DIRECTION-OF-ARRIVAL ESTIMATION FOR SIGNAL-OF-OPPORTUNITY RECEIVER

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I. Abstract

In this presentation, a smart antenna technology for CubeSat platforms is developed that allows to maximize the gain of antenna system in a desired direction to interrogate selected target and minimize the antenna gain in other directions to suppress unwanted signals entering the receiver.

II. Motivation

In the Signal of Opportunity (SO) technology (used for remote sensing) a passive and inexpensive receiver is used to receive a direct signal from a SO transmitter and also its reflected signal from a target of interest. The direct as well as reflected signals can be processed with sophisticated signal processing to retrieve physical properties of reflecting targets. However, the antennas used on a CubeSat platforms for remote sensing as well as for communication are omni-directional and hence prune to electromagnetic interference from unwanted directions/targets. In these application it will be advantegous to have a technology that allows estimation of direction of arrival more accurately with smaller size antenna aperture.

In this work, we developed a VHF (240-270 MHz) receiver embedded into a 6U CubeSat platform and used for estimating direction of arrival of a direct signal form a SO transmitter in the GEO orbit and its reflected signal from the specular point on the Earth surface.

Figure 1 shows concept of SO technology for remote sensing . UFO communication satellite in a GEO acts as a SO transmitter (250 MHz). A CubeSat operating in LEO is equipped with multichannel passive VHF receiver. Cross dipole on the top receives the direct signal and the cross dipoles at the bottom receives signal reflected from the earth surface

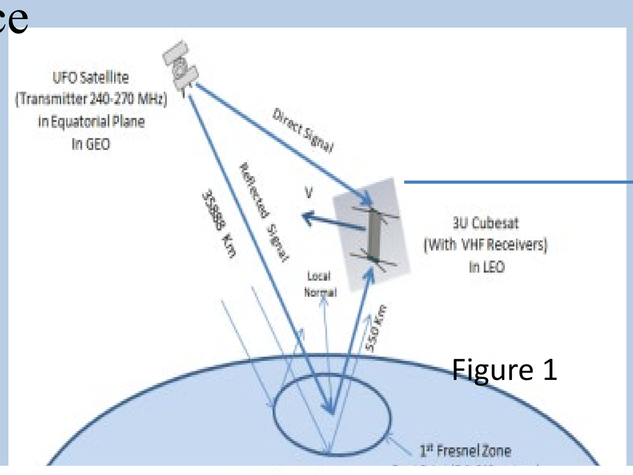
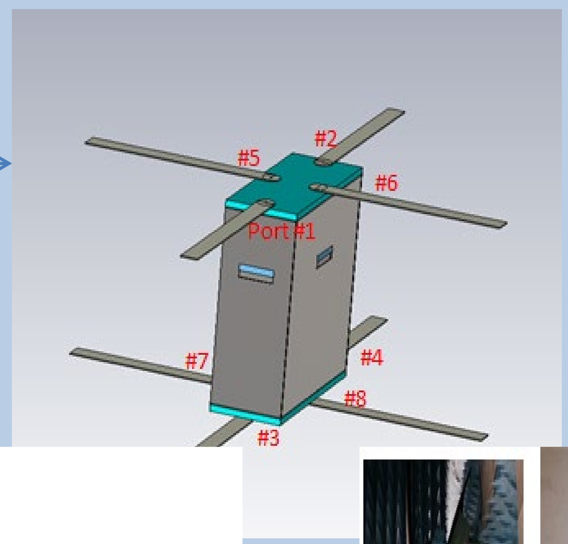


Figure 1



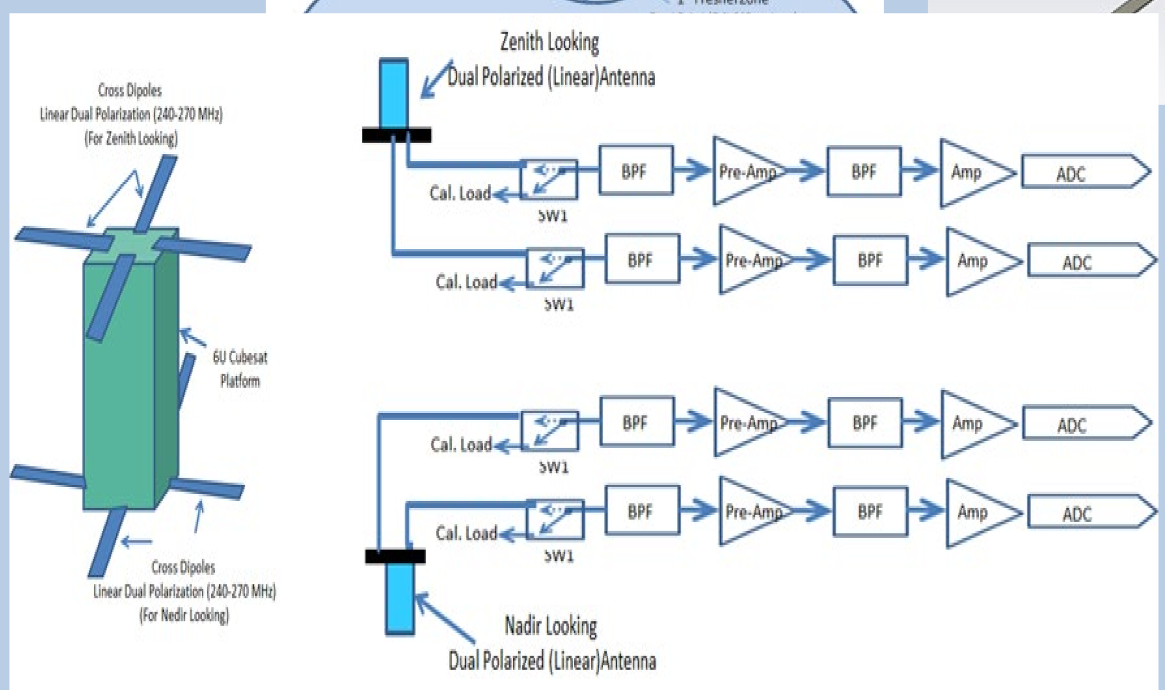


Fig 2. 4-Channel VHF receiver block diagram to receive direct and reflect signals with VHF antennas mounted on 6U CubeSat platform.

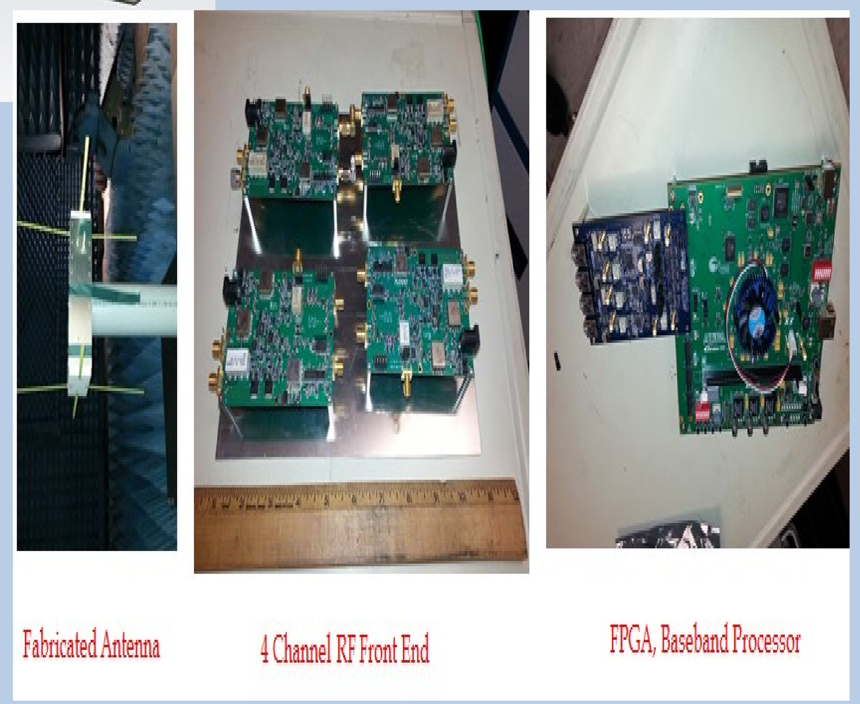


Fig 3 4 Channel VHF receiver hardware

Since UFO satellite transmit circular polarization, two cross dipoles pairs impedance matched to 250 MHz were designed and tested for their impedance performance as well as for their radiation patterns as shown in Figure 4. Figure 4 shows both the measured and computed performance of these antennas

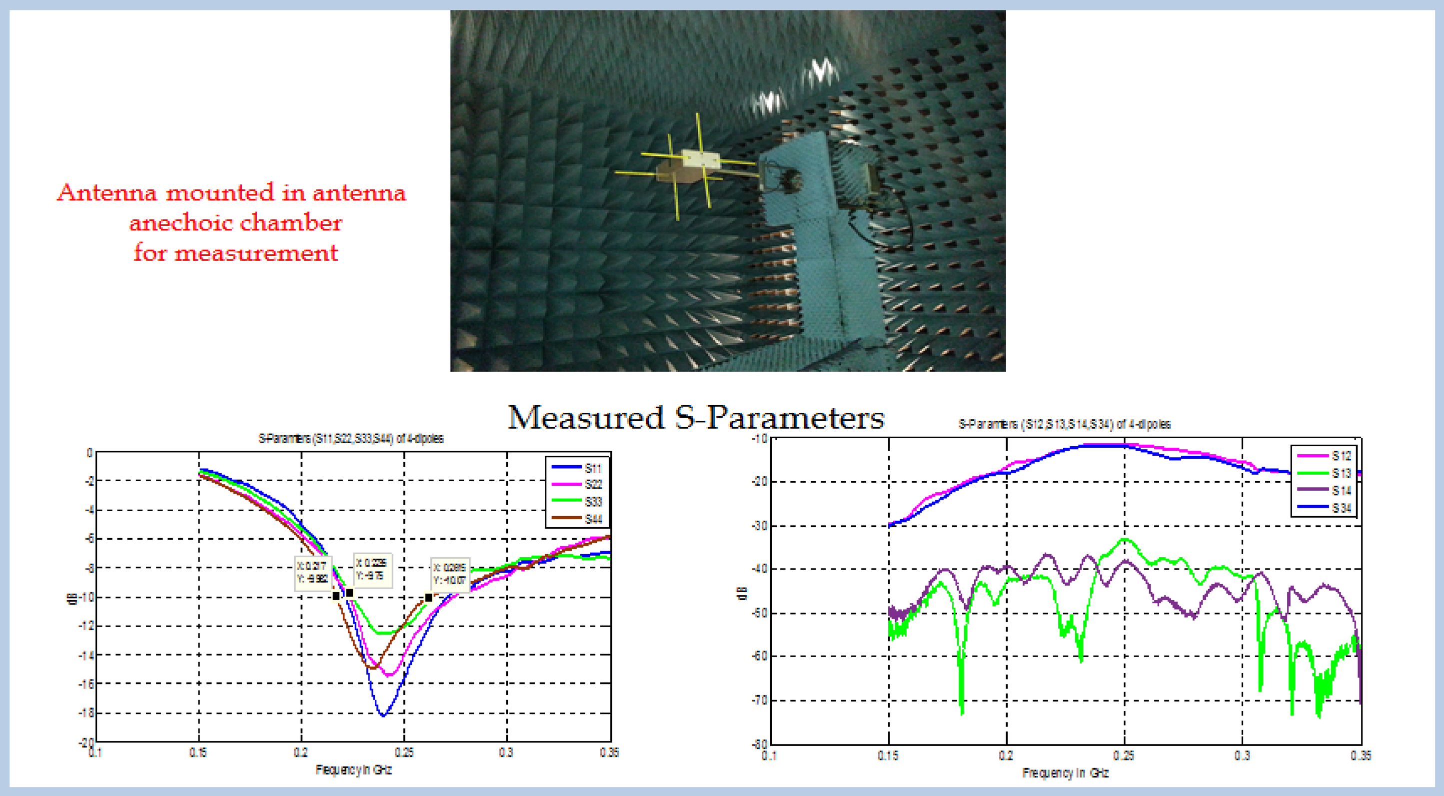


Fig 4. VHF antenna radiation patterns and input VSWR measurement results

Using the receiver, we performed measurement of UFO satellite direct signal as shown in Figure 5.

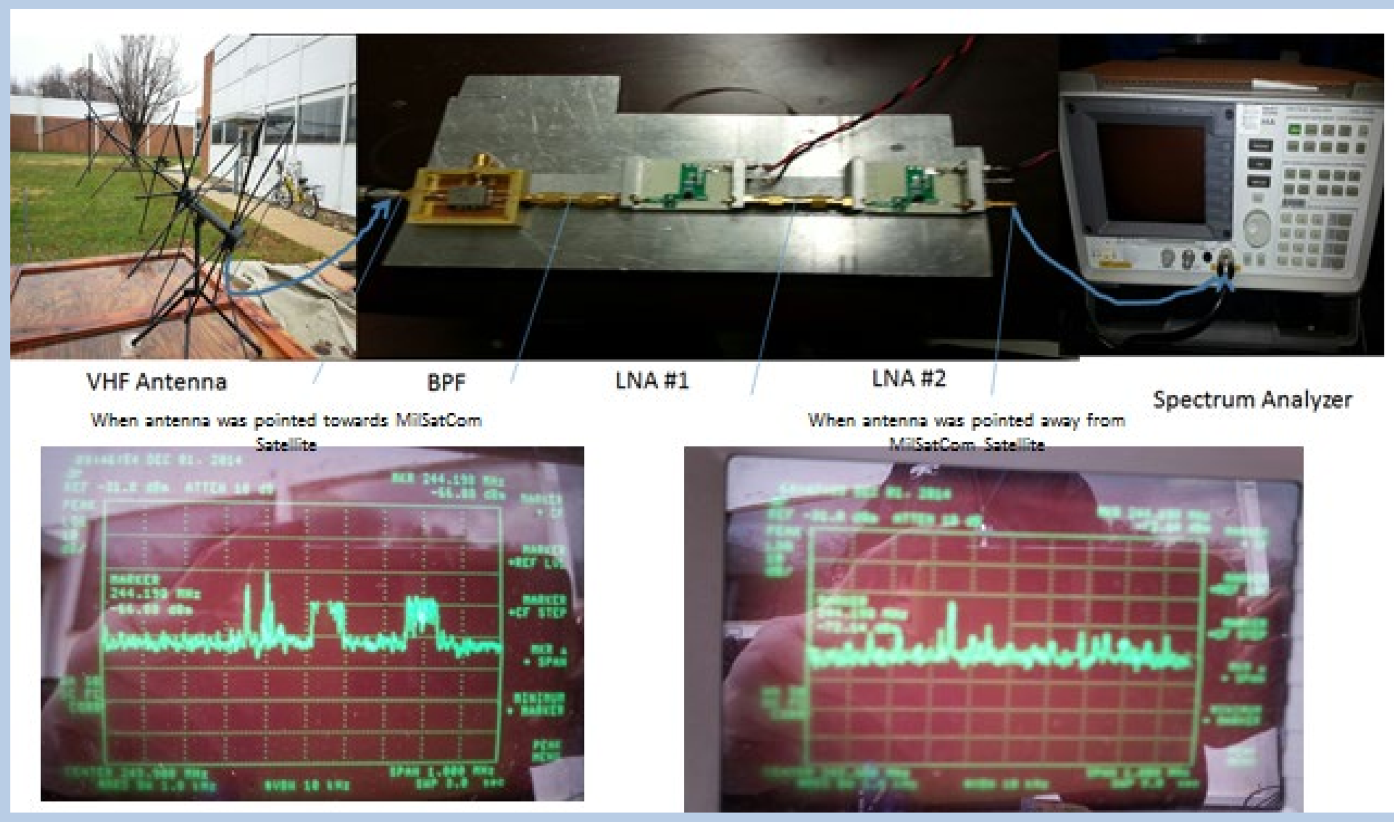


Fig 5

III. Directional-of-Arrival Estimation

Space borne microwave remote sensors at VHF/UHF frequencies are important instruments to observe reflective properties of land surfaces through thick and heavy forestation on a global scale. One of the most cost effective ways of measuring land reflectivity at VHF/UHF frequencies is to use signals transmitted by existing communication satellites (UFO operating at VHF/UHF band) as a signal of opportunity (SoOp) signal and passive receivers integrated with airborne/space borne platforms operating in the Low Earth Orbit (LEO)

One of the critical components of the passive receiver is two antennas (one to receive only direct signal and other to receive only reflected signal) which need to have ideally high (>30dB) isolation.

The 4-channels VHF (240-270 MHz) receiver embedded into a 6U CubeSat platform is connected to four custom designed linear dipole antennas operating over the VHF band. Because of the broad beam patterns of these dipole antennas, each channel will receive signal from all directions. Hence it is challenging to make each channel directional to receive RF signal from a desired direction. These four antennas are mounted on a 6U CubeSat and hence are strong mutual coupling. This strong mutual coupling is used to make the combined system directional. Hence novelty in our approach is that, the signals from each channel are combined appropriately so that maximum beam direction can be steered in any desired direction.

Figure 6 below shows radiation patterns of VHF antenna elements after using smart antenna beam forming to increase isolation between direct and reflect channels

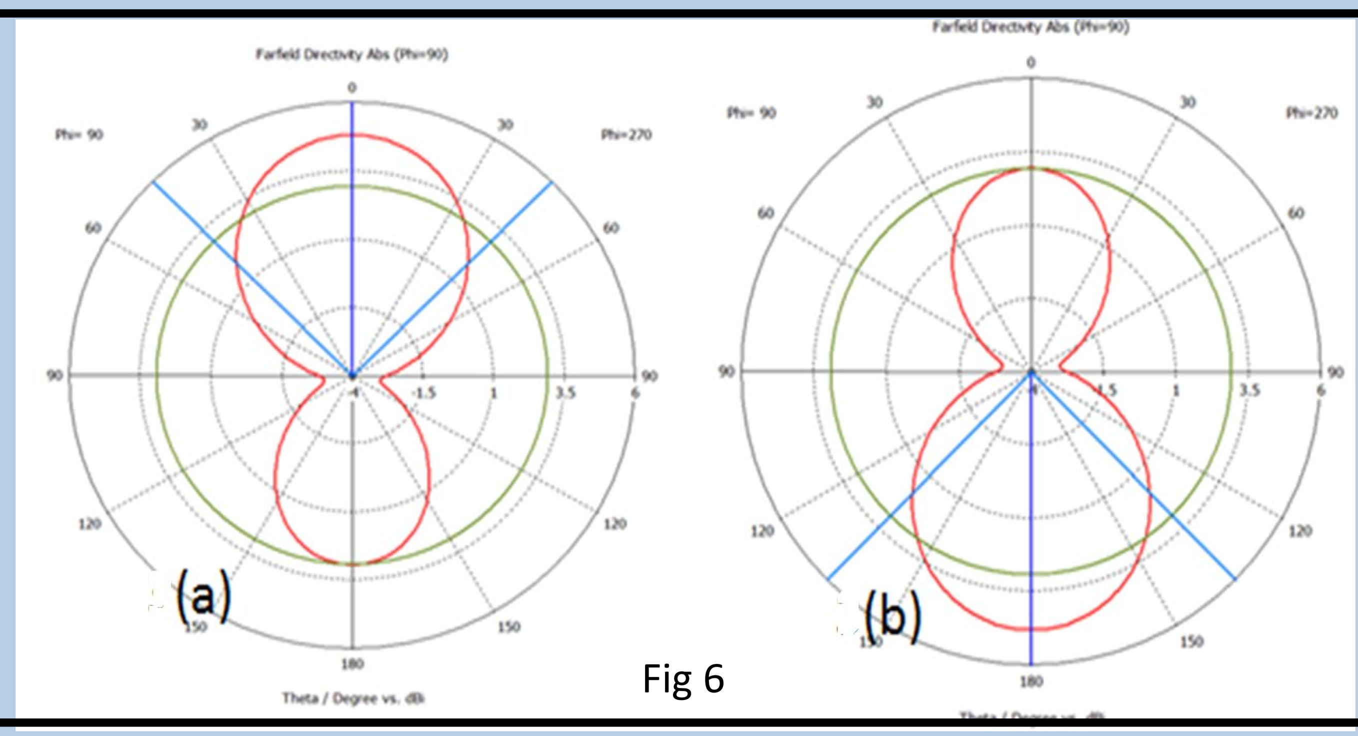


Fig 6

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S. J. Katzberg, et al, "Calibration of reflected GPS for tropical storm wind speed retrievals, " Geophysical Research Letter, Vol. 33, No. 18, 2006