Microstrip Antenna using EBG Substrate

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Abstract**—**The Performance of a microstrip antenna integrated with an electromagnetic band gap substrate is described. Electromagnetic Band Gap (EBG) substrate is used as antenna structure to improve the performance of the patch antenna. The antenna structure is made from common FR-4 substrate and operates at the 2.486 GHz wireless band. The design of the microstrip patch antenna, band gap substrate, and their integration is presented. The band gap array consists of 7x7 elements and improves the antenna gain. In this paper the antenna performance in terms of resonance frequency, return loss, radiation pattern, antenna gain, directivity, bandwidth and efficiency is observed**.**

Keywords*- Microstrip Patch Antenna, Resonance frequency, Electromagnetic band gap (EBG) substrate, Gain, Return loss, Directivity.*

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I. INTRODUCTION

The electromagnetic band gap substrate is used in planar antenna to improve the performance of antenna like antenna gain, return loss, antenna directivity and bandwidth. The electromagnetic energy device between the interfaces, and forming into surface waves, is valuable an elementary dipole, placed on a uniform substrate with no losses. The dual-band EBG material is used which act as a high-impedance surface to reduce backward radiation and make the antenna bearable to positioning on the body and Simulated by using CST software (1). However, in last year's there has been considerable effort in the EBG structure for antenna application to reduce the surface wave and overcome the limitations of the antenna. Many works have been done to enhance the performance of the patch antennas (2-5).

The EBG structure utilizes the inherent properties of dielectric substrate materials to improve the microstrip antenna performance. The characteristics of EBG substrate depend on the shape, dimension, periodically and the materials used in their designing. There are four basic parameters influencing the performance of mushroom like EBG substrate such as EBG patch dimension, EBG gap, substrates thickness and substrates permittivity (6). To overcome these limitations of microstrip patch antennas two techniques have been used, namely micromachining and periodic arranged structures is called as the electromagnetic band gap (EBG) structures (7).

In this paper the proposed wideband antenna with photonic band-gap structure is used as substrate which consists of a rectangular patch with two rectangular notches at the two bottom ends of the rectangular patch and a partial ground plane having the slot structure (8). Electromagnetic band gap (EBG) have found wide variety of useful in advance components for microwave and millimeter wave devices, as well as in antenna designs (9). In UWB communication systems have the main problem is the design of a dense antenna along with wideband characteristic over the whole operating frequency band. Due to their characteristics of wide bandwidth, omni directional radiation pattern, simple structure and rest of construction various wideband monopole antenna designs, such as circular, rectangular, and elliptical shapes have been proposed for UWB applications (10).

In this paper, the design of a photonic band-gap substrate for microstrip patch antennas has been discussed. Here instead of dielectric poles and slots, the presented spiral structure was used. Also, they focus on enhancement of antenna performance with change in photonic crystal parameter such as adjust in dimension of spiral (11). This paper was to design conventional patch antenna and the patch antenna integrated with EBG substrates of different EBG patch width, with same physical dimensions, with the resonance frequency of 10GHz and measured the performance parameter of patch antenna when EBG structure added on it (12).

II. ANTENNA DESIGN

A. EBG Structure Design

The electromagnetic band gap structure has been designed for many novel antenna applications. Electromagnetic band gap structures can be defined as periodic (or sometimes non-periodic) objects that prevent or assist the propagation of electromagnetic waves in a specified band of frequency for all incident angle and polarization state. Two commonly employed characteristics are suppressing unwanted substrate modes and acting as an artificial magnetic ground plane. The main advantage of EBG structure is their ability to suppress the surface wave current. The generation of surface waves degrades the antenna efficiency and radiation pattern.

Fig. 1 shows the top view (a) and EBG unit cell view (b) of our proposed EBG structure. As can be seen in Fig. 1(a), the 7x7 dimensional periodic plus shape EBG substrate is formed. The dimension of plus shape EBG substrate is 50X50mm as shown in Fig. 1(a). The top plus shape EBG structure is connected to the bottom plane by a conductive wires at the center with 0.5mm radius. The unit cell of our proposed structure with 5 X 5 mm dimension is shown in the Fig. 1(b). The FR-4 substrate is used with thickness 1.6mm and relative dielectric constant 4.3

ISSN: 2321-8169
73 – 76

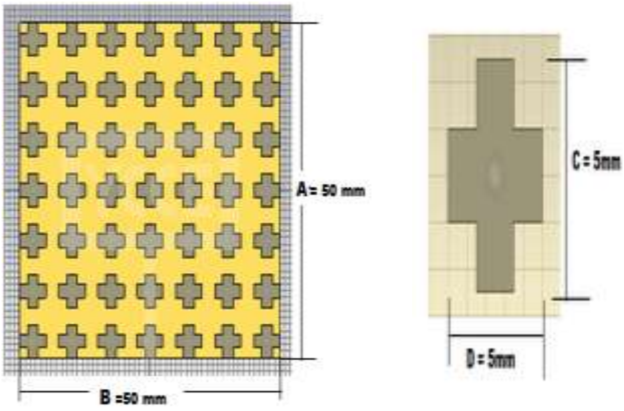

Figure 1: Design of EBG structure (a) Plus shape EBG substrate (b) EBG unit cell

B. Antenna Design

The proposed microstrip antenna is patch antenna on a 1.6mm thick FR-4 substrate with relative permittivity of 4.3. The microstrip antenna size of 50mm X 50mm X 1.6mm. The design process of this microstrip antenna has started by combining the logo of Yeshwantrao chavan college of Engg. Nagpur, India (YCCE). To design symmetric antenna the letters Y , C, C and E are arranged horizontally in a straight line as shown in Fig. 2. The main controlling parameter in our microstrip patch antenna are the letters and the rectangular patch. By controlling the dimension of rectangular patch the input impedance of the antenna could be matched or improved. All dimensions of microstrip patch antenna are shown in Table 1. The designed antenna operates from 2.3088 GHz to 2.6651 GHz frequency. The patch of the antenna has a width of 2.4mm is fed by a 50 ohm microstrip feed line. The logo type microstrip patch antenna has almost Omni directional pattern.

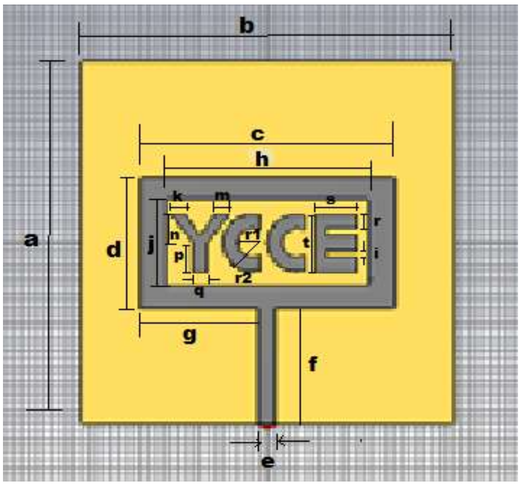

Figure 2: Patch antenna (Front view)

Fig. 3 shows the back view of microstrip patch antenna, which is called as ground plane and all the dimensions of this partial ground plane is shown in table 1. The conductive patch and the ground plane are of copper material with the thickness of 0.038mm. In addition, the full ground has a square ring slot and the dimension of the inner square is 20x20 sq. mm and outer square is of 24x24 sq. mm.

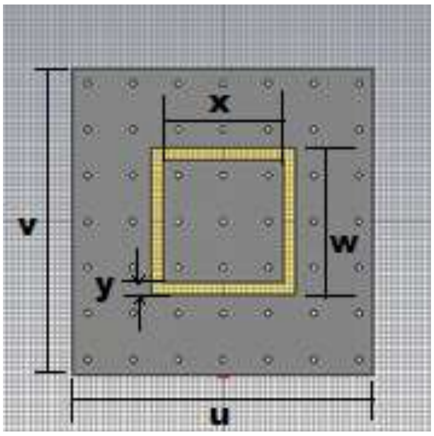

Figure 3: Ground (back view)

Table 1: Dimensions in mm

Sr No.	Parameters	Dimensions (in mm)
1	a	50
2	b	50
3	c	34
4	d	18
5	e	2.4
6	f	16
7	g	15.8
8	h	27
9	i	1
10	j	12
11	k	2
12	m	2
13	n	4
14	p	4
15	q	2
16	r	2
17	s	5.5
18	t	8
19	r 1	4
20	r 2	2
21	u	50
22	v	50
23	w	24
24	x	20
25	y	2

C. Patch Antenna With EBG Substrate

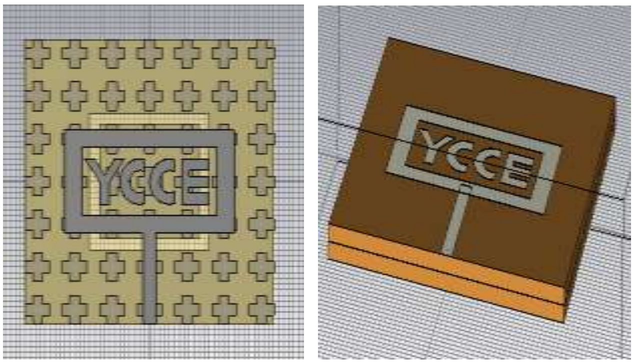

Figure 4: Patch antenna with EBG substrate (a) Top view and (b) Side view

Fig. 4(a) shows the top view of microstrip antenna with plus shape EBG substrate. As shown in Fig. 4(b) the side view, we can see that its two layer antenna. First layer consist of EBG substrate with conducting ground plane , FR-4 substrate and at the top plus shape 7x7 periodical EBG Substrate. The layer first having the thickness of 1.676mm. The above the EBG substrate again FR-4 substrate is placed and then at the top conducting YCCE patch is given as shown in Fig. 4(b) The overall thickness of this microstrip antenna with EBG substrate is 3.314mm.

III. RESULT AND DISCUSSION

A. S-Parameter analysis for microstrip antenna with EBG substrate permittivity, εr =4.3:

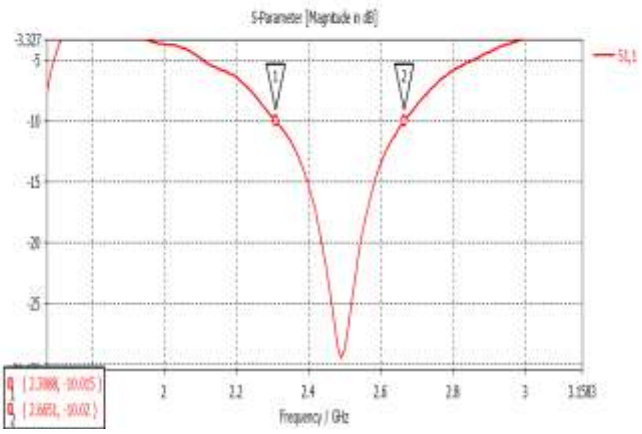

Figure 5: Simulated S-parameter result

The s-parameter plot of the microstrip antenna with EBG substrate is shown in Fig.5 shows that the operating frequency has a bandwidth of 356.3 MHz which resonance from 2.3088 GHz to 2.6651GHz with a return loss of -28.9917 dB.

B. ZRadiation pattern:

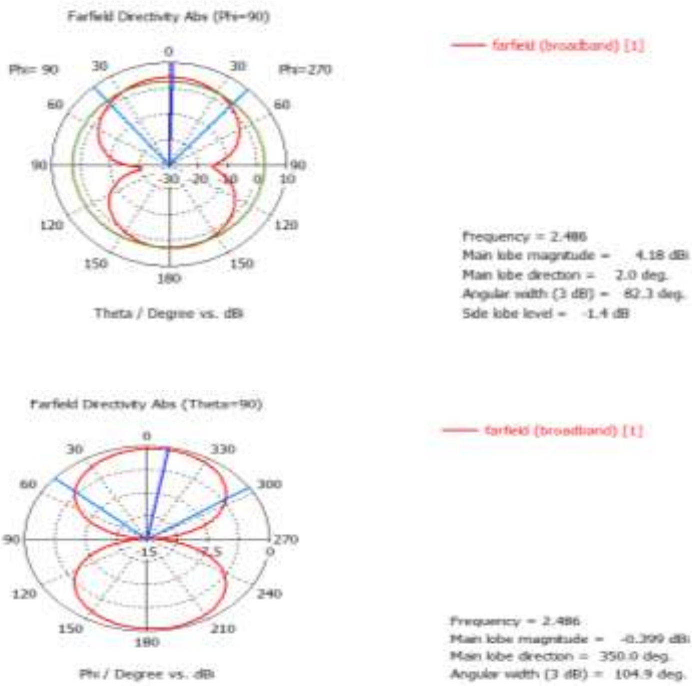

Figure 6: Radiation pattern at 2.486 GHz frequency.

C. Antenna Gain:

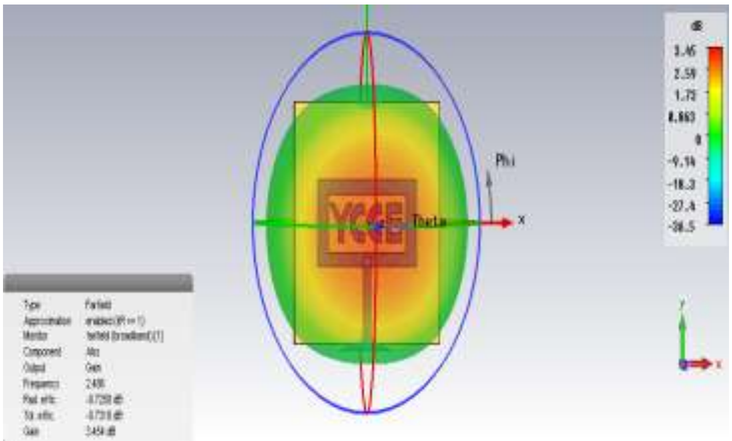

Figure 7: Gain of microstrip antenna with EBG at 2.486 GHz resonance freq.

The microstrip antenna has gain of 3.454dB at resonance frequency 2.486 GHz as shown in Fig. 7. The simulated result of microstrip antenna with EBG substrate is given in Table 2.

ISSN: 2321-8169
73 – 76

Table 2: Simulated Result of Microstrip Antenna with EBG Substrate

Resonance frequency (GHz)	S11 (dB)	VSWR	Gain (dB)	Directivity (dBi)	Band-Width (MHz)	Efficiency (%)
2.486	-28.99	1.0738	3.454	4.180	356.3	82.77

IV. CONCLUSION

In this paper a microstrip patch antenna with plus shape EBG substrate for WLAN (i.e. WiFi and Wi-Max) applications has been presented. From the return loss, realized gain and radiation patterns measurements at 2.486 it can be concluded that the microstrip antenna with EBG substrate covers the band of WiFi with proper gain.

This paper presents a novel microstrip EBG antenna with College name initials, YCCE, for WLAN applications. The radiation pattern of the antenna is Omnidirectional.

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