# Design of Antenna at Terahertz Frequency Band using Metamaterial

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*Abstract:* **Metamaterials (MTMs) , due to their attractive properties, are nowadays experimentally used in many engineering applications like negative refraction , perfect lens , cloaking, antenna miniaturization and so on .Metamaterial absorber has large thickness as compare to microwave absorber. In this paper, the properties of two dimensional photonic group crystals (electromagnetic crystal) substrate on the enactment of a rectangular microstrip patch antenna at THz (0.1&0.3 THz) frequency are simulated in software and the fabrication is done on the 'C' band . PBG has been used as substrate substantial for high gain and highly steering resonant antenna. The Directivity, Gain and Return Loss of the intended antenna of software results are 8.08dB, 8.02dB and -10.6dB at 6GHz respectively and the hard ware results of antenna return loss is -32dB. The simulation of this antenna is performed using HFSS software.**

*IndexTerms* - **Terahertz Antenna, Photonic Band Gap, Terahertz Space Communication.**

## I. INTRODUCTION

Up to the recent past, the terahertz (THz) region (with the wavelength typically ranging from 30 um to 3mm) has been regarded as a 'gap' in the electromagnetic range, enclosed between the ultraviolet and microwave regions. The reason for that was the lack of efficient sources and devices to manipulate THz waves. This has recently changed the researchers interest in the THz region has raised in the last decade and recent innovations in THz. A conventional antenna using Metamaterial can be formed by designing metamaterial unit cell on a substrate of various shapes and microwave antenna on that substrate giving coaxial feed to an antenna. Technologies are bringing a wide variety of applications including time-domain spectroscopy, biological imaging, high-speed communication, THz imaging, THz radars, etc[1].

The possibility existence of material by conducting microwave experiment on twisted structure. Later, the physicist presented a theoretical investigation on medium whose permittivity is negative. The negative refractive index is now widely accepted, focus has moved toward applications. The word was first coined by Rodger M. Walser (2001)[5] who gave the following definition "Metamaterials are distinct as macroscopic composites partaking a manmade, three dimensional, episodic cellular architecture planned to produce an enhanced combination, not obtainable in nature, of two or more replies to a specific excitation.". "They are artificial episodic structures with frame constants that are much minor than the wavelength of the event radiation. Therefore providing negative refractive index characteristics"[5]. This word is a combination of "meta" and "material", Meta is a Greek word which means something beyond, altered, changed or something advance as presented in Sihovola (2007)[7]. In a precise way, Meta-materials can have their electromagnetic properties altered to something beyond what can be found in nature.

The current future of meta-material research is involved in scheming and making nanostructures that are talented for working electromagnetic surfaces at the visible incidence range. Now adding, at advanced frequencies, metals initiate to turn from a perfect conductor and increase the matter of energy dissipation in meta-materials. The newest research in meta-material main to optical nanostructures that are in fields of communication, micro-scope, and security. Optics, the THz field denotes a main study area of meta-material[16].

At incidence range outside THz range, the manufacture of meta-materials can be actual stimulating with-present machineries. The data obtained from terahertz meta-material can be beneficiaal to the education of optical meta-materials. Moreover, thz dimension schemes, in specific THz, proposition an excessive deal of litheness unavailable as of other spectro-scopic modalities. The broad-band amplitude and phase recognition composed with the stretchy outline of the structure certifications the full depiction of meta-material assets. From these explanations, the Thz frequency band is striking used for experimental demonstrations of meta-material models [16].

In this paper, a micro-strip patch antenna is proposed and operated at (0.1-0.3)THz band along with Photonic substrate which rises the gain and directivity which is valuable for wireless space communication.

## II. DESIGN OF THZ ANTENNA

Micro-strip patch antenna has numerous benefits such as little weight, ease of construction and addition, less charge. Other benefit by means of patch antenna is suitable on any coiled surface. Correct impedance can be attained by enhancing the positionof supplement of the patch antenna. Therefore these antennas are finest right for space-communication which need minor size, less cost feelers and which can be easily fitted.

## III. Design of Microstrip Patch

**'Fig-1'** shows a rectangle micro-strip patch antenna which contains a ground plane, substrate, patch and a transmission line that are placed overhead one another. The fringing field arise among the ground plane besides the patch effects in energy in micro-strip patch antenna. The patch and the ground plane is PEC(Perfect-Electric-Conductor), the substrate used is RT Duroid 5880 which has a dielectric constant 2.2.

The resonant incidence of the strategy is measured as 0.154 Thz. Through these values the mandatory measurements of the antenna are intended and-are shown under in Table I. Return loss indicates the amount of power that is lost to load and does not return as reflection. Return loss is a parameter similar to VSWR to indicate how well the matching between transmitter and antenna has taken place.

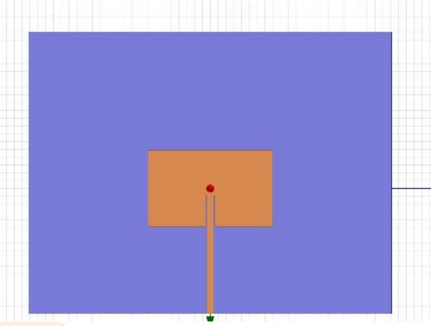

**Figure 1**: Patch antenna using Infeed

**Table 3.1:** Dimensions of Inset Feed micro-strip antenna

| ***Design Structures*** | ***Values*** |
|---|---|
| Substrate thickness | 0.254mm |
| Dielectric constant | 2.2 |
| Length of patch | 0.4873mm |
| Width of patch | 0.79mm |
| Infeed length | 0.2mm |
| infeed width | 0.01mm |
| Substrate length | 1.8mm |
| Substrate width | 2.314mm |

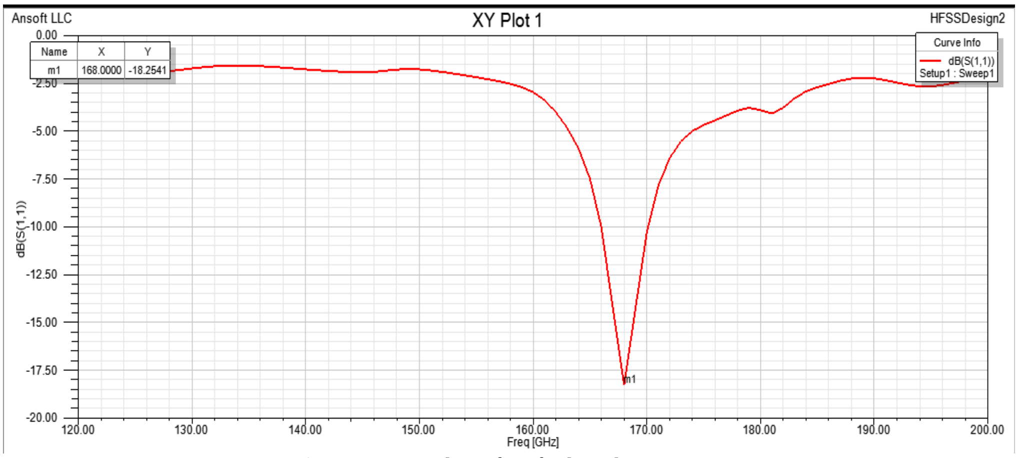


**Figure 2**: Return-loss of in-feed Patch antenna

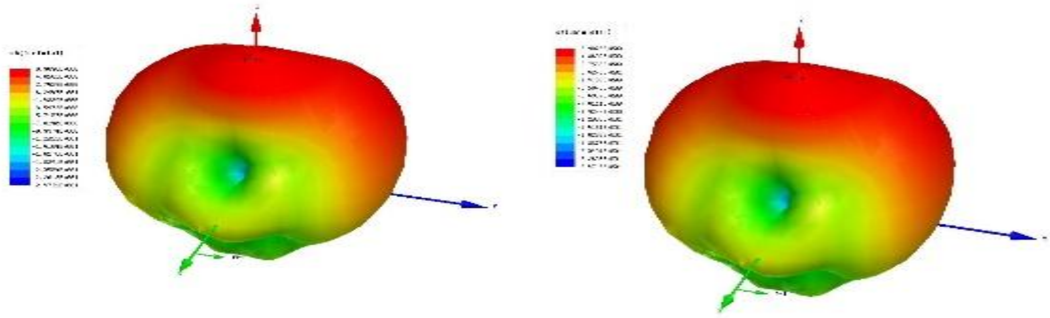

**Figure 3**: Gain and Directivity of in-feed antenna

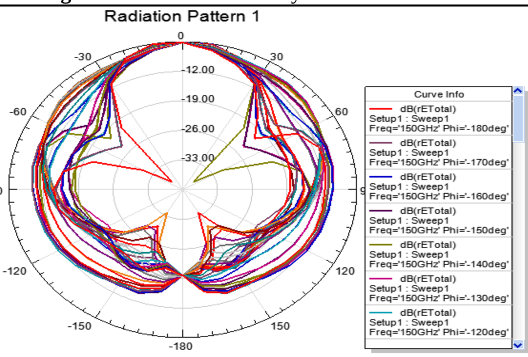


**Figure 4**: Radiation Pattern of in-feed antenna.

The Infeed antenna is intended by means of the measurements mentioned in table1 and sham in HFSS and obtained results of gain and directivity are 6.98dB and 6.96dB respectively.

***Design of PBG Based Microstrip Patch Antenna***

Photonic is intended by implementing air-gap cylinders irregularly on-a substrate as revealed in Fig-4 which assistances in dropping the real dielectric-permittivity of the substrate [10]. Photonic structures decrease wave broadcast in certain frequency group holes [12]. Owing to-these incidence air-gaps exterior waves be able to reduced up to max limit and thus increase the gain and directivity.

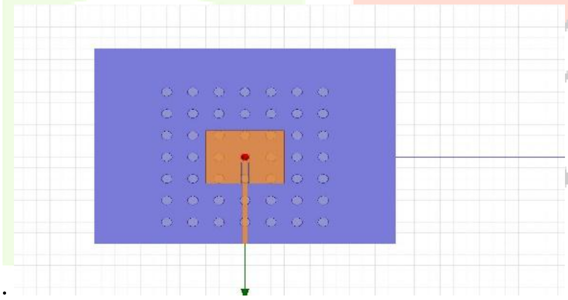

**Figure 5**: Patch antenna using PBG

The Infeed antenna model is planned using measurements cited in table2, simulated in HFSS and obtained the results of gain and directivity are 7.45dB and 7.8 dB respectively.

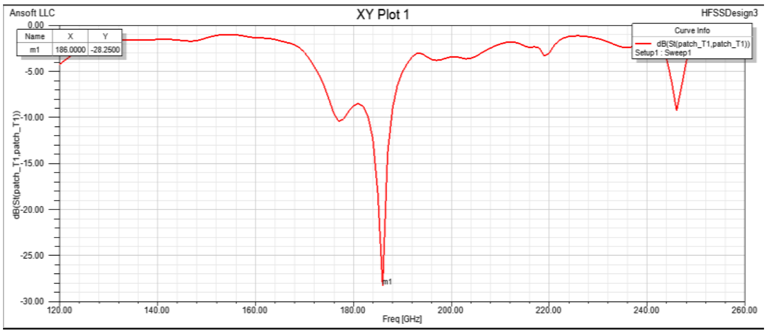


**Figure 6:** s11 of Patch antenna using PBG

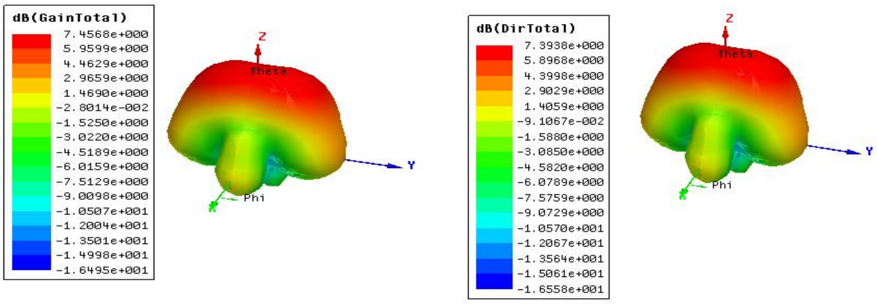


**Figure 7**: Gain and Directivity of in-feed antenna using PBG.

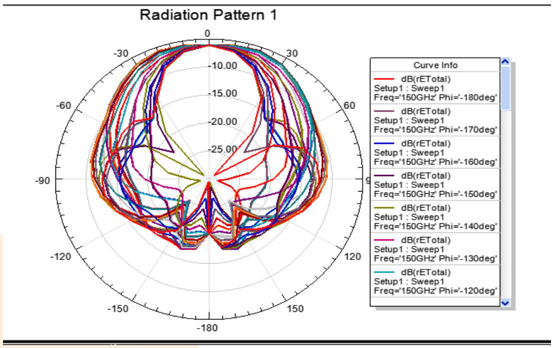


**Figure 8:** Radiation pattern of in-feed antenna using PBG

In THZ frequency the feed used for the antenna is very difficult to fabricate so for that purpose the scale down is done from THz to 'C' band range which is simulated in software using metamaterial and also fabricated the design and values is as shown below.

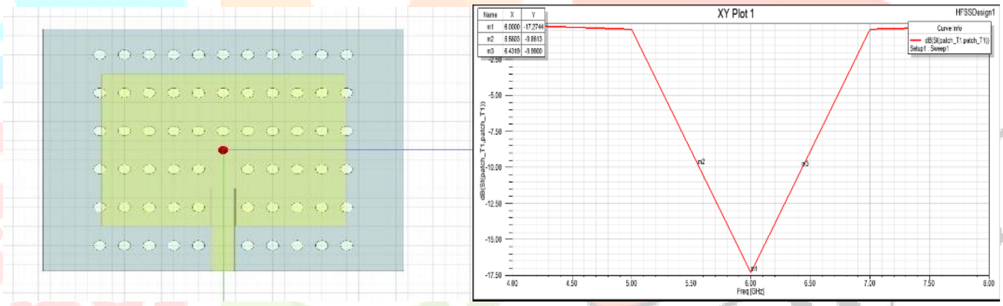


**Figure 9**: Patch antenna using PBG at C band and its return loss

**Table 2:** Dimensions of Inset Feed micro-strip antenna using PBG

| ***Design Structures*** | ***Values*** |
|---|---|
| Substrate thickness | 1.5748mm |
| Dielectric constant | 2.2 |
| Length of patch | 15.9mm |
| Width of patch | 19.75mm |
| Infeed length | 4mm |
| infeed width | 0.1mm |
| Substrate length | 25.3488mm |
| Substrate width | 29.1988mm |

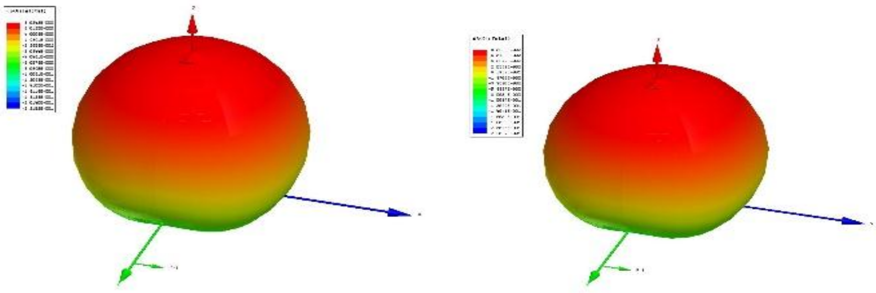

**Figure 10**: Gain and Directivity of Patch antenna using PBG at C band.

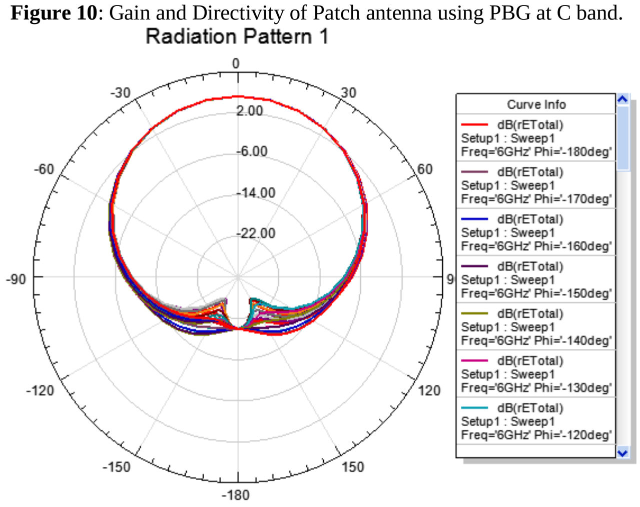


**Figure 11**: Radiation pattern of Patch antenna using PBG at C band.

While comparing the two antennas with and without metamaterial the return loss, gain and directivity is increased because the surface wave losses will be decreased using metamaterial.

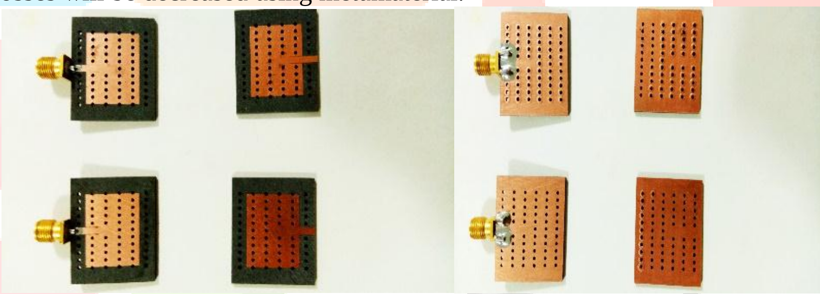

**Figure 12:** Fabricated antenna at C band using PBG along with In-Feed.

The holes used here are NPTH holes which is a PBG metamaterial and these are through from top to bottom. The holes will work in the form of slot on the patch antenna and also as a metamaterial so as to increase the gain of the antenna. The holes can be in any shape it is not mandatory that it should be in row and column we can also arrange it randomly in any shape. As it is in C band the connector used here is a SMA connector the material used is duroid 5880 and the material used on patch and the ground is the copper.

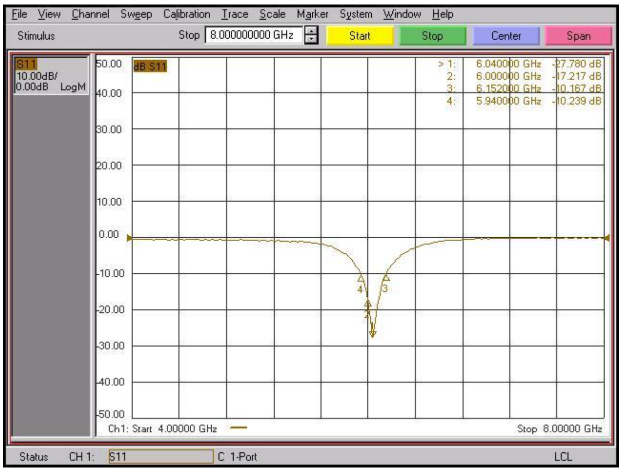


**Figure 13:** Measured Return-loss of Fabricated antenna at C band using PBG along with In-Feed.

While comparing the measured results with the software one, here we are getting S11 at -17.2047dB at 6GHz and at 6.04GHz we got -27.7dB.

## IV. Conclusion and Future Scope

A micro-strip patch antenna is designed on a photonic substrate by HFSS software. The design used an inset Feed method to get suitable impedance matching between the feed and the patch. The return loss, gain and directivity of the antenna are -17.27dB (S11), 8.011 dB and 8.08 dB correspondingly in software. While in hardware part the return loss is almost at dB. The application of this antenna is, it can be used in THz telescope for communicating with the satellites which were observed by the telescope. As the antenna is low gain and directional antenna, the THz telescope consists of both low gain and high gain antennas. The usage of these antenna has compensations also in aircraft collision avoidance system, on-vehicle satellite relations, projectile radars, put in the ground and intra-orbital communications, communications private space-vehicles and extra-space built uses.

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