Multi-Hop At Night on 160-Meters

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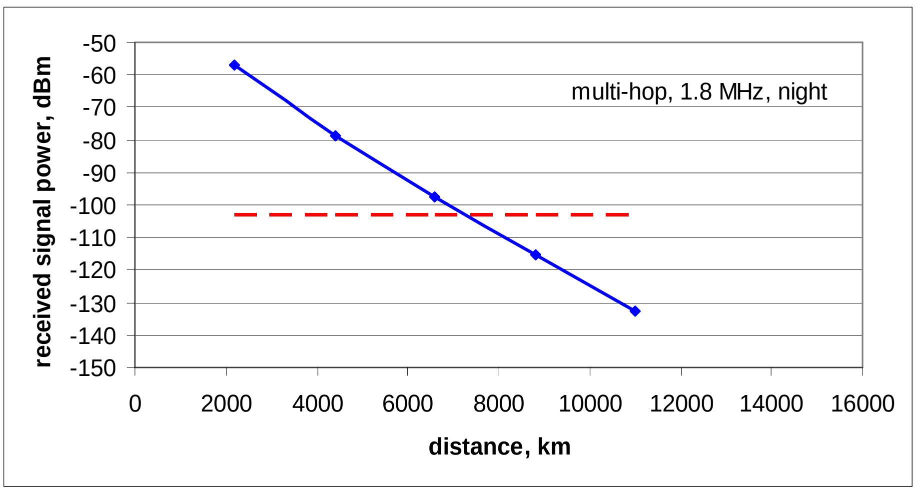
Perhaps you've seen comments about or you've read about ducting on 160-Meters. Why do we need to invoke ducting? What's wrong with multi-hop? There's nothing wrong with multi-hop on 160-Meters – except for that fact that the losses add up quickly and appear to put a limit on how far multi-hop can go before it's below a typical noise level.

We can estimate this limit by using the equation $P_R = P_T + G_{RX\text{-}ANT} + G_{TX\text{-}ANT}$ – free space path loss – ionospheric absorption – ground reflection loss, where P_R is the received power (in dBm), P_T is the transmitted power (in dBm), G are antenna gains (in dBi), and ionospheric absorption and ground reflection loss are self-explanatory (and in dB). We can calculate these parameters to derive P_R.

For P_T, we'll assume 1000 Watts (+60 dBm). For antenna gains, we'll assume quarter-wave verticals over average ground with 0 dBi maximum gains. For the free space path loss we'll use the equation $FSPL = 32.5 + 20\log F_{MHZ} + 20\log D_{KM}$ (dB). For ionospheric absorption we'll use 12.5 dB per hop from ray tracing with Proplab Pro V3. For ground reflection loss we'll use 3 dB per ground encounter (an average value from reflection loss data for vertical polarization at 1.8 MHz over various ground conditions).

For the hop length we'll use 2200 km (again from ray tracing with Proplab Pro). This may seem a bit short, but unfortunately the amount of refraction is inversely proportional to the square of the frequency, and thus RF at 1.8 MHz necessarily doesn't get as high into the ionosphere as RF at HF – and this results in shorter hops. Doing these calculations results in the following plot of P_R versus distance.



Per the assumptions noted above, the received power P_R is around -60 dBm after one hop. The power decreases by about 20 dB per hop, which puts it around -100 dBm after three hops (6600 km). Although a typical receiver has an MDS (minimum discernible signal) of around -130 dBm, we are usually limited by external noise – specifically man-made noise. The dashed red line is the noise in a CW bandwidth (500 Hz) on 1.8 MHz for a quiet rural location per ITU-R P.372-7 titled *Radio Noise*.

Thus multi-hop appears to be limited to around 7000 km under the conditions assumed. To go farther, antennas with gain (4-Squares) and low-noise receive antennas (Beverages) could probably increase multi-hop to 10,000 km. After that, some other mode offering less ionospheric absorption and less ground reflection loss must come into play.