C Band Microstrip Patch Antenna with EBG & Superstrate Structure

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Abstract— EBG structure and a dielectric layer over a microstrip patch antenna have remarkable effect on its input characteristics and bandwidth. In proposed paper we studied both electromagnetic band-gap structure and a superstrate to increase the bandwidth of patch antenna. We measured bandwidth with and without EBG to design an Antenna for resonance frequency 4 GHz. And then implemented superstrate in EBG structure. This antenna designed on Ansoft HFSS designer software, impedance bandwidth ,VSWR ,return losses & smith charts are observed and experimentally studied. Details of simulated results are presented and discussed.

Keywords- Microstrip Patch Antenna**,** Coaxial Feed**,** Electromagnetic band-gap (EBG), Superstrate layer.

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I. INTRODUCTION

Compact microstrip antennas have recently received much attention due to the increasing demand of small antennas for personal as well as communication equipment commercial. It has been demonstrated that equilateral triangular microstrip patch can effectively reduce the required patch size for a given operating frequency [1]. In mobile communication system such as satellite, RADAR, Global Position System (GPS) often require extremely small size,light weight .Microstrip Antenna also possess some limitations such as narrow impedance bandwidth ,low efficiency and gain.many process are used to overcome its limitations are reported[2]-[3].

Many techniques are uses to increase bandwidth like stacked patches with truncating the opposite corners [4]L-shaped probe with impedance matching network [5] but such processes require large antenna height and some additional impedance matching network that creates some problem to design antenna. The EBG structure shows high impedance characteristic. There are various type of EBG structure are proposed but mushroom type structure are widely used [6] Like EBG a dielectric layer over patch antenna also plays a important role to improve impedance bandwidth of microstrip antenna . However , the presence of superstrate may affect the performance of antenna like gain and efficiency.

In proposed paper we compare the bandwidth of equilateral triangular patch in three condition –

(A) Patch without EBG and superstrate
(B) With EBG
(C) With EBG and superstrate.

We also discuss the details and simulated study of proposed antenna.

MICROSTRIP PATCH ANTENNA

Microstrip patch antennas are the most common form of printed antennas. They are popular for their low profile, geometry and low cost [4].A microstrip device in its simplest form is a layered structure with two parallel conductors separated by a thin dielectric substrate. The lower conductor acts as a ground plane. The device becomes a radiating microstrip antenna when the upper conductor is a patch with a length that is an appreciable fraction of a wavelength (λ), approximately half a wavelength ($\lambda / 2$). In other words, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig. 1.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape.

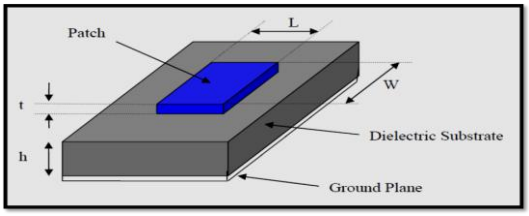

Fig.1.1: Typical microstrip patch antenna

COAXIAL FEED

The coaxial feed or probe feed is a very common contacting scheme of feeding patch antennas. The configuration of a coaxial feed is shown in figure 1.2 . As shown in figure1.2, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

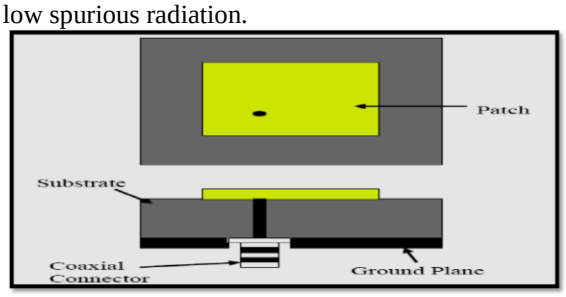

Fig. 1.2: Coaxial feed for patch antenna

ELECTROMAGNETIC BAND-GAP (EBG) STRUCTURE

Electromagnetic bandgap (EBG) structures, also known as photonic bandgap (PBG) structures with origin in the area of optics have attracted much attention among researchers in the microwave and antenna communities in the recent past [6]. In general, EBG material is a periodic structure that forbids the propagation of all electromagnetic surface waves within a particular frequency band called the bandgap. Because of this, it permits an additional control of the behavior of electromagnetic waves other than conventional guiding and/or filtering structures. EBG has the potential to provide a simple and effective solution to the problems of surface and leaky waves [15].

EBG structures have been found to have a wide variety of applications in components of the microwave and millimeter wave devices, as well as in antennas. In the recent years, various types of EBG structures have been studied for different applications [11].

In one of the first applications by using EBG materials to antennas, a planar antenna mounted only on EBG substrate was considered to increase the overall radiation efficiency of the device. Increasing antenna directivity was studied using an EBG structure. A mushroom like EBG structure was designed by Sievenpiper *et al* [6].

This structure is characterized by having high surface impedance. A fork-like shape novel EBG structure was later studied which is very compact in nature. The area of the fork-like structure was about 44% less than when compared to the conventional mushroom EBG structure [13]. A compact spiral EBG structure was studied for microstrip antenna arrays. Spiral EBG structures, because of their compact nature are very useful in wireless communications where size matters. These spiral EBG structures have also been examined to improve the performance of a triple band slot antenna [by etching them on the feed line [16].

The original EBG structure fabrication method needs painstaking work of drilling through the substrate in order to form periodic array of dielectric inclusions with a dielectric constant different from that of the host dielectric. It costs a lot and time is wasted. Then comes the second method, which just etches the periodic lattice on the ground plane of microstrip line. This method is cheap and convenient [17].

SUPERSTRATR LAYER

A superstrate together with its antenna ground plane forms a resonance structure, [2]-[3],which gives rise to a field distribution that produces a larger effective aperture. The resultant increase in the overall directivity of a single patch can be quite significant depending on sizes of the superstrate and the antenna ground plane. A superstrate can be constructed in several ways, including use of multiple layers of dielectric materials with high dielectric constants, layers of EBG FSS structures, and use of parasitic patches. The superstrate have been very effective in reducing the antenna size and increasing the bandwidth at the expense to some extent of antenna gain [16]. It is noteworthy that a superstrate (cover) layer on top of a microstrip antenna may significantly influence the radiation properties. If the substrate is thin enough, a superstrate layer may be used to eliminate surface wave excitation, resulting in a radiation efficiency of 100%.

II. DESIGN OF ANTENNA

In proposed paper we uses an modified equilateral triangular patch whose dimensions' is 27×27 mm ,and uses 2.54 mm thick Rogers RT /Duriod 5880 with a permittivity of 2.2 and dielectric losses of 0.001. The modified patch is made by cutting the each corner of triangle patch is shown in figure 2.1. The EBG structure of proposed antenna is shown in figure 2.2.

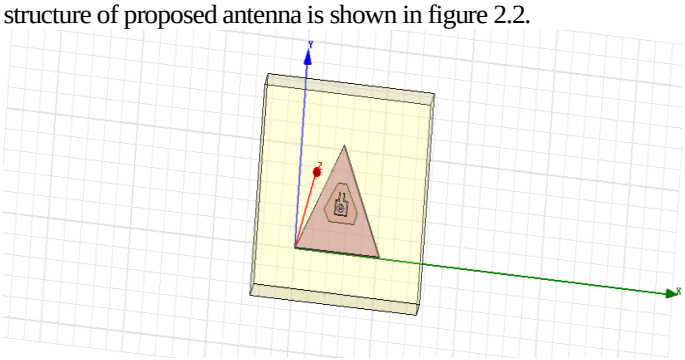

Fig. 2.1: Modified triangle patch antenna without EBG and Superstrate

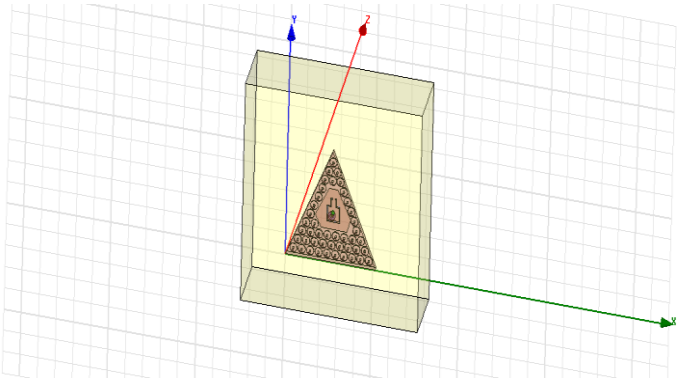

Fig. 2.2: EBG structure of patch antenna

In EBG structure mushroom like structure is implemented in which unit cell dimensions of 2.06×2.06 mm with separation of 0.5 mm. total 44 EBG structures are implemented in proposed design.

Next we implemented a superstrate layer of thickness 12.70 mm shown in figure 2.3. We observed that improved bandwidth is achieved by implemented superstrate layer over electromagnetic band-gap structure.

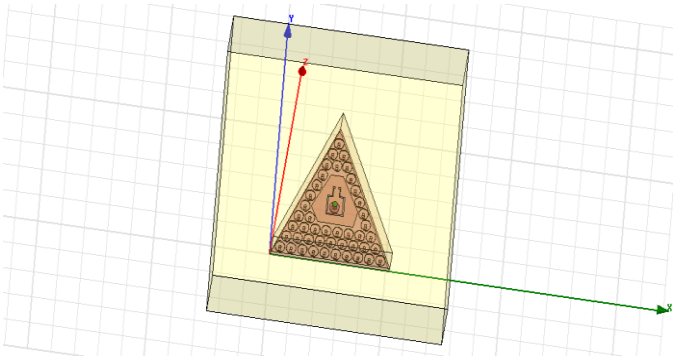

Fig. 2.3: Patch antenna with EBG and superstrate

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III. SIMULATION RESULT

1. Microstrip Patch Antenna without EBG and Superstrate :-

The antenna is simulated using Ansoft HFSS 11.1 which employs finite element method . The measured return loss is -29.4356 dB & impedence bandwidth is 38.62%. In this case measured VSWR is 1.0698 & resonance frequency is 4.9594 GHZ. Measured return loss, VSWR, smith chart and radiation pattern is shown in fig.3.1.1-fig 3.1.4.

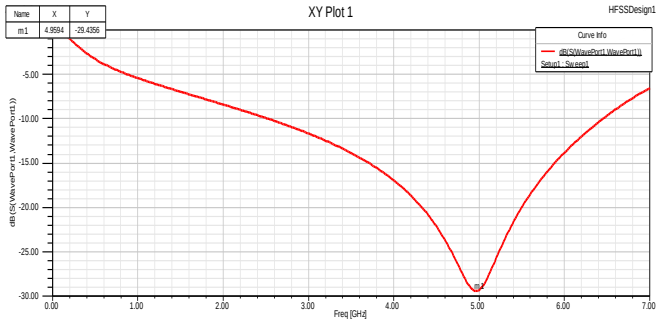

Fig. 3.1.1 : Measured impedance bandwidth

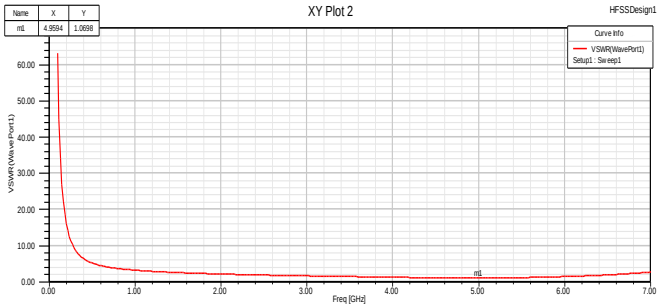

Fig. 3.1.2: Measured VSWR

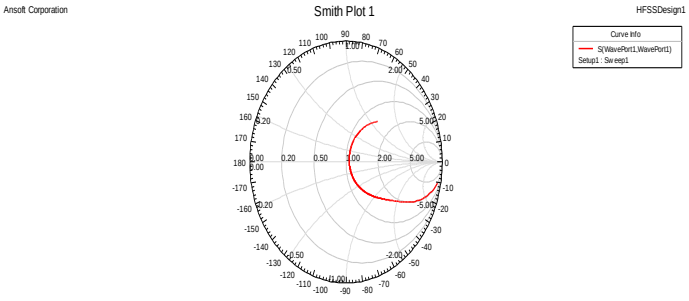

Fig.3.1.3 : Input impedance loci using smith Chart

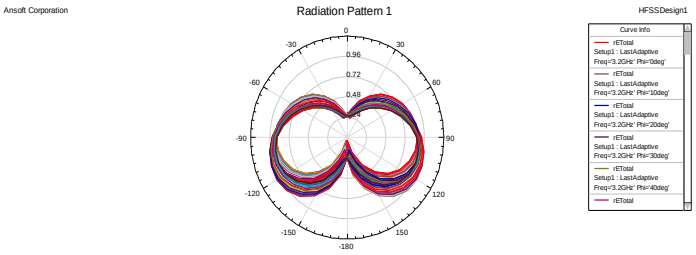

Fig.3.1.4 : Radiation Pattern

2. Microstrip Patch Antenna with EBG Structure :-

The antenna is simulated using Ansoft HFSS 11.1 which employs finite element method . The measured return loss is -28.1369 dB & impedence bandwidth is 41.29%. In this case measured VSWR is 1.0816 & resonance frequency is 5.0977 GHZ. Measured return loss, VSWR, and smith chart is shown in fig.3.2.1-fig 3.2.3.

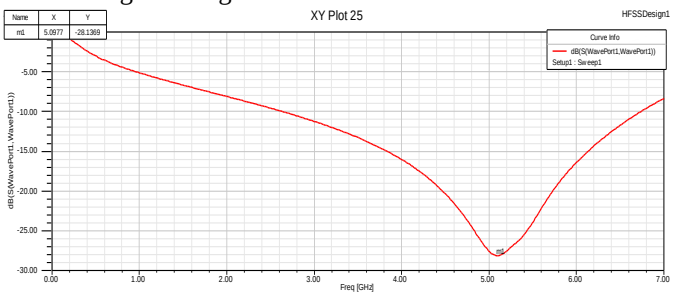

Fig. 3.2.1: Measured impedence bandwidth

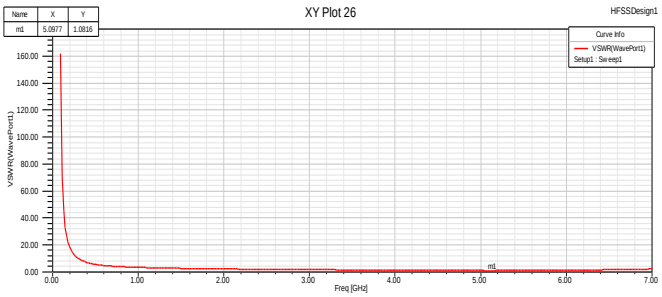

Fig.3.2.2: Measured VSWR

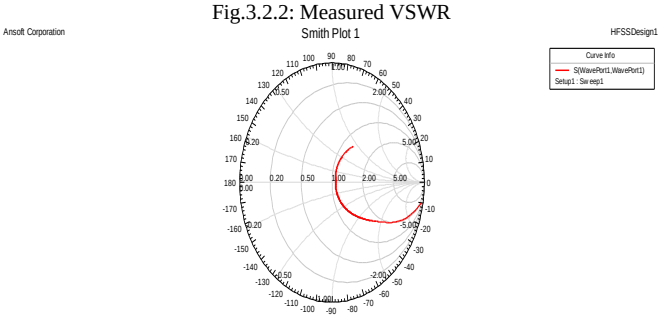

Fig. 3.2.3 : Input impedance loci using smith chart

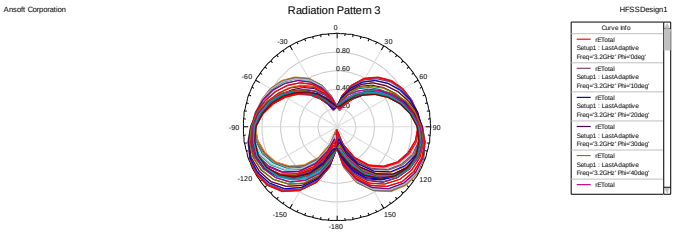

Fig.3.2.4 : Radiation Pattern

3. Microstrip Patch Antenna with EBG and Superstrate :-

The antenna is simulated using Ansoft HFSS 11.1 which employs finite element method . The measured return loss is -22.1642 dB & impedence bandwidth is 44.95%. In this case measured VSWR is 1.1691 & resonance frequency is 4.8156 GHZ. Measured return loss, VSWR, and smith chart is shown in fig.3.3.1-fig 3.3.3.

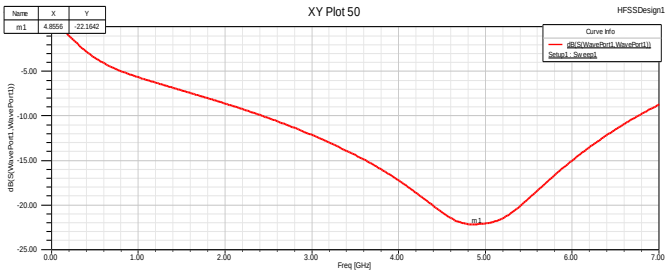

Fig. 3.3.1 :Measured impedance bandwidth

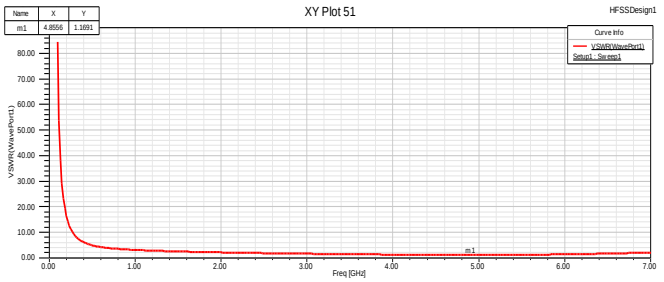

Fig. 3.3.2 : Measured VSWR

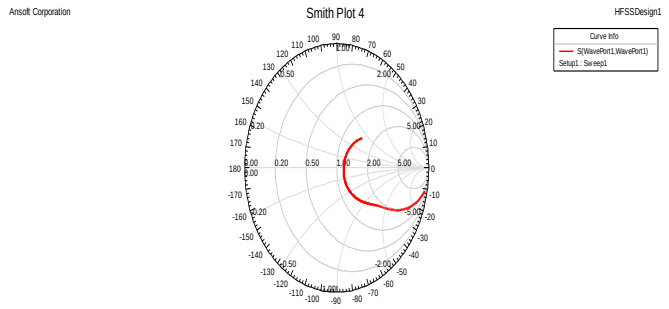

Fig. 3.3.3 : Input impedance loci using smith Chart

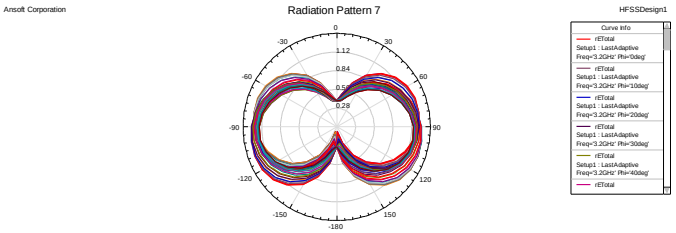

Fig.3.3.4 : Radiation Pattern

IV. COMPARISON TABLE

Table 1. Comparison of simulated Result

Microstrip Patch Antenna	Bandwidth	VSWR	Return loss (db)
Without EBG and Superstrate	39.82%	1.0698	**-29.4356**
With EBG Structure	41.29%	1.0816	-28.1369
With EBG and Superstrate	44..95%	1.1691	-22.1642

As comparison table 1 shows bandwidth of patch antenna is increased by 1.47 % by implementing Electromagnetic band gap structure, return loss is also minimized by implementing electromagnetic band –gap structure. Further when we implemented superstrate layer over electromagnetic band –gap structure bandwidth is increased by 5.13% but return loss is maximized.

V. CONCLUSION

In this paper, design microstrip patch antenna with electromagnetic band gap (EBG) and with superstrate has been studied.

The main impact for studying this antenna structure with electromagnetic band gap structure and with superstrate is to increase the impedance bandwidth of patch antenna, the antenna has successfully improved impedance bandwidth.

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