The Basics of HF Propagation

PW Editor Don Field G3XTT took part in the RSGB Commonwealth Contest and uses it as a basis for explaining the basics of HF propagation

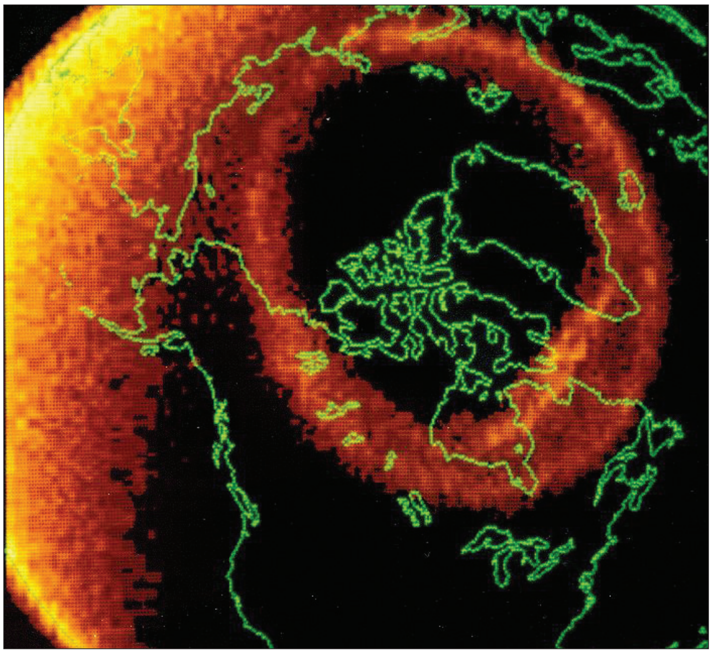

Fig. 1: The auroral oval surrounds the magnetic north pole, its extent depending upon auroral activity.

Having just made about 350 contacts in the RSGB Commonwealth Contest (still, for historical reasons, referred to by many as BERU from when it was called the British Empire Radio Union event), it occurred to me that the experience provided a classic object lesson in HF propagation. The contest covers the 80, 40, 20, 15 and 10m bands and runs for 24 hours, one diurnal cycle. This year the solar flux was just above 140 with an A index of four; in other words reasonably settled band conditions with expectations of a maximum usable frequency (MUF) high enough to support 10m propagation **Tim Kirby**, in his VHF column, reports that some trans-equatorial contacts have even been made from the UK on 6m in the past month, probably the first time this occurred during the current solar maximum.

The Commonwealth contest is on CW and the idea is to work stations around the British Commonwealth. In practice this means that the majority of contacts will be with Australia/New Zealand and Canada, with a useful sprinkling of stations from the Indian sub-continent, Africa and Caribbean. To make things more interesting, several UK contesters make a point each year of heading out to interesting locations. This year, for example, G3PJT was operating from Grenada as J34G, G3TXF from the Cayman Islands as ZF2XF, M0PCB from Montserrat as VP2MXI, G3RWF from Rwanda as 9X0NH, G3LET as VY2GQ from Prince Edward Island, Canada, C5/M1KTA from the Gambia and G3XAQ from Uganda as 5X1XA. This spread of activity from around the world and the lack of callers from Europe and the USA to confuse things (the only Commonwealth counters in Europe that were active were Malta and Gibraltar) means that you really do get an idea of which long-distance propagation paths are open at any given time. Further background to the contest can be found on G3PJT's BERU website.
www.beru.org.uk

1000 – 1100 UTC

I had agreed to be part of the Thames Valley team so I was aiming to make a reasonably serious effort. The contest begins at 1000 on the Saturday so the first question was on what band to start. I had been listening for a few minutes beforehand and it was clear that 10m was going to be in good shape so that seemed like a good starting point. Sure enough, in the first ten minutes I worked four Australian stations, one from Singapore and one in West Malaysia, plus 9X0NH and ZS1EL (S. Africa).

One of the tricks is to check other bands on a regular basis because there are bonus points for the first three contacts on each band from each Commonwealth call area. At 1000 UTC, stations to the east have been in daylight for many hours but stations to the west (given that the first landfall is across the Atlantic) are only just approaching dawn and the MUF will still be much lower. A quick move to 15m netted Australia on that band too, while a further move to 20m gave me another Australia contact plus my first Canadian QSO. This remained pretty much the pattern for most of that first hour, 10m providing the loudest signals from Australia simply because as the MUF rises, signal absorption on the lower bands will rise too. When 10m is in good shape, you really can work the world with low power and the proverbial wet noodle for an antenna.

1100 –1300 UTC

The second hour of the contest was as expected. I worked my first Canadian station on 15m, a sign that as daylight moved across North America the MUF was rising in that direction. Before that, though, I worked J34G and ZF2XF on 15m. This is to be expected. Although these stations were as far west as Canada, being much farther south the MUF would have increased earlier, because the sun's radiation is more intense over the equator than over Canada's more northern latitudes.

The path to Africa remained good throughout this time. HF operators will be well aware that trans-equatorial propagation is highly reliable, again because the sun's energy is more intense over the equator. The other major factor is that northerly propagation paths that touch on or pass through the auroral oval, **Fig. 1**, are adversely affected by auroral disturbances. The higher the propagation A index, the worse these effects will be. Any of you who have flown to California, for example, will be well aware, that the great circle path (shortest route) takes you well to the north across Greenland and northern Canada, even though we think of California as being to the west. Radio waves follow the same great circle route for the most part. There are instances where, when the MUF is insufficient on the direct path, beaming further south can make a contact possible but that discussion is for another time.

My first contacts with Canada on 10m were just after midday although excursions to 15 and 20m were still producing contacts with Australia to the east and Canada to the west. VE7RAC (British Columbia) was my first west coast station at 1223 on 20m – again, it was too early for the higher bands to be open so far west. After all, Canada stretches something like 3000km or more from east to west.

1300 – 1500 UTC

During the 1300 to 1500 UTC period the pattern was much the same, with an increasing number of more westerly stations from Canada but with Australia having dropped out on 10m (late in the day there) although still workable on 15 and 20m and I note my first New Zealand QSO of the contest, on 20m at 1431.

Another interesting contact was C5/M1KTA on 15m. Dominic was running just 5W and simple antennas. I also worked him the following morning on 20m but, in an exchange of e-mails after the contest, he told me that it was a struggle to make contacts and he thinks that was mainly because most stations in the contest, particularly from the UK, were beaming east or west for much of the time rather than looking south towards Africa.

1500 – 1700 UTC

The 1500 to 1700 time slot was quite a busy period, with Canadian stations remaining workable on the three high bands and stations still coming in from the east (Australia, New Zealand, India) on 20m as the MUF was falling in that direction.

Incidentally, I always find it helpful to have a greyline map open on my screen to watch the terminator move across the globe. Not only does it give you a pictorial representation of when an area moves into darkness but also, at the actual time of dawn and dusk, there is often a clear signal enhancement on the lower bands (80 and 40m). This is primarily due to a gradient in the refractive index of the ionosphere as that part in daylight is experiencing a different level of radiation to the part in darkness. In daylight the F layer splits into the F1 and F2 layers, **Fig. 2**. They then recombine after dusk. The effect is to take signals that arrive at high angles and refract them onwards at a low angle. Given that most of us are unable to erect antennas for 40 and 80m with a low take-off angle (a dipole would have to be at least half a wavelength above ground and a vertical is unlikely to be very efficient at very low angles unless we are near seawater), this greyline effect gives us something for nothing. Remember that low angles of radiation give us increased range because the signal travels farther before its next reflection.

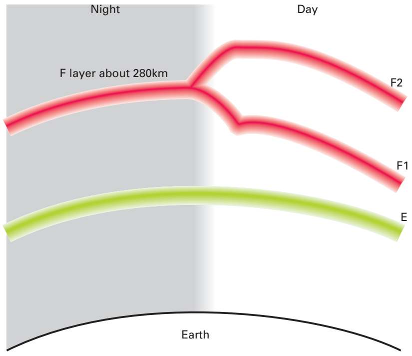

Fig. 2: The F layer rises and splits after dawn, leading to a tilting of the ionosphere at the terminator (dawn/dusk boundary), which can help to launch signals at a lower angle.

Fig. 3 shows a typical greyline display. You can call one up from the qsl.net site, there is a configurable version as part of the DX Atlas suite of programs and many logging programs such as Logger32 include one as a feature.

http://dx.qsl.net/propagation/greyline.html
www.dxatlas.com
www.logger32.net

1700 – 2100 UTC

The period spanning UK sunset necessitated frequent band changes in order not to miss anything. My first 40m QSO was with ZM4G (ZL2IFB, also G4IFB) at 1739, with VK6LW and 9V1YC in the 40m log soon afterwards. I also caught a couple of African stations on 40m during this period while still managing to work Canadian and Caribbean stations on 15 and 20m.

More interesting, though, was that 10m, having largely dropped out to North America other than for a few of the 'big guns', opened up via the long-path to New Zealand and I worked ZM4M at 2014, beaming to the south-west.

2100 – 2400 UTC

The late evening period saw more Eastern stations on 40m, including a couple of Indians but with the first Canadian station, VO1RAC, in the log at 2147. It's not surprising that my Canadian contacts on 40m started with Newfoundland, given that it's the most easterly part of Canada and therefore the first landmass to go into darkness.

I worked my first Caribbean station on 40m, VP2MXI, at 2247. By this time both 10 and 15m had dropped out for me but 20m was still producing the occasional Canadian and Caribbean contact. 80m was disappointing. I struggled to work VK6LW around his sunrise (VK6, the Perth area, is always the easiest part of Australia to work on the low bands, being something like 2500km closer than the Sydney VK2 area). However, an Eastern European contest running at the same time made the band hard going.

By midnight I decided it was time for some sleep but, based on propagation in the 2013 contest (it always pays to study previous years' logs), I knew I would need to get up well before dawn if I wanted to catch some interesting DX on 20m.

0400 – 1000 UTC

I restarted just after 0400 and, as I had expected, there were some huge VK and ZL signals on 20m, coming in via the long path. I put a number of these in the log while also checking 40 and 80m where I was able to work into Canada and the Caribbean. I see that I worked VE7IO (British Columbia) on 40m at 0520 so low band propagation had reached the west coast by that time.

My very next contact, also on 40, was ZM2IO and there were a few more New Zealand and Canadian west coast contacts to be had during the following hour but it wasn't until 0651 that I worked Australia on 40m the long way round – VK4CT in Queensland at the western end of the country, which would have been moving into darkness at that time. Equally, the UK was

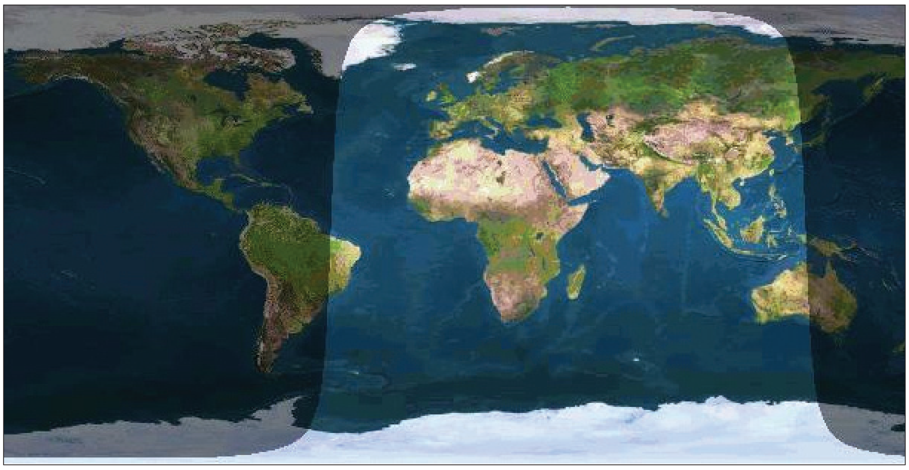

Fig. 3: A typical greyline display, showing those parts of the earth in daylight and darkness.

moving into daylight and, with the good solar conditions, the MUF started to climb rapidly here in the UK so that, for example, I worked ZL6HQ at 0735 on 10m, once again via the short path to the north east. I also caught a nice long path contact to P29NO (Papua New Guinea) on 10m at 0850.

It is entirely possible, given the high level of solar activity, that there was a path right round the world at that time (sometimes it's even possible to hear your own signals that have travelled a full circle) and what mattered more was the direction that the distant station was beaming. I have the benefit of a 3-element SteppIR antenna, which allows me to switch direction by 180° in a matter of seconds. Since I put it up it's been a real eye-opener in terms of learning about propagation paths.

The remainder of the contest was very much like the first couple of hours, with a high MUF to the east and plenty of signals coming in from that direction (albeit, I had already worked many of them from the previous day so the going was somewhat slower).

Summary

It is clear, as we would expect, that through the course of a day the MUF follows a curve, climbing rapidly after sunrise and decaying after sunset. In the middle of the day the lower frequencies will suffer absorption such that 80, 40 and even 20m to an extent become unusable for long-haul contacts. During the hours of darkness the pattern is reversed in that 80 and 40m (and 160m, but that didn't feature in the contest described) become the bands of choice, with the MUF dropping below 14MHz for at least some of the time. In practice, given the high level of solar activity in March, the 20m band remained open to at least some areas for much of the night hours, whereas at times of sunspot minimum I have known the night time MUF to drop below 7MHz so that even

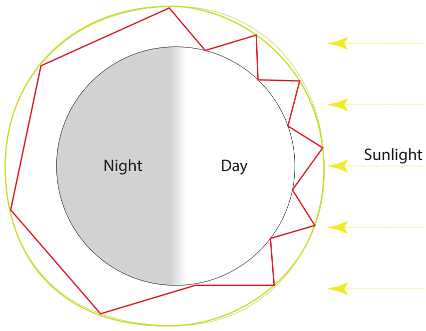

Fig. 4: Chordal hop (to the left on this diagram) can allow signals to propagate with fewer reflections and less attenuation that the more traditional propagation mode (to the right).

the 40m band is unable to support long distance propagation.

I hope this short article has given you a feel for how HF propagation changes during the course of a typical 24-hour cycle. At times of lower solar activity the pattern will be similar but the maximum MUF will be lower so that, for example, east-west paths on 10m may not open at all (usually you can still expect at least short openings down to Africa). The pattern also varies according to the time of year, simply because northern latitudes receive more of the sun's energy over the summer months but absorption will also be higher. Summer band openings will be much shorter on the 40 and 80m bands (and 160m, too) because the nights are shorter and the higher levels of D layer absorption during daylight hours will also take longer to reduce than in the winter months. Summer static tends to be a problem for receiving, too.

It isn't possible to cover all aspects of HF propagation in one short article. I hope, however, that it has provided a useful overview. Don't be put off simply because your station is limited. During this year's contest, **Roger Western G3SXW** ran 5W to an HF Yagi plus wire antennas for 40 and 80 and made 200 contacts. **Dave Sergeant G3YMC** ran 5W to wire antennas and still managed a creditable 80 contacts, including quite a few with Australia/New Zealand. In part, of course, this is down to the significant signal-to-noise benefits of CW compared with SSB operation but, for example, digital modes are at least as effective nowadays so a lack of proficiency in CW need not be a bar to making these long-haul contacts.

It's worth pointing out that New Zealand can often be far easier to work from the UK with low power and modest antennas than places that are much nearer. There are two reasons for this. One is that signals can travel for much of the distance without intermediate reflections from the earth, an effect known as chordal-hop, **Fig. 4.** We know this because a calculation of path losses makes it clear that the multiple reflections that would otherwise be required would attenuate the signals very much more than is observed. The other effect is antipodal focusing. In a sense there is no 'long path' or 'short path' to New Zealandbecause every great circle from the UK passes through or close to New Zealand. You don't actually need a beam antenna because, whatever direction your signal takes on leaving your antenna, it will still arrive at the same place on the other side of the earth.

Further Reading

I have had to drastically oversimplify some of the preceding discussion to summarise HF propagation in just three pages. Perhaps, though, it has encouraged you to delve deeper. There are many excellent books and internet sites that cover the subject. Search for HF radio propagation on Wikipedia, for example, and you will find a very good overview. The *RSGB Operating Manual* has one chapter covering propagation while **John Devoldere ON4UN's** *Low-Band DXing* focuses on propagation as it affects 40, 80 and 160m propagation. If you want to dig deeper, one of the classics is *Sun, Earth and Radio* by **J A Ratcliffe**, long out of print unfortunately but often available on eBay or from Amazon. There are many other internet sources too, easily found through the usual search engines. ●