# For wireless applications, design and analysis of patch antenna at 2.45 GHz

**Md. Sohel Rana[1,2], Shake Zion Haider Ovi[1], A.S.M. Tanvir Ul Islam[1], Piyal Mistry[1], Sahriar Islam Shipon[1], Md. Jahidur Rahaman[1], Md. Shahriar Rakib[1], Omar Faruq[3]**
[1]Department of Electrical and Electronic Engineering, Northern University of Business and Technology Khulna, Khulna, Bangladesh
[2]Department of Electrical and Electronic Engineering, Independent University Bangladesh (IUB), Dhaka, Bangladesh
[3]Department of Electrical and Electronic Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

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**ABSTRACT**

This research designs, analyzes, and studies a 2.45 GHz rectangular microstrip patch antenna (RMPA). The antenna design uses Rogers RT5880 (lossy) substrate material with 2.2 dielectric permittivity, 1.5 mm thickness, and 0.0009 loss tangent. Additionally, the antenna was designed and simulated using computer simulation technology (CST) studio 2019 software. Plot designs were again created using Origin Pro Software. The simulation results showed that the return loss (S11), voltage standing wave ratio (VSWR), gain, directivity, bandwidth, efficiency, and surface current were -45.992 dB, 1.0101, 6.115 dBi, 6.534 dBi, 70.8 MHz, 93.59%, and 49.9 A/m, respectively. This paper aims to increase return loss to a typical VSWR value near 1. Besides boosting antenna gain, directivity, and efficiency, it can be used in future wireless applications, including mobile phones and wireless LANs. The proposed antenna design outperforms earlier experiments, demonstrating that the research has increased performance.



***Corresponding Author:***

Md. Sohel Rana
Department of Electrical and Electronic Engineering, Northern University of Business and Technology Khulna, Khulna-9100, Bangladesh
Email: sohel.rana@uits.edu.bd

## 1. INTRODUCTION

Microstrip patch antennas are low-profile antenna configurations typically used in applications operating at frequencies higher than 100 MHz. They comprise a metallic patch positioned close to the ground plane and separated from it by a dielectric material. This configuration is known as a microstrip. Copper and gold are the most popular conductive materials for the upper surface patch. The design requirements determine the conductor’s precise geometric shape, which can take on various forms, including but not limited to square, rectangular, elliptical, or ring shapes. These multipurpose microstrip antennas find widespread utility in multiple applications, such as aeroplanes, spaceships, satellites, missiles, mobile radios, and wireless communications. Because they are so compact, microstrip patch antennas are ideally suited for installation in uncrewed aerial vehicles. Microstrip patch antennas provide an efficient and compact solution for various wireless communication requirements [1]. These days, tiny telecommunications devices like smartphones, tablets, and wireless routers require miniaturized antennas that can resonate at a suitable frequency for telecommunications technology [2].

In wireless communication networks, the antenna is an essential component, and this is especially true in the mobile communication industry, which places a premium on portability, cost, and a low-profile design. Microstrip patch antennas have been produced in various types to accommodate the numerous demands on mobile communication systems. Microstrip patch antennas are compatible with all these standards and offer compatibility. Microstrip patch antennas were first conceived in the 1950s, but in the 1970s, when printed circuit board (PCB) technology was developed, they were used on a widespread scale. This process took approximately 20 years. Microstrip patch antennas are notorious for having a narrow bandwidth, one of their many drawbacks. However, current wireless communication systems are built to accommodate considerable capacity needs, which helps mitigate the impact of this disadvantage [3].

The structure of the antenna is made up of three essential components: the patch, the substrate, and the ground plane. The dielectric constant of the substrate is commonly found to be somewhere in the region of $2.2 \leq \varepsilon_r \leq 12$. These antennas are notable for the ease with which they may be customised, their low prices, and their lightweight nature, in addition to their straightforward designs. However, they have a few limitations, the most notable of which are restricted bandwidth and low power capabilities [4]. The microstrip patch antenna can be broken down into four primary parts: the microstrip patch, the dielectric substrate, the ground plane, and the feed. It would help to use a thick dielectric substrate with a low dielectric constant to get the best antenna performance, higher efficiency, wider bandwidth, and better radiation characteristics. Various feeding mechanisms are utilized to feed the microstrip patch antenna. In addition, the output of the antenna, as well as its overall performance, can be improved by using a variety of design strategies [5]. Figure 1 are below the simple geometry structure of microstrip patch antenna [6]. Figure 2 the physical construction of the microstrip patch antenna, and the design was done using computer simulation technology (CST) software.

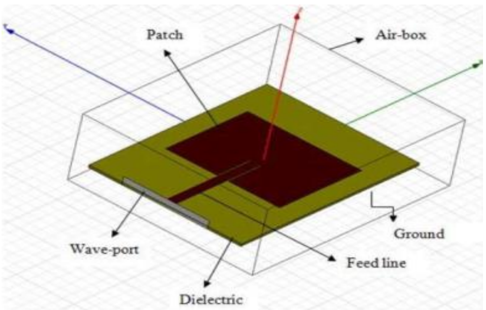



Figure 1. Geometry of microstrip patch antenna

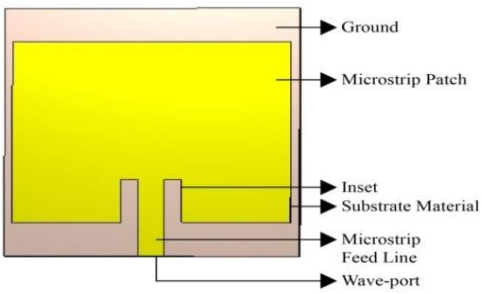
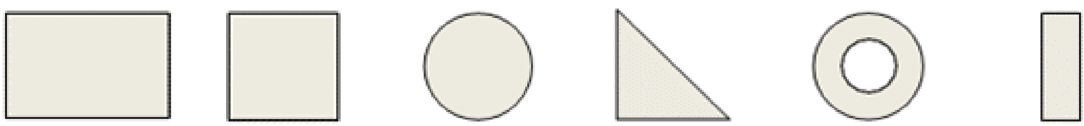



Figure 2. Physical construction of proposed antenna design

The rectangular microstrip patch antenna (MPA) can be adapted to various other shapes, as depicted in Figure 3(a)-(f). These shapes include a rectangle Figure 3(a), square Figure 3(b), circular Figure 3(c), triangle Figure 3(d), donut Figure 3(e), and dipole Figure 3(f). Furthermore, Figure 3 showcases the different MPA shapes. [7].



(a) (b) (c) (d) (e) (f)

Figure 3. Different shapes of microstrip patch antennas: (a) rectangle, (b) square, (c) circular, (d) triangle, (e) donut, and (f) dipole

The paper is organized into six chapters. The introduction is presented in the first chapter. The second chapter comprises the literature review, which discusses relevant studies and research conducted in the field. The third chapter examines the proposed antenna material and methodology. The fourth chapter focuses on the proposed antenna design and simulation results. In chapter five, the obtained results are further analyzed as the research gap, providing a detailed examination and interpretation of the data gathered from the simulations. A summary of the study's most critical findings and consequences is presented in chapter six, which serves as the conclusion section.

## 2. LITERATURE REVIEW

A metallic device that is capable of transmitting and receiving information through the use of radio waves is known as an antenna. Antennas play an essential role in wireless communication systems due to their responsibility. The only option is to establish a working wireless communication system with a correctly configured antenna arrangement. Any mistake made throughout the gearbox or receiving process can cause the entire system to crash. As a result, the most crucial consideration in designing a wireless communication system is to provide careful attention to the design and selection of the antenna. As the number of portable wireless devices continues to increase exponentially, there will inevitably be an urgent need for antennas that are small in size, inexpensive, and have a high level of performance.

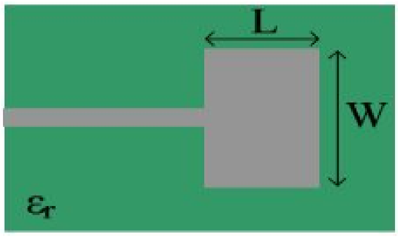
In this scenario, microstrip antennas stand out as the best option, as they are the only type of antenna that can satisfy all of the prerequisites for a wireless communication system [8]. In this section, a variety of worldwide standard journals and conference papers that have been published on microstrip patch antennas with an operating frequency of 2.45 GHz are discussed. After reviewing the data, it was discovered that the proposed antenna produced results far superior to those of the prior antennas, making it an excellent choice for use in wireless applications. Research by Rana and Rahman [9], design and analysis of a patch for wireless applications and the key goals of this research work is communication technology. The fundamental goal of this research is to achieve lower return losses, higher gains and standard voltage standing wave ratio (VSWR). This research study [10], discusses the examination, design, and analysis of a rectangular microstrip patch that operates at a frequency of 2.45 GHz, among other topics. Several outputs were produced due to the simulation, consisting of return loss, VSWR, gain, directivity, bandwidth, and efficiency. A typical VSWR value near 1 is the study's primary goal: to lessen the return loss. A further objective of the researchers was to improve the antenna's gain, directivity, and efficiency. In this paper [11], introduces normalized thickness and a scaling factor to translate structures, albeit only in patch dimensions. This study derives additional feed line dimension formulas to expand this idea. First-time measurements for the new antenna are taken using traditional methods. The following situations are simulated in parallel using the improved feed line dimensions formulas, Bhatnagar's patch postulate, and initial design calculations. Its success proves the proposed procedure works. Research by Rana *et al.* [12], designs and analyzes a 2.45 GHz S-band microstrip patch antenna. This antenna may be utilized in future wireless communications. This antenna's primary goal is to achieve a minimal return loss and a near-ideal VSWR near to 1, boosting its gain, directivity, and efficiency. The tested antenna outperforms others described in recent scientific journals and conferences. Therefore, this antenna has great potential to meet the needs of diverse wireless applications. Research by Shimu and Ahmed [13], designs and evaluates a 2.45 GHz ISM band single-element rectangular microstrip patch antenna (RMPA). These antennas have been carefully designed to optimize their parameters and achieve high gain, resonant frequency, and radiation efficiency in a tiny package. Return loss, gain, directivity, and bandwidth (BW) augmentation characterize two-element patch array performance.

Research by Akash *et al.* [14], focuses on designing and simulating a RMPA operating at 2.45 GHz. Extensive simulations assess radiation factors, such as return loss, gain, directivity, efficiency, and radiation pattern, respectively. According to the findings, increasing the number of antenna elements might increase gain while simultaneously narrowing the beam width. This work contributes to understanding the antenna's performance and potential for wireless applications. Research by Adami *et al.* [15], discusses a flexible wireless power-harvesting wristband that operates at 2.45 GHz and converts 24.3 dBm of radio frequency energy into a net DC output. This system is now running at its intended capacity. At a level of 20 dBm, the rectifier displays the highest efficiency in its class, which is 33.6%; it was built on a solid substrate. To match the output of the rectenna, we need a self-powered boost converter with a quiescent current of 150 nA and a matching efficacy of more than 95%. When the signal strength is -7 dBm, the end-to-end efficiency can achieve its highest possible level of 28.7%.

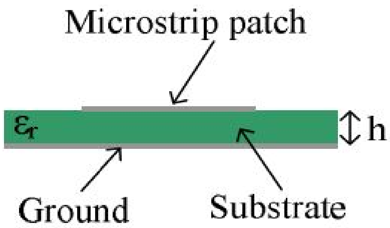
According to Muhammad *et al.* [16], provides a method for constructing a rectangular patch antenna suitable for usage in worldwide wireless local area network systems. In addition, it investigates how various antenna factors, such as the antenna's radiation pattern, directivity, gain, BW, VSWR, return loss, and far-field, influence the antenna's performance. Based on the findings from the simulations, the designed antennas have good radiation patterns and characteristics for WLAN communication.

## 3. MATERIALS AND METHODS

Several essential features must be considered to successfully create a rectangular patch antenna for wireless applications. In addition to the thickness and the resonance frequency, the substrate dielectric constant is also included in these parameters. When determining the resonance frequency of the antenna, the primary factors that are taken into consideration are the patch's size and the substrate's dielectric constant. It is necessary to select these settings with the utmost respect to ensure that the antenna functions within a suitable frequency range. This is essential to facilitate communication that is both dependable and efficient. By utilising a microstrip line with 50 Ω impedance and a traditional rectangular patch design, the antenna can achieve better impedance matching [17]. In recent years, there has been a rise in the use of microstrip patch antennas in wireless communication. The most basic arrangement of a patch antenna uses a rectangular shape. As expected, the most common shape for a patch geometry employed in implementing wireless antennas is rectangular, as can be seen in Figures 4 (a) and (b) [18] [19].




(a)




(b)

Figure 4. Basic shape for: (a) structure of rectangular and (b) significant parts of patch antenna

To determine the values of the parameters, this inquiry makes use of the equations that are shown below. The patch antenna's width is accounted for when performing measurements in the microstrip format. To determine the required values for the parameters, this research makes use of [20], [21].
Step 1: width of the patch.

$$Wp = \frac{c_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{1}$$

In the equations that have been supplied, the symbol "c" stands for the velocity of light in a vacuum, which has a value of three times 108 meters per second. The symbol for the dielectric constant of the substrate is "$\varepsilon_r$, (epsilon), and the frequency that is needed for the antenna design is indicated by "$f$".
Step 2: the effective dielectric constant of the substrate.

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\times\frac{h}{Wp}\right)^{-0.5} \tag{2}$$

Where, $h$ is the height of the substrate and and the effective dielectric constant is $\varepsilon_{reff}$ :
Step 3: the calculation of the effective length of an antenna is an essential aspect of antenna design.

$$L_{eff} = \frac{c_o}{2f_r\sqrt{\varepsilon_{reff}}} \tag{3}$$

Step 4: the process of calculating the length extension of an antenna.

$$\Delta L = 0.412h\,\frac{\left(\frac{Wp}{h}+0.3\right)\left(\varepsilon_{reff}+0.264\right)}{\left(\varepsilon_{reff}-0.258\right)\left(\frac{Wp}{h}+0.8\right)} \tag{4}$$

Step 5: one of the most important calculations in antenna design is the determination of the length of the antenna.

$$L = L\,eff - 2\Delta L \tag{5}$$

Step 6: ground of plane width and length are.

$$Lg = 6h + L \tag{6}$$

$$Wg = 6h + Wp \tag{7}$$

## 4. PROPOSED ANTENNA DESIGN AND SIMULATION RESULTS

CST software illustrates the proposed antenna design, which may be found in Figure 5. Copper, a material that is well-known for the inherent losses it possesses, is utilized in the construction of the ground plane. The substrate material is used in Rogers RT5880 which is thickness of 1.5 mm and dielectric permittivity of 2.2. The patch is used in copper which is thickness of 0.035 mm. The proportions of the antenna, which are 55×53×1.5 $mm^3$, make it a good choice for applications that include wireless technology. CST software is used in both the design and simulation stages of the antenna design process. Because of this, it is possible to conduct a comprehensive investigation of the antenna's performance and features.

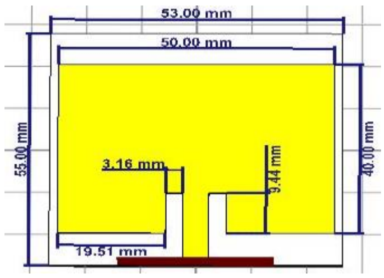



Figure 5. The design of the suggested antenna was created with the help of CST software

### 4.1. Antenna parameter

In Table 1, the several parameters that are associated with the antenna that is designed are shown. This section describes one of these characteristics: the size of the antenna patch and the ground, including the length and width of each of these dimensions simultaneously. In addition, the table offers information regarding many factors, including height, thickness, loss tangent, the transmission line's width, and the inset's length and width. This detailed summary presents essential information concerning the physical features of the antenna as well as its vital components.

Table 1. Dimensions of the antenna model that has been optimized

| Parameter | Wg | Lg | Wp | Lp | Hs | t | $I_L$ | $I_W$ | $T_x$ |
|---|---|---|---|---|---|---|---|---|---|
| Dimension (mm) | 53 | 55 | 50 | 40 | 1.5 | 0.8 | 9.435 | 3.16 | 4.66 |

### 4.2. Return loss and bandwidth

In the context of telecommunications systems, return loss refers to the measurement of the signal magnitude reflected off the receiving antenna. This frequently occurs in the optical fibre or transmission line system due to discontinuities. It is preferable for signal transmission efficiency that the magnitude of the return loss is as low as possible. This implies that a tremendous amount of energy is transferred to the antenna. On the other hand, if the magnitude of the return loss is more significant, this indicates that less energy is effectively communicated to the antenna. Because of this, a higher return loss in telecommunications systems is frequently preferred because it signals improved energy transfer and enhances the system's overall performance [22]. At 2.45 GHz, the simulation of the antenna reveals the behaviour of the antenna's S-parameter at a frequency range that extends from 2 GHz up to 2.90 GHz. The results of the S-parameter analysis are presented in Figure 6, which is a graphical depiction of the findings. In the simulation, the value of the S-parameter was found to be -45.992 dB, and the bandwidth was found to be 70.8 MHz at -10 dB.

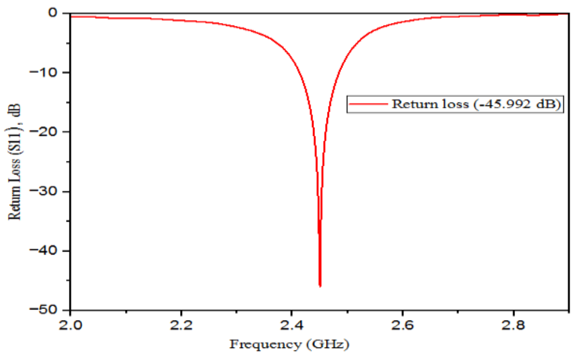



Figure 6. Return loss versus frequency is presented

### 4.3. Voltage standing wave ratio

It is essential to achieve a good impedance match between the transmission line and the antenna to guarantee efficient power delivery to the antenna that is meant to receive it. The VSWR is a measurement that determines how efficiently electricity is transmitted from a power source to a load via a transmission line. It provides a quantitative measure of the effectiveness of power transfer via radiofrequency. If the magnitude of the VSWR is smaller, this implies that the impedance of the antenna and the transmission line are more closely matched. In everyday language, this indicates that more power is successfully sent to the antenna, improving signal transmission and reception efficiency [22]. For efficient antenna performance, the value of VSWR should fall between 1 and 2. Figure 7 illustrates the simulated VSWR. The plot indicates that at the operating frequency of 2.45 GHz, which is commonly used in wireless applications, the VSWR value remains below 1.01. This observation suggests that the antenna exhibits a highly favourable impedance match with the transmission line, resulting in efficient power transfer and improved performance for wireless communication at the specified frequency [23].

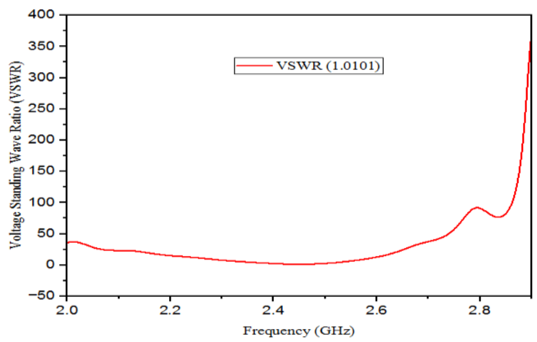



Figure 7. Frequency vs VSWR graphical representation

### 4.4. Gain and directivity

A “gain” is the direction in which an antenna produces the greatest radiation; thus, the term “gain” is used in the context of antennas [24]. The term “antenna gain” refers to how effectively an antenna concentrates radiated power in a specific direction or absorbs incident power from that direction relative to a reference antenna. These units show the antenna is directional and how much better it is than a standard reference antenna at receiving or sending signals [25]. According to the simulation’s findings, the recommended antenna gain is 6.115 dBi, as shown in Figure 8. In addition, the result of the simulation of the gain plot is shown in Figure 9. The directivity (D) of an antenna is calculated by taking the power density of the antenna in the direction in which it emits the most energy in three-dimensional space and dividing that value by the antenna’s average power density. It has a solid connection to the radiation pattern that the antenna emits. Looking at Figure 10, one can deduce that the suggested antenna has a directivity of 6.53 dBi. It is essential to consider that the directivity value must consistently be greater than the antenna’s gain [26]. Figure 11 presents the results of a simulation of the directivity plot as a function of frequency. Additionally, this plot is shown below.

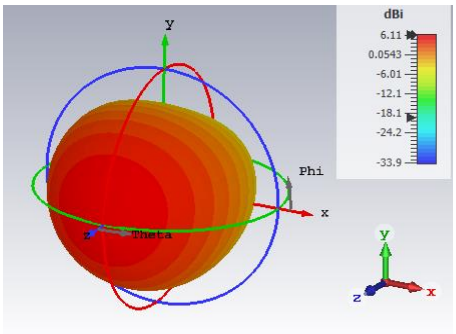



Figure 8. 3D fairfield gain of the proposed antenna

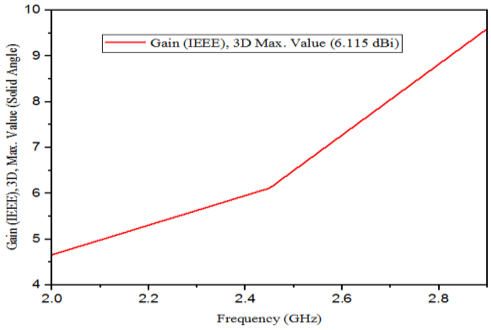



Figure 9. Gain plot of proposed antenna

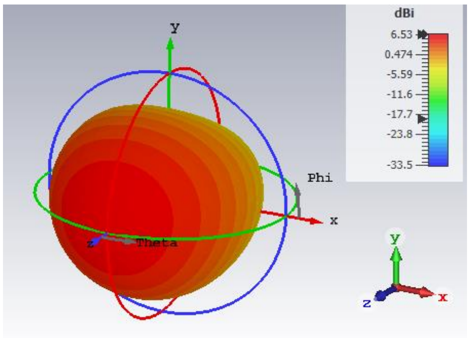



Figure 10. 3d fairfield directivity of the proposed antenna

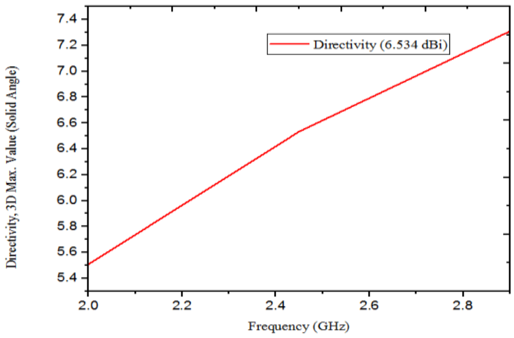



Figure 11. Directivity plot of proposed antenna

### 4.5. Radiation pattern

In this part, the antenna's radiation pattern is an essential quality that displays the antenna's performance in a distant field. The size of the antenna can determine this performance. The radiation pattern considers significant characteristics, including gain, directivity, and electric fields. It is feasible to obtain insights into the antenna's performance and to make informed decisions to optimize its operation for specific applications if the radiation pattern is thoroughly analyzed. In wireless communication systems, it is vital to have a solid understanding of the radiation pattern and to optimize it to achieve the coverage, beam direction, and signal intensity sought. The polar far-field gain of the proposed antenna is depicted to the right in Figure 12. The central lobe of the radiation pattern was measured to have a magnitude of 6.11 dBi when measured at a frequency of 2.45 GHz. Observations have shown that the orientation of the central lobe is at an angle of 5 degrees. According to estimates, the central lobe has an angular width of roughly 88.9 degrees. Furthermore, the side lobe level is found to be -14.5 dB. These parameters provide valuable insights into the antenna's radiation pattern and ability to focus and direct the signal in the desired direction while minimizing radiation in other directions. Additionally, the directivity pattern is shown in polar form in Figure 13. The magnitude of the centre lobe at this point is 6.53 dB, and the direction in which it is pointing is 5.0 degrees. In addition, it is essential to remember that the width angle is $88.9^{0}$. Considering that it functions as it should, this antenna has a sidelobe level of -14.5 dB.

### 4.6. Efficiency, radiation efficiency and surface current

In the context of antennas, the term "efficiency" refers to the quantity of energy that must be supplied to an antenna to communicate with other antennas efficiently [27]. The power given to an antenna and the power that it emits or dissipates can be used to determine its effectiveness. An antenna with low efficiency will either lose most of the energy sent to it due to losses within the antenna itself or will reflect away due to an impedance mismatch [28]. Figure 14 shows the antenna efficiency curve.

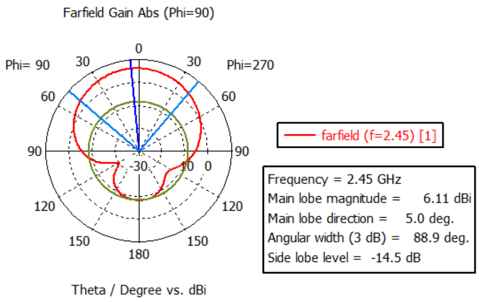



Figure 12. The polar version of the farfield gain

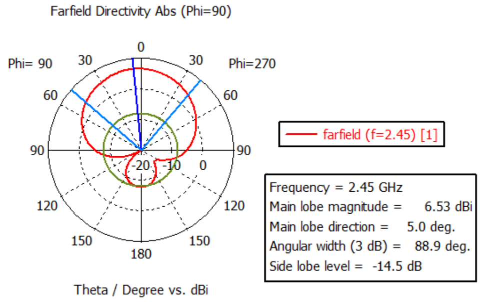



Figure 13. The polar form of the farfield directivity

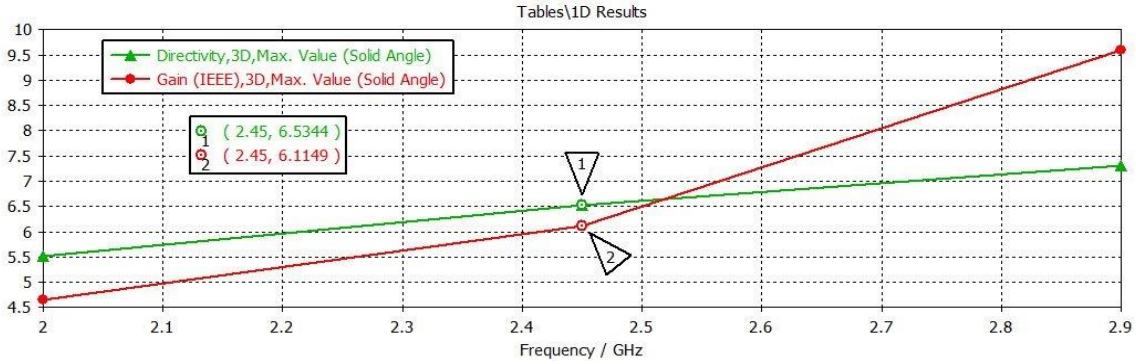



Figure 14. Recommended antenna efficiency

$$Antenna\ efficiency = \frac{Gain(dBi)}{Directivity(dBi)} \times 100\% = (6.115/6.534) \times 100 = 93.59\% \tag{8}$$

An antenna’s overall efficiency can be determined by multiplying its radiated efficiency by the impedance mismatch loss of the antenna when it is linked to a transmission line or a receiver. This calculation can be done to determine the overall efficiency of the antenna. Because of this, the antenna can function at its highest possible efficiency [23]. The ratio of an antenna’s full power to the net energy it receives from a connected transmitter measures its radiation efficiency [29]. Surface current is a type of electric current caused by applying an electromagnetic field, and it is most commonly found in metallic antennas [22]. Besides, how the current is spread on the antenna helps it send out electromagnetic waves more effectively [30]. Figure 15 shows the surface current of proposed antenna. This paper proposed surface current is 49.6A/m.

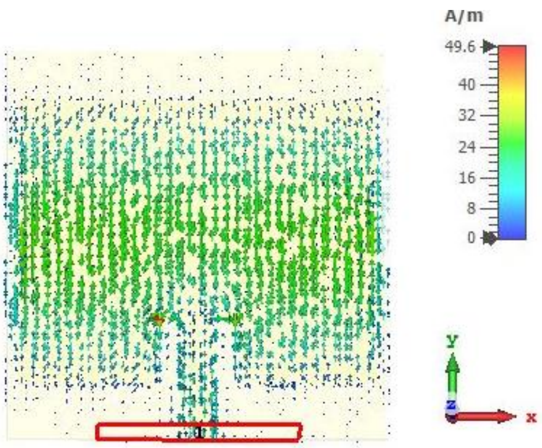



Figure 15. Surface current of proposed the antenna

## 5. RESULT ANALYSIS AND RESEARCH GAP

In this section of the article, the findings of the suggested antenna are provided and discussed in detail. Return loss, VSWR, gain, directivity, bandwidth, and efficiency are some of the performance measures included in the findings. It has been determined that the values obtained are -45.992 dB, 1.0101, 6.115 dBi, 6.534 dBi, 70.8 MHz, and 93.59%, respectively. Compared to research published in journals and conference papers that are well-known on a global scale, these findings demonstrate an outstanding performance, particularly in the field of wireless communications applications. Due to their numerous advantages, such as their low cost, ease of design, modelling, and fabrication, microstrip patch antennas have gained a lot of popularity among academics in recent years. According to the findings, the Rogers RT5880 material has the potential to be a good choice for wireless applications that run at a frequency of 2.45 GHz. In addition to exhibiting remarkable directivity and gain, the suggested antenna operates within the high-band frequency range. Combining these characteristics makes it an attractive choice for a wide range of wireless applications. While providing excellent performance in terms of radiation characteristics and efficiency, these antennas offer a solution that is both cost-effective and efficient. The positive results from the proposed antenna provide credence to the potential of microstrip patch antennas to satisfy the needs of contemporary wireless systems. The findings contribute to the existing body of knowledge and provide valuable insights for further advancements in antenna design and optimization for wireless applications. Simulation results are summarised in Table 2.

Table 2. The results of the simulation are summarised in this feature

| Parameter | $S_{11}$ | VSWR | BW (GHz) | Gain | Directivity | Efficiency |
|---|---|---|---|---|---|---|
| Value | -45.992 | 1.0101 | 70.8 MHz | 6.115 dBi | 6.534 dBi | 93.59% |

This paper describes a study utilizing CST software to simulate a proposed MPA design. In this study, the performance of the antenna design will be evaluated, and the results will be compared to those of earlier research published in high-quality international journals and conference papers. The comparison tables provide a complete examination of the proposed findings and the differences between those findings and the findings of earlier studies (Tables 3, 4, 5, and 6). The maximum return loss, VSWR, and bandwidth of the microstrip patch antenna MPA are displayed in Table 3. At the same time, the simulation results are presented in their entirety. In addition, it provides information regarding the substrate materials and thicknesses utilized in earlier experiments, enabling a comprehensive comparison to be constructed. Tables 4, 5, and 6 present a comparison of the gain, directivity, and efficiency of the MPA design that has been proposed. Based on the results acquired from the simulations and the comparison tables, this study implies that the proposed discoveries perform better than the results achieved in the past.

As a consequence of this, the methodology that has been suggested for the design of the microstrip patch antenna has the potential to provide a solution to the issue that is being addressed. With a specific focus on wireless technology applications, the study intends to contribute to improving antenna design by providing fresh insights and developments. The findings of these simulations and the comparison tables offer helpful information for designing and optimizing microstrip patch antennas in wireless technology applications.

Table 3. Regarding works that have been published in the past

| Ref. | Operating frequency | DP ($\varepsilon$) | Return loss (dB) | VSWR | BW (GHz) |
|---|---|---|---|---|---|
| [2] | 2.45 GHz | 4.4 | -45.36 | - | - |
| [12] | 2.45 GHz | 2.2 | -12.542 | 1.6176 | 34.9 MHz |
| [13] | 2.45 GHz | 3.8 | -38.5 | 1.02 | 59 MHz |
| | | | 37.67 | 1.02 | 79.2 MHz |
| [14] | 2.45 GHz | 4.4 | -18 | - | - |
| [31] | 2.45 GHz | 4.3 | -17.47 | 1.311 | - |
| [16] | 2.45 GHz | 2.3 | -22.58 | 1.160 | 25.2 MHz |
| [32] | 2.45 GHz | 4.7 | -19.62 | | - |
| [33] | 2.42 GHz | 6.15 | -22.242 | - | 50.47 MHz |
| [34] | 2.45 GHz | 3 | -28.28 | - | 24 MHz |
| | | | -22.03 | - | 27MHz |
| [35] | 2.45 GHz | 4.4 | -25.28 | - | 32.02 MHz |
| This work | 2.45 GHz | 2.2 | -45.992 | 1.0101 | 70.8 MHz |

Table 4. Compared with the gain

| Ref. | Operating frequency | Gain (dBi) |
|---|---|---|
| [13] | 2.45 GHz | 5.49<br>8 |
| [14] | 2.45 GHz | 2.05 |
| [31] | 2.45 GHz | 3.019 |
| [32] | 2.45 GHz | 3.050 |
| [35] | 2.45 GHz | 6.29 |
| This work | 2.45 GHz | 6.115 |

Table 5. Compared with the directivity

| Ref. | Operating frequency | Directivity (dBi) |
|---|---|---|
| [14] | 2.45 GHz | 6.33 |
| [31] | 2.45 GHz | 5.483 |
| [32] | 2.45 GHz | 2.76 |
| [36] | 2.45 GHz | 5.109 |
| [37] | 2.45 GHz | 5.78 |
| This work | 2.45 GHz | 6.534 |

Table 6. Compared with the efficiency

| References | [13] | [14] | [16] | [31] | [38] | [36] | [39] | [40] | This work |
|---|---|---|---|---|---|---|---|---|---|
| Operating frequency (GHz) | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 |
| Efficiency (%) | 68.62 | 37 | 83.06 | 55.74 | 89 | 77.17 | 73.46 | 89.6 | 93.45 |

## 6. CONCLUSION

This research emphasizes the importance of microstrip patch antennas in wireless applications due to their lightweight, tiny package, and easy fabrication. CST Studio can design, simulate, and analyze antennas to examine design parameters. MPA development for wireless communication systems is the proposed study. The MPA that was proposed has a return loss of -45.992 dB, a gain of 6.115 dBi, a directivity of 6.534 dBi, a bandwidth of 70.8 MHz, a VSWR of 1.0101, and an efficiency of 93.59%. These findings indicate that the suggested MPA has competitive gain, S-parameter, and radiation efficiency, making it appropriate for mobile phones and wireless local area networks. The antenna can be built and compared to simulations. Microstrip patch antennas are crucial for wireless applications, and CST Studio can design and simulate them. The MPA design is shown as a viable solution with competitive performance metrics, and its potential applications in wireless communication systems are examined.

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## BIOGRAPHIES OF AUTHORS

**Md. Sohel Rana** received a B.Sc. Engineering Degree in Electrical and Electronic Engineering from Prime University (PU), Dhaka, Bangladesh, in 2015. In 2018, he got his first Master of Science (M.Sc.) in Telecommunication Engineering from the University of Information Technology and Sciences (UITS), Dhaka, Bangladesh. He completed his second M.Sc. in Engineering (Master of Science in Engineering in Information Systems Security) from Bangladesh University of Professionals (BUP), Dhaka, Bangladesh, in 2022. He has completed his third Master of Science (M.Sc.) in Electrical and Electronic Engineering at Independent University, Bangladesh (IUB), Dhaka, Bangladesh, in 2023. His research interests include microstrip patch antenna, wireless communication, image processing, renewable energy, solar cell, biomedical engineering, control systems, and power electronics. He has published more than 40 research articles in peer-reviewed journals and international conferences. At present, he is a Lecturer and Head (In-Charge) in the Department of Electrical and Electronic Engineering at the Northern University of Business and Technology Khulna, Khulna-9100, Bangladesh. He can be contacted at email: sohel.rana@uits.edu.bd.

**Shake Zion Haider Ovi** is a student in Departement of Electrical and Electronic Engineering at the Northern University of Business and Technology in Khulna, where he is in his final year of study as an undergraduate. His scientific interests include antenna design as well as wireless communication and renewable energy. He can be contacted at email: skovi649183@gmail.com.

**A.S.M. Tanvir Ul Islam** graduated from Bangladesh Army University of Science and Technology (BAUST) Saidpur, Bangladesh with a Bachelor of Science (B.Sc.) in Electrical and Electronic Engineering degree in 2021. He is currently pursuing his Master of Science (M.Sc.) in Departement of Electrical and Electronic Engineering at Khulna University of Engineering and Technology (KUET). Some of his research interests are in photonics, supercontinuum generation, and nonlinear optics. At present, he is working as a Lecturer at the Northern University of Business and Technology Khulna, Khulna-9100, Bangladesh in the Department of Electrical and Electronic Engineering. He can be contacted at the email: asmtanvir98@gmail.com.

**Piyal Mistry** is currently in his final year of studies as an undergraduate at the Northern University of Business and Technology in Khulna. He is majoring in Departement of Electrical and Electronic Engineering. The design of antennas, VLSI, wireless communication, and renewable energy are some of his scientific areas of interest. He can be contacted at email: pgpiyalm@gmail.com.

**Sahriar Islam Shipon** is an undergraduate final-year student at Northern University of Business and Technology Khulna in Departement of Electrical and Electronic Engineering. His research interests are antenna design, renewable energy, and wireless communication. He can be contacted at email: sahriarislam896@gmail.com.

**Md. Jahidur Rahaman** is currently in his final year undergraduate student at the Northern University of Business and Technology Khulna in the Departement of Electrical and Electronic Engineering. His scientific areas of interest include the design of antennas, Power system, wireless communication, and renewable energy. He can be contacted at email: jahidur725@gmail.com.

**Md. Shahriar Rakib** is a student in Departement of Electrical and Electronic Engineering at the Northern University of Business and Technology in Khulna, where he is in his final year of study as an undergraduate. His scientific interests include antenna design as well as wireless communication and renewable energy. He can be contacted at email: shahriarrakib778@gmail.com.

**Omar Faruq** Ph.D. Research Fellow, Department of Electrical and Electronic Engineering (EEE), Bangladesh University of Engineering and Technology (BUET). Received his Post-Graduate degree from the School of Communication and Information Engineering, Chongqing University of Posts and Telecommunications (CQUPT), China. and graduate degree in Electrical and Electronic Engineering from Daffodil International University, Bangladesh. His research interests: free-space optical communication, wireless communication, image and signal processing, machine learning and deep learning. He is trying to develop long-distance wireless communication with top speed and noiselessness. He can be contacted at email: smomarfaruq99@gmail.com.