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Design and Development of L Slotted, Monopole Notch Band Rectangular Microstrip Antenna

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Abstract: A novel design of L slotted monopole rectangular microstrip antenna is proposed for multi band operation and ominidirectional radiation characteristics. The proposed antenna has been constructed from conventional rectangular microstrip antenna by placing L slots on the patch. A ground plane of height equal to the length of microstripline is placed on the top of the patch with a gap of 1 mm on either sides of the microstrip line. It is found that retaining the fundamental resonant mode all the secondary bands merges into a single band by varying the horizontal length of L slot on the patch. The antenna operates from 4.75 GHz to 15.8 GHz with a notch band from 4.94 GHz to 7.07 GHz. Experimental results are in close agreement with the simulated results. The proposed antenna may find application in microwave communication systems.

Keywords: Microstip antenna, monopole, slot, ominidirectional

1. INTRODUCTION

Microstrip antennas (MSAs) are very popular because of their attractive features such as low profile, light weight, compact, planar configuration, low cost and easy to fabricate. These features makes the antenna more useful for many microwave communication applications. Dual or multiband compact in size monopole ominidirectional radiation pattern antennas have become very attractive in many modern microwave communications systems. Number of investigations have been reported in the literature for the realization of monopole rectangular microstrip antenna [3-9]. Most of the monopole antennas presented in the literature are either complex in antenna structure or bigger in antenna size for practical applications. But in this paper a simple technique has demonstrated to construct the monopole antenna. By varying the horizontal length of L slot placed on the patch, a notch band property is found without affecting the monopole characteristics of the antenna.

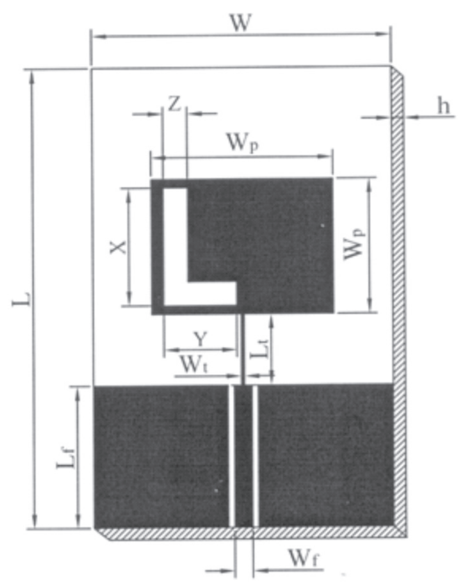

Figure 1: **Top View Geometry of LSMRMA**

2. DESIGN OF ANTENNA GEOMETRY

The art work of the proposed antenna is sketched by using computer software Auto-CAD to achieve better accuracy and is fabricated on low cost FR4-epoxy substrate material of thickness of h = 1.6 mm and permittivity $\varepsilon_r = 4.4$.

Figure 1 shows the top view geometry of L slotted monopole rectangular microstrip antenna (LSMRMA). In this figure the selected area of the substrate is L × W cm. On the top surface of the substrate a ground plane of height which is equal to the length of microstripline feed L_f is used on either sides of the microstripline with a gap of 1 mm between the ground plane and microstripline feed. On the bottom of the substrate a continuous ground copper layer of height L_f is used below the microstripline. The LSMRMA is designed for 3 GHz using the equations available for the design of conventional rectangular microstrip antenna in the literature [2]. The length and width of the rectangular patch are L_p and W_p respectively. The feed arrangement consists of quarter wave transformer of length L_t and width W_t which is connected as a matching network between the patch and the microstripline feed of length L_f and width W_f. A semi miniature-A (SMA) connector is used at the tip of the microstripline feed for feeding the microwave power.

In Figure 1 the L slot is placed on the patch from one side of its vertical edge W_p for providing different surface current paths so as to produce multi resonant modes. The vertical length, horizontal length and width of L slot are X, Y and Z respectively. The L slot is kept at a distance of 2 mm from the vertical edge W_p of the radiating patch. The horizontal length Y of L slot is varied from 8.1 to 7.1 mm keeping X and Z constant. The design parameter of the proposed antenna is given in Table 1.

Table 1
Design Parameters of Proposed Antennas

Antenna Parameters	*Dimension in mm*
L_p	23.4
W_p	30.4
L_f	24.8
W_f	3.0
L_t	12.4
W_t	0.5
L	80.0
W	50.0
X	2.04
Y	8.1
Z	4.1

3. EXPERIMENTAL RESULTS

The antenna bandwidth over return loss less than -10 dB is simulated using HFSS simulating software and then tested experimentally on Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The variation of return loss verses frequency of LSMRMA when Y = 8.1 mm is as shown in Figure 2. From this graph the experimental bandwidth (BW) is calculated using the equations,

$$BW = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\ \%$$

were, f_1 and f_2 are the lower and upper cut of frequencies of the band respectively when its return loss reaches – 10 dB and f_c is the center frequency of the operating band. From this figure, it is found that the antenna operates between 4.75 to 16 GHz and gives four resonant modes.

The resonant mode at 4.81 GHz is due to the fundamental resonant frequency of the patch and others modes at 7.37, 8.74 and 14.01 GHz are due to the novel geometry of LSMRMA.The fundamental resonant mode frequency shifts from the designed frequency of 3 GHz to 4.81 GHz due to the coupling effect of microstripline feed and top ground plane of LSMRMA The magnitude of experimental -10 dB bandwidth measured for BW_1 to BW_4 are found to be 130 MHz (2.69 %), 560 MHz (7.69 %),

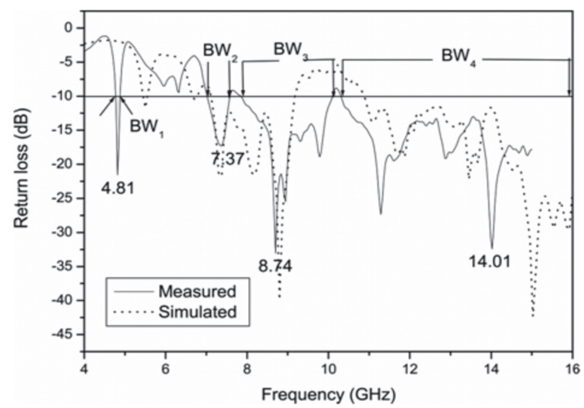

Figure 2: Variation of Return Loss versus Frequency of LSMRMA when Y = 8.1 mm

2.26 GHz (25.25 %) and 5.72 GHz (43.53 %) respectively. The variation of return loss verses frequency of LSMRMA when Y = 7.6 mm is as shown in Fig. 3. It is seen that the antenna operates for triple bands. The magnitude of these operating bands measured at BW_5 to BW_7 are found to be 200 MHz (4.07 %), 430 MHz (6.92 %), and 8.9 GHz (77.05 %) respectively.

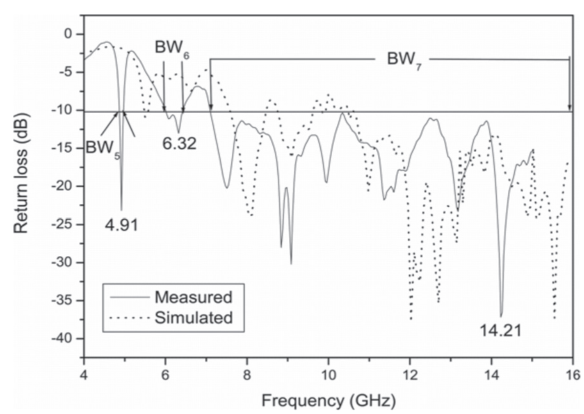

Figure 3: Variation of Return Loss Versus Frequency of LSMRMA when Y = 7.6 mm

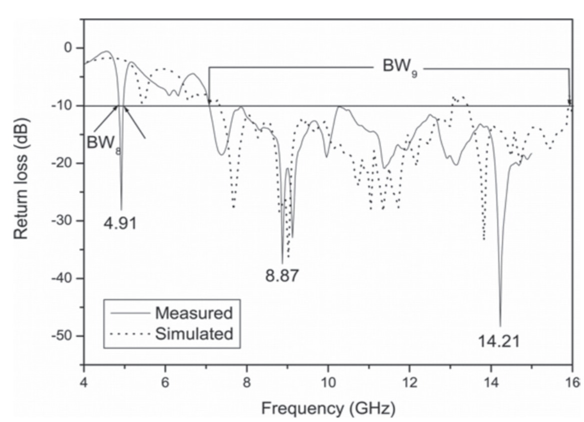

Figure 4: Variation of Return Loss Versus Frequency of LSMRMA when Y = 7.1 mm

The variation of return loss verses frequency of LSMRMA when Y = 7.1 mm is as shown in Figure 4. Form this figure it is clear that, the antenna operates for two bands BW_8 and BW_9. The two bands BW_6 and BW_7 shown in Figure 3 merges into a single band BW_9 as shown in Figure 4. The magnitude of each operating band BW_8 and BW_9 are found to be 130 MHz (2.66%) and 8.93 GHz (77.41%) respectively. Further it is clear from Figure 4 that, a notch band appears from 4.94 GHz to 7.07 GHz between the bands BW_8 and BW_9. However the fundamental resonant mode of BW_8 remains unchanged when compared to fundamental resonant mode frequency of BW_5 shown in Figure 3 inspite of merging of two bands BW_6 and BW_7 in to a single band BW_9. Further the fundamental resonant frequency mode 4.91 GHz shown in Figure 3 and 4 shifts towards upper frequency side when compared to fundamental resonant frequency mode 4.81 GHz shown in Figure 2 due to variation of Y in L slot. The simulated results of LSMRMA is also shown in Figure 3 and 4. The experimental and simulated results are in close agreement with each other.

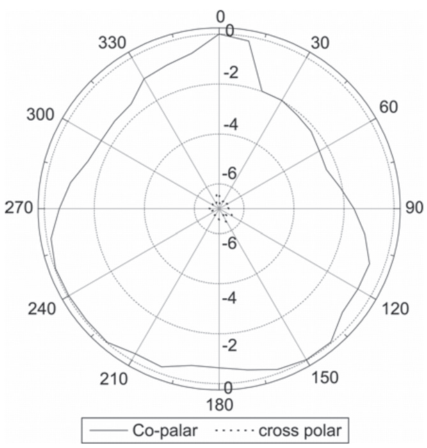

Figure 5: **Radiation Pattern of LSMRMA with Y = 7.1 mm Measured at 4.91 GHz**

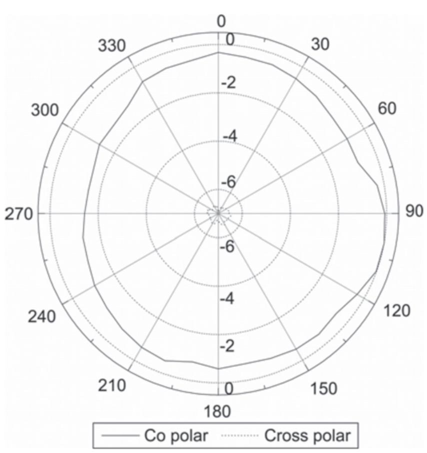

Figure 6: **Radiation Pattern LSMRM with Y= 7.1 mm Measured at 8.87 GHz**

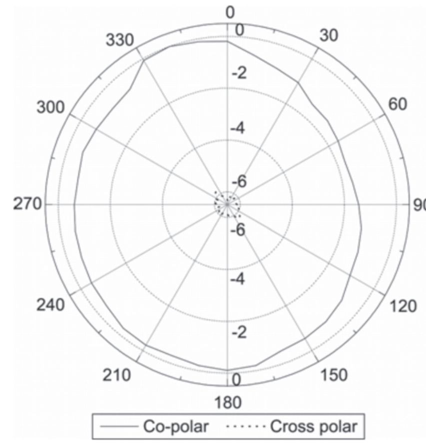

Figure 7: **Radiation pattern of LSMRMA with Y= 7.1 mm measured at 13.14GHz**

The co-polar and cross-polar radiation pattern of LSMRMA when Y = 7.1 mm is measured in its operating bands. The typical radiation patterns of LSMRMA measured at 4.91 GHz, 8.87 GHz and 13. 14 GHz are shown in Figure 5 to 7 respectively. The obtained patterns are ominidirectional in nature.

The gain of the proposed antenna is measured by absolute gain method [1] using formula

$$(G)dB = 10\ \log\left(\frac{P_r}{P_t}\right) - (G_t)dB\ -\ 20\log\left(\frac{\lambda_0}{4\pi R}\right)dB$$

where, P_t is the power transmitted by pyramidal horn antenna, P_r the power received by antenna under test (AUT), G_t the gain of the pyramidal horn antenna and R the distance between transmitting antenna and AUT. The experimental gain of LSMRMA when Y = 7.1 mm is measured across the band. The variation of gain verses frequency of this antenna is as shown in Figure 8. It is seen that maximum 13.19 dB gain is achieved at 8.87 GHz.

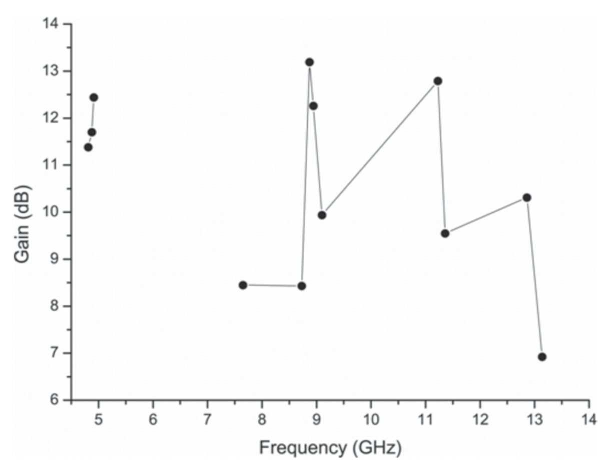

Figure 8: Variation of Gain versus Frequency of LSMRMA when Y = 7.1 mm

4. CONCLUSION

From the detailed experimental study, it is concluded that the LSMRMA derived from conventional rectangular microstrip antenna is quite capable in producing multiband operation. When the horizontal length of L slot is kept at 7.1 mm on the patch all the secondary bands merges in to a single band. The antenna operates from 4.81 GHz to 15.8 GHz with a notch band from 4.94 GHz to 7.07 GHz. The antenna gives ominidirectional radiation characteristics in its operating band. The simulated and experimental return loss results of LSMRMA are in close agreement with each other. The proposed antenna is simple in its design and fabrication. The antenna is constructed using low cost FR4 substrate material. This antenna may find any applications in microwave communication systems.

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