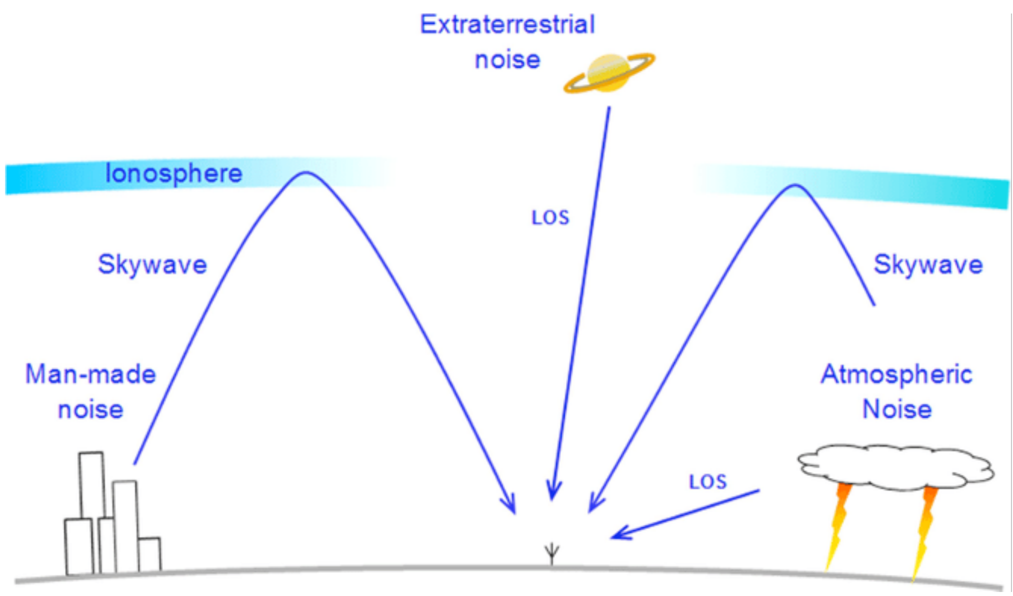
Chapter 19

Background Noise and Signal Fading



19 Background Noise and Signal Fading

Background noise and signal fading are two of the most serious problems affecting HF radio communications. Signals that sink into the background noise cannot be received. Signals that fade in and out are very difficult to copy.

19.1 Background Noise

There is always a certain amount of background noise and interference associated with HF radio communications. It cannot be avoided!

Signals weaker than the background noise (below the noise floor) cannot be heard. Successful HF communications depends on operating at power levels above the noise floor. In addition, there must be a sufficient noise margin so that the received signals do not fade below the noise. In Figure 1 the noise floor is -120 dBm. This system has been designed with a noise margin of 20 dB enabling signals as weak as -100 dBm to be successfully received. Receiving signals at -100 to -120 dBm is iffy. Signals below -120 dBm cannot be heard at all.

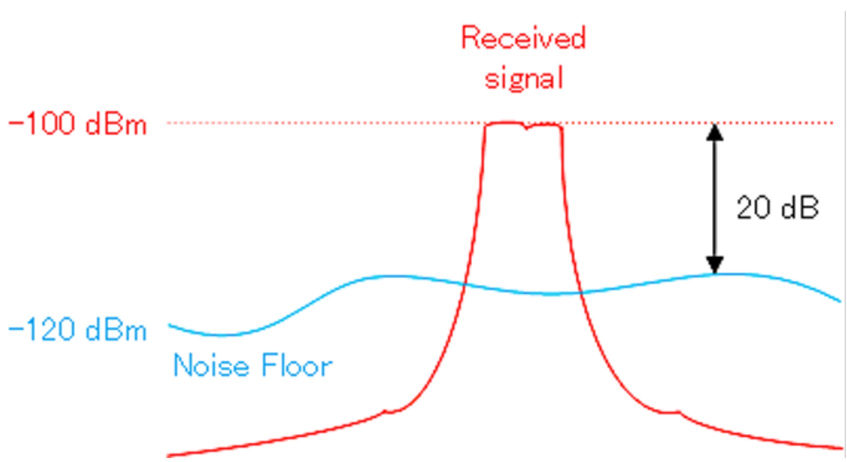


Figure 1 Noise floor (source: Circuit Design Inc)

The primary sources of background noise, illustrated in Figure 2, include:

- Atmospheric noise,
- Galactic noise, and
- Man-made noise.

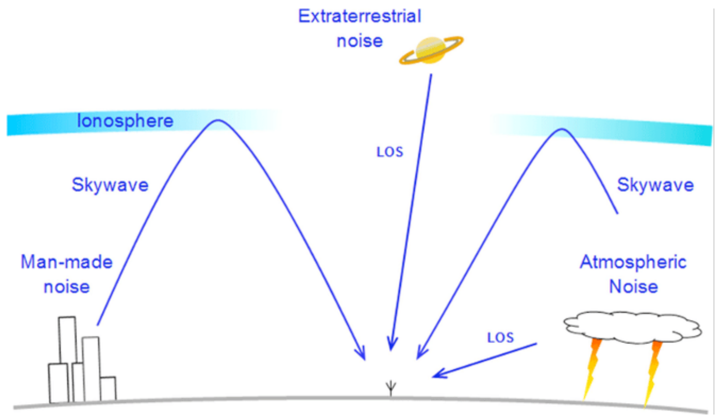


Figure 2 Primary sources of background noise (source: ResearchGate)

Atmospheric noise is created primarily by local and distant lightning strikes. A single lightning stroke emits hundreds of megawatts of power over a very broad range of frequencies from medium frequency (MF) through the HF frequency bands. Radio waves emitted by lightning travel via skywave propagation throughout the world just like the radio waves from HF transmitters. In addition, RF energy from local lightning strikes can travel by line of sight directly to your radio receiver, often with sufficient energy to destroy your receiver front end. It is imperative that you disconnect the antenna from your radio equipment during a lightning storm.

Atmospheric noise is partially absorbed in the D region of the ionosphere during the day, as illustrated in Figure 3. At night, the protection afforded by the D layer is gone, causing atmospheric noise to increase. Atmospheric noise is greatest in the summer when there are more thunderstorms and at low latitudes which incur the greatest number of thunderstorms.

Galactic noise is the result of radio emissions within our galaxy. We are affected by galactic noise only at frequencies above the F2 critical frequency (f_cF2). Lower frequency galactic noise cannot penetrate the ionosphere. Instead, it is refracted back into outer space as illustrated in Figure 4. Galactic noise that does make it through the ionosphere is generally not as important as atmospheric noise, except in remote areas far from urban centers where it can be detected at frequencies above 10 MHz.

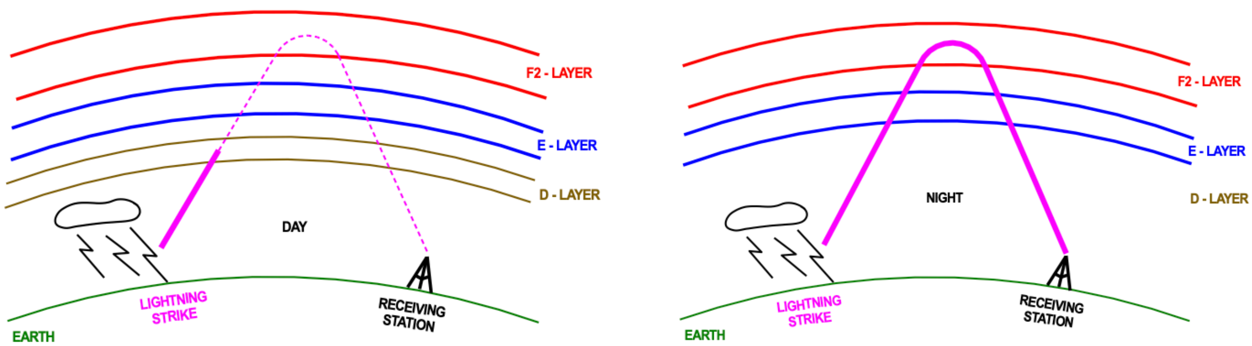


Figure 3 Day vs night propagation of atmospheric noise (source: author)

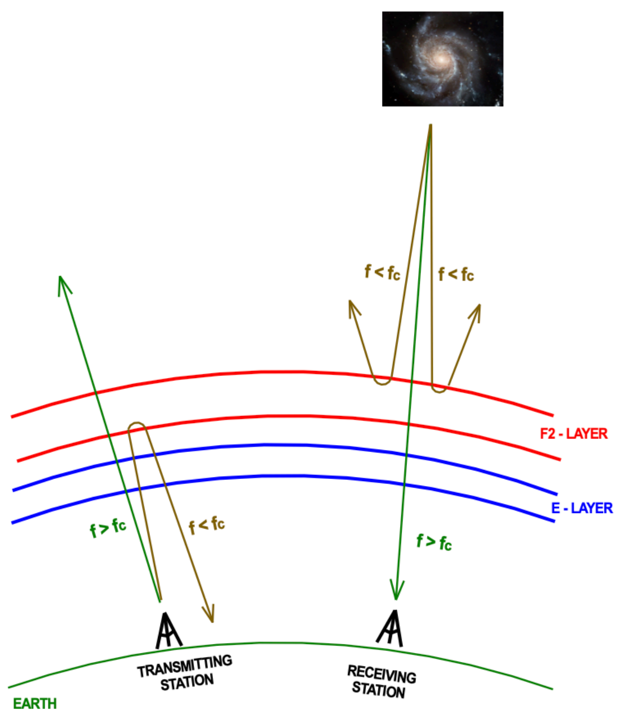


Figure 4 Galactic noise propagation (source: author)

Man-made noise and interference is created by power distribution systems, welding equipment, electric motors, vehicle ignitions, home appliances etc., as illustrated in Figure 5. Man-made noise in urban areas can at times be greater than atmospheric and galactic noise combined seriously interfering with HF radio communications

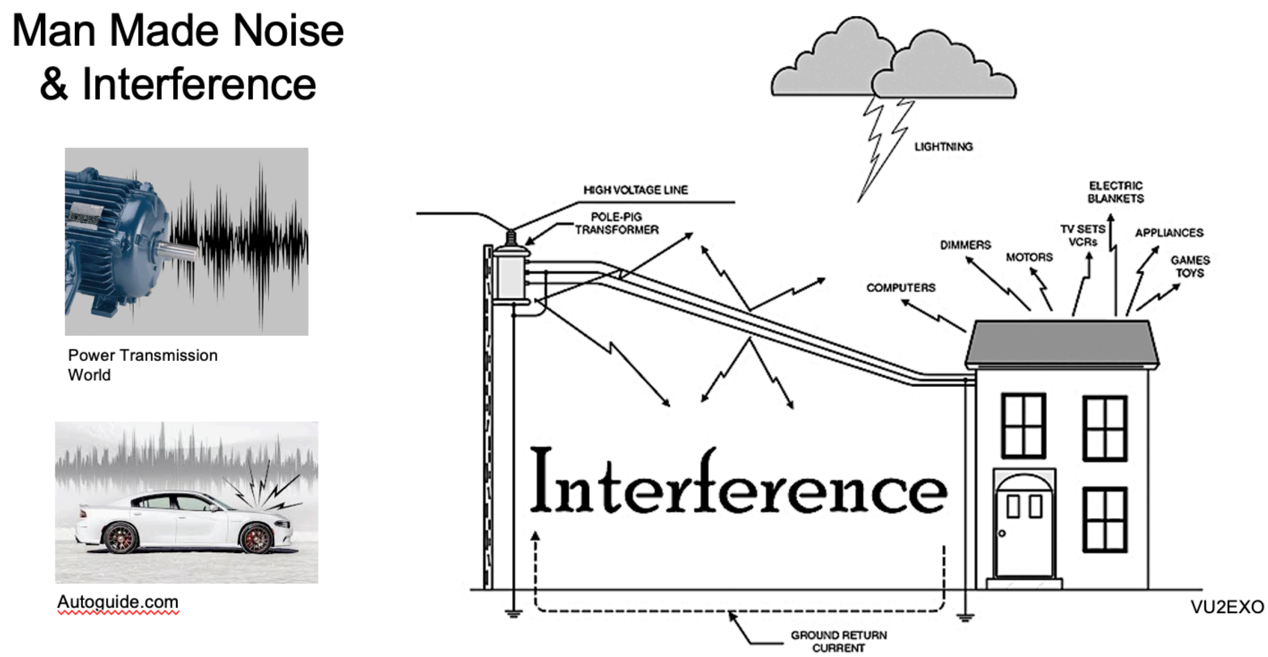


Figure 5 Sources of man-made noise

Noise and interference problems are reduced by

- Minimizing receiver bandwidth,
- Modulation and encoding techniques,
- Horizontally polarized antennas, and
- Directional antennas.

A wide receiver bandwidth allows more noise and interference to enter your receiver. Consequently, one of the most effective ways to minimize noise is to operate your receiver using the narrowest bandwidth filter suitable for your mode of operation. In Figure 6 the receiver's standard bandwidth (BW) receives the desired signal along with a significant amount of noise (red trace). Switching to a narrow bandwidth still receives the desired signal while reducing the amount of noise.

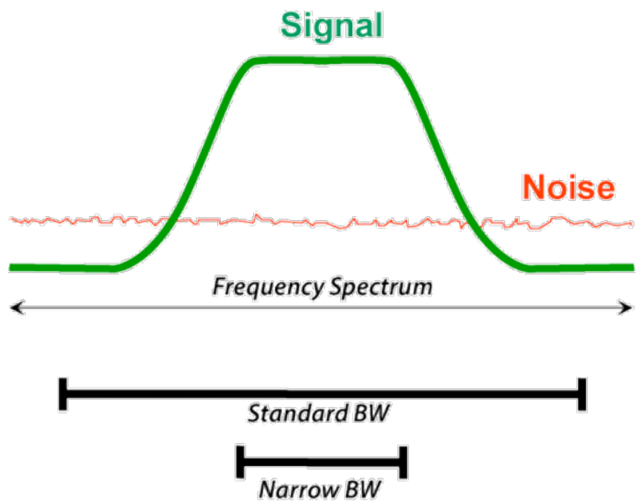


Figure 6 Using a narrow bandwidth reduces noise (source: MRIquestions.com)

Reducing receiver bandwidth was one of the motivations for switching from amplitude modulated (AM) to single side band (SSB) operation. Figure 7 shows the spectrum of an AM radio signal. The modulated signal consists of the carrier (the signal being modulated) in addition to lower and upper sideband signals carrying the original audio signal. The two sidebands are redundant. Each carries the desired audio. Thus, only one sideband is actually needed. Switching to single side band operation illuminates the carrier frequency and one of the sidebands, reducing the bandwidth of the SSB signal, typically 2.7 KHz, to one half that required for a 6 KHz AM signal.

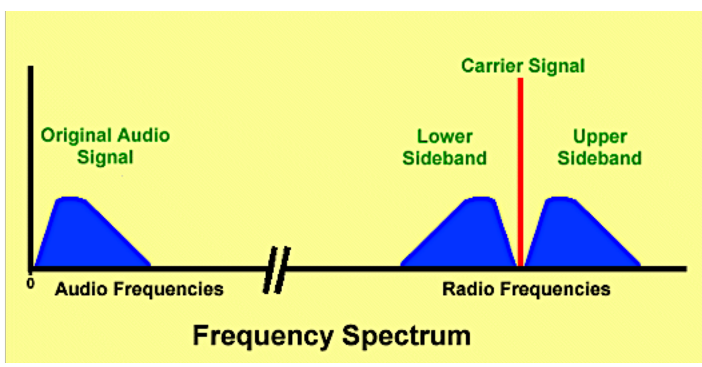


Figure 7 Spectrum of a voice modulated radio signal (source: Hawaii.edu)

Most modern-day receivers incorporate digital signal processing (DSP) circuitry which allows the receiver's bandwidth to be varied and shifted beyond that allowed by the receiver's crystal filters alone. In addition, DSP circuitry improves reception and receiver performance by notch filtering, which takes out close-by carriers, and by noise blanking and noise reduction which reduces the amount of background noise heard by the radio operator.

Signal encoding and digital signal processing techniques that allow signals to be pulled out of the background noise are very effective. Early digital transmission modes, including radio teletype (RTTY), were very susceptible to frequency selective fading and noise. Modern modulation and signal encoding techniques take into account selective fading and noise problems resulting in very robust digital communication modes.

Horizontal antennas tend to be lower noise antennas than verticals because most man-made noise is vertically polarized. Directional antennas reduce noise the most, including atmospheric noise. In Figure 8 the dipole antenna receives both the desired signal coming from the right as well as unwanted signals arriving from the left. In contrast, a directional yagi antenna receives the incoming signal but heavily attenuates unwanted signals and noise coming in from the left.

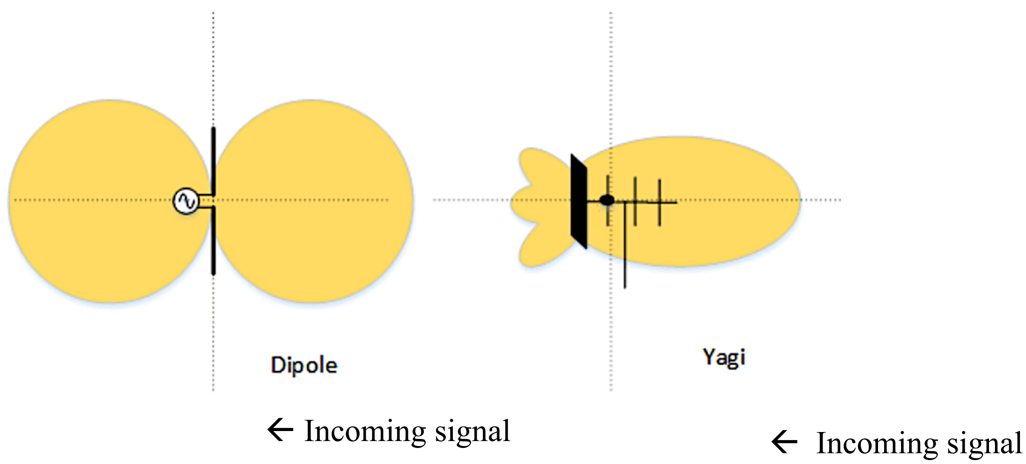


Figure 8 Directional antennas reduce incoming noise (source: Circuit Design Inc.)

19.2 Signal Fading

Signal fading is what makes skywave communications difficult. We can generally receive a steady signal, even if the signal is weak. But a signal that repeatedly peaks, fades below the noise level, reappears, and fades again is difficult to deal with. Fades vary in depth from shallow, only a db or so, to deep, fading more than 40 db. The duration of fades also varies from short, a fraction of a second, to long fades lasting several hours. Six types of fading are generally encountered:

1. Interference Fading,
2. MUF Fading,
3. Skip Fading,

4. Absorption Fading,

5. Frequency Selective Fading, and

6. Polarization Fading

19.2.1 Interference Fading

Interference fading is by far the most common type of fading. This type of fading is caused by a signal radiating from the transmitting antenna over a broad range of elevation angles. For the antenna in Figure 9 the elevation angles range from 30 to 90 degrees illuminating most of the sky. This wide swath of radiation travels through the ionosphere to a receiving station over many different paths of continuously varying lengths, some of which are illustrated in Figure 10.

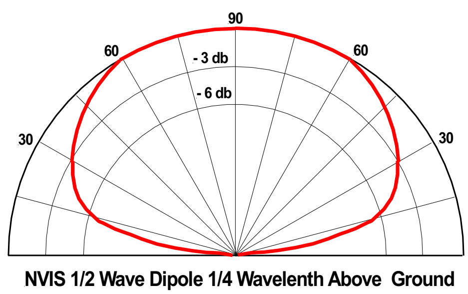


Figure 9 NVIS antenna floods most of the sky with RF energy (source: author)

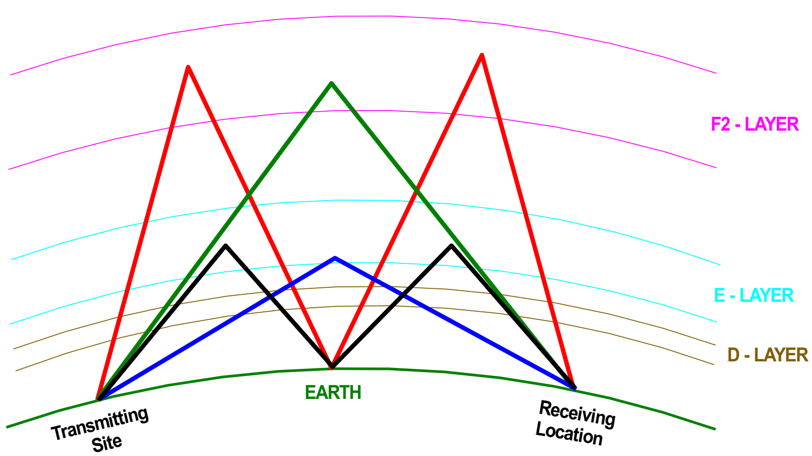


Figure 10 Signals follow multiple paths to the receiving station (source: author)

At the receiver these signals interfere with each other both constructively, creating signal peaks, and destructively creating deep fades as illustrated in Figure 11. This is known as interference fading.

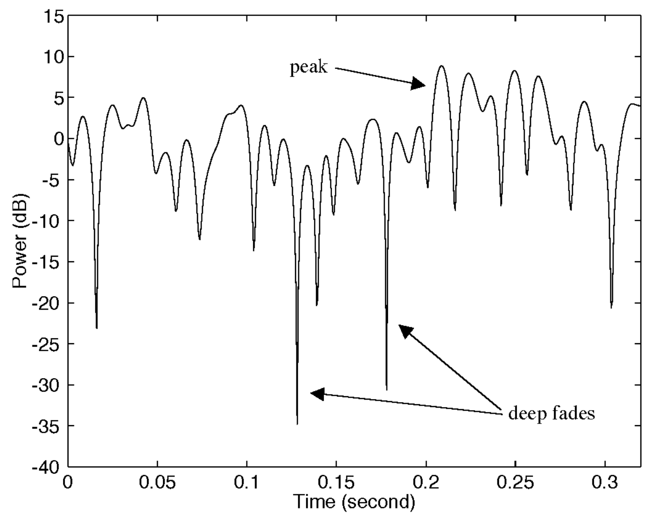


Figure 11 Interference fading (source: Ericsson Inc.)

Receiver Automatic Gain Control (AGC) was invented in part to deal with interference fading. An AGC circuit detects the strength of the received signal and automatically adjusts the receiver gain to maintain the receiver's audio output within an acceptable range. The effects of deep fading can be substantially reduced if the AGC attack and recovery times are closely matched to ionospheric fading characteristics.

There is more to the interference fading issue.

We tend to think of the ionosphere as a smooth flat surface that reflects our radio waves much like the reflections from the perfectly smooth lake in Figure 12. But the ionosphere is not a smooth flat surface. It is wispy. It tends to drift around, wobble, and wrinkle. The ionosphere is more like a rough lake surface. The rough lake in Figure 13 scatters light in all directions creating a badly blurred reflection. In a similar way, the turbulent ionosphere scatters reflected radio waves in many different directions. A signal that arrives at the intended destination one moment (blue trace in Figure 14) ends up some place else the next moment causing the signal at the receiving site to fade in and out.

Figure 12 Reflections from a perfectly smooth lake (source: Wikipedia)

Figure 13 Blurred reflections from the rough surface of a lake (source: olympus-lifescience.com)

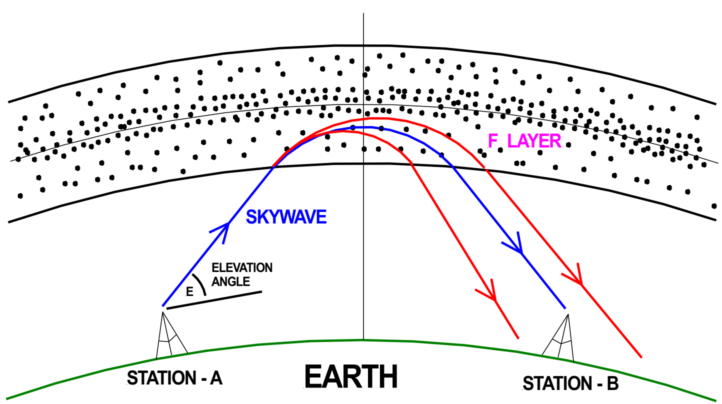


Figure 14 A signal's path through the ionosphere is constantly changing (source: author)

We also tend to think of our transmitted radio signal as being a very narrow laser like beam of RF energy that travels through the ionosphere from the transmitter (Station-A) to the receiver as depicted in Figure 15.

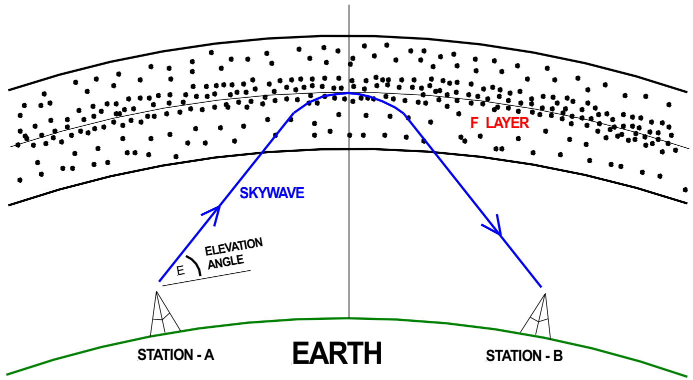


Figure 15 Idealistic radio signal traveling between Stations A and B (source: author)

However, this is NOT the case. In fact, skywave communications would be impossible if our signal really was a laser like beam of energy. The reason for this is that the ionosphere is constantly altering the path followed by a single ray of energy as in Figure 14. Sometimes a ray of energy reaches the intended destination. A few seconds later it does not.

Successful skywave communications occurs only because we flood the ionosphere with RF energy, hoping that at least a small part of that energy will end up at the intended destination. In Figure 16 signals follow multiple simultaneous paths from the transmitting station to the receiving location. Energy radiating from the transmitting antenna at a relatively high angle requires two hops through the ionosphere's F region to reach the receiving station (red path). Energy radiating at the same time from the same antenna but at a lower angle reach the receiving station in one hop (green path). Energy radiated at a slightly lower angle refracts in the E layer instead of in the F region, reaching the receiving station in two hops (black path). Energy radiated at an even lower angle also refracts in the ionosphere's E region reaching the receiving station in one hop (blue path).

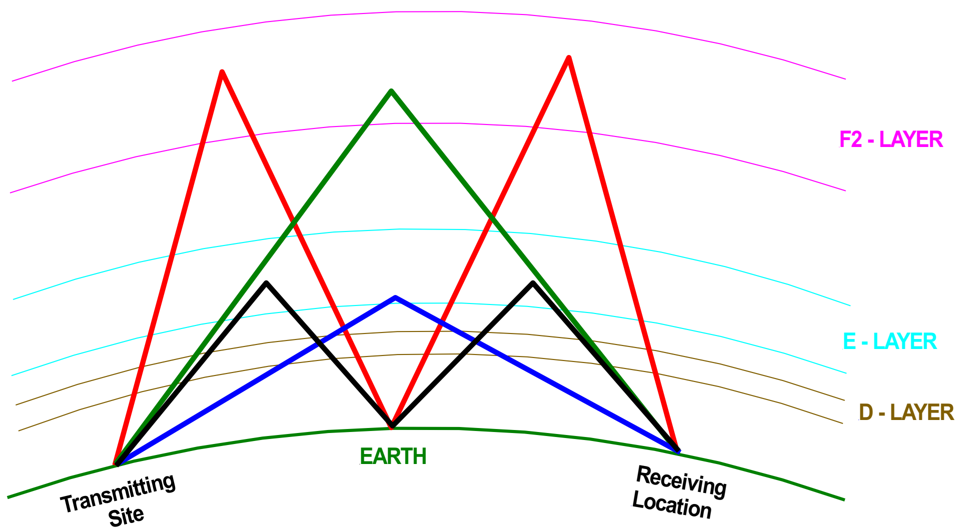


Figure 16 Signals follow multiple paths to the receiving station (source: author)

Our rather crude antennas are responsible for flooding the ionosphere with RF energy. The antenna in Figure 17 illuminates most of the sky with RF energy, particularly at elevation angles from 30 to 90 degrees. Consequently, the energy radiated by this antenna simultaneously follows all of the propagation paths shown in Figure 16, and more.

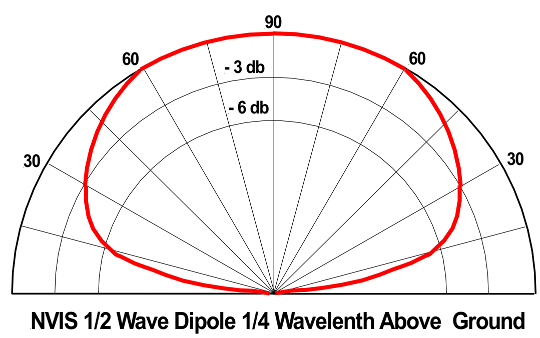


Figure 17 NVIS antenna floods most of the sky with RF energy (source: author)

What is actually received at a distant location is not a single signal but the multitude of signals illustrated in Figure 16, originating from the same transmitter, at the same time, but arriving via different paths with different amplitudes and phase angles. What results at the receiver is interference fading as the various signals interfere both constructively and destructively producing the received signal shown in Figure 18.

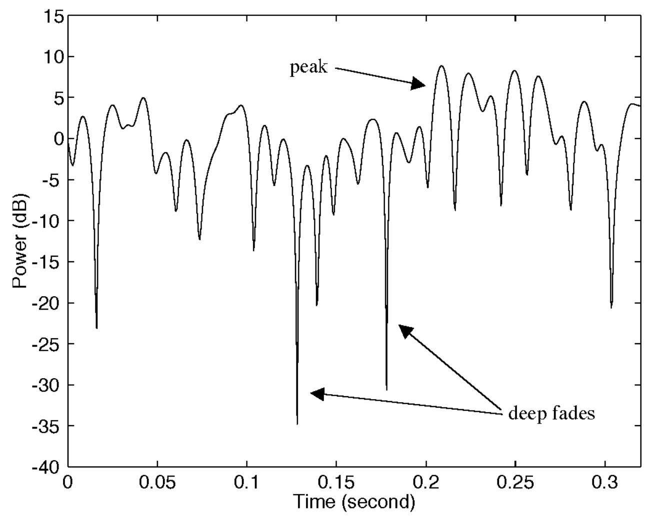


Figure 18 Interference fading (source: Ericsson Inc.)

19.2.1.1 Multipath Fading

In some cases, interference fading, often called multipath fading, can be controlled by properly selecting the transmitting frequency. For example, multipath fading will likely occur on radio circuits in which single and double hop paths simultaneously exist between the transmitting and receiving sites, as illustrated by the Los Angeles to Denver circuit shown in Figure 19.

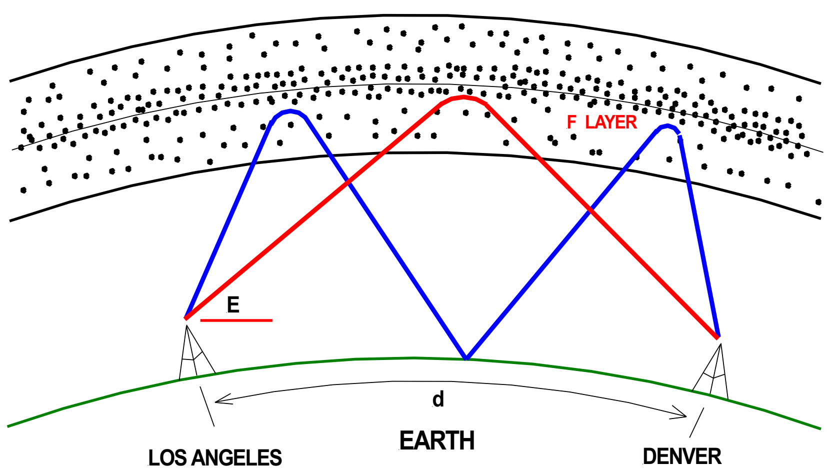


Figure 19 Communications between Los Angeles and Denver (source: author)

In this example communications between Los Angeles and Denver, a distance of 800 miles, can occur on 40 meters in either one hop or in two hops of 400 miles each as illustrated in Figure 19.

The 40-meter skip distance chart in Figure 20 shows that at a F2 height of 350 km (gray trace) an elevation angle of roughly 25^o is needed to reach Denver in one hop while an angle of 45^o is required for the double hop path. A critical frequency of 6.0 MHz supports both paths.

In general, we have relatively little control over the elevation angle at which our antenna radiates. The 40-meter half wavelength dipole shown in Figure 21 radiates at all angles from 20 to 90^o. Radiation from this antenna will reach Denver following both the single and double hop propagation paths. There is nothing that we can do about this!

The single and double hop signals will be out of phase when they arrive in Denver since the double hop signal has to travel a longer distance to get there. Consequently, the two signals will interfere with each other reducing the strength of the received signal, in addition to producing distortion and fading.

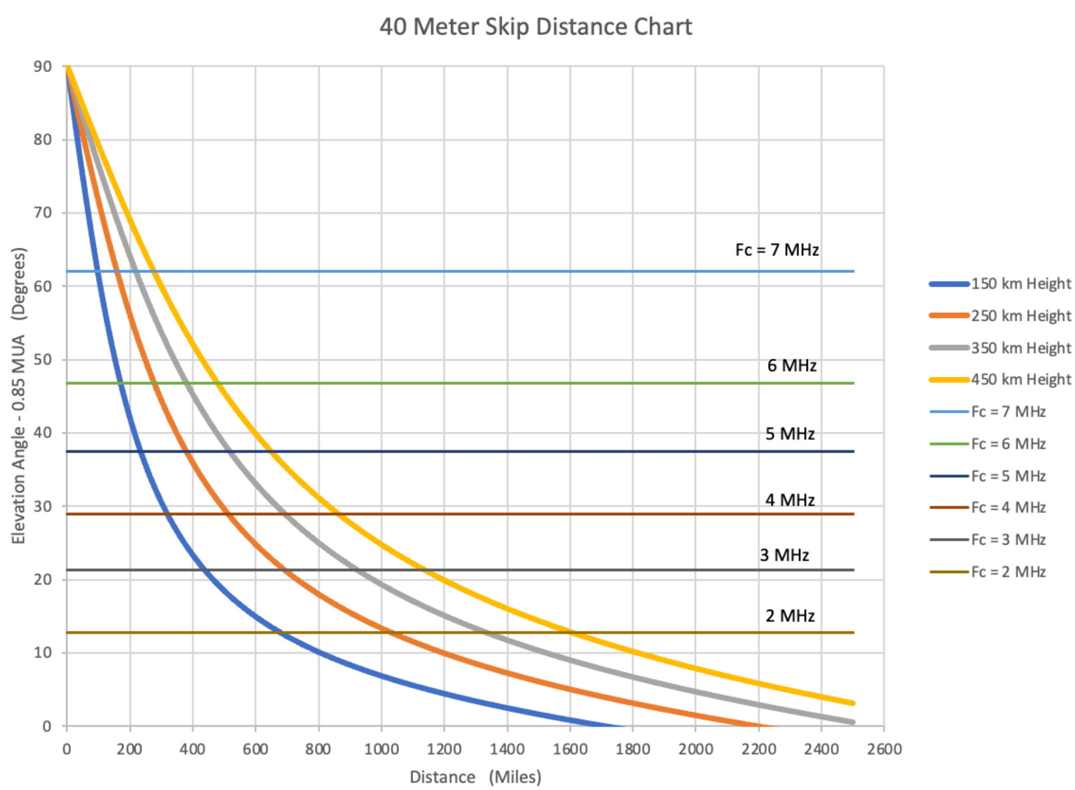


Figure 20 Skip distance chart - 40 meters. (source: author)

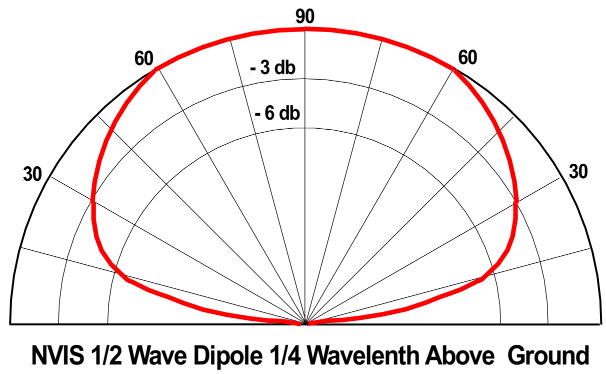


Figure 21 Elevation pattern for an NVIS 40 meter antenna (source: author)

The maximum usable frequency at a critical frequency of 6.0 MHz and an elevation angle of 25° is

$$[MUF]_{25^\circ} = \frac{f_{cF2}}{\sin E} = \frac{6.0\ MHz}{\sin 25} = 14.2\ MHz$$

At an elevation angle of 45° the maximum usable frequency is

$$[MUF]_{45^\circ} = \frac{f_{cF2}}{\sin E} = \frac{6.0\ MHz}{\sin 45} = 8.5\ MHz$$

Consequently, the double and single hop propagation modes are supported since the 40-meter operating frequency of 7.2 MHz is below the MUF for both the 25° and 45° elevation angles.

The 25° elevation angle MUF of 14.2 MHz supports communications with Denver on 30 meters (10.1 MHz), but the 45° elevation angle (MUF = 8.5 MHz) does not. This is illustrated by the 30 meter skip distance chart in Figure 22. In this chart an elevation angle of 45° is above the 31° elevation angle permitted by the 6.0 MHz critical frequency. Transmitting at an elevation angle of 45° on 30 meters will result in the transmitted signal penetrating the ionosphere and being lost to outer space. However, Denver is easily reached by transmitting on 30 meters at an elevation angle of 25°. In fact, this is the only possible path to Denver on 30 meters. Moving from the 40 meter to the 30 meter frequency band eliminates the Los Angeles to Denver multi-path interference problem.

This brings us back to a common theme. Optimum communications through the ionosphere is achieved by operating at the highest possible frequency.

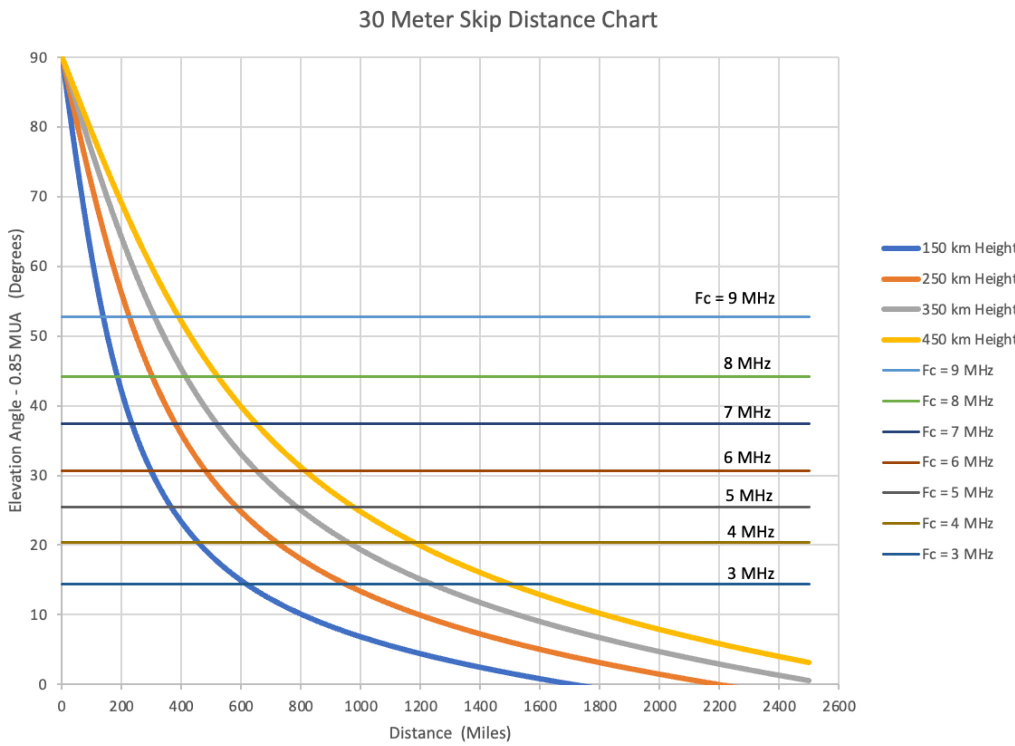


Figure 22 Skip distance chart - 30 meters (source: author)

19.2.1.2 Close-in Multipath NVIS Problems

If there is no skip, all Near Vertical Incident Skywave (NVIS) stations can be reached from the base of your antenna outward for many hundreds of miles. However, like it or not, line-of-site (LOS) and ground wave (GW) propagation, illustrated in Figure 23, always exist from your antenna out 30 to 40 miles or so. Consequently, multi-path interference problems between NVIS, ground wave, and line-of-site propagation can cause signal degradation and fading problems close-in when NVIS conditions are otherwise excellent. In Figure 23, multi-path interference problems occur between the nearly vertical (green) NVIS signal, line-of-sight (LOS - blue), and ground wave (GW – brown) propagation. Beyond line-of-sight distance, multi-path interference still exists between the magenta NVIS skywave signal and ground wave propagation. Multi-path interference problems between skywave and ground wave propagation are the most severe when skywave and ground wave signals are equally strong as illustrated in Figure 24. Beyond ground wave distances, NVIS signals (red trace) propagate in the clear free of LOS and GW interference.

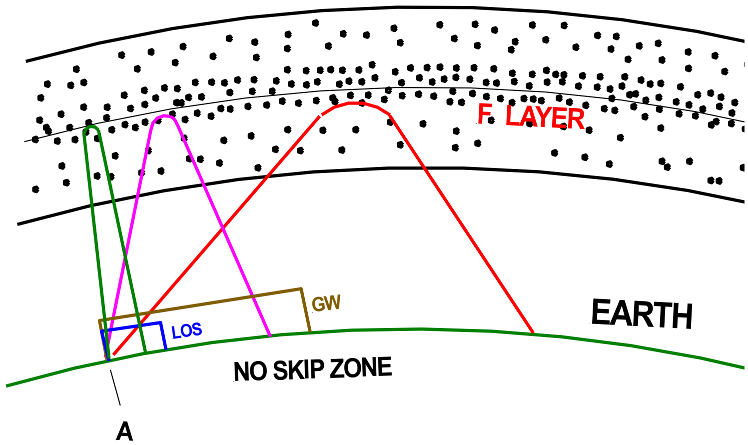


Figure 23 NVIS multipath problems (source: author)

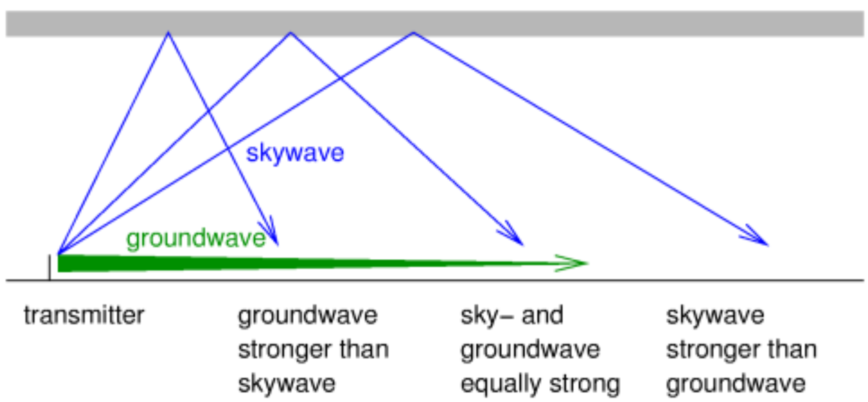


Figure 24 Relative strength of skywave and GW signals (source: *PA3FWM* pa3fwm@amsat.org

HF line-of-sight signals suffer the same reflection, diffraction, and scattering problems as VHF and UHF signals. Figure 25 shows some of the difficulties encountered by HF line-of-sight signals. In addition, ground and skywave signals interfere with line-of-sight and vice versa, all resulting in signal degradation and fading

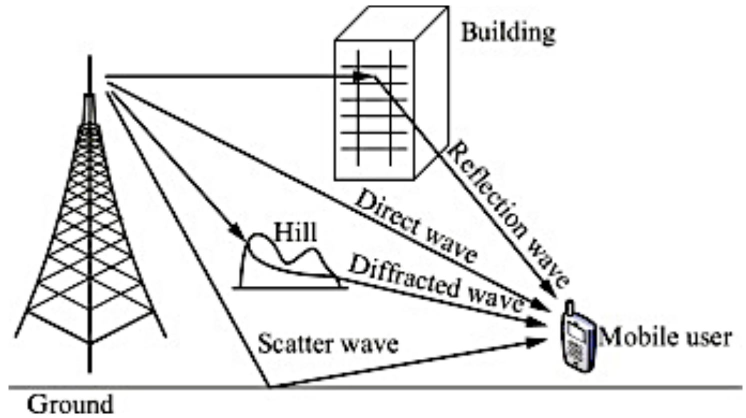


Figure 25 Line-of-sight HF problems (source: https://www.sciencedirect.com)

19.2.2 MUF Fading

As we know, operating at the highest possible frequency is often desirable. Doing so results in long hops for DX work, minimizes D Layer absorption, and eliminates multipath interference. However, operating at the maximum usable frequency (MUF) is literally living on the edge. In Figure 26 the transmitting station (Station-A) is operating at the maximum usable frequency. Its MUF signal, the red trace in Figure 26, achieves the desired long hop to the distant receiving station (Station-B). But, if the ever-changing ionosphere causes the MUF to drop just slightly, the transmitting station will find itself operating above the maximum usable frequency. This means that its transmitted signal will penetrate the ionosphere (black trace) and be lost to outer space. If a second or so later the MUF returns to its original value, the signal from the transmitting station will again reach Station-B. What the receiving station ends up hearing is the signal from Station-A fading in and out.

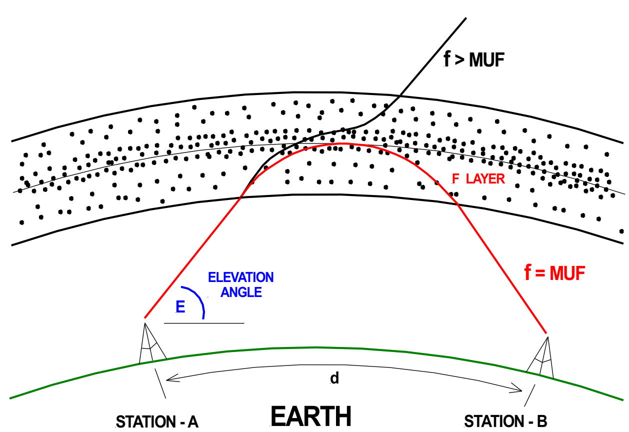


Figure 26 Signal with f > MUF is lost to outer space (source: author)

The situation is illustrated further in Figure 25. Each blue trace in Figure 27 represents a signal transmitted at a specific frequency f_o (12, 14, 16 MHz, etc.) from a transmitting station to a receiving station D km away. For all of the blue transmission curves the distance between the transmitting and receiving station is the same D km. A different set of blue transmission curves are required for a receiving station located at a distance of G km.

The horizontal axis in Figure 27 is the frequency of the red ionogram trace. For example, the spike in the red trace at a frequency of 2.9 MHz is the E region critical frequency at the time and date this ionogram was generated. Similarly, the spike at a frequency of 4.8 MHz is the F1 region critical frequency. Finally, the F2 region critical frequency is indicated by the spike at 9.4 MHz.

The intersection of a blue transmission curve with the red ionogram trace identifies the virtual height of reflection for that signal when transmitted at a frequency f_o. For example, a signal transmitted at a frequency of 16 MHz intersects the ionogram trace at 4 places, points A and A' in the F2 region plus d and d' in the F1 region. These 4 points are the only points in the ionosphere from which the 16 MHz signal can be reflected and reach the receiving station a distance of D km away. The 4 points also identify four propagation paths from the transmitting to the receiving station, a high and low propagation path in the F2 region and a high and low path in the F1 region.

In this example, an 18 MHz signal intersects the ionogram curve only at points B and B' in the F2 region of the ionosphere. The 18 MHz signal does not intersect the ionogram curve in either the E or F1 region. At a transmitting frequency of 18 MHz the only propagation paths from the transmitting to the receiving station are through the F2 region. Point B reflects the 18 MHz transmitted signal at a virtual height of 320 km while the virtual height for point B' is around 590 km. The low propagation path to the receiving station passes through point B while the high path passes through point B'.

Notice that the virtual heights for the two 18 MHz reflection points (B and B') are closer together than the 16 MHz reflection points A and A'. A virtual height of 270 km separates B and B' while A and A' are 400 km apart.

Increasing the transmitting frequency to 22 MHz causes the low-path and high-path reflection points to merge at a single point C. In fact, the 22 MHz transmission path is tangent to the ionogram curve at point C. At point C there is only one propagation path from the transmitting to the receiving station. Increasing the transmitting frequency just a little more, say to 23 MHz, will cause the 23 MHz transmission curve to miss the ionogram altogether. In this example, 22 MHz is the highest possible frequency for transmitting a signal a fixed distance of D km from the transmitting to the receiving station. 22 MHz is the maximum usable frequency for communications between these two stations. A signal transmitted at a frequency higher than 22 MHz will penetrate the ionosphere and be lost to outer space.

The above discussion assumes that the ionosphere is stable resulting in a fixed ionogram curve. But the ionosphere is not stable. The red ionogram curve is constantly moving. In Figure 28 the location of the ionogram curve has changed resulting in 19 MHz becoming the maximum usable frequency

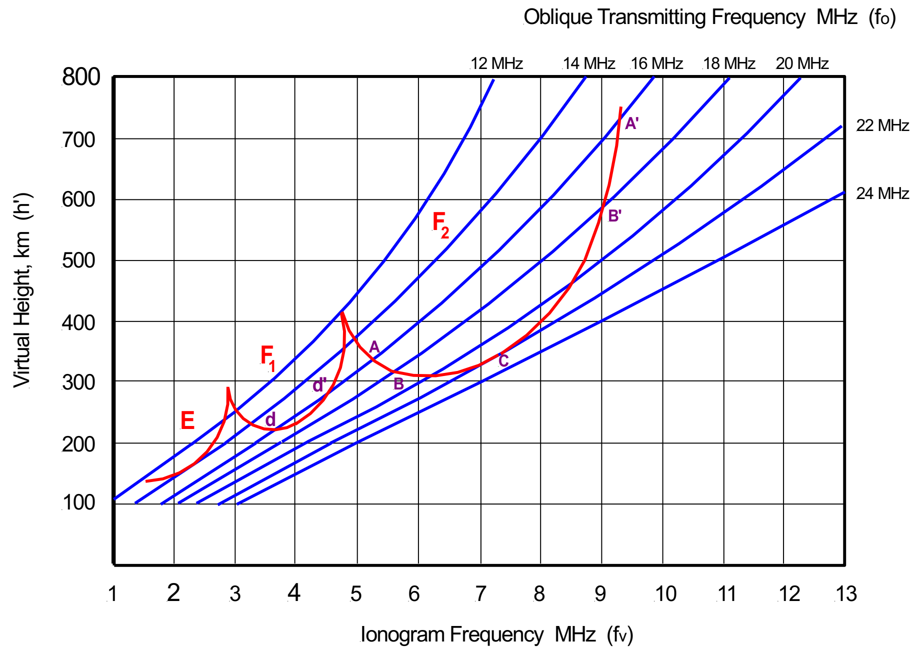


Figure 27 Ionogram superimposed on transmission curves (source: author)

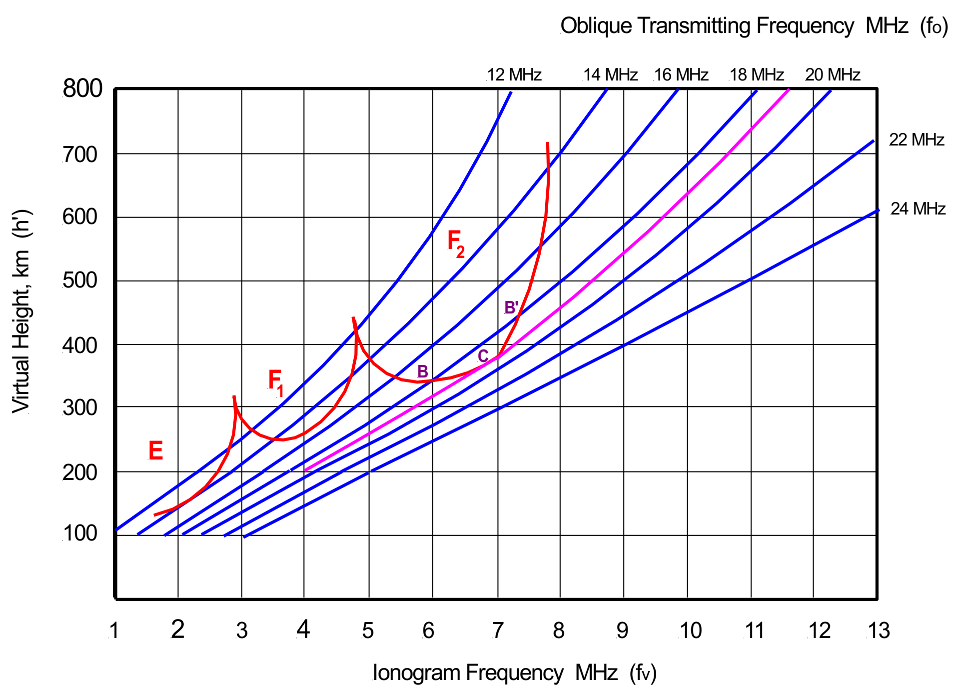


Figure 28 MUF decreases from 22 to 19 MHz (source: author)

with the 22 MHz signal disappearing into outer space. That is, the 22 MHz signal from the transmitting to the receiving station fades away. A few seconds later the constantly changing ionogram curve results in the MUF drifting back upward to 22 MHz or even higher. The 22 MHz signal from the transmitting to the receiving station reappears, but only briefly. It then disappears again as the MUF moves back to a lower frequency. Attempting to operate at the MUF causes communications between the transmitting to the receiving station to repeatedly fade in and out, a condition known as MUF fading.

The 18 MHz blue transmission curve intersects the red ionogram trace in both Figures 12 and 13. The 18 MHz signal does not fade in and out but remains stable. In this example, MUF fading is eliminated by operating at 18 MHz. In general, the MUF fluctuates about $\pm 5\ to\ 10\%$. MUF fading can be avoided by operating at 80 to 85% of the MUF. This frequency, 18 MHz in the example, is known as the Frequency of Optimum Transmission (FOT).

19.2.3 Skip Fading

Skip fading is encountered by a receiving station on the edge of the skip zone (the blue RMS station in Figure 29). The skip zone "breaths" increasing and decreasing in size over seconds and minutes as ionospheric conditions constantly change. At one moment the green RMS receiving station is outside the skip zone clearly receiving Station-A. Next moment the receiving station is inside the skip zone unable to hear Station-A. The RMS station changes color from green to red. Consequently, Station-A continuously fades in and out as the skip zone expands and contracts.

For Winlink and other forms of HF emergency communications, skip fading is minimized by avoiding stations located near the skip zone circle as illustrated in Figure 30. Instead utilize Remote Message Server (RMS) stations well outside the skip zone to relay emergency traffic.

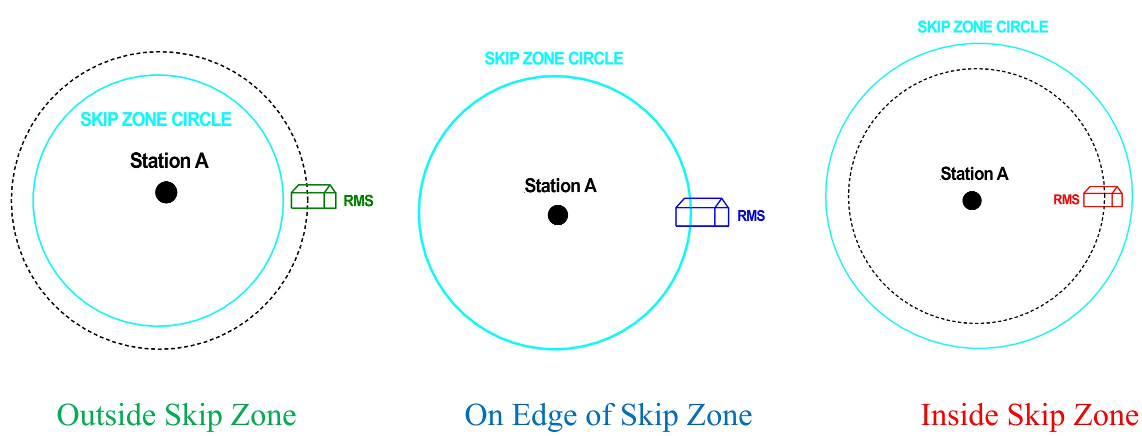


Figure 29 Skip fading (source: author)

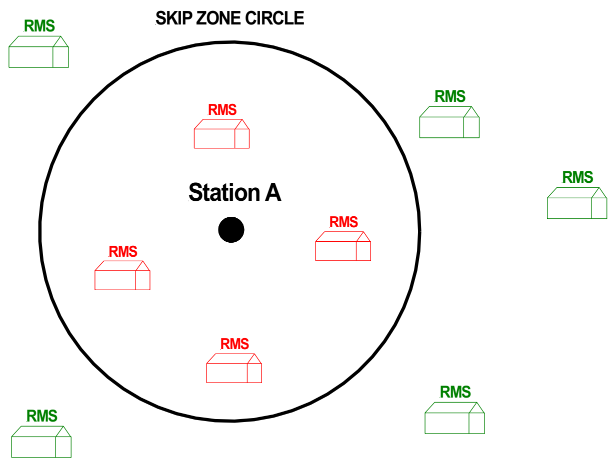


Figure 30 Avoiding skip fading (source: author)

19.2.4 Absorption Fading

Absorption fading is the result of continuously changing conditions and irregularities in the D region of the ionosphere. An extreme example is the complete absorption of all signals from 2 thru 15 MHz or more following a major solar flare. Fades can vary in length from a few seconds to several hours following a flare.

Figure 31 shows the region affected by a solar flare occurring in 2005. The region of greatest signal absorption occurred in the orange area with absorption decreasing outward. For this flare absorption was intense, affecting frequencies up to 25 MHz throughout North and South America. In this figure the overhead position of the Sun is marked by the black diamond. The region affected by a flare moves from east to west as the Earth rotates. Signal strengths fluctuate widely, rapidly fading in and out, as D level absorption moves into a given location, in this case with signals below 25 MHz becoming completely absorbed. Signals again fluctuate widely as the absorption zone leaves a geography location.

Absorption fading is minimized by operating at the highest possible frequency, typically the frequency of optimum transmission (FOT = 85% MUF), since absorption is inversely proportional to frequency squared according to

$$Absorption \propto \frac{1}{f^2}$$

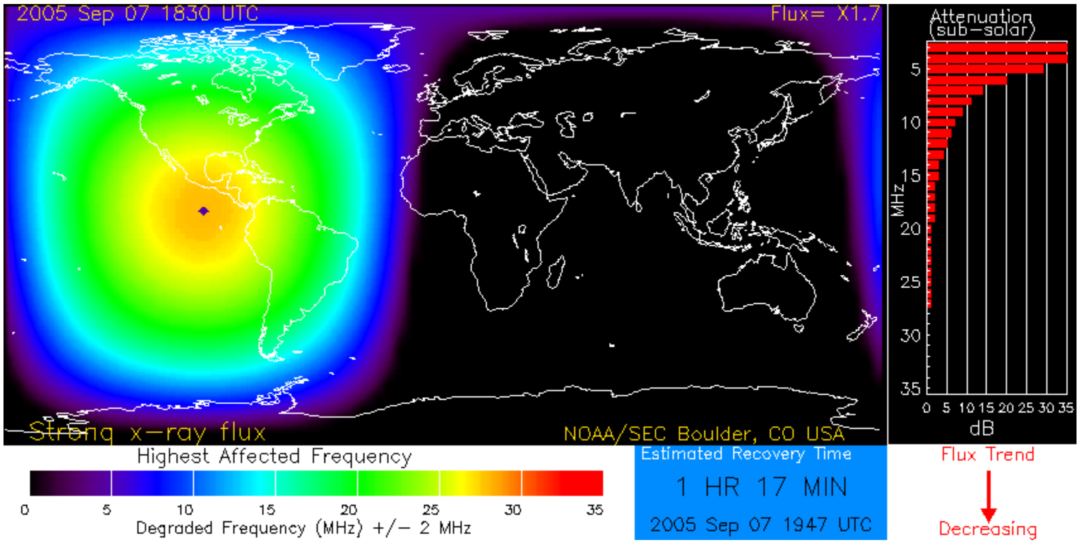


Figure 31 Signal absorption due to a solar flare (source: NOAA)

19.2.5 Frequency Selective Fading

We know from studying the ionosphere that the ionosphere's index of refraction is frequency dependent. As a result, long wavelength signals are refracted back to Earth lower in the ionosphere than short wavelength signals. That is, the ionosphere is frequency dispersive. In Figure 32 an 80 meter signal is refracted back to Earth shortly after entering the ionosphere. However, a 20 meter signal travels nearly to the center of the ionosphere before refracting back to Earth. In Figure 32 the 15 meter signal does not return to Earth at all but instead penetrates the ionosphere and is lost to outer space.

What is not so obvious is that frequency dispersion also occurs within the bandwidth of a modulated signal. For example, Figure 33 shows the frequency spectrum of an amplitude modulated (AM) radio signal. This signal consists of a carrier plus upper and lower sideband signals. The higher frequency upper sideband signal (blue trace in Figure 33) penetrates slightly further into the ionosphere than the lower frequency lower sideband signal (green trace). The difference in penetration depth causes the upper (USB) and lower (LSB) sideband signals to travel slightly different paths. When they reach the receiver, they are out of phase causing them to interfere with each other. This could be tolerable if the phase difference were constant. However, it is not. The phase difference is constantly changing as the ionosphere itself is constantly changing. As a result, the receiver's demodulated audio signal is distorted as well as fading in and out. This phenomenon is known as frequency selective fading.

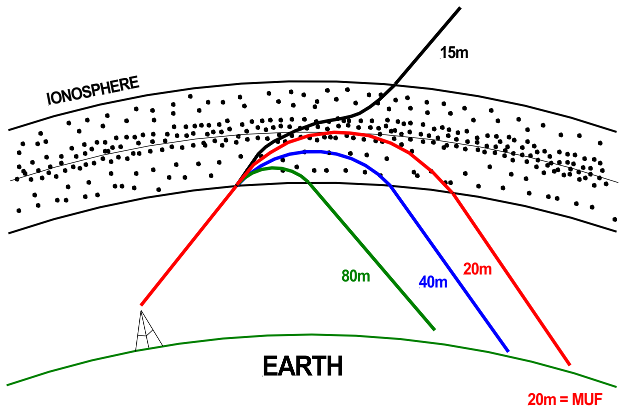


Figure 32 Frequency dispersion in the ionosphere (source: author)

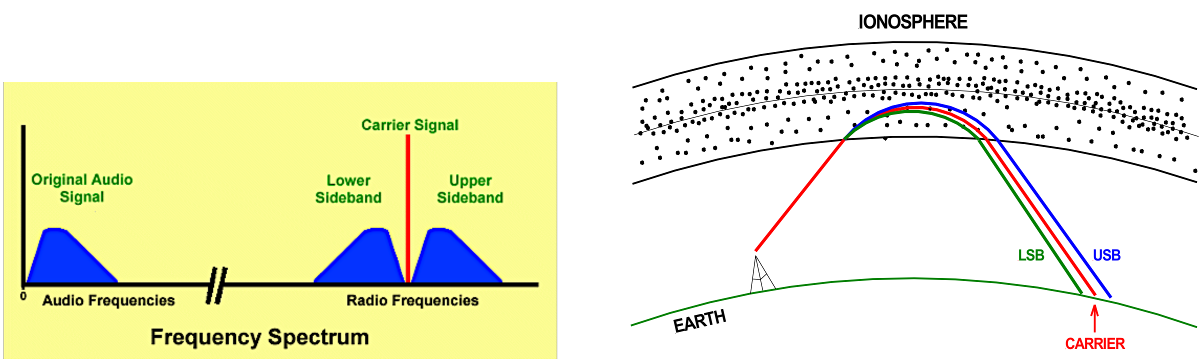


Figure 33 Frequency selective fading (source: Hawaii.edu and author)

Frequency selective fading was a serious problem when radioteletype (RTTY) was first developed in the 1930s and deployed during World War II. The problem resulted from the MARK and SPACE tones used by radioteletypes. These tones are a few hundred hertz apart in frequency and thus highly susceptible to selective fading. The unreliable performance of HF packet radio is also due in part to selective fading. Modern day HF digital protocols take selective fading into account and are far more reliable than HF digital communications in the past.

Selective fading was one of the compelling reasons for developing single side band (SSB). Selective fading is reduced considerable in SSB radio equipment by removing the carrier and one of the sidebands.

19.2.6 Polarization Fading

Polarization fading is the result of the incoming signal orientation changing with respect to the receiving antenna due to rotation and changing path lengths through the ionosphere. The strength of the received signal is maximum when the signal's E field is aligned with the antenna and minimum when perpendicular to the antenna as illustrated in Figure 34. In this figure the transmitting and receiving antennas on the left are both vertically polarized resulting in the receiving antenna absorbing 100% of the transmitted power. On the right, the transmitting antenna is horizontally polarized while the receiving antenna is a vertical. Consequently, the receiving antenna absorbs little if any of the transmitted signal.

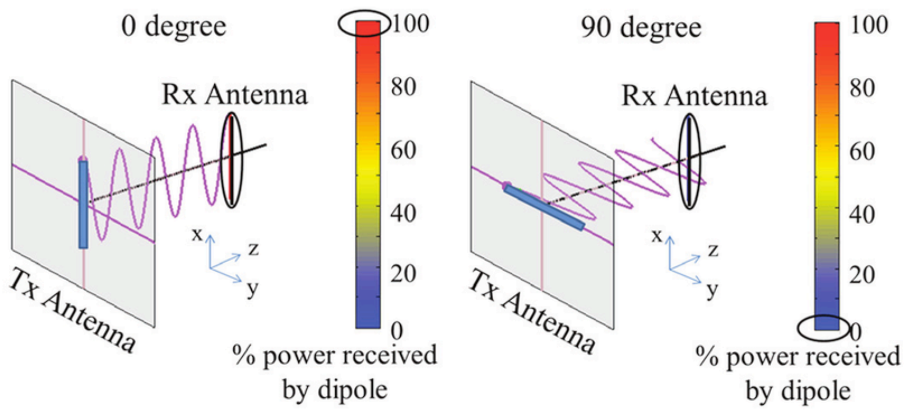


Figure 34 Polarization Fading. (source: ResearchGate)

Achieving the correct polarization alignment for the receiving antenna is difficult for skywave communications because the Earth's magnetic field causes the transmitted radio signal to split into ordinary and extra-ordinary waves that rotate as they travel through the ionosphere.

Polarization fading can be reduced by using two perpendicular receiving antennas, for example a vertical antenna and a horizontal dipole. When an incoming signal fades on one antenna it likely peaks on the other antenna.

Many modern day HF transceivers are built with two identical receivers, a main receiver and a sub receiver, permitting diversity reception. Diversity reception is achieved by routing the main receiver to the primary antenna and the sub receiver to an orthogonal receiving antenna. Earphones are typical used. In operation, instead of fading out, the received signal seems to "move around in your head" as signal strength peaks one antenna and then on the other.

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