IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁙ Impact Factor 8.102 ⁙ Peer-reviewed / Refereed journal ⁙ Vol. 12, Issue 4, April 2023

DOI: 10.17148/IJARCCE.2023.124173

REVIEW ON PRINTED PATCH ANTENNA DESIGN FOR 5G APPLICATIONS

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Abstract: In this review, a literature survey of printed Patch Antenna designs at various resonant frequencies is presented. Performance parameters such as gain, return loss and radiation pattern of the patch antenna are analysed. We try to attain higher gain and bandwidth than existing structures by suitably modifying the antenna structure.

Keywords: Microstrip Patch antenna (MSA), Return Loss, Radiation Pattern, Gain, 5G, 28GHz.

I. INTRODUCTION

Utilising the substantial amount of spectrum present in the millimetre wave, the fifth-generation network is anticipated to significantly increase the communication capacity. It can also deliver and support extremely high data rates, comparable to 100 times the capacity of fourth generation. Satisfying extremely high data rate and capacity requires complex network as well as antenna design for 5G communication systems. One of the most popular antenna structures is the Microstrip Patch Antenna (MSA), which has wide range of uses in wireless communication and is simple to manufacture. These days, they are directly printed onto the circuit boards, making them incredibly handy. These are some advantages of MSA: - A. Light Weight B. Low Profile C. Capable of dual and multiple frequency operation.

It also has some drawbacks like low gain, low bandwidth. To overcome this type of disadvantage, MSA is designed with a single layer of a substrate and various parameters are optimised. The motive of the work is to meet increasing demands of wireless communication in various applications. In this research, a single microstrip patch antenna is proposed for 5G communication. The proposed antenna is designed to resonate at 28 GHz and has a low-profile structure with dimensions of 6.395 mm × 7.235 mm × 0.8 mm.

II. LITERATURE REVIEW

M. K. Alkhafaji et al.,[1] designed a new antenna for four-pole microstrip filtering. The filtering antenna is made up of: a monopole patch antenna with a bandpass filter that incorporates four resonators. The filtering antenna features a large bandwidth required for high-speed data transmission, roughly 1.22 GHz. The filtering antenna was designed using RT/Duroid 5880, RO3003, and FR-4 as three different types of dielectric substrate materials. Software for Computer Simulation Technology (CST) is used to simulate the filtering antenna design, which is based on three different dielectric substrate materials.

M. T. Islam et al.,[2] presented a new high gain and highly efficient Microstrip Patch Antenna for Ku band application. 14 The proposed antenna uses a copper (annealed) patch imposed over the FR-4 substrate. The constructed design offers Return loss = −26.5578 dBi, Gain = 6.31 dBi at resonant frequency 12.54 GHz, Voltage Standing Wave Ratio = 1.0986392.

S. I. Latif et al.,[3] performed a thorough simulation and experimental research to comprehend the antenna behaviour and optimise for broadband operation. It is demonstrated that changing the slot shape from straight to L and T shapes aids in the generation of additional resonances, which when linked to the initial resonances of the slot, further expand impedance bandwidths. The L and T slots' curved forms lower their height and give greater room for electronics on the ground plane.

R. Mir et al.,[4] designed single-layer single-feed Circularly Polarized (CP) circular patch antenna with loading of shorting pins is shown. The proposed antenna has a compact size with dimensions of 0.49λ0 × 0.49λ0 ×0.0147λ0 at 2.76

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GHz. The return loss and radiation properties are measured and compared with simulation results. The proposed antenna 11 has a 3 dB axial ratio bandwidth of 1.8% (2.73–2.78 GHz). The measured gain is 6.1dBic at 2.76 GHz.

C. Peixeiro et al.,[5] presents a historical perspective of the development of microstrip patch antennas. A survey on 1 microstrip antenna papers is carried out initially to evaluate the evolution of the research activity on the topic along the last 40 years. The early years of the microstrip technology and specifically of microstrip antennas are analysed in detail. The fast evolution of the research and development activities that happened in the last 30 years is described in the context of the associated technologies and areas of application. Finally, the present situation of the microstrip antenna field and trends of possible future evolution are examined.

E. Sandi et al.,[6] have shown a design of ultra-wideband microstrip array antenna using a stepped line cut and U-slot combination for 5G millimetre-wave applications is proposed. The feeding technique used in the proposed design is a proximity coupling technique to improve bandwidth performance. The proposed antenna bandwidth performance is compared with the conventional antenna array design to determine the bandwidth increase. Numerical and simulation results show a significant increase in bandwidth performance compared to conventional design. The proposed antenna design can operate at frequency band 28 GHz with a bandwidth 4.47 GHz and gain 8.71dB. These results prove that the proposed antenna design can be used for 5G technology applications in the millimetre-wave band.

M. Singh et al.,[7] designed a highly efficient multiband optimized slotted pentagonal terahertz patch antenna and its 2 × 2 multi-input multi-output (MIMO) planar array is proposed for multiple terahertz (THz) application. the proposed patch antenna is developed from the simple rectangular patch antenna (SRPA) by optimizing the shape of radiating patch and ground plane. antenna is designed on the transparent polyimide substrate material having a dielectric constant of 8 r = 3.5 and thickness 21.5 µm. It covers wide bandwidth, which resonates at 3.00 THz, 4.85 THz, 7.02 THz, 8.87 THz, 9.43 THz, and 10.785 THz frequencies having reflection coefficient less than −10 db. A.

Ullah et al.,[8] created a compact dual-band MIMO antenna array for mobile 5G applications. The MIMO antenna comprises of eight folded monopole antennas operating in the 3.45 GHz band (3300-3600MHz). Aside from that, the edges of the system circuit board are lined with antenna components that are 6.8 x 6.6 x 4 mm in size, or roughly 0.078 x 0.075 x 0.046 at 3.45 GHz. By using decoupling structures, the isolation between inner antenna elements in the 3.45 GHz range (3300-3600MHz) has enhanced from 10dB to 15.1dB. The inner antenna units can provide an additional operational band covering the frequencies of 2400–2700 MHz as a result of the coupling effect between the antenna components and the recommended decoupling structures. This is encouraging because it may help to solve the terminal space scarcity problem.

H. Werfelli et al.,[9] used Advance Design System Momentum (ADS) to create a rectangular microstrip antenna. Antenna 4.1GHz is its resonance frequency. For frequencies between 3.1 and 5.1 GHz, the reflection coefficient is less than -10 dB. The suggested rectangular patch antenna is made of FR4 glass epoxy, which has a loss tangent of 0.02 and a dielectric constant of 4.4. Utilising transmission lines of both length and width, this rectangular patch is excited. From ADS Momentum, various parameters are obtained for the designed rectangular antenna, including gain, S parameters, directivity, and efficiency.

A. S. Za'aba et al.,[10] described the creation of a flexible antenna built of a patch of 5 copper and polydimethylsiloxane (PDMS). The patch and ground plane of the antenna are made of Cu tape, and the substrate is PDMS composite and SMA connector as the coaxial feed, with patch radius of 21.5mm, substrate area of 60x60x3, and ground plane area of 60x60mm. In this investigation, a Mesoglass microsphere composite was also made to replace the 15-m PDMS substrate. The performance of the antenna might be improved by the Mesoglass addition, which lowers the relative permittivity and loss tangent of PDMS to 1.9 and 0.014, respectively. The antenna was enclosed with a second thin layer of PDMS/mesoglass substrate of 0.6mm thickness to guarantee a constant spacing in order to resolve the adhesiveness issue between Cu patch and PDMS substrate.

Haraz et al.,[11] designed an elliptically shaped aperture is etched in the ground plane to enhance the antenna bandwidth. A shunt stub is used to get more enhancement of the impedance bandwidth of the antenna. To reduce the interference between the 5G system and other systems, π-shaped slot is etched off in the feed line to create a notched band of 30-34 1 GHz. The simulated results show that the designed antenna has a dual band function at 28/38 GHz that covers future 5G applications. The proposed antenna provides almost omni-directional patterns, relatively flat gain, and high radiation efficiency through the frequency band excluding the rejected band.

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R. Tiwari et al.,[12] concentrated on research based on several kinds of microstrip antenna. VSWR, bandwidth, resonant frequency, gain, and return loss are important metrics to evaluate an antenna's performance. A good return loss value is less than - 10dB. The VSWR's useful range is 1-2. CST Microwave Studio is a cutting-edge programme for designing and simulating various antenna, filter, and other components.

P. Gupta et al.,[13] reports a high gain linear 1*4 antenna array using circular slotted patch for 5G communication applications. The proposed antenna has been designed for 28 GHz frequency and supports TM as a fundamental mode at resonance. To feed the antenna array, microstrip feed technique has been utilized here. The antenna has been designed on Rogers RT/Duroid 5880 substrate with dielectric constant of 2.2 and thickness of 0.254 mm. Further, a detailed electromagnetic analysis of antenna has been done in the paper to provide better understanding of the proposed concept using commercially available CST Microwave studio.

A. J. A. Al-Gburi et al.,[14] designed and simulated hexagonal microstrip patch antennas for wireless backhaul at 3.5 21 GHz. Four types of antennas were simulated using Computer Simulation Technology (CST) software. The developed process started from designing the single element up to 1 × 8 arrays elements. The proposed 1 × 8 arrays antenna feds by microstrip corporate feed line and provided directional radiation, which is useful for the base station to provide high quality and high-capacity network connectivity. Moreover, this type of antenna is focused on long-distance point to point connections. The finalised antenna offered a high gain of 6.938 dB at 3.5 GHz and a return loss of -10 dBi. Overall antenna performance confirms that the proposed hexagonal patch antenna is proper for 5G communication.

S. E. Didi et al.,[15] presented a study and design of a rectangular-shaped microstrip patch antenna with a rectangular shaped slot at the operating frequency is 28GHz, for fifth generation (5G) wireless applications, using the microstrip line technique for feeding. The objective of this slot is to contribute to the improvement of antenna performance. This antenna is built on a Roger RT duroid 5880 type substrates having a relative permittivity equal to 2.2, a height of h = 0.5 mm, and a loss tangent of 0.0009. The compact size of this antenna is 4.2 mm × 3.3 mm × 0.5 mm. The simulations of this antenna were performed using high-frequency structure simulator (HFSS) and computer simulation technology (CST) software whose main purpose is to confirm the results obtained for this proposed antenna.

H. M. Rahman et al.,[16] presented a novel design for a multiple band millimetre wave antenna with a wide active region in the extremely high frequency (EHF) range. The antenna's performance was tested at three evenly separated frequencies: 60 GHz within the V-band region, 80 GHz within the E-band region, and 100 GHz. Simulation exhibits satisfactory results in terms of gain and efficiency, although the efficiency falling tendency for higher frequency persists.

M. M. Khan et al., [17] designed a 60 GHz printed Q-slot patch antenna for body-centric communication. The Q-slot has a slot gap of 0.2 mm and is etched on a 6.5 mm × 11 mm rectangular patch. The slotted patch is mounted on an FR4 (Flame Retardant) substrate that is 1.6 mm thick and has a relative permittivity of 4.3. With a partial ground plane of length of 2.2 mm, the antenna's overall dimension is 12.9 mm ×14 mm ×1.6 mm. Computer Simulation Technology (CST) microwave studio was used to design and simulate the antenna.

O. O. Wikiman et al.,[18] made research on the rise in body-centric wireless communications devices like augmented reality glasses, fitness trackers, and wireless headsets in the upcoming 5G network, compact antennas suitable for such applications operating in the millimetre-wave frequency band are in higher demand due to their advantages of miniaturisation and higher data rates. For wearable 5G wireless devices operating at 32GHz, a unique compact planar inverted-F antenna (PIFA) was created in this study. 86% efficiency and a gain of 2dB are present.

U. Venkateshkumar et al.,[19] outlined concept two multiband antennas with a specific design and a conceptual blueprint for 5G communication. The design of one of them places the resonating frequencies between 450 MHz and 6 GHz. 2.4 GHz, 2.8 GHz, 4.1 GHz, 5.5 GHz, 5.9 GH, 6.6 GHz, 7.9 GHz, and 9.3 GHz are among the frequencies at which this proposed antenna will resonant. Additionally, a multiband antenna that operates in the millimetre waveband (24 GHz–86 GHz) has resonances at 14.601 GHz, 23.3.01 GHz, and 28.9 GHz. A FR-4 substrate with a dielectric constant of 4.4 was used to make the designs. The suggested antennas have a low VSWR, a high gain, a high degree of directivity, and little return loss. In addition to 5G applications, these patch antennas can be used for WiFi, WiMax, Bluetooth, and WLAN.

I.Gharbi et al.,[20] investigated on the creation of 28 GHz rectangular patch antenna arrays fed by coaxial and microstrip lines. The goal was to create a four-element antenna array with a maximum radiation gain and a bandwidth greater than 1 GHz. According to simulation results, the performance of the rectangular 4*1 and 2*2 patch antenna arrays constructed on Rogers RT/Duroid 5880 substrate is superior when supplied by microstrip line to that of the 2*2 antenna array fed by

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coaxial cable. obtained a bandwidth of 2.15 GHz and 1.3 GHz, respectively, with gains of close to 13.3 dBi for the topology of a 4*1 rectangular patch array antenna.

S. Ghosh et al.,[21] have developed a design to attain adequate bandwidth (>1 GHz), high radiation efficiency (>85%), good gain (>7 dB), and desired radiation characteristics. Due to the compact size and superior antenna performance at 28 GHz mm-wave frequency band, the proposed shapes of patches can be an excellent choice for designing phased array, and multiple-input multiple-output (MIMO) antenna system in 5G communication devices.

III. SUMMARY AND OBSERVATION

In the proposed work, drawbacks of previous designs have been overcome to a great extent. The design, modelling and simulation of the antenna is done using Computer Simulation Technology Microwave Studio. The proposed antenna resonates at a frequency of 28 GHz which falls under 5G band. Parametric modification is done to attain optimum gain and bandwidth.

IV. CONCLUSION

Due to the increase in demand of mobile data and portable devices, a rectangular microstrip patch antenna resonating at 5G frequency has been proposed. The performance parameters such as VSWR, return loss, gain and directivity are calculated at resonating frequency. As compared to existing designs reported in the literature survey, the proposed antenna shows significantly better performance in terms of gain and efficiency due to combined optimization of parameters. Therefore, the designed antenna in this paper is a good candidate for 5G wireless applications.

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International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⋇ Impact Factor 8.102 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 12, Issue 4, April 2023
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