Design and Development of Multi Band Microstrip Antenna with Ominidirectional Radiation Characteristics

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Abstract: A novel design and development of slotted rectangular microstrip antenna is proposed for multi band operation and also it exhibits omnidirectional radiation characteristics. The multibands are achieved between 4.80 to 15 GHz. The proposed antenna is simple in its geometry and has been constructed from conventional rectangular microstrip antenna by placing slots on the patch at a distance of 1.5 mm from the edges. 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 between them. Experimental results are in close agreement with the simulated results. The proposed antenna may find application in radar communication system.

1. INTRODUCTION

Microstrip antennas (MSAs) are finding increasing applications in microwave communication systems because of their diversified uses such as low profile, light weight, planar configurations, easy to fabricate and low cost [3-6]. The microstrip antenna operating at more than one band of frequencies is quite useful because each band can be used independently for transmit receive applications. The multiband operation of microstripp antenna with omnidirectional radiation characteristics is an additional advantage of the device and can be used more conveniently in many stationary and moving targets. In this study a conventional rectangular microstrip antenna has been modified to get multiband operation and omnidirectional radiation characteristics by simply loading slots on the conducting patch and by placing a ground plane of height equal to the length of microstripline. The ground plane is kept at a distance of 1 mm from the microstripline. This modification does not affect the size of the conventional patch designed for the same resonant frequency.

2. DESCRIPTION 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 slotted rectangular microstrip antenna (SRMA). The selected area \( A \) of the substrate is \( L \times W \) cm. On the top surface of the substrate a ground plane of height which is equal to the length of microstripline feed \( L_{g} \) is used. A gap of 1 mm is used between the ground plane and microstripline feed. On the bottom of the substrate a continuous copper layer of height \( L_{l} \) is used below the microstripline. The SRMA 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 \( L_{g} \) and width \( W_{g} \). A SMA connector is used at the tip of the microstripline feed for feeding the microwave power.

Figure 1: Geometry of SRMA
In Figure 1 the rectangular slots are placed on the patch from its edges for providing different surface current paths so as to produce multi resonant modes. The length and width of slots are $L_s$ and $W_s$ respectively and both the slots are kept at a distance of 1.5 mm from the edges of the radiating patch. The design parameter of the proposed antenna is given in Table 1.

<table>
<thead>
<tr>
<th>Design Parameters of Proposed Antenna</th>
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<tbody>
<tr>
<td>$L_p$ = 23.4 mm</td>
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<tr>
<td>$L_t$ = 24.8 mm</td>
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<tr>
<td>$L_s$ = 12.4 mm</td>
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<tr>
<td>$L$ = 80.0 mm</td>
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<tr>
<td>$L_s$ = 20.4 mm</td>
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3. EXPERIMENTAL RESULTS

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

$$BW = \frac{f_t - f_c}{f_c} \times 100\%$$

where $f_1$ 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 4.80 to 15 GHz.

In Figure 2 it clearly seen that the antenna gives seven resonant frequency modes. The resonant mode at 4.88 GHz is due to the fundamental resonant frequency of the patch and others modes at 7.23 GHz, 8.18 GHz, 10.48 GHz, 11.48 GHz, 12.90 GHz and 13.99 GHz are due to the novel geometry of SRMA. The magnitude of experimental -10 dB bandwidth measured at $BW_1$ to $BW_7$ are 160 MHz (4.75-4.91 GHz), 590 MHz (6.91-7.50 GHz), 1640 MHz (7.76-9.40 GHz), 460 MHz (10.35-10.81 GHz), 690 MHz (11.23-11.92 GHz), 690 MHz (12.64-13.33 GHz) and 1240 MHz (13.76-15 GHz) respectively. The simulated results of SRMA is also shown in Figure 2. The experimental and simulated results are in close agreement with each other.

The co-polar and cross-polar radiation pattern of SRMA is measured in its operating bands. The typical radiation patterns of SRMA measured at 8.14 GHz and 12.90 GHz are shown in Figure 3 and 4 respectively. The patterns are omnidirectional in nature.

4. CONCLUSION

From the detailed experimental study, it is concluded that the SRMA derived from conventional rectangular microstrip antenna is quite capable in producing multiband operation.
The antenna operates at seven resonant modes between 4.80 to 15 GHz of frequency and gives omnidirectional radiation characteristics at each operating band. The simulated and experimental return loss results of SRMA are in close agreement with each other. The proposed antenna is simple in its design and fabrication. The antenna is constructed using low cost substrate material. With these features the antenna may find any applications in radar communication.

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REFERENCES
