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REGULAR ARTICLE

Enhanced Patch Antenna Performances for Wireless Communication using Metamaterial Structure

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Over the past few decades, Terahertz (THz) innovation has gained a lot of focus. Because to its appealing characteristics of a higher data rate, a wider range, and a smaller size, THz antennas are essential parts of wireless communication for sending and receiving electromagnetic fields because of their desirable qualities of a higher data rate, a larger range, and a smaller size. The performance of the antenna is looked into this work, and a rectangle patch antenna with slots built onto a metamaterial structure is proposed. This article examines the antenna's performance and suggests a distinct slotted rhombus patch antenna (RPA) built on a metamaterial construction. Conventional antennas have been demonstrated to be somewhat ineffectual, despite the fact that the metamaterial structure modulates electromagnetic radiation and enhances enactment. The proposed metamaterial antenna produces the result of – 59.34 dB return loss (RL), 1.0033 voltage wave standing ratio (VSWR) and 8.9 dBi at 2.10 THz. THz waves provide exceptionally large bandwidth, ranging from tens to hundreds of GHz, allowing for wireless data rates of tera bits/second (Tbps). THz is harmless for human use and non-ionizing, in contrast to X-rays. THz communications encounter less interference from current wireless spectrum.

Keywords: Metamaterial, Patch antenna, Electromagnetic waves, Wireless communication.

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1. INTRODUCTION

The issue of spectrum availability to meet these demands is brought up by the rapidly increasing the developments in mobile data traffic demand toward higher rates of data, which are expected to reach several tens of gigabits per second by 2020. In addition to developing wireless communication systems with spectral efficiency among tens of bits/s/Hz, which is challenged to accomplish within practically possible bounds, the only alternative is to expand the accessible bandwidth to many tens of GHz. Anyway, it is completely impossible to detect such a large amount of spectrum in the total section of the frequency bands below 300 GHz that is regulated. Because it hasn't been assigned to any other radio service yet, the spectrum above 300 GHz is a good option for providing enough spectrum. For example, among the earliest uses of THz communications that might materialize is a fixed wireless connection that permits the growth of wireless networks' backbone capability. An application of this kind will be used outside. This also applies to WLAN/WPAN solicitation, which are primarily designed for within nomadic clients with a few tens of meters of connection range.

2. LITERATURE SURVEY

The focus of this literature study is an artificial content in the form of substrates for microstrip -lap -antenna made from different materials. Evaluation of the efficiency of the antenna, radiation pattern, reflection loss and voltage wave conditions (VSWR) are the main goal.

The design of the proposed design to promote performance and reduce withdrawal loss includes tracks in the middle part of the patch. Engineer Material Design reduces the loss of wave and increases general efficiency.

El's Rashmi Pant [1] proposed informal frequency spectrum has been under pressure recently, the future communication system will focus on the THZ region to increase the signal tape width, data transfer rate and information capacity. THz is perfect for building a modern wireless telecom infrastructure, as its power - resistant shooting frequency is 100 GB/second. THz technology has a very promising future for fast data transfer between electrical devices. Terahertz radiation can provide a more active flag, which can improve the signal effect efficiency and save energy consumption. One of the main features of THZ radiation is that many materials that absorb visible and infrared light appear transparent in the THZ frequency range. The frequency range can provide a relatively high spatial resolution required to produce high quality images.

Jesie Abad at El. [2] on Terahertz (THz) technology, which ranges from 0.1 to 10 THz, has drawn interest due to its special qualities, such as safety and broadband

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capabilities, which make it appropriate for a variety of uses, including spectroscopy, transmission, and medical imaging. With characteristics including high gain, ultra-broadband response, and reconfigurability, on-chip, metamaterial based, and graphene antennas have improved THz system performance. Both accurate spectroscopic analysis and quick communication are supported by these antennas. Advanced beam-scanning capabilities and cost effectiveness have resulted from the integration of 3D printing technology into THz antennas. The flexibility of THz technology is demonstrated by its application in domains such as body-centric wireless systems and semiconductor production. In order to improve communication for next-generation applications, such as 6G and beyond, novel designs such intelligent reflecting surfaces are used to overcome issues like inter-symbol interference in MIMO THz systems.

Mukherjee and Gupta [3] outline the idea of THz frequency generating methods and point out the appropriate materials for THz antenna construction. The THz band's characteristics and quantum cascade methods were described in the study. Nevertheless, since the paper was published in 2008, there isn't much important literature about the needs of 5G and B5G applications. Instead of focusing on antenna design and material selection, the paper highlights frequency generation. The most recent study and overview of THz communication designs is provided by Elayan et al [4]. The most recent poll was released during the fourth quarter of 2019. Channel models, THz spectrum applications, THz generating techniques, and comparisons with other wireless communication technologies are all covered in the article.

Hao [5] Microstrip patch antennas are light and flat because to the planar structure that the substrate and patch for situations where weight and space are crucial considerations, their small size and simplicity of construction make them extremely appealing. By altering the size of the radiating patch and the qualities of the substrate, microstrip patch antennas can be configured to operate at specific frequencies in the microwave range.

According to Yejun He [6] et al, Terahertz (THz) antennas are crucial elements of THz systems for transmission and reception THz electromagnetic waves for the reason that their small size, broad frequency bandwidth, and high data rate. Most THz antennas have relatively large loss and limited construction techniques because of their tiny size in THz wave high frequency bands. THz antennas come in three different varieties: metallic, dielectric, and new material. According to standard classification, terahertz electromagnetic waves have a wavelength between 0.03 and 3 mm and a frequency range between 0.1 and 10 THz (1 THz = 10^{12} Hz).

Osama M. Haraz [7] and colleagues introduced the two distinct methods for improving directivity and gain. The monopole antenna was suspended under the metallic ground in the first procedure. By adjusting the suspended ground's proportions, the monopole antenna's gain might be raised. If the proper diameters are applied, it may act as a reflector and generate unidirectional broadside radiation patterns. Compared to a conventional antenna, the gain was enhanced by approximately 3 dB when employing suspended ground. It had also become compact due to a change in resonance frequencies toward lower frequencies. The other method used a metamaterial superstrate with metallic printed strips to boost the gain and directivity. Above the monopole antenna, at about 11 mm above the ground, was a metamaterial superstrate with metallic printed strips on the bottom side. A gain improvement of regarding 3 dB was achieved with the addition of superstrate.

Wang [8] Compared to a similar helical antenna; patch antennas are smaller and lighter. Because they are manufactured using printed circuit boards, many patch antennas are affordable and long-lasting. Patch antennas have a high degree of radiation efficiency and are high "Q" antennas by design. When a drone is equipped with a patch antenna, it can transmit high-quality video farther and for longer than if it were only equipped with a wheel or helical antenna. FPV drone may have a 50% longer range. These antennas are frequently undetectable because to their flat design and ability to be covered in plastic. Patch antennas are not able to receive a wide range of frequencies; they only have good gain on specific frequencies. There is spurious radiation in a number of microstrip-based antennas, such as printed dipole, microstrip patch, and microstrip slot antennas. Its low efficiency is caused by losses in the dielectric and conductor. It yields a lower profit. It radiates more cross-polarization. Its ability to manage power is diminished. It has a smaller impedance bandwidth by design. The microstrip antenna's structure radiates from feeds and connection points.

3. PATCH ANTENNA

Flat antennas with one or more "patches" to receive the signal are called patch antennas. Microstrip antennas, flat panel antennas, and panel antennas are other names for patch antennas [9-12]. Two separate plates are used to create the patch antenna. A larger ground plane is the site of the smaller radiating patch with a dielectric substrate. The antenna's feed point extends from the patch on the patch antenna to the rear of the whole antenna. Compared to circular polarized patch arrays, linear polarized patch antennas often operate over a larger frequency range and have a little higher gain.

However, heavy multipath settings, like those between big buildings in a metropolitan location, are frequently where circular polarized patch arrays perform well. Important parts of their creation include the reference plane, excitation system, insulating layer, and radiating element. Microstrip patch have disadvantages like reduced efficiency, cross polarization radiation, and restricted power handling capacity, but they also have advantages like cost-effectiveness, directional radiation, small size, and low profile. Typically, a transmission line provides the radio frequency signals needed to generate electromagnetic impulses to the patch.

4. METAMATERIAL FOR ANTENNA DESIGN

According to the Latin word material, which means "matter" or "material," and the Greek word meta, which means "after", a metamaterial is a type of material that is created to possess a characteristic that is often rare in naturally occurring materials. It is generated from the newly built structures of the basic materials rather than from their inherent qualities. Metamaterials are generally composed of various materials, including metals and polymers, and are arranged in repeating patterns at sizes smaller than the wavelengths of the phenomena they affect. They have "smart" properties that allow them to regulate seismic and electromagnetic waves by bending, amplifying, blocking, or absorbing them better than previous methods. This is made possible by their exact form geometry, dimensions, position, and organization.

5. IOT BASED PATCH ANTENNA

The Internet of Things (IoT) is a computer network that has incorporated technology to facilitate information communication between devices in wireless and ambient settings. Through wireless connection via the network, IoT makes it possible to remotely control these devices, which has certain financial advantages and increases efficiency. The study by Shi et al. claims that IoT is known to function between the frequency range of 100 MHz and 5.8 GHz, have a decent data rate, and be inexpensive. Everything that has internet connectivity is categorized under the name "IoT," which goes beyond conventional desktop or mobile devices.

5.1 Material

The materials used in the antenna design. In this respect, the suitability of several materials to deliver the performance required for ultra-high-speed networks is evaluated.

5.2 Frequency

"Frequency (THz)" displays the antenna's operational frequency in terahertz (THz). The frequency at which an antenna operates greatly affects both its functionality and transmission potential.

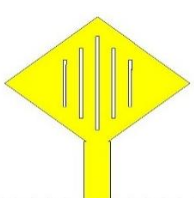

Fig. 1 – Antenna design

RETURN LOSS

The quantity of power that returns to an antenna as a result of an impedance mismatch is known as return loss. Stronger power transmission results from improved impedance matching, which is indicated by a lower RL.

$$RL = -20\log_{10}|\tau| \tag{1}$$

$$\tau = \frac{Z_{in}-Z_0}{Z_{in}+Z_0}$$

$$RL = -20log_{10}\left|\frac{Z_{in}-Z_0}{Z_{in}+Z_0}\right| \tag{2}$$

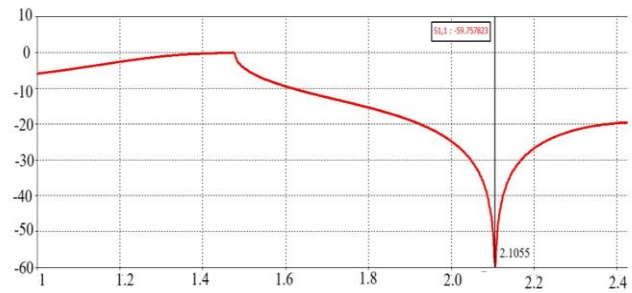

Fig. 2 – Return loss

$$VSWR = \frac{1+10^{(-RL/20)}}{1-10^{(-RL/20)}} \tag{3}$$

$$VSWR = \frac{1+|\tau|}{1-|\tau|}$$

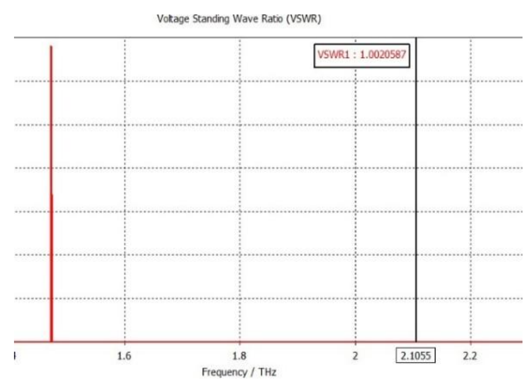

Fig. 3 – VSWR

5.3 Gain in Antenna

In comparison to a reference antenna, the term "gain" refers to a critical statistic that evaluates an antenna's capacity to focus power transmission or receiving in a particular direction. Since it determines the power of the signal and transmission range, an antenna's gain, which is stated in dB, is necessary for these properties.

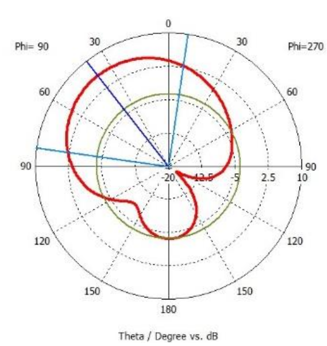

Fig. 4 – 1D gain

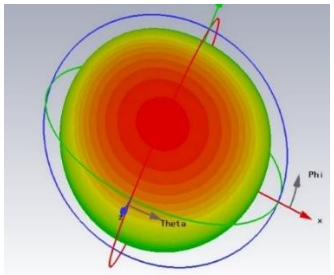

Fig. 5 – 3D gain

The following formula can be used to ascertain an antenna's gain.

$$GAIN(dB) = 10\log_{10}(Point/Pin)$$

Point: The strength that the antenna's emission or reception directs in the envisioned direction.

Pin: The power that a rigid standard antenna transmits or receives under the same circumstances.

6. CONCLUSION

An example of a custom antenna is a metamaterial antenna, which uses materials known as metamaterials specifically designed to actively regulate and control electromagnetic radiation. Focusing on the transition from C Band Network, this research examined the concept, development and distribution of a patch antenna according to the meta content of wireless communication. The ability of metaphors to change the antenna creation and distribute small high organizations that provide spontaneous interaction, and the better quality of the signal is investigated in this thesis. Metamaterials are important for meeting the requirements to develop wireless communication technology because of their many benefits, including better benefits, resistance, data transmission and loss of withdrawal.

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Покращені характеристики патч-антени для бездротового зв'язку з використанням метаматеріальної структури

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Протягом останніх кількох десятиліть інновації в галузі терагерцового (ТГц) діапазону привернули значну увагу. Завдяки своїм привабливим характеристикам, таким як вища швидкість передачі даних, ширший діапазон та менший розмір, ТГц антени є важливими частинами бездротового зв'язку для передачі та прийому електромагнітних полів. У цій роботі розглядається продуктивність антени, і пропонується прямокутна патч-антена з прорізами, вбудованими в метаматеріальну структуру. У цій статті розглядається продуктивність антени та пропонується окрема щілинна ромбоподібна патч-антена (RPA), побудована на метаматеріальній конструкції. Було показано, що звичайні антени дещо неефективні, незважаючи на те, що метаматеріальна структура модулює електромагнітне випромінювання та покращує ефективність. Запропонована метаматеріальна антена забезпечує результат – втрати на відбиття (RL) 59,34 дБ, коефіцієнт стояння хвилі напруги (VSWR) 1,0033 та 8,9 дБі на частоті 2,10 ТГц. ТГц-хвилі забезпечують надзвичайно широку пропускну здатність, від десятків до сотень ГГц, що дозволяє передавати бездротові дані зі швидкістю терабіт/секунду (Тбіт/с). ТГц нешкідливий для використання людиною та неіонізуючий, на відміну від рентгенівського випромінювання. ТГц-зв'язок стикається з меншими перешкодами від сучасного бездротового спектру.

Ключові слова: Метаматеріал, Патч-антена, Електромагнітні хвилі, Бездротовий зв’язок.