BANDWIDTH ENHANCEMENT ON MICROSTRIP RECTANGULAR PATCH ANTENNA WITH ELECTROMAGNETIC BAND GAP STRUCTURE FOR WI-FI APPLICATION

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Abstract - Use of microstrip patch antenna is very popular, but microstrip patch antenna suffer from a number of disadvantages such as narrow bandwidth. In this paper, a planar Electromagnetic Band-Gap (EBG) structures are used for further enhances the antenna bandwidth. An inset rectangular patch antenna was designed to work with a design frequency of 2.4 GHz. To analyze the EBG properties, the suspended transmission line method is used. In order to bandwidth enhancement, 1x3 EBG array arrange on the same layer of antenna's patch but the distance between patch and EBG were optimized. Simulation and measurement result are compared. In the end, it resulted the bandwidth of the rectangular microstrip antenna has increased 1.79 % noticeably by using the EBG structures for simulation result and increased 4.8 % for measurement result, and inclusion of EBG structure also improve gain as much as 0.345 dB and increase directivity of antenna 0,309 dBi. Application of EBG structure succeeds to increase the performance of antenna in simulation and measurement result respectively.

Index term- microstrip patch antenna, planar Electromagnetic Band-Gap (EBG).

Introduction

Nowadays, the use of small size and low-cost electronics systems is increasing due to advancements in integrated systems. Recent developments in microstrip patch antennas make entire world acceptable as low profile radiator [1]. Microstrip antennas are very attractive from the side of designing compact and cost effective wireless communication systems. In contrast to the merits such as light weight, low profile, ease of integration with printed circuits, but microstrip antennas suffer from excitation of surface waves, poor radiation efficiency and low gain [2].

Recently, the scientific community showed a very particular interest in a new technology for the improvement of the performances of antennas. It is a matter of the technology of EBG (Electromagnetic Band Gap) structures applicable to a frequential spectrum extremely wide covered from the acoustic until the optical frequencies. EBG structures are periodic structures in which the electromagnetic wave propagation is forbidden for an exciting incident wave with certain defined space direction. In other words, EBG structures allow controlling the electromagnetic wave propagation in function to the characteristics of the periodic texture composing the structure [3].

EBG substrates have found possible applications in the antenna technology to improve performance like reducing mutual coupling between effects due to truncated surface waves that would be excited in a standard antenna substrate [4]. EBG substrates can also be used to eliminate scan blindness phenomena presented in array antennas. EBG structures basically made of dielectrics or metals. These structures are periodic in one, two or three dimension.

Design of Antenna and EBG Structures

Microstrip Antenna

The proposed microstrip antenna was design on FR-4 substrate with dielectric permittivity is 4.3 and 1.6 thickness. FR-4 is a low cost material, has good strength, and well known as material with high flexibility. FR-4 can operate in 10 MHz until 10 GHz frequency.

The design strategy is try to keep the return loss as minimum as possible. Design procedure is conventional based on existing literature. Here two important parameters in microstrip inset feed line is inset gap width (notch width) and the inset fed (notch length). Figure 1 shows the geometry of microstrip rectangular patch antenna. Figure 2 shows fabricated microstrip antenna.

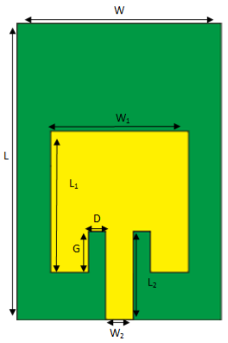


Figure 1. Geometry of microstrip antenna

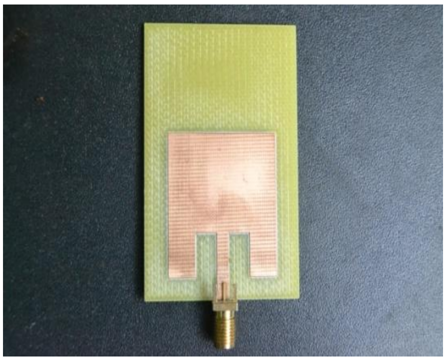


Figure 2. Fabricated microstrip antenna

The dimension of the microstrip rectangular patch antenna is given in table 1

Table 1. Microstrip antenna specification

Label	Size (mm)
L	60
L_1	31.1
L_2	14.4
W	40
W_1	28
W_2	3.1
G	9.5
D	5.5

Electromagnetics Band-Gap (EBG) Structures

The planar EBG is used in this research. Planar EBG is chosen due to easy to fabricate. Planar EBG when integrated with other microwave devices exhibits some interesting features such as distinctive passband and stopband, slow wave effects, low attenuation in the passband and suppression of surface waves [7]. Geometry of EBG is showed in Fig. 3. This figure shows the model of the unit cell of the EBG. The dimension of the EBG structure is given in Table 2.

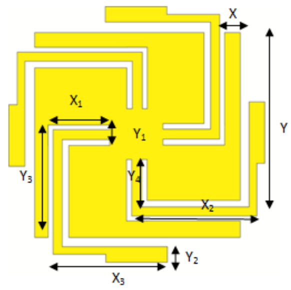
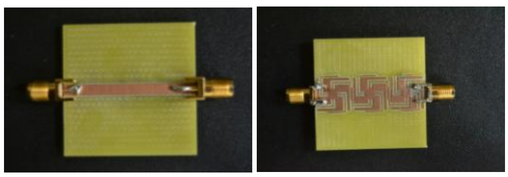


Figure 3. Geometry of Electromagnetic Band Gap (EBG) unit cell.

Table 2. EBG specification

Label	Size (mm)
Y	11
Y_1	0.3
Y_2	0.4
Y_3	6.25
Y_4	2.5
X	0.75
X_1	2.5
X_2	6.3
X_3	3.025

The periodic transmission line method is most popular technique to analyze EBG structure [7] . The advantages of microstrip have been well established, and it is a convenient form of transmission line structure for probe measurements of voltage, current and waves a microstrip transmission line is a "high grade" printed circuit construction, consisting of a track of copper or other conductor on an insulating substrate. There is a "backplane" on the other side of the insulating substrate, formed from a similar conductor. EBG is used as ground plane in this method (Fig. 4)



(a) (b)

Figure 4. Fabricated proposed EBG (a) top view (b) bottom view

S_{21} parameter is investigated to get band gap characteristic of EBG. The comparisons between simulated and measured of S_{21} value of both EBG are shown in Figure 5. From this figure, simulated result shows minimum value of S_{21} is -24.93 dB at 2.4 GHz, meanwhile from measured result of S_{21} is -16.17 dB at 2.4 GHz.

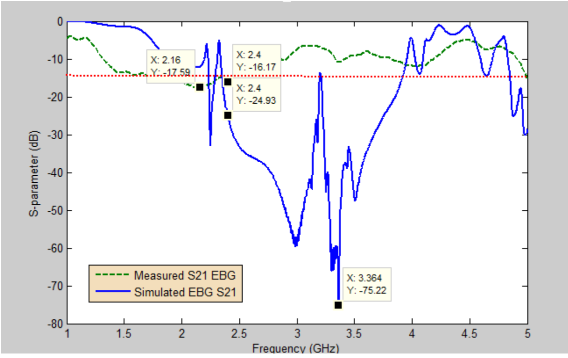


Figure 5. S_{21} comparison between simulated and measured EBG structure

Antenna with EBG Structures.

To improve the performance of the antenna, arrangement 1 x 3 array of EBG structures is employed with the antenna. EBG applies in same layer with antenna's patch. The optimum distance between the antenna's patch and the EBG is 1.5 mm (as shown as in Fig. 6). The EBG and antenna size are identical with that mentioned previously.

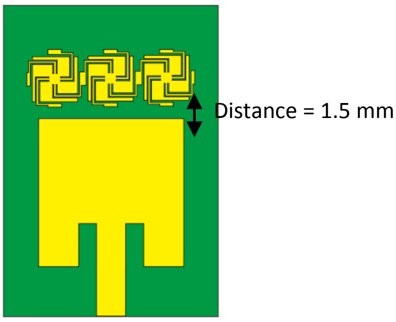


Figure 6. Geometry of antenna with EBG structure

Result and Discussion

Figure 7 shows the bandwidth comparison of simulated antenna without EBG and simulated antenna with EBG. With the criteria of S_{11} less than -10 dB, the antenna without EBG obtained 32.5 MHz bandwidth and the antenna with EBG obtained 36.7 MHz bandwidth. The bandwidth increases about 4.2 MHz. Figure 8 shows the bandwidth comparison between measured antenna without EBG and with EBG. With the criteria of S_{11} less than -10 dB, the bandwidth of 40 MHz and 50 MHz for antenna without EBG and with EBG respectively are obtained.

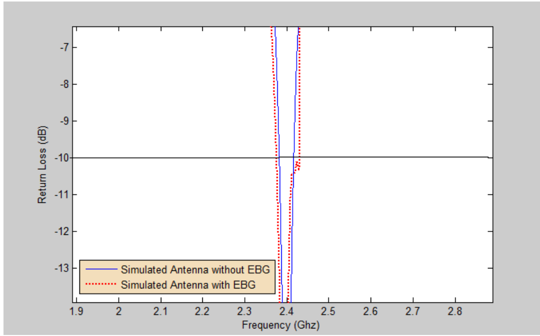


Figure 7. Bandwidth Comparison of Simulated microstrip antenna with and without EBG

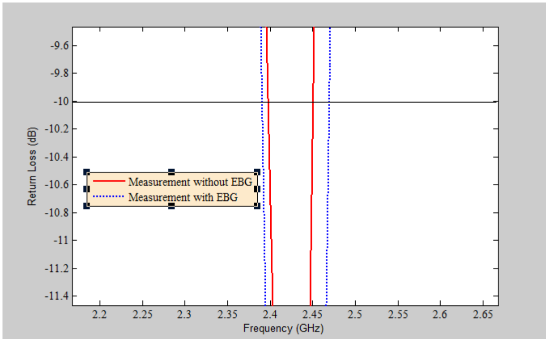


Figure 8. Bandwidth Comparison of measured microstrip antenna with and without EBG

Based on the simulation result, gain of antenna is increased when the EBG structure is employed with microstrip antenna. As shown as in Fig.9 antenna without EBG structure has 5.345 dB gain antenna, meanwhile (as in Fig. 10) antenna with EBG structure has 5.690 dB gain. The gain is increased by 0.345 dB.

Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Gain
Frequency	2.4
Rad. effic.	-0.3364 dB
Tot. effic.	-0.3606 dB
Gain	5.345 dB

Figure 9. Gain of microstrip patch antenna without EBG

Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Gain
Frequency	2.4
Rad. effic.	-0.2212 dB
Tot. effic.	-0.3447 dB
Gain	5.690 dB

(b)

Figure 10. Gain of microstrip patch antenna with EBG

Table 3 and Table 4 show the summary of the simulated and measured results respectively.

Table 3. Simulation Results.

	Antenna Microstrip without EBG Structure	**Antenna Microstrip with EBG Structure**
Return loss, S_{11}(dB)	- 22.56	-18.46
Bandwidth (%)	13.5 (32.5 MHz)	15.29 (36.7 MHz)
Gain (dB)	5.345	5.690
Directivity (dBi)	5.602	5.911

Table 4. Measurement Result.

	Antenna Microstrip without EBG Structure	**Antenna Microstrip with EBG Structure**
Return loss, S_{11}(dB)	-15.19	-15.09
Bandwidth (%)	16 (40 MHz)	20.8 (50 MHz)

Conclusion

Application of EBG structure increases bandwidth of a microstrip patch antenna. Also, EBG structure implementation in the design of microstrip antenna increases antenna directivity and antenna gain without sacrificing the bandwidth of the array antenna. Finally, the antenna gain is increased to 5.690 dB and directivity is increased to 5.911 dBi.

Acknowledgement

Author would like gratitude to Rudy Yuwono, S.T., M.Sc Dr. Zuhairiah Binti Zainal Abidin. Brawijaya University and UTHM Malaysia for the support.

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