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PRINTED TAPERED COMPACT UWB ANTENNA WITH SINGLE BAND NOTCH CHARACTERISTICS

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ABSTRACT

A simple and compact microstrip line -fed ultrawideband planar monopole antenna with single band-notch characteristics is presented. Wide impedance bandwidth is achieved by inserting two rectangular slots on both sides of the microstrip feed line on the ground plane. Band notching is achieved by embedding a half wavelength C shaped slot on the radiator. The antenna is investigated numerically and validated experimentally for impedance matching, frequency notch characteristics and radiation performance. The designed antenna has a compact size of 18 × 19 mm^2 and operates over the frequency band between 3.1-12 GHz for VSWR < 2 while demonstrating band rejection performance in the frequency band of 5 to 6 GHz. The antenna exhibits omni directional characteristics with average gain of 2.26 dB.

Keywords: *Compact, Microstrip Line Feed, Slot, UWB Antenna*

1. INTRODUCTION

Ultrawideband is a radio technology for transmitting information over a wide spectrum from 3.1-10.6 GHz that can be used at low energy level for short range, high bandwidth communication. This technology has greatly spurred the research and development of antennas for communication, imaging and RADAR applications [1-3]. One of the promising commercial applications is in the area of consumer electronics with short range but high data rate wireless communication.

Compact antenna design is strongly desired for portable devices. The compact antennas are playing critical role with specific requirements of broad impedance matching, acceptable gain and consistent radiation pattern. Usually, the requirement of small design limits the antenna performance as size affects the gain and bandwidth of the antenna significantly. Thus miniaturizing the antenna with broad impedance bandwidth with acceptable gain is a challenging task. Plenty of antenna solutions are proposed [4-7] for the best compromise between performance and desirable compactness, low profile and low cost objectives.

Printed antennas are most popular choice for the above requirements, where the radiating element and ground plane are coplanar or atleast printed on each side of a single dielectric substrate. Two broad groups dipole/monopole and slot based antennas have been proposed [7-8]. Printed monopole antennas are good choice for use in UWB wireless technology because of their wide impedance bandwidth and nearly omni directional azimuthal characteristics.

Over the designated bandwidth of the UWB system, WLAN (IEEE 802.11a and HIPERLAN2) operating in the 5.15-5.825 GHz band coexists with the UWB system. A band rejection filter is needed to avoid the interference with existing wireless network standards. To reduce the complexity, band notching can be applied directly to various UWB planar antennas by loading the resonant slots like C-shaped, U-shaped or rectangular slots at the center frequency of stop band [9-11].

Reducing the size of the antenna causes deterioration on the antenna performance such as impedance bandwidth, gain and efficiency [12]. So researches on very compact UWB antenna are investigated and most of the research has compact dimension by using high dielectric constant material, but also has additional matching circuit or parasitic patch [13].

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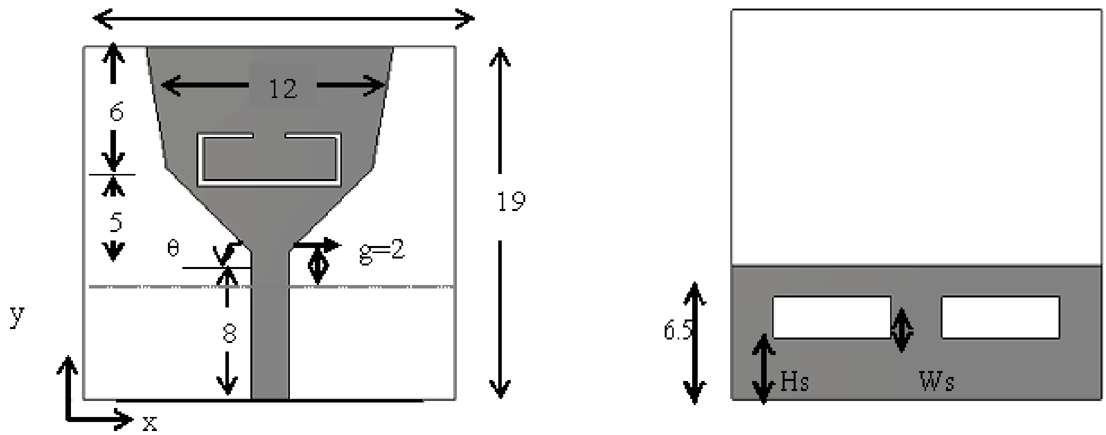

(a) Top view (b) Bottom view

Fig.1. Geometry of the proposed planar monopole antenna (units: mm)

In this paper a compact ultra wideband antenna is proposed for wireless application. Reduction in bandwidth due to size miniaturization is compensated by beveling the antenna with a pair of slots in the ground plane. These slots enhance the bandwidth by introducing two resonant modes. The proposed antenna is further extended to band notch function by inscribing a C shaped slot.

2. ANTENNA DESIGN

2.1 Antenna Geometry

The configuration of the proposed antenna is shown in Fig.1. It consists of a beveled radiating patch with a C shaped slot, partial ground plane with rectangular slots. The overall size of the antenna is 18 × 19 mm^2. The gap between the radiator and ground plane is 2 mm. A 50Ω, 1.86 mm wide micro strip line connects the patch and feed. The antenna is printed on both the top (radiating patch and feed line) and underside (ground plane) of a FR4 substrate, with relative permittivity ε_r = 4.4, loss tangent of 0.02 and thickness of 1.6 mm. The radiating patch is symmetric around y-axis.

2.2 Parametric study

A parametric study was carried out to achieve UWB bandwidth and band rejection operation using CST Microwave Studio based on Finite Integration Technique [14]. Every geometrical parameter has different effects on the performance of the proposed antenna. The investigation revealed that the operating band of the antenna and band notch is mainly determined by the gap between the patch and the ground plane (g), width of the slot (W_s), position of the slot (S_p) and tapering angle of the patch (θ).

2.2.1 Effect of the ground plane (g)

The ground plane of the proposed antenna is also part of the antenna. At low frequencies current is mainly distributed over the radiator and the ground plane. Simulated VSWR of the antenna as a function of frequency for different values of feed gap with other parameters fixed is shown in Fig.2. It is observed that the impedance bandwidth at the upper operating frequency increases as ground plane length increases. It is also observed that the additional resonance occur at 10.5 GHz due to capacitive and inductive effect caused by EM coupling effect between the patch and ground plane.

2.2.2. Effect of Slot Width (W_s)

The effect of slot width on the antenna performance is studied by varying the width. As W_s is varied from 1 mm to 3 mm in steps of 0.5 mm, upper notch frequency increases from 5.934 GHz to 6.515 GHz as shown in Fig.3. The impedance bandwidth of the antenna and center frequency of the notch remains unchanged.

2.2.3. Effect of slot position (S_p)

The simulated VSWR characteristics for various slot positions are depicted in Fig.4. It is observed that the high frequency band is reduced as

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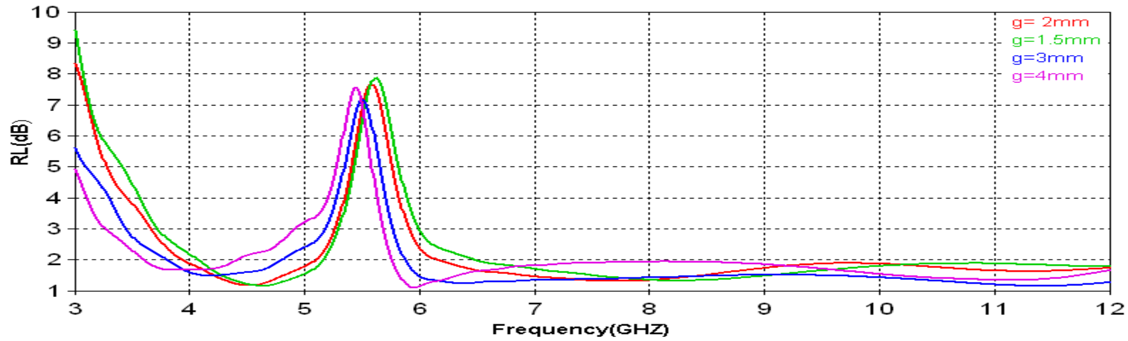

Fig.2 Effect of Ground plane

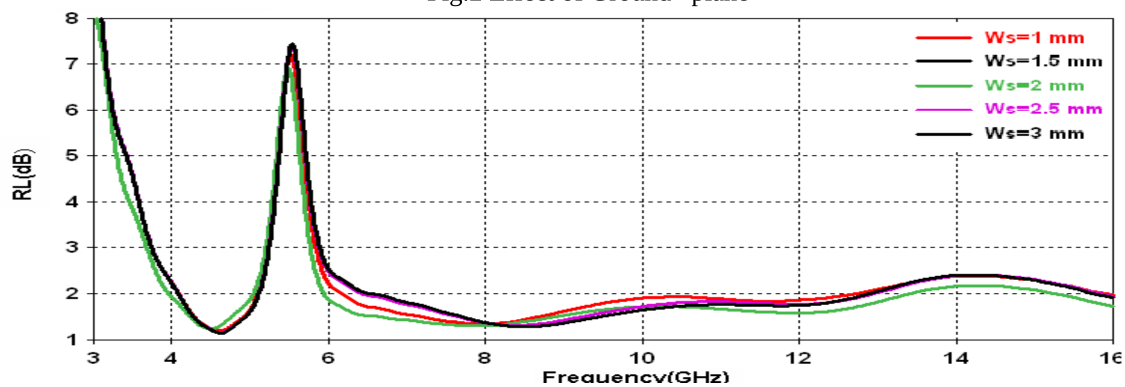

Fig.3 Effect of slot width

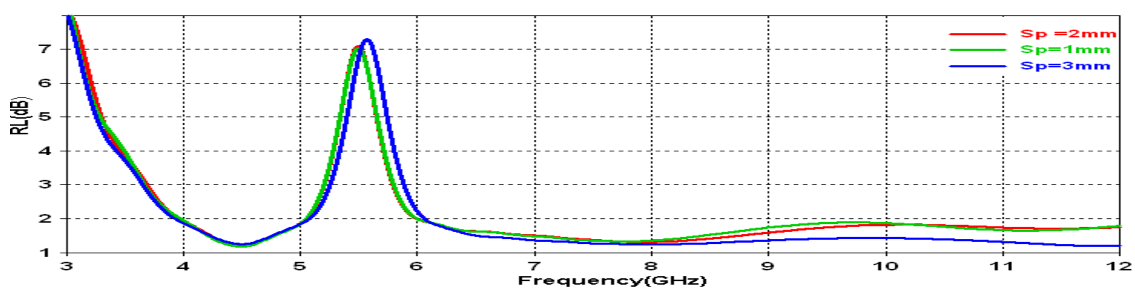

Fig.4 Effect of slot position

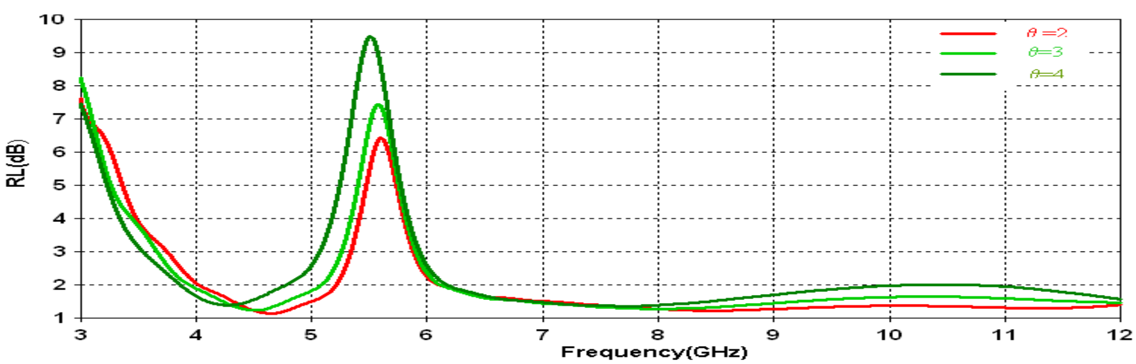

Fig.5 Effect of tapering angle

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the slot position is closer to the edge of the ground plane. Hence slot position is chosen to be 3 mm from the edge of the ground plane.

2.2.4 Effect of tapering angle (θ)

The gap between the radiating patch and ground plane has an important effect on impedance matching of the proposed antenna. As the angle between the patch and feed line decreases, the notch frequency band widens and the center of the notch band shifts from 4.8093 GHz to 6.115 GHz as shown in Fig.5. High frequency band reduces due to improper matching between the feed and the patch. Hence band notch and bandwidth can be controlled by varying angle between the feed and the patch.

3. EXPERIMENTAL RESULT AND DISCUSSION

After the optimization of antenna parameters the proposed antenna was fabricated and the VSWR characteristics were measured using Agilent N5230A network analyzer. The simulated and measured results evidenced a significant similarity. Measured results shows that the impedance bandwidth is 8.9 GHz stretching over the frequency range from 3 GHz to 12 GHz for S_{11}<-10 dB.

A sharp increase in VSWR is observed at notched frequency band 5-6 GHz as shown in Fig.6. The photograph of the fabricated antenna is shown in Fig.7.

The 3D radiation pattern for total radiated electric fields was measured at 3.5 and 4.5 GHz by using Orbit-MiDAS far-field measurement system in a CTIA validated full anechoic chamber. The dimension of the chamber is $8 \times 4 \times 4$ m^3. The measurement was performed using a standard double ridge horn antenna as a reference antenna. The distance between the transmitting and receiving antenna is 4 m. The measured and simulated H-plane (x-z plane) and E-plane (y-z plane) radiation characteristics at 3.5 and 4.5 GHz are shown in Fig.8 and Fig. 9 respectively.

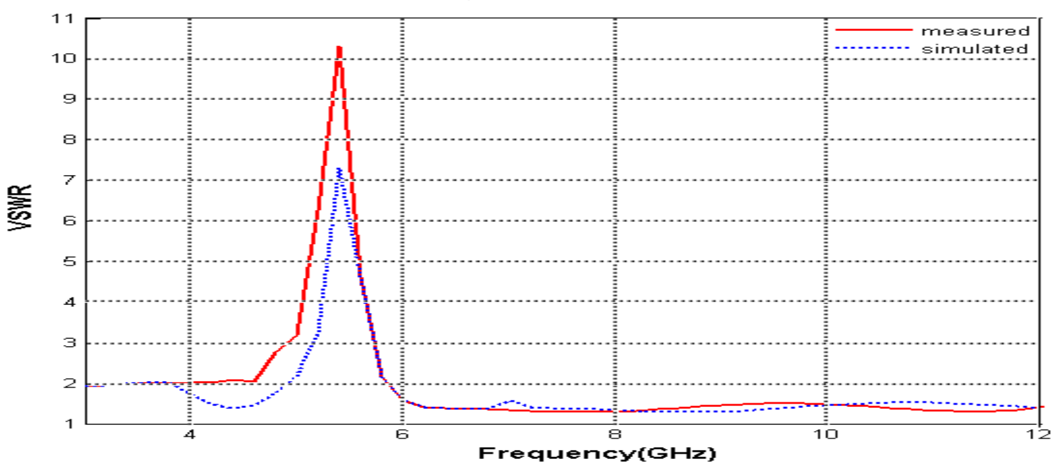

Fig.6 Measured and simulated VSWR of the proposed antenna

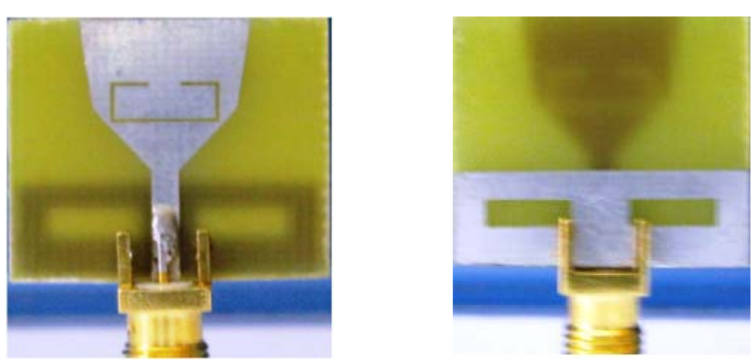
(a) Top view (b) Bottom view

Fig.7. Photograph of the fabricated antenna

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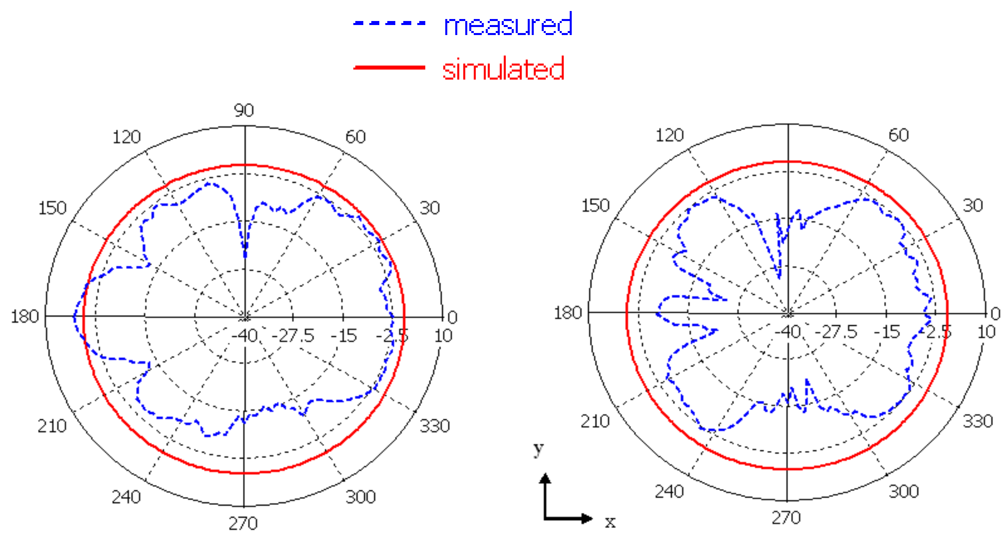

Fig.8. Measured and simulated radiation pattern in the xz plane at (a) 3.5 GHz (b) 4.5 GHz

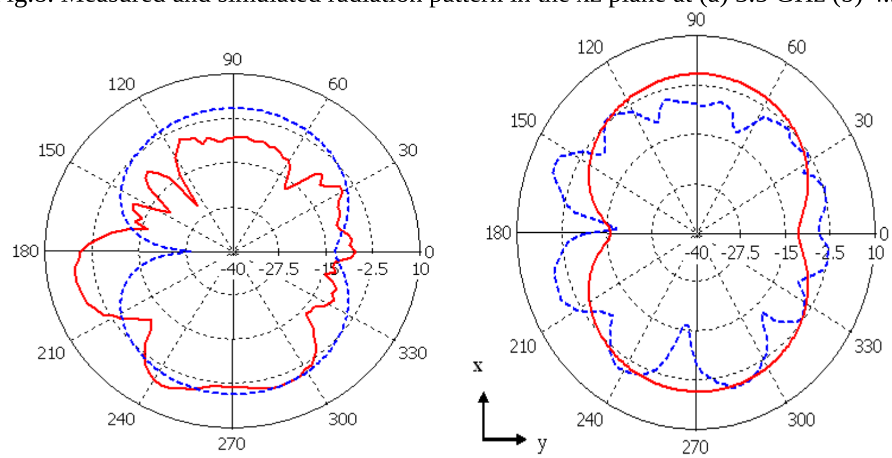

Fig. 9 Measured and simulated radiation pattern in the yz plane at (a) 3.5 GHz (b) 4.5 GHz

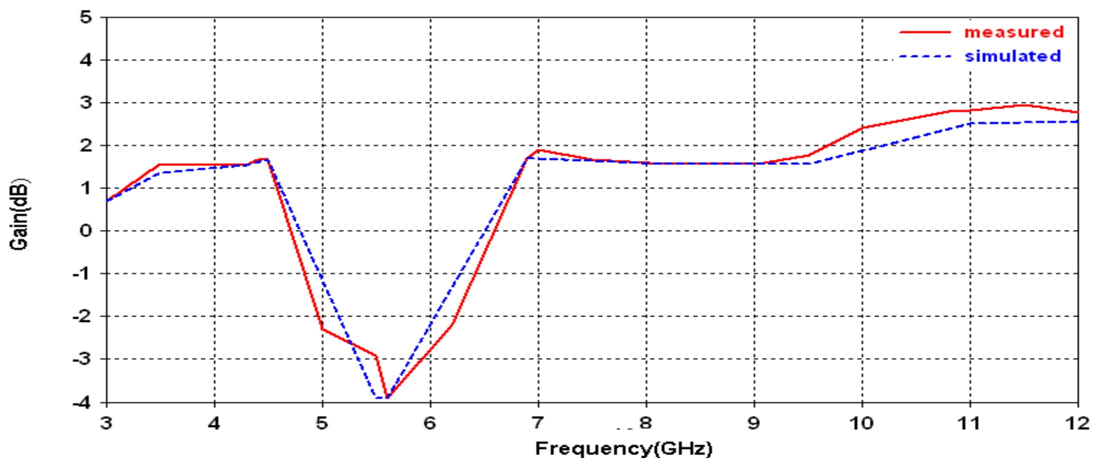

Fig.10.Simulated and measured antenna gain

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It can be seen that the radiation pattern in the H-plane are nearly omni directional similar to the typical printed monopole antenna. The measured E-plane patterns follow the shape of the simulated ones. There are many ripples and distortions on the measured curves, which are caused by the feed connector and the coaxial cable. The antenna gain variations are less than 3 dB throughout the desired UWB band. The gain at 5.5 GHz, demonstrates that the antenna has much lower gain of -4.0296 dB. The reduction in gain at the notch frequency is significantly greater than the reduction of power fed into the antenna caused by return loss. This is because most of the current are trapped in a small region of the parallel LC equivalent circuit and the resultant radiation fields cancel out and thus the antenna does not radiate. Simulated gain of the proposed antenna has good gain flatness over the operating band except for the notch band as shown in Fig.10.

4. CONCLUSION

A compact 18 × 19mm^2 microstrip line fed planar monopole antenna with UWB bandwidth of 3-12 GHz except for the notch band of 5-6 GHz has been proposed and implemented. Compact size with wideband width is achieved by truncating the low current region, tapering the antenna structure and beveling the ground plane using slots. Several design parameters have been investigated for optimal design. Band stop characteristic is achieved by etching a C shaped slot. It is seen that the proposed antenna has omni directional radiation pattern with flat gain variation over the full UWB band except for the notch band. Therefore the proposed antenna is suitable for UWB communication and at the same time prevents interference with the WLAN system.

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