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Design and Fabrication of a Compact Microstrip Antenna with Notch Functions

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Abstract— A compact microstrip antenna with multiple band-notch characteristics is proposed. The proposed antenna has an operating frequency of 3.2 to 9 GHz, with six notch functions to reduce interference with existing systems. The notches created are C-band downlink (3.8-4.5GHz), WLAN (5.18-5.825GHz), Standard C-band uplink (5.825-6.425GHz), Extended C-band uplink (6.425-6.725GHz), Super Extended C-band uplink (6.725-7.025GHz) and X-band downlink (7.025-7.75GHz) using CST STUDIO SUITE 2010 .A return loss of -10dB has been achieved in the operating frequency range, other than the notches. There is a decrease in gain at the notch frequencies. The antenna is fabricated and the results attained from the network analyzer confirms the validity of the design which matches with the simulated results.

Index Terms — C-band, Microstrip antenna, multiple band-notches, C-band, return loss, ultrawideband (UWB).

1 INTRODUCTION

In recent years, with an increase in the number of wireless communication devices the electromagnetic interferences has also increased. In 2002, the Federal Communications Commission (FCC) released a new spectrum from 3.1GHz to 10.6GHz with a spectral mask of -41.3dBm/MHz. This led to the rapidly growing research efforts targeting UWB applications like high data rate communication, precise localization and through-wall imaging. UWB technology has become the preferred choice for short-range and high speed (Mb/s) indoor data communication. Unfortunately, within the UWB frequency band coexist other wireless narrowband standards such as WLAN (5.15-5.35 and 5.725-5.825 GHz), Super Extended C-band uplink (6.725-7.025 GHz) and other C-band (3.7-4.2 GHz) systems etc. which are likely to cause adverse interference with the operation of UWB systems. To reduce the interference from these frequency bands, bandpass filters could be utilized but this will increase the cost and overall system size. Thus, a compact UWB antenna with multiband rejection characteristics is desirable.

2 DESIGN CONSIDERATIONS

The basic design is intended to be constructed using printed circuit board (PCB) technology. It presumes an FR4 substrate with the dielectric constant, εr = 4.3 and loss tangent, tanδ = 0.025. Its overall size is L x W x H = 57mm x 32mm x 1.6mm.

A simple configuration is presented in figure 2.1 and 2.2. A rectangular stepped shaped slot is centred on the top side of an FR4 board.

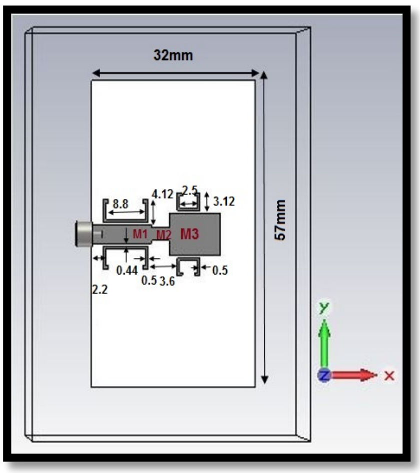

Figure 2.1 Top view of designed antenna

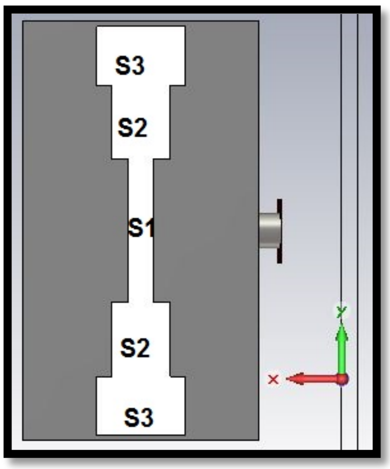

Figure 2.2 Bottom view of designed antenna

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The patch is fed by a 50ohms microstrip line. The gap between the patch and the ground plane is 0.6mm.With a compact profile of 57x32mm^2, the antennas operating frequency is sufficient to cover the UWB frequency band of 3.1-10.6 GHz. There are frequencies at which the antenna has a slightly higher peak realized gain values without the parasitic oval patch than with it. By inserting different slots on the antenna, the band-notched characteristic in the specified band is realised. The dimensions for the designed antenna are given in Table 1. Also, the feed dimensions are slightly changed to retain the ultra-wide impedance bandwidth whose values are LM1=11.7mm, WM1=3.63mm, LM2=3.5mm, WM2=2.35mm, LM3=8.4mm, WM3=8.5mm.

Table.1 Antenna dimensions

Label	S1		S2		S3	
Parameter	S_{1L}	S_{1W}	S_{2L}	S_{2W}	S_{3L}	S_{3W}
Value(mm)	19.5	3.5	10	8	7.8	12
Label	M1		M2		M3	
Parameter	L_{M1}	W_{M1}	L_{M2}	W_{M2}	L_{M3}	W_{M3}
Value(mm)	11.7	3.63	3.5	2.35	10	8.5

3 SIMULATION AND DISCUSSION

The reflection coefficient and VSWR for different values are obtained by using parametric sweep and are compared as shown in Figures 3.1 and 3.2 respectively. The variable 'b' represents the length of S3, i.e. b= S_{3L}. All through the design, the steps dimensions are kept symmetric along the width and length of the antenna, to ensure circularity of the radiation patterns. Further, to have less cross polarisation, the microstrip feed is made to cross the slot orthogonally and at the center. The feed line extends beyond the slot to form a tuning stub. The stub reduces the high impedance offered by the slot. Alternately, to improve the impedance matching, the feed can be placed offset from the center or can be made inclined. However, with offset feeding the far-field patterns get distorted while, with inclined feed, polarization purity gets affected.

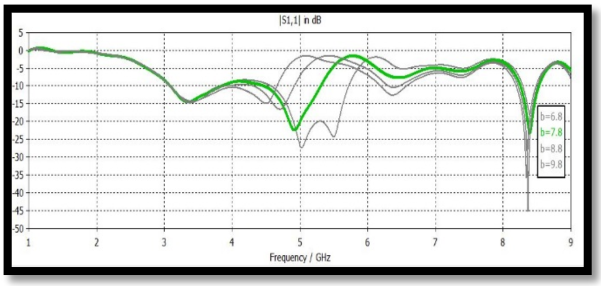

Figure 3.1 Return loss of designed antenna

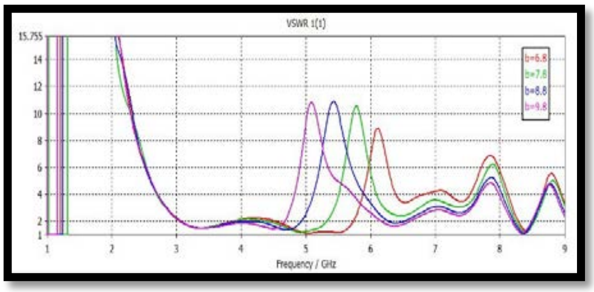

Figure 3.2 VSWR of designed antenna

In order to reduce interference of the proposed antenna with existing C-band downlink (3.8–4.5GHz), WLAN (5.18–5.825GHz), Standard C-band uplink (5.825-6.425GHz), Extended C-band uplink (6.425-6.725GHz), Super Extended C-band uplink (6.725-7.025GHz) and X-band downlink (7.025-7.75GHz) multiple band notches are created at these frequencies. In the design, following four C-shape metallic resonators are placed adjacent to the microstrip feed line. The overall length of the resonator is chosen 17 mm to cause the anti-resonance at various frequencies. It is observed that, for the fabricated antenna, the notch-band for rejecting the high frequency band for X-band communication is shifted by almost 300 MHz as compared to simulation. This can be attributed to the fact that the high frequency bands are more sensitive to fluctuation in relative permittivity of the substrate used.

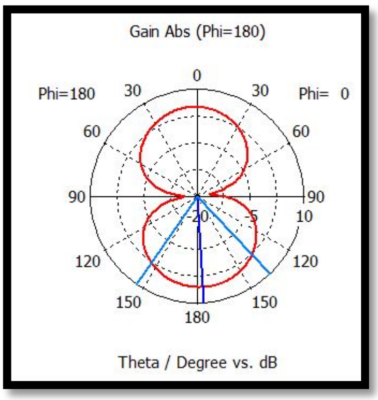

Figure 3.3 Gain of designed antenna

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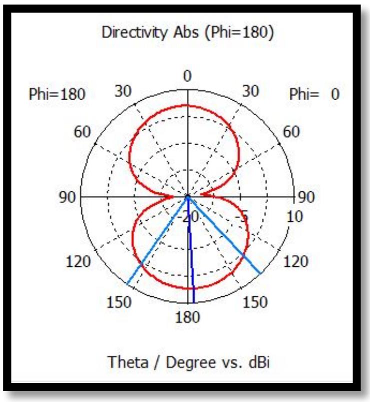

Figure 3.4 Directivity of designed antenna

The designed antenna has a gain of 5.5dB and directivity of 5.9dBi at a frequency of 4.5GHz as shown in figures 3.3 and 3.4 respectively.

4 FABRICATION AND MEASUREMENT

The designed antenna was fabricated using the optimized antenna parameters that were described in Figures 2.1, 2.2 and Table1. Fig.5 shows the photographs of the fabricated antenna with its top view and back view respectively. The antenna operates over 3.2–9 GHz. An SMA adapter was connected at one end of the microstrip line for measurement, which was directed by Agilent N9925A ENA RF network analyzer with the highest frequency at 20GHz. The correctness of the simulation results can thus be verified.

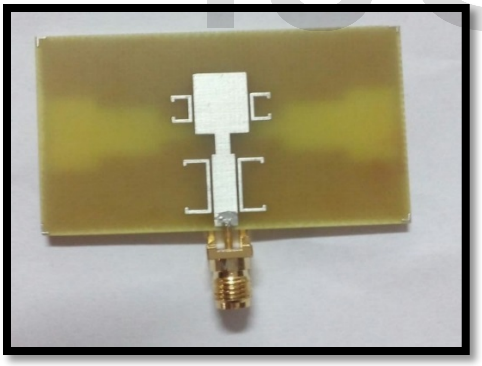

Figure 4.1 Front view of the fabricated antenna

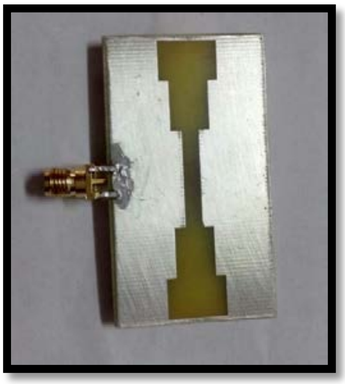

Figure 4.2 Back view of the fabricated antenna

The simulated and measured VSWRs for the designed antenna is shown in Figures 3.2 and 4.4. It illustrates the VSWR comparison of the antenna for different values with notches. When compared with the simulated VSWR, the measured VSWR of the band-notch design shows a slight shift to the lower side which may be attributed to fabrication errors.

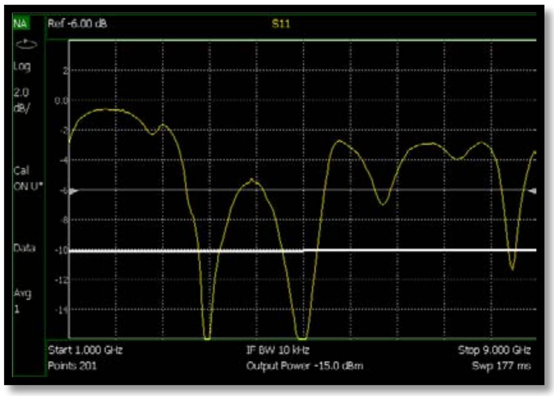

Figure 4.3. Measured reflection coefficient

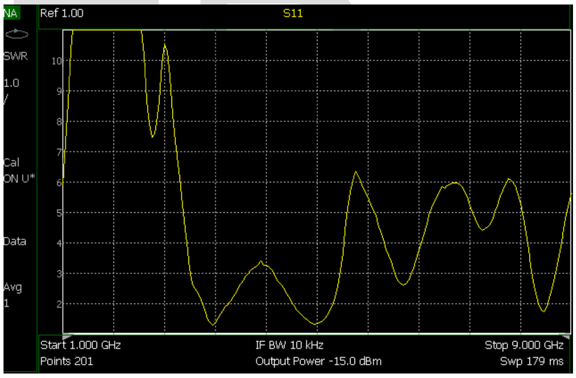

Figure 4.4. Measured VSWR

At the band-notch frequency, the strips present acts as a short circuit to the input microwave energy. As a result, there is a high current density on them and these currents reaching the slot end are reduced which minimizes the radiation.

5 CONCLUSION

The microstrip patch rectangular stepped slot antenna with multiple band-notch characteristics was designed for UWB use. The performance of the antenna was studied in terms the antenna parameters and the -10 dB return loss has been attained in the operating frequency range of 3.2 to 9GHz with bandwidth of 7.99GHz. The obtained results were in accordance with the simulated results showing that the antenna performs well at the required range with considerable slot dimensions. The slot shape and dimensions are preferred such that stable and symmetric radiation patterns are achieved with maximum gain in the broadside direction. The peak gain of the proposed antenna is around 5.5 dBi. The proposed antenna can be beneficial for wireless communication devices too. In future, it can be enhanced by obtaining a better value of gain and directivity.

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