

Shared Aperture Microstrip Patch Antenna Array for L and S-Bands

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Abstract—A dual mode shared aperture antenna consisting of two planar arrays of ring antennas is designed for L and S bands. The array of larger dimension surrounds the array of smaller dimension. The antennas are isolated from one another and fed separately. The antenna dimensions are optimized and prototyped. The antennas radiate separately in L and S bands with least coupling or no coupling. Measured results are in agreement with the simulations, depicting good performance in terms of impedance bandwidth, isolation, and gain.

1. INTRODUCTION

The development in communication technology leads to the increase in number of components on a compact system, which adds complexity to the system. Due to the constraints of space and weight, it is desired to make system perform the tasks simultaneously by using different techniques, i.e., multifunctionality of the system. The system multifunctionality may be like dual band operations. Dual band or multiple band operations can be achieved by excitation of orthogonal modes [1–4], stacking of patches [5–7], and with suitable slots or notches embedded on the radiating element [8, 9]. In all above techniques, bandwidth is a constraint having an order of 1–2% in individual band. One of the methods uses the same aperture for designing multiple antennas resonating and working independently of one another. These antennas achieve dual band or multi-band operations, which results in better impedance bandwidth without band interference.

In sharing aperture, frequency ratio plays a critical role in designing antenna. Frequency ratio and design of antenna have inverse relation between them, i.e., the lower the frequency ratio is, the easier the design is, and vice-versa. Most of the antenna designs using shared aperture have a frequency ratio less than 1 : 4, and few antenna designs have been reported for frequency ratio 1 : 2. Antennas of adjacent bands have high ratio which is difficult to design due to least difference in dimensions of antenna elements, thus posing the challenges in designing and placing these antenna elements sharing the same aperture.

Different researchers have developed antenna designs for L/C [10, 11], L/X [12], L/S/X [13], and L/S [14] by aperture sharing. Independent dual band or triple band operations are obtained by designing and exciting individual antenna elements for each band and placing the antenna elements in stacked configuration, thus increasing the overall size of antenna. In the present communication, an array antenna is designed for L and S bands using common aperture. One of the antennas shares the vacant space inside the other antenna on the aperture. The designed antenna is composed of a 2×2 array of planar annular rings of smaller and larger radii in shape of C. The array of larger rings surrounds the array of smaller rings. The optimized design is prototyped and tested for L and S bands.

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2. ANTENNA DESIGN

The prototype of proposed antenna is shown in Fig. 1. The antenna is printed on a glass epoxy (FR-4) substrate of height 1.6 mm, relative permittivity 4.3, and loss tangent 0.025. Following [15–18], the antenna structure was designed for simulation. The final dimensions of the proposed antenna were obtained by optimizations with the parameters for the best results. The annular ring with a larger radius is designed for S-band (2–4 GHz), while the annular ring with a smaller radius is designed for L-band (1–2 GHz). The annular ring patch antenna with a larger radius has radii $R1$ (12 mm) and $r1$ (5 mm). The four rings are placed symmetrically separated by a distance 20 mm apart from their centers and are connected to each other by a microstrip line of length 18 mm and width 4 mm, leaving one side open.

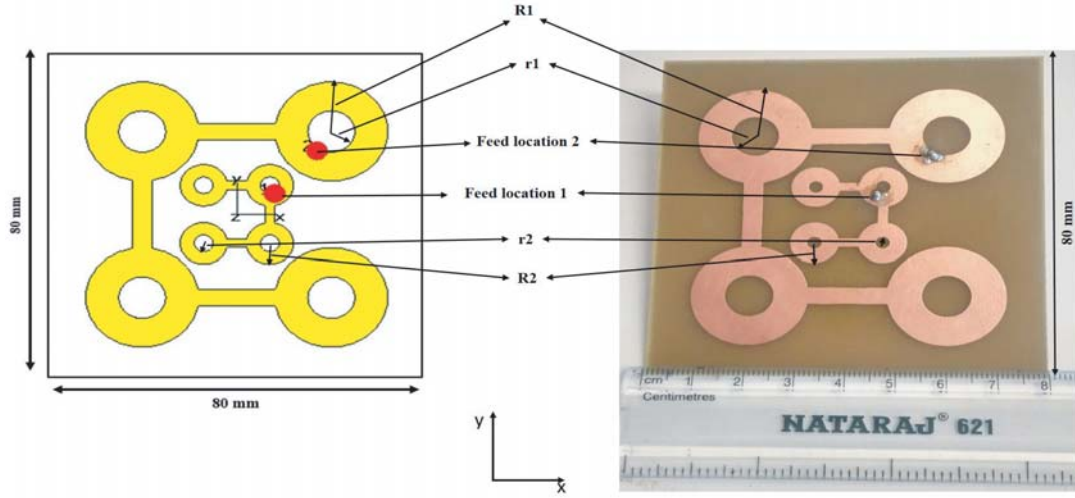


Figure 1. Layout of simulated and fabricated antenna.

The second antenna is again an annular ring patch antenna having radii of ring $R2$ (5 mm) and $r2$ (1 mm), respectively. The rings of the inner antenna are separated by a distance of 7 mm apart from their centers and are interconnected with microstrip line of length 5 mm and width 2 mm with one side open. The antenna for S-band engulfs the antenna for L-band, and they share the common aperture. The separation of different elements and feed point location was optimized to obtain the best possible result. On the basis of the results, a prototype of the antenna was fabricated and tested for different parameters.

3. RESULT AND DISCUSSION

The simulated and measured results of the antenna are shown in Fig. 2–Fig. 5. The scattering parameters of the antennas are shown in Fig. 2 with resonant frequencies of 1.25 GHz and 3.14 GHz for simulated data and 1.37 GHz and 3.06 GHz for measured data. The bandwidth of 28.5% is obtained in L band with measured resonant frequency 1.37 GHz. For S band, about 6.9% bandwidth is obtained with resonant frequency 3.06 GHz. The shift in the resonant frequencies between simulated and measured results is very low and may be due to fabrication or limitations in simulations. The antenna structures are independent of one another with no cross talk, and the same is represented by the isolation which is better than 20 dB and is shown in Fig. 3. It is also observed that measured radiation patterns for L and S bands are in good agreement with simulated radiation pattern as shown in Fig. 4 and Fig. 5 with realized gains about 5 dBi and 7.16 dBi for L and S band operations.

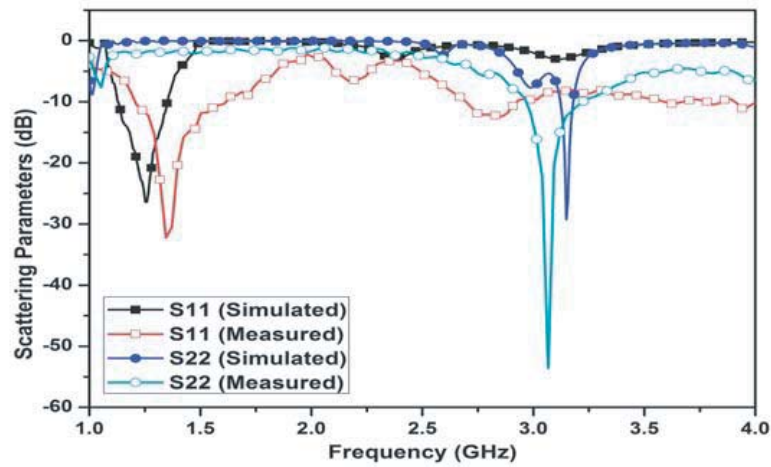


Figure 2. Scattering parameters of the antenna.

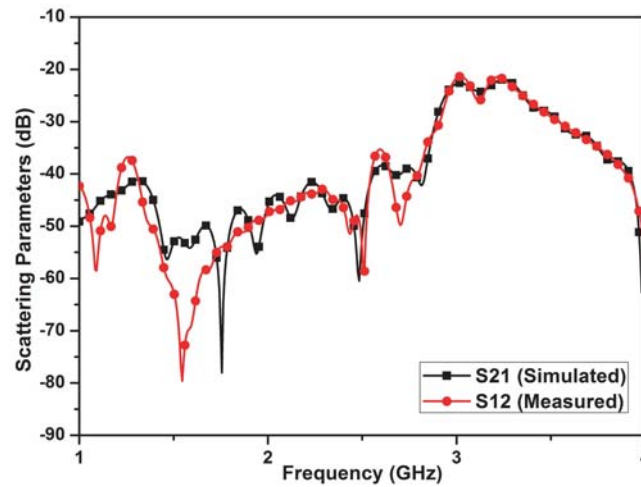


Figure 3. Isolation between patch antennas.

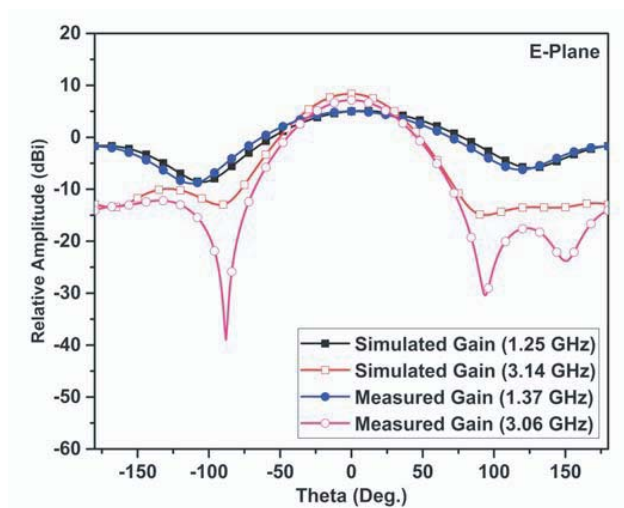


Figure 4. Far-field plot for E -plane.

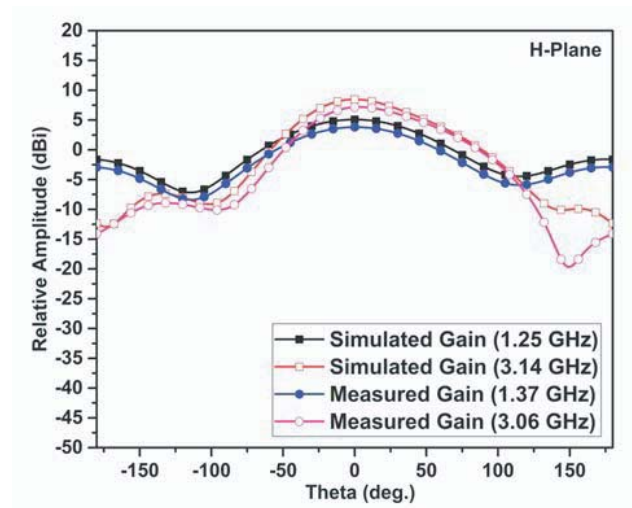


Figure 5. Far-field plot for H -plane.

4. CONCLUSION

The design of a shared aperture antenna array for L and S bands printed on an FR4 based printed circuit board (PCB) has been presented. The designed antenna is light weight, simple in shape, cost effective and integrable with communication systems. The simulated and experimental results are presented and in good agreement. The proposed antenna can be used in surveillance radio, radar, synthetic aperture radar (SAR), global positioning system (GPS), and mobile communication.

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