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TRIPLE-BAND CPW-FED TRANSPARENT ANTENNA FOR ACTIVE RFID TAG

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***Abstract*—A Triple-band CPW-fed transparent antenna for active RFID tags is designed and the designed antenna can be operated at 2.4 GHz, 3.5 GHz and 5.1 GHz. The antenna consists of polygon shaped and T-shaped patches and C-shaped slot on it. The CPW-fed patch is designed with AgHT-8 thin film, includes the silver coated polyester as conductive layer on Polyethylene terephthalate (PET) as substrate. The transparent antenna is designed with high transparency of above 80%. The overall dimension of the proposed antenna is 41 36.7 0.175 mm^3. The simulated results shows that the antenna is suitable for ISM, Bluetooth and Wi-Fi applications.**

***Index Terms*—AgHT-8, CPW-fed,PET, Transparent, Triple-band**

I. INTRODUCTION

Transparent UWB antennas basically evolved from non-transparent antennas and these antennas are becoming more popular in today's world. Transparent antennas can be made by either transparent conductor or fabricated from meshes. The transparent conductor antennas can be invisible but generally it has low transparency if reasonable antenna performance is required. The transparent antenna fabricated from meshes can be highly transparent yet effective but it is visible to eyes in most cases. Except for the antenna produced using Indium Tin Oxide (ITO) or AgHT, most of the transparent antennas are simply antennas constructed by coating transparent polymer substrates with non-transparent conductive traces of silver or other conductive ink. Such kind of transparent antennas cannot be really categorized as fully transparent antennas since the traces are visible to the naked eye.

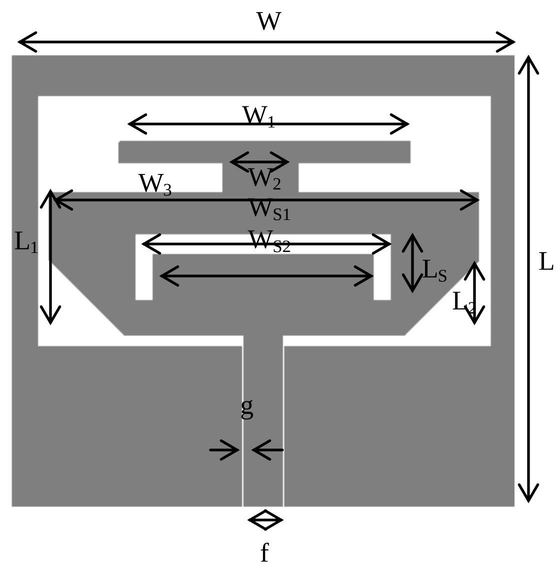
The CPW-feed facilitates the use of an active device placed near the antenna's radiating surface as well as monolithic integration of circuits. Radio-frequency identification (RFID) is used to transfer data, for the automatic identification and tracking of tags which is already attached to the objects. The operating bandwidth of RFID antenna for UWB application is from 3.1 GHz to 10 GHz and particularly for ISM band is from 2.4 GHz to 5.8 GHz.

The paper [2] presents a feasibility study on an optically transparent monopole lozenge antenna at 60 GHz ISM band and its results shows that the behavior of both transparent and non-transparent antenna are most identical. In [4] a transparent monopole antenna is designed for WMAX application and the conductive material for both radiating element as well as ground plane are AgHT-4, while the substrate is made of glass. In [15] a novel technique is introduced to improve the performance of AgHT-8 transparent polymer antenna. In that a split ring resonator is introduced on the patch to enhance gain.

In [13] a single UHF band probe-fed transparent antenna for RFID applications is analyzed using the printed conductive polymer on the PET substrate. In which [13], a modified polymer is used to increase the conductivity of the material with increased the visibility to the human eyes. In that design the feed line is shifted from the exact position of the feel line, it will decrease the performance of the antenna. To avoid this drawback CPW-fed technique could be used [10].

Fig. 1. Antenna geometry of the proposed antenna

The research on the material AgHT-8 thin film shows that it has good adaptation with green technology [7]. Some other researches [3,6] reported on AgHT-8 transparent antenna



working in UHF and microwave bands and results in the lack of research on dual-band transparent antennas. This problem is overcome by dual-band CPW-fed transparent antenna for RFID tags is designed by using the transparent conductive material(AgHT-8) on PET [1].

In this paper, a triple-band CPW-Fed transparent antenna is proposed for ISM, Bluetooth and Wi-Fi applications for active RFID tags. After optimization the proposed antenna is designed with the size of 41 36.7 0.175 mm^3. The proposed antennaconsists of single layer metallic structure with a hexagonal shaped patch as well as T-shaped strip attached to the feedline and C-shaped slot on the polygon patch.

The manuscript is organized as follows: In section II, the design of proposed antenna is presented. In section III, the simulation results are presented and discussed, followed by conclusion in section IV.

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II. ANTENNA DESIGN

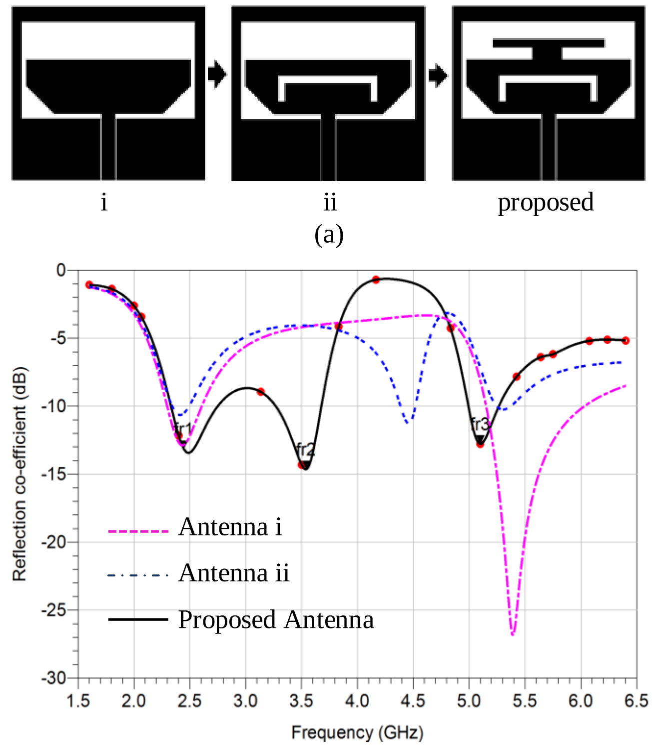
In this research, the proposed antenna is designed with AgHT-8 thin film which possesses the silver coated polyester as conductive layer on PET substrate. In general AgHT-8 has conductivity of $\sigma = 1.25 \times 10^5\, S/$, surface resistant of $8 \pm 2\Omega/$ and, shielding effectiveness of 20-40 dB. The Polyethylene terephthalate substrate has the relative permittivity of $\varepsilon_r = 3.$ and overall thickness of antenna is 0.175 mm [1]. The proposed antenna is designed and simulated by using commercially available software Agilent's ADS. The designed antenna is fed by 50 CPW line with the effective permittivity of $\varepsilon_{eff} = 2.$ and the distance between the feed line and symmetrical ground plane is about $g = 0.2m$[1]. The geometry of the proposed configuration shown in Fig. 1

TABLE I
PARAMETERS OF THE PROPOSED ANTENNA

Parameters	Length (mm)
W	41.0
W_1	23.7
W_2	6.2
W_3	35.0
W_{S1}	21.0
W_{S2}	18.0
g	0.2
f	3.0
L	36.7
L_1	11.5
L_2	6.0
L_3	5.5

The rectangular radiator is cut-out by two symmetrical triangles at both sides of the rectangle to tune the antenna for making it suitable for ISM and Wi-Fi applications. In order to introduce the third band of operation C-shaped slotis introduced at the polygon shaped patch and to tune the antenna so that it can be operated at three different frequencies such as 2.4, 3.5 and, 5.1 GHz a T-shaped Strip was introduced. After the optimization of the design parameter the overall width and length of antenna are $W = 41\ m$ and $L = 36.7\ m$ respectively. The parameter L_2 is the dimension of the equal sides of the isosceles right angled triangle cuts. These triangular cuts are introduced in the rectangular radiator in order to increase the current flow to the upper levels of ground planes by reducing the mutual coupling between the ground planes and the radiator. The parameter f is the width of the CPW feed line and L_3 majorly affects the performance of the antenna. The optimized parameters of proposed antenna is listed in Table I.

The design evolution of the proposed antenna and its simulated reflection co-efficient are shown in Fig. 2. The construction of antenna begins with the design of Antenna i, which has only the structure which is formed by cut the two isosceles right angled triangles from a rectangular patchof size $W_3 \times$ and this design can be operated over the frequencies of2.4 GHz to 5.8 GHz.



(b)

Fig. 2. (a) Design evolution of proposed antenna, and (b) its simulated reflection co-efficient results

Nevertheless the aim of this project is to design a triple band antenna hence proceed the next step. The Antenna ii is formed by introducing a C-shaped slot in Antenna i and the Antenna ii is operated at three different frequencies such as 2.4, 4.5 and 5.3 GHz yet these are not optimum frequencies of required applications, hence the third design is proceed. In proposed antenna a T-shaped strip is introduced in order to tune the antenna for required applications.

III PARAMETRIC STUDY AND DISCUSSION

The return loss for different values of the length of the patch L_1 is illustrated in Figure 3.By adjusting the length L_2 from 0 mm to 8 mm, the resonant frequencies are habitually changed, when L_2=6 mm the antenna is operated at 2.4, 3.5 and 5.1 GHz.

To further analyze, the simulated co-efficient disparity for the changes in the parameter L_2 is shown in Fig. 4 (a) and the disparity in the reflection co-efficient for the changes in the disparity in the parameter W_1 is shown in Fig. 4 (b).

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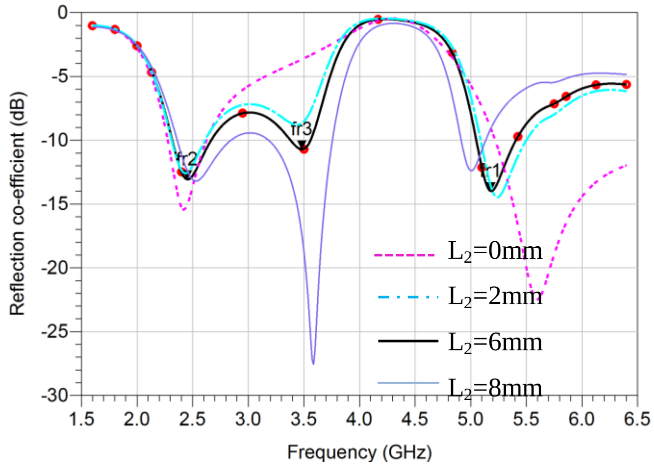
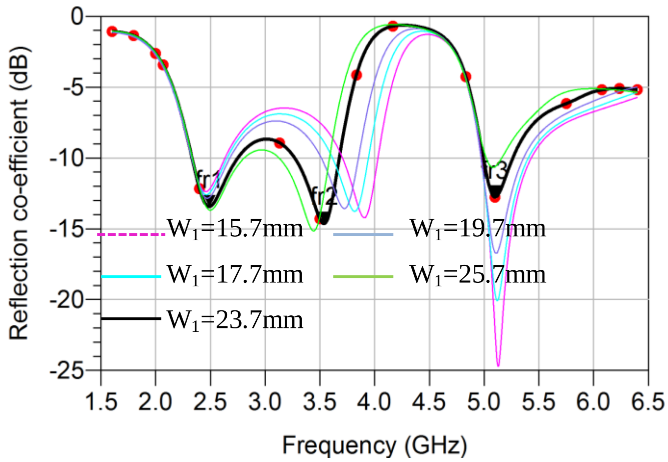


(a)



(b)

Fig. 4.(a) Simulated reflection co-efficient as a function of (a) the parameter $L_2$and (b) the parameter W1

As shown in Fig. 4 (b) W_1severely affects the resonant frequency of the proposed antenna particularly the second resonant frequency. As shown in Fig. 4 (a) the design parameter L_1also affects the reflection co-efficient of the proposed design. From the Fig. 4. (a) and (b) the optimized value of W_1 and $L_1$are 23.7 mm and 6 mm respectively.

IV. RESULTS AND DISCUSSION

The graph in Fig. 5.is the simulated reflection co-efficient of the proposed antenna. The results shows that the operating frequencies are obtained at 2.4 GHz, 3.5 GHz and 5.1 GHz, with reflection co-efficient ≤ -10 dB.

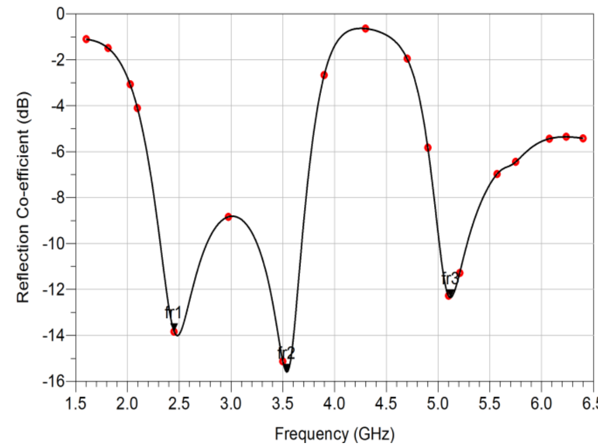


Fig. 5. Simulated reflection co-efficient of the proposed antenna

The simulated results shows that the proposed antenna is suitable for ISM band (2.327 GHz to 2.744 GHz), Bluetooth (3.271 to 3.677 GHz) and Wi-Fi (5 GHz to 5.263 GHz).

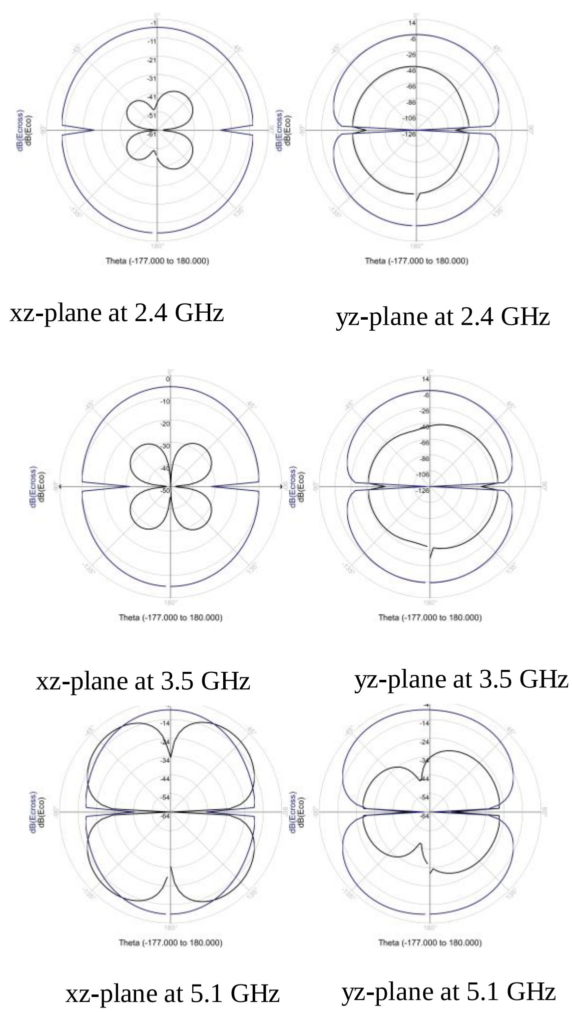


Fig. 6. Simulated radiation pattern at 1.8 GHz, 3 GHz and 5.1 GHz for xz-plane and yz-plane

In Figure 6, the co-polarization and cross-polarization of the radiation pattern of the proposed triple band antenna at 2.4 GHz, 3.5 GHz and 5.1 GHz is exemplified. At the three resonant frequencies the obtained radiation pattern is almost omnidirectional. The obtained gain for these frequencies are also in acceptable range.

V. CONCLUSION

A triple-band CPW-fed transparent antenna for RFID tags working at 2.4 GHz, 3.5 GHz and 5.1 GHz is presented. The overall dimension of the proposed antenna is about

41A36.7A0.175 mm^3 hence it can be used on the surface of the tags in many RFID applications such as warehouses, supply chains and access controls because of its lightweight structure, low thickness and high transparency. The proposed antenna can be suitable for ISM, Bluetooth and Wi-Fi applications.

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