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AN ORGANISED AND FOCUSED REVIEW OF A MICROSTRIP PATCH ANTENNA FOR ITS DEPLOYMENT IN BIOMEDICAL APPLICATIONS

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Abstract - Reviewing microstrip antennas for diverse applications is the goal of this paper. The designing of microstrip patch antennae is a new study subject established for utilise in 5th generation communications applications. An antenna is a group of interconnected devices that work together to transmit and receive radio waves as a single antenna. Antennas come in many sizes and shapes. An antenna design that is low profile, lightweight, and results-oriented is the microstrip patch. In the future, microstrip patch antenna may be used for various 6G communication systems applications. Furthermore, 6G communication applications can be developed for additional devices, such as autonomous cars, machine learning, artificial neural network algorithms, radar, internet of things (IoT), biomedical, and vehicle-to-vehicle (V2V) communication. In the past, 4G wireless applications employed the multiple input, numerous output (MIMO) pattern as a standard geometry. This study covers several types of antennas, their geometric structures, different methods for analyzing their features, and their dimensions. The component of the substrate substances, loss tangent, the thickness, return loss, bandwidth, voltage-standing-wave ratio (VSWR), gain, and orientation from the earlier publications will also be covered.

Keywords – microstrip, patch, antenna, IoT, biomedical, V2V, MIMO, VSWR

Introduction –

Vital parts of the telecommunications sector are antennas. In simpler terms, it functions as a transducer, converting electrical energy into radio signals and radio signals into electrical energy. People who reside in geographically far places can interact with each other by sending and receiving signals thanks to wireless communication technology. Microstrip patch antennas (MPAs) are used in many different applications these days because of their low profile, low cost, and low volume. By optimizing the design of the antenna with a microstrip for several aspects, its performance can be enhanced. There are several different operating frequencies at which a printed antenna can be used for wireless communication. The world of wireless communication is rapidly changing and fast-paced these days. Antennas with dual or multiband capabilities have been crucial in the development and proliferation of several wireless service application categories.

There have been a lot of the development team in order efforts in the field of microstrip antennas that are concentrated on application criteria. Common types of arrays include predictable antennas and microstrip patch antennas. Compared to microstrip patch antennas, predictable antennas offer greater advantages and superior analysis. We need an antenna that's extremely small and well-organized in order to perform all of the wireless applications. Microstrip patch antennas and predictable antennas are common forms of arrays. There is general agreement that predictable antennas perform better than microstrip patch antennas. Predictable antennas have more sophisticated analytical characteristics and improved capabilities. It's important to remember that the decision between these two kinds is based on the demands of the particular application [1].

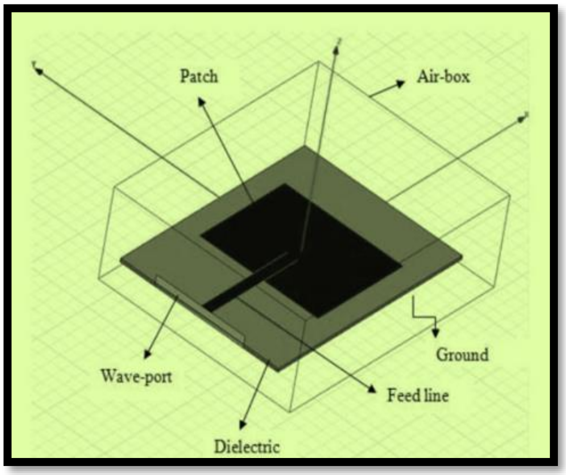

Figure 1. Microstrip patch antenna

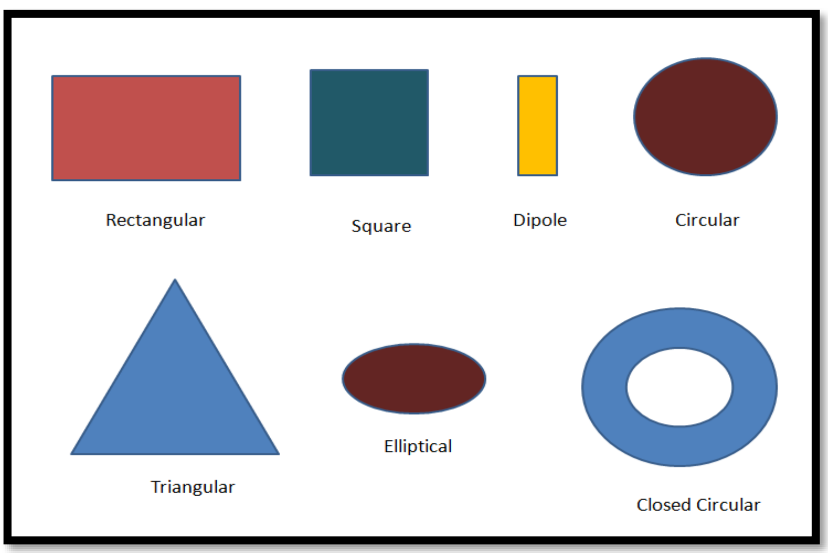

Figure 2. Different shapes of antenna

Extremely tiny and well-organized antennas are becoming more and more in demand in the field of wireless applications [2]. In order to meet this need, microstrip patch antennas—which are renowned for their lightweight and low profile—have grown in favour. They are appropriate for a wide range of wireless communication applications due to their small form factor, particularly when it comes to 5th and 6th century communication. Microstrip patch antennas are excellent at addressing the difficulties brought on by the growing demands for efficiency and miniaturization in wireless technologies, even though predictable antennas provide better analysis. These technologies may combine in the future to produce even more compact, effective, and adaptable solutions for a range of wireless applications. To further push the envelope of performance in the rapidly changing field of wireless communication, engineers and researchers are constantly investigating the synergies between microstrip patch antennas and predictable antennas.

Literature Review –

We will talk about the various uses for microstrip patch antennas in this section. This work aims to review the applications of microstrip patch antennas used by the authors. Currently, this antenna had been utilised in a number of situations. With the advancement of technology, these antennas are becoming more and more common. Its use in different sectors, including wireless communication, therapeutic science, electronics, wireless power transmission, self-driving automobiles, medical physics, and machines learning, is rising everyday. Several nations have employed this antenna for 6G applications.

The creation and modelling of hexagonal patches of microstrip antenna operating at 3.5 GHz are presented by Gburi *et al.* [3]. The stripes feed line is one of the components of the proposed 18 array antenna. Because of its directed electromagnetic energy, the base station's antenna can deliver network access that is both superior and high-capacity. Long-distance point-to-point connections are the intended application for this antenna. At 3.5 GHz, the finished antenna had an output of 6.938 dB & an output loss of -10 dB. This antenna has a the direction of 7.6 dB, a bandwidth of 1.06 GHz, an incidence coefficient of -20.95 dB, and a bandwidth of 7.5 dB, according to the results published in the study article [4]. The frequency at which it runs is 27.97 GHz. Moreover, 99.98% of its efficacy is achieved. This article examines the configuration and usage of patch antennas in 5G wireless networks.

Tsao *et al.* [5], created a 2-connection dual-band & dual-polarization many the input, simultaneous output (MIMO) antennae for 5G wireless applications at 28 and 38 GHz. The MIMO antenna had features such as frequency diversity and orthogonal polarisation. The antenna exhibited a gain of 5.7 dBi in the 27.5–30.9 GHz frequency range and 6.28 dBi in the 37.3–44.6 GHz frequency range. It can be utilized in femtocell and microcell 5G antenna arrays.

A simple, slanted microstrip squares patch antenna that can function at millimetre wave frequency was described by Subitha *et al.* [6]. This device is intended for use in 5G and higher-speed wireless communication systems. The results produced by the optimised antenna are noticeably superior than those of the unoptimized antenna. Its maximum gain is 6.46 dB, and its return loss is -38.3 dB. Owing to the fact that

5G and 6G wireless communication equipment are often smaller than their predecessors, the antenna's three sides measure 5.12 x 5.12 x 0.9 millimetres.

A novel lightweight monopole-like end-fire antennae with customisable radiation patterns is presented by Wang *et al.* [7] with the intention of being used in 5G applications. The antenna is small and has broadband capabilities. This work presents and initiates the analysis of a half-sized end-fire structure that exhibits a wideband response, resembling a monopole. The mirror principle is the foundation of this arrangement. The suggested antenna is compact, features an easy-to-understand design, is capable of flexible beam switching, and has a broad frequency range. It is a formidable competitor for new radio applications running below 6 GHz in 5G.

Thaher *et al.* [8], The five band at the resonance frequency that can be achieved by the suggested antenna, based on its size on FR-4, are 9.658 GHz, 11.68 GHz, 16.054 GHz, 21.28 GHz, and 29.704 GHz, respectively. In wireless applications, this antenna is employed within the X-band, Ku-band, Kaband, K-band, and 5G spectrums. Furthermore, it can identify fast-moving cars using radar, satellite communications, wireless networks for laptops health care equipment, and local multi-point TV. The broad MIMO antenna layout for 5G smartphone terminals is described by Alhaqbani et al. [9]. The proposed MIMO antenna array consists of eight-port dual-polarized L-shaped lines that strongly excite radiating slots at each of the four corners of a 75 mm^2 x 150 mm^2 small mobile unit. The 8x8 smartphone's diversity MIMO antenna is made to facilitate 5G commercial sub-6 GHz communications. It has good decoupling among the antenna ports and is also able to cover the 3.5 GHz range.

The construction of a MIMO antenna array appropriate for 5G millimeter wave (mm-wave) systems of communication is covered by Khan *et al.* [10]. The setup that is suggested makes use of two antennas. Four equally spaced elements make up each antenna array, and both of them are put together 90 degrees apart. The 5G millimeter-wave band at 37 GHz is covered by the planned MIMO antenna array. DG and ECC fall below the typical cutoff. The working frequency band contains more than 85% of the radiation efficiency of the MIMO antenna array. The suggested architecture might be applied to millimeter-wave 5G systems.

A microstrip patch antenna was designed and described by Rana *et al.* [11] to use it in the implementation of potential wireless communication technologies. This study set out to develop a means of decreasing the voltage-standing-wave ratio (VSWR) and raising gain at the same time as decreasing the amount of return loss. An analysis of a 5G high-band slanted micros Strip antenna was conducted by Rana *et al.* [12]. It is feasible to achieve high bit rates, lower traffic, and more user retention by using the antenna. By placing a square slot on top of a round slot in a rectangular microstrip antenna, the return signal loss, gain, and bandwidth can all be increased. The supplied antennas increase bandwidth, gain, and return loss.

A hash-shaped slot microstrip antenna that can be used for wireless communication is presented by Rana *et al.* [13]. The antenna boosts bit rate, lowers freight, and improves customer engagement. The return loss, gain, and bandwidth of a conventional rectangular microstrip antenna are increased onto -32.159 dB, 8.07 dB, and 3.848 GHz, respectively, by adding a hashshape slot to the patch. Ultra-wide multi-slotted microstrip patch antennas were suggested by Biddut et al. [14] as a viable remedy for usage in future wireless communication technologies. The V-band would be used by this antenna. The patch has certain random slots added to it in order to boost bandwidth. This approach offers a viable substitute for creating next-generation wireless communication technology. The antenna's specs include a gain of 7.486 dBi, a return loss of 18.117 dB, and an effective bandwidth of 21.064 GHz.

For UWB applications, Singh *et al.* [15] microstrip patch antenna is intended to operate between 3.1 and 10.6 GHz. A microstrip antenna featuring a hexagonal patch is designed in this study. The suggested microstrip patch antenna has a 90.88% radiation efficiency and is hexagon-shaped. The antenna has a 5.32 decibel peak gain. Applications that make use of UWB can operate with it. The construction of a tiny double band microstrip antenna based on a split ring resonator and radiating element is covered by Rosaline *et al.* [16]. The dual frequency operation of this antenna is its intended use. The antenna is 20 x 20 x 0.8 mm3. It has an impedance spectrum ranging from 250 MHz and 860 MHz at -10 dB and covers the 2.5/5.2/5.8 GHz IEEE 802.11 b/g/a WiFi local area network (WLAN) frequencies. The suggested antenna is constructed, and the simulations and actual data agree.

With a highest gain of more than 24 dB, Nissanov *et al.* [17] propose and study innovative microstrip antennas with high gains for 6G cellular communication at 112.5 GHz. With an operating frequency of 24.89 GHz, an output of 25.7 dB, a peak orientation of 27.27 dB, plus a total performance of 77.95%, the first suggested antenna is quite impressive. With an operating frequency of 18.3 GHz, a gain of 25.74 dB, a peak orientation of 27.2 dB, and a total effectiveness of 77.95%, the second suggested antenna is quite impressive. These findings seem to indicate that the designs put forth are suitable for usage as 6G mm-wave/THz towers.

Both a planned 77 GHz antenna and a tooth-shaped dipole for driverless vehicles are detailed by Foysal et al. [18]. Because of the patch antenna design, gain is boosted and mutual coupling is reduced. The tooth-shaped antenna patches has a gain of 9.4 dB and a current distribution of 1.3610.303 A/m. The standard patch values were 4.99 instances 10-2 amps per metre (A/m) and 7.2 decibels (dB). A tooth-shaped antenna has a return of -37.9441 dB. The developed antenna is something that will be used by next 6G autonomous vehicles.

An antenna made of graphene microstrip patch is described by Mollah *et al.* [19]. It supports wireless communication at 2.45 GHz. There are displays for the input impedance, VSWR, return loss, and H-plane radiation pattern. The simulation indicates that the efficiency is 93.14%, the mean directivity is 7.302 decibels per inch, the increase in noise is 6.801dB, & the return on loss is –23.673dB. This article discusses the creation or an antenna using microstrip patches with graphene serving as the substrate. These days, wireless communication uses graphene. Compared to conventional patches, microstrip patch antennas anticipate and perform better. Ultimately, a graphene-based patchy antenna design was created in this work.

Hussain *et al.* [20], this group of research led to the creation of a broadband microstrip patch antenna with a V-band application in mind. The suggested antenna offers a high gain of > 9.5dB within the bandpass area and exhibits a bandwidth of impedance that spans 63 GHz to 74 GHz. The work that was suggested has a wide operating band, a small size, a simple geometrical configuration, good gain, and is a viable contender for 5G communications in the V-band. Furthermore, the functioning band is really broad. To simulate an e-shaped slot Microstrip patch antenna for 5G, GPS, and WiMAX/WLAN applications, Talukder and Islam [21] used HFSS. Using a DGS microstrip rectangular antenna patch with a narrow slot, multiband performance is being investigated. The proposed antenna echoes at 4.6 GHz, 8 GHz, and 10 Mhz with 90 MHz-500 MHz width and 8.03 dB gain.

In Kantipudi *et al.* [22], a unique way to building an ISM band microstrip antenna is analysed and simulated. The dimensions and shape of the antenna determine its resonance frequency, which is determined and synthesized through the use of an ANN, or artificial neural network, model. To design the antenna, the dimensions of the antenna for the frequency of operation are determined. Geometries of RBF, MLP, and conventional formulas match well. RF and microwave components can be included in the ANN design model. The design of this ANN antenna can be expanded to communications antennas using metamaterials.

According to Al-Hetar & Aqlan [23], millimetre wave (MMW) devices are finding commercial use as bandwidth requirements rise. Gain and bandwidth can be engineered into a patch shape. A patch antenna form is suggested in the paper. The microstrip antenna that is under consideration has an 8.2 dB gain and a 5 GHz bandwidth. Significant changes in radiation pattern and spectrum for passively MMW imaging in a map array are revealed by the simulation. Rubber substrates with varying carbon filler concentrations—natural rubber, 20% cement filler, 25% charcoal filler, or 50% carbon filler—are used in the construction of an antenna made from microstrip patches by Ruslan et al. [24]. The developed antennas' performance is contrasted with that of RO3003 and poly dimethyl siloxane (PDMS). The three parameters that are employed to assess an antenna's performance are gain, bandwidth, and return loss. There is additional discussion of how antenna bending affects performance. A slot patch microstrip antenna designed for 5G applications is presented by Li *et al.* [25]. It is made using ink-printing. The antenna operates in three different frequency bands: 5.73 GHz, 6.16 GHz, and 8.34 GHz, with an average gain of 5 dBi. Furthermore, the antenna uses all of those frequencies concurrently. It comes with a slotted patch and is made up of three layers. Fadhil & Thaher [26], a new microstrip patching antenna for GPS is devised. The GPS antenna components in the suggested model are rectangular patch featuring two truncated corners and have a gain of 4.974 dBi. To get the ideal return loss resonant frequency, a large number of slots are carved into the ground plane and the patch. A network analyzer that uses vector networks was used in the model's development and validation (VNA). The creators of a brand-new GPS patch microstrip antenna are described by the writers in Zerith et Nesasudha [27]. 5G microstrip antennas working at 28 GHz are discussed by Teresa and Umamaheswari [28]. There are three suggested models of slotted microstrip antennas. Antenna design for 5G uses 28 GHz. Examine and contrast the antenna's bandwidth, efficiency, gain, directivity, and return loss. This article presents [29], a novel method for designing a high-frequency microstrip antenna that can be used in 5G systems. The suggested antenna can work in the frequency range assigned to local multipoint distribution services (LMDS) and has a core frequency of 28 GHz. The antenna that is the subject of this article has a wide operational range of 5.57 GHz, an energy amplification of 3.6 dBi, a low reflection factor of -22.51 dB, and great energy efficiency. Each of these features adds to the overall performance of the antenna.

For usage in millimeter-wave uses in the band ranges of 26.5 GHz to 29.5 GHz and 24.25 GHz to 27.5 GHz, Viswanadh *et al.* [30] presents a microstrip antenna array. In the end, a 4-element radio array with dual-band S_{11} characteristics of -35.07 dB for 29.35 GHz as well as 10.30 dB gain, and -32.88 dB that 24.67 GHz with 8.67 dB gain, was produced. The resultant loss, gain, and VSWR of the finished structure are contrasted with those of the preliminary and intermediate designs. According to Gundewar *et al.* [31], the suggested method designs a 900 MHz patch microstrip antenna and tests the moisture content of several materials. Accurate measurements of the moisture content of materials or grains are required by numerous businesses. Noncontact moisture measurement of samples is accomplished using horn and microstrip antennas. progressively adding water to the sample while monitoring return loss. Returns are increased by moisture.

A neural network-based model for creating an ultra-wideband patch antenna with a microstrip was developed by Kaur et al. [32]. The suggested design bandwidth grows as the ground area decreases. The outcomes of the suggested method are in good agreement with electromagnetic (EM) modeling programmes. A tiny microstrip antenna patch with WBAN 2.4 GHz uses is presented by Ali et al. [33]. A ground plane and a radiating patch are included in the design. The radiating region of the antennas is 62×43×1.67 mm. The far-field radiation of the suggested on-body & off-body antenna is small, stable, and has very little specific absorption (SAR). Higher than current literature are the off- & on-body efficiencies of 53% and 46%, respectively. Measured and simulated findings agreed rather well. The suggested design can be applied to ISM-band WBANs because of its favorable outcomes.

Ansoft HFSSV13 patch microstrip antenna is designed by Asokan *et al.* [34]. Antennas for microstrip patches with two sides are created. The 2.4 GHz antenna is composed of 4.4 dielectric constants FR4 material. For WLAN and ISM applications, the proposed antenna has an expected loss that is less than 10 dB. We have simulated and examined radiation pattern, return loss, mutual coupling, VSWR, and gain. A straightforward patch antenna with a microstrip is intended for WLAN applications, according to Priya *et al.* [35]. It describes a ground plane printed on FR-4, single-band, high-gain microstrip antenna. The suggested patch antenna has a -39.008 dB return loss and covers 2.4 GHz. ADS 2014 was employed to mimic. This study investigates the design and execution for 41 or 81 microstrip patches (arrays) using an FR4 dielectric compound with a permeability of 4.28, tangential loss of 0.002, or height of 1.6 mm. According to Casu *et al.* [36], the created antenna performs well for WLAN. The antennas' height is expressed in millimeters. A novel microstrip antenna construction for wi-fi devices is studied by Sharma et al. [37]. The goal of this project is to create an affordable indoor/outdoor patch antenna. Evaluations are done on gain, directivity, VSWR, radiation pattern, and return loss. The suggested antenna is simulated and optimized by HFSS. Simulations validate the efficacy of the designs. After the suggested antenna has been created and refined using simulation software, it is put to the test.

This study [38] discusses a specific to application rectangular patch microstrip antenna intended for usage on the 915 MHz frequency. Among the various uses for these applications are ZigBee and Bluetooth. Printed antennas have played a major role in the development of antennas that function at several frequencies in recent years. The recommended antenna operates between 902 and 928 MHz and has good Omni directional emission patterns.

Reference	Loss tangent	Substrate	Thickness
[8]	0.002	FR-4 substrate	0.035 mm
[10]	0.0009	Rogers RT5880	0.254 mm
[11]	----	Rogers RT / Duroid 5880	0.345 mm
[12]	0.025	FR-4 substrate	0.8 mm
[13]	0.025	FR-4 substrate	0.8 mm
[14]	0.0009	Rogers RT5880	0.5 mm
[15]	0.02	FR-4 substrate	1.59 mm
[18]	0.02	FR-4 substrate	0.8mm
[20]	0.0009	Rogger / RT Duroid 5880	0.508 mm
[36]	0.002	FR-4 substrate	1.6 mm
[38]	0,02	FR-4 substrate	1.6 mm
[39]	-	RT Duroid 5880	0.5 mm
[40]	0.0009	RT Duroid 5880	0.127 mm
[41]	-	RT / Duroid 5880	0.254 mm
[42]	0.0009	RT Duroid 4350	0.127 mm
[43]	-	Rogers RT 5880	-
[44]	0.0009	Rogers RT 5880	0.17 mm-
[45]	0.2	Rogers RT 5880	-
[46]	0.0009	RT Duroid 5880	-
[47]	0.0010	FR-4 substrate	-
[48]	-	Rogers RT 5880	1.57 mm
[59]	-	Rogers RT 5880	0.2 mm
[61]		Rogers RT / Duroid 5880	0.3451 mm
[62]	0.0009	Rogers RT 5880	0.5 mm

Table 1: The thickness and loss tangent of the substrate materials used in various antennas are assigned varying values.

Currently, antenna design is a hot topic around the globe. The globe was amazed by the researchers' various antenna designs, including a microstrip patch antenna concept. Among other antennas, the usage of microstrip patch antennas is rapidly growing. A few of the distinctions between the studies that different researchers have previously worked on are shown in Table 2. Table 2 displays the return loss, gain, VSWR, and bandwidth figures from several earlier publications.

Reference	Gain (dB)	VSWR	S_{11} (dB)	Bandwidth (HHz)
[11]	5.23	1.22	-20.03	2.11
[12]	6.51	1.0072	-48.87	3.088
[13]	8.07	1.14	-32.15	3.484
[14]	7.486	-	-18.11	21.064
[19]	6.801	2	-26.67	13.83
[26]	4.974	1.0328	-35.84	1.575
[27]	1.9	-	-26.82	100 MHz
[35]	4.685	-	-39.00	2.4
[43]	6.58	1.82	-19.61	10
[44]	9.21	-		27.3
[47]	2.73	< 2	-35.12	915 MHz
[48]	10	-	-3.4	3.5
[49]	6.63	1.53	-13.48	0.847
[50]	4.46	2.13	-18.27	0.2
[51]	5.5	1.6	-12.54	3.5
[52]	6.72	1.27	-17.40	28
[53]	9.82	-	-42	1.29
[54]	2.28	-	-16	1.44
[55]	7.69	-	-43	0.769
[56]	5.8	1.02	-40.28	200 MHz
[57]	3.53	1.16	-22.10	27.7
[58]	7.17	1.04	-33.02	-
[59]	6	7	-	-
[60]	5.2	0.12	-42.97	-
[61]	8.198	1.024	-38.34	3.464
[62]	8.42	1.013	-43.77	3.033

Table 2: A comparative analysis of other published antenna

Conclusion

This overview analyses and discusses the many types of micros strip patch antennas and the uses those antennas have in modern technology. for which the use and use of antennas is growing daily. Patch antennas with micros are perfect for mobile devices and other applications since they are inexpensive, lightweight, and easy to build. Its low power, little bandwidth, and poor gain. Techniques for enhancing microstrip patch antennas are covered in this work. The gain, size, as well as return loss of patch antennas are all improved by defective ground structure. In future work, one or more of these techniques may be applied to the design and performance enhancement of a range of microstrip antennas intended for use in communication systems that are wireless.

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