The Design of Small Size Chip Antenna for 2.4/5.8 dual ISM-band applications

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Abstract — **This paper proposed a novel chip type ceramic dielectric antenna by using the advanced meander line technique for 2.4/5.8 dual ISM-band applications. This antenna is composed of a ceramic dielectric(8x4x1.5mm^3, alumina) and substrate(1.52 mm thickness, TMM-4). And to minimize the antenna's available area on the substrate and to reduce the coupling effect with the ground plane, the antenna is located on the corner of substrate. The measured bandwidth and maximum radiation gain of the proposed antenna is 2.35-2.57 GHz(VSWR<2), 2.07 dBi @2.44 GHz and 5.29-6.01 GHz, 1.17 dBi @5.75 GHz. From the result, it is demonstrated that our proposed antenna can be applicable to the dual-ISM band applications.**

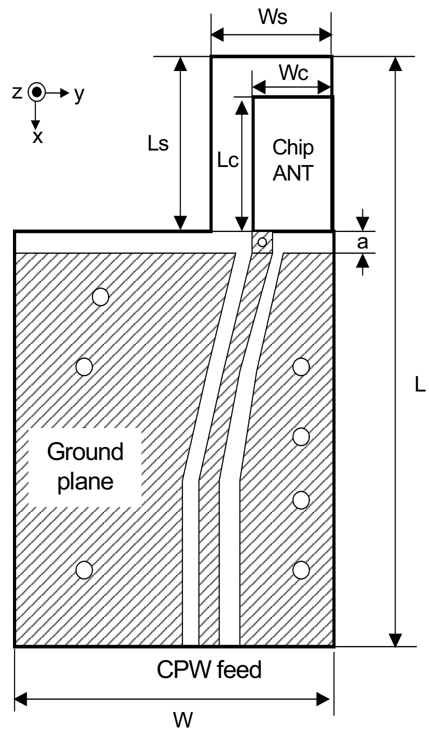
I. Introduction

The wireless communication market has a lot of variations and the use of ISM(Industrial, Scientific, Medical) band is becoming an important means of it. There are also many kinds of radio frequency components in the communication field. One of those is the antenna that many researchers have tried to make with good performance.[1]-[6]

In the recent years, the internal type antenna(intenna) with small size is strongly focused on.[1]-[3] Among various possible antennas, ceramic chip antennas have the advantages of compact size and are very suitable for the wireless applications. However, because ceramic material has a high dielectric constant, it is easy that ceramic chip antenna has narrow bandwidth and low radiation gain.[6] To overcome these problems the proposed antenna used the advanced meander line technique and alumina(Al_2O_3, ε_r=7.7) for ceramic chip by optimizing the relation between bandwidth and dielectric constant. As a result, this paper presents the performance of the new dual-frequency antenna operating at 2.4(2.4-2.4835 GHz)/ 5.8 GHz (5.725-5.85 GHz) dual-ISM bands.

II. A NOVEL CHIP TYPE CERAMIC DIELECTRIC ANTENNA DESIGN

Fig. 1, Fig. 2, and Fig. 3 show our proposed antenna model and metal patterns on each layer. As shown in these figures, this antenna for small volume is composed of ceramic dielectric material and modified meander line. And CPW(Co-planar Waveguide) with ground plane is used to feed this antenna. The ceramic chip is made by alumina(Al_2O_3, ε_r=7.7) and some part of meander line is printed on the ceramic chip by using silver paste and screen printer. Finally, the ceramic chip with metal pattern is mounted on the top plane of substrate(Rogers TMM-4, ε_r=4.5) through reflow process. The design parameters denoted in Table I was optimized by using commercial program based on the FEM method[7]



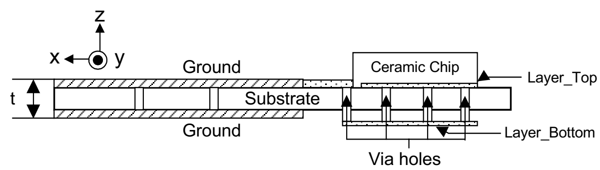


Fig. 1. Proposed Antenna Structure.

W	26.0 mm	*L*	47.2 mm
Ws	7.0 mm	*Ls*	12.2 mm
Wc	4.0 mm	*Lc*	8.0 mm
a	2.2 mm	*t*	1.52 mm

Table I
The design parameters of the proposed antenna

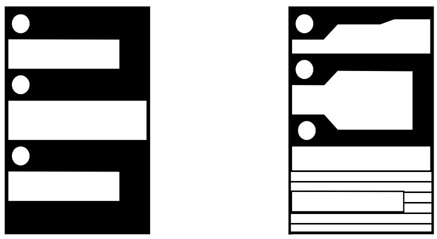

<Layer_Top> <Layer_Bottom>

Fig. 2. The metal patterns of *layer_Top* and *layer_Bottom*

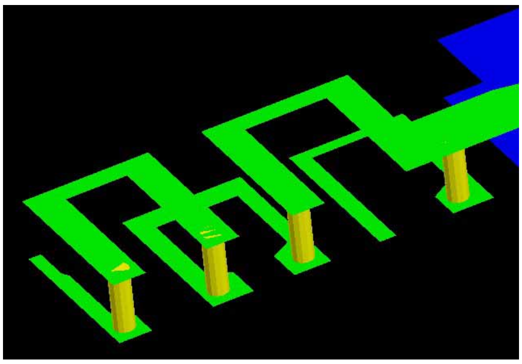


Fig. 3. 3-dimensional view of the metal patterns

The meander line of this antenna is composed of two layers (*layer_Top* and *layer_Bottom*) shown in Fig. 2. These patterns forming a modified meander line are connected with via-hole through substrate. The *layer_Top* is formed on the interface between the bottom of ceramic chip and the top plane of substrate. The *layer_Bottom* is done on the bottom face of substrate. From these figures, it is known that the metal pattern on *layer_Top* is a part of this small antenna and is also used to attach the ceramic chip on the substrate. For dual ISM-band application in the metal patterns, the part filled with solid in Fig. 2. is designed to resonate at 2.44 GHz and the other part drawn by horizontal lines in that is done to resonate at 5.75 GHz. Additionally, to minimize the antenna's available area on the substrate and to reduce the coupling between this small antenna and the ground plane, the antenna is located on the corner of substrate. The resonant frequency of antenna and impedance match can be shifted and tuned easily by trimming the edges of metal pattern on *layer_Bottom.*

III. THE RESULTS

A. Return Loss

Fig. 4 shows the comparison data between measured and simulated return loss of this antenna. The measured data can be acquired by Agilent 8510C Network Analyzer. In Fig. 4 the solid line denotes the measured return loss and the short dashed line does the simulated ones. The measured bandwidth is 2.35-2.57 GHz(VSWR<2) and 5.29-6.01 GHz. And the simulated bandwidth is 2.37-2.65 GHz and 5.67-5.97 GHz. From this result, we know that this antenna is satisfied with the 2.4/5.8 dual ISM band applications and has a broad bandwidth(beyond 12%) around 5.8 GHz.

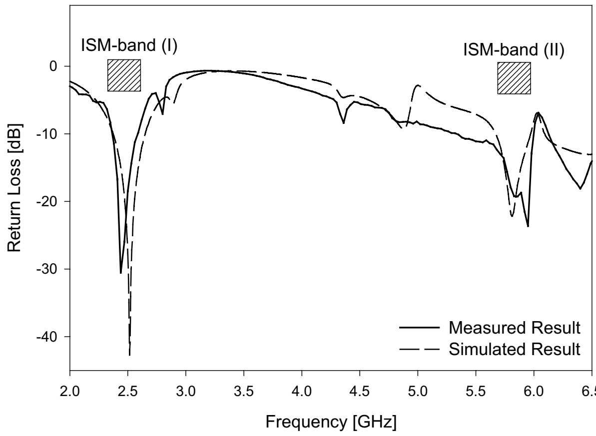
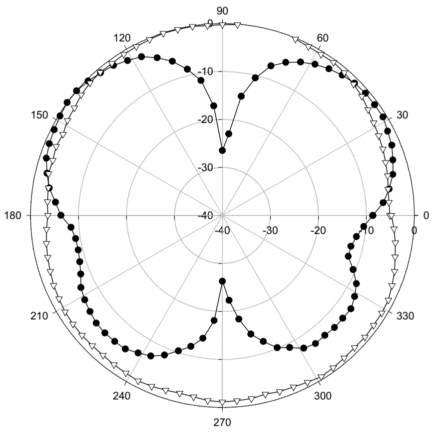


Fig. 4. The comparison between the measured and simulated return loss of the proposed dual ISM-band antenna

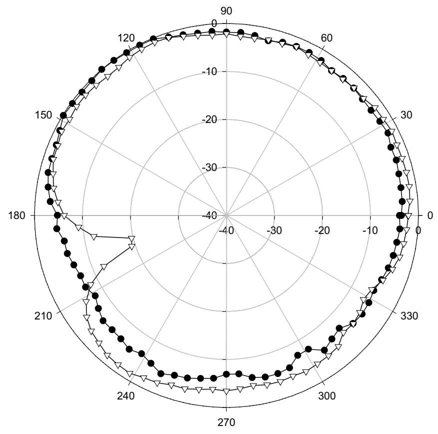
B. Radiation Patterns and Gain

The measured radiation patterns for co-polarization and cross-polarization of our antenna are shown in Fig. 5. Fig. 5(a), (b), and (c) present the radiation patterns at 2.44 GHz and (d), (e), and (f) denote those at 5.75 GHz. As shown in Fig. 5, because the current distribution on the meander lines is not only vertical to the ground plane but also horizontal, the level of cross-polarization is not always lower than that of co-pol.[ref] However, the radiation patterns at 2.44 GHz is very similar to those of the general monopole antenna which is vertically mounted on the infinite ground plane.

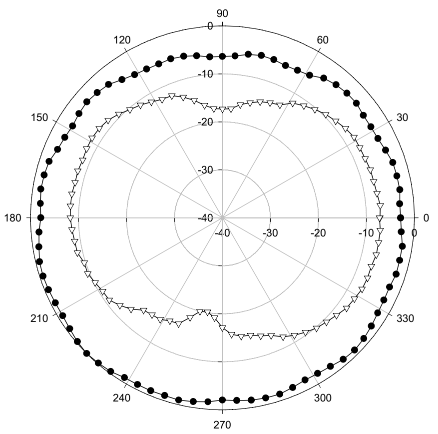
The measured maximum radiation gain is 2.07 dBi at 2.44 GHz and 1.17 dBi at 5.75 GHz, respectively. And the simulated maximum radiation gain is 2.3 dBi at 2.44 GHz and 2.82 dBi at 5.75 GHz. The difference between measured and simulated gain is due to the dielectric loss of ceramic chip and metal patterns which is not perfect conductors. And these losses are proportion to the frequency.



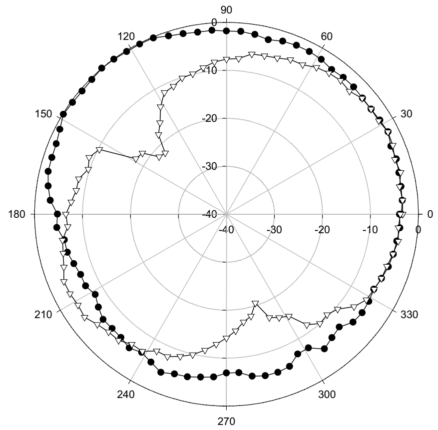
(a) XZ-plane@2.44 GHz



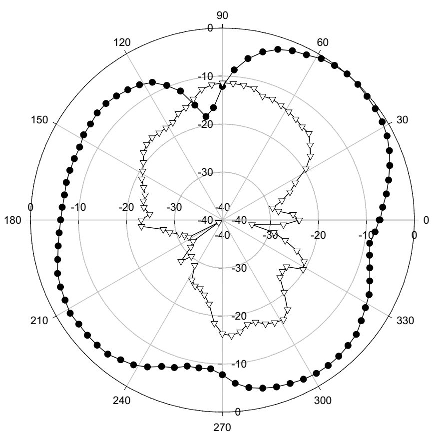
(d) XZ-plane@5.75 GHz



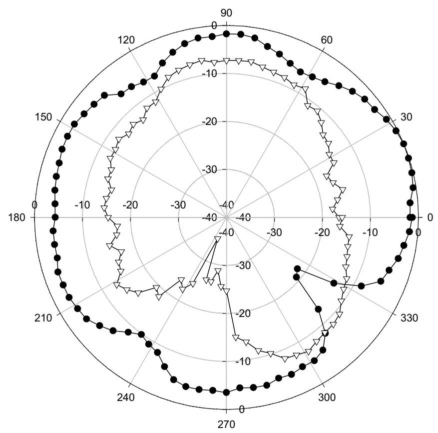
(b) YZ-plane@2.44 GHz



(e) YZ-plane@5.75 GHz



(c) XY-plane@2.44 GHz



(f) XY-plane@5.75 GHz

Fig. 5. The measured radiation patterns for co-polarization(—●—) and cross-polarization(—△—) of the proposed dual ISM-band antenna

IV. CONCLUSIONS

In this paper, we suggested a novel chip type ceramic dielectric antenna by using the advanced meander line technique for 2.4/5.8 dual ISM-band applications and confirmed the performance of it. This antenna has 8 x 4 x 1.5 mm^3 volume and is mounted on the substrate(TMM-4, ε_r=7.7) that has 1.52 mm thickness. Additionally, to minimize the antenna's occupied area on the substrate and to reduce the effect of ground plane, the antenna is located on the corner of substrate. As a result, the measured bandwidth and maximum radiation gain of antenna is 2.35-2.57 GHz(VSWR<2, 2.07dBi@2.44 GHz) and 5.29-6.01 GHz(1.17dBi@5.75 GHz). Therefore it is demonstrated that our proposed antenna can be applicable to dual ISM-band applications.

ACKNOWLEDGEMENT

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