves' first return to earth. Signals from the transmitter can't be heard in the skip zone.

Ionospheric Refraction

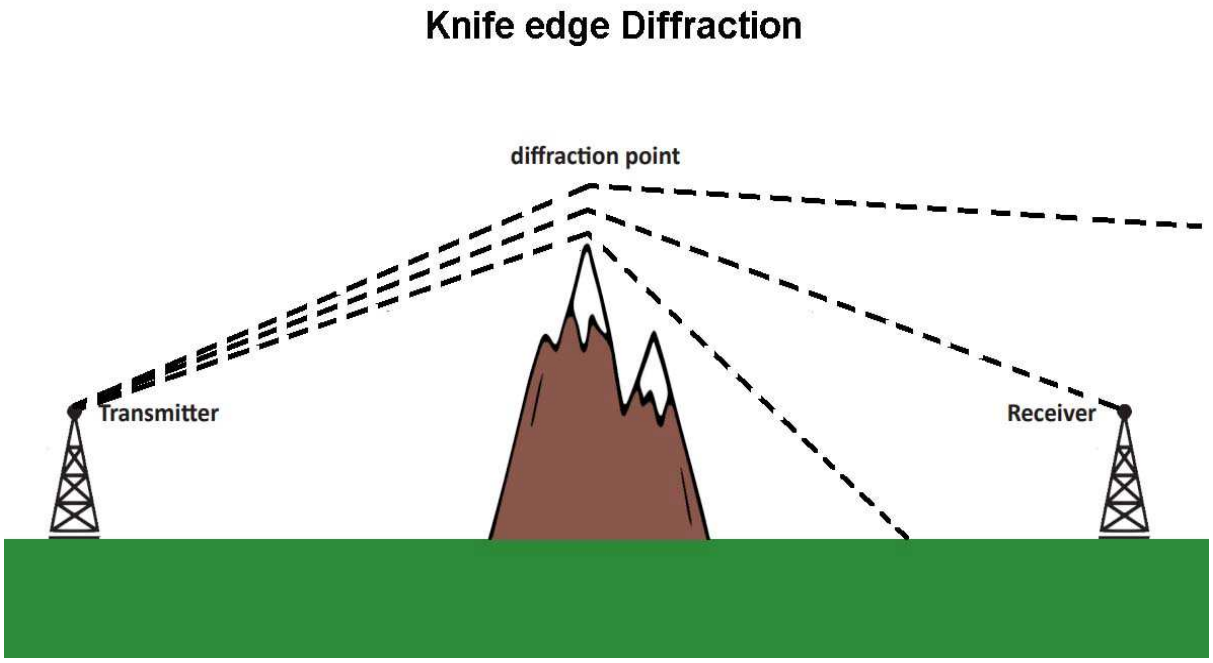


Diffraction

It is possible for VHF/UHF signals to propagate to a receiver that is out of the direct line of sight, by the effect of diffraction.

If a beam of light is passed over a sharp edge like the blade of a knife, some light is bent into the shadow area. The sharper the edge the greater the bending. This is called *knife edge diffraction.*

The same effect occurs at radio frequencies where the definition of 'knife edge' is not as obvious. At VHF and UHF frequencies a mountain range or even a hill can act as a 'knife edge', with signals diffracted into what would otherwise be in a 'radio shadow'.



The range of VHF and UHF Signals

With direct line of sight, VHF/UHF signals can travel over great distances, as seen with satellites and space probes.

Signals between ground stations however, under normal atmospheric conditions, are limited in range when not in 'line of sight' due to curvature of the earth or obstructions such as hills and buildings.

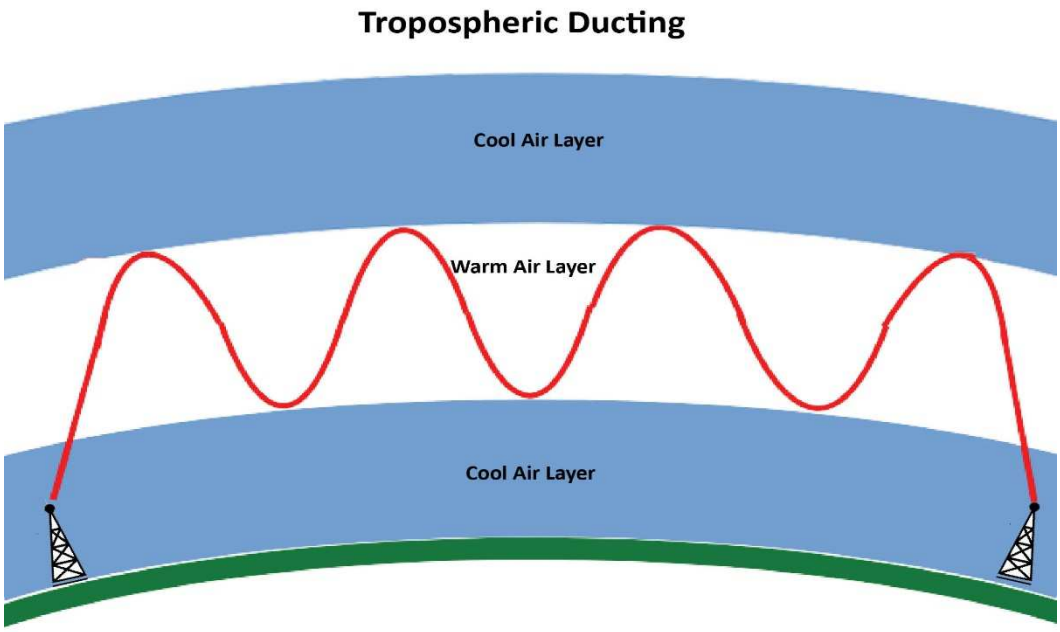
The communication range can be improved by placing antennas as high as possible. Higher transmission power and good receiver sensitivity also assist in extending the range.

Extended VHF/UHF range under unusual conditions

Unusual conditions can allow propagation over very long distances, for example, from Australia to New Zealand. A well-known phenomenon that typically occurs in mid-latitudes during summer, is the formation of 'ducts' where signals are trapped between hot and cold layers in the troposphere.

The troposphere is the lower layer of the atmosphere where we live. Radio waves normally pass straight through this layer, but can be 'ducted' to a distant station as shown in the diagram.

There can also be unusually long propagation via the lower levels of the ionosphere, across the equator ('trans-equatorial' propagation).



The Sun Spot Cycle

On the surface of the sun are areas of intense solar activity, called sunspots. The radiation from these spots is a major cause of ionization, so that HF propagation is better when there are more sunspots.

The impact of solar radiation on the earth's atmosphere is an incredibly complex and fascinating subject. There is a roughly eleven year cycle between peaks in the number of sun spots.

Knowledge of solar activity is not required for amateur radio exams, but it is a fascinating topic which is worthy of study, particularly if you are interested in long-distance ('DX') radio communication.

Question 1:
The Ionosphere is mostly affected by:

A) rainfall
B) wind
C) the amount of sunshine on a day
D) conditions on the surface of the Sun

Question 2:
VHF/UHF signals can sometimes be propagated over 1000's of kilometres, this could be caused by:

A) tropospheric ducting
B) reflection from the ionosphere
C) nearby cloud cover
D) using a vertical antenna

Question 3:
Radio waves travel in straight lines unless they are subjected to?

A) reflection
B) refraction
C) diffraction
D) all of the above

Question 4:
Where would be the best place to position a VHF/UHF antenna?

A) outside the ground floor window
B) attached to the house gutter
C) on top of a tower
D) half a wavelength above the ground

Question 5:
As the distance from the transmitting antenna increases, radio waves:

A) remain constant in strength
B) become weaker
C) shift down in frequency
D) shift up in frequency

Question 6:
A radio wave passing over a mountain range may be:

A) diffracted
B) refracted
C) reflected
D) redacted

Question 7:
Long distance propagation of HF signals can be caused by:

A) tropospheric ducting
B) Ionospheric refraction
C) atmospheric enhancement
D) stratospheric curvature