Compact CPW-Fed Dual Band Triple Square Ring Uwb Antenna

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Abstract— **In this letter, a triple square ring antenna for ultra wideband (UWB) applications is proposed. The proposed structure can be used as the microwave absorber (MA) for the indoor application anechoic chambers. The overall shape of antenna consist of two square ring resonator with different sizes, back ground plane and substrate with a 1mm thickness. The antenna consists of small square ring resonator radiating patch is surrounded by large square ring radiating patch. This square ring resonators Provides a broadband due to two peaks. This antenna will operate at 9.4GHz. This antenna proposed to overcome the narrow bandwidth. The measured result reveals that we get dual resonance one at the range of 4-6GHz &other at 8-10GHz. 4-6GHz is called as C-band used for application like satellite services, WiMAX and WLAN. 8-10 GHz is called X-band and used for application like radar. The patch design simulated in Soft HFSS software shows satisfactory performance.**

Keywords— CoPlanar Waveguide, square ring, resonator, Narrow bandwidth, return loss, radiation pattern.

I. INTRODUCTION

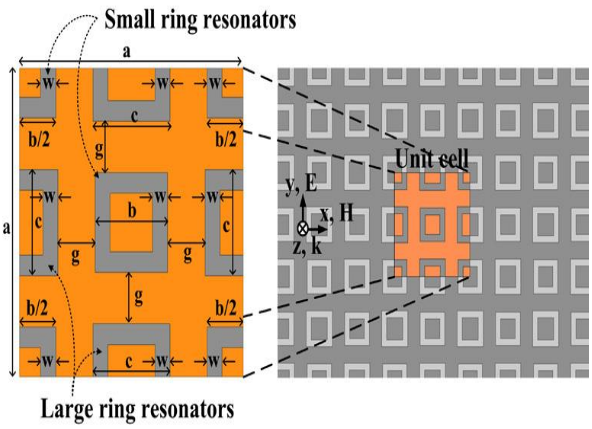
Ultra wideband (UWB) technology plays a vital role in the wireless communication world in recent years due to their great features such as low power consumption and high speed data rate. Slot antennas are currently under consideration for use in broadband communication systems due to their attractive features, such as wide frequency bandwidth, low profile, light weight, easy integration with monolithic microwave integrated circuit, low cost, and ease of fabrication [1]. These antennas have several advantages over common microstrip antennas as they provide good impedance matching, and bidirectional or unidirectional radiation pattern. According to Federal Communication Commission (FCC) the frequency band from 3.1-10.6 GHz is specified for UWB in 2002. Slot antenna using CPW feeding mechanism provides several advantages over microstrip line feed, such as low dispersion, low radiation leakage, ease of integration with active devices [2]-[3]. When the antenna is fed by microstrip line, misalignment can result because etching is required on both sides of the dielectric substrate. Using CPW feeding technique alignment error can be eliminated. In CPW the conductor formed a center strip separated by a narrow gap from two ground planes on either side. Slot antenna results into wideband characteristic with CPW fed line having square slot [4] and CPW-fed hexagonal patch antennas [5] are demonstrated in the literature. In CPW-fed slot antenna by varying the dimensions of the slot and keeping it to the optimum value for wide bandwidth and proper impedance matching. In slot antenna geometries different tuning techniques has been carried out like circular slot [6], bow-tie slot [7], and wide rectangular slot [8].

Research involving electromagnetic absorbers (EMAs) has been widely conducted for various applications such as anechoic chambers, electromagnetic interference/ electromagnetic compatibility (EMI/ EMC) control systems, and concealment applications [9]–[10]. EMAs are primarily classified into three types. The most widely used absorber type is the wedge tapered absorber [11]. It usually has a pyramidal-shaped array to absorb and scatter electromagnetic waves in the broadband and is commonly used in anechoic chambers. However, this absorber is bulky and fragile and therefore, is not suitable for portable applications. Another type of EMAs is the lossy absorber, which uses high-permeability or permittivity-composite materials [12]. It also has high absorptivity in the broadband. However, it is quite expensive because of the scarcity of the materials. Generally, in FSS absorber design, a periodic resonator patch is located on the top side of a lossy substrate and the ground is placed on the back side of the substrate [13].

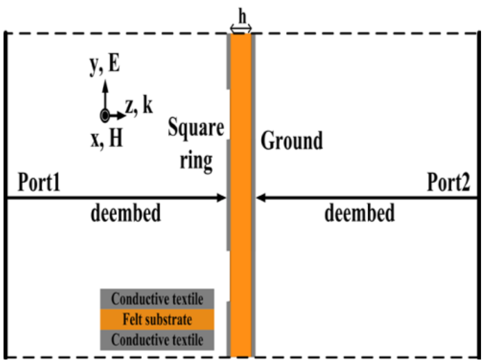
UWB technology or concept was used in the first spark based radio invented by Marconi in 1895. The modern UWB for wireless communications started with the study of time domain electromagnetic in 1960s and was developed for wireless communications in 1970s and 1980s. A lot of pioneering work has established the basis of the impulse radio systems for military communication applications. Meanwhile, academia and industry are exciting to the release of extremely wide spectrum for commercial UWB application but facing many technical challenges for practical applications. Among the UWB wireless connection systems, the high data rate wireless USB may be the most promising applications. Therefore, the antenna designers especially from industry have long paid attention on small and embeddable UWB antennas. Both academic and industry have proposed many types of small UWB antennas especially on PCB or ceramic. The antennas with low profile are easy to be integrated into other RF circuits on the PCB or embedded into small and portable devices. Proposed antenna design model is studied at multiband [14-16],[19] and is applicable for UWB technology. In this paper, a UWB antenna which can operate as microwave absorber (MA) for indoor radar clear applications is proposed. To overcome the narrow absorptivity bandwidth of the resonance-based microwave absorber, a unit cell of the proposed MA is designed to have dual resonances at 5.8GHz and 9.7 GHz. Because the MA has polarization- and deformation-insensitive features, it can be integrated on the cloth and used for indoor radar-absorbing materials.

II. EASE OF USE

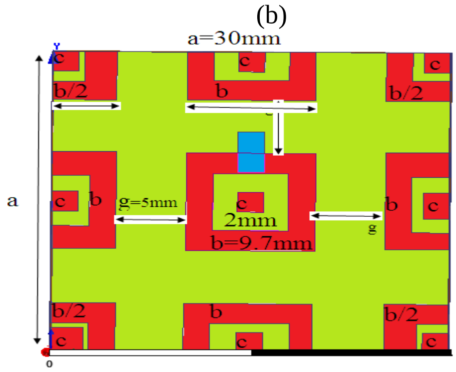
Fig. 1 shows the geometry of the proposed MA UWB antenna. The unit cell of the absorber consists of square ring resonators, a backing ground plate, and a felt (εr=1.2; tanδ=0.02) substrate with a thickness of 1 mm. On the top of the substrate, a square ring grid array consisting of smaller square rings and larger square rings is used, as shown in Fig.1(a).



(a)



(b)



(c)

Fig. 1. Geometry of the proposed WMMA (a = 30 mm, b = 9.7 mm, c = 10.3 mm, w = 2 mm, g = 5 mm, and h = 1 mm): (a) magnified view of the unit cell and periodic structure, and the (b) side view indicating the direction of the incident waves (c) Layout of modification

Employing the grid array with two types of resonators generating different resonances is utilized to achieve the broadband absorptivity. The full ground is placed on the bottom of the substrate, as shown in Fig. 1(b). To analyze the performance of an infinite array of the proposed WMMA shown in Fig. 1(a), the unit cell is simulated with periodic boundary conditions and Floquet-port excitations using ANSYS HFSS [15-17].

To determine the absorptivity values, the incident electromagnetic wave is excited along the z-axis, as shown in Fig. 1(b). Since 2002, the FCC has concentrated in the research and design of commercial UWB system [18], we have proposed this structure. The proposed antenna is formed by etching one wavelength slot λg located symmetrically with respect to the center of the CPW fed line

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$$\lambda_g = \frac{c/f}{\sqrt{\varepsilon_{eff}}} \quad (1)$$

where ε_{eff} is the effective dielectric constant of CPW fed line and f is the resonant frequency.

In the CPW, the effective dielectric constant is independent of geometry and is equal to the average of dielectric constants of air and of the substrate.

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

III. USING THE TEMPLATE

CPW fed slot antenna is model using FR-4 substrate with ε_r = 4.3, height of the substrate h= 1.59 mm and loss tangent 0.01 with ground plane of size 24×23 mm. The basic structure of the proposed system consists of 3 layers. The lower layer constitutes the ground plane, covers the square shaped substrate with 30×30 mm. The middle substrate which is made of FR4 epoxy Constant ε_r = 4.4 and height 1 mm. The upper layer, which is the patch, covers the rectangular top surface.

The square patch has sides 30×30 mm. we consist of two port one port is placed at the front and other is placed backside. With the assignment of lumped port the simulation was performed using HFSS. Convergence was tested for a number of times. Once convergence was obtained simulations were conducted in order to obtain swept frequency response extending from 4-6GHz to 8-10GHz. The optimized dimensions are given in table .1.

TABLE.1. OPTIMIZED DIMENSION OF PROPOSED ANTENNA

Parameter	Description	Optimal value in mm
a	Width of square ring	30
b	Width of of small ring resonator	9.7
c	Length of small ring resonator	10.3
w	Gap between inner & outer layer in small ring resonator	2
g	Spacing between unit cell	5
h	Substrate thickness	1

CPW feeding technique eliminates all counter problems as it provides low Dispersion, reduces Radiation loss, supports surface mounting of active and passive devices, Bandwidth enhancement , Reduces cross-talk. In the CPW two fundamental modes are supported: the coplanar mode, and the parasitic slotline mode. CPW supports Quasi-TEM mode of propagation hence it has longitudinal components in the direction of propagation. Using conductor backed CPW it has additional ground plane at the bottom surface of the substrate. It provides mechanical support to the substrate and also acts as a heat sink for active and passive circuit devices. In CPW the conductors formed a center strip separated by a narrow gap from two ground planes on either side. In CPW, the substrate thickness plays a less important role due to the fact that the fields are concentrated in the slots. CPW has ODD mode also called as Co-planar mode where the fields in the two slots are 180 out of phase and an EVEN mode known as coupled slot line mode where the fields are in-phase. Since the number of the electric and magnetic field lines in the air is higher than the number of the same lines in the microstrip case, the effective dielectric constant εeff of CPW is typically 15% lower than the εeff for microstrip, so the maximum reachable characteristic impedance values are higher than the microstrip values. The effect of finite dielectric substrate is almost ignorable if h exceeds 2b = W+2s.

A. Return Loss

Return loss is another measure of impedance match quality, which is also dependent on the value of 'Γ' or 'S'. Antenna return loss is calculated by the following equation:

$$ReturnLoss = -10\log|S_{11}| \, or - 20\log(|\Gamma|) \quad (3)$$

A good impedance match is indicated by a return loss lesser than -10 dB. A summary of desired antenna impedance parameters include Γ≤0.3162, VSWR≤2, and return loss ≤-10 dB.

As a rule of thumb, -10 dB return loss level can be considered for the impedance bandwidth computation. Hence, the same is conceived for the return loss simulation of the proposed antennas. Figure 2 clearly points out that the two resonant received at 5.6 GHz and 9.7 GHz with the return loss of -13.7608 and -18.4780 dB respectively.

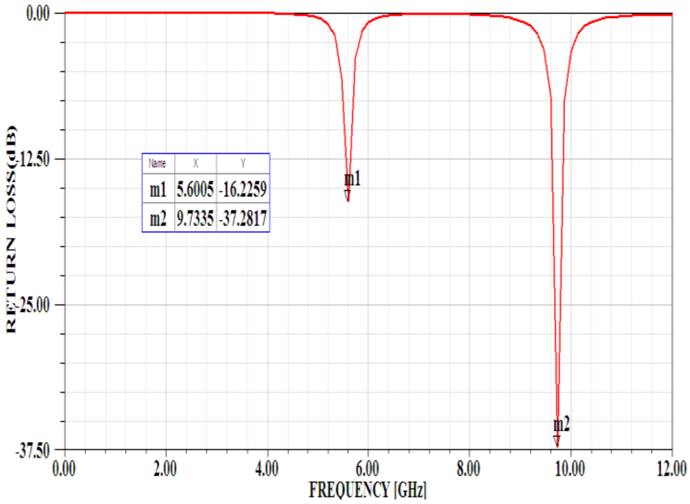


Fig. 2. Simulated return loss responses of antenna

B. VSWR

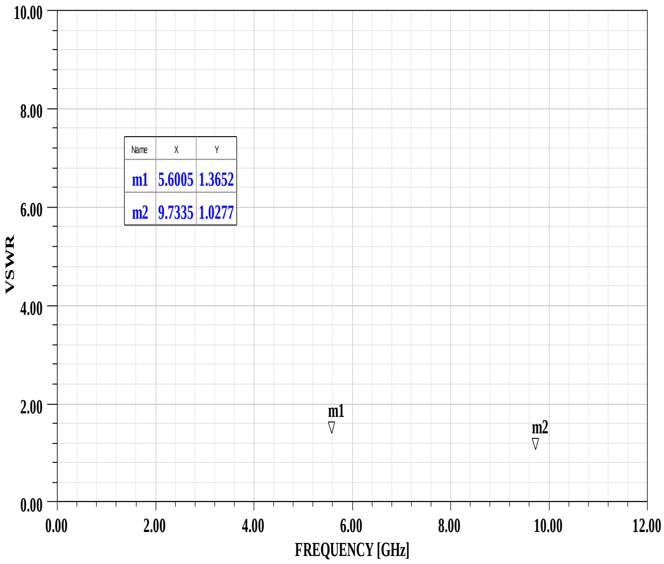
The VSWR is a way of calculating how well impedances are matched over the operating band. The value of VSWR ranges from one to infinity, with the value one means that the impedance matching is perfect. With respect to antenna design, VSWR that is as low as possible is desired because any reflection between the load and the antenna will reduce the effectiveness of the antenna. The VSWR is defined as,

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (4)$$

For most of the applications, the VSWR is required to be smaller than 2, which is considered good impedance match. In our work, as per the figure.3, at the two resonant the VSWR values are 1.5198 at 5.7 GHz and 1.1791 at 9.7 GHz respectively. The simulated results clearly explain that the proposed structure has good impedance match.

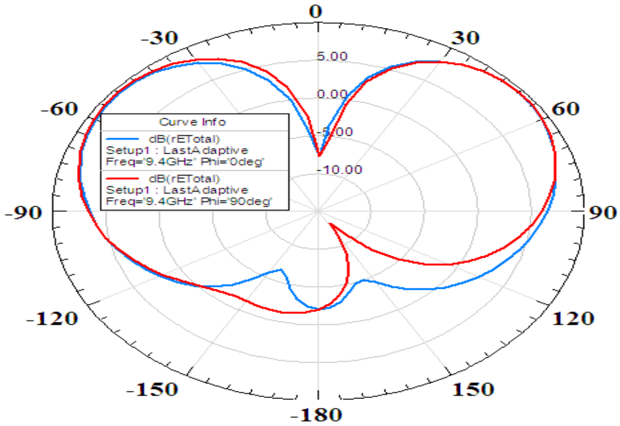
C. Radiation Pattern

A radiation pattern or antenna pattern is a graphical representation of the radiation (far field) properties of an antenna. The power received at a point by a receiving antenna is a function of the position of the receiving antenna with respect to the transmitting antenna. The graph of the received power, which is at a constant radius from the transmitting antenna, is called the power pattern of the antenna, which is the spatial pattern. The spatial pattern of the electric or magnetic field is called the field pattern. The E plane is the plane containing the electric field vector which is perpendicular to the direction of propagation and the H plane is the plane containing the magnetic field vector which is perpendicular to the direction of propagation.

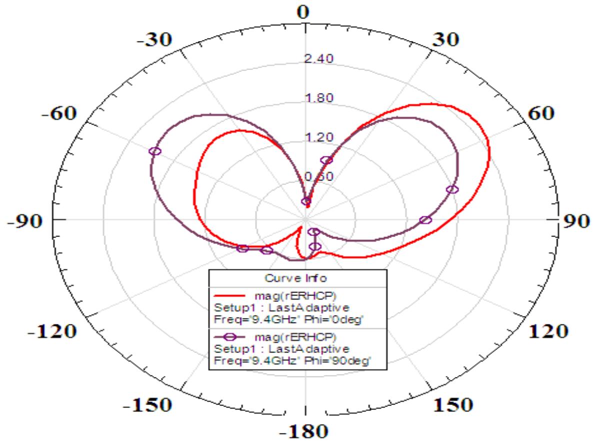


(d)

Fig.3.Simulated VSWR of two resonant at 5.6 GHz and 9.7GHz



(a)



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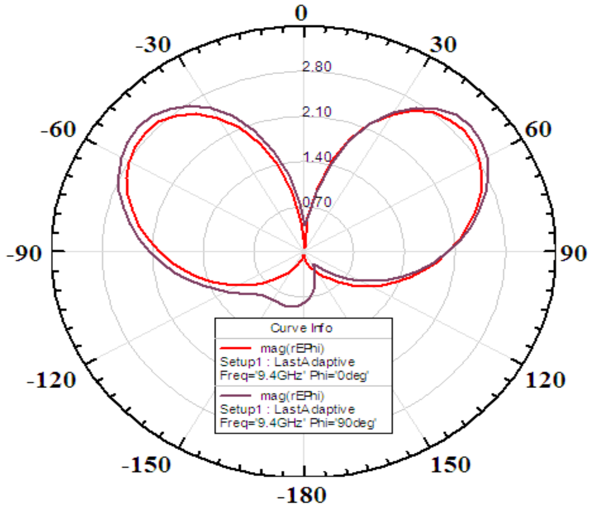

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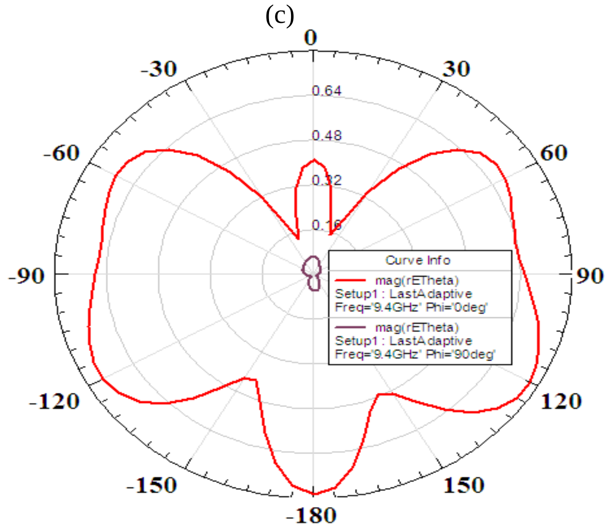

(d)

Fig.4. Simulated radiation pattern at 9.4GHz of proposed antenna (a) Total E and H plane (b) LHCP (c) E plane at Phi (d) E plane at Theta

The antenna radiation pattern at 9.4 GHz for total electric filed distribution, LHCP (Left Hand Circular Polarization), in terms of Phi and Theta are shown in figure 4 (a), (b) ,(c) & (d) respectively. It is observed that the field pattern is omnidirectional in H plane and bidirectional in E plane.

It is also observed that the radiation patterns are nearly Omnidirectional over the entire operating bandwidth. The results have proved that the design stands out as a potential candidate for future UWB applications.

IV. CONCLUSION

The design of a low profile CPW –fed square ring UWB antenna has been proposed. The ground plane, serving as an impedance matching circuit, tunes the input impedance. The fabricated antenna is compact with dimensions of 30 × 30 × 1.2 mm^3suitable for integration with electrical circuits. The designed antenna covers the WLAN and WiMax application with resonant at 5.6 GHz and UWB application having resonant at 9.7 GHz. The proposed antenna can operate from 5.2 to 12.5 GHz with two bands. The lowest return loss received by simulation is -17.5 db with corresponding VSWR value of 1.5. The proposed antennas widely used in wireless applications.

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