A Cascaded Brick Shaped Slot Antenna Design for WLAN and WiMax Applications

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***Abstract:** A low profile Dual Band slot antenna using a microstrip resonating feeding line to improve upper and lower band edge selectivity is discussed in this paper. The proposed antenna covers multiple frequency bands (4.3-5.8GHz and 7.25-7.4GHz). Compared with the traditional slot antennas, the proposed antenna has more specific advantages of band-edge selectivity, size and is suitable for WiMax, WLAN and satellite communication applications. The proposed antenna is of the dimensions 24.5mm × 12.5mm × 0.8mm which is fabricated on FR4 epoxy substrate which is having a dielectric constant of ε_r=4.4 and a loss tangent of 0.02. The ascertain measured results show that the antenna exhibits a dual band coverage with acceptable reflection coefficient loss less than -10 dB from 4.3 to 5.8GHz and from 7.25 to 7.4GHz,. The proposed antenna is simpler and cost effective.*

***Keywords:** Dual Band, Slot Antenna, WLAN, WiMax, Satellite Communication Applications, Cascaded Brick Shaped Slot Antenna (CBSSA).*

I. INTRODUCTION

Nowadays slot antennas are becoming more attractive because of their low profile, less weight, conformal to the surface of objects and easy fabrication. Some of the frequency bands and their corresponding applications are mentioned here. WLAN applications requires three bands which are popularly known as low band (2.4-2.484GHz), middle band (5.15-5.35GHz) and upper band (5.725-5.825GHz). For the WiMAX applications requires three bands which are popularly known as low band (1500-2690MHz), middle band (3200-3800MHz) and upper band (5200-5800MHz). In previous literature various models of slot antennas are proposed in [1]which operates at multiple frequencies for applications of Personal Communication Service(PCS), Wireless Local Area Network(WLAN) and Worldwide Interoperability for Microwave Access(WiMAX) but all are designed with broader dimensions. A U-shaped bridge fed is used to excite the four shorting strips antenna which resulted a dual band is discussed in [2] but the feeding technique is complex when compared with microstrip line feed. A multi band frequency operating antenna at the frequencies 1.8, 2.4 and 5.8GHz is proposed in [3] and it yielded 2:1 Voltage Standing Wave Ratio(VSWR) perating bands at these frequencies but the antenna's design is a bit complex and it is larger in size. The meandering and the backed microstrip line techniques are investigated in [4] and achieved an acceptable return loss at the frequencies 2.4 and 5.8GHz respectively but the techniques used are quite complex and the fabrication cost is also an issue when compared to the proposed design.. The size of the antennas from the literature survey is compared in Table 1.1.

Table 1. Dimensions comparison between the literature survey antennas and the proposed antenna

Ref	Dimensions (mm^3)	ε_r
6	100×40×0.8	4.4
5	41×48×0.8	4.4
9	38.5×38.5×1.6	4.4
11	37×25×1.524	3.48
10	30×25×1.6	4.4
8	28×28.5×0.8	2.55
7	25×25×1.5	3.38
Proposed Antenna in the work	24.5×12.5×0.8	4.4

This paper consists of a novel compact sized brick shaped slot antenna which is proposed using cost effective epoxy FR4 material.

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From the Table 1 the proposed antenna designed with smaller dimensions that has low profile than the conventional slot antennas. This paper is organized as Section II which presents the Antenna Design Procedure, followed by Section III which consists of Results and Discussion and Section IV delivers the Conclusion.

II. ANTENNA DESIGN PROCEDURE

The proposed antenna is fabricated on epoxy FR4 substrate with dielectric constant of 4.4, loss tangent is 0.02 and Lande G Factor is 2. The dimensions of the proposed antenna are 24.5mm × 12.5mm × 0.8mm, which occupies an area of 306.35mm^2 and a volume of 245mm^3 which is quite less than a conventional slot antenna. The proposed antenna design contains of two conductors which lie parallel to each other and metalized on both sides of the substrate which are popularly known as Patch (the upper conductor) and Ground (the bottom conductor).The ground plane is designed with circular slots to improve the frequency band of operation. The antenna uses one of the simplest feeding technique i.e. micro strip line feeding. The width of the micro strip feeding line is 2mm which is used to match 50-ohm impedance of coaxial line. To maintain lower cutoff frequency is at 4.1GHz antenna designed with width of 12.5mm and the length is considered 1.96 times of the width. The initial design is carried out through printing a cascaded brick shaped design as the patch by including the circular slots on the patch. The Defected Ground Structure (DGS) designed with rectangular slots on it. In the second design, some slight changes on the patch and defected ground structure was done where the circular slots are mounted on the ground and the patch is rearranged as a cascaded brick shaped design without adding circular sots on it. Now to the Defected Ground Structure (DGS) the circular slots with radius 0.5mm are added and all are placed by equidistant of 0.5mmto each other. In the third design i.e. the final design has the same DGS of the second model, but the patch is modified to get the anticipated results of the antenna. To the patch's brick shaped slots are extended by mounting triangles at the end to make a sharp apex which is pointing out. The extension of the triangular loads on the patch enhances the S_{11} (return loss) curve and radiation pattern of the antenna. The directivity will also get increased further.

Figures and Tables

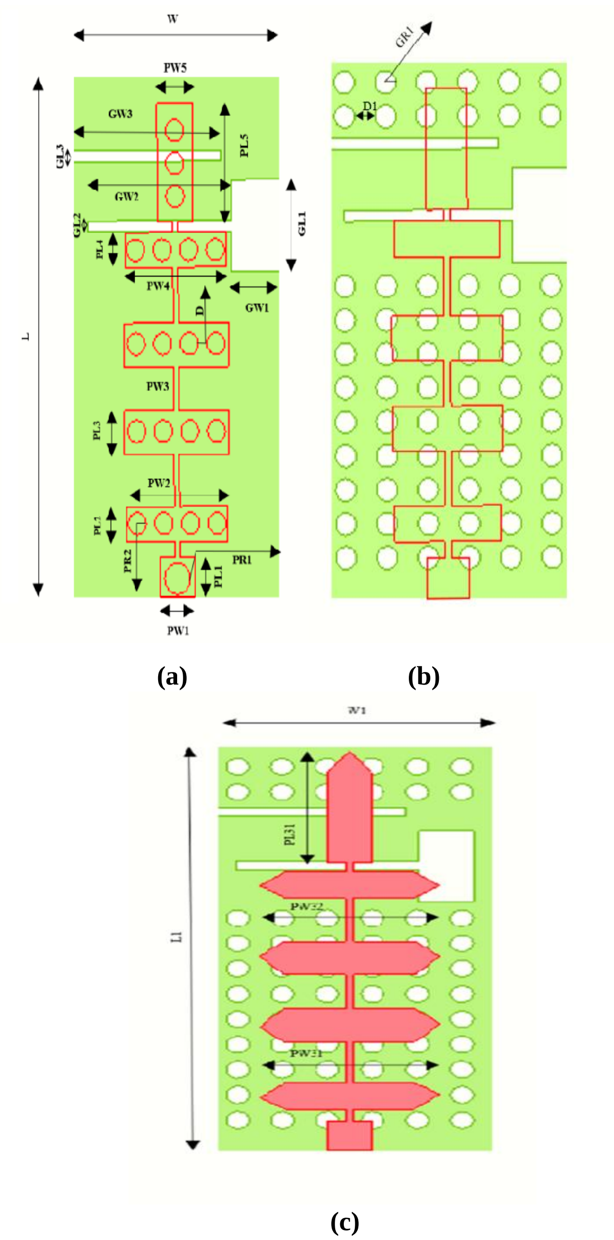

Fig . 1 Design of the Cascaded Brick Shaped Slot Antenna (a) Model_1 (b) Model_2 (c) Model_3

The evolution of the models is done using parametric analysis and is shown in Figure 1. The hardware implementation is also done, and verification of the hardware results is presented in the paper. The hardware design is connected with an edge mounted SMA (Subminiature version A) connector. The dimensions of the three models of the antenna are in the Table 2.

Table 2. Dimensions of the Antenna

Parameter	Value (mm)
L	24
W	12
L_1	24.5
W_1	12.5
PL_1	2
PW_1	2
PL_2	1.6
PW_2	5.7
PL_3	2
PW_3	5.9
PL_4	1.6
PW_4	5.7
PL_5	5.4
PW_5	2
GL_1	4.2
GW_1	2.9
GL_2	0.5
GW_2	8.1
GL_3	0.5
GW_3	8.5
PR_1	0.72
PR_2	0.5
D	0.5
D_1	1
GR_1	0.5
PL_{31}	6.7
PW_{31}	8.002
PW_{32}	8

III. RESULTS AND DISCUSSION

The proposed antenna's simulation analysis is carried out through High Frequency Structure Simulator (HFSS) software tool. The fabricated antenna is shown in Figure 2.The return loss plot of the three models is shown in Figure3.The proposed antenna operates at dual frequency bands with return loss less than -10dB which can be observed from the plot. The gain of the antenna is positive in all three evaluation models. The maximum gain of 2.1086dB is observed for the proposed design model. The radiation patterns of the antenna are observed at the operating frequencies 5,5.5, and 7.25GHz. The deign yielded an efficient return loss at the frequency band of5.15-5.35GHz which is used in the applications of the WLAN and another frequency band of 7.25-7.4GHz which is used for satellite downlink transmission. This satellite transmission at 7.25 GHz occurs in the C–band communication. The fabricated antenna is in small size, and it occupies less area. The hardware design yielded a dual band in the return loss plot. The hardware design is practically tested, and the results mapped with the simulated results of the software. The S_{11} return loss plot of the fabricated antenna is displayed in Figure 5.

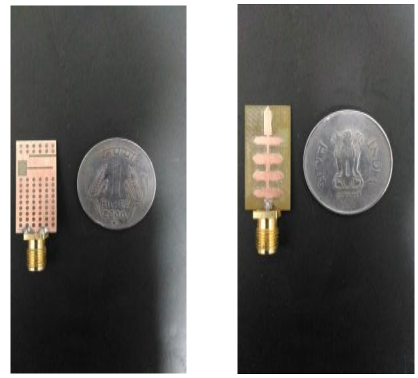

Fig . 2 Images of the fabricated Antenna with edge mounted SMA connector (a) Patch (Top View) (b) Ground (Bottom View)

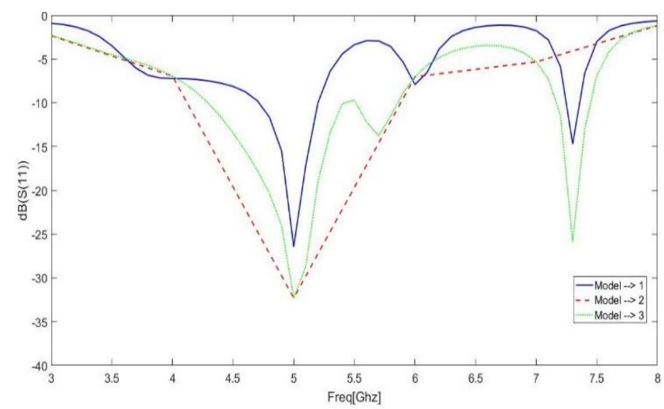

Fig. 3 Return loss plot of the simulated antenna

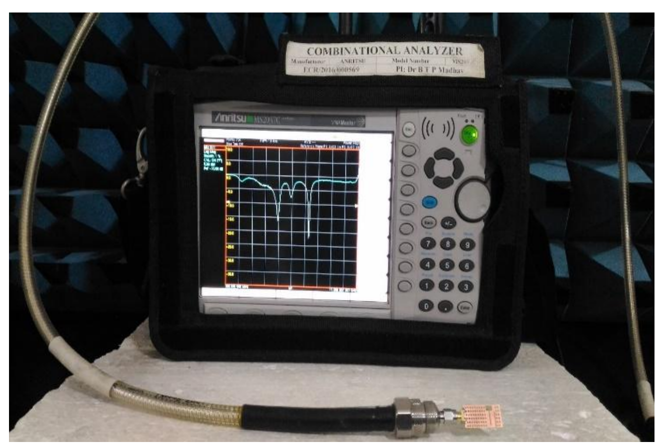

Fig . 4 Hardware measurements of the antenna

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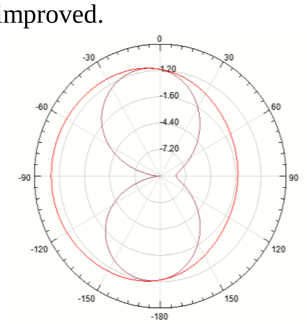
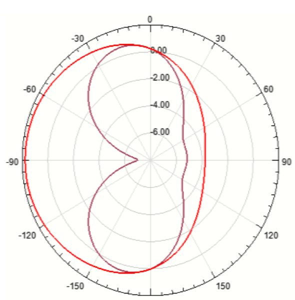
The hardware measurements of the fabricated antenna are shown in Figure4 where the antenna gets excited from the current through the probe. The probes are connected to the Digital Storage Oscilloscope (DSO) to display the values. The return loss measurement of the fabricated antenna is where it almost approached the simulated antenna return loss but, there are some minute variations in the hardware measured results when compared to simulated software results due to inaccuracy in connector, antenna fabrication and improper calibration of the measuring device. Despite all these factors the proposed antenna holds good for the applications in WLAN, WiMAX and Satellite communication. The proposed antenna occupies a very less area, volume and is cost effective, so it can be used vastly in the Wireless Communications.

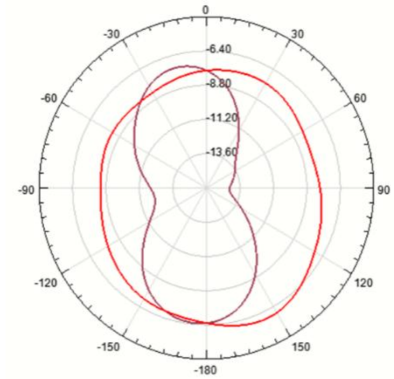
Fig . 5 Hardware Measurement of the return loss plot

The radiation pattern of the antenna at 5, 5.5, 7.25 GHz frequency is plotted in the Figure 6. As the radiation pattern is imprinting a perfect eight shape, the directivity and gain is improved.





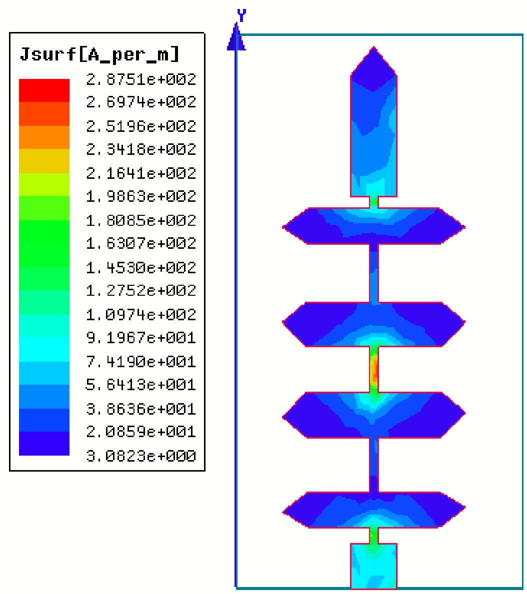
(a) **(b)**



(c)

Fig . 6 Radiation pattern (a) at 5GHz (b) at 5.5GHz (c) at 7.25GHz

The radiation pattern of the antenna at 5GHz, 5.5GHz and at 7.3GHz frequency is plotted in the Figure.6. From The radiation patterns most of power radiate through main lobe with high directivity and gain. The surface current distribution of the proposed antenna is displayed in Figure 7 of the patch and the ground. The E- filed distribution also shown in the Figure 8.



(a)

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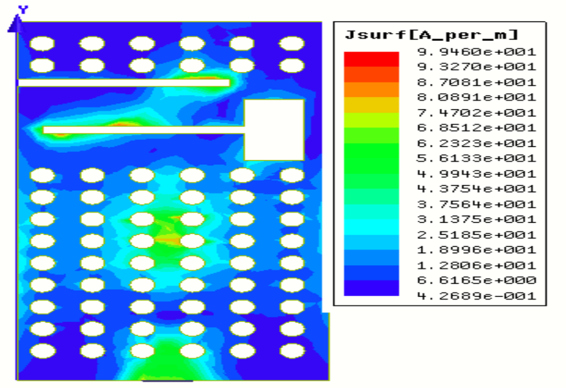
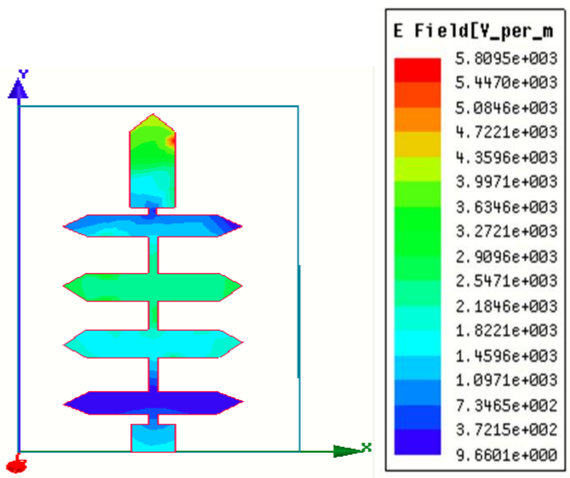
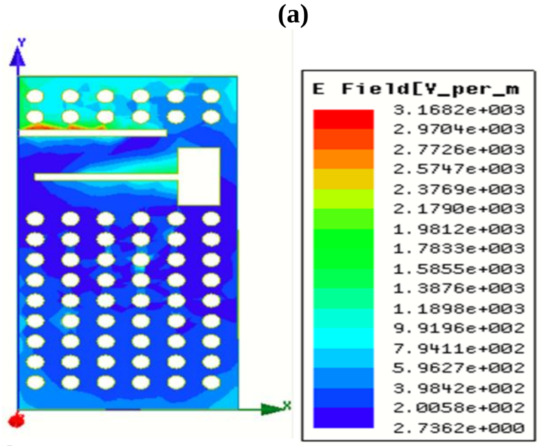


(b)

Fig . 7 Current distribution plot (a) on patch (b) on ground



(a)



(b)

Fig . 8 E- field distribution on (a) patch (b) ground

III. CONCLUSION

In this paper a new antenna design proposed with miniature dimensions which are small when compared with conventional slot antennas. The antenna covers multiple frequency bands (4.3-5.8GHz and 7.25-7.4GHz) with a good return loss less than -10dB. A better return loss is observed in the operating frequency range i.e. at 5GHz the return loss yielded is -32.3013dB. The gain yielded was 2.1086. The proposed antenna is best suitable in the application field of WLAN and WiMax along with satellite communication that is C band operation. The simulated results and the fabricated results have a very high correlation between them.

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