FACTA UNIVERSITATIS
Series: **Mechanics, Automatic Control and Robotics** Vol.3, N° 15, 2003, pp. 1121 - 1125

STUDIES OF FIELD COUPLING BETWEEN STACKED MICROSTRIP PATCH RESONATORS AND DESIGN OF BROADBAND RADIATORS

UDC 621.372.4

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Abstract. *Electromagnetic field coupling between the coax-fed inverted microstrip stacked patch resonators has been thoroughly examined for various dimensional parameters. Possibility of using this structure as dual band or broadband radiators are also investigated on the basis of simulation and experimental results.*

INTRODUCTION

Stacked microstrip patches with different feeding mechanisms have been investigated for multiple resonating bands or broadband applications [1-3]. Inverted microstrip geometry with circular patch finds a number of applications in active antenna design [4-7] and as such, stacked inverted microstrip circular patches should be an attractive candidate in its broadband uses. In this paper, we have studied an inverted microstrip dual element geometry fed by coaxial probe to examine the field sharing between the dual resonators and the suitability of the structure in obtaining wide impedance bandwidth. The electric fields are confined in the air and dielectric media, respectively, as shown in Fig. 1. The primary patch is excited by a coaxial probe. Our investigations are based on the simulation results obtained with Ansoft-HFSS and experimental studies on a few prototype structures on HP 8722 Network Analyzer.

DESIGN AND RESULTS

The sharing of electric fields in the magnetic wall cavities under the dual resonator is quite interesting. For a set of microstrip and patch dimensions, the fields are found to be

Received April 20, 2003

predominantly coupled with the upper resonator when the feed located near the center of the primary patch with $\rho/a_1 \leq 0.2$. This has been examined from the studies of the simulated return loss curves for different substrate heights (air-gap in Fig. 1) of the lower patch as shown in Fig. 2. With the increase in the air-gap height, the Q factor (revealed from the minimum value of S_{11}) increases and thus it indicates that the resonance obtained in Fig. 2 is due to a patch/resonator other than the lower one. The studies have been confirmed through the investigations in Fig. 2. Here, the dimension of the upper patch has been varied along with the air-gap height, keeping the lower patch unaltered and that significantly affects the resonant frequency. This shows that the resonances observed are due to the upper patch. The excitation of the upper patch with low ρ/a value can be explained as the modified input impedance profile of the composite patch geometry and its matching. The studies in Fig. 3 clarifies the impedance matching as a function of the location of the feeding probe of 50 Ω impedance. As the feed is located away from the center of the lower patch the second resonance grows due to the excitation of the magnetic wall cavity under the lower patch and that becomes significant with $S_{11} < -10$dB as $\rho/a > 0.8$.

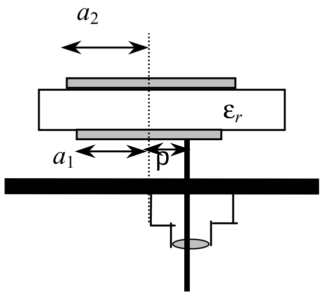
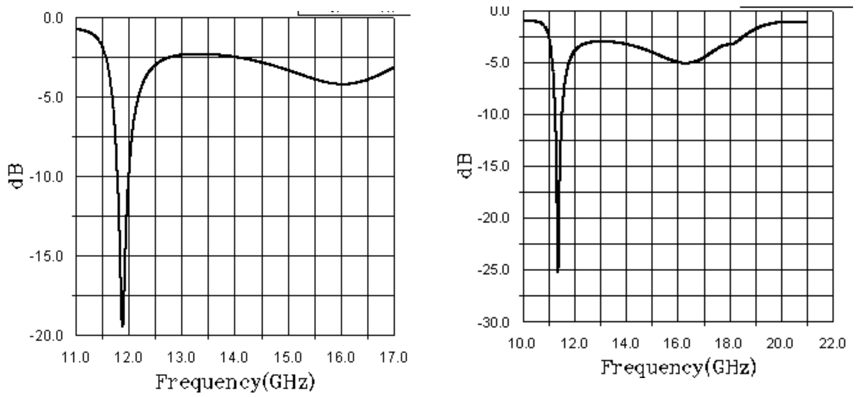
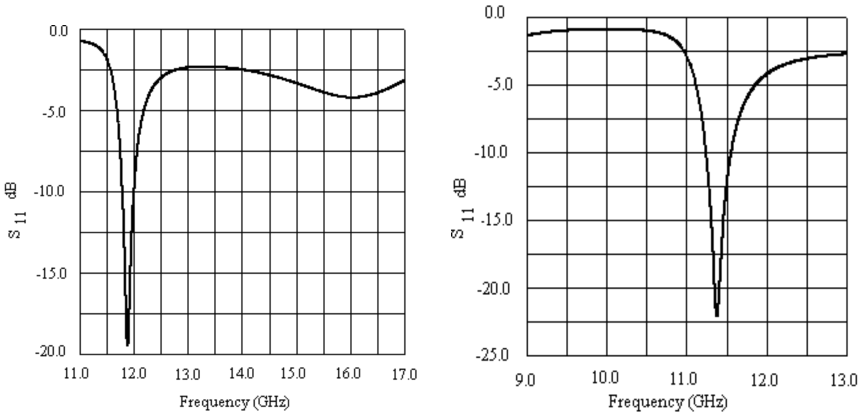


Fig. 1. Coax-fed inverted microstrip stacked patch resonator



(a) (b)

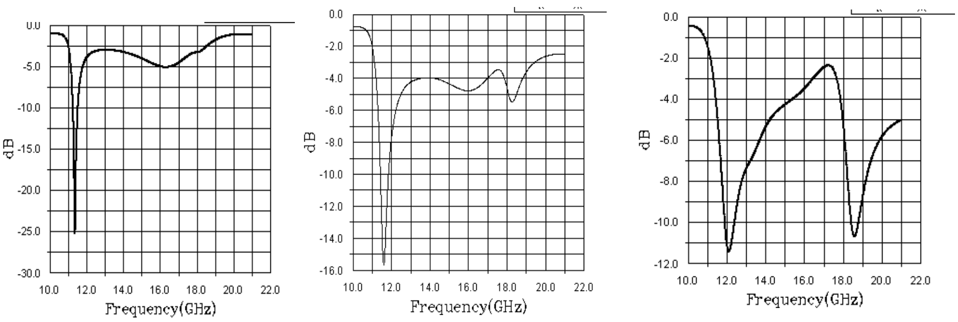
Fig. 2. Simulated Return loss of a concentricstacked microstrip resonator for different air-gap heights. $a_1 = 5.5$, $a_2 = 7.0$ mm, $h_2 = 1.55$ mm, $\rho = 2$ mm, $\varepsilon_r = 2.2$.
(a) $h_1 = 0.5$ mm (b) $h_1 = 1.6$ mm



(a) (b)

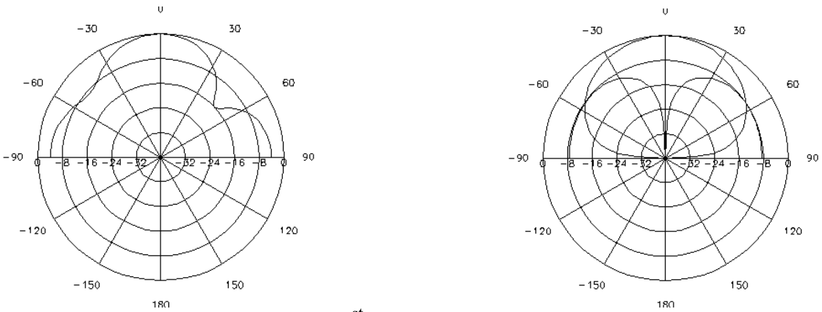
Fig 3. Return loss characteristics. $a_1 = 5.5$, substrate thick = 1.55, ρ = 2
(a) $a_2 = 7$, *air gap* = 1.0 (b) $a_2 = 6$ *air gap* = 1.6 , all dimensions in mm

This basically occurs due to the matching of the input impedance of the coupled resonator, which appears to be a complicated function of the substrate parameters. The resultant mutual coupling results in two or multiple resonances and thus a wider impedance bandwidth. More than 20% bandwidth with $S_{11} < -10$dB has been achieved both theoretically and experimentally by optimizing the parameters of the stacked geometry. The principal plane radiation patterns at dual band operating frequencies of an optimum design of concentric stacked patch radiator (Fig.4c) is shown in Fig. 5. The E-plane patterns are purely co-polar where as the cross-polarization level in H-planes are significantly high at the oblique directions at both the resonating frequencies. However, for mobile communication purpose this is quite acceptable.

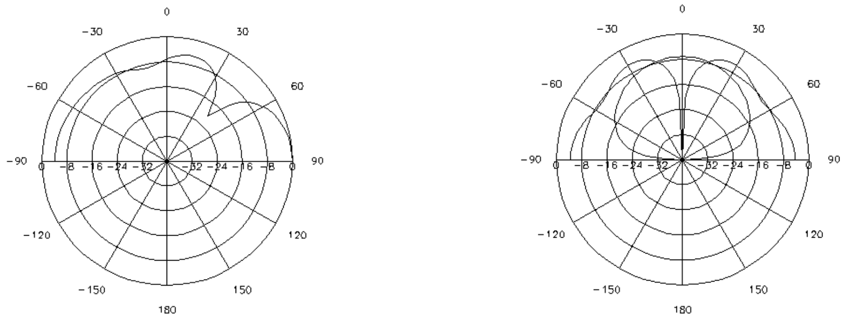


(a) (b) (c)

Fig. 4. Simulated Return loss of a Concentric stacked microstrip resonators for different feed (ρ) locations. $a_1 = 5.5$, $a_2 = 7.0$mm, $h_2 = 1.55$ mm, $h_1 = 1.6$ mm, $\varepsilon_r = 2.2$.
(a) ρ = 2 mm (b) ρ = 3.0 mm (c) ρ = 4.5 mm



1st Resonance



2nd Resonance

E-Plane H-Plane

Fig. 5. Principal plane radiation patterns at dual resonance frequencies as in Fig. 4 (c)

CONCLUSIONS

A stacked patch configuration employing inverted microstrip circular patches is investigated. Proper dimensions of the structure optimized using simulation results show enhanced impedance bandwidth. The significance of proper feeding position is also examined to obtain optimum results.

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STUDIJA ELEKTROMAGNETNE SPREGE IZMEDJU RAZVIJENOG MIKROSTRIP PATCH REZONATORA I ŠIROKOPOJASNIH RADIJATORA

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Posmatrana je elektromagnetna sprega izmedju razvijenog mikrostrip patch rezonatora i invertovanog koaksijalnog napojnog voda i ispitan uticaj geometrijskih veličina. Pomoću simulacije sistema i merenja ispitane su mogućnosti da se ova sprega koristi za napajanje dvokanalnih i širokopojasnih antena.