A NOVEL COMPACT CPW FED SLOT ANTENNA WITH EBG STRUCTURE

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ABSTRACT

A compact CPW fed antenna is designed for the dual band operation. Here electromagnetic band gap structures of rectangle-shaped lattices are placed for the harmonic suppression. We observed that EBG structures are not only exhibiting the band stop characteristics, but also help to magnify the proposed antenna bandwidth. The rectangular lattice like EBG's have a frequency band gap and high surface impedance characteristics, which generally represent as in-phase reflection band. We succeeded in integrating the rectangular lattice EBG's in compact slot antenna with a CPW feeding line, to decrease the surface wave losses and bandwidth enhancement. The complete antenna analysis with radiation characteristics are presented in the current study.

Keywords: electromagnetic bandgap structure, coplanar wave guide feeding, slot antenna, bandwidth enhancement.

1. INTRODUCTION

Coplanar waveguide feeding is one of the mostly used feeding techniques for the advanced antennas which exhibit wide band and multiband characteristics. The advantages of this design includes less dispersion, very low leakage in radiation, independent characteristic impedance behavior with substrate height and more over with unipolar configuration [1-2]. The current model deals with the uniplanar slotted antenna with EBG structures which aids in suppressing unwanted harmonics and surface wave losses. The proposed model is exhibiting dual band characteristics when square lattice EBG structures incorporated in the basic design.

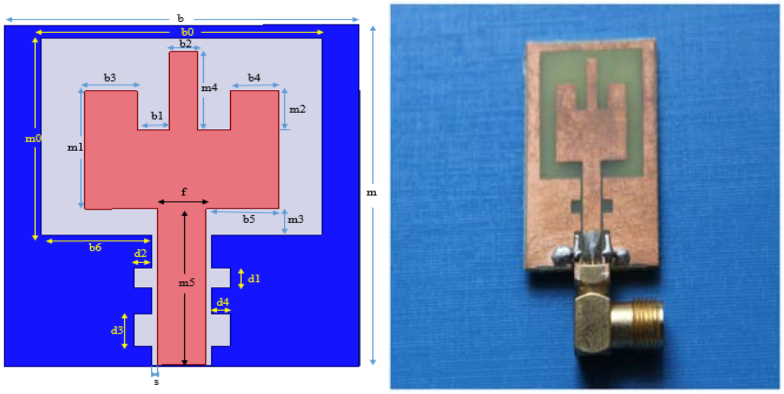

Figure-1. CPW Fed Slot Antenna with EBG Structure.

Recent reports have suggested a simple structure for CPW-fed dual band antennas which is responsible for decreasing the size of the models [3-4]. Another antenna named compact planar inverted-F antenna (PIFA) was presented which has a complex structure with a drawback of large size [5-6]. We are familiar to that the higher order modes bandwidth will improve parallely and may cause a severe drawback of electromagnetic interference and compatibility. To reduce this drawback in conventional CPW-fed slot antenna, the electromagnetic bandgap (EBG) structure proves to be better solution. Optical systems and microwave applications are main purposes where EBG structures got originated for the well known capability to hinder the transmission of electromagnetic waves along all directions within definite range of frequencies [7]. The main purpose of utilizing EBG structures in microstrip patch antenna is to eliminate the harmonic modes which are caused by EBG's appealing low pass filter characteristics [8-9].

2. Antenna geometry

The proposed model is a two tapered patch model with slots on the either side of the patch i.e. on the ground plane as shown in Figure-1. The performance characteristics are showing applicability of this model suitable for communication systems applications in the desired band. The impedance bandwidth of the suggested model is also superior when compared with original CPW fed antenna without EBG structure.

The antenna is fabricated on FR4 substrate with thickness 1.6mm and a dielectric constant of 4.4. The size of the antenna is 22×26×1.6mm. The basic model is modified by placing EBG's on the basic model as shown in Figure-2(a). By placing double-sided EBG and triple sided EBG, the performance characteristics are obtained. These models are shown in Figure-2(b) and Figure-2(c). The rectangular EBG lattice having the dimension of 0.9×1 mm.

Table-1. Antenna Dimensions.

b	b0	b1	b2	b3	b4	b5	b6
22 mm	17.425 mm	1.77 mm	1.75 mm	3.48 mm	3.23 mm	4.5 mm	6.8625 mm

m	m0	m1	m2	m3	m4	m5
26 mm	15 mm	9 mm	3 mm	2 mm	6 mm	11.9 mm

d1	d2	d3	d4	s	f
1.5125 mm	1.65 mm	2.4625 mm	1.15 mm	0.35 mm	3 mm

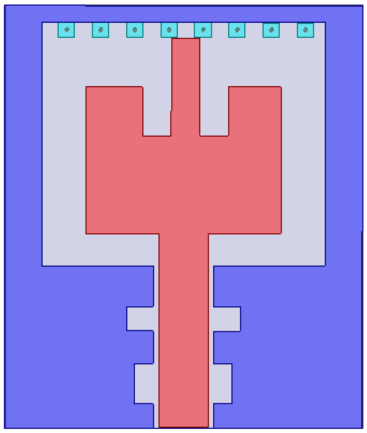

Figure-2. (a) Single Sided EBG,

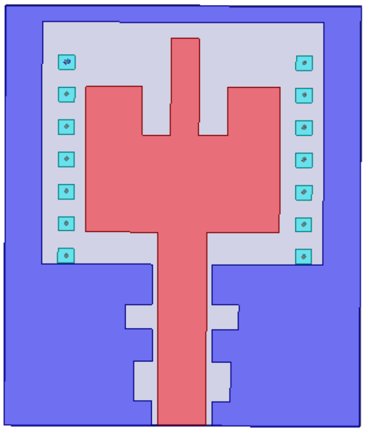

Figure-2. (b) Double Sided EBG,

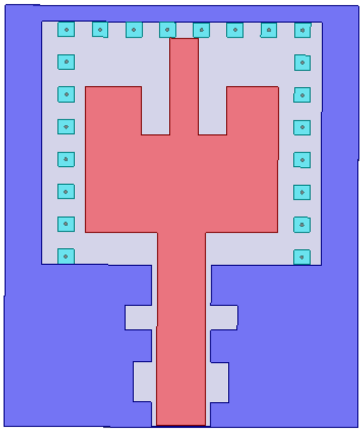

Figure-2. (c) Triple Sided EBG.

3. RESULTS AND DISCUSSIONS

The complete analysis of the antenna is done with Ansys HFSS 15.0 EM tool. Figure-3 displays the return loss of the antenna with single sided EBG, double sided EBG, triple sided EBG and without EBG. Triple sided EBG is showing better return loss and enhancement in the bandwidth with respect to the other models. In the basic structure we obtained impedance bandwidth of 22% and 32% with reference to the applicable resonant frequencies. The attained bandwidths are covering the S and X-bands. The proposed antenna with EBG structure of rectangular lattice shapes is producing impedance bandwidth of 38% with reference to the resonant frequency.

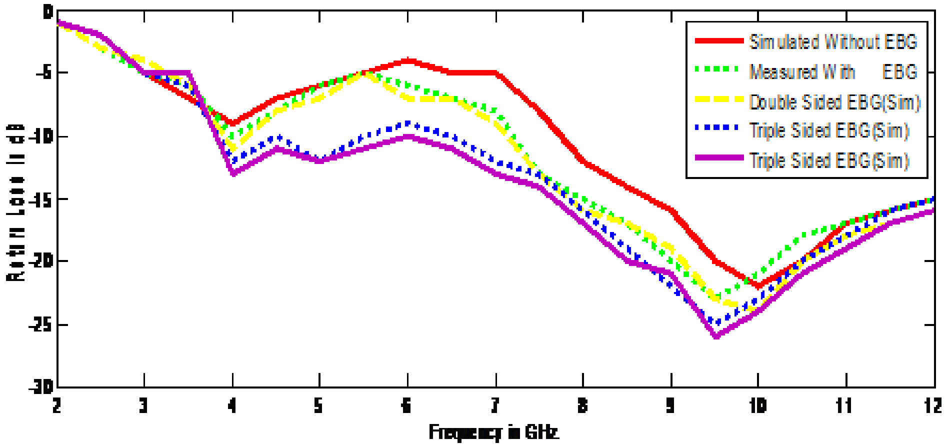

Figure-3. Measured and Simulated Return loss Vs Frequency curve.

From results it is observed that almost identical values are obtained when compared to the measured with the simulated results. The parametric analysis is done with respect to the change in the width at the top side of the slotted patch (b1). Figure-4 shows the frequency Vs Return Loss Curve for the parametric analysis with change in b1. It is observed that by increasing b1 from 1mm to 2mm the first resonant frequency in the dual band is improving i.e. losses are decreased while at the second resonant frequency the losses are little bit increased. By changing the width b1 we got an improved impedance bandwidth at 2mm when compared with other dimensions of b1.

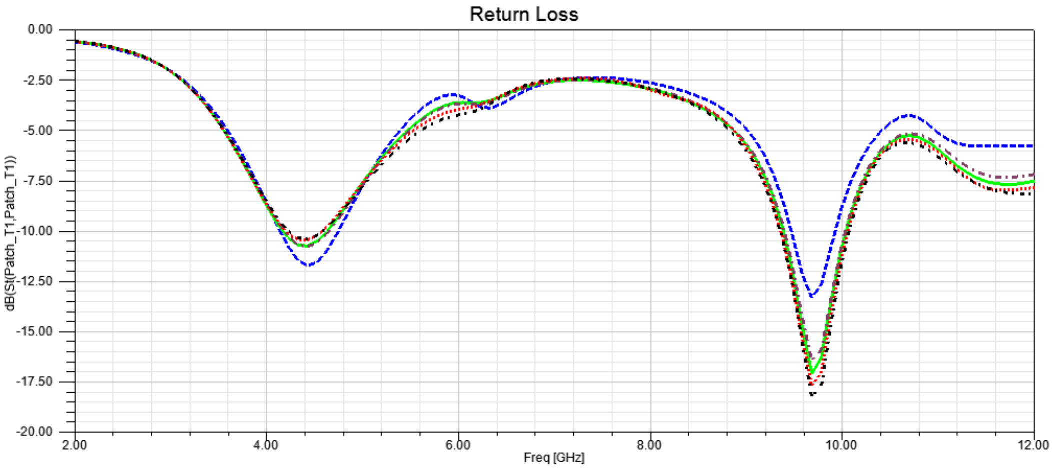

Figure-4. Parametric analysis for change in b1.

The parametric analysis is done for the change in d2 from 0.9 to 1.6mm and change in d4 from 0.9 to 1.6 mm are shown in the evaluated graphs as Figure-5 and Figure-6.

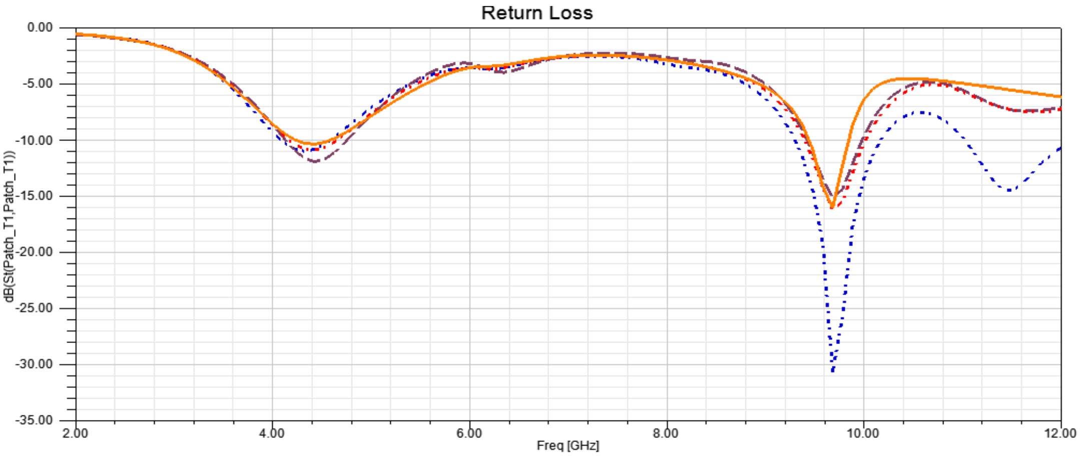

Figure-5. Parametric analysis for change in d2.

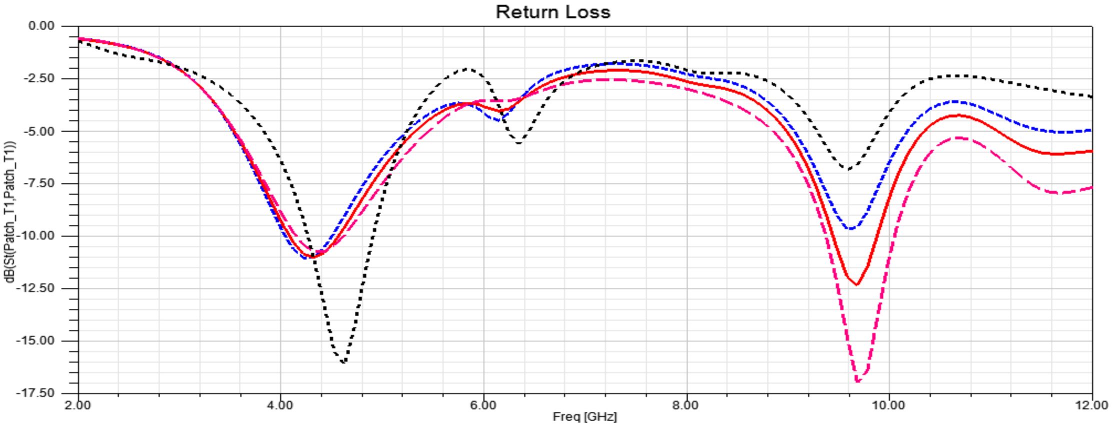

Figure-6. Parametric analysis for change in d4.

The proposed antenna's radiation characteristics is also considered and presented in Figure-7. The E and H-plane radiation patterns include co-polarization and cross polarization at 4.4 GHz and 9.6 GHz respectively, for the proposed antenna.

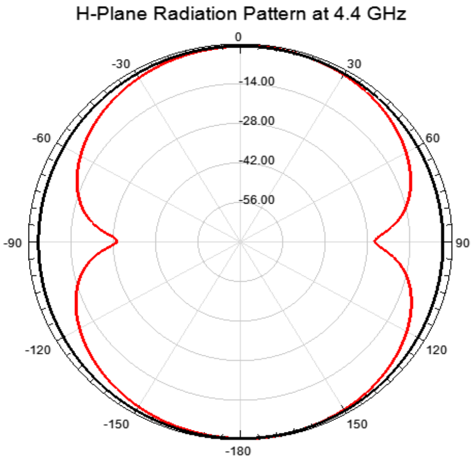

Figure-7(a)

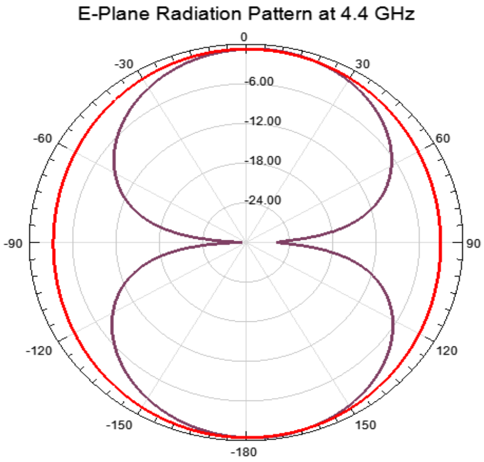

Figure-7(b)

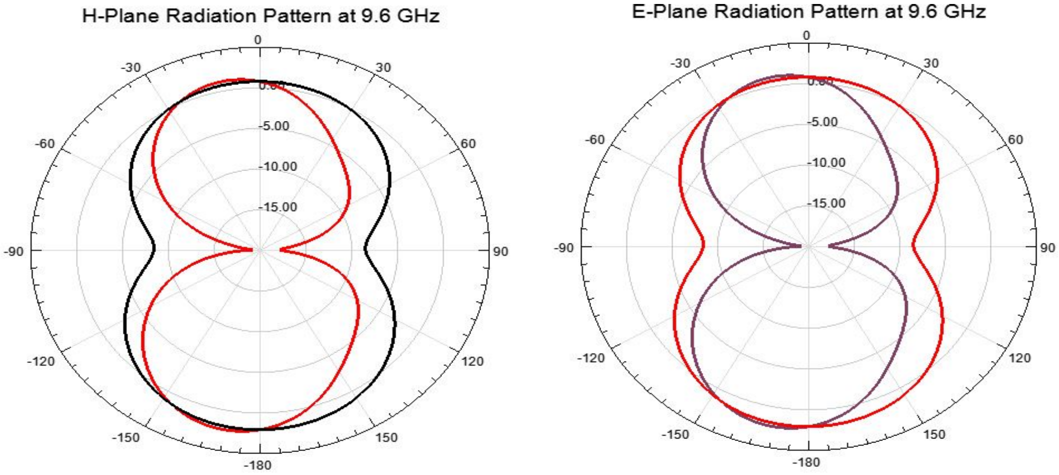

Figure-7(c) Figure-7(d)

Figure-7. Radiation Pattern of the antenna in E and H-plane at 4.4 and 9.6 GHz.

The simulated antenna gains for operating frequencies across the bands are shown in Figure-8. The simulated average gains are measured as 1.5 and 2.9 respectively within the bandwidths of 4.4GHz and 9.6GHz.

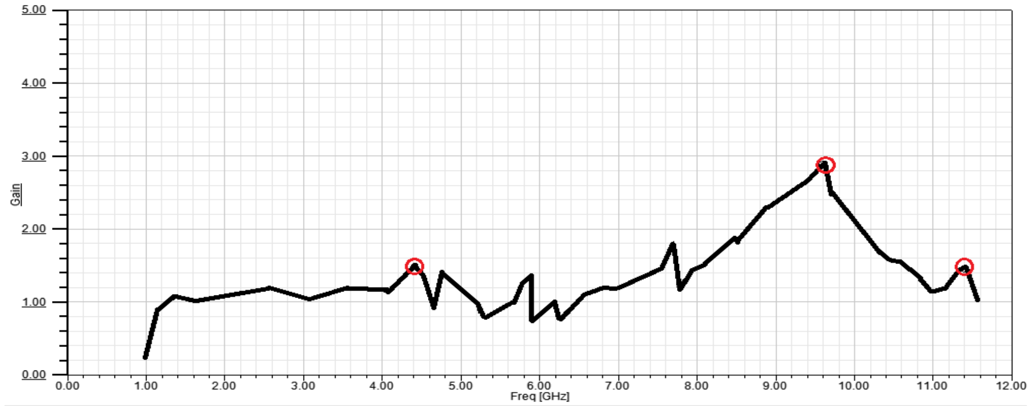

Figure-8. Frequency Vs Gain.

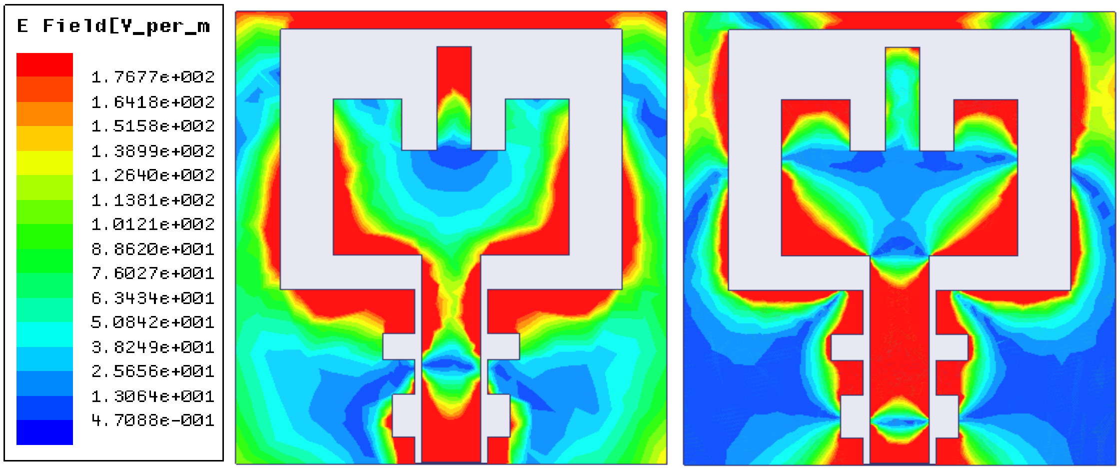

Figure-9. E-Field Distribution on the antenna without EBG at 4.4 and 9.6 GHz.

The electric field distribution over the surface of the antenna is as shown in Figures 9, 10 for the basic model and proposed triple sided EBG model. From Figures we understood that, with and without EBG structures the electric field distribution is having considerable variation. Considering the case without EBG, the maximum intensity level is 1.676e2 and with EBG the maximum intensity level is 2.6e2. The Figures 9, 10 are showing field distributions at 4.4 GHz and 9.6 GHz respectively.

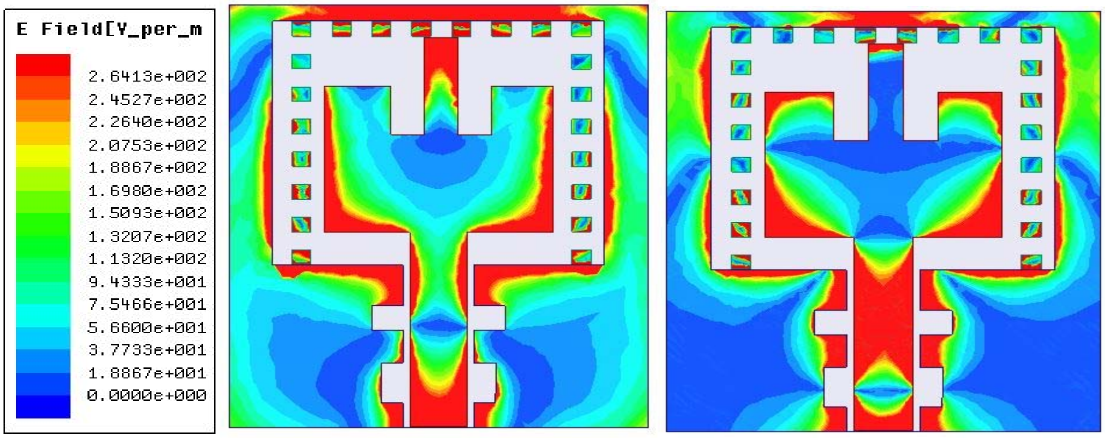

Figure-10. E-Field Distribution on the antenna with EBG at 4.4 and 9.6 GHz.

Table-2. Antenna parameters at 4.4 GHz.

S. No	Parameter	Without EBG	Single sided EBG	Double sided EBG	Proposed model
1	Max U	0.0012077	0.0010817	0.0011495	0.001028
2	Peak Directivity	1.7799	1.7186	1.7407	1.7358
3	Peak Gain	1.6337	1.5594	1.5784	1.5724
4	Peak Realized Gain	1.5177	1.3593	1.4445	1.3858
5	Radiated Power	0.0085267	0.0079092	0.0082983	0.0079839
6	Accepted Power	0.0092896	0.0087168	0.0091518	0.0088134
7	Incident Power	0.011	0.011	0.011	0.011
8	Radiation Efficiency	0.91788	0.90735	0.90674	0.90587
9	Front to Back Ratio	1.1338	1.1056	1.1474	1.1144

Tables 2 and 3 shows antenna parameters for all models at 4.4 and 9.6 GHz. It is observed that at 9.6GHz resonant frequency the peak directivity and gain for double sided EBG is relatively more when compared with other models.

Table-3. Antenna parameters at 9.6 GHz.

S. No	Parameter	Without EBG	Single sided EBG	Double sided EBG	Proposed model
1	Max U	0.0023089	0.0022373	0.0023948	0.0023058
2	Peak Directivity	3.4826	3.3528	3.5979	3.4583
3	Peak Gain	2.937	2.8341	3.017	2.9054
4	Peak Realized Gain	2.9015	2.8116	3.0095	2.8976
5	Radiated Power	0.0083314	0.0083857	0.0083645	0.0083787
6	Accepted Power	0.0098792	0.0099206	0.0099751	0.0099732
7	Incident Power	0.011	0.011	0.011	0.011
8	Radiation Efficiency	0.84333	0.84528	0.83854	0.84012
9	Front to Back Ratio	2.1349	1.8728	2.1827	1.8886

CONCLUSIONS

An EBG structured model with co-planar wave guide feeding is used on rectangular slot antenna. The antenna performance characteristics are determined for the case of with and without EBG structures. Different orientations like single, double and triple sided rectangular lattice structured EBG's are incorporated in the design to eliminate unwanted higher order modes. The proposed model of double sided EBG is showing excellent characteristics like wide impedance band width and harmonic suppression compared to other models. The dual operating bands of the presented antenna have the similar radiation characteristics and the proposed models having compact size with simple structure.

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