Mark Musil
mmusil@pdx.edu
March 30th, 2017
Portland State Aerospace Society

SatNOGS Ground Station Antenna Report

For the purposes of the Portland State Aerospace Society's SatNOGS ground station, a 434 MHz central frequency helical right hand polarized antenna (intended to operate at 436.7 MHz) was built and tested by Mark Musil. The SatNOGS project intends to create a large network of satellite ground stations using a low-cost, open-source satellite-tracking platform and is explained further at satnogs.org. The antenna was constructed as one piece of this modular platform and this report is a synopsis of the completed antenna along with its test results.

Figure 1: The completed antenna.

Construction

The antenna was built using the instruction manual found in the SatNOGS documentation ([1]). This ensures that the antenna is easily replicable by other amateur enthusiasts who wish to follow the OreSat

[1] Papadeas, P. (2016, April 3). *Helical Antenna v4.* Retrieved from http://satnogs.dozuki.com: http://satnogs.dozuki.com/Guide/Helical+Antenna+v4/11

Mark Musil
mmusil@pdx.edu
March 30th, 2017
Portland State Aerospace Society

mission. All components were made from commonly available hardware supplies and require only access to a laser cutter, 3d printer, and soldering iron in addition to basic hand tools.

One unique aspect of this antenna is its use of a copper sheet triangle of specific dimensions as a quarter-wave transformer (see Figure 2.) This increases the affordability of the antenna with little losses introduced as a result. The base reflector as well was constructed from wire mesh sold at any hardware stores and provides increased directionality for the antenna.

Figure 2: The copper triangle serves as a quarter-wave transformer.

Testing

Mark Musil
mmusil@pdx.edu
March 30th, 2017
Portland State Aerospace Society

Upon completion, the antenna was tested on a vector network analyzer as well in an insulated RF chamber. A screen shot of the Smith chart produced for a frequency sweep from 430 – 440 MHz is below (Figure 3). At 436 MHz (Near the operating frequency of 436.7 MHz) the complex impedance of the antenna is 34.688 – 6.2827**j** Ohms. This is well within the 2:1 standing wave ratio circle and confirms the electrical reliability of the antenna.

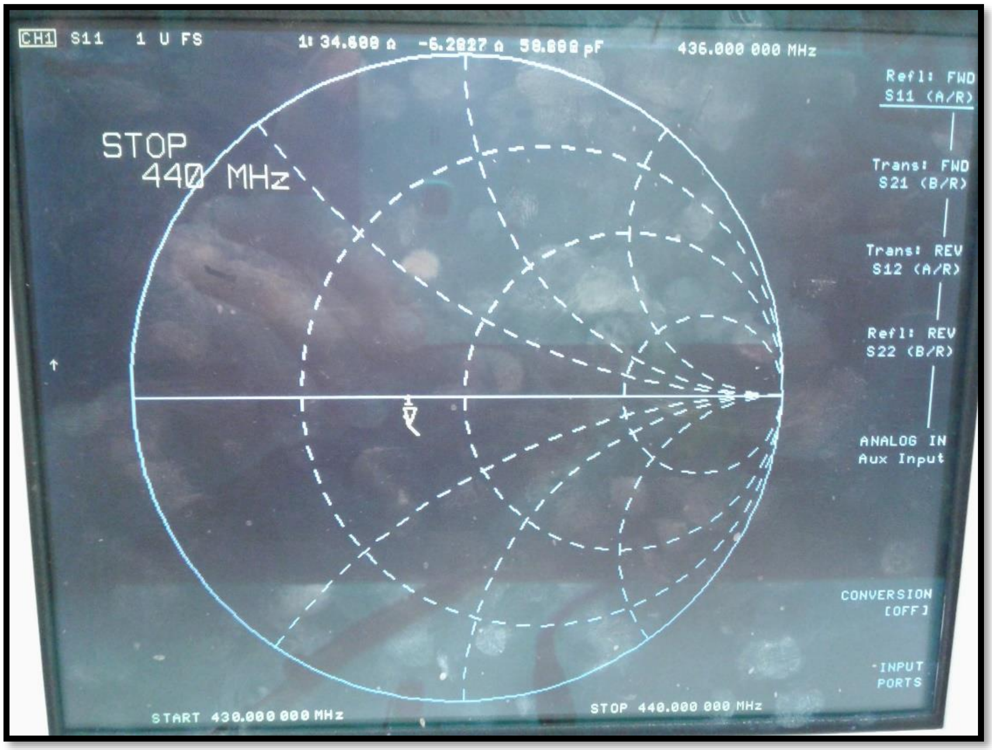

Figure 3: VNA sourced Smith Chart of antenna impedance for a frequency sweep from 430 – 440 MHz.

The antenna was then tested in an insulated RF chamber (Figure 4). The antenna was made to broadcast a 10dBm signal at 436.7 MHz 3 meters away from a receiving antenna. The antenna was first placed such that it directly faced the receiving antenna at the same height and at 3 meters away (defined as 180 degrees). The antenna was then rotated 90 degrees in the azimuth orientation in both directions away from the original placement and the received power was recorded at 10 degree increments.

The only test performed was the 180 degree azimuth sweep. The antenna was not tested past 90 degrees in either direction as it is a directional antenna and is known to lose most power past 90 degrees. The antenna was not rotated along the axis of the helix as it is known to have symmetry and is thus non-polar about the axis of the helix.

Mark Musil
mmusil@pdx.edu
March 30th, 2017
Portland State Aerospace Society

Figure 4: The 'head-on' orientation of the constructed antenna (left) facing the receiving antenna (right). From this orientation the antenna was rotated 90 degrees azimuth both directions.

The antenna testing produced the following graphs, which display the power at the receiving antenna of the transmitting antenna with respect to its orientation in degrees. Note that the testing chamber did not have a reference antenna for such a large antenna so the results in relation to an isotropic source (dBi units) are unavailable. Furthermore, it was difficult to create a polar plot in MATLAB which could clearly convey that the 180 degree orientation resulted in the highest power. The existing polar plot is in positive units of dBm, which results in an inverted plot. Please compare it with the left hand plot for accurate understanding.

Mark Musil
mmusil@pdx.edu
March 30th, 2017
Portland State Aerospace Society

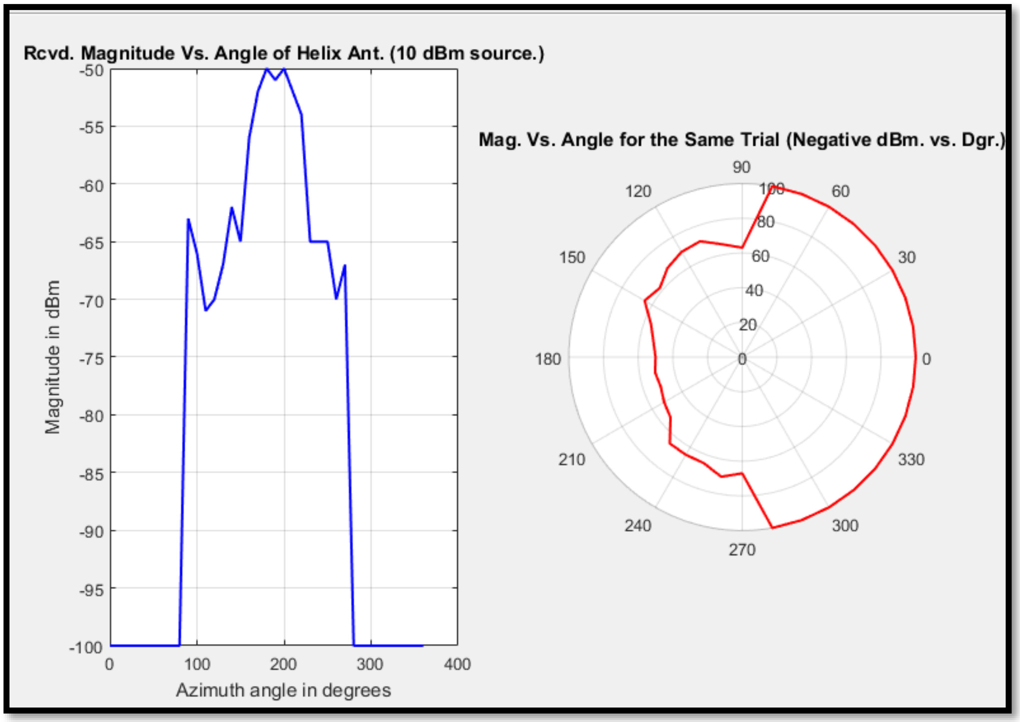

Figure 5: The graphs that resulted from the RF chamber testing. (Left) The highest power received occurs at 180 degrees with symmetric loss of power with change in either direction. (Right) The inverted polar plot. At low positive values, power is highest.

Summary

This antenna was an interesting exploration in the basics of applied electromagnetics and gave the student a good overview of construction, and testing. The construction was tedious and required exact measurements and procedures. However, the end result shows that an effective ultra-high frequency antenna can be constructed by hand using only basic hardware supplies. The application, satellite communication, is significant because it means that citizen scientists and aerospace enthusiasts can build antennas at an affordable price.