© March 2024| IJIRT | Volume 10 Issue 10 | ISSN: 2349-6002

Design of Microstrip Patch Antenna for Terahertz frequencies

P. Suresh Babu[1], Bindigi Bhavani[2], Jyothi Abhinay[3], Vemula Chandar Goud[4]
[1]*Asst. Professor, Department of ECE, VNRVJIET, Bachupally,*
[2,3,4]*Department of ECE, VNRVJIET, Bachupally, Hyderabad, India – 500090*

Abstract-The development of compact, efficient antennas is being driven by increasing demand for wireless communication systems with high-speed that operate in the terahertz frequency range. The lightweight, more affordable, smaller, and low-profiledesign method of the microstrip patch antennaon printed circuit board (PCB) makes it popular. Due to its low conductivity and lower mobility, copper has difficulty acting as a conductor at terahertz frequencies. A high-speed terahertz microstrip patch antenna can be designed by HFSS microwave studio.

The design of the antenna is based on a microstrip patch, which has a number of benefits, such as low cost, ease of production. The utilization of fractal geometry allows for compact dimensions without compromising performance, which allows for the shrinking of the antenna. Additionally, multiband operation is made possible by the fractal design, which is essential for supportingseveral THz communication standards. The fast data rate, non-ionizing properties, wider bandwidth, and higher resolution of the terahertz frequency range make it anattractive option for wireless communication. In the long run, the THz frequency spectrum will offer high-resolution broadcast facilities, quick transmission speeds, and vast channel capacity. Its spectral range is between themicrowave and mid-infrared wavelengths, with a bandwidth that can approach hundredsof GHz.

Keywords- Microstrip patch antenna Terahertz communication and spectrum, Antenna design, Bandwidth and Resonant frequency Radiation pattern and Gain, Electromagnetic waves.

INTRODUCTION

The electromagnetic spectrum's 0.1–30 THz band, which lies between the microwave andinfrared areas, is known as terahertz (THz) radiation. The extensive bandwidth within the THz band has opened numerous possibilities for high-speed data applications. The demand for rapid wireless connectivity continues to rise, prompting the exploration of THz radiation in various industries, including explosive and weapon detection, medical imaging, and pharmaceutical research.

THz-based devices have the unique ability to penetrate materials like plastic, clothing, and crumpled cardboard, making them invaluable for identifying hazardous substances, concealed weapons, and synthetic pharmaceuticals. Their effective reflection by non-metallic and non-polar objects makes THz radiations highly applicable in security and information technology applications. To harness the potential of the THz spectrum effectively, there is a pressing need for innovative multiband and wideband antennas. Nonetheless, wireless communication faces formidable challenges in the high THz range, including high attenuation, multipath fading, absorption, and path loss. These obstacles significantly degrade signal quality and can disrupt communication links. Printed antennas have become a popular choice in wireless communication components due to their compact size, low profile, and ease offabrication. Researchers have, therefore, focusedon developing printed planar antennas suitable for THz range wireless communication.

A common form of planar antenna in millimeter wave and microwave applications is the microstrip patch antenna. Their advantages of simplicity, cheap cost, and ease of manufacture are also leading to their investigation for usage atterahertz (THz) frequencies.

ANTENNA DESIGN AND CONFIGARATION

Compatibility with a wide range of electrical components, low cost, and ease of fabrication characterize the microstrip patch antenna. Building a high-performance antenna requires a deep grasp of a variety of antenna characteristics. These characteristics include the feeding plan, loss tangent, dielectric constant, suitable thickness dielectric material, and radiating patch. With the same length and breadth,the substrate material is positioned between the ground plane and the radiating patch. With a loss tangent of 0.0023 and a relative permittivity of 10.2, the Arlon 1000 substrate is used to construct the suggested antenna. The projected measurements of the substrate materials are 45 µm, width, and length. The antenna is directly impacted by the substrate material's permittivity or dielectric constant (εr).. A 60 µm x 70 µm rectangular radiating patch form with a microstrip feed line has been implanted across a distance of 120 µm. The antenna's radiating route and ground plane are constructed from graphene and high conductivity copper, respectively. The suggested antenna has overall dimensions of 120×120×45 µm3. The antenna can be fed in a number of ways, such as via proximity coupling, coaxial coupling, aperture coupling, and microstrip line. The suggested antenna uses microstrip edge line feeding technology for an easy-to-build and well- matched input signal impedance. The chosen excitation source in the suggested microstrip antenna is a waveguide port.

SOFTWARE REQUIREMENTS

HFSS:

Powerful commercial finite element method solver Ansys HFSS (High-Frequency Structure Simulator) is made for modeling electromagnetic structures. This software package offers a wide range of advanced solver technologies to accurately model and analyze electromagnetic phenomena. In Ansys HFSS, users input the geometry, material properties, and desired frequency range for each simulation. This automated solution processor is widely used by engineers for designing and simulating high- speed, high-frequency electronic components found in various applications, including radar systems, communication systems, satellites, microchips and Internet of Things (IoT) devices. Additionally, Ansys HFSS is versatile and has been applied to simulate the electromagnetic behavior of diverse objects such as automobiles and aircraft. One of the key advantages of using Ansys HFSS is its ability to precisely simulate the high-frequency behavior of circuits and electromagnetic systems on a computer. This capability significantly reduces the time and costs associated with building multiple physical prototypes during the product development phase. It also minimizes the amount of final testing and verification work needed for the system. Ansys HFSS excels at creating 3D representations of objects, accounting for their shapes, geometries, and material compositions. One of the various commercial tools for creating complex radio frequency electrical circuit parts, such as filters, transmission lines, and packaging, is this antenna designtool.

Fig.1.Hfss Software

METHODOLOGY

Substrate selection: The substrate material should have a high dielectric constant to support the low-frequency modes of the antenna, and a low loss tangent to minimize radiation losses. Common substrate materials for terahertz antennas include silicon, gallium arsenide, and quartz.

Patch shape and size: The patch shape and size are determined by the desired operatingfrequency and bandwidth. Rectangular, circular, and elliptical patches are common shapes for terahertz antennas. Larger patches are needed for lower frequency operation since the patch size is inversely related to the operating frequency.

Feed design: The feed is the mechanism by which power is coupled into the antenna. Severaldifferent feed types can be used, including microstrip lines, waveguides, and probes. The feed should be designed to minimize impedance mismatch and radiation losses.

Ground plane design: The ground plane provides a reference for the electric field and helps to confine the radiation to the desired direction. The ground plane should be large enough to prevent reflections from the edges of the substrate.

Simulation and optimization: To verify the antenna's performance, electromagnetic simulation software should be used. Parameters like radiation pattern, gain, bandwidth, and returnloss should all be included in the simulation. Afterthat, the antenna may be adjusted to fulfill the required performance standards.

Fabrication: antenna can be fabricated using a variety of techniques, including photolithography,etching, and metallization. The fabrication process should be carefully controlled to ensure that the antenna dimensions and tolerances are correct.

Testing: The fabricated antenna should be tested to verify its performance against the simulated results. Radiation pattern, gain, bandwidth, return loss, and other factors should all be tested.

Block Diagram

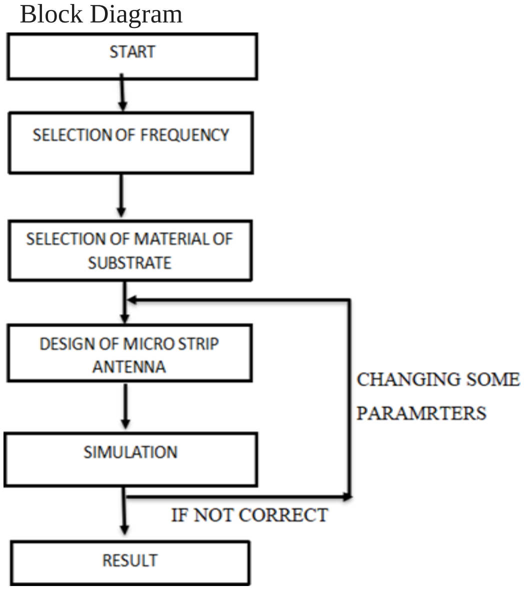

Fig.2.Block Diagram

RESULT AND DISCUSSION

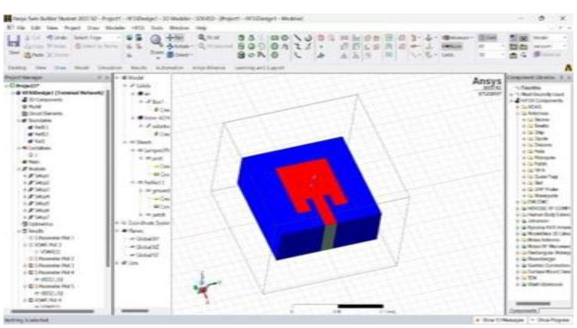

Fig.3.Top View Schemantic

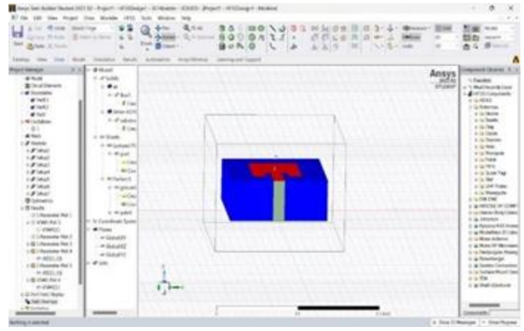

Fig.4.Side View Schemantic

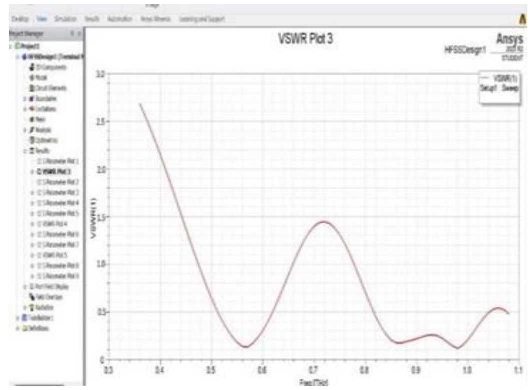

Fig.5.VSWR Plot

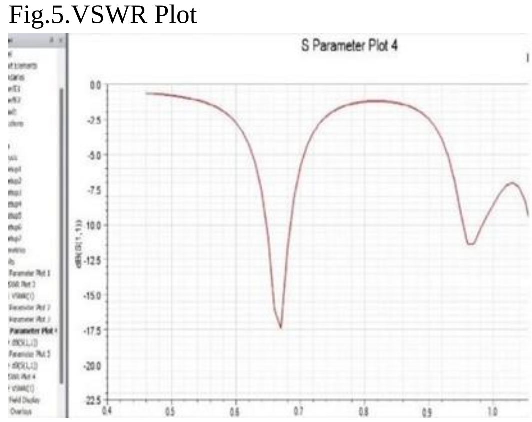

Fig.5.S Parameter Plot

CONCLUSION

The present study analyzes a compact, low-cost, low-profle microstrip patch antenna based on graphene. The result demonstrates that the proposed antenna may function at center frequency from 0.53 to 0.84 THz and has an impedance bandwidth of 37.50%. At the resonance frequency of 0.72 THz, a goodradiation pattern allowed for the achievement of the maximum return loss of 59.87 dB.. At the frequency of 0.72THz, the maximum directivity of 6.60 dB and VSWR of 1.007 are likewise attained.

Applications for the proposed antenna include medical imaging, the detection of tumorsand malignant cells, explosive and chemical detection, and home protection systems. A wideband THz microstrip patch antenna's successful design depends on striking a careful balance among several factors, including patch geometry, substrate material qualities, and feed configurations. Wideband operating in the THz spectrum necessitates cutting-edge design strategies and a solid knowledge of electromagnetic concepts. Further, effective implementation of these designs requires fabrication techniques with sub-millimeter precision.

REFERENCE

[1] Garima Sharma, Manoj Kumar Nigam, Ratnesh Tiwari "Design and implementation of wideband terahertz on-chip antenna for terahertz frequency application" https://doi.org/10.1016/j.matpr.2023.04.096

[2] Sai-Wai Wong; Zhi Ning Chen, YejunHe; Yaling Chen; Long Zhang "An overview of terahertz antennas" DOI: 10.23919/J.CC.2020.07.011

[3] Khan, M.A.K., T.A. Shaem, and M.A. Alim. "Analysis of Miniaturized Terahertz Patch Antennas Using Graphene for Single and Dual Band Operation." Optik 194 (2019).

[4] Shalini, M. "Predicting the Performanceof Slotted Graphene Patch Antennas for Multi-Band Operation in the Terahertz Regime." Optik 204 (2020)

[5] Prashant Kumar Singh, Shashank Kumar Singh, Gufran Ahmad, Palash Das, Sandipan Mallik, Dilip Kumar Choudhary, Hare Krishna, Shivendra Pratap Singh "Design and Simulation ofMicrostrip Antenna for Terahertz Applications"

[6] Muhammad Umar Khan, Mohammad Said Sharawi, Raj Mittra "Microstrip patch antenna miniaturisation techniques: a review" https://doi.org/10.1049/iet- map.2014.0602

[7] A.K. Shackelford; Kai-Fong Lee; K.M. Luk "Design of small-size wide- bandwidth microstrip-patch antennas" Published in: IEEE Antennas and Propagation Magazine (Volume: 45, Issue: 1, February 2003) 10.1109/MAP.2003.1189652

[8] Muhammad Imran Nawaz; Zhao Huiling; Muhammad Sabir Sultan Nawaz; Khalid Zakim; "A review on wideband microstrip patch antenna design techniques" 2013 International Conference on Aerospace Science & Engineering (ICASE) 10.1109/ICASE.2013.6785554

[9] Houda Werfelli; Khaoula Tayari; Mondher Chaoui; Mongi Lahiani; Hamadi Ghariani "Design of rectangular microstrip patch antenna" 2016 2nd International Conference on Advanced Technologies for Signal and Image Processing (ATSIP) 10.1109/ATSIP.2016.7523197

[10] F. Zavosh; J.T. Aberle "mproving the performance of microstrip-patch antennas" IEEE Antennas and Propagation Magazine (Volume: 38, Issue: 4, August 1996) 10.1109/74.537361