A COMPACT PRINTED UWB ANTENNA WITH TRIPLEBAND NOTCH CHARACTERISTICS

[1]AMJADIQBAL, [2]OMAR A. SARAEREH

[1]Department of Electrical Engineering, CECOS University Peshawar, Pakistan, [2]Department of Electrical Engineering, The Hashemite University, Zarqa, Jordan
Email - [1]amjad730@gmail.com, [2]eloas2@hu.edu.jo

Abstract - A printed triple notch band UWB antennais presented in this paper. A modified maple leaf shaped main radiating patch with partial ground and a 50 Ω microstrip transmission line is used in the proposed antenna. The proposed antenna shows the UWB operation in the frequency range (1.4 GHz-11.3 GHz) with VSWR<2 except the notch bands and three band notches centered at 2 GHz, 3.1 GHz and 5.8 GHz. Introduction of meandered slot lines in the radiating patch and U-shaped slot in the feed line results in the notches.The other notch is achieved by placing E shape resonator on the back of the substrate connected through via with main radiating patch. Low loss substrate of Rogers 5880 having relative permittivity of 2.2 is used in the proposed UWB antenna. The proposed antenna novelty is its shape and its ability to support UWB bandwidth requirements but also rejects three bands to avoid possible interference with existing communication system.The proposed antenna has good gain and efficiency at pass bands.

Index terms - Band notching,UWB.

I. INTRODUCTION

Ultra-wideband (UWB) has been getting progressively well-known from the scholarly and industry fields because of unlicensed band declared by the Federal Communications Commission (FCC) in 2002. As important part of UWB wireless communication system, the UWB antenna has drawn expanding consideration [1-4]. The possible UWB antenna ought to be designed with small size, good impedance matching, level group delay and omnidirectional radiation pattern [5]. In any case, a perpetual test is that there are interference between the composed UWB framework and some overlapping frequency bands. In order to avoid the interference, it is important to sift through the covering frequency bands. A common way to address this need is to connect filters to the UWB RF front end to block unnecessary frequency bands. However, this approach may consume an excessive amount of room and prompts huge increment in the outline intricacy. A feasible way is to implement band notching in UWB antenna to mitigate the interference. However designing and placement of these notch creating structures are challenging as compared to the traditional RF filtering technique [6-7]. In spite of the fact that different UWB printed antennas with band-notched functionality have been as of late displayed, a large portion of which were composed with one notched band [8], two notched bands [9-10], or three notched bands [11] at their mentioned frequency bands. In [12], a quadrilateral slot patch and ring resonators are designed on multilayered planes to produce notches at desired frequency bands. For instance, in [13] a single notch is created in UWB antenna by utilizing an open loop resonator on the back side of the substrate. A couple of nested C-shaped stubs are used in [14] to generate multiple notch bands.

In [15] crescent-shaped resonators are designed on the ground plane of the antenna and shorted with radiation element through via holes to generate multiple notches. Further, utilizing more minimal resonators for band-notch printed antennas is additionally worth concentrating on.This paper presents a modified UWB antenna of [10] in addition to modified E shape stub resonator on the back of the substrate to generate a third notch. In this paper a novel structure for the UWB antenna is proposed and analyzed in term of Reflection Coefficient, VSWR, Gain and Radiation Pattern. The notch bands in the proposed antenna are achieved using U-slot and meandered lines in the feeding line and radiating patch respectively. The third band is achieved by placing a modified E shape stub on the back of the substrate.

II. ANTENNA DESIGN

Figure 1 shows the geometry and configuration of the proposed antenna. The proposed UWB antenna is designed on Rogers 5880 having dielectric constant $\varepsilon_r = 2.2$ and height $h_s = 1.575mm$. The length of the feed line is λg/2 (where λg is guided wavelength). In order to obtain the characteristic impedance of 50 Ω, the microstrip line is calculated as 4.78 mm. The radiating element and the feed line are designed on the top of the substrate and the ground plane is designed on the bottom of the substrate. The modified E shape stub resonator is placed on the bottom of the substrate. The E shape stub resonator is connected with the radiating patch through via. The rectangular radiating patch is modified by double step cut in the lower edge of the main radiator. Bandwidth of the antenna is enhanced by proper cutting in the radiating patch.

The optimized parameters of the proposed antenna are given in Table 1.

Parameter	Dimensions(mm)	Parameter	Dimensions(mm)
a	4.5	g	2.54
b	4.0	h	4.04
c	4.5	i	8
d	2.275	j	5.1
e	7.85	k	5.6
f	4.31	l	4
Ws	4.78	Lg	8
ls	10.3	L1	11.5
L	34	L2	6
L3	5	L4	12

Table 1: Summary of the Dimensions of the proposed Antenna

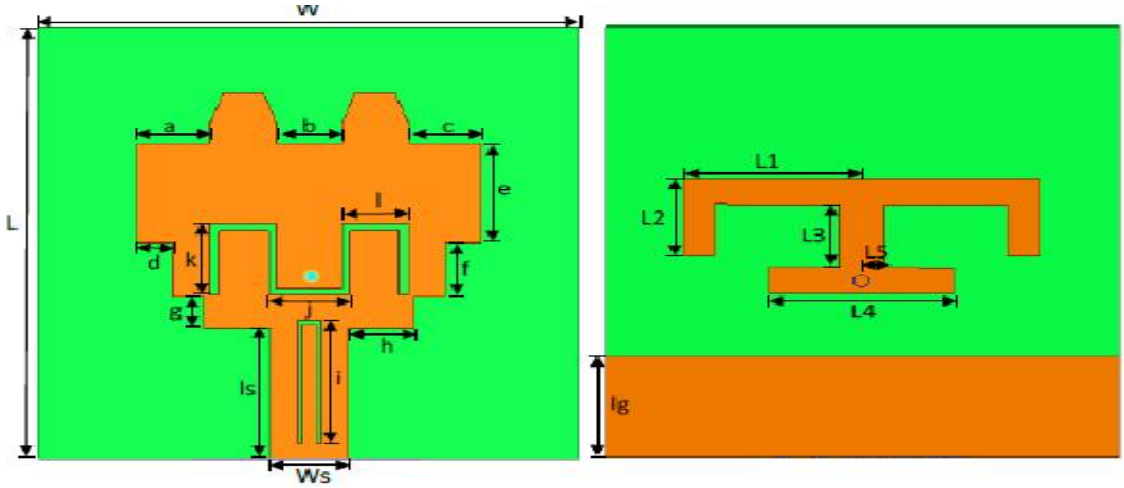

Fig. 1. Top and bottom view of the proposed UWB Antenna

The important challenge in the employment of band notching is proper placement of notching structures in the feed line, radiating patch or ground plane to effectively filter out the band of interest. The proposed notching structures are designed on the position where maximum current density can be achieved. HFSS software is used to conduct Finite Element Method (FEM) based simulations for this design. The antenna is analyzed with and without band notching functions. Firstly a modified maple leaf shape UWB antenna is designed and results showed that the proposed antenna covers a wide range of frequencies without having single notch. Meandered slots are made in radiating patch and feed line in the same design to achieve band notch functionality. The third notch band is achieved by placing a modified E shape stub resonator on the bottom of the substrate. The proposed design with band notch functionality is shown in Fig. 1. The band notch is implemented by using the following formula.

$$f_r = \frac{C}{2L\sqrt{\varepsilon_{eff}}} \quad (1)$$

And

$$\varepsilon_{eff} = \frac{(\varepsilon_r+1)}{2} \quad (2)$$

Where f_r = resonant frequency and L= length of the slot.

A. **Notching Structure for 2 GHz**

Figure 1 shows that modified E shape stub resonator is placed on the bottom of the substrate and is connected to the main radiating patch through via of radius 1mm. The modified E shaped stub is considered to be two $\lambda_g/4$ type resonators. The physical length of the resonator can be calculated by the following calculations.

$$L1 + L2 + L5 \approx \lambda_g/4$$

Surface current concentrated around the modified E shape stub is having opposite direction to the main radiation patch at the desired frequency to be blocked. Notch is created at desired frequency because of cancellation of the surface current of main radiating patch and E shape stub. The physical length calculated by the above calculations is 17.7 mm while the optimized value used in simulation to create a notch at the desired frequency is 18.1 mm. Surface current density of the proposed antenna at 2 GHz is shown in the figure 2.

B. Notching Structure for 3.11 GHz

The first structure of meander lines are designed on the main radiating patch to produce a notch at 3.11 GHz. Calculated length of the meandered linesto produce a notch at 3.11 GHz is 38 mm. The surface

current density of the proposed structure is presented in Fig. 3.

C. Notching Structure for 5.8 GHz

The second structure of U-shape slot is designed on the feeding line to filter out the unwanted frequencies centered at 5.8 GHz. Calculated length to produce a notch at 5.8 GHz is 20.4 mm. The surface current density of the proposed structure is presented in Fig. 4.

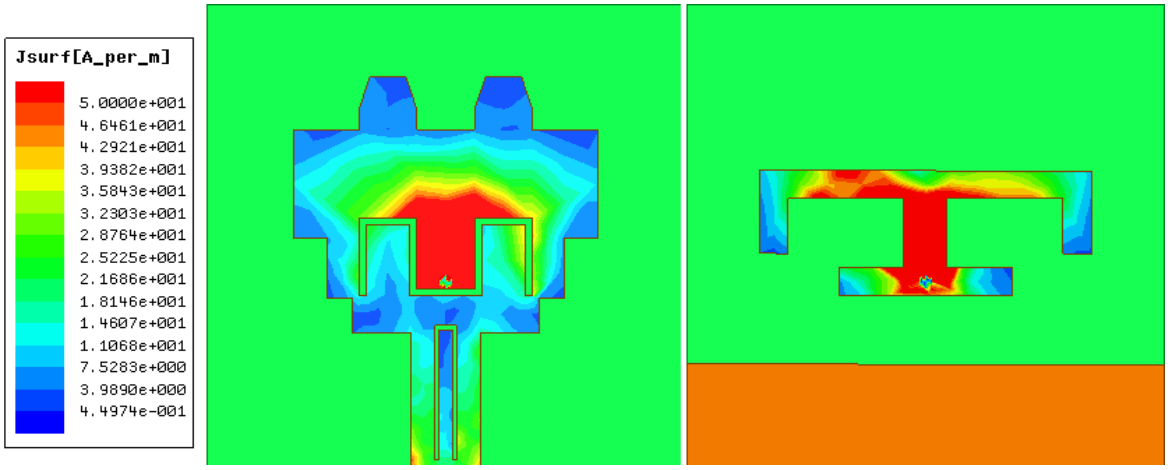

Fig. 2. Surface Current density at 2 GHz

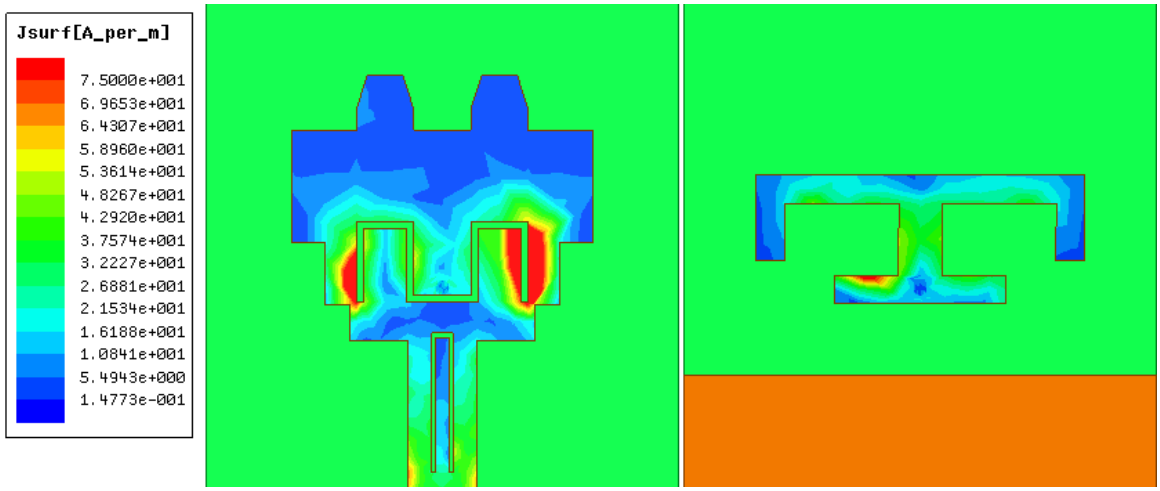

Fig. 3. Surface Current density at 3.11 GHz

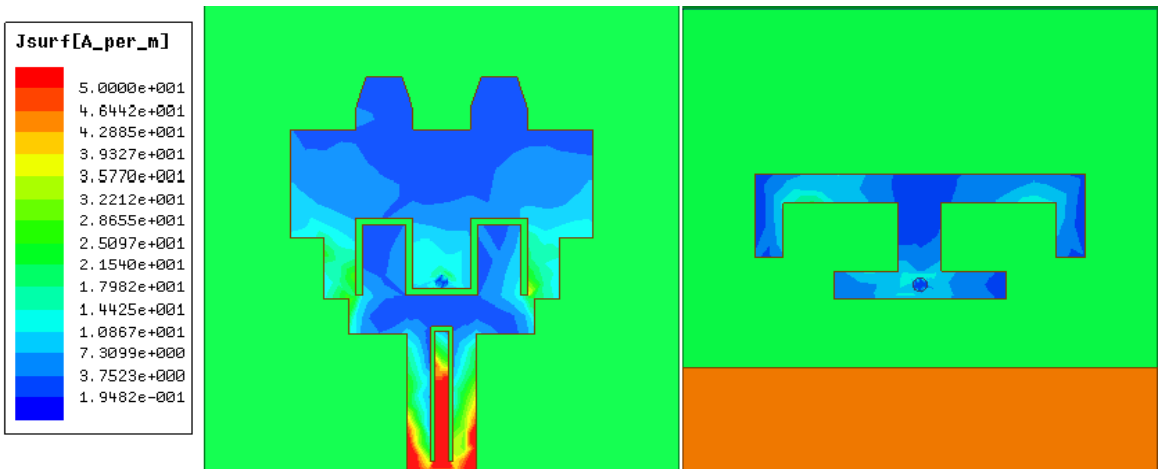

Fig.4 Surface current density at 5.8 GHz

III. RESULTS AND DISCUSSION

The results of the proposed UWB antenna design have been presented here. The reflection coefficient (S11), Voltage Standing Wave Ratio (VSWR) and gain of the proposed antenna are analyzed in the following sections.

A. Reflection Coefficient

Reflection coefficient (S_{11}) shows the fraction of power being reflected backwards from the antenna input to the excitation port. It is measured in decibel (dB) and is given by:

$$S_{11} = -20\log_{10}\left|\frac{Z_{in}-Z_0}{Z_{in}+Z_0}\right| \qquad (3)$$

Where, Z_{in} is the driving point impedance of the proposed antenna and Z_0 is the characteristic impedance of the 50 Ω SMA port. The simulated and measured result of the proposed UWB antenna is presented in Fig. 5.

It is obvious from Fig. 5 that the operating frequency of the proposed antennais from 1.4 GHz to 11.3 GHz. Modified E shape stub resonator is placed on the bottom of the substrate and connected with main radiating patch through via to produce notch at 2 GHz. Meandered line is made on the radiating element to produce notch at 3.11 and U-shape slot on the feeding line to produce notch at 5.8 GHz.

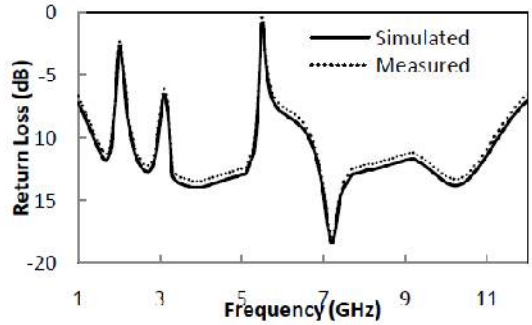

Fig. 5. S_{11} of the proposed antenna with and without notches

B. Voltage Standing Wave Ratio (VSWR)

VSWR is the ratio of the maximum to minimum voltage (or electric fields) along the transmission feed line of theproposed antenna. Fig. 6 compares the simulated and measured results of the proposed UWB antenna. The proposed antenna have VSWR<2 for all frequencies from 1.4 GHz to 11.3 GHz except the notch bands.

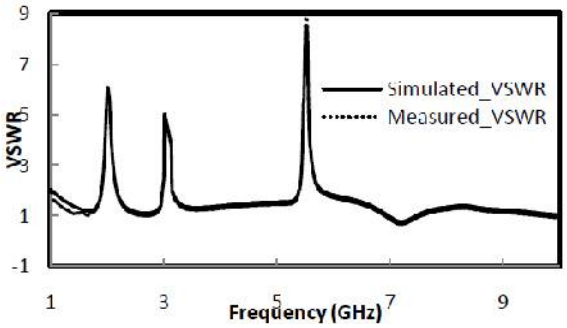

Fig.6 Simulated and Measured values of proposed UWB antenna

A good agreement between the simulated and measured results is observed.

C. Surface Current Density (Jsurf)

The effect of the notching structure is analyzed with the help of surface current density as shown in Fig. 2, Fig. 3 and Fig. 4. High surface current density is observed around the notching structure at relevant resonant frequencies.

D. Radiation Charateristics

The radiation characteristics of the tri band notch UWB antenna are analyzed at 1.6 GHz, 2.66 GHz and 7.2 GHz. Simulated and measured Radiation Pattern for phi= 0^0 and phi= 90^0 are shown in Fig. 7, Fig. 8 and Fig. 9. It is clear from Fig. 7, Fig. 8 and Fig. 9 that the radiation pattern at lower frequencies is omni directional while a little distortion at higher frequency is observed. The gain of the antenna is found to be 4 dB at 1.6 GHz, 3.7 dB at 2.6 GHz and 4.5 dB at 7.2 GHz.

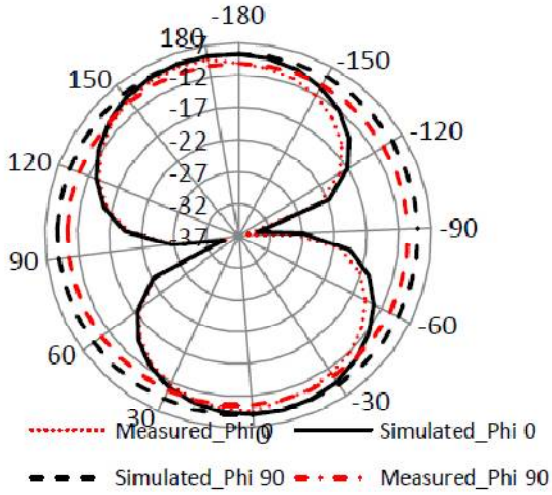

Fig. 7Radiation Pattern of the proposed UWB antenna at 1.6 GHz

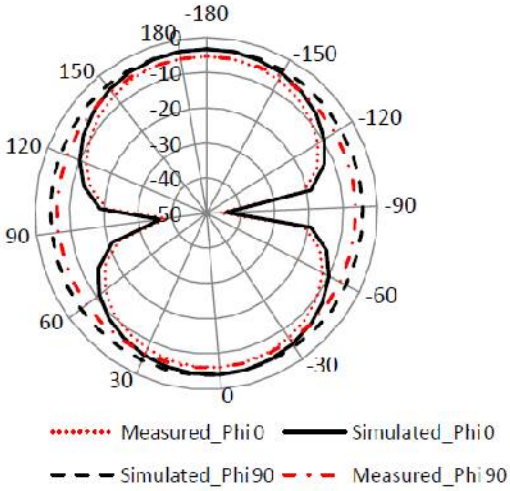

Fig. 8 Radiation Pattern of the proposed UWB antenna at 2.66 GHz

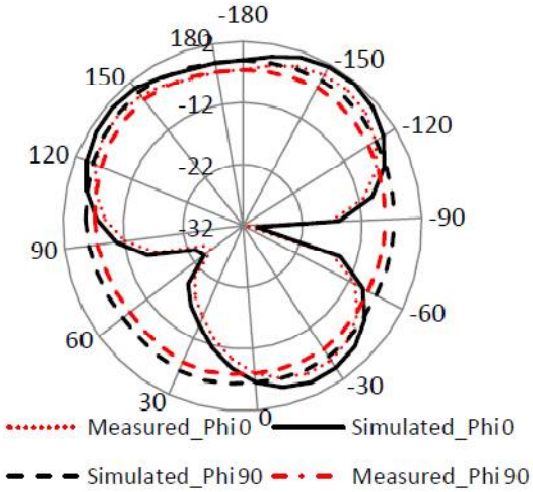

Fig. 9 Radiation Pattern of the proposed UWB antenna at 7.2GHz

E. Gain

The simulated maximum gain of the proposed UWB antenna is shown for the tri band notch in Fig. 10. It is very clear from Fig. 10 that the proposed UWB antenna has somewhat flat gain for all pass bands. Howeverthree sharp reductions in the gain representing three band notches can be observed as shown in Fig. 10. The reduction in the gain is because of the three sharply notched bands.

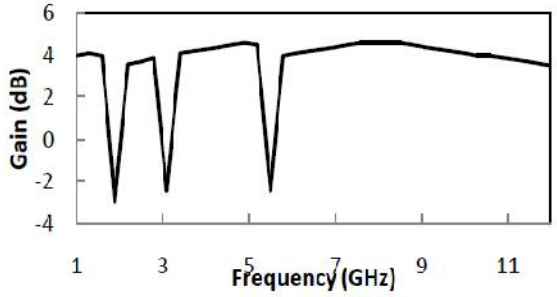

Fig. 12. Simulated Gain of the proposed antennas with dual notches

CONCLUSION

This paper proposes a modified Maple leaf shape UWB antenna with tri band notch functionality. The antenna is simulated and fabricated on the low loss material of Rogers 5880 substrate having relative permittivity of 2.2. The antenna system has compact dimensions of 33×34×1.575 mm. Notches in the proposed antenna are created by optimally placing notching structures in the radiation element, feeding line and placing modified E shape stub resonator on the bottom of the substrate connected with radiating patch through via. Antenna system is analyzed with help of Return loss, VSWR, surface current density and radiation characteristics and gain. A good agreement is observed between the simulated and measured results.

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