A Microstrip-Fed UWB Antenna for WCDMA and X-Band Applications

Alaa desher farhood[1], Maham kamil naji[2], Dr.Seham ahmed hashem[3]

1) *Middle Technical University(MTU), Assist. Lecturer., Technical Electronics Department,Technical Instructors Training institute , Baghdad, Iraq.*
2) *Middle Technical University(MTU)Assist. Lecturer., Technical Electronic Department, Institute of Technology, Baghdad, Iraq.*
3) *Middle Technical University(MTU), Lecturer., Technical Electronics Department,Technical Instructors Training institute , Baghdad, Iraq.*

Abstract— In this paper, a novel ultra-wideband (UWB) antenna is proposed. This proposed antenna is microstrip-fed in design. The proposed antenna has dual band characteristics for Wideband Code Division Multiple Access ,WCDMA (1.9-2.1 GHz) at the center frequency of 2 GHz and X-band (8-12 GHz) with resonant frequency of 10 GHz. The design of proposed structure comprises of a rectangular patch and two inverted and identical rectangular strips. A rectangular patch design is employed to operate antenna on UWB frequency band from 3.1-10.6 GHz. The dimensions of proposed antenna is also minimized to increase the antenna gain and high impedance bandwidth. On the back side of antenna, a ground plane is designed. The ground structure is modified and connected with two inverted L-shaped strips to obtain the dual band characteristics resonant at 2 GHz and 10 GHz respectively. The proposed antenna is designed using FR4 substrate of compact dimension 25 mm × 25 mm × 1.6 mm. The microstrip antenna is fed by 50 Ω. The simulated results of proposed antenna are good and shows neary omnidirectional radiation pattern, constant gain, small group delay. The return loss (S11) is < -10 dB and VSWR is also < 2 throughout the UWB band. At 2 GHz and 10 GHz resonant frequencies, the S11 are -21dB and -23dB respectively. The designed antenna configuration is simulated and analysed by using high frequency structure simulator (HFSS).

Keywords - *Ultra-wideband (UWB), WCDMA, X-band, Microstrip antenna, Antenna gain, Return loss, HFSS, VSWR*

I. INTRODUCTION

In 2002, the Federal Communications Commission (FCC) allotted the spectrum bandwidth for ultra-wideband system with the frequency bandwidth from 3.1 to 10.6 GHz including EIRP of -41.3 dBm/MHz as an effective isotropic radiated power [1]. The microstrip UWB antennas have lots of good features such as negligible power consumption, simple structure, cost effective, maximum data rate, omnidirectional, easy to fabricate with maximum accuracy. Therefore, UWB antennas become most promosing research area for result of modern communictions and it attracts lot of researcher's concentration for the development and to improve the performance of UWB antenna. While in designing, microstrip UWB antennas also face some challenges like small in size, electromagnetic interference and good impedance matching, channel capacity [2]. Due to the limited bandwidth and high usage, it is necessary to use a single antenna for radiation more than one frequrency bands [3-8]. IEEE 802.15.3a (TG3a) provides the solution for UWB technology [9]. The microstrip antenna contains of patch, ground and substrate materials. The radiating patch is designed on the upper surface of substrate and that of ground plane is on the lower surface of the substrate [10].

To design UWB antennas working in 3.1 – 10.6 GHz bandwidth, different types of antennas have been designed and the shaped of radiating patch is also different such as planar square, disc antenna, diamond shape antenna, butterfly shape, rectangular, circular, and elliptical [11-15]. The discussed different shape of antennas are used to achieved larger impedance bandwidth using several radiating patch structure. UWB antennas with compact size have also designed with different structure like circular, cone slot, tapered patch antennas [16-18]. In order to integrate multiple frequency band with UWB applications, several types of antennas are used like slot antenna [19], combination of T-shape and E-shape slots for multiple bands [20] like GSM/WCDMA/WLAN. A triangular patch with ring slot provides dual band result [21]. A hexagonal shape radiating patch is used to obtained triple band integrated UWB antenna, fork-shaped UWB antenna integrated with Bluetooth application [22-24].

In this research article, a novel compact UWB antenna is proposed and integrated other two dual band characteristics for WCDMA at 2 GHz and X-band at 10 GHz respectively. The designed structure consists of rectangular patch above the dielectric and ground structure is at the lower surface of dielectric. This ground is connected with two similar inverted L-shaped strips. The function of strip is to obtain other two dual band frequency bands.

II. ANTENNA DESIGN AND CONFIGURATION

The configuration of the proposed design is shown in fig.1. The geometry of the proposed design consists of radiating patch element, substrate and a ground plane. The radiating patch is rectangular with slot and placed on top surface of dielectric. The rectangular ground structure is attached with two inverted L-shaped strips to obtain dual resonant frequency. The antenna is designed on an FR4 substrate of dimension 25 mm × 25 mm of thickness 1.6 mm. The dielectric constant (ε_r) and loss tangent ($\tan\delta$) are 4.4 and 0.024 r espectively. The UWB characteristics is obtained by using rectangular patch and the length of antenna is about quarter-wavelength $\lambda_g/4$ and the λ_g is given by

$$\lambda_g = \frac{\lambda_r}{\sqrt{\varepsilon_{eff}}} = \frac{c}{\sqrt{\varepsilon_{eff}}\, f_r} \quad \ldots\ldots. \quad (1)$$

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

In above equations, c represents the velocity of light, λ_r is the resonant wavelength, f_r is resonant frequency, ε_r is the permittivity of material and ε_{eff} is effective dielectric constant.

The size of ground is 8 mm × 25mm.The connected identical strips are responsible of extra two bands. The size of each identical inverted L-shaped strip is (16 + 9.6) mm × 1mm .

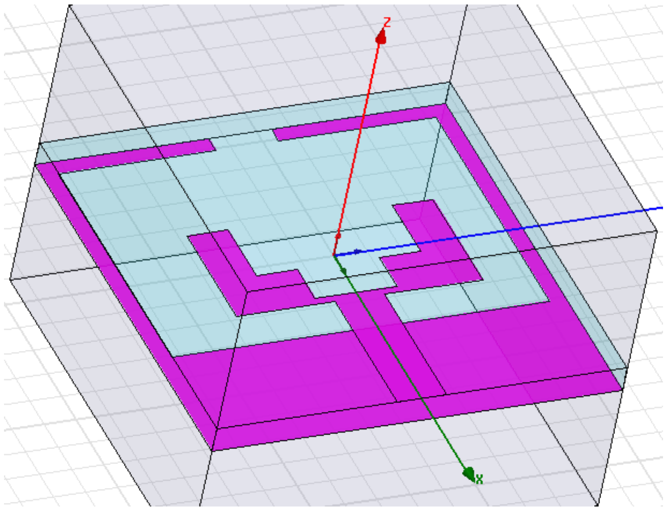
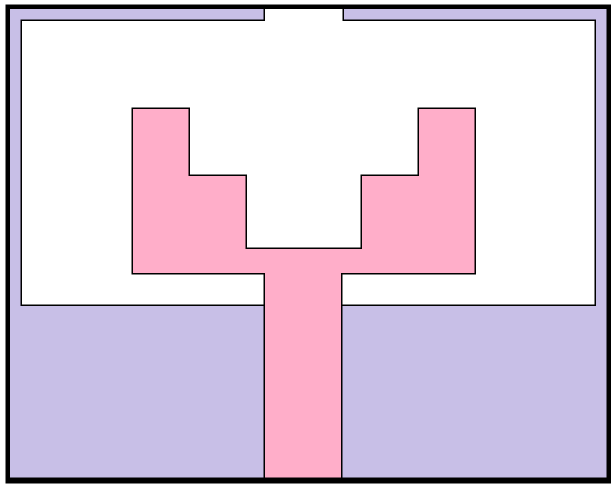
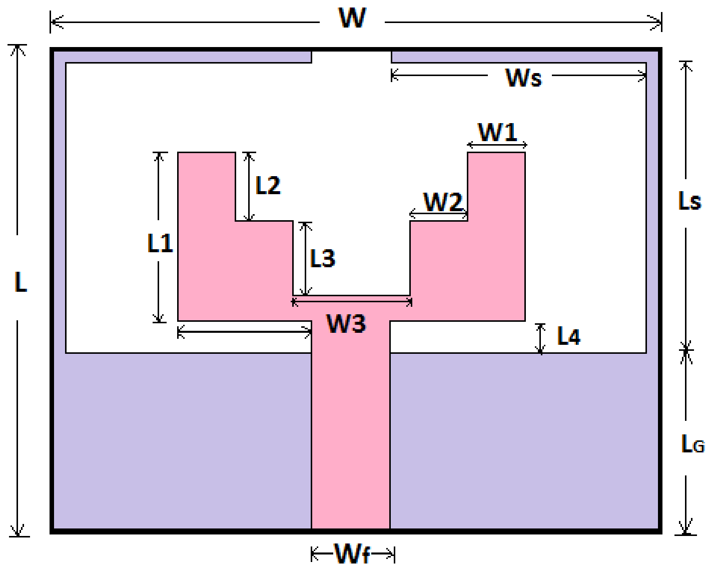


Fig.1. HFSS design of proposed antenna



(a) Genereal view of proposed antenna.

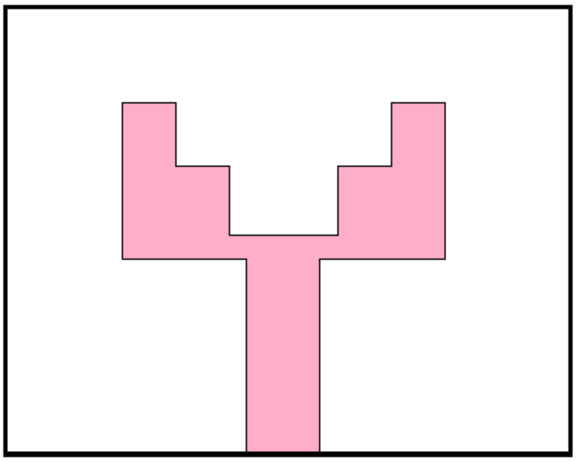


(b) Design parameters and dimensios of proposed antenna

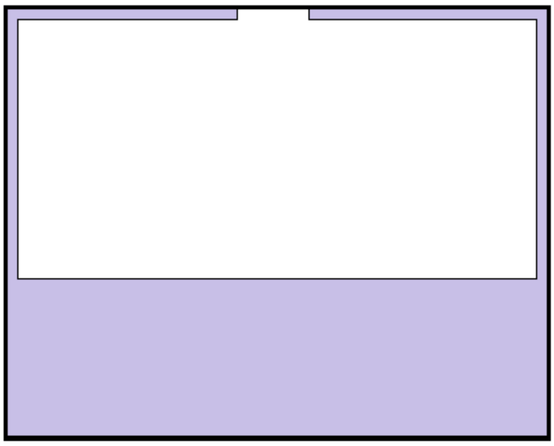
Fig.2. Schematic configuration and dimensions of the proposed UWB antenna

Table1: Antenna design parameters and dimensions

Parameters	Value (mm)	Parameters	Value (mm)
L	25	W	25
L1	7	W1	2.5
L2	4	W2	2.5
L3	6.5	W3	5
L4	0.8	W_f	3
Ls	16	Ws	9.6
L_G	8	h	1.6



(a) Top View



(b) Bottom View

(c) Front View

Fig.3. Different views of proposed antenna (a) Top view (b) Bottom view (c) Front view

III. RESULT AND DISCUSSION

The structure of proposed UWB microstrip antenna is designed by using Ansoft HFSS software. The antenna is simulated by using HFSS tool. This simulation software is most widely used tool for high frequency application and is worked on FEM technique [25]. From the simulation, the various types of electromagnetic parameters are simulated such as return loss, VSWR, radiation pattern and gain.

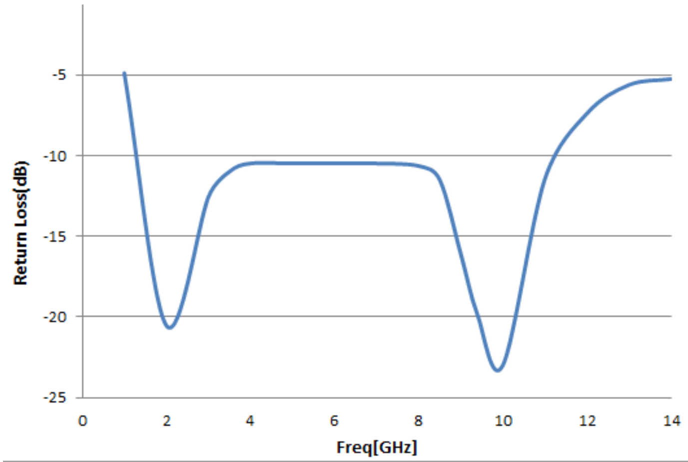


Fig.4. Return loss (S_{11}) of proposed UWB antenna

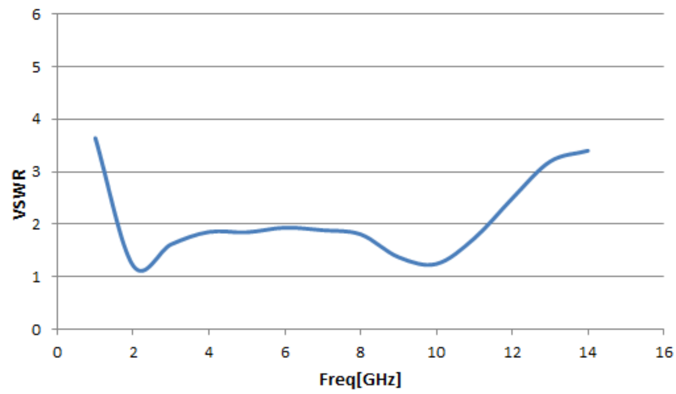
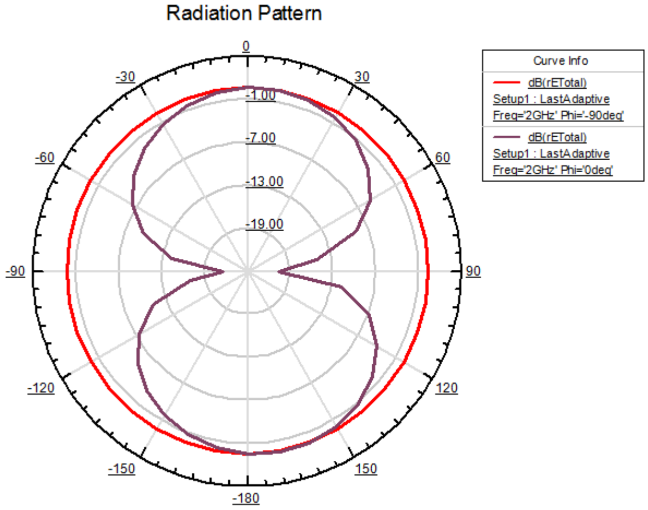
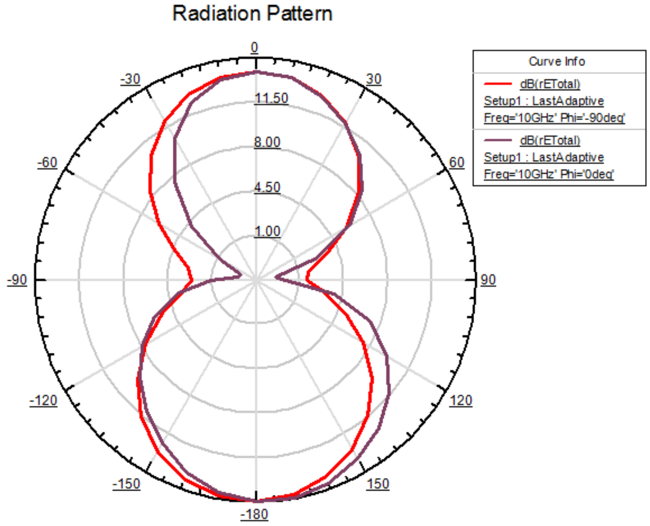


Fig.5. VSWR of proposed UWB antenna

In fig.4, the return loss of proposed antenna is obtained and it is < -10 dB throughout the desired frequency bandwidth. It covers the UWB spectrum with good agreement result along with other two values -21 dB at 2 GHz and -23 dB at -23 GHz frequencies respectively. In fig.5, VSWR of proposed antenna is presented, which is also satisfactory result and it is < 2 for the entire frequency band.

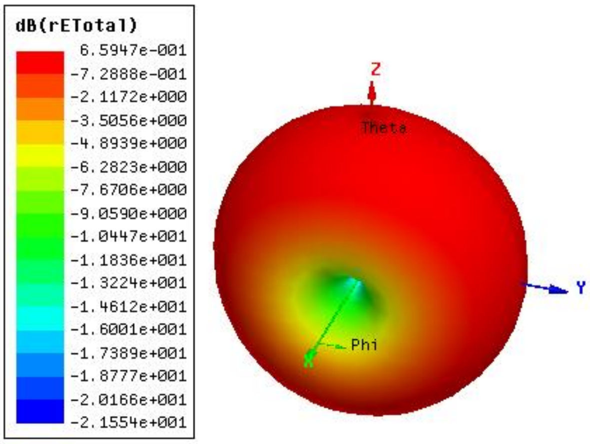


(a) Simulated Radiation pattern at 2 GHz

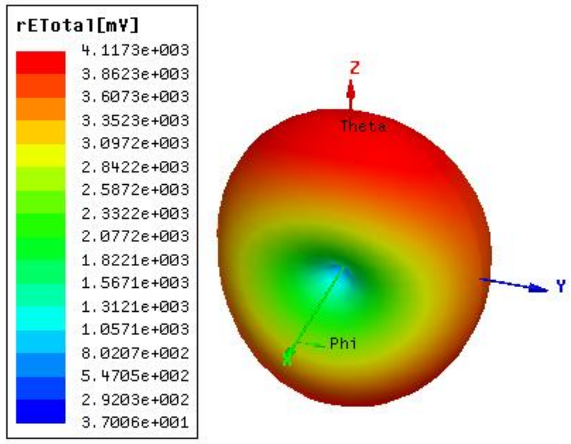


(b) Radiation pattern at 10 GHz

Fig.6. Radiation pattern of proposed UWB antenna (a) at 2 GHz and (b) at 10 GHz



(a) 3-D Field pattern at 2 GHz



(b) 3-D Field pattern at 10 GHz

Fig.7 3-D field pattern of the proposed UWB antenna (a) at 2 GHz and (b) at 10 GHz

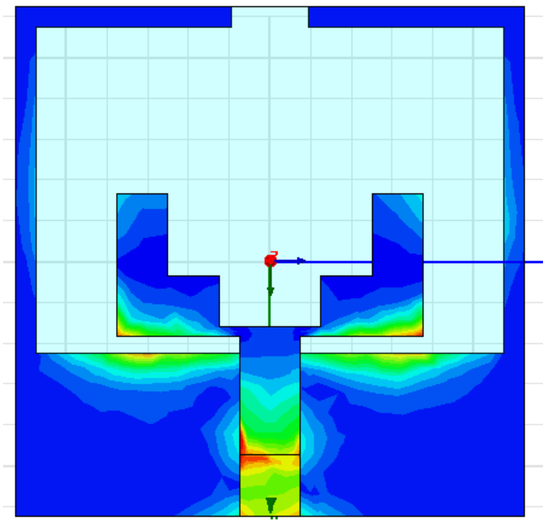


Fig.8 E-field in the proposed UWB antenna

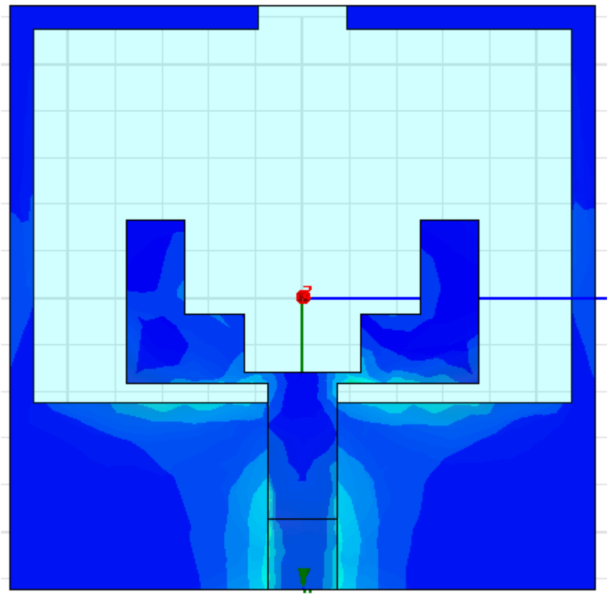


Fig.9 H-field in the proposed UWB antenna

IV. CONCLUSION

A new type of UWB antenna is desingned in this paper. It is cost effective, simple and small in size antenna. The above designed antenna is applicable for both UWB frequency spectrum from 3.1 to 10.6 GHz frequency spectrum and other two frequencies bands such as at 2 GHz and 10 GHz respectively. The lower frequency band ie 2 GHz is utilize for Wideband Code Division Multiple Acess (WCDMA) applications and the upper frequency band ie 10 GHz is utilize for X-band applications such as radar application. By designing the rectangular patch, UWB antenna result is obtained and by using two identical reversed L-shaped strips attached to the ground plane, other two frequencies bands are integrated along with original result. From the simulated result, all the electromagnetics parameters are under the desired and good conditons. The simulated return loss is less than -10 dB and VSWR is also less than 2 for both UWB and dual band range. The return loss for WCDMA is -21 dB and -23 dB for X-band. Also the antenna result provide good impedance matching, omnidirectional radiation pattern throughout the frequency spectrum 1.8 – 11.8 GHz. Therefore the proposed antenna is good candidate for UWB system and integrated with dual band applications.

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