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A Compact CPW-Fed UWB Antenna with Single Band-Notch Characteristic

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Abstract- In this paper, a compact co-planar waveguide (CPW) -fed Ultra-wideband (UWB) antenna with single band-notch characteristics is proposed. The proposed design consists of conventional rectangular patch with the loading of inverted L-shape strip. The antenna has a compact size of 25 mm × 32.4 mm with thickness of 1.6 mm. The proposed antenna is designed on a low-cost FR4 epoxy dielectric substrate with relative permittivity of $\varepsilon_r = 4.4$. The proposed antenna can operate from 3.1 – 10.6 GHz of UWB frequency range with single band notch from 2.4 – 4.0 GHz frequency band for WiMAX application. The proposed antenna provides good return loss (S11) of < - 10 dB and VSWR ≤ 2 under the desired frequency range. The antenna provides resonance frequency at 7.2 GHz with -34.65 dB as a return loss. The proposed antenna is designed and simulated with the help of Ansoft HFSS electromagnetic simulator software. The simulated results of the proposed antenna such as return loss, VSWR, radiation pattern, field plots are presented.

Index Terms- Compact, CPW, Ultra-wideband (UWB), WiMAX, Return loss, VSWR, Resonance frequency, HFSS

1. INTRODUCTION

The Federal Communications Commission (FCC) released unlicensed frequency spectrum from 3.1 - 10.6 GHz for UWB commercial communication applications [1] with the value of EIRP is less than - 41.3 dBm/MHz. The UWB antenna has several advantages like low profile, easy integration with monolithic microwave integrated circuits (MMICs), simple patch structure, high data rate, low cost and ease of fabrication. Therefore UWB antenna now become an integral part of all wireless communication systems for short-range high-data applications, ultra-fast communications, sensing applications and so on. In nowadays, there is increasing trust on wireless communication to deliver products and services from mobile telephone to wireless internet to network devices and peripherals so that UWB technology is required [2-3] and this is why many researcher have given their attention to design UWB antenna. On the other hand, UWB antenna has some issues to design compact size antenna to cover whole UWB frequency band while retaining special attractive features of UWB antenna such as large bandwidth, Omni-directional radiation patter, planar monopole antennas, simple structure [4-5]. To design UWB antenna, many wideband planar antennas structure have been described [6-8]. Different shapes of monopole antennas such as rectangular patch [9-10], circular monopole with steps [11-12] and Fork-Shaped monopole antenna [13] are reported.

However, the UWB frequency spectrum has been assigned for different applications such as WiMAX, WLAN, and Radar etc. So that it is necessary to use a band-notch filter characteristics that will stop the desired frequency band but this will increase the complexity level of the UWB structure. Therefore, many antennas with band-notch characteristics have been reported [14-16] such as inverted cone slot [17], tapered slot with tuning patch [18], band-notched monopole antenna [19], tapered-shape slot antenna [20], dual band-notched with folded SIRs [21], open-slot antenna [22].

In this paper, a novel, compact, simple and low cost UWB antenna with band-notch characteristics is proposed and designed. The proposed antenna consists of radiating patch and ground structure. The radiating patch is rectangular in shape which is loaded with inverted L-shape strip. The compact rectangular aperture antenna is fed by a 50Ω CPW transmission line in which end is terminated by a rectangular tuning stub. The proposed antenna provides good radiation pattern and can be operate from 3.1GHz – 10.6 GHz frequency band except 2.4 GHz – 4.0 GHz frequency band. The IEEE 802.16m standard is adopted for Worldwide Interoperability for Microwave Access (WiMAX) of wireless communication which provide multiple physical layer (PHY) and Media Access Control (MAC) options. WiMAX covers 2.5 GHz – 5.8 GHz frequency spectrum. The entire WiMAX frequency band is divided into three bands namely low band (2.5 GHz-2.69 GHz), middle band (3.2 GHz- 3.8 GHz) and upper band (5.2 GHz – 5.8 GHz). The simulated result shows that the low band and upper band are notched with resonance at 3.24 GHz.

2. ANTENNA DESIGN

The geometry and dimension of the proposed UWB antenna is shown in Fig.1. The antenna is designed on the FR4 Epoxy substrate of relative permittivity ε_r = 4.4. The overall size of the antenna is L × W where L = 25 mm and W = 32.4 mm with thickness of h = 1.6 mm. The width of the CPW fed is Wf to achieve the 50Ω characteristics impedance. The width of the feed line Wf where Wf = 3.2 mm and the distance between the feed line and ground is fixed at t = 0.8 .mm. The length of ground is Lg1 and Lg2 where Lg1 = 10 mm and Lg2 = 8 mm. The proposed antenna design consist of a rectangular patch of dimension L1 × W1 where L1 = 5.8 mm and W1 = 14 mm. The rectangular patch is loaded with in inverted L-shaped strip with dimension parameters of a, b and c. In the proposed UWB antenna, the inverted L-shaped strip is designed at the right side of the rectangular patch antenna. The strip width is 1 mm wide.

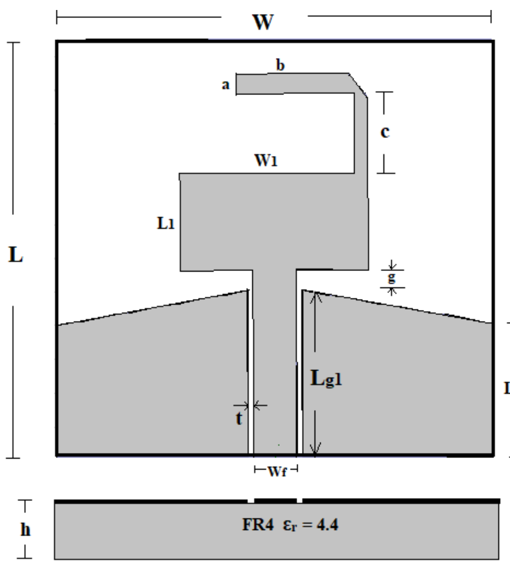

Fig.1. Schematic geometry of the proposed CPW-fed UWB antenna

Table -1: Proposed UWB antenna design parameters

Parameters	Value (mm)	Parameters	Value (mm)
L	**25**	**Wf**	**3.2**
L1	**5.8**	**t**	**0.8**
Lg1	**10**	**g**	**1.2**
Lg2	**8**	**a**	**1**
W	**32.4**	**b**	**7**
W1	**14**	**c**	**4.7**

The resonator can be designed by the following equation

$$\lambda_g = \frac{c}{f\sqrt{\varepsilon_{eff}}}$$

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

3. SIMULATION RESULT

The proposed UWB antenna is designed and simulated with the help of HFSS simulator tool. The simulated results such as return loss, VSWR, radiation pattern are shown in following figures.

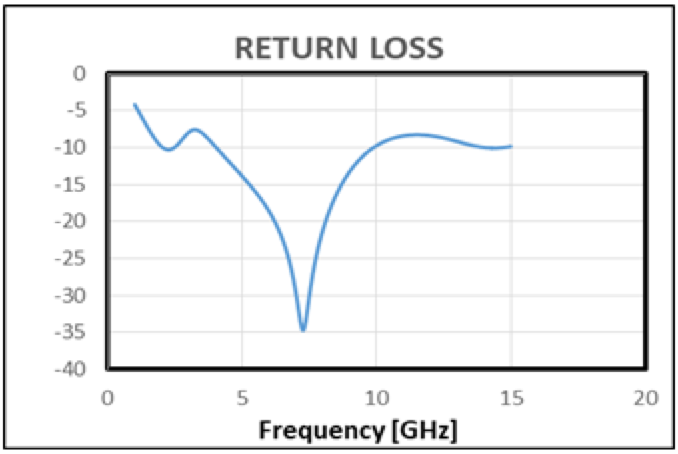

Fig.2. Simulated return loss (S11) of the proposed UWB antenna

In fig.2, the simulated return loss of the proposed UWB antenna is shown. From the graph, it is seen that the proposed UWB antenna satisfy the minimum requirement criteria of return loss of < -10 dB in the required frequency spectrum as well as in band-notch spectrum.

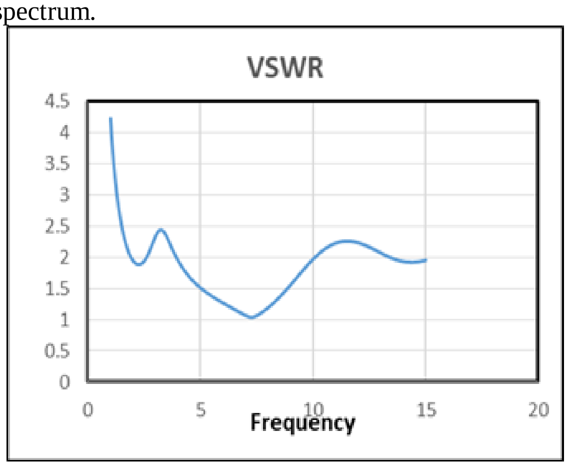

Fig.3. Simulated VSWR of the proposed UWB antenna

In fig.3, the simulated VSWR is presented of the proposed UWB antenna. The result shows that it fulfils the requirement criteria (VSWR ≤ 2) for both operating frequency band and band-notch spectrum.

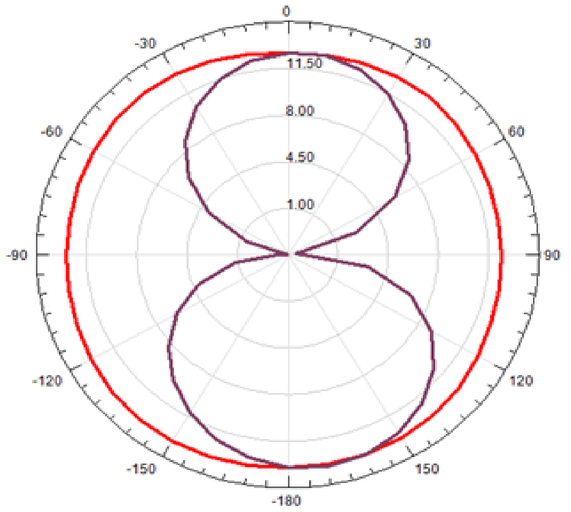

Fig.4. Simulated radiation pattern of the proposed UWB antenna

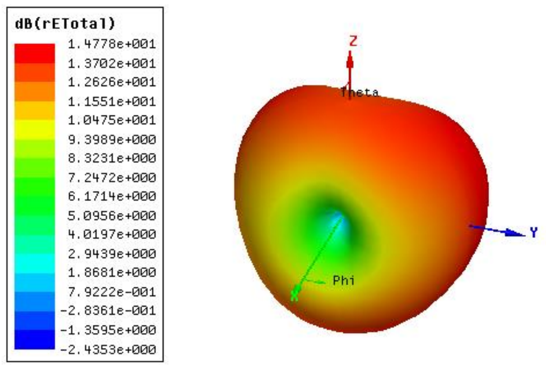

Fig.5. Simulated 3-D Polar Far Field pattern of the proposed UWB antenna

In fig.4 and fig.5, the radiation pattern and 3D polar far field pattern of the proposed UWB antenna are presented. From the figure it is clear that the proposed antenna is omnidirectional and stable radiation pattern over the entire operating bandwidth.

4. CONCLUSION

A novel, compact and light weight UWB antenna is designed with rectangular shaped loaded with inverted L-shaped strip as a radiating patch element. The size of the designed antenna is 25 mm × 32.4 mm which is compact in size. The proposed antenna exhibit excellent return loss, VSWR, radiation pattern, far-field pattern over the entire UWB frequency band from 3.1 GHz -10.6 GHz where low band (2.5 GHz-2.69 GHz) and middle band (3.2 GHz – 3.8 GHz) of WiMAX frequency band are notched. Therefore the simulated results makes the proposed antenna is a suitable candidate for Ultra-wideband (UWB) applications along with band-notch characteristics.

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