Design and Analysis of a Novel Probe-feeding method for Stacked Microstrip Patch Antennas

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1. Introduction

In many wireless applications and other vehicular communications, it is desirable to use microstrip patch antennas that are small in size and have dual-frequency mode of operation. The solution is to have a broadband antenna covering the frequency range of interest, or to provide independent antennas with a shared aperture. Dual frequency stacked patches can also be used as feed arrays for reflector antennas. In [1,2,3,4] the authors discuss various methods for obtaining the dual frequency characteristics, such as placing shorting pins for separating the two frequency bands, or by simply stacking the patches together, or using genetic algorithms to design dual-frequency patches. Stacked patch antennas can have separate feeds for each frequency and polarization, or may use a single feed to obtain dual frequency and dual polarization. A novel type of feed mechanism for stacked patches is addressed in the present design. To test the concept, L-band frequencies were chosen – 1.575GHz for the upper patch and 1.228GHz for the lower patch as in Ref [5]. The Finite Difference Time Domain (FDTD) code developed at UCLA was employed to analyze the patch, due to its flexibility and ability to model heterogeneous and complex geometries. Unique features and applications of the code can be found in Ref [6]. In this paper, we present details of our design for stacked patch using the center-feeding method, results from computational analysis and measurement. Finally, a potential application of the concept for dual-polarization and array configurations is investigated.

2. Stacked Patch Antenna Design and Analysis with Center-feeding

Fig. 1 shows a side-view of the center- fed stacked microstrip antenna configuration. The stacked patch has been designed to cover the two GPS bands. In this configuration, two square patch elements with dielectric constant ε_r=2.2 and equal substrate heights of h = 3mm each were used. The ground plane was 12cm x 12cm. The dimensions of the lower patch were $L_1 = W_1$ = 7.94cm, to obtain a resonant frequency of 1.228GHz. The upper patch dimensions were $L_2 = W_2$ = 6.13 cm, for a resonant frequency of 1.575GHz. The upper and the lower patches have their centers along a common axis. Probe feeding is used for both patches and the feed points are selected for a 50Ω impedance match. The feeds for the patches were small diameter coaxial cables. The lower patch was fed in the usual manner, from below. To feed the upper patch the coax probe is extended through a hole in the center of the ground plane and the lower patch and is fed from above forming a small loop from the center to the 50Ω feed point on the upper patch. A hole at the center of the lower patch is used because the field-null at the center does not perturb the fields between the patch and ground plane and the upper and lower patches. The substrate for the upper patch extends considerably beyond the patch edge (>2h), to account for the

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fringing fields. The outer conductor of the co-ax is soldered to the upper patch and the inner conductor extends to the lower patch.

Figs. 2a and 2b show pictures of the stacked patch built in the lab at UCLA. The return-loss and isolation between the ports were simulated using FDTD. The grid for the stacked patch used in the FDTD code is shown in Fig. 2c. The S_{11} simulation results are shown in Fig. 3a. The individual feeds matched to a return-loss of less than -10dB, and isolation between the ports was -24dB. The stacked configuration was built, and measurements for return-loss and radiation pattern were performed. Fig 3b shows the return-loss for the stacked patch. The solid lines in the plot are the S_{11} measured on a network analyzer when fed at the upper and lower patch. The dotted lines show the results, when the lower patch is measured with the upper patch present and when the upper patch is measured in the presence of the lower patch. It is seen that there is a better match for the upper patch in presence of a larger ground plane. Fig. 4a shows the simulated radiation pattern in both planes and Fig. 4b shows the measured radiation pattern. The measurements and simulations were done at the frequency that has the best match. The cross-polarization was slightly higher in measured results due to an asymmetry in structure while fabrication.

3. Implementation of center-feeding to array configurations

To extend the design to dual polarization applications, and to incorporate in an array configuration, various numerical studies were performed on feeding the patch from above by bringing the probes from the side. Fig. 5a shows a stacked array configuration with two upper patches at same resonant frequency, a lower patch and ground plane. The resonant frequencies are far apart so that the lower patch serves as a ground plane for the upper patches. Two coaxial probes are brought from the center of the ground plane and lower patch to feed the upper patches. The lower patch is fed in the usual manner. For obtaining dual-polarization, four coax probes can be used for the upper patch and two coax probes for the lower patch. Figs. 5b and 5c show the front-view and side-view of a dual frequency, dual polarization stacked patch array fabricated at UCLA.

4. Conclusion

A patch antenna is an excellent choice for wireless, vehicular and other advanced communication applications. The central-feeding scheme described in this paper is a useful antenna arrangement to obtain two band responses where space is a constraint, with good isolation between the two bands. Good impedance matching of less than -10dB were obtained at the two frequencies with no large pattern-imbalance. This new method of feeding has a potential advantage for use in communication receivers, in feed arrays for illuminating reflectors, and in communication vehicles for remote sensing applications. It was also determined that with a variation in the feeding method, dual-polarization and array configurations can be incorporated.

References

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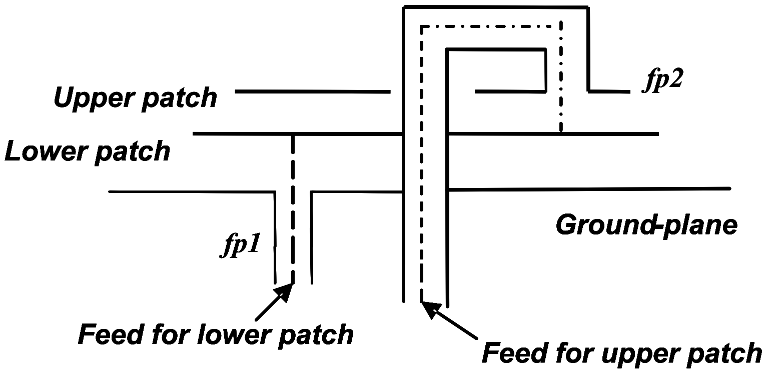
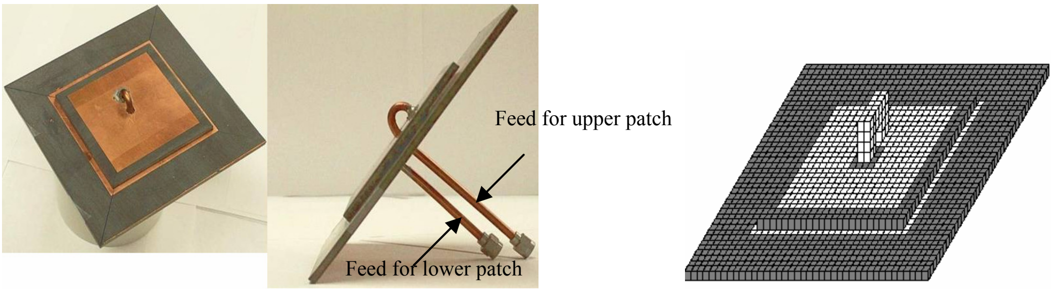
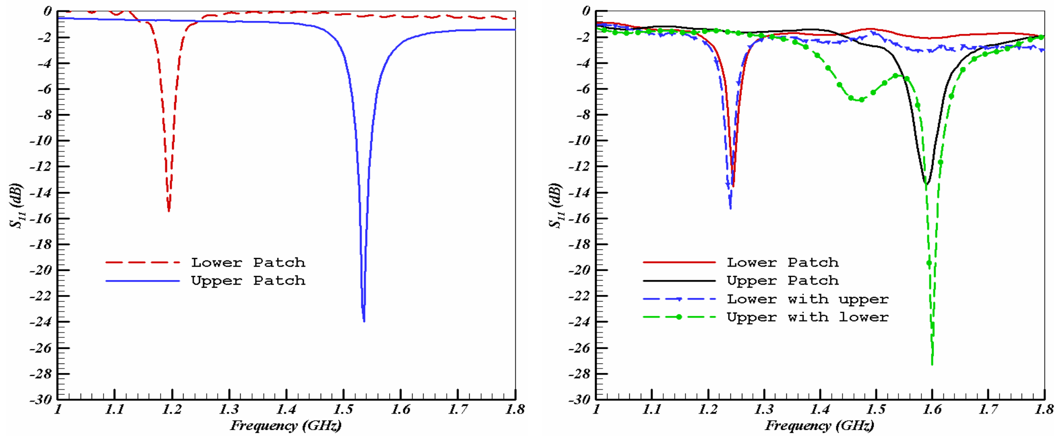


Fig. 1. Side-view of stacked patch antenna showing the feeding positions (fp1, fp2) for the lower and upper patches.



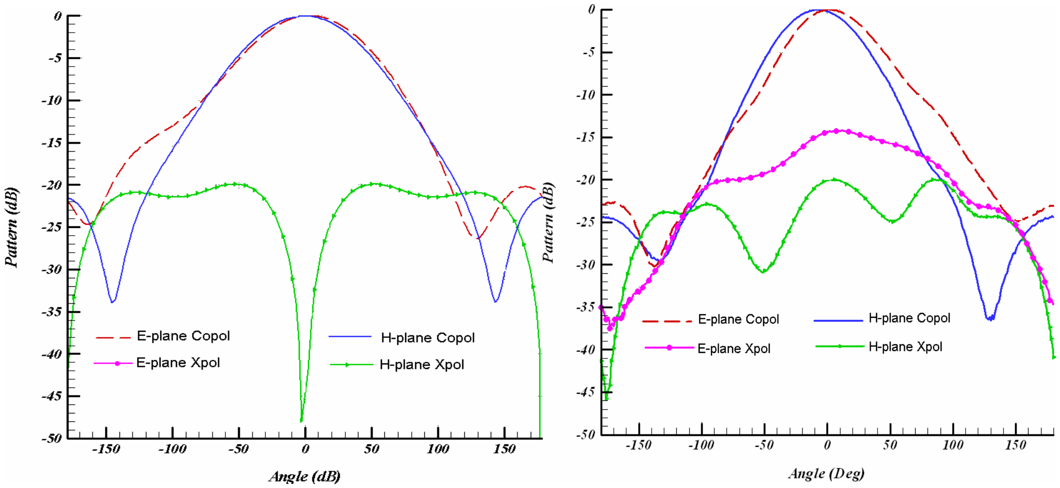
(a) (b) (c)

Fig. 2. (a) Top-view of stacked patch antenna built in the lab at UCLA. (b) Side-view of the stacked patch antenna. (c) Grid for the stacked patch used in FDTD simulation.



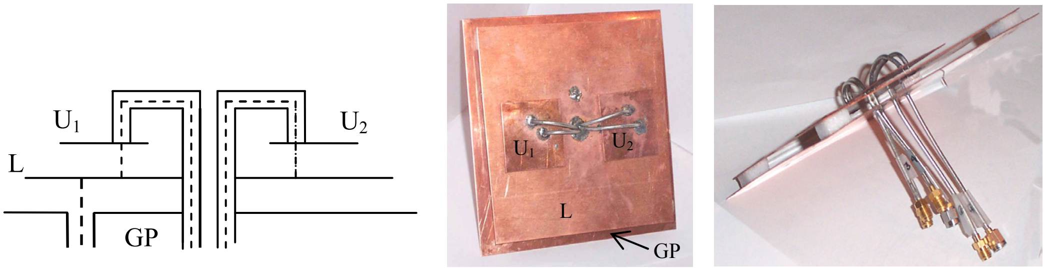
(a) (b)

Fig. 3. (a) S_{11} simulation results for stacked patch. (b) S_{11} measurement results for the stacked patch.



(a) (b)

Fig. 4. (a) Radiation pattern simulation results for stacked patch. (b) Radiation pattern measurement results for stacked patch.



(a) (b) (c)

Fig. 5. (a) Array implementation of the center-feeding stacked patch. (U_1, U_2 are upper patches, L is the lower patch and GP is the ground plane). (b) Front-view of the stacked patch array.
(c) Side-view of the stacked patch array. (six coax cables are shown, four for upper two patches and two for lower patch for dual-frequency and dual-polarization).