Design of Six Band Microstrip Antenna

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Abstract: **In this paper, design of multi-band microstrip antenna with a U-shaped slot and two linear slots with a copper post at the center has been presented. It is observed that frequency bands and gain of the antenna with copper post are increased as compared to the corresponding antenna without copper post. The proposed antenna has been designed for use in wireless devices in the frequency range between 5 GHz to 9 GHz.**

Keywords: **Multiband microstrip, Shorting Probe**

I. INTRODUCTION

Due to the rapid progress in the wireless/mobile communication system and the increasing demand for a number of applications in a single mobile device through the single internal antenna, there is a need of design of multi-band antenna for multi system handset. The multi-band microstrip antenna has been widely used as an internal antenna in the applications of the wireless mobile communication system [1]-[9]. By using the U-shaped slot in the patch of the antenna one can get dual /multiple bands of frequencies [10]-[15] and introducing a shorting copper post in the patch antenna one can get more frequency bands in with copper post antenna [16][17].

II. ANTENNA DESIGN

The geometry of proposed multi-band microstrip antenna with a U-shaped slot and two linear slots with copper post is shown in Figure 1. The microstrip antenna consists of a main radiating patch, dielectric layer, ground plane and feeding point.

The resonant frequency of the proposed antenna has been selected appropriately between 5 GHz to 9 GHz. Hence, the proposed antenna designed is able to operate between these frequencies. Using transmission line model [1]-[3], the maximum and minimum dimensions of the proposed antenna are calculated according to the frequency operation range between 5 GHz to 9 GHz. The dimensions obtained at minimum frequency, f= 5 GHz are length, L=39 mm and width, W = 47 mm.

The dielectric constant of Teflon dielectric layer is 2.25. The height of the dielectric substrate is selected as 3 mm since the height of substrate increases the bandwidth of the antenna.

The U-shaped slot provides the multi-band frequency operation The lengths S_2, S_3 and slot width G of the U-shaped slot have been varied such that a higher resonance can be found. For each variation in the geometry, the simulation is carried out and the return loss is checked at the desired frequencies. The best geometry of the U-shaped slot, thus obtained is given as S_2 = 13 mm, S_3 = 13.5 mm, and slot gap G = 0.8 mm. Inserting two straight slots in U-shaped slot antenna provides the long path for the current density distribution in the patch; and due to this we get other two other resonant frequencies. The dimensions of the two straight slots are obtained as S_1= 34 mm and slot gap G= 0.8 mm.

The simulation is performed by using the IE3D software [19] for different dimensions. Out of these simulations, we have chosen those dimensions generating higher resonance and multi-bands. Using this procedure the best dimensions obtained are length, L=39 mm and width, W = 47 mm which provide the maximum resonance and maximum number of bands in frequency range from 5 GHz to 9GHz. Six center frequencies, namely 5.24GHz, 5.48GHz, 7.12GHz, 7.28GHz, 8.51 GHz and 8.68GHz have been obtained with return loss below -10 dB, as shown in Figure 2.

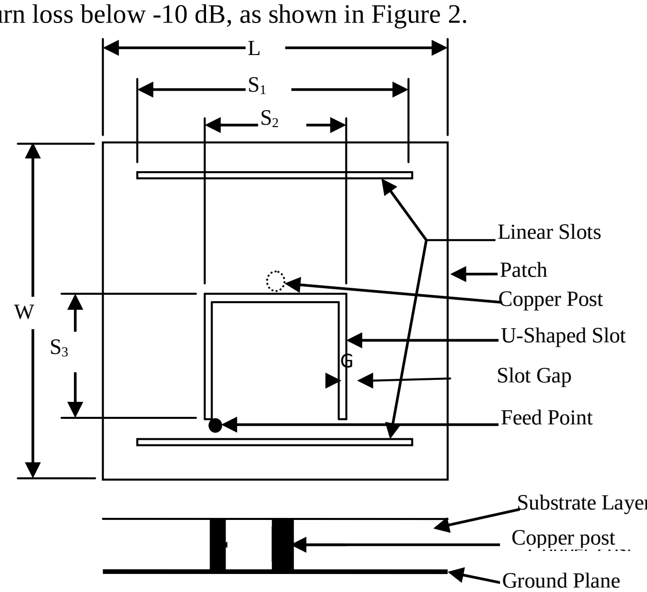

Figure 1 Proposed Antenna with Copper Post

2.1 Determination of Feed Point Location

A coaxial probe type feed is used in the proposed design. The feed point location is varied on the patch so that the input impedance may be obtained as 50 Ohm.

Table 1 shows the return loss values corresponding to different values of frequencies and feed location varying along Y-axis and then X-axis. At the feed point (13, 9), the return loss equal to -21.35 dB is obtained corresponding to the center frequency 8.10 GHz, which is the optimized location of the feed point.

2.2 Determination of Post Radius

In the design of proposed antenna there is a copper post which is used for shorting the patch with ground plane at canter where the electric field should be zero. The post is in cylindrical shape with the radius *r*. The return loss at the operating frequency bands depends on the radius of the copper post. Different values of return loss corresponding to different values of copper post radius and frequencies are shown in Table 2. The optimum value of radius is obtained to be 0.9 mm for the antenna operation in all six frequency bands.

2.3 Simulated Parameters of the proposed antenna

It has become necessary to observe the antenna parameters for the performance of the proposed antenna such as return loss, *VSWR* and antenna efficiency. The characteristic plots obtained from simulation of the proposed multi-band antennas are discussed below.

2.3.1 Return Loss Characteristics

The return loss is the main parameter for the operation of the antenna. The return losses for the proposed antenna with copper post have been found to be -10.98 dB, -16.35 dB, -10.90 dB, -16.32 dB, -13.22 dB and -15.45 dB corresponding to 5.24 GHz, 5.48 GHz, 7.12 GHz, 7.28 GHz, 8.51 GHz and 8.68 GHz, respectively as shown in Figure 2 from which the antenna bandwidths have been calculated. Thus bandwidths have been found to be 44 MHz, 94 MHz, 31 MHz, 130 MHz, 100 MHz and 110 MHz with center frequencies at 5.24 GHz, 5.48 GHz, 7.12 GHz, 7.28 GHz, 8.51 GHz and 8.68 GHz, respectively.

2.3.2 VSWR Characteristics

The voltage standing wave ratio (*VSWR*) characteristics versus frequency of the proposed multi-band antenna with the copper post has been shown in Figure 3. The *VSWR* is found to be less than 2.0 for the each frequency of operation. The values of *VSWR* are found to be 1.81, 1.44, 1.8, 1.37, 1.59 and 1.42 at 5.24 GHz, 5.48 GHz, 7.12 GHz, 7.28 GHz, 8.51 GHz and 8.68 GHz respectively.

2.3.3 Antenna Efficiency and Gain Characteristics

The maximum field gain of the antenna at the higher frequency band operation is obtained to be near about 6 dBi for the proposed antenna with copper post has been shown in Figure 4. The efficiency graph of the proposed antenna is shown in Figure 5. The six efficiencies are obtained about 69%, 78%, 52%, 67%, 70% and 63% for the 5.24 GHz, 5.4 GHz, 7.12 GHz, 7.28 GHz, 8.51 GHz and 8.67 GHz frequency bands, respectively.

2.3.4 Gain Pattern

The gain pattern for the proposed antenna is shown in Figure 6. The gain pattern obtained for the antenna with copper post is improved to greater extant.

III. RESULT

The multi-band microstrip antenna, using IE3D software, has been designed and simulated. The basic structure of the antenna has been estimated using the transmission line model. This antenna has been simulated for the operation for a six band microstrip antenna with the centered copper post.

The performances of proposed antenna are observed through the values of return loss and VSWR. The maximum bandwidth for the proposed antenna is obtained 130 MHz with center frequency at 7.28 GHz.

The maximum total field gain of the proposed antenna is obtained about 6dBi. The maximum efficiency is obtained about 78% for 5.48 GHz band and the antenna gain pattern is also improved.

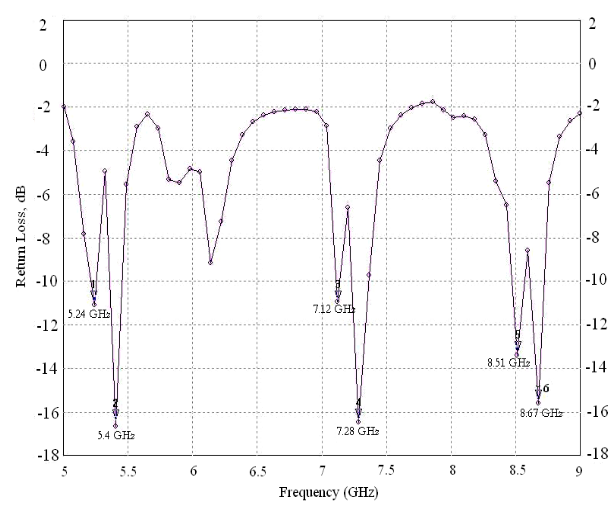

Figure 2 Return Loss v/s frequency of the proposed antenna

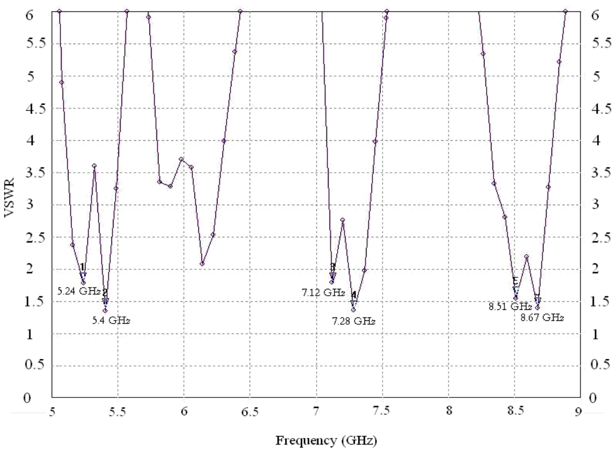

Figure 3 VSWR v/s frequency of the proposed antenna

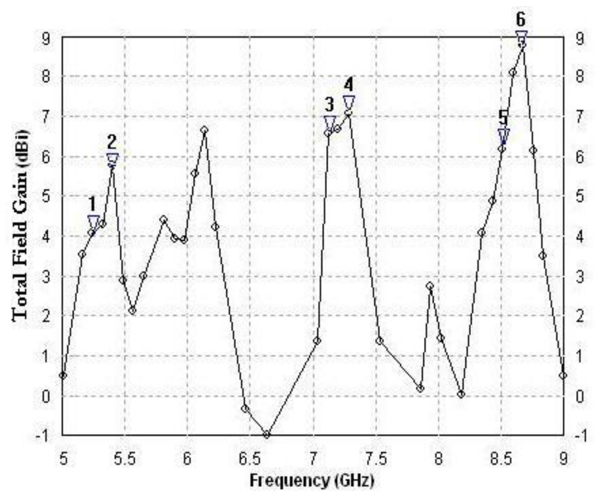

Figure 4 Total field gain v/s frequency of the proposed antenna

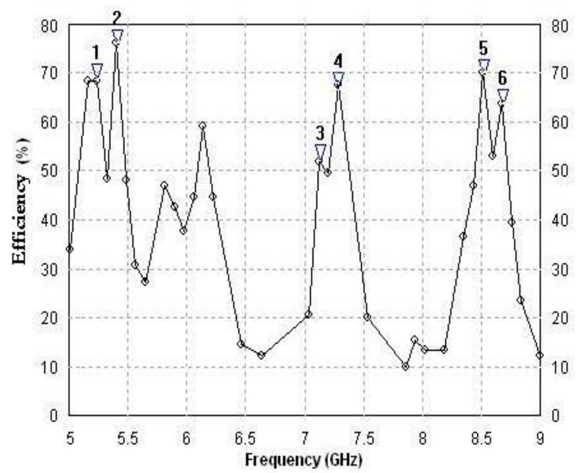

Figure 5 Efficiency v/s frequency of the proposed antenna

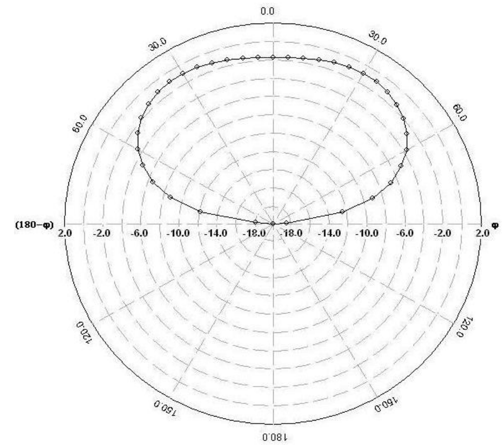

Figure 6 Gain Pattern of the proposed antenna

Freq. (GHz) / r (mm)	5.24	5.4	7.12	7.28	8.51	8.67
0.7	-10.71	-03.66	-08.78	-09.48	-06.10	-18.62
0.8	-01.10	-00.53	-01.95	-02.08	-07.94	-11.98
0.9	**-10.98**	**-16.35**	**-10.90**	**-16.32**	**-13.22**	**-15.45**
1.0	-09.72	-18.10	-11.49	-16.25	-12.10	-15.20
1.1	-07.70	-16.75	-12.15	-16.23	-12.00	-14.90
1.2	-06.53	-06.56	-06.15	-09.51	-06.32	-18.57

Table 1 Return loss between frequency v/s feed position

Freq. GHz / Feed Position	5.82	6.86	7.85	8.10
(24,17)	-3.68	-0.75	-0.85	-0.95
(24,12)	-4.16	-1.26	-2.0	-1.36
(24,9)	-4.45	-2.54	-5.86	-2.48
(19,9)	-14.55	-3.67	-2.32	-1.62
(13,9)	**-14.02**	**-10.91**	**-10.68**	**-21.35**
(11,15)	-3.40	-2.76	-3.92	-1.85
(11,12)	-5.69	-2.17	-3.99	-2.56

Table 2: Return loss between frequency v/s post position

IV. CONCLUSION

In this paper, multi-band microstrip antenna has been successfully designed and simulated. The six band microstrip antenna is simulated by inserting the copper post into the four band microstrip antenna. The proposed antenna can be used for wireless communication systems which includes modern mobile handsets and laptops for WLAN application and for satellite communication.

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