VE7SL to VK4YB On 630-Meters

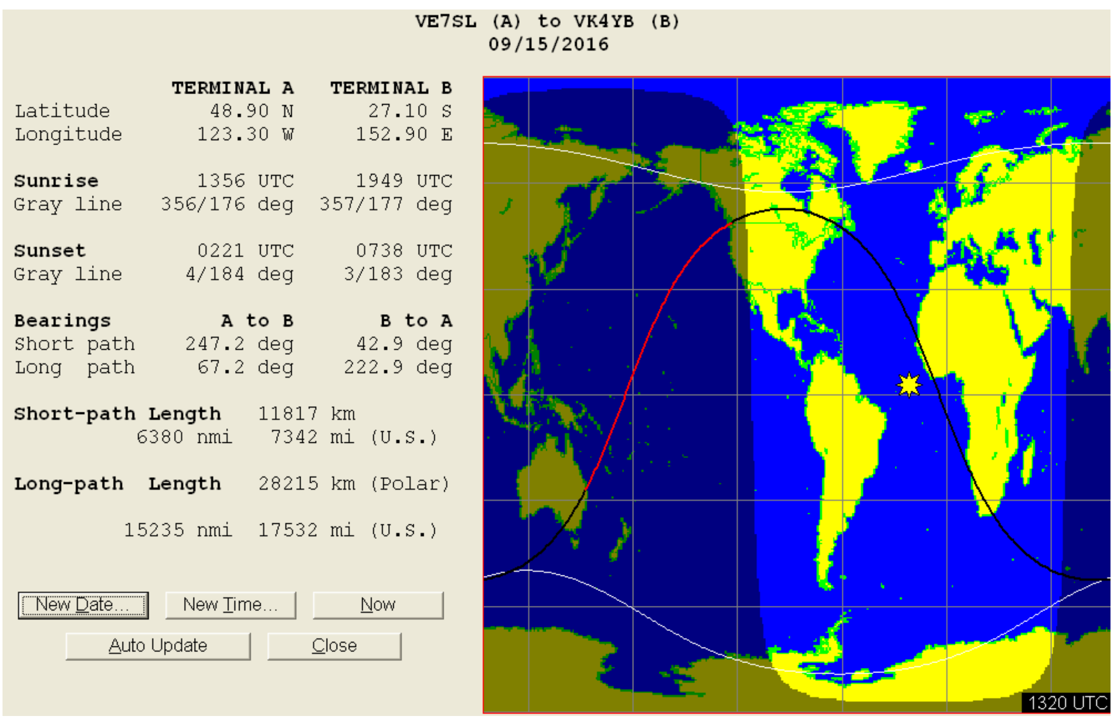
Carl Luetzelschwab K9LA December 2016 – Revised May 2017 (see revisions at end)

The two Monthly Features for November 2016 looked at ducting in the nighttime electron density valley on 1.8 MHz and on 990 KHz. Both frequencies showed a duct mode. This Monthly Feature looks at ducting in the aforementioned valley on other bands, starting with 630-Meters.

630-Meters (474 KHz)

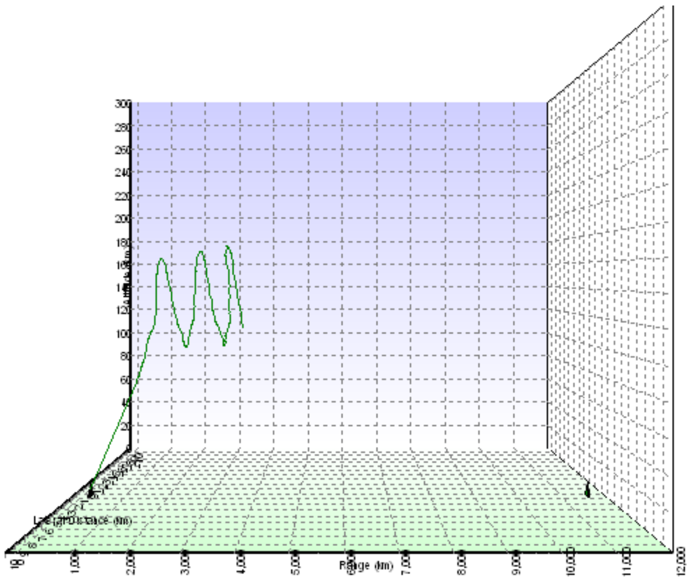
On September 16 of this year, Bill NQ6Z advised me of the September 15 JT9 QSO on 630-Meters (472 – 479 KHz) between VE7SL and VK4YB, which is a new distance record (11,820 km) on the 630-Meter band. With Canada and Australia limited to 5 Watts EIRP [note 1], my initial thought was that a multi-hop mode of propagation was not likely due to ionospheric absorption adding up prohibitively on each hop (along with ground reflection losses). This suggests that a ducting mode in the nighttime electron density valley may have occurred. Visit http://njdtechnologies.net/091516/ for more discussion of this QSO by VE7SL.

I've done ray traces on 630-Meters before, but those were simple one-hop paths at relatively high elevation angles to better understand ionospheric absorption and polarization. Looking for a duct on 630-Meters is a new effort for me. But first, as we did last month for the KRSL reception in Finland, let's look at the big picture (thanks W6ELProp).



The red line is the short path between VE7SL and VK4YB. As expected, this QSO took place near sunrise on the eastern end of the path. On our low bands (especially 160-Meters), this condition can produce a sunrise enhancement in signal strength. It is likely to happen on 630-Meters, too.

Now on to the ray trace. After setting up Proplab Pro V3 for the path from VE7SL to VK4YB on September 15, 2016 at 1320 UTC, I played with elevation angles from 1 degree to 15 degrees. The ray trace at an elevation angle of 6 degrees gave the following result:



It looks like ducting in the nighttime electron density valley is a possibility for this QSO on 630-Meters. It should be noted that now the ordinary wave has excessive absorption, and the extraordinary wave is the likely candidate. I believe this is due to 630-Meters being <u>below</u> the electron gyro-frequency (the frequency at which electrons spiral around magnetic field lines).

One concern expressed at http://njdtechnologies.net/091516/ is the terrain out of VE7SL interfering with low elevation angles. A map is shown with distance (in miles) and height (in feet) of the terrain along the path to VK4YB. I'm hesitant to use that map as my investigation with Google Earth shows different results on the 247 degree heading (from the earlier W6ELProp map) out of VE7SL. My results are summarized in the following table.

247° heading out of VE7SL			
distance from VE7SL (miles)	peak height (feet)	location of peak	elevation angle to peak
0.5	100	Mayne Island	2.2°
5.1	200	Prevost Island	0.4°
8.7	550	east side of Saltspring Island	0.7°
11.1	1300	west side of Saltspring Island	1.3°
16.4	1500	east of Duncan	1.0°
26.7	2500	southwest of Duncan	1.0°

Some simple math shows that the angle to the worst case terrain peak is around 2.2 degrees, which says the VE7SL terrain to the southwest was not a problem since a duct looks possible (from the ray tracing above) at the higher elevation angle of 6 degrees.

As for received signal power to determine if ducting provides a readable signal, we can come up with a very rough estimate based on 5 Watts EIRP and a duct mode. From the equation in either of the November 2016 Monthly Features, we see that Pr = Pt + Gt + Gr – FSPL – abs – gnd refl.

Since the EIRP is 5 Watts, Pt + Gt = 37 dBm. I'll assume Gr = 0 dBi. FSPL = 108 dB. Being in a duct says gnd refl = 0 dB. This then reduces to Pr = -71 dBm – abs. For a readable signal, ionospheric absorption must be less than 32 dB if we assume the noise environment is around -103 dBm in 500 Hz (a quiet rural location in a CW bandwidth). But JT9 can decode signals around 25 dB below the noise, so that says ionospheric absorption (going up to get into the duct and coming down out of the duct) must be less than about 57 dB.

From my other investigations of ionospheric absorption on the lower frequencies, 57 dB of absorption is not prohibitive at 630-Meters. So the 5 Watts EIRP appears to be capable of making the 11,820 km trip under good conditions. That's as far as I'll go with this.

2200-Meters (137 KHz)

At night the E region critical frequency is in the neighborhood of 0.4 MHz (400 KHz). This says an electromagnetic wave around 137 KHz launched from a transmit antenna will not penetrate the nighttime E region – regardless of the elevation angle (even straight up). Thus ducting in the nighttime electron density valley is not possible because the RF can't get there.

What helps these very low frequencies is that they don't get too high into the ionosphere. In fact, 137 KHz hardly gets up to the D region, so ionospheric absorption is very low. It also helps that collisions between electrons and neutral atmospheric constituents is so high that ionospheric absorption at these frequencies is lowered even further (it's in the math for absorption). Remember LORAN-C at 100 KHz? It was a world-wide navigation system, and solar disturbances were much less a problem since the electromagnetic wave didn't get up into the ionosphere where the most effect from disturbances occurs.

In summary, propagation at 137 KHz is going to be very interesting, with some good DX at times. Of course the low antenna efficiency and external noise (both man-made and atmospheric) will be extremely important factors.

Higher Frequencies

We've seen that ducting in the nighttime electron density valley can occur on 630-Meters (this Monthly Feature), on 990 KHz (the November 2016 Bonus Monthly feature) and on 1.8 MHz (the normal November 2016 Monthly Feature). What about the higher frequencies?

Ed N4II wrote a great article in the November/December 2016 QEX magazine (published by the ARRL) titled "Gray Line Propagation, or Florida to Cocos (Keeling) on 80m". He analyzed North American QSOs with VK9CZ on 80-Meter CW from March 30 to April 13, 2013. He used Proplab Pro V3 to show a duct mode around 10 degrees elevation occurring from both ends of the path between Florida and VK9CZ. Thus ducting appears to be possible on 75- and 80-Meters. I should point out that the Florida end of this path was near sunset and the VK9CZ end of the path was near sunrise for this duct mode – more on this in the next two paragraphs.

How about 40-Meters? How about 20-Meters? Using the Kansas to Finland path in the November 2016 Bonus Monthly Feature, I searched for duct modes out of Kansas in Proplab Pro

V3 and found none on 3.5 MHz (I was trying to confirm the earlier Florida to VK9CZ results), none on 7 MHz and none on 14 MHz. Why weren't there any ducts in the dark ionosphere in the nighttime electron density valley out of Kansas on these frequencies?

There weren't any because the operating frequencies (3.5 MHz, 7 MHz and 14 MHz) were so high that there was not enough bending by the E region in the dark ionosphere (a critical frequency of only 0.4 MHz as stated earlier) to get into the duct. What enabled the Florida to VK9CZ duct on 3.5 MHz was that fact that both ends of the path were near the terminator, where the E region critical frequencies would be much higher and conducive to the ducting mechanism.

This also explains why ducting in the dark ionosphere is likely to be prevalent on 1.8 MHz. With a nighttime E region critical frequency of around 0.4 MHz, the maximum useable frequency at very low elevation angles would be on the order of 2.0 MHz (from The Rule of 5 for the E region of the ionosphere), resulting in low elevation angle 1.8 MHz signals being refracted back to Earth from the nighttime E region. But higher angles would go through the nighttime E region to the higher F region. Thus there could be ducting in the nighttime electron density valley at in-between angles.

Summary

This summary is about ducting in the nighttime electron density valley. We're not talking about ducting during the daytime.

Ducting in the nighttime electron density valley does not appear to be possible on 2200-Meters.

Ducting in the nighttime electron density valley appears to be possible on 630-Meters and 160-Meters in the dark ionosphere.

Ducting in the nighttime electron density valley does not appear to be possible on 75- and 80-Meters (and higher frequencies) in the dark ionosphere.

Ducting in the nighttime electron density valley appears to be possible on 75- and 80-Meters when the path is near the terminator. Ducting in the nighttime electron density valley near the terminator may be possible on 40-Meters with a greatly reduced probability. Ducting in the nighttime electron density valley near the terminator on 20-Meters is extremely unlikely.

Note 1 – EIRP stands for effective isotropic radiated power. At these very low frequencies, antenna system efficiency is very low. A big amplifier may be needed to get to 5 Watts EIRP.

Revisions (thanks to Steve VE7SL for bringing these to my attention):

1. Corrected Canadian EIRP on 630-Meters from 1 Watt to 5 Watts
2. Deleted terrain figure from http://njdtechnologies.net/091516/ and added my table generated from Google Earth data