Terahertz Microstrip Patch Antenna Design for detection of Plastic Explosive SEMTEX

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Abstract – *Terahertz frequency regime has gained high attention because of high potential for numerous number of applications. The proposed paper demonstrates the design and analysis of terahertz microstrip patch antenna for detection of plastic explosive SEMTEX by deploying Fr4 material as substrate of thickness 1.62 μm with dielectric constant of 4.4 whereas the radiating patch and ground plane are made up of copper material having high conductivity and low resistivity. The reduced ground plane has been used in order to acquire the desired resonant frequency. For the designing and analysis of the proposed antenna Computer Simulation Technology (CST) Microwave Studio 2016 has been deployed. It has been observed that the proposed antenna has an input impedance of 49.15 Ω which resonates at 4.32 THz frequency with return loss of -52.10 dB and with a gain of 5.88 dB and directivity of 5.75 dBi which makes it highly suitable for detection of plastic explosive SEMTEX.*

Key Words: SEMTEX, Plastic explosive, Gain, Directivity, Input impedance.

1.INTRODUCTION

The part of electromagnetic spectrum present between classical microwave and the infrared region is known as terahertz frequency band (0.1THz- 10THz), it is gaining popularity and becoming technologically more pertinent due to large number of applications which can be potentially supported by it i.e. sensing, imaging, medicines etc. [1][2]. Developments are going on so as to generate and detect terahertz radiation so as to use terahertz frequency spectrum for detecting the presence of unobtrusive materials [3]. They can easily penetrate through substances like paper, plastic etc. because the terahertz radiation is transparent in many dielectrics and has low photon energy due to which terahertz radiations are mainly used for detection purposes [4]. However, they are like light waves as they can be easily manipulated with the help of lenses and mirrors [5]. In the past few decades the development of THz sources and detectors had played a crucial role [6] in advancement of terahertz technology and for bringing it to the limelight of the technical world.

In the past few decades an increase in research for explosive detection has taken place. Researchers are trying to develop more analytical techniques to enable faster, more sensitive and simpler determination pathways so as to trace or identify explosive substances [7]. They are detected on the bases of their spectral signature as many solid-state explosives exhibit different absorption characteristics in THz frequency. These spectral signatures are the result of intramolecular and intermolecular vibrational modes of the materials [8]. Basically we make use of THz-TDS (Terahertz time domain system) [9] and terahertz microstrip patch antenna for the various applications like standoff detection of explosives [10], medical imaging [11] etc. Terahertz time domain spectroscopy technique is way to generate and detect terahertz efficiently which emerged as the main spectroscopic modality with more compactness and stability [12] whereas Terahertz microstrip patch antennas has built up an easy pathway for detection and determination of illicit drugs, explosives etc. moreover their small size, light-weight, reliability, high-efficiency makes them suitable for employability [13]. Due to this reason in the proposed paper a Terahertz microstrip patch antenna has been designed for the detection of plastic explosive SEMTEX [14] which is considered as one of the strongest explosives in world. It is so much powerful that 250 mg of SEMTEX has capability to destroy a commercial airplane. It is easy to obtain but difficult to detect because of its stable nature [15]. It is very similar to plastic explosive named as C-4 but it is very stable at higher temperature ranges also plus it is waterproof in nature [16]. The proposed system has the capability to detect such a strong explosive at resonant frequency of 4.32 THz.

The proposed paper comprises of four section as described below:

Section II consists of antenna geometry and antenna dimensions of the top view, bottom view and side view of the proposed antenna design. Further section III consists of simulated results based upon various antenna parameters and Section IV concludes the proposed technique and observations formulated through it which shows that the proposed paper is suitable for detection of plastic explosive SEMTEX.

2. Antenna Geometry

Designing and simulation of the proposed antenna design has been done using Computer Simulation Technology (CST) Microwave Studio 2014. In the proposed antenna design Flame Retardant (Fr4) material has been used as substrate having thickness of 1.62 µm with dielectric constant of 4.4. Both patch and ground plane are made up of conducting material copper of thickness 0.02 µm.

Reduced ground plane has been used so as to acquire the desired resonant frequency and to improve other antenna parameters like S-parameter, gain, directivity etc. The proposed antenna has an input impedance of 49.15 Ω so as to match the impedance of coaxial cable in order to have minimum reflections and maximum power transfer. Fig. 1 shows the top view of the proposed antenna along with its dimensions whereas the fig. 2 shows the bottom view of the proposed antenna along with its dimensions.

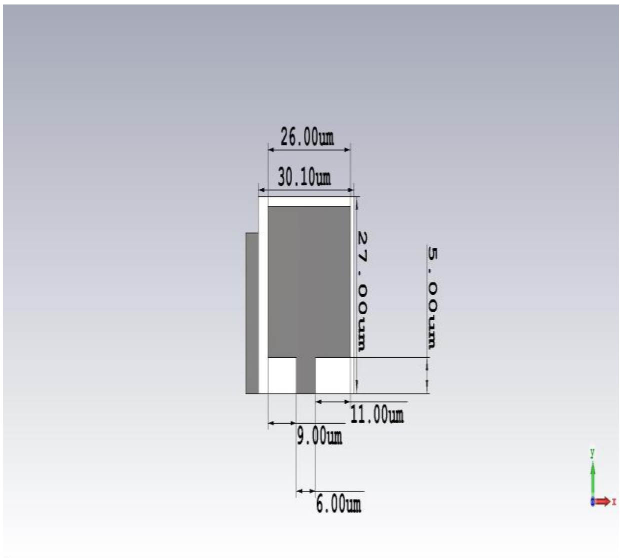

Fig-1: Top view of the proposed antenna

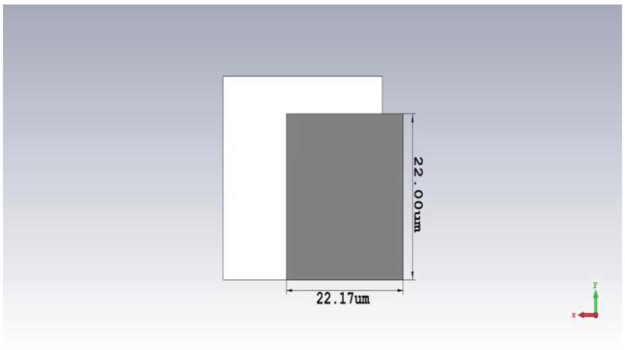

Fig-2: Bottom view of the proposed antenna

3. Simulated Results and Observations

To analyze the antenna on the basis of various antenna parameters Computer Simulation Technology (CST) Microwave Studio 2014 has been deployed. It is used because of its user friendly environment and more accurate calculations.

The antenna analysis has been done on the basis of gain (dB), directivity (dBi), S-parameter (dB), impedance (ohms) and HPBW (degrees). The proposed antenna resonates at 4.32 THz with a return loss of -52.10 dB having gain of 5.88 dB and directivity 5.55 dBi. It has an input impedance of 49.15 Ω in order to have minimum reflections and to transfer maximum power to the antenna and HPBW of the proposed antenna is 91.3 degrees. The reduced ground plane has been used in order to improve the return loss plot of the proposed antenna and other antenna parameters. Fig. 3 represents the return loss of the proposed antenna at resonant frequency of 4.32 THz, fig. 4 represents the gain of the proposed antenna, fig. 5 represents the directivity of the proposed antenna, fig. 6 represents the smith chart plot of the proposed antenna and fig. 7 represents the HPBW of the proposed antenna. The table I shows the simulated results.

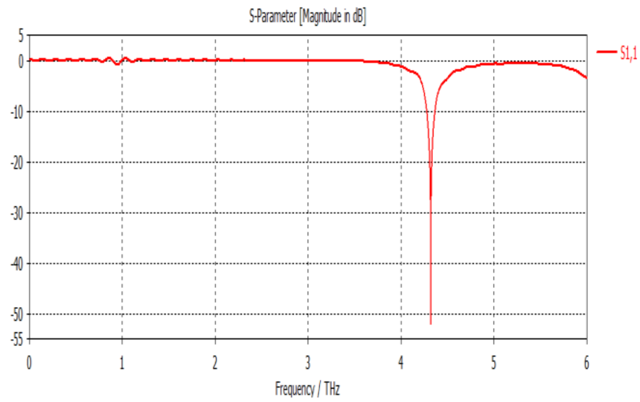

Fig-3: Return loss plot of the proposed antenna

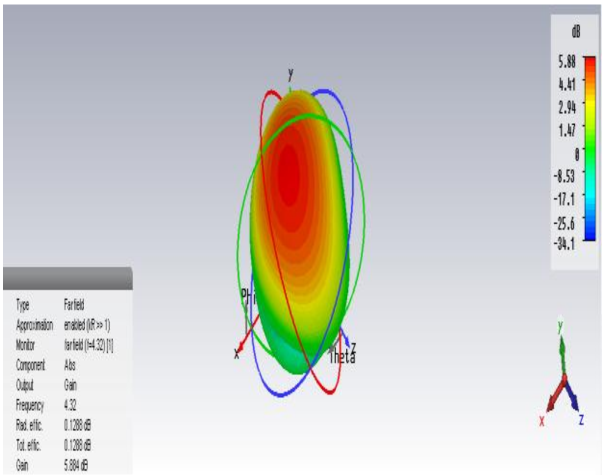

Fig- 4: Gain of the proposed antenna

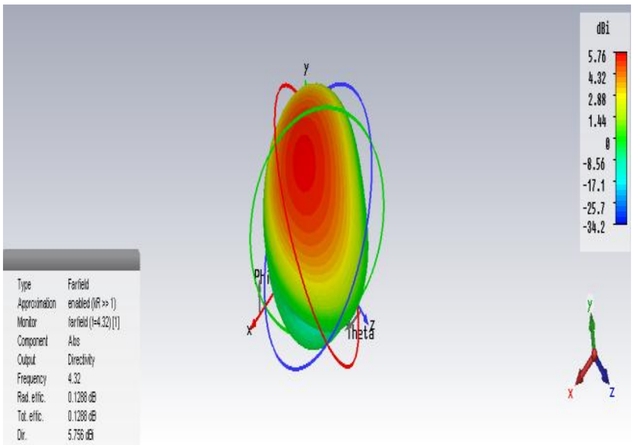

Fig- 5: Directivity of the proposed antenna

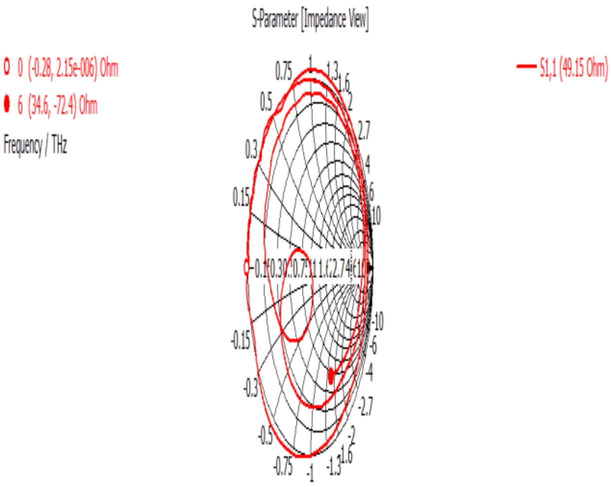

Fig- 6: Smith chart of the proposed antenna

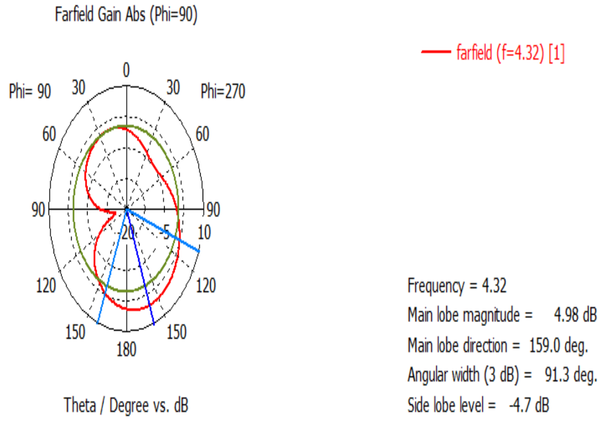

Fig- 7: HPBW of the proposed antenna

Table-1:

S.no.	Parameter	Value
1.	Return loss	-36.40 dB
2.	Impedance	50.77 Ω
3.	Gain	5.69 dB
4.	Directivity	4.56 dBi
5.	Bandwidth	0.15 THz
6.	Half Power Beamwidth	83.5 deg

4. CONCLUSION

The proposed paper focuses on designing and analyzing of a terahertz microstrip patch antenna for detection of plastic explosive SEMTEX by employing Computer Simulation Technology (CST) Microwave Studio 2016. The proposed antenna resonates at 4.32 THz which act as the peak absorption frequency of the plastic explosive SEMTEX. It acts as its unique spectral signature over which the SEMTEX can be detected.

In the proposed antenna design Fr4 material has been deployed as substrate with thickness of 1.62 μm and with dielectric constant of 4.4 whereas the radiating patch and ground plane are made up of copper of thickness 0.02 μm. The substrate is sandwiched between the patch and the reduced ground plane. The reduced ground plane has been used in order to improve the return loss plot and other antenna parameters like gain, directivity etc. So as to acquire the desired results and to make antenna suitable for detecting the plastic explosive SEMTEX at resonant frequency of 4.32 THz.

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