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Design of Microstrip Fed Monopole Antenna Using Photonic Band-Gap Structure for Ultra Wideband Application

Pooja Sharma and Govind Kumar

Electronics and Communication Deptt.
Government Engineering College, Ajmer

Abstract

This paper presents the design of a microstrip fed monopole antenna with photonic band-gap structure as substrate for ultrawide band application with dual band notched characteristics. The microstrip antenna designed and optimized by using CST Microwave Studio (CSTMWS) was found to operate satisfactorily. The measured results presents that the proposed dual band-notch monopole antenna offers a very wide bandwidth of 3.1-13 GHz with two notched bands, covering 3.5/5.5-GHz WiMAX and 8/12-GHz X-bands. And with further change in photonic structure it can be specified to operate only for X-band.

Keywords- Ultrawide band, monopole, photonic crystal.

I. Introduction

Ultra Wide Band (UWB) is a revolutionary technology with extraordinary potential in terms of its throughput, performance and low cost implementation. The unique property of UWB is its ability to transmits over wide bandwidth of several GHz, around a low center frequency, that also at very low power levels [1].

In UWB communication systems, one of the main issue is the design of a compact antenna along with providing wideband characteristic over the whole operating frequency band. Due to their appealing features of wide bandwidth, simple structure, omnidirectional radiation pattern, and ease of construction several wideband monopole configurations, such as circular, square, and elliptical have been proposed for UWB applications [2]. But they are not suitable for integration with printed circuit boards since they do not have planar structures. Thus, a microstrip-fed monopole antenna is suitable candidate for integrating with hand-held terminal for possessing its attractive features such as low profile, low cost, and light weight.

The photonic crystals (PhCs) have attracted a great deal of attention because of its ability to control the emission and propagation of electromagnetic waves into a dielectric substrate to an extent that was previously impossible [3].Also it is known as electromagnetic band gap (EBG).Now they have found wide variety of applications in developing components for microwave and millimeter wave devices, as well as in antenna designs [4].

The 1-D photonic crystals were proposed in 1887. The 2-D and 3-D photonic crystals were proposed over 100 years later. PhCs are composed of periodic dielectric or metallo-dielectric nanostructures that have alternate low and high dielectric constant materials in one, two or three dimension (s), which affects the propagation of electromagnetic (EM) waves inside the structure. PBG material, prohibit the propagation of electromagnetic surface waves within a particular band of frequency called the band-gap.

In this paper, the design of a photonic band-gap substrate for patch antennas has been discussed. Here instead of dielectric rods and holes, the proposed spiral structure has been used. Also,we focus on improvement of antenna performance with change in photonic crystal parameter such as change in dimension of spiral.

II. Design Structure

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

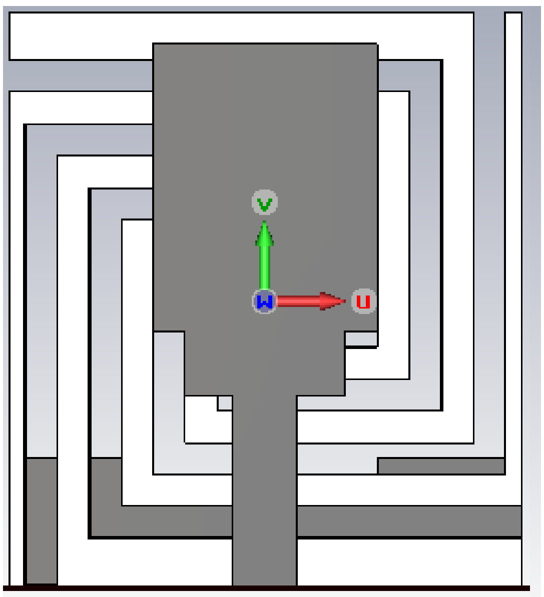


Fig. 1. Configuration of the proposed microstrip-fed monopole antenna with photonic band-gap structure (front view)

The proposed antenna, which has compact dimension of 16 mm ×18 mm (W_{sub} × L_{sub}), is constructed on RT/D6010 photonic substrate with thickness (t) of 1.6 mm and relative dielectric constant of 10.2. The width W_f of the microstrip feedline is taken as 2 mm. On the upper surface of the substrate, a rectangular patch is printed with size of W × L.The rectangular patch has a distance of L_3 from the ground plane that is printed on the back surface of the substrate. By cutting the two notches of suitable dimensions (W_1 × L_1) at the two lower corners of patch, which enhances the impedance bandwidth 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, the good wideband matching of the proposed antenna is achieved by the separation between the rectangular patch and the notch in the ground plane.

The photonic structure is usually created by inserting periodic holes on dielectric substrate. But here instead of hole and dielectric rods the proposed spiral structure is created where spiral arms are rotated in the counter clockwise direction, and are found to be equal to the separation between arms (s) and is equal to 1 mm.

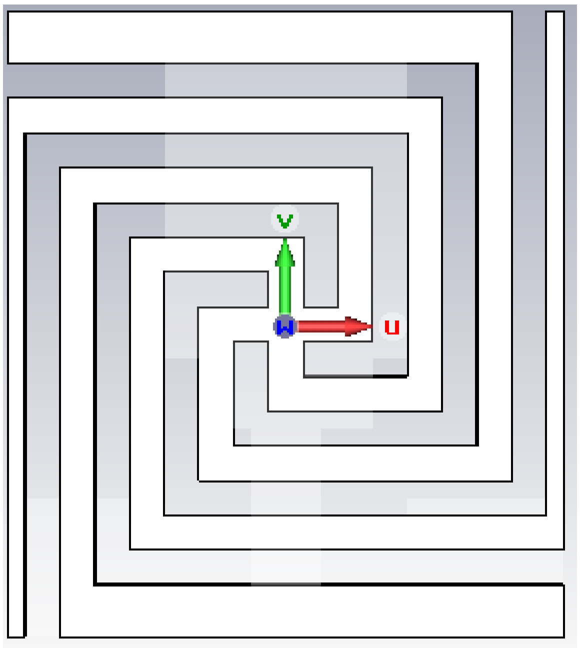


Fig. 2. Configuration of the proposed microstrip-fed monopole antenna with photonic band-gap structure

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

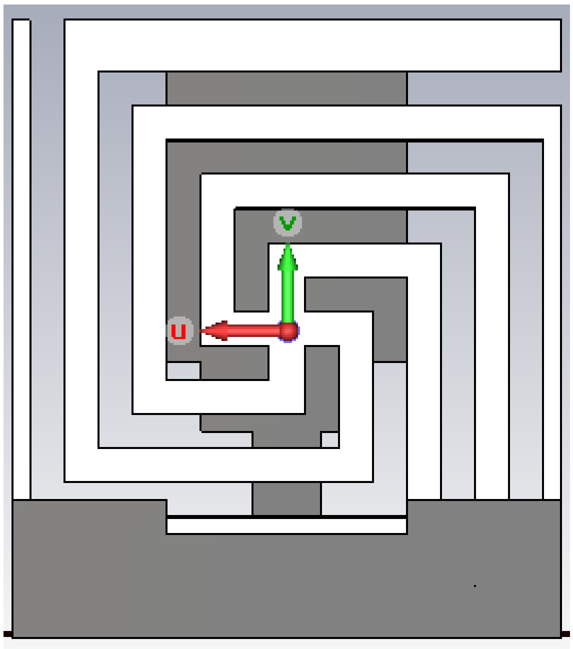


Fig. 3. Configuration of the proposed microstrip fed antenna with photonic band-gap structure (back view)

Table I Optimal dimensions of the designed antenna

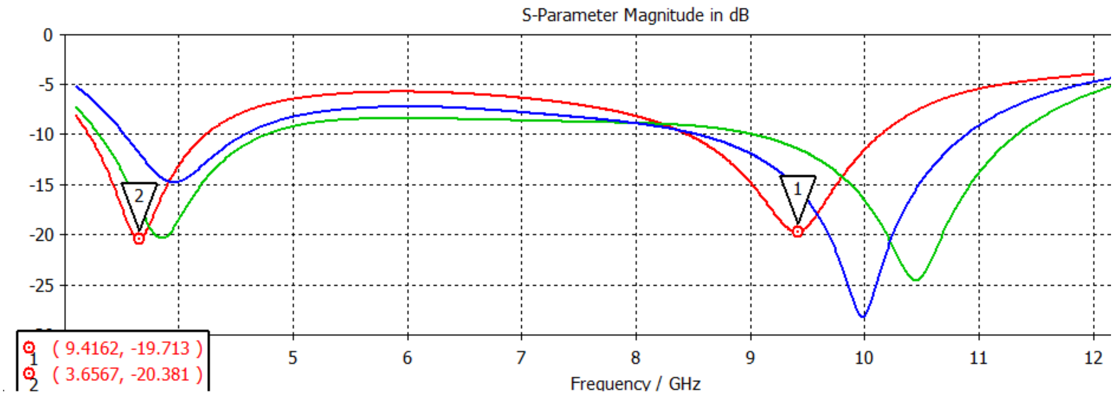
Parameter	mm	Parameter	mm	Parameter	mm
W_{sub}	16	L_{sub}	18	W_f	2
W	7	L	11	W_1	1
L_1	2	W_2	7	L_2	1
L_3	3	L_{gnd}	4	s	1

III. Simulation 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 4.The fabricated antenna satisfies the 10-dB return loss requirement from 3.1 to 13 GHz with two band notch obtained one located at 3.21–4.2177 GHz used for WiMAX and other notch is obtained at frequency ranging from 8.4568–10.151 GHz used for X-band.Also we can see on decreasing the spiral spacing from 1mm to 0.5mm the 10-dB return loss requirement get best fulfilled at X-band.

Antenna impedance thus we obtained with this design is also satisfactory shown in fig 5.The simulated radiation patterns thus evaluated are shown in Figure 6.This pattern is shown for frequency 3.6 GHz, 7.05 GHz and 9.4 GHz. From radiation pattern we get, it is clear that we obtain a omnidirectional pattern i.e equal radiation in all direction.

The surface current distribution on the radiating patch of proposed antenna has also been measured at two notch frequency shown in Figure 7.



s=1 mm
s=0.75mm
s=0.5mm

Fig. 4. Simulated return loss characteristics for an optimized microstrip-fed monopole antenna with photonic band-gap structure

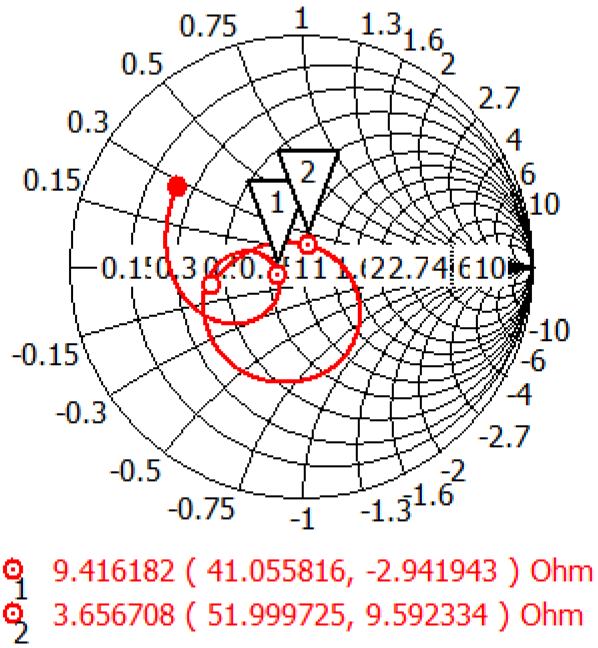


Fig. 5. Antenna Impedance of microstrip fed monopole antenna using photonic band gap structure at two notch frequency

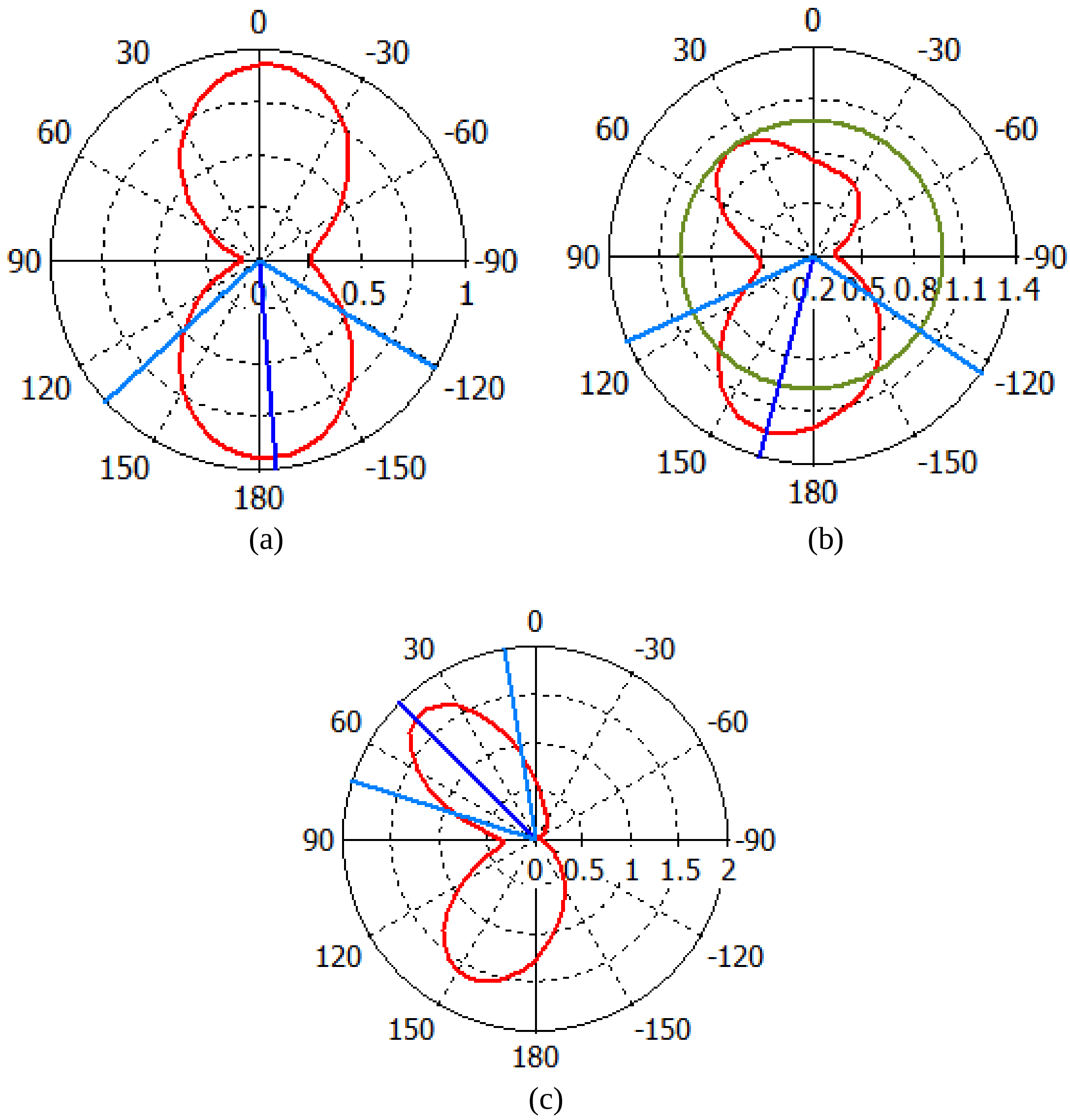


Fig. 6. Measured radiation patterns of the proposed antenna. (a) 3.6 GHz. (b) 7.05 GHz. (c) 9.4 GHz.

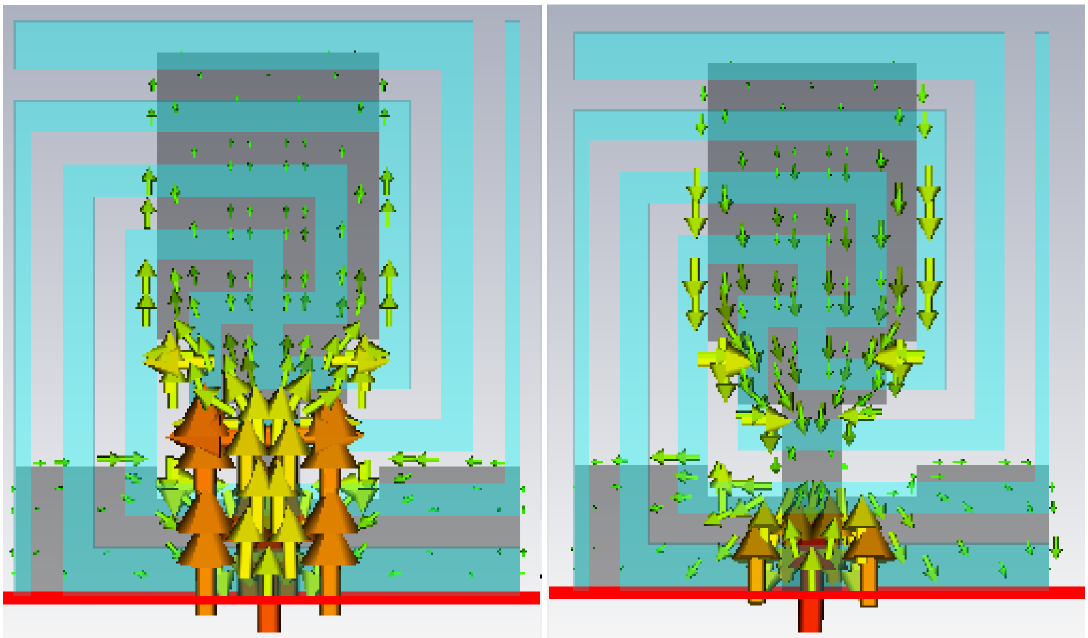


Fig. 7. Simulated surface current distributions on the radiating patch for the proposed antenna shown in Fig. 1 at (a) 3.6 GHz (first notch frequency) and (b) 9.4 GHz (second notch frequency).

IV. Conclusion

Simulations and measurements of a patch antenna with Photonic band-gap structure have been presented. As it is clear that the proposed antenna thus designed can operate from 3 to 12 GHz with two rejection bands around 3.21–4.2177 and 8.4568–10.151 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 band-gap substrate can be used as omni-directional antenna.

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