e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 1, January 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.54

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| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 1, January 2024 |

| DOI:10.15680/IJMRSET.2024.0701007 |

Review of Microstrip Rectangular Patch Array Antenna for C-Band Wireless Applications

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ABSTRACT: Microstrip patch antennas are mostly preferred over other antennas to be fit in Mobile, Aircraft and Satellites due to very small sizes. Hence designing and development of superior & cost effective microstrip patch antenna is an active research area. A Microstrip line fed, line slot, double-band, rectangular microstrip patch antenna is designed which is most suited for telecommunication applications. Microstrip patch antenna array design gives improved result in terms of return loss, bandwidth and gain. In this paper various work related to antenna array is discussed. Most of the research work proposed for long term evolution wireless communication application.

KEYWORDS: C-band, LTE, Microstrip, patch, antenna, array.

I. INTRODUCTION

An antenna is a device which is designed to transmit or receive the electromagnetic waves. In other words an antenna is a transitional structure between free space and guiding device that converts guide wave in the free space and vice versa. In many applications, it is necessary to design an antenna with very high directive properties (very high gain) and work at the multi frequency range which can also fulfill the demand of long distance communication or satellite communication. In the past decade, microstrip antennas have played an active role in communication area due to its inherent properties and became a major research topic [1-5]. In their simplest form, microstrip antennas have two conducting layers separated by a thin dielectric substrate. The upper surface contains a radiating metallic patch or an array of patches while lower conductor functions as a ground plane. Conventional Microstrip antennas have narrow bandwidth and low gain and therefore they could find sufficient applications in their original form. For application in wireless and mobile communication systems, size reduction and wider bandwidth criteria are becoming major design consideration for practical antenna. Since microstrip antennas fulfill compact size requirement and it may be put inside the handset without any protrusion they are ideal candidate for modern wireless communication systems. These antennas are now getting application in some of the commercial appliances including mobile satellite communication systems, direct broadcasting systems, GPS systems, remote sensing and Blue tooth systems as well as in military appliances such as missiles, rockets, aircrafts and satellites.

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| DOI:10.15680/IJMRSET.2024.0701007 |

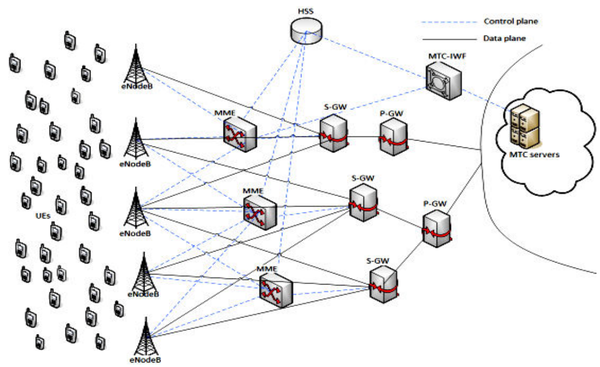

Figure 1: Antenna network LTE [2]

The antenna design is simulated and parameterized by using CST Microwave Studio to obtain the most optimum performance. The result shows that the 4×4 microstrip rectangular patch array antenna has an overall gain of 13.7 dB, and from the return-loss graph shows, the working bandwidth is 734 MHz ranges from 3.794-4.528 GHz. These results indicate that the proposed antenna design is suitable and promising for C-band satellite applications [1]. Importantly, the proposed bandwidth enhancement technique does not affect the desired broadside radiation patterns significantly. Therefore, it can be utilized to modify the tri-modal patch antenna without degrading its potential for massive MIMO array application. Measurement results show that the technique enhances the 10 dB impedance bandwidth from 4.3% to 19.7% with the largest antenna dimension of 0.48λc , where λc is the wavelength in air at the center frequency. The design example of the proposed technique is able to cover widely used 3 GHz bands in 5G communication systems and its potential usage in massive MIMO arrays is demonstrated [2]. The isolation between array elements is improved by using a meander-lines based near-zero-index epsilon-negative (NZI-ENG) metamaterial decoupling structure. The array elements are placed on the top-layer, whereas common connected ground plane and decoupling structure is placed on the bottom-layer. The metamaterial-based decoupling structure offers an isolation of more than 28 dB for antenna elements arranged in across and side-by-side configuration. Moreover, simulated and measured MIMO performance parameters i.e. Total Active Reflection Coefficient (TARC) <; -18 dB, Envelop correlation coefficient (ECC) <; 0.1 and Channel capacity loss (CCL) <; 0.3 are in acceptable limits. The proposed non-planar 3D-MIMO antenna system can be employed for indoor localization systems and wireless personal area network applications, where different 5G devices are wirelessly linked to a centralized server. Moreover, a good agreement between simulated and measured results is achieved for the non-planar MIMO antenna system [3].

II. LITERATURE REVIEW

B. P. A. Mahatmanto et al.,[1] proposes a microstrip array antenna consist of a 4×4 rectangular-shaped patch radiating element with a microstrip line feeding technique using a quarter-wavelength transformer impedance matching. The array antenna technique has the purpose of obtaining high gain and achieving greater directivities. This research considers an FR-4 Epoxy substrate in which the thickness and dielectric constant are 1.6 mm and 4.3, respectively, to deploy the antenna structure.

C. -Y. Chiu et al.,[2] A technique for enhancing the bandwidth of a broadside tri-modal patch antenna is described. The key idea of the technique is to incorporate a dual-resonance structure into the broadside tri-modal patch geometry. By increasing one edge of the tri-modal patch while decreasing its size at the opposite edge, the resulting structure can be viewed as two superimposed Y-shaped structures of different resonant frequencies. This intuition is confirmed using characteristic mode analysis (CMA). Furthermore, guided by CMA, further modifications enable two sets of resonant modes to be tuned for increasing the bandwidth of the tri-modal patch antenna.

T. Shabbir et al.,[3] In this article, a low-cost 16-port non-planar Multiple-Input-Multiple Output (MIMO) antenna system is proposed for future 5G applications. The non-planar MIMO antenna system is established around a 3D-octagonal-shape polystyrene block. The MIMO elements are arranged on the eight-sides of octagonal-shape block, whereas bottom and top faces of polystyrene block are left void. The single antenna element comprises of slotted microstrip patch with a stepped chamfered feed line and defected ground plane. Each MIMO element is designed on FR-4 substrate with a size of 22 mm × 20 mm, to cover the frequency band of 3.35 GHz to 3.65 GHz for the fifth-generation (5G) applications.

H. Li et al.,[4] This work introduces a practical design of distributed and simple millimeter-wave phased arrays for 5G mobile handset. Three types of antenna arrays and four different arrangements are investigated in perspective of coverage efficiency and coverage map. According to the analysis, a distributed design, including four 1 × 2 quasi-Yagi arrays along each edge of the chassis and one 2 × 2 planar patch array along the longer edge of the chassis, is adopted, considering both the antenna performance and the complexity of the feeding networks. The gain of the handset antenna system is always above 2 dBi for all the incident angles. The coverage efficiency reaches 50% for a gain of above 7 dBi, with the relatively low-gain area mainly towards the backward direction. Feeding networks are designed to verify the beam shaping ability of the arrays. The prototype was fabricated and measured. All the arrays can cover the frequency band from 27.85 GHz to 28.62 GHz, with an isolation of above 35 dB. The maximum measured realized gain is 12.1 dBi and 12.6 dBi for the Yagi and the patch arrays, agreeing well with the simulated results. High gain, large coverage efficiency, robust performance and simple feeding networks make the proposed design a good candidate for 5G mobile handsets.

J. Xu et al.,[5] A vertically folded slotted circular patch operating at the Ka -band is proposed in this communication. Fed by a low-profile microstrip feeding structure, the proposed circular patch resonates at its quasi-TM21 mode and exhibits a wide operational band of 23.5%, which is more superior than many reported millimeter-wave circular patch antennas. A full-corporate fed 2 × 2 linearly polarized (LP) subarray based on the proposed circular patch is designed without any additional substrate layer, which is further extended into a 4 × 4 LP array and a 4 × 4 circularly polarized (CP) sequential rotation array. Both the LP and CP arrays are fabricated and measured. A good agreement between the simulated and measured results has been observed, thus validating the proposed design techniques. With the enhanced performance, for example, wideband, low-profile, low cost, and compact size, the demonstrated array antennas can present promising candidates for some popular Ka -band applications, such as 5G millimeter-wave communications and satellite communications.

Z. U. Khan et al.,[6] This letter presents a microstrip patch antenna array fed with a low-loss and highly efficient feeding structure called empty substrate-integrated waveguide (ESIW). The proposed antenna array targets 5G wireless communication systems operating at 28 GHz. The antenna array consists of 4 × 4 radiating patches, where every four radiating elements are grouped together forming a 2 × 2 subarray and each of the subarrays is fed by ESIW feeding network by aperture coupling. The experimental results demonstrate good agreement with the simulated results, offering a wide |S 11 | <; -10 dB bandwidth of 12.4%, i.e., 26.5-30 GHz. A peak gain of 18.2 dBi and a high efficiency of about 91% are achieved using the proposed structure. Furthermore, the low-profile substrate of the ESIW feeding structure makes seamless integration of the proposed antenna array with the millimeter-wave front end. The advantages, such as low fabrication cost and high efficiency, make the proposed antenna array a suitable solution for millimeter-wave 5G wireless communication systems.

S. J. Yang et al.,[7] This article presents a novel dual-polarized millimeter-wave (mm-Wave) patch antenna with bandpass filtering response. The proposed antenna consists of a differential-fed cross-shaped driven patch and four stacked parasitic patches. The combination of the stacked patches and the driven patch can be equivalent to a bandstop filtering circuit for generating a radiation null at the upper band edge. Besides, four additional shorted patches are added beside the cross-shaped driven patch to introduce another radiation null at the lower band edge. Moreover, by embedding a cross-shaped strip between these four stacked patches, the third radiation null is generated to further suppress the upper stopband. As a result, a quasi-elliptic bandpass response is realized without requiring extra filtering circuit. For demonstration, a prototype was fabricated with standard PCB process and measured. The prototype operates in the 5G band (24.25-29.5 GHz) and it has an impedance bandwidth of 20%. The out-of-band gain drops over 15 dB at 23 and 32.5 GHz, respectively, which exhibits high selectivity. These merits make the proposed antenna a good element candidate for the 5G mm-Wave massive MIMO applications to reduce the requirements of the filters in the mm-Wave RF front ends.

N. Hussain et al.,[8] This work presents the design and realization of a metasurface-based low-profile wideband Circularly Polarized (CP) patch antenna with high performance for Fifth-generation (5G) communication systems. The antenna consists of a modified patch, sandwiched between an array of 4 x 4 symmetrical square ring Metasurface (MTS) and a ground plane. Initially, the intrinsic narrow bandwidth of the conventional patch antenna is increased using a diagonal

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rectangular slot. For further performance enhancement, the additional resonances and CP radiations are achieved for wideband operation in terms of impedance and Axial Ratio (AR) by effective excitation of surface waves propagating along the MTS. The stacking of MTS on the modified patch without any air gap resulted in an overall compact size of 1.1λ0x 1.1λ0 x 0.093λ0. Simulated and measured results show that the MTS-based antenna offers a wide impedance bandwidth ranging from 24 - 34.1 GHz (34.7%) for |S11| <; -10 with a maximum gain of 11 dBic and a 3-dB AR bandwidth of 24.1 - 29.5 GHz (20.1 %). Moreover, the proposed antenna has a smooth gain response with a small variation in its gain (9.5 - 11 dBic) and a stable left-hand CP radiation in the desired frequency range. The operating bandwidth of this antenna is covering the proposed entire global millimeter-wave spectrum (24.2 - 29.5 GHz) for 5G communication systems.

B. Feng et al.,[9] A dual-wideband dual-polarized antenna using metasurface for the fifth generation (5G) millimeter wave (mm-wave) communications is proposed. It is designed and analyzed based on characteristic mode theory (CMT). The proposed metasurface is mainly composed of a 3×3 square-patch, in which its four corner patches are further sub-divided into a 4×4 sub-patch array, while the size of the other four edge patches is reduced and the center patch is etched with a pair of orthogonal slots. By doing so, the side lobe level can be effectively reduced and the main beam radiation can be enhanced. The metasurface is excited by a pair of orthogonally arranged substrate-integrated-waveguide (SIW) to grounded-coplanar-waveguide (GCPW) dual-polarized feeding networks that help to reduce the insertion loss and expand the frequency bandwidth of the feeding ports. In order to yield higher gain, four proposed metasurfaces are fed by a pair of 1-to-8-way power divider feeding networks including a pair of low-transmission-loss E-plane phase shifter. Measured results show desirable impedance bandwidths of 13.85% (24.2-27.8 GHz) and 14.81% (36.9-42.8 GHz) in the lower and upper frequency bands, respectively, and their corresponding average gains are 13.96 and 15.46 dBi.

N. -S. Nie et al.,[10] A hybrid metasurface (HMS) is proposed to form a low-profile wideband antenna array. The antenna element is an array of 4 × 4 square metal patches and fed by a 50 Ω microstrip line through an H-shaped coupling slot on the ground plane. Only are the edge patches of HMS antenna element grounded by shorting pins for the suppression of surface waves and crosspolarization levels as well as the enhancement of the gain. With the HMS antenna element, a compact 2 χ 2 array with an overall size of 1.58λ 0 × 1.58λ 0 ×0.068λ 0 (λ4 is the free-space wavelength at 5.0 GHz) is designed, where the adjacent elements share the edge patches of the elements. The measurement shows the impedance bandwidth of 28% (4.41-5.85 GHz) for |S 11 | ≤ -10 dB is obtained, and the boresight gain is greater than 8.4 dBi across the operating band, covering both fifth-generation (5G) sub 6 GHz and WiFi bands.

Y. Luo et al.,[11] Millimeter-Wave (mmWave) antennas for 5G mobile terminals require a wide bandwidth, large-angle beam scanning, low-profile design, and multi-substrate compatibility for module-level integration. In this work, we propose one candidate design employing a patch structure with the shorting pin to particularly generate extra zero modes. By taking advantages of the 2 nd zero-mode with the TM 01 mode, we can obtain a wide bandwidth covering 23.5~28 GHz, a large-angle beam scanning with ±60°, as well as keep the substrate as low profile as 0.508 mm. Thanks to the zero-mode induced patch-type design, it is compatible to multi-layer configuration possessing the extensibility and flexibility for further module design. We experimentally valid the design of a 4 × 2 array with multi-layer configuration in a cell phone environment. Good RF performances with ±60° scanning in the wide bandwidth indicate this proposed design can be an appropriate candidate for 5G mobile terminals.

K. L. Wong et al.,[12] A multipolarized wideband circular patch antenna for multi-input-multi-output operation in the fifth-generation band of 3300-4200 MHz is presented for access-point applications. The circular patch antenna is excited by three probe feeds (Ports 1-3) equally spaced by 120° to generate three different polarized waves in the fundamental (TM11) mode. Each port on the circular patch is surrounded by a printed ring slot to achieve good impedance matching and isolation, thereby achieving good antenna performance in 3300-4200 MHz (measured efficiency better than about 88% and peak antenna gain about 6.6 dBi). Additionally, very low measured envelope correlation coefficients (<;0.05) of the three generated waves are obtained.

III. ANALYSIS METHODS

Analysis for the microstrip antenna can basically be isolated into two social events; procedures that rely upon the equivalent alluring stream course around the patch edges and moreover techniques that rely upon the electric stream dispersal on the patch channel and the ground plane. For this kind of assessment strategies, the radiation from the microstrip antenna is resolved from the corresponding alluring current apportionment around the edge of the transmitting patch, which is gotten from the looking at voltage movement. Means the examination issue is centered on finding the edge voltage appointment for a given excitation and for a foreordained mode. Two guideline systems reliant on this kind of examination are transmission line appear and the pit show. For the electric stream transport based procedure, the Methodology for a considerable length of time is the most generally perceived. This procedure is considered as a full wave show which fuses basically important conditions or Moment System. The logical arrangement for the assessment techniques are showed up in the Figure 2.

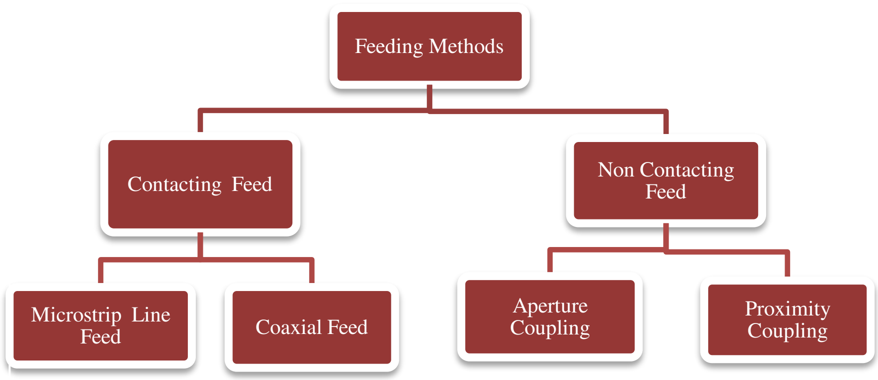

Figure 2: Analysis methods for the microstrip antenna

All in all, the transmission line shows is minimal complex of all technique used and it gives extraordinary physical recognition yet it is tolerably less exact when appeared differently in relation to other model used. The cavity show is continuously precise and gives incredible physical observation as well yet it is tolerably staggering to structure. The full wave models, for instance, the Strategy for a considerable length of time is a lot of flexible, exact, and can treat single segments, stacked parts, limited exhibits and boundless bunches, even emotional formed segments and coupling. These characters give less physical understanding when stood out from the two models referenced above and it is undeniably progressively complex in nature. In the accompanying territories, the three procedures referenced above are discussed rapidly.

IV. CONCLUSION

5G mobile communications have been rapidly evolving together with state-of-the-art technologies based on multiple elements such as array, Microstrip patch antenna array are very recent design among researchers. Bandwidth and gain can be enhancing using array pattern. This paper give overview and previous work related to microstrip patch antenna array pattern. CST software will use to design such type of antenna pattern.

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| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54| Monthly Peer Reviewed & Referred Journal |

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