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DESIGN AND ANALYSIS OF MULTIBAND MICROSTIRP PATCH ANTENNA FOR WIRELESS COMMUNICATION SYSTEMS

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Abstract

An appropriate multiband micro strip patch antenna has been built and investigated in this study. As a substrate material, FR-4 (lossy) has been utilized. This material has a dielectric permittivity of 4.3. The antenna can be used for wireless applications in the electromagnetic spectrum's L, S, and C frequency bands. For example, these uses include radars, cell phones, satellite communication, satellite navigation, satellite broadcasting, Bluetooth, Wi-Fi, Zigbee, Wi-Max, and radio LAN. Different wireless applications today need different kinds of antennas, which are made and used accordingly. Unfortunately, the device will now be more sophisticated and larger because of this. The study that is being suggested will look at how to make an antenna that can be used in most wireless applications. CST software is used throughout the process to design and simulate the task. There was software for antenna design, such as CST, HFSS, FEKO, ADS, and MATLAB. It is very convenient to work with CST software and get a fine output. It is also optimized several times to achieve modest results. The goal of this research was to find a return loss, standard VSWR, and bandwidth that were appropriate for the multiband wireless applications. The outcome discovered through this simulation was superior to the work done in the past. Because of this, it can be a good candidate for use in wireless applications.

Keywords: Microstrip patch antenna, CST, VSWR, FR-4, Wireless, HFSS, MATLAB**.**

1. Introduction

Mobile communication systems are becoming increasingly popular, so new antennas are needed for both base and mobile stations. To be reliable, mobile, and work well, antennas used in wireless communication systems must have certain qualities, such as a low profile, a lightweight, a high gain, and a simple design [1]. In the past few years, there has been a huge increase in demand for wireless communication systems that can meet both customer and market needs for higher transfer rates and wider bandwidths [2]. The patch antenna is essential to wireless communication and global positioning systems. Patch antennas are radio antennas with a low profile and can be installed on a flat surface. A patch antenna is a narrowband antenna made out of a flat rectangular sheet set on top of a larger sheet of metal referred to as a "ground plane." It functions very well in wireless communication networks [3].

Antennas that are both tiny in size and have multiple bands are in high demand for use in wireless systems. This is because antennas of this type can accommodate a variety of functions.

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But it is very hard to make a multiband antenna that is small and electrically efficient without sacrificing the antenna's performance [5]. Recent research has led to the creation of many multiband patch antennas (MBPA), which are meant to make it easier for mobile phones to use WiFi and WiMAX. One of the most important technologies in wireless communications is the multiband antenna. Multiple-band polarization antennas (MBPAs) are better than single-band antennas because they can support multiple operations with a single resonator element, are easy to receive, and send signals at multiple frequencies. Additionally, MBPAs can support multi-operation with a single resonator element.

Recent research has focused on using modified structures as radiating elements in constructing compact and multiband antennas. For example, adding slots or cuts can involve changing the structure. Rectangular patch antenna talked about in this paper is made to work across multiple frequency bands. It is flat and gets its power from a microstrip line. The antenna is made not only to have a high level of performance but also to have a high level of visibility for the person who will be using the equipment. It is best suited to being mounted externally on the device. Using CST (Computer Simulation Technology), a simulation of the antenna is created [5].

The actual construction of the patch antenna is depicted in Figure 1. The metal and substrate that make up the MPA are stacked in three layers its construction. At the bottom of the building, copper is one example of a material used to build the ground structure layer. The substrate layer, also called the intermediate layer, can be made of any dielectric material, like air, FR4, Rogers, etc. Copper or another highly conductive material is used as the foundation for the top layer, which is also referred to as the patch and design layers [6].

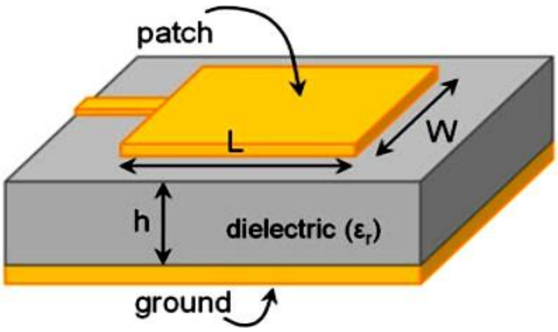

Figure 1: Geometry of microstrip patch antenna

The document has been split into four parts to organize the presented information better. In addition, Chapter I is the introduction, Chapter II is a review of literature, Chapter III is about antenna design and simulation, Chapter IV examines the results, and the conclusion is Chapter V. The following chapter will find all the cited references for this section.

2. Literature Review

Multiband antennas are an essential component of modern-day communication systems. The objective is to expand the capability of various operations while maintaining a compact volume size; this is a significant problem for modern transmitters and receivers. A multiband antenna

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offers several advantages over a conventional antenna of the same class. In many different kinds of wireless applications employed today, patch antennas of many varieties are used [7]. Because of these advantages, many scholars have concentrated their efforts on MSA research.

In this paper [7], design and implementation of a basic stretched elliptical patch antenna for multiband operation is shown and discussed.A slit in the shape of an ellipse has been etched in the middle of the patch to increase the bandwidth. The results showed that the acquired bandwidth had a range of (3.2–11.5) GHz with multi-resonance frequencies, which are beneficial for various wireless applications. Prema and kumar [8], proposed a multiband microstrip patch antenna can work at seven different frequencies from 4 GHz to 14 GHz. The ground plane of the patch antenna might have a rectangular slit cut into it so it could support many frequency bandsAt 4.30 GHz, 5.51 GHz, 6.42 GHz, 8.55 GHz, 9.55 GHz, 11.47 GHz, and 12.58 GHz, it is capable of achieving reflected power levels of -19.58 dB, -15.24 dB, -20.12 dB, -19.27 dB, -27.13 dB, -14.46 dB, and -25.69 dB, respectively. The width of the band is satisfactory.

Palla and NaikKetavath [9], describes how to make a microstrip patch antenna that works on more than one frequency band. A patch has slits cut into it as part of the design, which allows a single structure to function across different frequency bands. The design process involved using defective ground technology to expand the antenna's bandwidth. The antenna's operation supports multiple frequencies, including 6.5156GHz, 8.2511GHz, 9.9622GHz, 10.5244GHz, and 14.9978GHz. The proposed antenna can send and receive radio signals and keep an eye on the weather in the area.

Naik and Chari [10], describes how to make a slotted microstrip antenna with an inverted HE shape on three different substrates. Since the patch has an HE slot, a single antenna can work on four different frequencies regardless of how it is set up. We can obtain the specifications without raising the substrate's thickness. When you compare how well an antenna made on FR4 and one made on Rogers 4350 works, you can see that RT-Duroid works better. When the constant dielectric increases, the antenna size decreases. Nevertheless, an antenna with a lower dielectric constant performs better regarding voltage standing wave ratio (VSWR), return loss, gain, and directivity.

In this paper [11], describes a new six-band frequency reconfigurable antenna that can be used in the 9.1-10.2 GHz (X-band), 2.4 GHz (WiMAX), and 5.3 GHz (WLAN) frequency bands. The suggested antenna takes up only 22 mm×30 mm of space and has a lower resonance frequency of 4.2 GHz. The antenna can work on more than one frequency band by putting a round hole in the middle of a rectangular patch antenna and square slots in the ground plane. Sunthari and Veeramani [12], design a multiband microstrip patch antenna for 5G wireless applications using MIMO techniques. The single built-in antenna has a gain of -17.26dB for 28GHz and -22.08dB for 37GHz. This means that the frequency band resonates from 28 GHz to 37 GHz. MIMO antennas are able to attain gains of -22 dB, -37 dB, -10 dB, and -19 dB while resonating at frequencies of 28 GHz, 37 GHz, 41 GHz, and 74 GHz, respectively. The study talks about the simulation's results regarding S-parameter output, VSWR, and radiation pattern.

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Mehedi Farhad et al. [13], describes an antenna array that can work in both the Ku band (12 GHz to 18 GHz) and the K band (18 GHz to 27 GHz) and can be used for radar and CubeSats. The antenna that has been designed has a total of 64 radiating elements, all of which have dual feeds, and they are grouped in a 2x2 subarray format. This antenna fulfils the requirements for high gain, high bandwidth, and many outputs, which are necessary for its use in radar and cube-sat applications. These requirements can now be satisfied.

In this paper [14], a tri-band microstrip slot antenna designed for wireless applications is presented. An FR-4 epoxy substrate with a permittivity of 4.4 and a tangent loss of 0.02 is used to build the proposed antenna. The antenna is made of a patch with six thin slits and a ground plane. This configuration allows it to generate three bands of frequencies at 10.6GHz, 17.2GHz, and 19.4GHz.

Venkateshkumar et al. [15], introduces a general idea of how two multiband antennas can be used for 5G communication. One of them is built so that the resonating frequencies fall between 450 MHz and 6 GHz, and here is how the other one is made. The resonant frequencies of this suggested antenna are 2.4 GHz, 2.8 GHz, 4.1 GHz, 5.5 GHz, 5.9 GHz, 6.6 GHz, 7.9 GHz, and 9.3 GHz. Another multiband antenna works in the millimetre wave band, which goes from 24 GHz to 86 GHz. Its resonance frequencies are 14.601 GHz, 23.3.01 GHz, and 28.9 GHz. In addition to a low VSWR, high gain, and high directivity, the suggested antennas also offer a low return loss. These patch antennas are ideal for use in 5G applications, but they are also acceptable for use in WiFi, WiMax, Bluetooth, and WLAN applications.

Isa et al. [16], discusses a multi-band notched patch antenna made just for 5G applications. 5G technology is mostly being made because of its many uses, such as the growing number of mobile devices and the faster speeds at which data can be sent. This makes it possible for the antenna to resonate at more frequency bands. For cellular network use, the antenna works at frequencies between 27.3GHz and 49.2GHz. For WiGig use, it works at frequencies between 60.75GHz and 75.38GHz. According to the simulations of the antenna, the proposed antenna had a total wide bandwidth of 4.1GHz at the lower bands and 7.5GHz at the higher bands. Because the design offers a high gain across all of the operational bands, it is an excellent choice for use in 5G-related applications. Dadhich et al. [17], a new compact multiband microstrip patch antenna (MMSPA) was built specifically for use in wireless applications. The antenna consists of a rectangular patch with V and U slots etched, a ring slot on the ground plane that covers the patch from the back, and line separation in the ground plane. Additionally, the patch has a line separation in the ground plan. The antenna has resonant frequencies of 2.4, 4.1, and 7.98 GHz when the separation cut is connected at the back of the feed line (ground plane), as well as 2.5, 7.7, and 10.5 GHz, with S11 values of 21.3, 13.7, and 20.6, 16.5, and 20.2 dB, respectively, for each of these frequencies. The proposed antenna has the potential to be utilized for applications involving the ITU#10 band, IEEE 802.15.1 (band 2.402–2.480 GHz), TD-LTE 2300/2500 (band 2.2–2.5 GHz), and X-Band Satellite Communication Service (XSCS). Mahabub et al. [18], describes a multiband patch antenna that can be used for Wi-Fi, WiMAX, and 5G networks.The suggested antenna can work well at 2.4 GHz for Wi-Fi, 7.8 GHz for WiMAX, and 33.5 GHz for 5G communication. For each of the above systems'

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working frequencies, the proposed antenna arrays have had directed radiation patterns, very small voltage standing wave ratios, high gains, and great directivity. This antenna was designed with multiband functionality; thus, it will be useful for Wi-Fi and WiMAX networks and 5G use cases.

3. Antenna Design and Simulation

During wireless communication, electromagnetic waves are often sent into space with the help of a microstrip patch antenna. The four primary elements that make up a microstrip patch antenna are the ground, the substrate, the patch, and the feed. On the one hand, it has a dielectric constant; on the other hand, it has a ground plane. It can be found in various shapes, such as a square, ellipse, circular, rectangle, and ring [19]. Figure 2 shows what happened when CST software was used to simulate the multiband microstrip patch antenna. The CST program modeling the antenna design can show several metrics, such as return loss, VSWR, and bandwidth. Using these antenna parameters, we will show and talk about a summary of the results of the simulated antenna designs for the designed multiband MPA. This will be used to figure out how well the proposed antenna design works as an antenna.

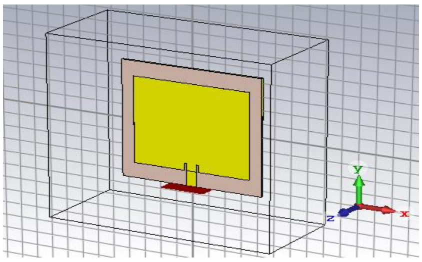

Figure 2: Antenna The design of antenna in CST

To compute the parameters, this study uses the equations shown below.

The width of the microstrip patch antenna

$$Wp = \frac{c_0}{2f_r \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (1)$$

The Dielectric Constant of Effective Potential

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12 * \frac{h}{w}\right)^{-0.5} \quad (2)$$

Lengthened Measurement

$$L_{ext} = \frac{c_o}{2f_r\sqrt{\varepsilon_{reff}}} \quad (3)$$

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Using the following equation, you can get rid of the fringe effect and find out how long the patch is.

$$\Delta L = 0.824h \frac{\left(\frac{w}{h} + .0.3\right)(\varepsilon_{reff} + 0.264)}{(\varepsilon_{reff} - .258)\left(\frac{w}{h} + .8\right)} \qquad (4)$$

3.1. Antenna Parameter

Table 1 contains the various measurements that were taken of the antenna. The notations Wg and Lg, respectively, are used to indicate the width of the ground as well as the length of the ground. In addition, the width (w_p) and length (L_p) of the antenna patch, as well as the height of the substrate (H_s) and thickness (t), are provided. Other parameters stand in for the values of the many components that make up the whole.

Table 1: Optimized Dimensions of the Antenna

W_g	L_g	W_p	W_L	H_g	t
85.89	88	71.12	65.40	1.5	0.035

3.2. Return Loss

The simulated antenna return loss is discussed in that section. Figure 3 shows the simulated antenna return loss. Based on final simulation results of the simulation, the return loss parameters were determine to be accurate. The default value is set to -10 dB, which is an ideal level for mobile or wireless technologies [20]. The antenna is tuned to the required frequency to function properly. This simulation result provides frequency band which 1.356GHz, 2.0879GHz, 2.568GHz, 2.68GHz, 3.496 GHz, 4.148GHz, 4.4472GHz ,4.66GHz and their return loss are -13.474dB, -26.654dB, -27.549dB, -21.12dB, -37.338dB, -11.252dB, -19.137dB and -41.633dB respectively. In the last step, the antenna is designed and tested with the help of a piece of software called CST Suite Studio 2019.

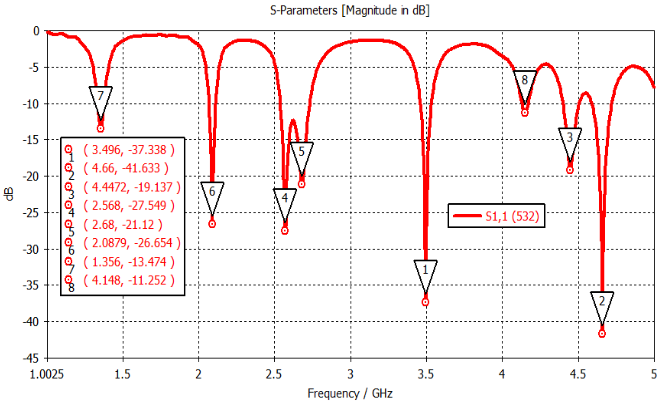

Figure 3: Graph of frequency versus return loss

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3.3. VSWR and Bandwidth

The voltage standing wave ratio, also known as VSWR, is a representation of the power that is reflected by the antenna. The value of the VSWR should be a number that is both positive and actual. The lower the VSWR value, the better the antenna's performance [20]. Figure 4 shows a plot of the designed simulated VSWR for the multiband MPA. A VSWR value of less than two and closer to one is best. The simulation results indicate different VSWR values for different frequency bands. This simulation result provides frequency bands of 1.356GHz, 2.0879GHz, 2.568GHz, 2.68GHz, 3.496 GHz, 4.148GHz, 4.4472GHz, 4.66GHz, and their VSWR are 1.5398, 1.2614, 1.1149, 1.1947, 1.0908, 1.7686, 1.2484, and 1.0223 respectively.

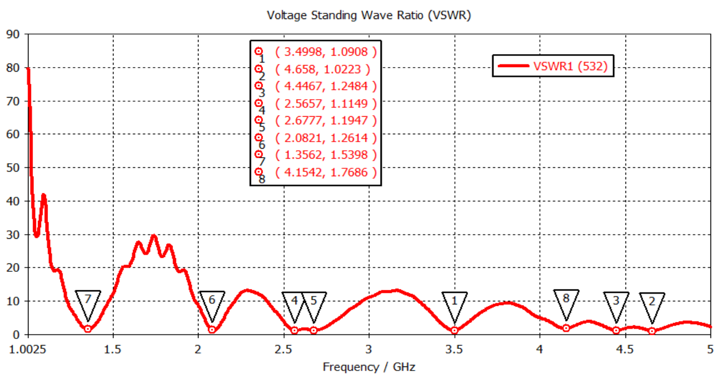

Figure 4: Graph frequency versus VSWR of simulation result

According to Figure 5, the antenna has a frequency range of 1.374 GHz to 1.3336 GHz, 2.118GHz- 2.0674GHz, 2.7307GHz-2.5364GHz, 3.5327GHz-3.459GHz,4.1694GHz-4.1283GHz, 4.506GHz-4.399GHz, 4.7199GHz 4.5887GHz with their bandwidth of 0.0404GHz, 0.0444GHz, 0.1943GHz, 0.0737GHz, 0.0411GHz, 0.1070GHz, and 0.1312GHz respectively. The amount of bandwidth successfully produced in this work is ideal for various applications.

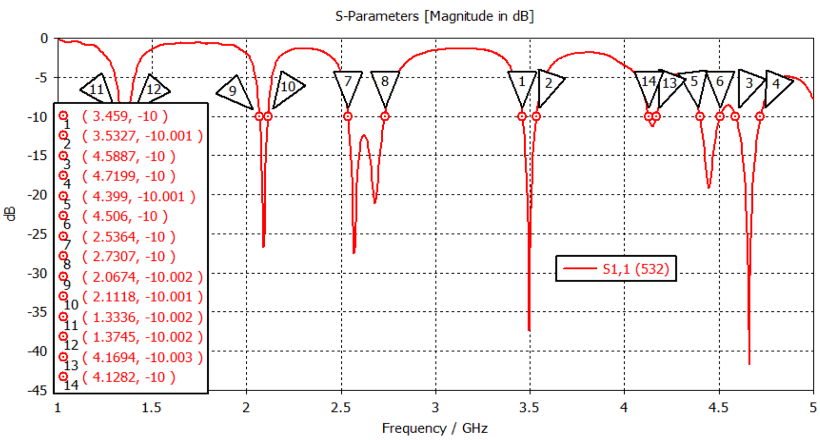

Figure 5: Graph frequency versus Bandwidth of simulation result

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4. Result Analysis

The results of the simulations are broken down and analyzed in this section of the proposed multiband MPA. In this study, we look at some of the conclusions the simulation produced for the parameter values of the antenna. These outcomes include the return loss, VSWR, and transmitted signal bandwidth. A simulation of the proposed multiband MPA design was run to evaluate the effectiveness of the antenna that was conceived with the help of CST software.

Researchers have researched and published international quality journals and conference papers on multiband microstrip patch antennas. In the paper, a new multiband MPA is designed and analyzed, and return loss, VSWR, and bandwidth are discussed. The VSWR value is brought closer to 1 by increasing the return loss. Also, different bandwidths have been calculated for different resonant frequencies. As seen in Table 2, the proposed antenna has attained the desired return loss and a lower VSWR and bandwidth.

Table 2: Summarizes the Simulation Results

Resonance Frequency (GHz)	Return Loss (dB)	Bandwidth (GHz)	VSWR
3.4960	-37.338	0.0737	1.0908
4.660	-41.633	0.1312	1.0223
4.4472	-19.137	0.1070	1.2484
2.568	-27.549	0.1943	1.1149
2.68	-21.12		1.1947
2.0879	-26.654	0.0444	1.2614
1.356	-13.474	0.0404	1.5398
4.148	-11.252	0.0411	1.7686

5. Conclusion

During the inquiry, a brand-new multiband microstrip patch antenna was constructed for usage in wireless communication systems. The suggested antenna is compatible with a broad spectrum of frequencies, ranging from 1 GHz up to 5 GHz. The simulation results showed that the return loss for each resonant frequency is less than-10 dB, and the suggested design satisfies the requirements for return loss, VSWR, and bandwidth. The outcomes of the simulations present a more favourable scenario for wireless communication than before. Based on the results of the simulations, it looks like the antenna could be a great choice for use in wireless communication systems. This conclusion was reached based on the findings of the simulations. Shortly, the antenna will be built so that measurements can be made and the results can be compared to the models.

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