Design and Development of VHF Antennas for Space Borne Receivers for SmallSats

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OUTLINES

1. Motivation and New Approach

2. Comparison with Other Conventional/Traditional Remote Sensing Methods

3. Description of SoOp Technology Hardware

4. Status of VHF (240-270 MHz) SoOp Technology Demonstration

5. Future Plans

6. Conclusions
**Motivation**

- **Need #1**: Global soil moisture with spatial resolution < 10 km & revisit time 3 days  
  (1) Correct Climate Model Development, (2) Global Water Supply,

- **Need #2**: Root Zone Soil Moisture is derived from surface soil moisture measurement  
  No direct measurement RZSM  
  Vertical moisture gradient to understand interaction of moisture with soil, surface,  
  and atmosphere.

**Currently Available Sources**

- SMAP mission is inadequate for SM measurement for surface covered with heavy  
  vegetation (L-band)

- Use of CYGNSS data over the ground is being planned to be used for SM measurement  
  Bi-static reflection is done at L-band,  
  Inadequate for surface covered with heavy vegetation

- AIRMoSS (JPL/USC): airborne instrument using radar operating in VHF range  
  not adequate for global measurement,
A Different Approach For Soil Moisture Measurements

• Our goal is to provide a different approach using signal of opportunity concept to measure SM as well as RZSM

• We plan to use a transmitter with following requirements
  (1) Illuminates global surface all the time & already in existence
  (2) with RF signal that are sufficiently longer wavelength to penetrate vegetation including RZ region

• MilSatCom satellites known as Follow-on in GEO location
Why MilSatCom Satellites as Signal of Opportunity Transmitter?

1. Illuminates the earth surface 24/7 with EIRP of 28 dBW at VHF frequencies (240-270 MHz). Higher Wavelength, good for RZSM measurements

1. Illumination area is shown below
Comparison With Conventional/Traditional Earth Science Remote Sensing Methods

<table>
<thead>
<tr>
<th>Conventional/Traditional Approach</th>
<th>VHF SoOp Technology</th>
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<tbody>
<tr>
<td><strong>L-Band (SMAP)</strong></td>
<td>_Deeper penetration into soil</td>
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<td>–Few cm penetration into soil</td>
<td>_Possible for direct RZSM measurements</td>
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<td>–Inadequate to measure soil moisture through vegetation.</td>
<td>_Simple and inexpensive passive receiver</td>
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<td>–Can not be used for direct measurement of RZSM</td>
<td>_Can operate without FCC permission</td>
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<td>_Spatial resolution depends upon antenna foot print</td>
<td>_Spatial resolution is decided by first Fresnel Zone</td>
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<td><strong>P-Band Radar</strong></td>
<td>diameter not by antenna foot print</td>
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<tr>
<td>–Difficult in getting permission from FCC for radiation</td>
<td>_Has a clear path for space application for global soil</td>
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<td>–Expensive from space</td>
<td>moisture measurements</td>
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Space Borne Concept
Design Steps for 4-VHF Dipole Antennas

Converting 8-Monopoles to 4 Dipole

S-Parameters of 4 Dipoles

8 x 8 S-parameters

S11 & S22

S-Parameters of 4 Dipoles
Antenna Design Summary
1. Four Dipole antennas operating over 240-270 MHz frequency

2. Two dipole antennas to receive direct signal and other two to receive reflected signal

3. Cross dipoles are used to receive RHCP for direct signal and LHCP for reflected signal

4. Radiation Characteristic shown below

Antenna mounted in antenna anechoic chamber for measurement
VHF Receiver Block Diagram For SoOp (Signal of Opportunity) Remote Sensing

This entire passive 4-channel VHF receiver needs to be fitted into 1/2U
Hardware Summary

Fabricated Antenna

4 Channel RF Front End

FPGA, Baseband Processor

PC
1. VHF antennas (four dipoles) mounted on a mock-up 6U CubeSat has been tested in GSFC’s antenna anechoic chamber and their performance is validated.
2. RF front ends including LNAs, SPDT switches, and digital attenuators for four channels have been tested and validated for their performances.
3. Four channel digital receiver has been integrated with the RF front end and validated.
4. Field data has been collected using 75 feet Boom Truck and currently being processed to extract ground reflectivity.
Future Plans

Space Borne Application:

1. For extending the SoOp VHF technology for space application we need to a multi-channel VHF receiver that can be integrated with a CubeSat platform.
2. Antennas packaging and development mechanism
3. Process the measured data to show validity of this concept.
Thanks