Dual Band Meta Material Inspired Antenna for Wireless Communication

Menka Singh,
Asst. Prof. (EXTC Dept.),
menka.singh@slrtce.in

Dipti Kale
Asst. Prof. (EXTC Dept.),
pooja.naik@slrtce.in

Khushbu Tikhe
Asst. Prof. (ETRX Dept.)
tikhe.khushbu@slrtce.in

Abstract— We propose a compact dual band meta material antenna for Wireless applications. The proposed antenna is microstrip rectangular patch loaded with EBG meta material on the same side of ground plane .The presence of U- slot in the radiating patch inserts a notch into the same matching band, resulting in a dual band feature . The ground plane of the proposed antenna is loaded with metallic rectangular EBG metamaterial patches which results in better impedance matching and gain enhancement. The antenna's operating band cover GSM frequency (1.99GHz) and WLAN/WiMAX frequencies (5- 5.6) GHz and(5.4-5.7)GHz .We have also demonstrated the effect of changing the size of the ground plane on the return loss and bandwidth of the antenna.

Index Terms*— Microstrip antenna; Dual band; U-slot technique ;Microstrip feed ; Metamaterial ; EBG*

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I. INTRODUCTION

In the planar wideband antennas, it has been seen that the insertion of a U-slot introduces a band notch, and so this has been implemented to minimize the interference [1-2]. By etching U-slots on the radiating patch, notches are introduced within the matching operational band, resulting in multi-band operation [3-4]. The U slot patch antennas can provide 25-30 % increase in impedance bandwidth for air – substrate and 20% for microwave substrate of similar thickness [5]. The antenna bandwidth enhancement is achieved by using the U-slot technique .In previously done research on the conventional U-slot etched printed antennas, the effect of the U-slot was analyzed on the performance of a patch antenna over the achieved bandwidth [6][7].

The U-slot technique works effectively in introducing notch in the matching band ,as it intercept the current maxima on the patch surface.[8] This technique is applied for the rectangular microstrip feed patch antennas in this article. The ground plane of the antenna is loaded with EBG metamaterial .The band -gap characteristics of EBG has been widely used to improve the efficiency ,impedance matching and to reduce mutual coupling between antennas[9]. EBG ground plane is utilized to reduce the multipath effect by blocking the propagation of surface waves and cross polarization component in a low profile antenna and also used to reduce the mutual coupling between elements [10]. The EBG structures can be utilized to enhance the performance of low profile antennas as they are helpful in suppressing the surface waves in antenna design[11].

The patch antenna was designed with U slot etched on the radiating patch and finite ground plane loaded with EBG metamaterialpatches , the size of the ground plane is reduced and modified to improve the return losses. Also we have optimized the EBG parameters such as size of EBG patch and also its repetition by using trial and error method.

The antenna design and its experimental results are discussed section 2. The measured results and related discussions are mentioned in section 3 and section 4. Also the concluding remarks for the proposed work are described in section 5 respectively.

II. DESIGNED ANTENNA

The geometry of the proposed metamaterial antenna is mentioned in this section. U slot is etched on the radiating rectangular patch, printed on FR4 substrate with dielectric constant 4.4 and thickness 1.529 mm. The rectangular patch has dimensions of length L and width W, and fed with microstrip feed-line.

The Antenna simulations were performed using software Computer Simulation Technology (CST STUDIO SUITE). CST Microwave Studio is based on Finite Integration Technique (FIT) for general purpose electromagnetic simulations.

A. Proposed Antenna Design

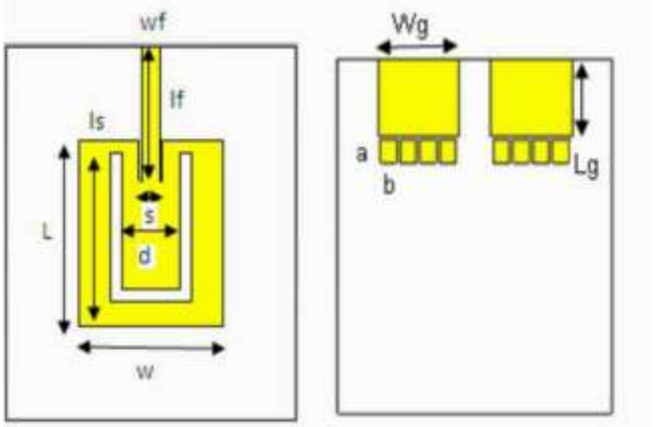
The Proposed antenna design is shown in figure 2.1. The geometric parameters of the proposed antenna are: length of rectangular patch L= 30 mm, width of rectangular patch W= 25 mm, feed-line width W_f= 2.5 mm, feed-line length l_f = 21 mm, with an inset of 6 mm and the space between the feed and inset is S =0.5 mm on both sides, slot length ls = 22 mm, slot width Ws =2 mm. The proposed antenna is mounted over the substrate size of length 60mm and width 50 mm and thickness (h+ t) 2.527mm.

The dimensions of the ground plane are, length of ground plane is Lg =17 mm and width of ground plane Wg = 14.8 mm respectively. The ground plane is modified in two by creating a slit or gap in between the ground with the gap width of 6.3mm, this gap width is optimizes by trial and error method. Also the ground plane is loaded with rectangular EBG patches parallel to the width of the ground with the spacing of 0.25mm.

The parameters of metallic EBG patches as follow: The length of EBG patch a=4mm , width b=3mm and the repetition gap g_e= 0.6mm . The final dimension of EBG patches and its repetition gap is achieved by trial and error method, the results are mentioned in table 2.1.

Table 2.1: EBG Trial Analysis for antenna

EBG Patches	a	B	g_e	Directivity (dBi)	Gain (dB)	Notches (GHz)	Return loss S_{11} (dB)
1. 6	4	4	1	2.9 at 1.9 3.8 at 5.5	2.8 at 1.9 3.5 at 5.5	1.9 , 5.5	26.5 at 1.9 -14.5 at 5.5
2. 7	4	4	1	2.9 at 1.9 3.8 at 5.5	2.7at 1.9 3.5 at 5.5	1.9 , 5.5	-26.5 at 1.9 -14.5 at 5.5
3. 8	4	3	0.6	3.6at 1.9 4.2at 5.6	3.4at 1.9 3.9 at 5.6	1.9, 5.6	-32 at 1.9 -36 at 5.5
4. 12	4	2	0.5	2.1 at 1.9 2.6 at 2.2	1.8 at 1.9 2.2 at 2.2	1.9, 5.45	-11 at 1.9 -20 at 5.45



Top view (Patch) Bottom view (ground)

Figure 2.1: The top and bottom view of antenna

III. SIMULATED RESULTS

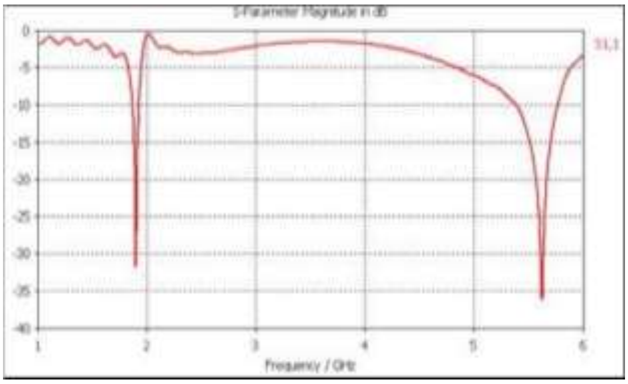


Figure 2.2: Simulated Return loss V/s frequency of antenna

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Figure 2.2 shows the return loss v/s frequency of antenna 2, where the U slot introduces a notch at around f_1 =1.9 GHz and another notch is introduced at around f_2 =5.62 GHz. The resulting dual band antenna have a frequency ratio $f_2/\ f_1$ = 2.76. The first band can be used in GSM 1900 applications, and second band for WLAN and WiMAX applications.

The return loss of -32 dB and -36dB is obtained at 1.9 GHz and 5.62 GHz respectively.

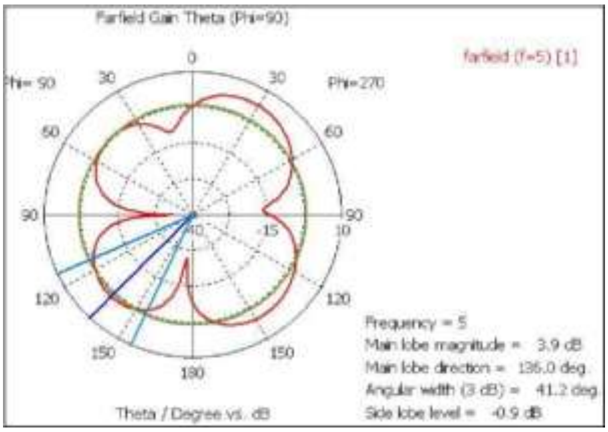

Figure 2.3: Far field radiation pattern of proposed antenna at 5 GHz.

Figure 2.3 and figure 2.4 shows far field radiation pattern of antenna at 5 GHz and 1.9 GHz respectively. The directivity obtained is 5.2 dBi at 5 GHz and 3.7 dBi at 1.9 GHz. Also figure 2.3 and figure 2.4 depicts the achieved gain of 3.9 dB at 5GHz and 3.4dB at 1.9GHz respectively. The obtained operational bands are (1.84-1.92) GHz with the bandwidth of 190.2 MHz at $f_1$and (5.37 -5.78) GHz with the band width of 4100MHz at f_2.

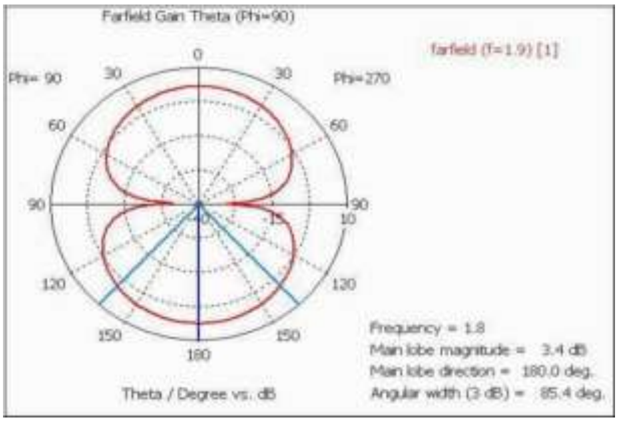

Figure 2.4: Far field radiation pattern of proposed antenna 2 at 1.9 GHz.

Thus from simulation results it was observed that as the dimentions of the EBG patches are modified the Parameters like gain ,directivity is increased along with improvement in return loss. But also the bandwidth of the antenna is reduced due modification in ground plane and periodicity of metalic EBG patches.

IV. EXPERIMENTAL RESULTS

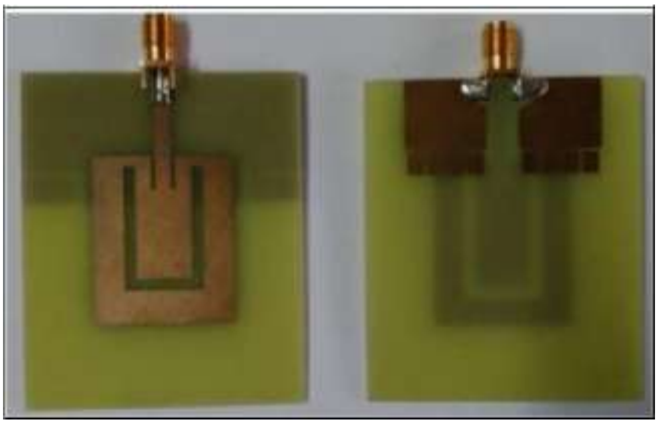

Figure 2.5: Top and Bottom view of fabricated antenna .

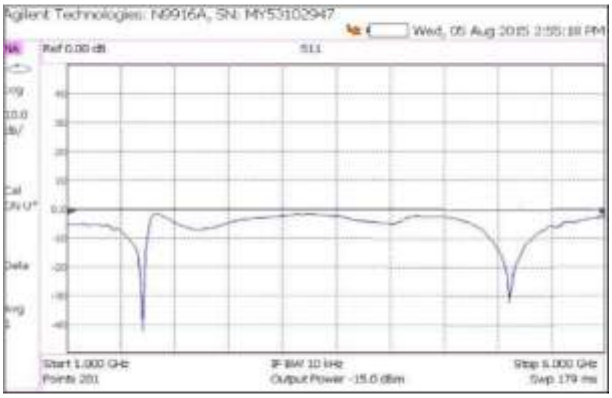

Figure 2.6: Measured Return loss V/s frequency of antenna .

Figure 2.5 shows the top and bottom layer of fabricated antenna and figure 2.6 shows the measured return loss V/s frequency plot of fabricated antenna. The fabricated antenna was tested on Network analyzer of Agilent technologies: N9916A, SN: MY53102947, operatesupto 16GHz.

Also practically it is observed that due to the modification in the EBG patches, the Parameters like gain, directivity is increased . Along with the improvement in return loss (S_{11}) the bandwidth of the antenna is reduced due modification in the dimension of ground plane .The differences in measured and simulated results is due to the defects in the prototype during fabrication and other fabrication errors .Also while testing the antenna the space constraint matters .

V. CONCLUSIONS

The compact dual band meta material antenna was introduced and analyzed. The proposed Antenna resonates at 1.9 GHz and 5.62 GHz with the gain of 3.4dB and 3.9 dB respectively. The achieved operational bands of Antenna cover the operation bands for GSM ,WLAN and WiMAX applications. The ground plane of antenna is modified to analyze its effect on parameters such as gain directivity, return loss (S_{11}) and bandwidth. Antenna gives better gain, directivity and return loss but at the cost of reduced bandwidth. Also due to loading of EBG patches on the Ground plane the efficiency of antenna is enhanced. In addition, the design technique is simple, compact and easy for fabrication, making it suitable for different wireless communication applications.

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