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A Review on Microstrip Patch Antenna Design For mmWave 5G Wireless Communication

Ravi Joshi [1], Avinash Sharma [2]
[1] M.Tech Student, Department of ECE, Jaipur Institute of Technology, Jaipur, Rajasthan, India
[2] Assistant Professor, Department of ECE, Jaipur Institute of Technology, Jaipur, Rajasthan, India

ABSTRACT
As 5G continues to evolve and expand its reach, antennas will remain at the forefront of this technological revolution. 5G relies on a diverse array of antenna technologies to deliver enhanced performance. These antennas operate across various frequency bands, including the sub-6 GHz and mmWave (millimeter-wave) frequencies, each presenting unique challenges and opportunities. In this paper give an overview about the microstrip patch antenna design for mmWave and 5G wireless communication and also done the comparative analysis on with the related work done by different authors for microstrip patch antenna design for mmWave and 5G wireless communication.
Keywords :- Multi Story, RC Frame, Shear wall, Earthquake, Lateral Forces.

I. INTRODUCTION

Antennas are pivotal components in 5G communication networks, playing a crucial role in transmitting and receiving high-frequency radio waves [1]. As 5G technology aims to revolutionize connectivity by providing faster speeds, lower latency, and greater capacity, antennas have undergone significant advancements to meet the demands of this next-generation wireless communication standard [2].

Unlike previous generations of wireless technology, 5G relies on a diverse array of antenna technologies to deliver enhanced performance. These antennas operate across various frequency bands, including the sub-6 GHz and mmWave (millimeter-wave) frequencies, each presenting unique challenges and opportunities [3]. At sub-6 GHz frequencies, where signals travel longer distances and penetrate obstacles better, antennas can be designed for wider coverage areas [4]. Beamforming techniques, enabled by multiple-input multiple-output (MIMO) systems, help focus the signal directionally, improving capacity and reliability [5-6].

On the other hand, the mmWave spectrum offers extremely high data rates but with limited coverage and susceptibility to blockages from physical obstacles. Antennas for mmWave frequencies are designed to form highly focused, narrow beams that enable high-speed data transfer over shorter distances. Beam steering and beamforming become critical in mmWave technology, as they help overcome the challenges posed by signal attenuation and environmental obstructions [7].

Furthermore, advancements in antenna technologies for 5G include phased array antennas, massive MIMO systems, and smart adaptive antennas. Phased arrays enable precise control over the direction and shape of transmitted or received signals by manipulating the phase of individual antenna elements. Massive MIMO involves employing a large number of antennas at the transmitter and receiver, enhancing spectral efficiency and capacity [7-10].

As 5G continues to evolve and expand its reach, antennas will remain at the forefront of this technological revolution. Their ability to adapt to different frequencies, support beamforming, and facilitate seamless connectivity will be integral in unlocking the full potential of 5G networks for various applications, including smart cities, IoT (Internet of Things), augmented reality, autonomous vehicles, and beyond [3].

II. LITERATURE REVIEW

In [2] presents a multiband MSP antenna tailored for millimeter-wave 5G communication (26, 28, and 30GHz) on Rogers RO4003C substrate with εr 3.55, simulated through CST software. In [11] introduces a high-gain MSP (Microstrip Patch) antenna designed for 5G wireless communication using Rogers RO3003 substrate and simulated using CST software. In [12] present a metameral loaded SIW antenna for multiband application and this antenna design using FR4 subtract. The antenna functions over the frequency range of 6-18 GHz, with a resonant frequency for Wireless LAN and WIMAX. In [13] proposes a circular mouth horn antenna for 28GHz mmWave frequency, optimized for optical signals of 1550nm and aperture size of 200mm. In [14] demonstrates a square-slotted MSA (Microstrip Antenna) for 37GHz in 5G applications, achieving a return loss of less than -43.05dB and a gain of 8.18dB. The focus is on a U-slotted square-slotted MSA for 37GHz in 5G cellular communication, attaining a return loss below -36.146dB and a gain of 5.737dB. In [15] introduces a multiband antenna for wireless digital cellular systems operating within the 1.71-1.88GHz range, employing RT Duroid5880 substrate with a return loss of -29.8 to -53.69dB. In [16] presents a circular MSP antenna utilizing Rogers 5880 substrate for 5G communication, with a return loss of -32.86dB and VSWR of 1.037. An antenna for 5G satellite communication is detailed in [17], utilizing an FR4 substrate (εr 4.4) and achieving a -23.3656dB return loss at 43.7GHz with VSWR at 1.18dB. In [18] proposes an antenna design for 37-43.5GHz bands in 5G cellular communications, employing printed circuit frequency scanning LWA topology for radiation efficiency and compact size. In [19] introduces an all-in-one module solution, including a two-band SiP and a patch array antenna for external 5G mmWave applications (37-40GHz) with a gain of 5dB and return loss less than 10dB. In [20] discusses work at 59.15-60.65GHz using MSA Array for 60GHz wireless communication, achieving a gain of 19.86dB. In [21] focuses on multiband MSA for 37GHz and 54GHz in 5G communication, achieving gains of 5.5dB and 6dB, respectively. These studies contribute to the ongoing research and development of antennas tailored for diverse applications within the expansive landscape of 5G communication.

Table 1. Comparative Analysis on Microstrip Patch Antenna Design for mmWave 5G Wireless Communication

Ref No., Year	Type of Antenna	Freq.	Return Loss (dB)	Gain (dBi)	Application	Size of Antenna (mm^3)
[2], 2023	Multiband Microstrip Patch Antenna	26, 28, 30GHz	-24.24/-43.35/-20.37	10.4/10/5.78	5G Wireless Communication	35 × 12 × 0.508
[11], 2023	Microstrip Millimeter Wave Antenna	60Ghz	-65	6.85	5G Wireless Communication	4 × 4 × 0.035
[13], 2021	MIMO	3.3–4.2 GHz	-23	5–6	5G Wireless Communication	75 × 150 × 1.6
[15], 2021	square-slotted microstrip patch antenna	37GHz	−43.05	8.18	5G Mobile Application	—
[16], 2021	U-slotted square microstrip path antenna	37GHz	−36.146	5.737	5G Cellular Communication	4.35 x 4.35 x 0.95
[17], 2020	Microstrip Patch Antenna	1.71–1.88 GHz	−29.8 to −53.69	—	Digital Cellular System	16×18×0.787
[18], 2020	Microstrip Circular Patch Antenna	28.5 GHz	-32.86	10	5G Communication	—
[19], 2020	Microstrip Patch Antenna	43.7GHz	-23.36	4.35	Satellite 5G Communication	7.39 x 8.6 x 0.8
[20], 2019	Microstrip Patch Antenna	38 GHz	-10	4.2	5G Wireless Cellular Communication	—
[21], 2019	Dual-Polarized Patch Array Antenna	37-40GHz	10	5	5G mmWave outdoor applications	30 x 50 x 1.5

III. CONCLUSIONS

As 5G continues to evolve and expand its reach, antennas will remain at the forefront of this technological revolution. Their ability to adapt to different frequencies, support beamforming, and facilitate seamless connectivity will be integral in unlocking the full potential of 5G networks for various applications, including smart cities, IoT (Internet of Things), augmented reality, autonomous vehicles, and beyond . 5G relies on a diverse array of antenna technologies to deliver enhanced performance. These antennas operate across various frequency bands, including the sub-6 GHz and mmWave (millimeter-wave) frequencies. the mmWave spectrum offers extremely high data rates but with limited coverage and susceptibility to blockages from physical obstacles. Antennas for mmWave frequencies are designed to form highly focused, narrow beams that enable high-speed data transfer over shorter distances. Beam steering and beamforming become critical in mmWave technology, as they help overcome the challenges posed by signal attenuation and environmental obstructions. In this study give detailed overview about the antenna design for mmWave and 5G wireless communication. Also done the comparative study on the related work done by different authors for mmWave and 5G wireless communication.

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