The HF Bands – For HF Newcomers

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The HF ham bands can be mysterious. Some work at night, some during the day. Some seem to be good for long distance contacts while some are better for nearby contacts. Even worse, they change tremendously from hour to hour and day to day.

Communications beyond a few miles on the HF bands occurs because of the Ionosphere. That is part of the Earth's atmosphere from roughly 35 miles to about 300 miles up. It is called the Ionosphere because at those elevations, radiation from the sun, primarily ultraviolet, ionizes atmospheric molecules. That ionization process absorbs most of the harmful solar radiation, making life on the surface of the Earth possible. It also causes the atmosphere to reflect radio signals.

The actual operation of the Ionosphere that allows us to communicate over long distances is very complex. At the bottom, air pressure is about a thousandth of surface normal. At the top, it is about eight orders of magnitude lower. Different wavelengths and kinds of solar radiation effect different heights. By bouncing radio signals off the Ionosphere, several main regions or layers within the Ionosphere have been identified. The layers we care about are labeled, from lowest to highest, D, E, and F.

The D layer, at about 35 to 50 miles up, is strongest during the daylight hours and is primarily an absorber of radio signals. It tends to absorb lower frequencies more than higher frequencies. The D layer is why 160 and 80 meters don't work very well during the day.

The E layer, at about 50 to 100 miles up, is a wild card in radio propagation. It is sometimes present and sometimes not. Sometimes it absorbs signals. Mostly, though, it reflects. Sometimes is reflects very well, even up into the VHF region.

The F layer is what does the real work of bouncing our signals around the country and around the planet. Its operation is primarily that of a reflector. Through extensive study of this layer with radio soundings, two main regions within it have been identified and labeled F1 and F2. The F1 layer extends from about 100 miles to 130 miles up and exists mostly during the daylight hours. The F2 layer extends from about 130 miles to about 300 miles up and, because of the very low atmospheric density, experiences very slow ion recombination so remains largely intact through the night.

As I said above, the operation of the Ionosphere on radio signals is very complex. The simple explanation above does not do it justice. It will, however, do OK as a general introductory description. For the most part, we don't really care how the Ionosphere operates as long as we can figure out roughly what bands and what times it will allow us to operate.

The Sun Spot Cycle

Now we come to an important aspect of HF radio operation: the sunspot cycle. Above we learned that HF radio signals bounce off the ionosphere because the sun ionizes air molecules at very high altitudes. Obviously if there is more solar radiation there will be more ionization. The more ionization we have, the better our signals bounce. It turns out that the radiation level from the sun follows the 11-year sunspot cycle. In general, the more spots we see on the sun, the more ionization we notice.

Now, in early 2007, we are just past the bottom of the sunspot cycle. Radio propagation on the upper HF ham bands is poor. By the next sunspot peak in about 2011 or 2012, the upper bands will be hopping with activity, with worldwide communications on 10 meters possible with low power and modest antennas. That is something most of us hams are looking forward to. Between now and then, we will see a slow, gradual rise in sunspot count and upper HF band performance. However, things will not be all peaches and cream when we reach the sunspot peak.

The sunspot peak is a turbulent time on the sun. Solar flares and X-ray bursts occur disturbing the upper atmosphere and disrupting HF operation. Day to day operation on the ham bands can vary widely. In general though, the higher the sunspot count, the better the upper HF bands operate.

Sunspot Count and Solar Flux

You will encounter two different measures of solar activity. The first is the visual count of sunspots. The second is the 10.7 cm (2800 MHz) solar microwave radiation level, called Solar Flux Index. The two values roughly follow each other, though on different numeric scales, but the Solar Flux Index tends to provide a more immediate and direct indication the effect of the sun on the Ionosphere. The current Solar Flux Index (SFI) is available from several sources on the Internet. It is also available in a voice broadcast on WWV at 18 and 45 minutes past each hour.

In general, SFI values above 200 are considered high, indicating bands up through 10 meters should provide long openings. SFI values below about 100 are considered low and typically mean that the higher bands will not be as good. As the SFI rises from 100 towards 200, upper band operation gradually improves. Openings become common during the day on 10 meters by the time the SFI reaches 180.

Night and Day

Ok, you have probably already realized that since it is primarily the sun that we care about for our use of the Ionosphere, night and day must matter. Each layer of the Ionosphere reacts to the diurnal changes differently. Since the air pressure is greater at lower altitudes, ions tend to recombine quicker there. That means that D layer absorption drops off rapidly as the sun sets and doesn't build up again until sunrise.

F layer ionization drops off at night. The lower F1 layer drops off quickly. The high F2 layer remains intact through most of the night.

The E layer seems to do its own thing. Its ability to reflect radio signals usually peaks at midday but occasionally it will provide nighttime communications opportunities. In general, we pay relatively little attention to it, enjoying its services when it helps, cussing it when it helps too much and reflects so well that it acts as a screen between you and the longer distance F layers.

In general, the lower bands, 80 and 160 meters are best at night because of daytime D layer absorption. 30 and 40 meters typically work both night and day but daytime distances are limited because greater distances require lower propagation angles, which, in turn, mean longer paths through the D layer. 15, 17, and 20 meters suffer much less D layer absorption problems but require higher levels of ionization in the F layers so work best during the day. 10 and 12 meters are almost exclusively daytime bands except for those years at the top of the sunspot cycle.

Summer and Winter

OK, if night and day makes a difference in HF propagation, what about summer and winter? Of course the seasons make a difference. Wintertime enhances the lower frequency nighttime bands and reduces operating times on the higher frequency daytime bands. The longer days in summer reduce the operating times for the lower frequency nighttime bands.

Actually, the summertime is when the 160 meter and 80 meters bands can be nearly unusable. While the shorter days have an obvious effect, the real problem is lightning storms. Summer is the time of year when thunderstorm activity is greatest. Lightning creates radio noise that is reflected off the Ionosphere just like regular radio transmissions. Some weeks, in the spring through early autumn storm season, thunderstorm activity within one or two Ionospheric hops will be continuous.

The good news about thunderstorm activity is that it drops off during the winter allowing good 160 and 80 meter operating conditions. Also, the amount of radio noise generated by thunderstorms decreases with frequency so that the higher daytime bands are relatively free of thunderstorm noise. That is, of course, unless the storm is close by.

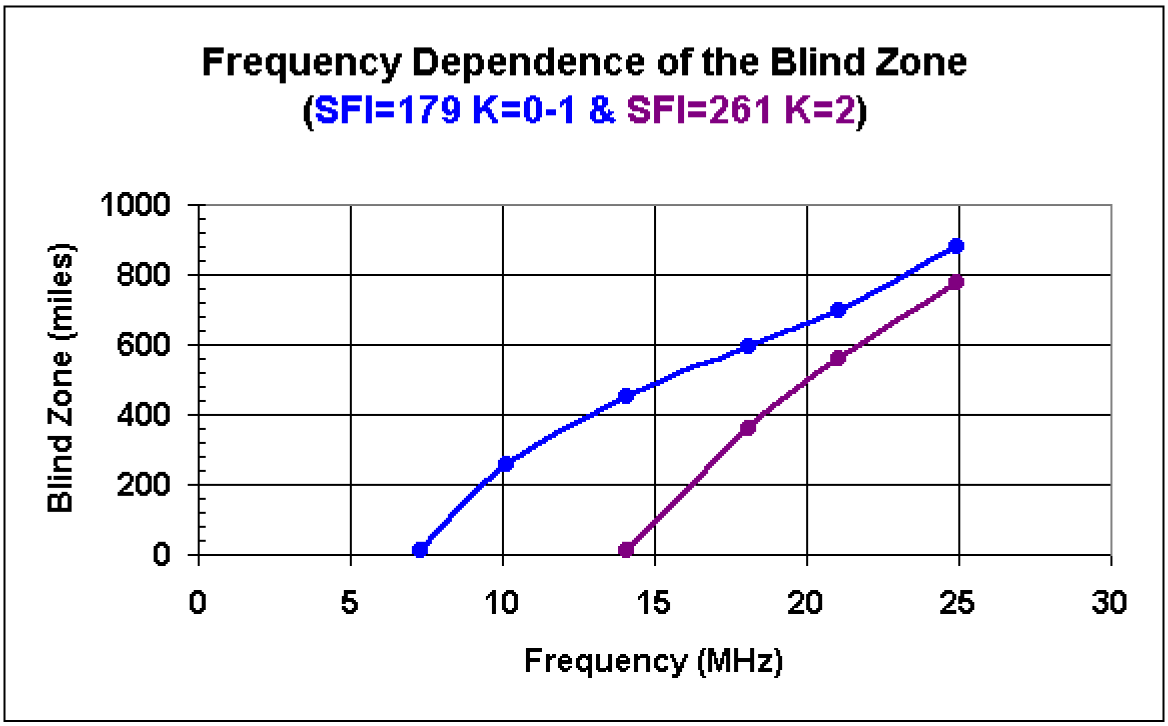
In general, 160, 80, 60, 40, and 30 meters are at their best during the winter. 20, 17, 15, 12, and 10 meters are at their best during the summer. The combination of day/night, summer/winter, and sunspot cycle variations keeps HF operation interesting. You never know for sure from moment to moment what you are going to encounter when you tune across the different ham bands.

The Skip Zone or Blind Zone

Another point worth noting is something called the Skip Zone. The term 'skip' has been misused so much that some folks are beginning to call this the Blind Zone. This is the result of another characteristic of the Ionosphere. There is something called the Critical Frequency, which is a frequency above which a signal sent straight up will not be reflected. In general, the higher ionization, the higher this vertical incidence critical frequency is.

The skip zone is effectively a hole in the Ionospheric reflection over your station. The diameter of that hole increases with frequency. Fortunately though, just like with light reflecting off a pool of water, the Ionosphere becomes more reflective as the incidence angle becomes less.

What this means is that the 20 meter band and the bands above it do not typically support local communications. Stations within the skip zone cannot be contacted via direct Ionospheric reflection. The chart below shows typical Skip Zone distances for both midway along the rise of the sunspot cycle and another near the top.



At the bottom of the sunspot cycle, skip zones are common on 40 meters at night and can occur even on 80 meters.

HPF, MUF, and LUF

On an hour by hour and day by day basis, we are interested in values known as Highest Possible Frequency (HPF), Maximum Useable Frequency (MUF), and Lowest Useable Frequency (LUF) for a given radio path between two locations. These values give us an indication of what frequencies and times we are most likely to have successful communications.

HPF is the highest frequency expected to be supported for a given path at a given time of day. Frequencies higher than the HPF will simply pass through the Ionosphere because of insufficient ionization. MUF is a frequency that is predicted to have a 50% probability of being below the HPF for that same time of day. LUF is determined primarily by D layer absorption.

Signal levels are generally best on frequencies at or just below the MUF. Signal levels drop off to useless as the LUF is approached. The MUF varies from predicted values quite a lot from day to day. An optimum working frequency choice for reliable communications is normally about 85% of the MUF as long as that is still above the LUF.

The ARRL provides on-line plots of HPF, MUF, and LUF predictions on a month-by-month basis. These plots may be found on the following web page:

http://www.arrl.org/qst/propcharts/

An example of these plots may be found on the last page of this document.

The HF Bands

The 10 ham High Frequency bands (actually 9 HF and 1 MF band since 160 meters is considered part of the Medium Frequency part of the radio spectrum) were chosen to take advantage of the varying propagation characteristics of the Ionosphere. They cover 16 to 1 frequency range from 1.8 MHz to 29.7 MHz. Each of the bands has unique propagation characteristics. Each could be a study unto itself. We don't need that here. Instead I will simplify and generalize.

160 Meters:

160 meters is primarily a nighttime regional band. Nighttime range is usually very good from next door out to about 500 miles when full size horizontal antennas are used. Worldwide DX is possible on this band, but tall vertical antennas with extensive ground radials for transmitting and long, low noise beverage antennas for receiving are necessary. Atmospheric noise from lightning can make this band nearly useless during the summer thunderstorm season.

80 Meters:

80 meters is again primarily a regional band though nighttime coverage often extends out to 1500 miles. Morning and afternoon operation out to about 200 miles is not uncommon. Worldwide nighttime DX is possible on this band and much more likely accessible than 160 meters because of the smaller antennas required. 80 meters suffers from high summer lightning noise but somewhat less so than 160 meters.

60 Meters:

60 meters provides a mix of the characteristics 80 meters and 40 meters. It has better daytime coverage than 80 meters. Due to power limits, practical operation even at night is typically limited to about 750 miles though transcontinental DX operation has been achieved.

40 Meters:

40 meters is a daytime regional band with good coverage out to about 300 miles with medium height dipole antennas. Nighttime coverage is often worldwide though this has turned out to be more of a problem than an advantage. Part of the 40 meter ham band is a short wave broadcast band in most other parts of the world. It is very difficult to find an empty spot to operate when band conditions are conducive to good DX operation. Summer night lightning noise is a problem on this band but not nearly as much as the lower bands.

30 Meters:

30 meters typically provides coverage out to about 1500 miles during the day but may have a skip zone preventing contacts closer than about 100 miles or so. Nighttime coverage remains good with transcontinental contacts common. The nighttime skip zone expands but this sometimes helps by excluding noise from regional lightning storms.

20 Meters:

20 meters is the king of the DX bands. It is usually below the MUF during the daylight hours and suffers less D layer absorption than lower bands. It usually has a skip zone extending out at least 300 miles, with 500 miles not uncommon, making regional operation impractical.

20 meters operation is profoundly effected by the sunspot count. At the peak of the sunspot cycle, this band can remain open to worldwide contacts 24 hours a day. At the bottom, it may open only during daylight hours and even then signal levels can be low. Evening contacts to the west are especially good since D layer ion recombination happens quickly as the sun angle decreases while the F layer ionization decreases much less rapidly. A similar but less noticeable effect happens with eastward contacts in the morning.

17 Meters:

17 is a lower keyed version of 20 meters. Being a higher frequency, it doesn't open as early as 20 meters and closes sooner but still provides plenty of DX and rag chew opportunities. The skip zone on 17 meters is somewhat larger than for 20 meters but good signals are generally available from about 500 miles out and farther. 30, 17, and 12 meters are known as the WARC bands and are protected by informal international agreement from contest operation. (WARC stands for World Administrative Radio Conference or some such thing. It is where governments make international agreements on communications issues. 30, 17, and 12 were awarded to amateur radio at one the WARC sessions.) Rag chew operation is common but Dxers will also use the band to

take advantage of the lower crowding. 17 meters is great for contacts to the east in the morning hours and to the west in the afternoon hours.

15 Meters:

15 meters continues the trend seen in the 20 and 17 meter bands. It opens later than 17 meters and closes sooner. It is common for 15 meters to be nearly dead, even during the daylight hours, for two or three years around the bottom of the sunspot cycle. As the sunspot count rises toward the next peak, 15 meters will begin opening up during the day. Being higher in frequency, it suffers even less D layer absorption than 20 meters so signal strengths tend to be good for open paths.

15 meters is large band, providing plenty of room for Dxers and Rag Chewers to coexist. The skip zone on this band is somewhat larger than what is seen on 17 meters so contacts with distant locations are far more likely than contacts with nearby locations. As with the other daytime bands, contacts to the east in the morning and west in the evening are typically improved over mid-day operation.

12 Meters:

12 meters is a combination of 15 meter and 10 meter characteristics. Being a WARC band, it is free of contest operation. It also suffers little interference from foreign broadcasters and other commercial radio services. 12 meters provides good DX opportunities during the high part of the sunspot cycle. Operation on this band tends to be fairly relaxed with rag chewing much more common than DX pileups.

10 Meters:

10 meters is especially interesting. It lies on the threshold of VHF. When this band opens up, even low powered radios and modest antennas can make world wide DX contacts. While the 10 meter F layer skip zone is relatively large, sometimes not allowing contacts closer than about 1000 miles, the E layer will sometimes provide contacts to much closer locations. The E layer is much lower than the F layer so reflections from the E layer hit the ground closer.

For 10 meters to perform up to its maximum potential, the sunspot count must be high. You can count on some exciting activity on this band starting two or three years from now.

So what band should I use?

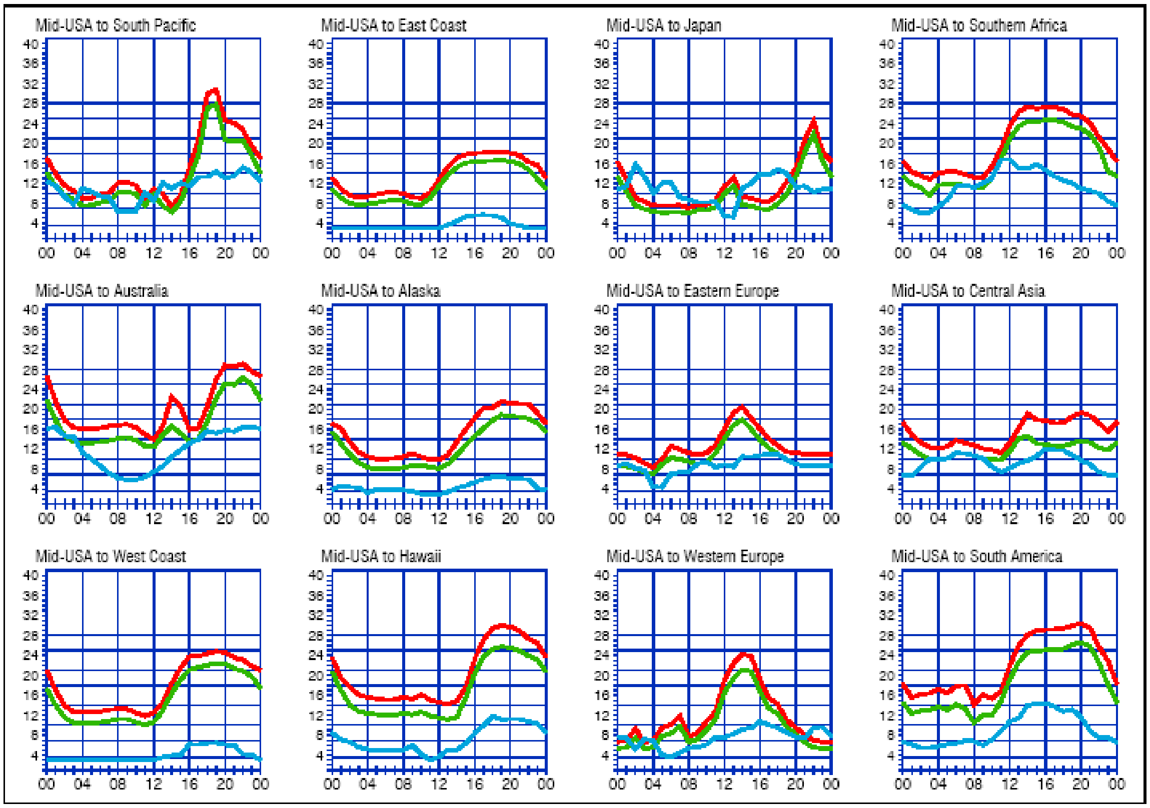
As was described above, each of the 10 HF/MF bands has its own individual characteristics. Each has advantages and disadvantages. In the lower part of the sunspot cycle, ham activity is most often found on 17 meters and lower in frequency. While the 15 through 10 meter bands will have occasional short openings to random locations, they are infrequent enough that little attention is paid to them until the sunspot count increases.

As the sunspot cycle improves, ham activity will gradually shift upward in frequency. With more consistent band openings, activity will increase providing more opportunities for contacts on the higher bands. Along with the improvement in the upper bands from increased solar radiation, lower bands experience greater D layer absorption, decreasing their communications effectiveness somewhat. Even with the increased absorption, though, the lower bands remain very useful for regional communications and rag chewing.

At the bottom of the sunspot cycle, as we are now, a combination operation of 40 meters during the day and 80 meters at night give the highest likelihood of making contacts. 160 meters is also a good choice for nighttime operation for those that have room for a 230 foot long dipole. 30 meters provides an interesting, uncrowded band to enjoy casual CW operation. 20 meters and 17 meters provide plenty of opportunities for both rag chew and DX contacts but primarily during the daylight hours.

For those interesting in making their first DX contacts, 20 and 17 meters are the best bet. DX operation is possible on all bands but is more easily achieved on 20 meters and above. Of course, as the sunspot cycle improves, gradually 15 meters, and then 12 and 10 meters will begin opening up.

The great thing about the HF/MF ham bands is that there is enough variety in characteristics to keep operation interesting. Enjoy the adventure of exploring them.



When are the bands open? These charts, generated using CAPman, show probabilities for average HF propagation in the month of **February 2007** for the paths indicated. The horizontal axes show Coordinated Universal Time (UTC), and the vertical axes frequency in MHz. On 10% of the days of this period, the highest frequencies propagated will be at least as high as the upper red curves (HPF, highest possible frequency) and on 50% of the days they will be at least as high as the green curves (MUF, classical maximum usable frequency). The blue curves show the lowest usable frequency (LUF) for a 1500-W CW transmitter. For SSB or a lower transmitter power, the LUF will be somewhat higher than the blue curves indicate. See Oct 1994 *QST*, pp 27-30, and Feb 1995 *QST*, pp 34-36, for more details. The predictions assume an observed 2800-MHz solar flux value of 73. This is a Very Low level of solar activity. See the detailed propagation tables on *The ARRL Antenna Book CD-ROM*.

Example ARRL propagation charts for February, 2007
http://www.arrl.org/qst/propcharts/