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Design and Development of Triple Frequency Compact Microstrip Patch Antenna Array for Wireless Application

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Abstract: Microstrip patch antenna arrays are very popular in present wireless communication system, especially when the signal propagates through different fading environment. It is very important to design compact communication tool to fulfill multi-purpose demands of communication world. In this paper, a double layered 2-element, slotted patch antenna array structure is proposed. It is designed to function in 1.8GHz, 2.45GHz and 3.0GHz bands. This is achieved by using additional slots to the lower rectangular patch of dimension 6.8cm by 5.5cm and upper patch of dimension 4.8 cm by 4.0 cm. The proposed antenna array is high gain, low-cost, low weight base station (BS) antenna, applicable to personal communication system (PCS) and wireless LAN. The characteristics analyses of the array have been investigated numerically by using IE3Delectromagnetic simulator (Zeland) and the measurements have been carried out with the help N5230A network analyzer (Agilent make). A parametric study has been conducted to optimize the performances at different frequencies. The EM-simulated return loss < -18dB, antenna gain > 10.33dBi, band width (B.W) >90 MHz and VSWR <1.35 have been achieved for the designed frequencies.

Keywords: Slotted microstrip patch, Double-layered antenna array. IE3D EM simulator, Antenna gain, Isolation of array elements, WLAN band..

1. INTRODUCTION

The array antenna structure is very contemporary and an interesting study which is widely applied to increase the range and reliability [1]-[3] of Wi-Fi LAN, Bluetooth ,PDA, DCS (Digital Communication System) [4], mostly in the field of mobile communication. In an array structure where multiple frequencies are transmitted or received, the antenna requires to be compact. Also there are different applications in the real communication world in which a number of various services are needed to be performed by the same antenna. Instead of installing large number of printed antenna elements in a single substrate, using less number of antenna elements and each is advantageous more than one frequency [5]-[6]. Also due to the increasing demand for higher band width and directive gain of the printed antenna, it is important to study various array structures. Few works in microstrip etch antenna system [7]-[10] are reported in this line devoted to multi-frequency operation of antenna arrays. They are mostly based on single-layer system. This design incorporates two rectangular patches printed on two stacked substrates separated by an air-gap as shown in Figure 1. The upper patch resonates at the frequency of 1.8 GHz and the lower slotted patch resonates at the frequencies of 2.45 GHz and 3.0GHz.To ensure a large ground plane for the upper patch, its dimension has been carefully chosen much less than the lower patch. The width and length of the microstrip patch have been calculated by the standard formulae [11] and the dimension of the transmission lines are calculated based on transmission line model [12].

2. ARRAY DESIGN

In the proposed design, same substrate for both layers with dielectric constant of 2.2 and thickness of 1.588 mm has been taken. For the design of centre frequencies of1.80 GHz, 2.45 GHz and 3.0 GHz the dimensions of the patch are found as L = 5.5 cm, W = 6.8cm for lower patch and L1 = 4.0 cm, W1 = 4.8cm for upper patch. The slots of (2.0x0.2) sq.cm and the other two slots of (2.0x0.5) sq.cm each are taken for this design. The distance between two elements has been maintained by7.5cm for minimum mutual coupling between the antenna elements.

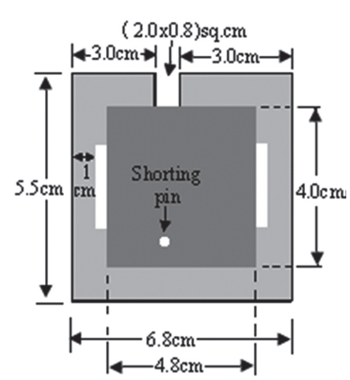

Figure 1: Sketch of Two-layered Microstrip Patch Antenna

The geometry of the array is illustrated in the Figure 2 and the prototype of the same is shown in the Figure 3.

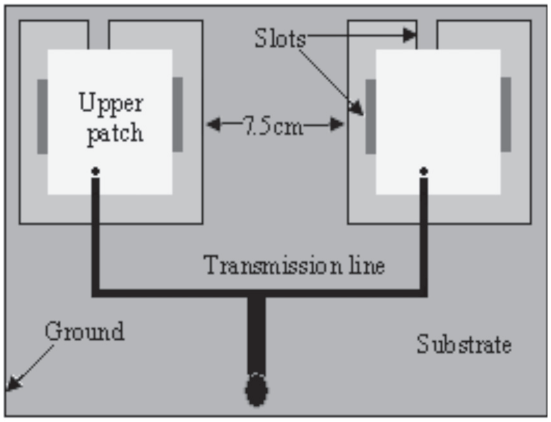

Figure 2: Array of Double Layered Patch Antenna with Feed Point

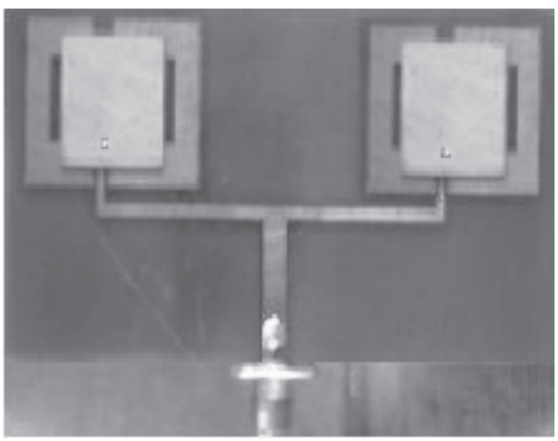

Figure 3: Photograph of Prototype of the Array Structure

3. SIMULATED RESULTS

3.1. Return Loss

The transmission line feed is very important in designing multilayer antenna. A trial and error method has been used to locate the approximate feed point for optimizing the characteristics of the designed antenna. The feed point with respect to the center of the patch was varied and point was located where the minimum return loss (RL) were observed for the design frequencies and the exact location is shown in the Figure 2. Using this array, RL for three frequencies of1.8GHz, 2.45GHz and 3.0GHz are -24.5dB, -22.0dB irrespectively were obtained. These are the maximum negative return losses from the above investigations. If the feed point is changed, there is a little change in the center frequency but the return loss changes noticeably. The graphical plot of return loss for the proposed antennas is shown in Figure 4.

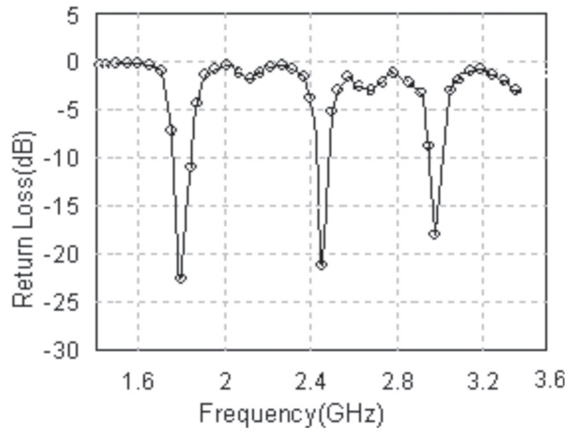

Figure 4: Simulated Results of RL of the Proposed Antenna

The bandwidths of the antenna array obtained from the simulation are illustrated in the Table 1.

Table 1

No.	*Center Frequency (GHz)*	*Return Loss (RL) (dB)*	*Bandwidth (MHz) RL > -9.5 db*
1.	1.80	-24.5	96.450
2.	2.45	-22.0	88.750
3.	3.00	-18.5	85.050

3.2. Radiation Pattern

The microstrip patch antenna radiates normal to the patch surface. It is important to study the elevation pattern for $\phi = 0$ and $\phi = 90$ degrees. The radiation patterns of E-plane and H-plane for design frequencies are shown in Figure 5, Figure 6 and Figure 7 respectably.

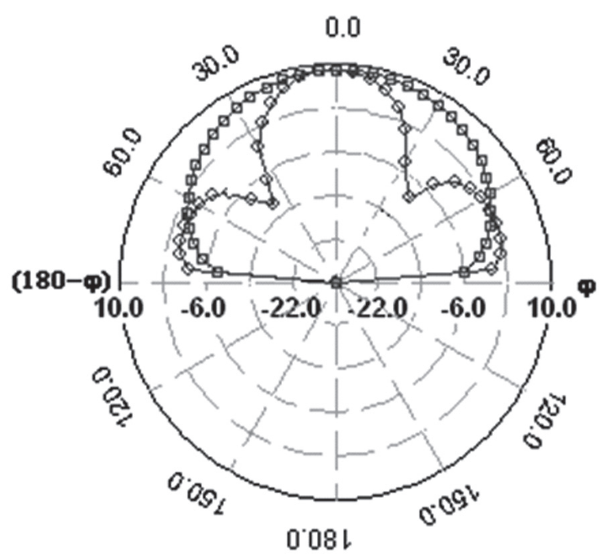

Figure 5: E-plane and H-plane Pattern at 1.80 GHz

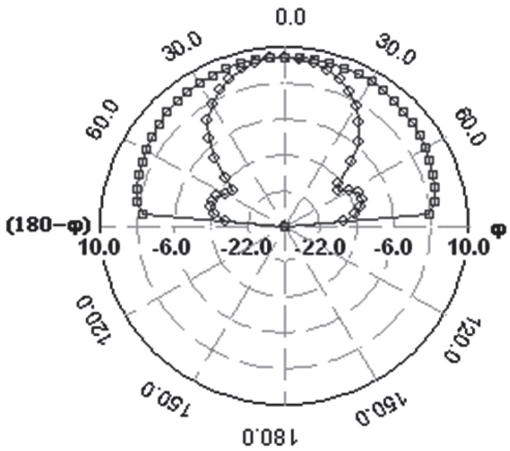

Figure 6: E-plane and H-plane Pattern at 2.45 GHz

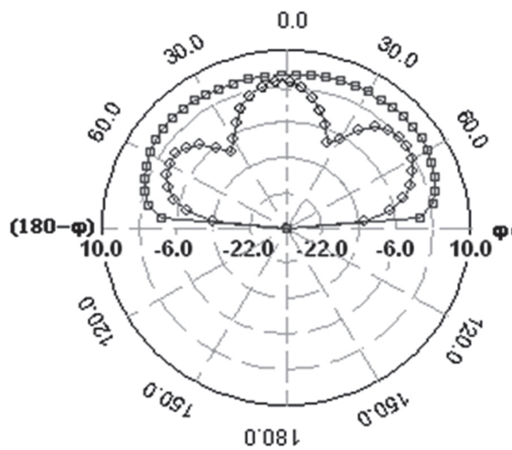

Figure 7: E-plane and H-plane Pattern at 3.0 GHz

The peak gain at frequencies 1.8 GHz, 2.45 GHz and 3.0 GHz are obtained as 9.5 dBi, 7.35 dBi and 6.43dB respectively. The VSWR shown in the Figure 8 for the corresponding frequencies are obtained irrespectively. Figure 9 shows the radiation efficiency and S-parameters are plotted in the Figure 10.

3.3. VSWR and Other Characteristics

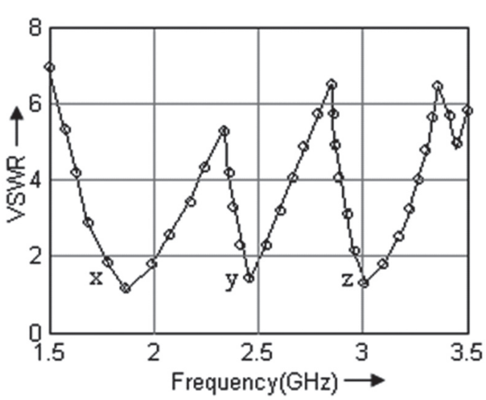

Figure 8: VSWR for Designed Frequencies of the Antenna

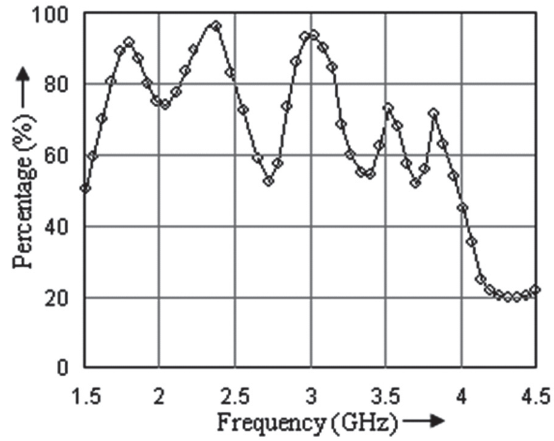

Figure 9: Radiation Efficiency for Designed Frequencies

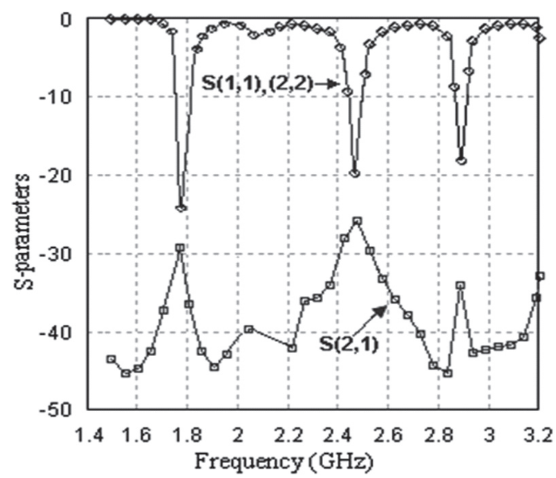

Figure 10: Simulated Results of S-parameters for the Proposed Array

3.4. Measured RL and VSWR

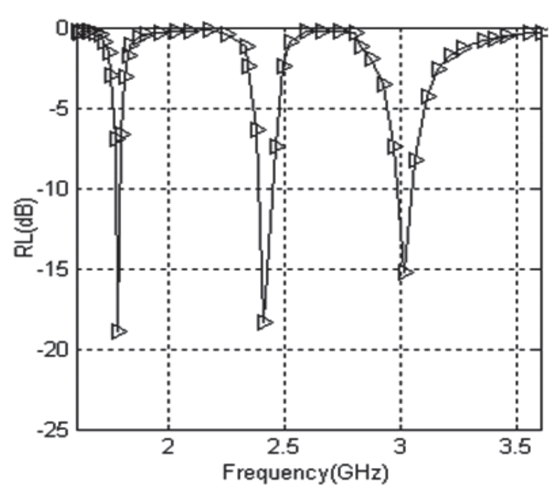

Figure 11: Measured Results of RL Characteristics of the Prototype Antenna at Three Different Frequencies

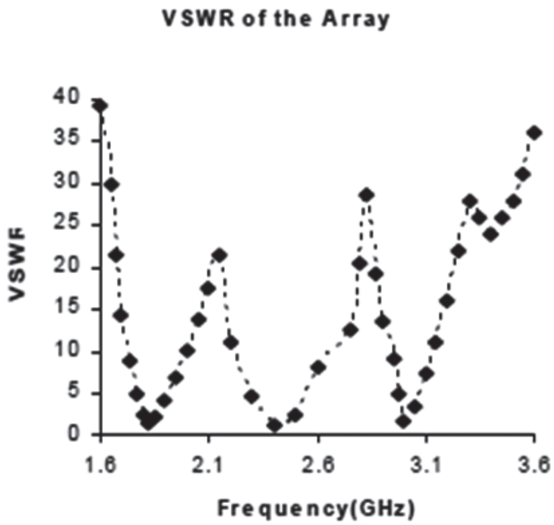

Figure 12: Measured Results of VSWR of the Prototype Antenna at Three Different Frequencies

4. CONCLUSION

A triple-band compact microstrip antenna structure for wireless communication has been investigated. The proposed structure operates in three different frequencies of 1.80 GHz, 2.45 GHz and 3.0 GHz. The radiation efficiency of the model for all three resonant frequencies is above 90%. From the simulated results, it is observed that the peak gain of the antenna decreases at higher frequencies. The lowest value of VSWR for the designed frequencies is ≤1.40 for all cases. The proposed antenna array increases the directive gain and also counteracts the channel fading due to multi-path propagation. Also this antenna system may be found suitable as base station antenna of WLAN and PDA terminals.

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