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ENHANCEMENT OF BANDWIDTH BY USING PHOTONIC BANDGAP STRUCTURE IN MICROSTRIP ANTENNA

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Abstract- Modern wireless technology has put a lot of emphasis on slim size and reliability, image processing, internetworking across the globe, making technology to be more intelligent and sophisticated to provide all time communication which should be cost effective, noise free, futuristic and robust. Micro strip technology can make antenna smaller in size and conformal to system component. With the use of Micro strip technology we can design an antenna which can transmit and receive the signal with greater reliability. But due to surface wave radiation the bandwidth becomes smaller, therefore to eliminate this drawback we use photonic band gap structure of substrate material to enhance the bandwidth and gain. In this paper we illustrate the methodology, design and simulation to implement such antenna to provide greater bandwidth for future communication system.

Keywords- Substrate, Directivity, Microstrip antenna, Photonic Band Gap Structure Bandwidth etc.

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Introduction

Antenna is very important component of communication system. An antenna is transducer which converts the electric signal into electromagnetic wave and vice versa. Due to light weight and planer structure and less fabrication cost micro strip antenna is best suitable. But the one drawback is inherent in micro strip antenna that the bandwidth becomes very small. In this paper we have introduced a method to enhance bandwidth of antenna.

Surface Wave Radiation in Patch Antenna

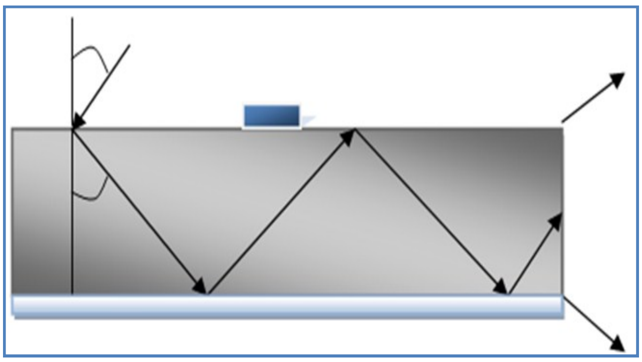

Fig. 1- Propagation of surface wave in substrate of a patch antenna

Surface waves are excited on micro strip antenna whenever the substrate $\varepsilon_r > 1$. Besides end-fire radiation, surface waves give rise to coupling between various elements of an array. These undesirable features of surface waves are depicted in [Fig-1].

Surface wave are launched into the substrate at an elevation angle θ lying between $\pi/2$ and $\sin^{-1}(1/\sqrt{\varepsilon_r})$. These waves are incident on the ground plane at an angle less than 90 degree and again it gets diverted towards air dielectric boundaries. Surface wave propagation is a serious problem in micro strip antennas. Surface wave reduces antenna efficiency, gain and limit the bandwidth.

Principle of Photonic Band Gap (PBG) Structure

Photonic band gap shapes are generally periodic structure in which surface wave radiation of a definite band of frequencies is prohibited [3]. PBG structure can be achieved by using metallic, dielectric, ferromagnetic implants. With the use of periodic PBG structure we increase the gain, and bandwidth. It has been found that Photonic band gap structure provides better bandwidth and less return loss [6]. Defected ground plane is used in place of normal conventional ground plane made of aluminium or any other material referred as ground. In this paper, a compact multiband design of Micro strip patch antenna using circular hole of 4mm radius is proposed. The gap between two hole is maintained at 2mm to allow proper suppression of surface wave. The design of Patch antenna is created using HFSS-13 and simulated. The dimensions are calculated using following equations.

Design Equations

Shape of Patch

The rectangular shape of micro strip antenna is selected and the size of rectangular antenna is decided by two equations:

$$L = \frac{c}{2\sqrt[2]{f_r}} \qquad (1)$$

$$W = \frac{C}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}} \qquad (2)$$

The length of patch is calculated based on given standard equation [1] .The width of patch calculated is more than length of the patch. The actual length of patch is again improved by considering the fringe factor. The w/h ratio is selected as more than 1. By using the above equations we can find the values of actual length of the patch as:

$$L = \frac{c}{2f.\sqrt{eff}} - 2\Delta l \qquad (3)$$

$$\epsilon_{eff} = \frac{(\epsilon_r + 1)}{2} + \frac{(\in r - 1)}{2} . \frac{1}{\sqrt{1 + 12\frac{h}{w}}} \qquad (4)$$

The fringe factor is calculated as 1.63 mm and ϵ_{eff} is calculated as 2.141 . At operating frequency 7 GHZ the length is 11.41 mm, which is taken as 12 mm, and width is 27mm.

Resonance Frequency

The lowest order mode, TM_{10} resonates when effective length across a patch is half of wavelength. Radiation occurs due to fringing field. A resonant frequency of PBG structure is given as follows:

$$f_{mn} = \frac{k_{mn}c}{2\pi\sqrt{\epsilon_r}} \qquad (5)$$

Where m,n = 0,1,2.... K_{mn} = wave number at m, n mode , c is the velocity of light, ε_r is the dielectric constant of the substrate, and

$$K_{mn} = \sqrt{\left(\left[\frac{m\pi}{(w)}\right]\right)^2 + \left(\frac{n\pi}{L}\right)^2} \qquad (6)$$

For TM_{01} mode, length and width of non radiating rectangular patches edge at certain resonance frequency and dielectric constant is given by above equations.

Design Parameter For Prototype Antenna

The antenna has a defected ground plane with substrate material of RT Duroid 5880. The rectangular patch is selected having approximately 2 mm gap between each patch to have coupling factor as minimum as possible. The substrate structure is Roger RT/ duroid 5880 with dielectric constant 2.33. A appropriate hole is drilled on ground plane with size of 4 mm radius to suppress the surface wave. The distance between two hole is kept 4 mm. six patch elements are mounted on substrate material for radiation. Having multiple elements will increase the gain of antenna [Fig-2].

Structure

Length of Patch (L) = 12 mm

Width of Patch (W) = 27 mm

Length of Ground Plate (L_0) = 42 mm

Width of Ground Plate (W_0) = 55 mm

Regular Square shape length and width (a) = 10 mm

Gap of regular square shape (b) = 03 mm

Dielectric Constant of the substrate ε_r = 2.33

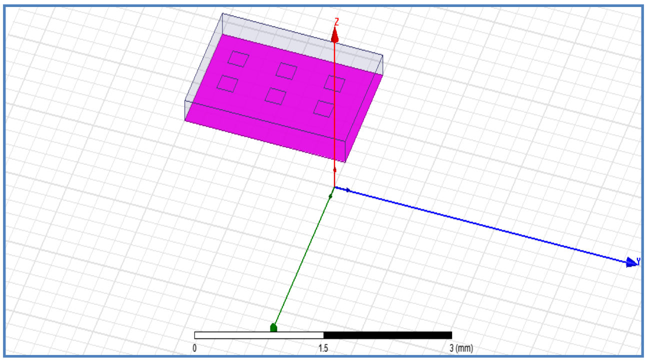

Fig. 2- Prototype Micro strip antenna

Result Analysis and Simulation

The design was created using HFSS-13 and simulated. The improvement in bandwidth is achieved as compared conventional micro strip antenna without PBG or EBG. Maximum improvement in bandwidth is attained at 11 GHZ as 32.95 percent. This type of antenna can be utilized in various wireless communication systems. The enhancement in bandwidth is as shown in [Table-1]:

Table 1- Improvement in bandwidth

Frequency Band	Bandwidth without PBG	Bandwidth with PBG
7 GHZ	2.76	6.5
8 GHZ	0	6.9
11 GHZ	3.72	32.95

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