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Design and Performance of Photonic Substrate for Monopole UWB Antenna

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ABSTRACT

This paper proposes a monopole antenna with photonic crystal structure as substrate for ultrawide band application with dual band notched characteristics.Improvements in all the main parameters of the antenna were obtained when using a PC.The measured results reveal that the presented dual band-notch monopole antenna offers a very wide bandwidth with two notched bands, covering 3.5/5.5-GHz WiMAX and 8/12-GHz X-bands.

Keywords: Ultrawide band, monopole, photonic crystal.

I. INTRODUCTION

The microstrip patch has been a popular antenna for many years due to some of its appealing features such as it is low profile, robust, conformable if required and inexpensive to manufacture.However, the technologies which are in use for wireless communication still need to be improved further so as to satisfy the higher resolution and data rate requirements.In UWB communication systems, one of important issue is the design of a compact antenna that could provide wideband characteristic over the whole operating band[1]. Due to their appealing features of wide bandwidth, simple structure, omnidirectional radiation pattern, and ease of construction several wideband monopole configurations, like circular, square, elliptical, pentagonal, and hexagonal have been proposed for UWB applications. However, their are some operational limitations related with patch antenna designs such as restricted bandwidth of operation, low gain and a decrease in radiation efficiency due to surface wave losses[2]. Thickening the substrate however increases the operational bandwidth, but at the same time it increases the excitation of substrate modes.

The photonic bandgap materials that was introduced in the late eighties allow to control the emission and propagation of electromagnetic waves into a dielectric substrate to an extent that was previously impossible[3].Also known as electromagnetic band gap(EBG),they have now found wide variety of applications in developing components for microwave and millimeter wave devices, as well as in antenna designs[4]. PBG material, in general, is a periodic structure that prohibit the propagation of electromagnetic surface waves within a particular frequency band called the band-gap. In this paper, the design of a photonic crystal as a substrate for patch antennas has been discussed. Also,we focus on improvement of antenna performance with change in photonic crystal parameter such as lattice constant and radius of holes.

II. DESIGN STRUCTURE

The figure below shows the configuration of the proposed wideband antenna with substrate as photonic crystal which consists of a rectangular patch with two notches at the two lower corners of the rectangular patch and a truncated ground plane with the notch structure[5].

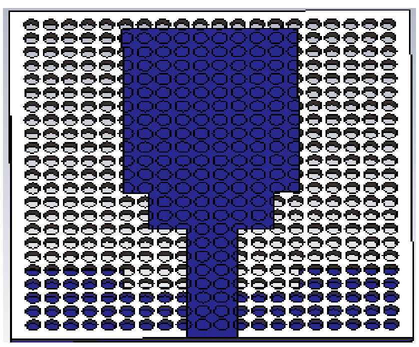

Figure 1. Configuration of the proposed microstrip-fed monopole antenna with photonic crystal as substrate (r/a=0.4,r=0.3,a=0.75) . (front view)

The proposed antenna, which has compact dimension of 16 mm ×18 mm ($W_{sub} \times L_{sub}$) , is constructed on FR4 photonic substrate with thickness (t) of 1.6 mm and relative dielectric constant of 4.4. The photonic substrate has been designed by inserting hole in dielectric substrate at periodic distance called lattice constant(a) where radius(r) of every hole is taken to be same for any photonic crystal. And the value of radius and lattice constant is predicted from r/a ratio. The width W_f of the microstrip feedline is taken as 2 mm . On the front surface of the substrate, a rectangular patch with size of W × L is printed. The rectangular patch has a distance of L_3 to the ground plane printed on the back surface of the substrate. By cutting the two notches of suitable dimensions ($W_1 \times L_1$) at the monopole's two lower corners, which there by enhances the impedance bandwidth achieved for the proposed antenna. This phenomenon occurs because the two notches affect the electromagnetic coupling between the rectangular patch and the ground plane. In addition, to achieve good wideband matching of the proposed antenna, the separation between the rectangular patch and the notch in the ground plane is used.

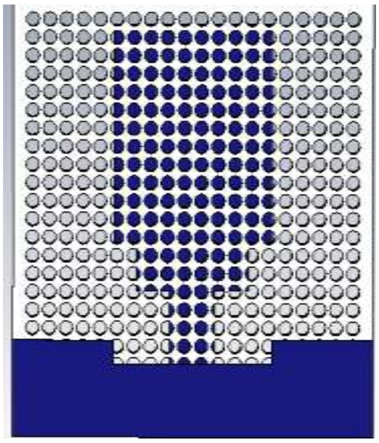

Figure 2. Configuration of the proposed microstrip-fed monopole antenna with photonic crystal as substrate (r/a=0.4,r=0.3,a=0.75) . (Back view)

The dimension of the notch ($W_2 \times L_2$) embedded in the truncated ground plane and feed gap distance L_3 are important parameters in determining the sensitivity of impedance matching.

Table 1: Optimal Dimensions of the Designed Antenna

Parameter	mm	Parameter	mm	Parameter	mm
W_{sub}	16	L_{sub}	18	W_f	2
W	7	L	11	W_1	1
L_1	2	W_2	7	L_2	1
L_3	3	L_{gnd}	4	t	1.6
r/a	0.4	r	0.3	a	0.75

III. SIMULATIONS AND RESULTS

The commercial software package CST-2011 has been used to simulate the performance of above designed monopole antenna configurations with photonic crystal as substrate.The simulated input return loss is shown below in Figure 3.The fabricated antenna satisfies the 10-dB return loss requirement from 3.1 to 13 GHz with two band notch obtained one located at 3-5.5 GHz used for WiMAX and other notch is obtained at frequency ranging from 8 to 12 GHz used for X-band . Antenna impedance bandwidth thus we obtained with this design is also satisfactory wide.

The simulated radiation patterns are depicted in Figure 4.This pattern is shown for frequency 3.6 GHz, 8.05 GHz and 10.2 GHz .From radiation pattern we get, it is clear that we obtain a directional pattern i.e greater radiation in one direction with side lobe in other direction.

The reduction in surface waves as a result of the using Photonic Crystal material as substrate is also clear from the surface plot of the electric field magnitude, as shown in Figure 5.Also the gain response of monopole antenna is increased by using substrate as photonic crystal.

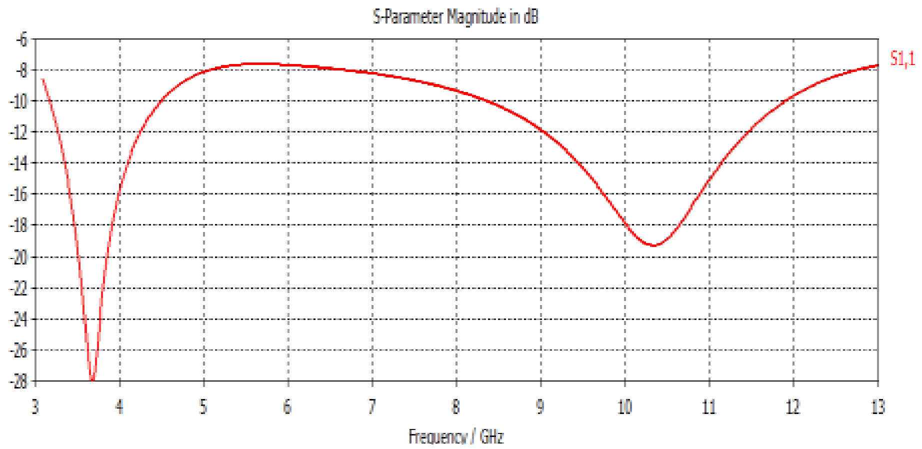

Figure 3. Simulated return loss characteristics for an optimized microstrip-fed monopole antenna with photonic crystal as substrate (r/a=..5, r=1mm, a=2mm)

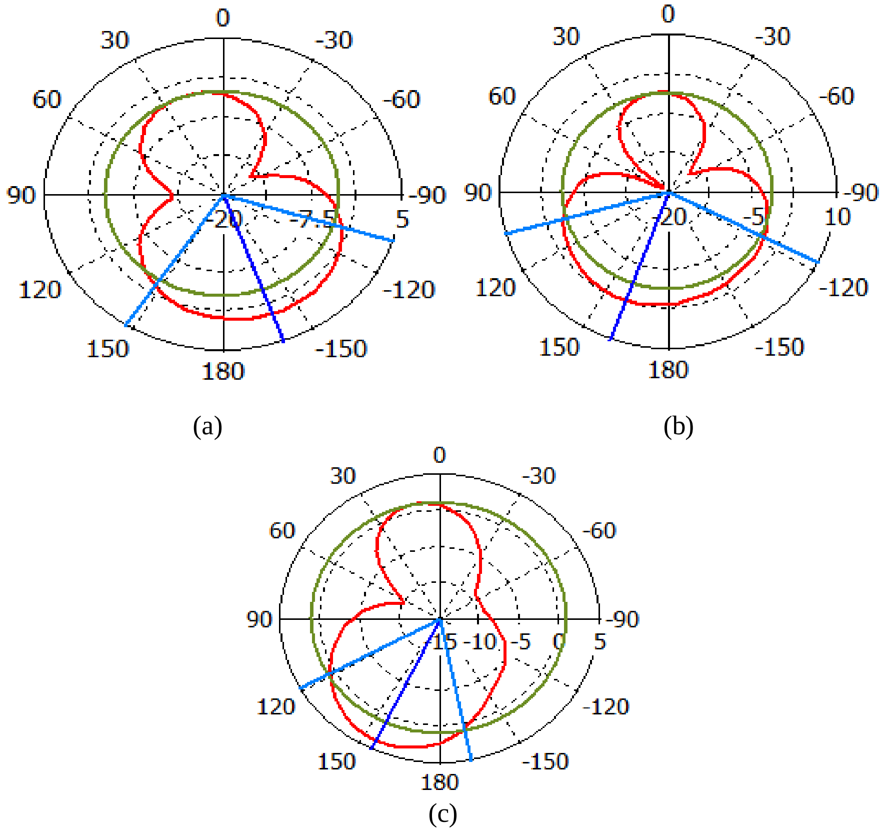

Figure 4: Measured radiation patterns of the proposed antenna. (a) 3.6 GHz. (b) 8.05 GHz. (c) 10.2GHz

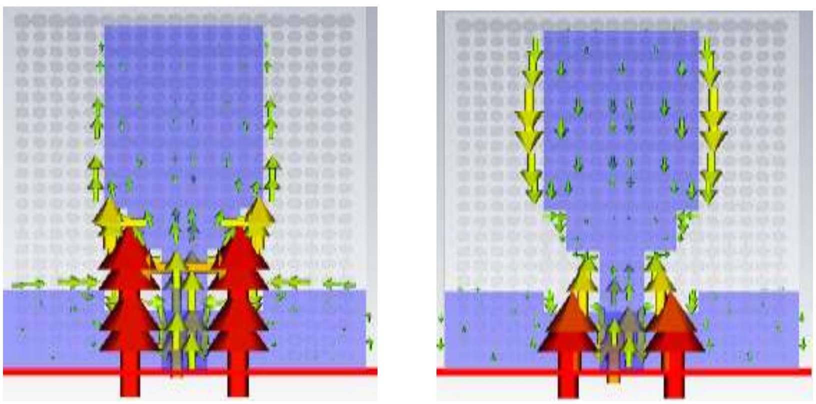

Figure 5. Simulated surface current distributions on the radiating patch for the proposed antenna shown in Fig. 1 at (a) 3.6 GHz (first notch frequency) and (b) 10.2 GHz (second notch frequency).

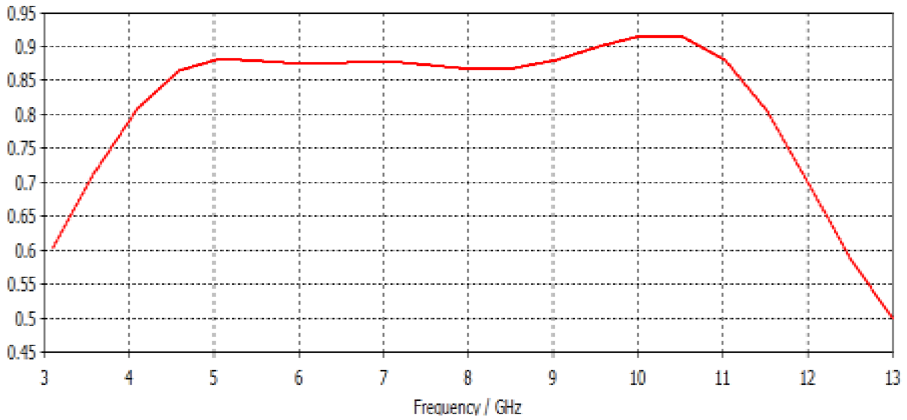

Figure 6: Gain Response of proposed antenna configuration

CONCLUSION

Simulations and measurements of a patch antenna with Photonic Crystal substrate have been presented. In this design, the proposed antenna can operate from 3 to 13 GHz with two rejection bands around 3.07–4.57 GHz and 7.73–11.9 GHz. Good return loss and radiation pattern characteristics are obtained in the frequency band of interest.

It is very clear from the above figure of radiation pattern that monopole antenna configuration with photonic substrate can be used as directional antenna as gain in the one direction increases significantly. The Photonic Crystal substrate have also reduce the surface wave mode propagation which is clear from above figures.

REFERENCES

[1]. Balanis, C. A., Antenna Theory. Analysis and Design, Second edition, John Wiley & Sons, Inc., 1997.
[2]. M. Mehranpour, J. Nourinia, Ch. Ghobadi, and M. Ojaroudi, " Dual Band-Notched Square Monopole Antenna for Ultrawideband Applications", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 11, 2012.
[3]. De Maagt, P. J. I., R. Gonzalo, and A. Reynolds, "PBG Crystals: periodic dielectric materials that control EM wave propagation," Microwave Engineering Europe, 35–43, Oct. 1999.
[4]. D. Nashaat, H. A. Elsadek, E. Abdallah, H. Elhenawy, and M.F. Iskander, "Enhancement of ultra-wide bandwidth of microstrip monopole antenna by using metamaterial structures," presented at the IEEE Int. Symp. on Antenna and Propagation Proceedings, Charleston, Jun. 2009.
[5]. Jihak Jung, Wooyoung Choi, and Jaehoon Choi, Member, " A Small Wideband Microstrip-fed Monopole Antenna", IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 15, NO. 10, OCTOBER 2005.