Compact Dual-Frequency Microstrip Antenna Feed for Future Soil Moisture and Sea Surface Salinity Missions

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Abstract— **The development of a compact, lightweight, dual-frequency antenna feed for future soil moisture and sea surface salinity (SSS) missions is described. The design is based on the microstrip stacked-patch array (MSPA) to be used to feed a large lightweight deployable rotating mesh antenna for spaceborne L-band (~1 GHz) passive and active sensing systems. This paper describes the design of a single-element stacked patch element and the 7-element array configuration.**

Microstrip antenna; soil moisture; sea surface salinity

I. INTRODUCTION

The development of a compact dual-frequency antenna feed for future soil moisture and sea surface salinity (SSS) missions is described. Soil moisture and SSS are high priority measurements for the study of global water cycle and hence climate changes. In response to these measurement needs, two missions, Aquarius (sea surface salinity) and Hydros (soil moisture), were selected recently for the third NASA Earth System Science Pathfinder (ESSP) program. Both mission concepts use the offset parabolic antenna designs with conical feed horns for integrated radar and radiometer operations at L-band (~1 GHz) frequency. The Hydros mission proposes a 6-m diameter lightweight deployable rotating antenna [1], while the Aquarius mission plans a 3-m diameter pushbroom antenna with three conical feedhorns. Future high-resolution systems operating at low microwave frequencies (L-band) will require large reflectors with multiple feeds [4,5]. These feeds must be compact and lightweight, with dual-frequency capability for passive and active sensing [1,3], which is the motivation for this development program.

The microstrip stacked-patch array will be a factor of 3 lighter, and a factor of 20 shorter, than the conical feedhorn design traditionally used to illuminate reflector antennas. The key feature is the stacked-patch design with two resonant frequencies at 1.26 and 1.41 GHz for L-band radar and radiometer operations. This is a three-year technology development, which was started in November 2002. The first task is to obtain an optimal design for a single microstrip stacked patch to achieve desired resonant frequencies and minimum return loss. The second task will be to develop the MSPA. The third task is to measure the insertion loss and stability of the MSPA with a cold sky radiometric calibration technique. This paper presents theoretical performance of the MSPA feed, together with preliminary results from the fabrication and testing a single-element design.

II. ANTENNA FEED DESIGN PERFORMANCE

Traditionally, feedhorns are used to illuminate reflector antennas. The major drawback of feedhorns is that they are heavy and occupy a large volume. An alternative approach is a microstrip patch array feed. Microstrip patches are low profile, lighter, and take up much less volume than a conventional feedhorn.

A preliminary design was undertaken to show that the microstrip patch array has a strong potential to achieve antenna pattern performance comparable to the conical horn. The technical approach here is the detailed design, fabrication, and test of a fully functional microstrip patch-array feed with stacked patch elements. The geometry of the preliminary stacked patch design is shown in Figure 1 for one element. The stacked patch resonates at each of the desired frequencies to achieve dual-frequency capabilities.

The patches are designed as perfectly electrical conducting elements. The lower radar patches sit on a honeycomb dielectric structure above a conducting ground plane. The honeycomb structure is filled mostly with air and therefore introduces only a small loss at L-band frequencies. On the top of the radar patches will be another honeycomb dielectric structure to support the radiometer patches. The patches are fed by 50Ω coaxial cables at locations chosen for good impedance match and dual polarization capability. The feed for the radiometer patch comes from the ground plane and goes through the radar patch at the desired location. The size of patches, thickness of honeycomb structures, and location of the patch feeds are design parameters to achieve two resonant frequencies of 1.26 and 1.41 GHz.

The first step of the preliminary design study was to find an array configuration for the patches that provided a similar

This work is sponsored by the National Aeronautics and Space Administration, Advanced Component Technology Program

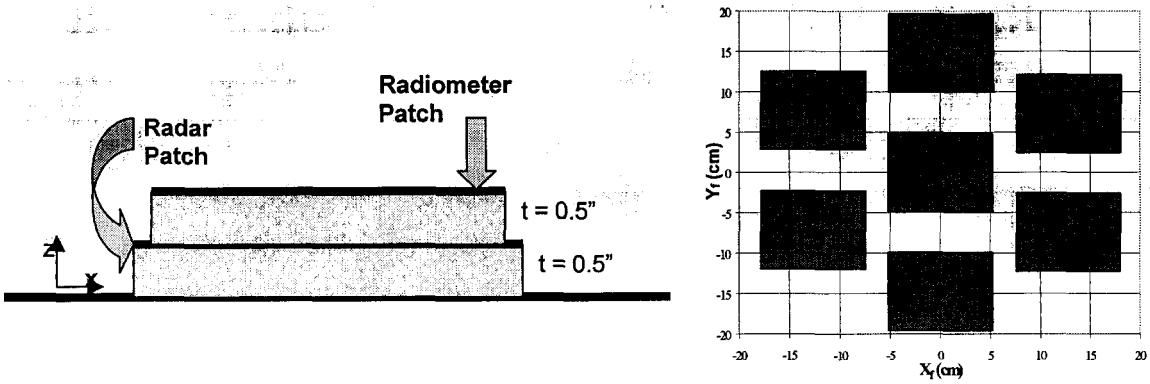

Figure 1. Left panel: Side view of a preliminary stacked patch design. The radiometer patch is on top of the radar patch and the radar patch is above the ground plane. Right panel: The locations of patches for a seven-element hexagonal patch array.

antenna pattern to the conical feedhorn. This study was performed with a single layer design for operation at the radiometer or radar frequency. Calculations were done using idealized ~0.5 wavelength (λ)-square patch elements. The optimal design was found to be a seven-element array with six patches arranged hexagonally around a central patch (Figure 1) [2]. For this design the outer patches are excited at –6 dB below the center element.

The second step of the preliminary design study verified the overall antenna pattern performance by using the hexagonal patch array feed to illuminate a 12-m diameter offset parabolic reflector. (The design is not limited by the size of reflector as long as the ratio of reflector focal length to diameter remains the same.) This simulation study again was performed for a one-layer honeycomb design for single frequency operation. A configuration of interest is the use of a seven-feed array for the reflector illumination as shown in Figure 2. The center feed is on the focus of the parabolic reflector, and the other six feeds are off the focus by about 60 cm. This microstrip feed array is compact with a width of about 1.8 m, which could fit inside the Taurus launch vehicle shroud. The location of patch-array feeds at the seven feed locations would be similar to those for the feedhorns. The seven-feed array provides seven beams that can be oriented in such a manner that they provide a seven-fold increase in swath width compared to a single beam antenna.

III. SINGLE-ELEMENT DESIGN

The detailed layout of the single element stacked-patch is shown in Fig. 3. Three Copper/Kapton layers will be bonded to the Astro-Quartz layers to function as the upper patch, lower patch and ground plane. The Copper/Kapton/Astro-Quartz layers and the Korex honeycomb layers will be drilled to allow attachment of the feed wires to the lower patch (radar) and the upper patch (radiometer). The lower patch will be fed through the ground plane, while the feed conductor for the upper patch will be brought through the center of the stacked patch and bent to feed the upper layer from the top. The layout illustrates the operation of single polarization. For dual-polarization operation, another pair of coax conductors will be installed.

ACKNOWLEDGMENT

The research carried out in this paper is performed by the Jet Propulsion Laboratory under a contract with the National Aeronautics and Space Administration.

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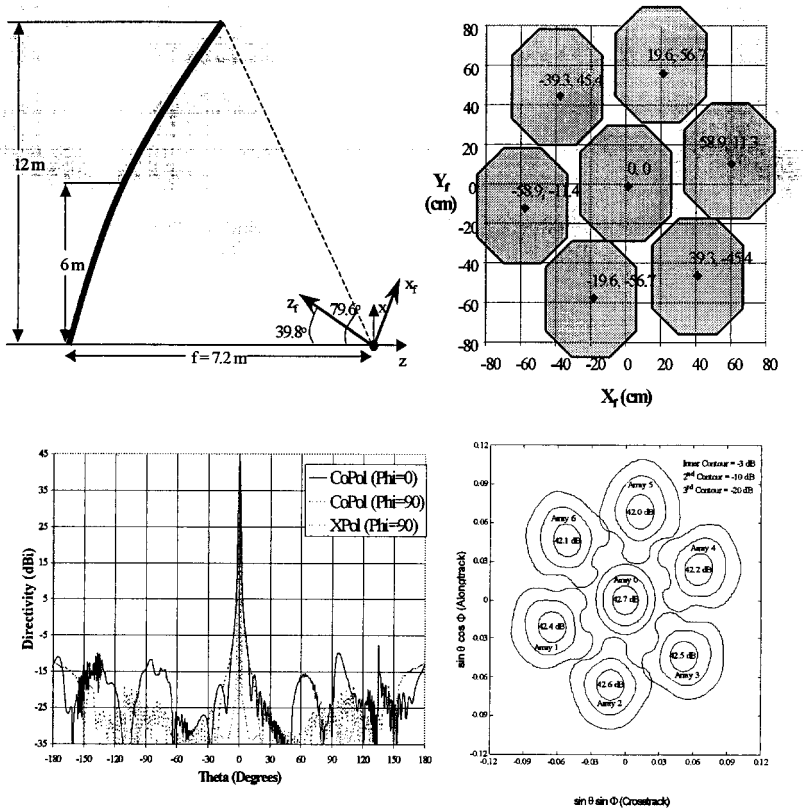

Figure 2. Antenna pattern analysis of a 12-m offset parabolic antenna with seven patch array feeds. Upper left panel: Vertical cross section of the parabolic reflector and feed geometry. Upper right panel: Geometry of the 7-feed array with each point representing the center of one feed. Lower left panel: Far field pattern for feed on focus. Lower right panel: Far field contour pattern for seven hexagonal array feeds.

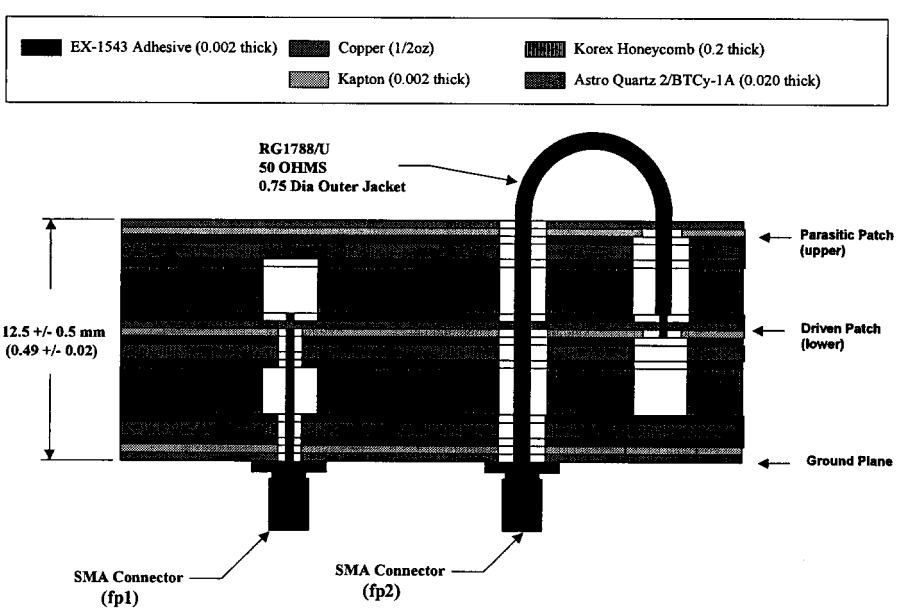

Figure 3. Detailed layout of the stacked-patch element.