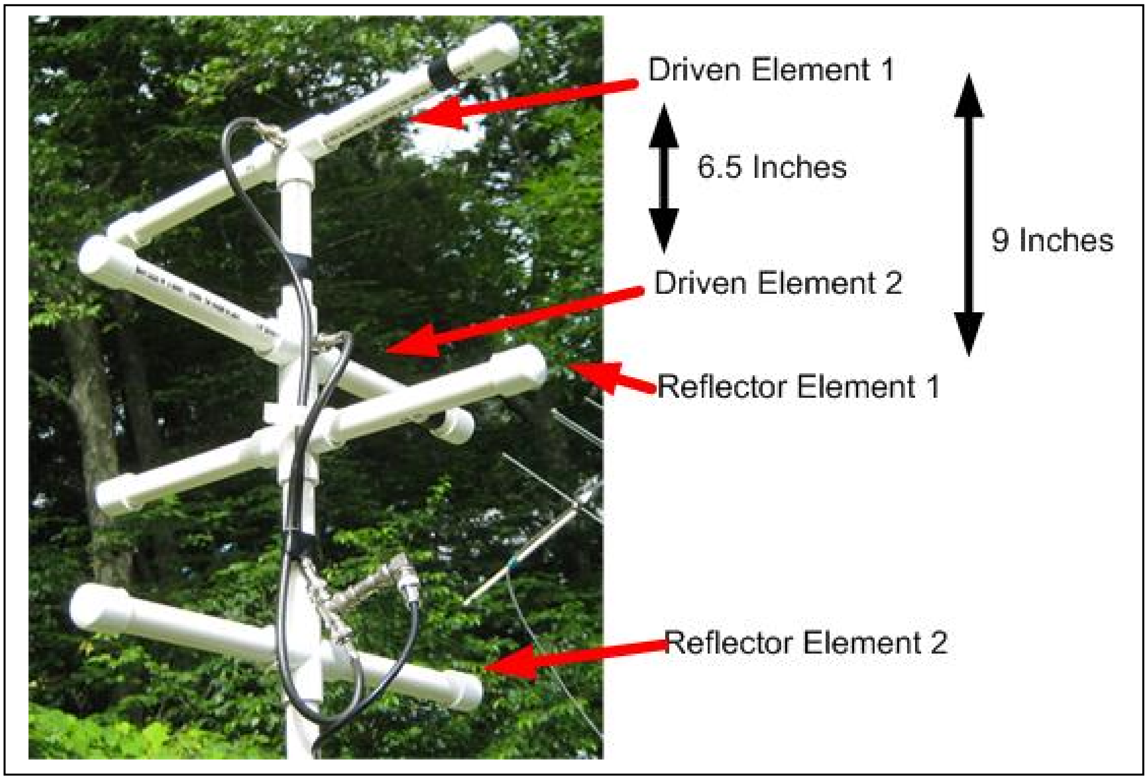
ISS Minimalist UHF Version

Due to operational necessity, the crew of the ISS has switched the operation of the packet system on-board the space craft over to the UHF frequency of 437.550 MHz. The operation on this frequency will probably be for a prolonged period, until such time as a replacement radio can be coordinated to be uplifted and installed in the ISS. This article describes an alternate UHF design of the ISS Minimalist antenna previously posted for the 2-Meter band.

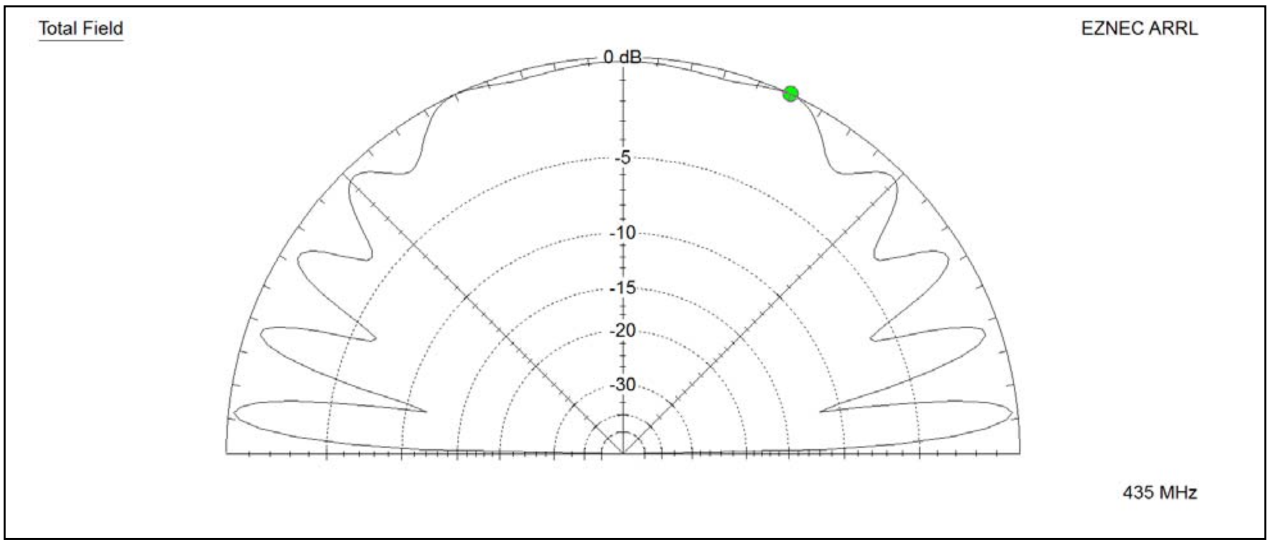
The design of the UHF turn-style antenna is basically a scaled version of the 2-meter antenna but uses a slightly different technique to achieve right hand circular polarization (RHCP). The driven dipole elements are made from 2 - 6 ¼ inch lengths of bare number 14 copper wires. The reflector elements are made from 13 ½ inch lengths of bare number 14 copper wire. As in the 2-meter version, the antenna elements are enclosed in a ½ inch PVC exoskeleton frame. The location and the spacing between the elements are illustrated in this picture of the completed antenna.



The transformer lines are ¾ wavelength sections of RG-6 coax with a lengths of 16 5/8th inches. You will notice when comparing this antenna to the VHF version, that there is a more significant distance between the two driven elements, in fact the two antennas within the UHF turn-style antenna are staggered with the bottom antenna displaced ¼ wavelength below the top antenna. There are two ways to realize the ¼ wavelength phase shift required to achieve RHCP; by the use of a ¼ wavelength phasing line made of 50 ohm coax, or by physically displacing the antennas. The latter technique is used here, therefore a phasing line is not required, only the transformer lines are required because the two 50 ohm antennas are connected in parallel at the transmission line feed point.

The proper orientation of the driven elements to achieve RHCP is accomplished the same way as described for the VHF version, sight along the axis of the antenna toward the pointing direction (up) and imagine that the radio wave reaches the top driven element first, and ¼ wavelength later, arrives at the bottom driven element.   If you note the location of the “hot” side of the driven elements (as was done in this example with the electrical tape), locate the bottom element ‘hot” side in a clock-wise rotation direction from the top element “hot” side.

Performance. If you model the UHF version of the antenna, you will see a similar shape to the elevation gain curve, and a similar gain performance (4.75 dB) as the VHF version.



However, you cannot expect to realize the same success with the UHF version of the antenna when receiving signals from the ISS because there is a significantly higher path loss between the ISS and the ground station because of the physics of wave propagation. What follows is a simplified explanation.

This is a simplified equation that describes the link budget between a satellite and the ground station:

$$dB_{loss} = 20log_{10}(d_{KM}) + 20log_{10}(f_{MHz}) + 32.44 - GTX_{dBi} - GRX_{dBi}$$

d is distance in KM, f is frequency in MHz, GTX is the transmitter antenna gain, GRX is the receiver antenna gain, and the constant is a fug factor.

The total signal loss in dB is equal to the loss due to the distance the signal travels, the loss due to the frequency being used, and these losses are offset by the gains of the transmitting and receiving antennas. If we assume that the frequency is the thing that has changed in this equation due to the shift in the ISS operation from VHF to the UHF frequency band, then the only additional losses will be due to the frequency change. Focusing on the $20log_{10}(f_{MHz})$ term, the calculated path loss contribution due to using a frequency of 145 MHz is 43.2 dB. The calculated path loss contribution due to using a frequency of 437 MHz is 52.8 dB. There is 9.6 dB more signal loss (1 ½ S units) when using the UHF band as opposed to using the VHF band. (Every 3 dB indicated the signal strength is cut in half, so for 9 dB, the UHF signal is 1/8th the strength of the VHF signal [strength* ½ * ½ * ½].) This signal loss could significantly degrade the signal quality particularly when dealing with Packet signals which generally require higher signal quality to realize reasonable data throughput.

The point here is that the UHF minimalist antenna is a work-around to the change in frequency, but in practice you should not expect the same level of performance that you would achieve on 2-meters. In practice, there are still usable packet signals from the ISS when using this antenna and it is worthy of consideration if an AZ/EL, gain antenna is not a possibility.