Earth Remote Sensing with SoOP - MUOS Antenna

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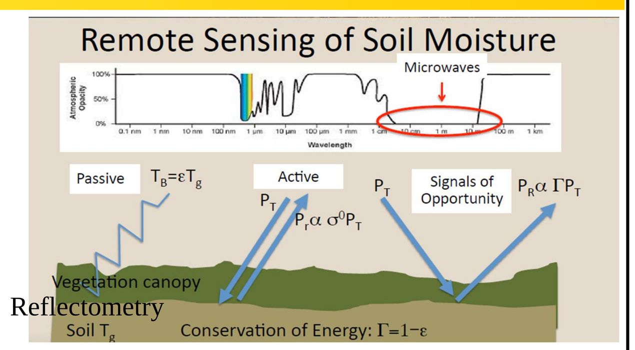
Problem Statement – The big picture!

Today, there are a huge number of satellites orbiting the earth, and there are specific frequency bands allocated for data transmission from these satellites. Signals from these satellites can be accessed at different places on earth, and be used for remote sensing. Lower frequency bands are being used in this project, which have not been used earlier for remote sensing. The main idea of this study is to use the principle of 'reflectometry' to correctly get signals from the MUOS system. MUOS satellites are equipped with a Wideband Code Division Multiple Access (WCDMA) payload that provides a 16-fold increase in transmission throughput over the current Ultra High Frequency (UHF) satellite system.

Idea of 'Reflectometry'

To use these signals as a source of illumination in a "bistatic" radar configuration, comparing the direct signal observed along a line-of-sight to the satellite, with the scattered signal reflected from the land surface.



MUOS Overview

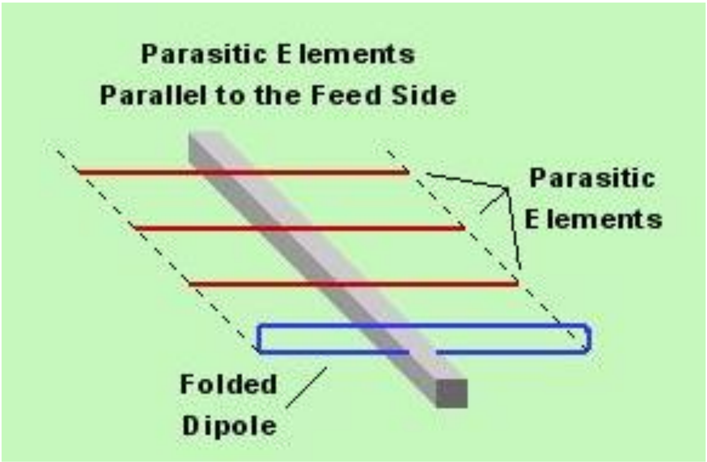
This research involves the building and design of antennas for a certain specific frequency range. The MUOS satellite transmits in the frequency range 360-380 MHz with a center frequency of 370 MHZ. These are military communications satellites, under the Mobile User Objective system. These satellites are replacing the UFO system of satellites.

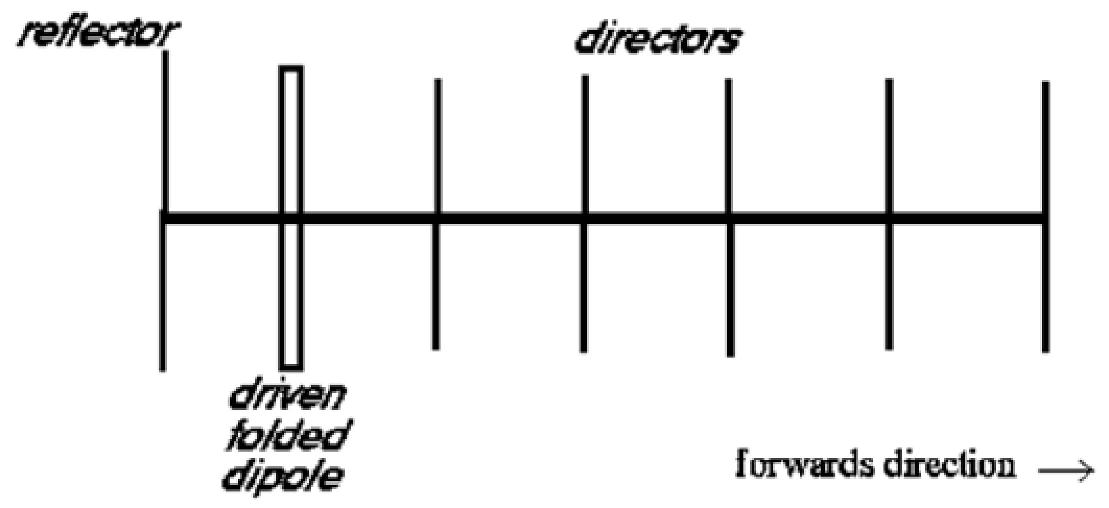
Satellite	Elevation	Azimuth
MUOS1	-8.8	269.8
MUOS2	**45.9**	**200.6**
MUOS3	**6.5**	**101.1**
MUOS4	-4.8	267.2

For the purpose of data collection, we are looking at MUOS 2 and 3. Their elevation angles are positive and can be viewed from our location.

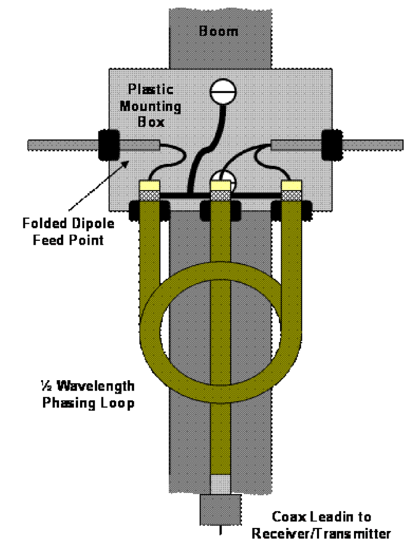
Antenna modelling & design

The Yagi – Uda antenna is a particular type of antenna design which works really well in the UHF band (ultra high frequency 300 – 1000 MHz). It is designed to have a very high gain in this region. The Yagi antenna consists of a single 'feed' or 'driven' element, which is indeed a dipole or a folded dipole antenna typically. This is the only member of the antenna which is actually excited (a source voltage or current applied). The rest of the elements, which are the reflector and directors, are parasitic, which essentially means that they reflect or help to transmit the energy in a particular direction.





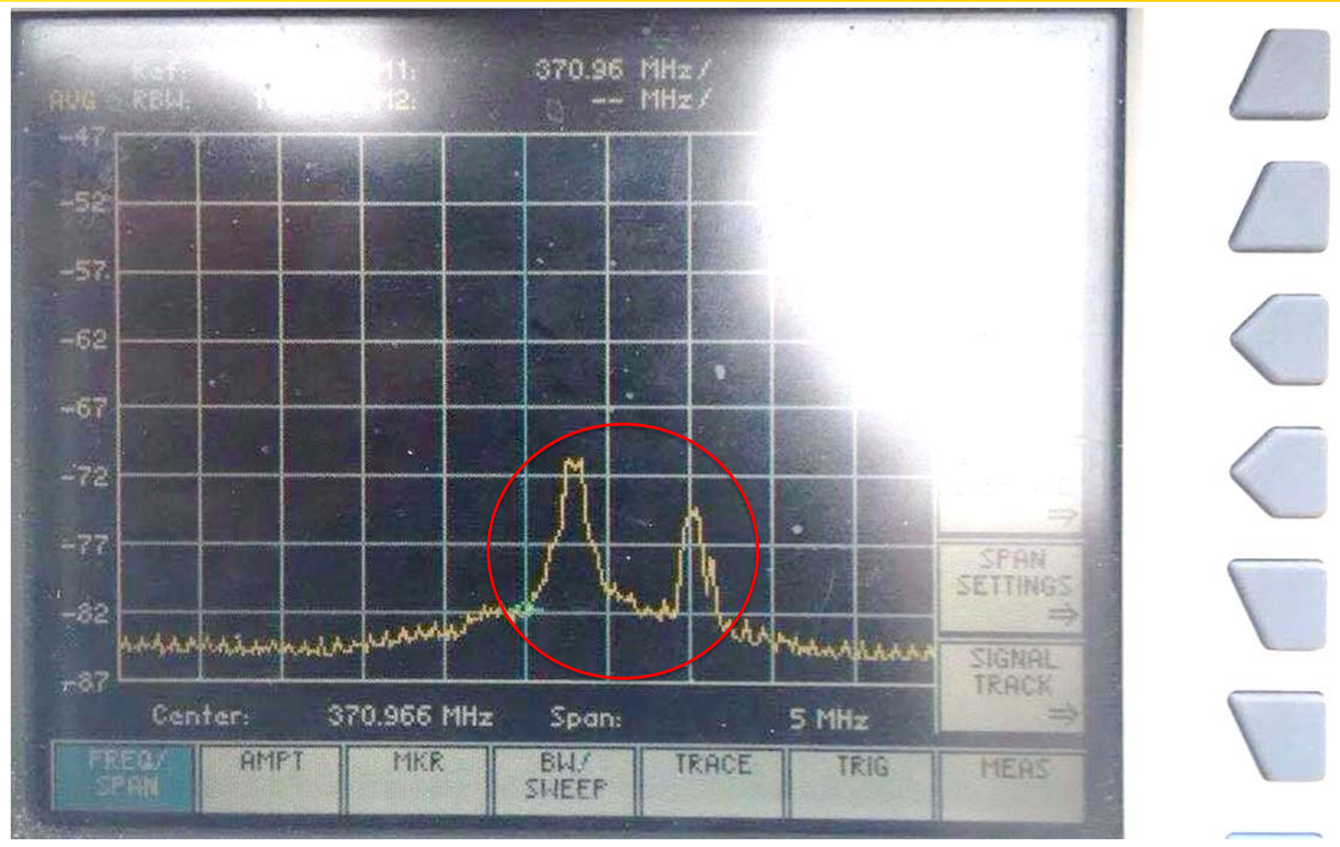
The diagram on the right illustrates the assembly of the 1/2 Wavelength Phasing Section and Folded Dipole Feed. The feedline connects to one side of the Folded Dipole Feed section along with one side of the 1/2 Wavelength Phasing Section.



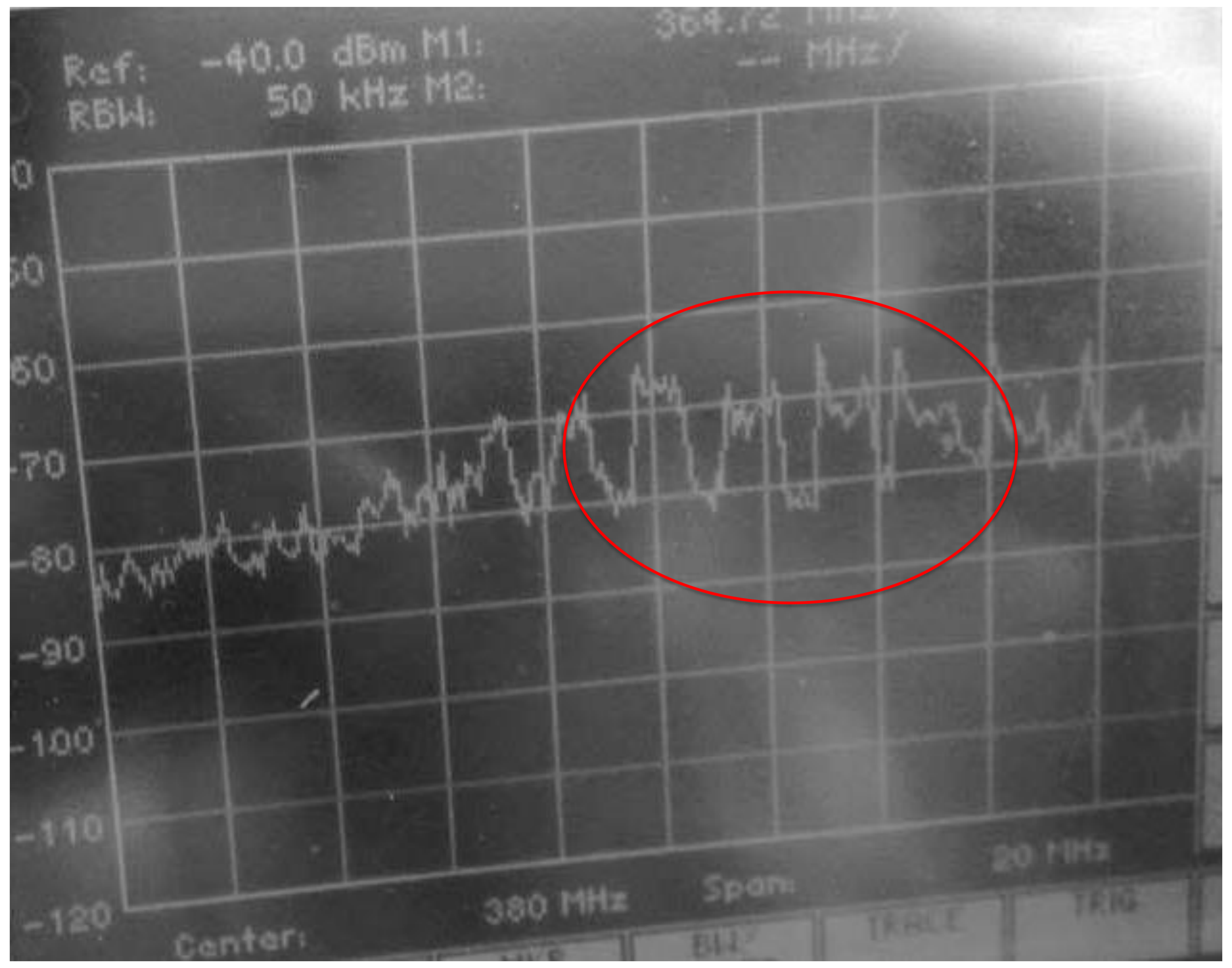
Experiments and Testing

After understanding the geometry of this antenna model, the matching and connector cables of the driven element were studied and fixed. Then, an online calculator is used to verify the lengths of the elements of the Yagi antenna and the cumulative spacing between them. It is a directional antenna, which essentially means that it has to be pointed in the direction of the particular satellite that we are recording data from.

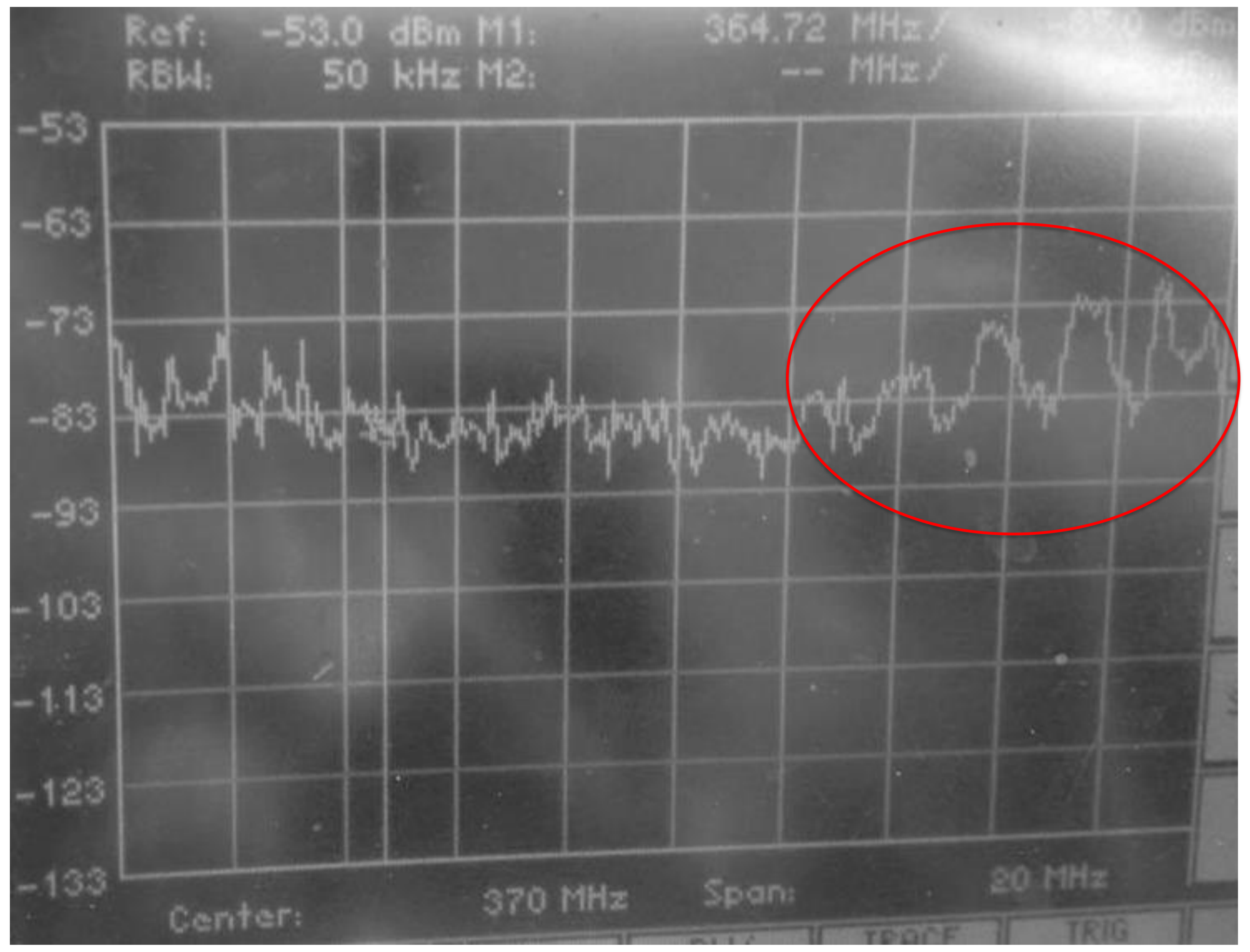
Signal Collection at ACRE
(7th April 4:45 pm EST)



The plot illustrates power gain (in dB) versus frequency (in MHz), as received from MUOS 2 initially, using the spectrum analyzer. The center frequency is set to 370 MHz.
(ARMS, 10th February 1:30 pm EST)



The plot shows signals received from MUOS 2 using the spectrum analyzer. The center frequency is set to 380 MHz. (ARMS, 5th April, 2:30 pm EST)



The plot shows signals received from MUOS 3 using the spectrum analyzer. The center frequency is set to 370 MHz.(ARMS, 5th April, 2:30 pm EST)

Results and conclusion

The design of the MUOS antenna was studied as per the modelling basics of a Yagi antenna. The matching cable and connector cable were fixed. The antenna was taken out for testing and plots were recorded on the spectrum analyzer at different locations. The antenna is RHCP (right hand circularly polarized). This was investigated by by individually pointing it towards the satellite and pointing it towards the ground and recording data. The data collected will now aid in further recording signals with the antenna and using the USRP's to compare and cross correlate them.

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Acknowledgement

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References

- Garrison, J. (n.d.). Ocean Remote Sensing with GNSS R. Retrieved from http://www.gfg2.eu/sites/gfg2.eu/files/garisson_reflectometry.pdf on January 26, 2015
- SMAD IV: Space Mission Engineering. (n.d.). Retrieved from http://www.sme-smad.com/index.asp on January 28, 2015
- Yagi-Uda Antenna. (n.d.). Retrieved April 08, 2016, from http://www.antenna-theory.com/antennas/travelling/yagi.php

- MUOS 2 - NORAD 39206 - 3D Online Satellite Tracking. (n.d.). Retrieved from http://www.satflare.com/track.asp?q=39206#TOP on February, 2015
- Martin E. Meserve - K7MEM - VHF/UHF Yagi Antenna Quick Designer. (n.d.). Retrieved from http://www.k7mem.com/Electronic_Notebook/ antennas/ yagi_vhf_ quick.html on March 4, 2015