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Review on Millimeter Wave Antenna for Future 5G Device

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Abstract: Millimeter-wave communications have demonstrated a promising future and are considered to be an appealing method in 5G fifth-generation wireless communication systems because of the rapid expansion of wireless data traffic.Moreover, to construct strong communication structures, understanding the channel dynamics in time and space at these frequencies is critical.Millimeter wave signals are particularly susceptible to blocking and because of their low signal attenuation, they have restricted communications abilities when particularly in comparison to microwave signals.Specifically, various designs from current papers are selected depending on their appealing features that assist 5G requirements and applications.In the mm-wave range, a T-shaped antenna can have a broad frequency range, including frequencies in the Ka-band such as 26.5 GHz to 40 GHz.Because ofits several benefits the PET substrate was chosen, including high flexibility,low cost, human body protection, and protection to environmental consequences. This review presents similar other mm-wave antenna array designs, and their strategies and challenges are discussed which are utilized to address the path loss that is unfavorableand mm-wave application blockage problems, which establish future directions.

Keywords*: *Millimeter-wave, microwave signals, wideband, 5G, blocking, antenna array, communication.

1.Introduction

There were active research efforts around the world to accelerate the creation of 5G wireless networks of the future.In recent wireless networks, wireless connections are required by over five billion devices to run voice,data, as well as additional applications.The development of portable yet effective antennas was being required for the efficient deployment of 5G systems.As per feasibility studies, since it provides high rates of data with reduced latency throughout the entire band, mm-wave spectrum is a significant candidate for 5G services.The antenna research community seems to be very interested in developing effective Future 5G antenna designs, particularly meant to run on two 5G frequency bands:38 and 28 GHz bands [3]. Antenna arrays improve directivity andgain. and service has become increasingly reliable, by suggesting enhanced gain antenna assemblies.Enhanced gain antenna assemblies can be one approach to increase the reliability of communication services and minimize the impact of atmospheric conditions. These antenna assemblies typically havea higher gain than traditional antennas, which means they can direct and concentrate more power in a specific direction, leading to improved communication quality.In 5G technology, the primary components are frequency utilization,wireless access systems, antennas, power consumption, and propagation.The millimeter wave spectrum includes 37 GHz, 64 - 71 GHz, 39 GHz, and 28 GHz bands, Particularly, 28 GHz and above, which has gone largely unobserved till now.These frequencies are being targeted by researchers for 5G applications.This review provides and relates various recent antenna designs for mm-wave 5G applications.The figure 1 represents the 5G millimeter wave antenna. This type of antenna is essential for enabling the high-speed, low-latency communication capabilities of 5G networks, as millimeter wave frequencies have much greater bandwidth and capacity than traditional microwave frequencies. The antenna design is crucial for achieving reliable and efficient communication at these frequencies, which can be affected by factors such as signal attenuation, interference, and path loss.

Specific applications of millimeter wave antennas in 5G systems include:

- High-speed mobile broadband: Millimeter wave antennas can be used to provide high-speed internet access for mobile devices such as smartphones and tablets.
- Fixed wireless access: Millimeter wave antennas can be used to provide high-speed internet access for homes and businesses, eliminating the need for traditional wired infrastructure.
- Internet of Things (IoT): Millimeter wave antennas can be used to support the massive number of devices that will be connected in 5G IoT networks,

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enabling advanced applications such as smart cities and autonomous vehicles.

- Virtual and augmented reality: Millimeter wave antennas can provide the high-speed and low-latency connectivity required for immersive virtual and augmented reality applications.

Overall, the millimeter wave antenna for 5G is a critical component for enabling the advanced communication capabilities of 5G networks, and its applications span a wide range of industries and use cases.

Fig 1: Milli meter wave antenna for 5G

1.1 Overview of 5G antenna

Several studies on the mm-wave spectrum have discovered constraints.Millimeter-wave antenna system's physical dimensions have become increasingly critical; additionally, the wavelength has become crucial in fading environments.An integrated antenna framework for 4G and mm-wave 5G handheld devices based on Defected Ground Structure (DGS) and wireless applicationswas introduced in NAQVI., et. al., [3].The suggested design is based on a substrate Rogers RT/Duroid 5880 with a thickness 0.508 mm and 75 mm 110 mm total dimension.The radiating structure is made up of antenna arrays that are stimulated by the T-shape.Power divider/combiner 1× 2.The 4G antenna array was being split up into two bands, with frequencies centered at 5.5 and 3.8 GHz, whereas the antenna array of 5G seems to have a 10dB, 24.4 - 29.3 GHz impedance bandwidth.In MAHMOUD., et. al., [3] researchfor 5G mobile base stations,it was demonstrated anadaptive array antenna of tri-band multi-polarized performance with directivity control and polarization.At 28/38/48 GHz,a tri-band multi-polarized adaptive array antenna's performance, an antenna element architecture with multiple bands of circular polarization was presented.On the basis of the a 32-element antenna element distributed as an octagonal prism was the basic structured antenna elementit was presented as a possible candidate in the development of mm-wave cellular networks if future 5G.The antenna array's performance was being evaluated in aspects of radiation efficiency,gain, return loss, and axial ratio for multiple situations, as well as coverage efficiency and total scan pattern metrics.

1.2 Requirement for 5G antenna

The primary goals of 5G are to increase the capacity of systems while offering more coverage at a lower cost.Lowered force utilizations were a significant goal of 5G, with a growing push for greener advancements yearly.The most fundamental target of all is "capability," which corresponds to the increasing user desire for higher and faster information rates.

1.3 Scope and Organization of the survey

In this research, recent advancements in the future Structure of a 5G mm-wave antenna as well as design guidelines were discussed. The remainder of the paper has the following structure: Section 1 discuss about the introduction, related works, and the need for the survey on the 5G millimeter wave antenna designs. In section 2, several researches are reviewed. The challenges in 5G millimeter wave antenna's design are explained in section 3. At last, in section 4, the survey is concluded through conclusion.

2. Future 5G Device Millimeter Wave Antenna

2.1 Dual band 5G antenna array

An antenna array model of dual-band and specific absorption rate (SAR) analysis for future 5G mobile communicationwas described in the research article Khan., et. al., [6].This research article describes the construction and for future 5G mobile communication SAR analysis of a dual-band antenna array.The important lobe of a single element 5G antenna's gain resonance frequencies was 7.73 dB and 7.71 dB at 38 GHz and 28 GHz, respectively.Since a 5G mobile communication system requires a gain of 12 dB, 1× 4 and 2× 2 antenna arrays are created to obtain that result.The gain on the bore side of the 2×2 antenna arrays were 15 and 12.3 dB, respectively, at frequency bands 28 and 38 GHz, the bore side gain of theantenna array 1× 4 is12.1 and 12.5 dB, respectively.Antenna with dual bands matched with a VSWR of 1.16 in both frequency bands. The research HE., et. al., [9]demonstrated a millimeter-wave patch antenna array of dual-polarized was adequate element mutual coupling and beam scanning abilities.The suggested antenna array achieves by using a stacked configuration with enlarged parasitic strips and capacitive feed method, it is possible to obtain a wide operating bandwidth of both the low bands and high bands.At 26 GHz, the element spacing is reduced to 0.36 wavelength. in terms of reducing the footprint of the array and improving beam scanning performance across both bands.Creating an array of dual-band microwave/mm wave patch antennas with a sharable aperture was designed in WANG., et. al., [44]. The antenna array is constructed of 3 printed circuit boards stacked on top of each other.The patches of Ka-band are directly fed by the Ka-band power divider networkmicrostrip linesas well as the patches of E-band were also coupled via antenna ground slots as a result of the power distribution network of E-band.To validate the shared aperture structure feasibility, initially, an antenna unit was constructed,researched, and measured.At last, an array of antennas, based on the antenna unit with shared apertures was constructed from a Ka-band array of 2×4-band and an E-band array of 8×16-band.

2.2Polarized and dual-polarized Millimeter wave antenna

An end fire planar folded slot antenna that is vertically polarizedwas employed in a 5G phased array (PFSA) that consumes little energyhas been presented and investigated in the research Park., et. al., [11].It was determined analytically that by integrating the antenna directivity idea, the 5G mobile antenna architecture energy efficiency (EE) was improved without impactingRange of EIRP and antenna beam steering. At 37-39 GHz, a V-pol end fire PFSA with an extremely small profile (1/90)and increased efficiency was measured, structured, and evaluated for the practical usefulness of this design.At 28 GHz, a four-element PFSA phased-array module was employed at the design stage, to illustrate the antenna topology that was suggested.The authors presented a new and portable mm-wave 5G cellular antenna array design with dual-polarizationin research by Parchin., et. al., [15].The suggested configuration ofsub-arrays of two planar end-fire lasers were used. in the dual-polarized array structure with varying polarization. All these sub-arrays wrap the 28 and 38 GHz bands and have adequate impedance matching, efficiency,gain, beam-coverage, and directivity properties.The used dual-polarized array was small and was printed on substrate’s one layer.

The measurement and outcomes of a 5G wideband planar phased array simulation were described in the research HUSSAIN., et. al., [20].A tightly coupled dipole array (TCDA) was used to obtain the preferred wideband operation. The suggested array is made up of dual-polarized dipole units that are tightly coupled, as well as two parasitic layers that are thin separated by an wide-angle impedance matching (WAIM)air gap.To boost the scanning performance of the array, the top matching layer was surrounded by a meta-surface comprised of sub-wavelength split-ring resonators (SRRs).For 5G mobile terminals with MIMO,a slot antenna array with 8 ports and 4 dual-polarization capable resonatorswas suggested byPARCHIN., et. al., [22].The structure was being composed of 4 dual-polarized square-ring slot radiators are linked by microstrip-line pairs.The radiation components are created to function at 3.6 GHz and are positioned on the corners of the mobile phone PCB.The properties of dual-polarization of square ring slot radiators are exceptional and basic radiation patterns that are similar.In terms of improving isolation and lowering mutual coupling among the dual-polarized radiators' adjunct microstrip-line feeding ports,every square-ring slot radiator has pairs of circular-ring/open-ended parasitic frameworks.

A phased array of mm-waveof broadband with end fire radiation anddual polarization, and broadside characteristics was suggestedin Yang., et. al., [23].Three substrate layers are used to make a dual-polarized orthogonally fed square patch element.The substrates are established to bottomfrom top with the parasitic patch, slot-coupled feed network, and driven patch.The parasitic patch that is stacked has the potential to increase the bandwidth and antenna element’s gain.The array seems to be capable of dual-polarized wide-angle beam scanning across both broadside and end fire directions with the appropriate phase differences among each element.Bow-tie slot arrays with dual-polarized cavity backingare organized and incorporated into the framework of a mobile phone in Li., et. al., [30].On the handset's longer metal frames, two antenna arrays comprised of 4 cavity-backed slot units with dual polarization are used.For gains greater than 7 dBi, every array has a scanning beam width of 138°.The antenna's 3D coverage efficiency is 52% at a 5dBithreshold gain.Because of their greater integration, dual-polarization, simple structure, andincreased gain,the antenna arrays suggested are ideal for mobile phones.A basic wheel-shaped copper microstrip antenna arrangement wasdesignedby Kamal., et. al., [31] for use in the 24 GHz frequency range.In this, a vertical polarization was produced using a coaxial feed probe, and horizontal polarization was produced using a microstrip with four coupling arms in the shape of a wheel.An antenna was constructed and verified experimentally using two copper sheets obtained among the air substrate.On a FR4 substrate, for this 5G millimeter wave antenna module, a broadband dual-polarized microstrip patch antenna has been presented in the research [42].Because of its reduced cost and comfort of mass production, the recommended antenna has been established utilizing a standard FR4 printed circuit board method (PCB). To compensate for the FR4 substrate's high loss tangent, an air cavity structure was presented.Capacitive elements like parasitic patches and the patch antenna's impedance bandwidth is increased by using proximity L-probe feedings.The antenna radiator was designed with a structural form to allow for the massive MIMO potential's polarization diversity, and the L-probe placement stimulates orthogonal resonant modes that allow for dual linear polarization.The suggested antenna's basic operation was thoroughly investigated using characteristic mode analysis (CMA).A multi-beam end-fire dual-polarized antenna array with fewer beams with a tiny footprint was suggested in the researchLu., et. al,[45]. The suggested antenna array consists of a transition,SIW beamforming network, and a 4-element antenna array. Among antenna element's air gaps are designed to decrease mutual coupling.The impedance bandwidth of a manufactured multi-beam end-fire dual-polarized antenna arraywas 11.3%, and the 41° range has been encased by the beam width3 dB overlapped of the 4 beams were generated in two polarizations.

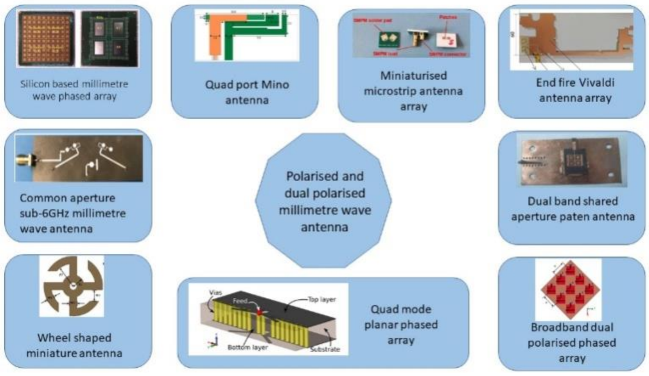

Fig 2: Future 5G device Millimeter wave antenna based on [11],[15],[20], [22-23],[30-31], [42], [45]

Table 1: Polarized and dual-polarized Millimeter wave antenna review

Reference	Author Name	Mm wave antenna type	Objective	Technique Used	Observation/ Findings	Advantages	Disadvantages
[11]	Park., et. al.,	Polarized	5G UEs particular challenges associated with millimeter wave beamforming antenna systems that use less energy were addressed.	A 5G phased array with an end fire planar folded slot antenna(PFSA) that is vertically polarised (V-pol)	The 5G mobile antenna architecture's energy efficiency (EE) was improved while maintaining the antenna beam steering range and EIRP.	V-pol end-fire PFSA with high efficiency	low height profile module creates low radiation efficiency.
[15]	Parchin., et. al.,	Dual-Polarized	The designs' vertical-polarization function was required, which was difficult to attain in a thin planar structure.	A novel and compact mm-wave 5G cellular antenna array structure with dual polarization has now been established.	The used dual-polarized array was small and printed on the substrate's one layer. Because of these benefits, the suggested dual-polarized antenna array was ideal for using it in communications of 5G mobile.	dual-polarized antenna array that is excellent for 5G. antenna is low-cost and easy to fabricate.	high gain levels are challenging to achieve.
[20]	Hussain., et. al.,	Dual-Polarized	This study's main contribution is the design and validations of the phased array.	a dual-polarized tightly coupled phased array with a wide bandwidth	Because of its compactness and three-plane scanning,measurements confirm the antenna's feasibility for 5G base station applications.	exhibits high gains, high efficiency.	The dual-polarized antenna array is not focused on5G beam scanning applications.

			are listed below. 1) A wide-bandwidth array capable of covering the 28 and 26 GHz bands.2) Scan up to ±60◦ planes at once. 3) Planar geometry with a straightforward feeding framework				
[22]	Parchin., et. al.,	Dual-Polarized	Some of the most important characteristics to consider when designing a dual-polarized antenna aresmall size, large bandwidth, and minimal mutual coupling	a novel reduced-coupling slot antenna array design	Throughout the user-head/user-hand availability, the MIMO antenna illustrated the effectiveness of good radiation.	A potential use for antenna in 5G mobile terminals is that it offers good features.	MIMO antenna system suitable for the mobile terminal applications are not focused.
[23]	Yang., et. al.,	Dual-Polarized	Beam-scanning arrays with those radiation patterns on the broadside and endfire were regarded to achieve broad beam coverage in multiple directions.	a dual-polarized broadband mm-wave phased array	Wide-beam dual-polarized coverage seems to have the ability to be used in 5G mm-wave wireless mobile terminals.	low cost and highly energy-efficient manner.	larger delay and lower bandwidth.
[30]	Li., et. al.,	Dual-Polarized	To achieve dual polarizations in the mm-wave bands	Dual-polarisation mm-wave antenna arrays	Because of its high integration, simple structure, larger coverage area, and dual polarization, with higher gain, it is ideal	Antenna has great potential in practice due to its simple structure, high	it was challenging to simultaneously fit eight connectors along the

					for use in a variety of applications. the suggested handset antenna has a lot of potential in practice.	integration, dual polarization and large coverage area with high gain.	edge.
[31]	Kamal., et. al.,	Polarized	To offer lower antennas with simple fabrication and omnidirectional circular polarization,	a small and straightforward antenna design	In aspects of S11 magnitude, radiation pattern, polarisation, good acceptable and agreement performance have been obtained.	Reduce the manufacturing cost and obtain high efficiency along with wide bandwidth.	The operating frequency range did not appear to have axial ratio values that were optimal.
[42]	Kim and Kim	Dual-Polarized	The antenna of the RFFE module was an important factor that must be meticulously constructed to meet both high-performance and challenging system requirements.	FR4-based dual-polarized broadband patch antenna	The suggested antenna meets all of the design criteria for a mobile device 5G millimeter wave antenna module.	high antenna gain.	I) high loss tangent value of FR4 substrate, ii) The narrow bandwidth of a planar patch antenna
[45]	Lu., et. al.,	Dual-Polarized	due to the SIW structure's inherent large size, to build a small beamforming network to provide dual-polarization feed to the antenna	A novel multi-end-fire dual-polarized mm antenna array was created.	The suggested antenna array is among the best candidates for millimeter wave communications since the calculated and observed results agree so well.	channel capacity is increased.	fabrication errors, SMA welding issues and environment effects.

2.3. Integrated Millimeter wave antenna

Microwave and millimeter-wave (mm-wave) dual-function slot antenna were suggested in research Ikram., et. al., [8].The system comprised of a ground plane slot of the framework.To obtain between 2.05 GHz and 2.7 GHzfrequency tunability, a short-circuited varactor diode with an optimum gain of 4.5 dBiwas used (4G, WLAN).For MIMOapplications to improve functionality, two distinct slots are organized orthogonally.The entire structure is built on a Rogers 5880 substrate, board size 70600:381 mm3.For revealing acceptable features of MIMO, estimation of envelope isolation and correlation coefficient (ECC) are done.A mobile terminal mock-up of 5G was composed of 4 different types of antenna elements with printed 28-GHz frequenciesin research XU., et. al., [17].Terminal housing implications are discovered after studying various types of terminal housing impacts separately, employing the inverse source and similar currentmethod.This research article presents a thorough analysis, findings, and novel ideas about the terminal housing impacts,as well as 5G mobile antenna design's practical knowledge and the characterization of radiation performance. A new method for combining a mm-wave end-fire beam steerable array antenna of 5G with PIFA such a reduced frequency was presented and was introduced by Taheri., et. al., [18]. This technique includes a low-frequency antenna that has been made transparent by putting a few grating strips in between the low- and high-frequency antennas.In such a mobile terminal, those end-fire radiation patterns quad-element mm-wave array whichhas been combined with a PIFA of dual-band low-frequency operating at 22-31 GHz.The research contribution was the coexistence of a higher endantenna arrayof 5G with such a low-frequency antenna of previous generation, like as 4G, while attempting to accommodate both frequency antennas high- and low in a confined space within a mobile terminal without interrupting with impedance or radiation pattern.The 5G antenna suggested consists of 22-31 GHz frequency range and ±50 degrees with less than 3 dB scan loss.This research articleSaedi., et. al., [28]explains the development,implementation, and the measurement results of a limited incorporated circularly polarized (CP) effective phased-array antenna (CP-APAA) development with sidelobe level (SLL) control and Enhanced throughput with K-band operation Land-to-Satellite communication.The suggested CP-APAA was being made up of rectangular grid array (4 ×16) 64 elements.There are currently 8 commercial monolithic microwave/mm-wave integrated circuits available.Controlling the antenna aperture's phase and amplitude, 8 RF output channels on MMICs were used.This research paperGU., et. al., [43] examines present development and research as well as future prospects for millimeter-wave phased array packaging and antenna integration techniques based on silicon in developing communication applications.Existing methods implementations Less than 100 GHz silicon-based phased arrays are described, substrate materials and processes, scaling array structures, antenna integrationselections, antenna design, and IC-package codesign are all highlighted. Figure 2 represents the millimeter wave 5G integrated antenna array module constructed particularly to achieve the Internet of Things' high demands,smartphone, and private/local 5G markets.

Fig 3: Integrated Milli meter wave 5G antenna array

2.4 Wideband Millimeter wave antenna

A low-cost, lightweight,compact, and simple to install and combined perturbed ground plane millimeter wave printed square loop antenna was suggested by KIANI., et. al., [2].The antenna is constructed from a substrate Rogers RT/Duroid 5880that was only 0.254 mm thickness.The antenna's frequency range is 26 to 40 GHz, with a 13 GHz bandwidth.Initially, a 9 mm 11 mm (0.84 0 1 0)single element of total dimensionswas structured, a transmission line, and 3 rectangular square loops.The loop elements are piled on top of one another, and a wideband resonance response was accomplished by inserting a square slot in the ground plane.By offering dual-beam inside the preferred frequency range, the proposed structure enables for spatial diversity whereas reducing the effect of intervention among neighboring cells.A higher-gain monolayer frequency selective surface (FSS) was presented by ULLAH., et. al., [21].The FSS is made up of 14 × 6-unit cells, each of which is 5 × 5 mm2 in size and has wideband behavior.The antenna, that is constructed on a substrate Rogers RT Duroid 5880, has anextremely broad bandwidth ranging to 65 GHz from 20 GHz and encompasses mm-wave 5G bands.The designed FSS has transmission characteristics in the stop band that are less than 59 GHz to 61 GHz and 10 dB to 42 GHzfrom 25 GHz.The FSS reflector was equipped with an eight-element antenna, resulting in a gain increaseat 38 GHz of10 dB to 12 dB, at 28 GHz 12 dB to 15 dB, and at 60 GHz 9.5 to 11 db.An array with 1.2 mm clearance of quad-mode endfire planar phased antennaswas suggested for 5G mobile terminalsby Syrytsin., et. al., [24].The suggested antenna appears to possess a higher impedance bandwidth than 8 GHz.These four modes in an array produce similar and broad embedded radiation patterns. In this research, a transition from coaxial to differential strip line was proposed.The differential feeding structure is extremely small, using only MMPX connectors and vias.In the 25GHz to 33 GHzfrequency range, the coverage efficiency that was calculated, and the simulated phased array antennas' cumulative scan pattern was being evaluated, there seems to be a high level of agreement among the evaluated and simulated outcomes.Zhang., et. al., [26] have suggested a 5G mobile applications dual-polarization end-fire phased array with a decreased profile of (0:10 at 26 GHz) 1.1 mm and a 3.5 mm clearance that performs from 26 GHz to 30 GHz.Vertically polarized substrate incorporated waveguide (SIW) elements are interspersed with horizontally polarized notch the array's elements. By incorporating a broad-band impedance transition made up of a metallic and parallel plate resonatorvia the use of in-between, the bandwidth of every SIW element was substantially enhanced.Markus., et. al., [41] have presentedthe fabrication, creation, as well as the development and phased array antenna ultra-Wideband (UWB) testing,with continuous mm-wave coverage of overall six allocated 5G and ISM bands.Using commercial processes, the entire array is constructed from a single printed circuit board (PCB),suggesting significant cost savings when compared to prior micro-fabrication-based models. Figure 3 represents theCoreIoT LTE Wide-Band antenna has already been designed primarily for all cellular, Wi-Fi applications functioning within the frequency range of 698MHz - 2700MHz, with just a space requirement of 98 mm * 20 mm * 1 mm.

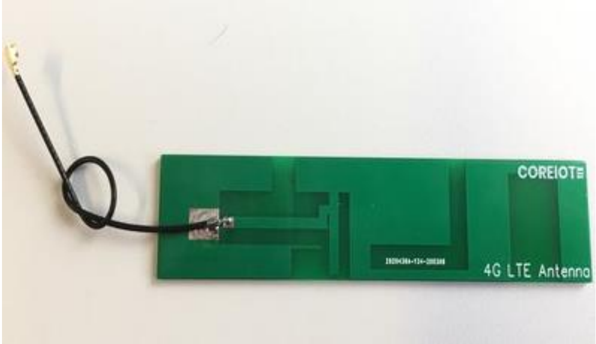

Fig 4: Wideband Millimeter wave 5G antenna array

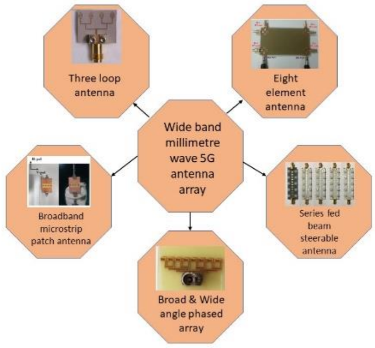

Fig 5: Wideband Millimeter wave 5G antenna array classification based on [2],[21],[24],[26],[41]

Table 2: Wideband Millimeter wave antenna review

Reference	Author Name	Millimeter wave antenna used	Objective	Technique Used	Observation / Findings	Advantages	Disadvantages
[2]	KIANI., et. al.,	Wideband	The proposed system's important focus was anincreased gain 10.1 dBi, efficiency 98%, a wide - ranging 13 GHzbandwidth, and dual beam characteristics in the millimeter wavefrequency range of 27 to 40 GHz.	A four-element wideband linear array	The results are consistent when comparing measured and calculated outcomes.	simple, light-weight, compact, economical, and simple to construct	it produces significance mutual coupling that can deteriorate antenna performance
[21]	ULLAH. , et. al.,	Wideband	The transmitter and receiver compensate for these losses antenna's gain was increased	single element antennaType -A to type-F	The measured and simulated outcomes	Using the embedded parasitic structure, the mutual coupling of	affects not only the operation frequency but also the bandwidth of the proposed

			while no additional power is used.		agreed well.	the adjacent radiators has been reduced significantly .	design
[24]	Syrytsin., et. al.,	Wideband	To improve the coverage of the phased mobile antenna array	A 5G mobile antenna array with Endfire quad-mode planar phased with a wide scan angle and reduced clearance.	With a 5 dBi gain, in the chosen frequency range, average coverage efficiency of 50% has been achieved.	Integration, simplicity and compactness	Low gain, low efficiency and degrade the overall systems signal to noise ratio
[26]	Zhang., et. al.,	Wideband	To increase the endfire V-pol radiation's bandwidth whil e keeping the profile, array inter-element distance low, and clearance.	A dual-polarized wideband endfire antenna array	A planar framework with a 1.1 mm profile and a 3.5 mm clearance	High performance antenna with low loss substrate	Integrating and packaging complexity. Potential performance degradation due to hybrid interconnection.
[41]	Markus., et. al.,	Wideband	millimeter-wave UWB array design and fabrication have been significantly simplified and planarized.	Planar UWB array with millimeter-wave frequencies	Its suitability for low-cost PCB fabrication	They provide a strong, stable wireless connection in often difficult to reach locations	inherently narrowband performance du e to its resonant nature

2.5 MIMOMillimeter wave antenna

A wideband 8-antenna array it was investigated for 5G New Radio (NR) mobile devices in the future in Sim., et. al., [1]. A parasitic shorting branch on an inverted-F antenna makes up every array element. The driving and shorting elements allow the antenna to operate in various modes.The open slit, parasitic element, and stub aid in matching impedance.It has an extremely peak channel capacity, and high efficiency more than 41% and 39 bps/Hz, respectively. ABBAS., et. al., [39] have suggested an antenna system with multiple inputs and outputs (MIMO) for 5Gand 4G mobile communications.By utilizing a single structure, the framework satisfies the entire demands for both 5G antennas and 4G antennas.At mm-wave, a tapered slot antenna’s structure, 5G end-fire radiation, and at 2 GHz, it functions as an enabling omnidirectional 4G radiation,open-ended slot antenna. The suggested design's slot antenna has a large bandwidth for 5G and 4G.

2.6 Review on types ofMillimeter wave antenna

Park., et. al., [4] have presented a new millimeter-wave hybrid antenna module aspect in order to achieve spherical beam steering coverage that was both systematically and structurally suitable for current cellular devices. The hybrid antenna module idea integrates different existing models, Antenna-on-Display (AoD), andAntenna-in-Package (AiP)to point the antenna's main lobe in broadside and end-fire directions. At 28 GHz, the impedance bandwidth of AiP2:1 VSWRa portable end-fire antenna array and AoD antenna array that is fully optically transparent are 0.85 GHz and1.67 GHz, respectively. A novel photolithographically built optically invisible antenna that was Park., et. al., [5] research has been incorporated OLEDs and LCDs are examples of active display panels.This proposed Antenna-on-Display (AoD) method is used to illustrate future mm-wave 5G cellular devices.It was created and tested the transparent diamond-grid antenna element TA.By using identical dummy-grids throughout the antenna region, complete optical invisibility was accomplished.To raise the antenna element's size, a multi-layer structure was being usedand convert it to a phased-array configuration.A novel phased array of SIW monopoles with a simple framework, increased gain, and broad coverage, making it suitable for future 5G mobile handsets was introduced by PAOLA., et. al., [7].The circuit is made up of 8 monopoles written on a substrate Rogers RO4003.4 antennas are situated at the PCB top to encompass the region behind the structure, and 4 are located on the bottom to scan the area in front of them. To avoid surface currents from flowing all the way across the ground plane, as well as adjusting beam pointing, a thicker dielectric is placed beneath the elements.

For millimeter-wave 5G cellular handsets a new quasi-Yagi antenna in the 28-GHz band has been developedwas suggested in Hwang., et. al., [10].The suggested antenna appears to be portable due to modified planar folded dipole architectures, enabling it to be installed within a tiny mobile terminal.To minimize the antenna's lateral width whereas preserving the properties of a planar folded dipole antenna, the antenna topology employs a multi-layer printed circuit board (PCB) and via hole structure stacked vertically.5th Generation (5G) wireless systems use the millimeter wave band, a two-element miniaturized microstrip antenna array was suggested by Shen., et. al., [12].The foundation for two distinct closely packed patch antennas was an electromagnetic band gap structures (EBG) surface working in New Radio (NR)of 5G with (26500 - 29500 MHz)frequency bandwidth. Despite the fact that the 2 E-shaped microstrip antenna elements are usedwithin the center frequencies wavelength, the free-space center-to-center distance is 0.3, acrossa whole band of interest, their mutual coupling outperforms 23 dB, and that's approximately 10 decibels louder than normal ground.The EBG ground has reserved all the major radiation features of the two arrays. A potential architecture that combines a patch structure with a shorting pin for generating additional zero modeswas proposed in the research by LUO., et. al., [13]. A wide bandwidth covering obtains 23.528 GHz, a huge beam scanning with ±60◦, and a reduced profile of 0.508 mm by Using the TM01 mode with the second zero-mode.Due to the structure of the patch-type with zero-mode induced,it is multi-layer compatible and multi-layer extensible, allowing for future module structure.

Zhang., et. al., [14] proposedfifth-generation (5G) handsets, a pattern phased array of a reconfigurable radiation- was controlled by p-i-n diodes.The suggested hybrid system for beam scanning and switching minimizes thetransmit-receive (TR) elements andnumber of arrays significantly while maintaining the same spatial coverage.The planar four-element array has only 4 mm of clearance, making it compatible for the majority of modern mobile phones.A single shielded strip line supplies each reconfigurable array element, which has three different radiation patterns: one end fire and 2 broadside.Beam switching is accomplished by sandwiching 2 reconfigurable directors between the dipole's two sides, which also reduces the antenna profileLEE., et. al., [16] designed a paper in which a portable end-fire antenna array on the elevation plane with a broad fan-beam is described for 5G mobile handsets.Four linear arrays' radiation characteristics are created employing the Vivaldi antenna array structure. To verify the feasibility, simulations and experiments are conducted.At 28 GHz, a reduced beam-steerable antenna is required for 5G mobile terminal applicationswas demonstratedby Deng., et. al., [25]. In this sandwich-like stack framework, the suggested array is composed of ten patch elements, two rows of slots on the ground plane, and a transmission feed line’s long microstrip.Since the transmission line and radiators are located on ground plane’s opposing sides, in addition to the feed network and the radiating pattern builds with great flexibility.To build relatively beam steering with frequently distributed phase shifters, switches are incorporated into the transmission line.Without the utilization of phase delay lines, a 2-bit phase shifter with 0°, 90°, 180°, and 270° phases is created.The upper hemisphere steerable angle is 121°, and continuous beam steering is possible.

Nguyen., et. al., [29] have presentedthe investigational study of the performance of the 5G terminal's antenna array's user's fingers effects, at 26 GHz in the 5G regulated band, in Europe.The radiation and matching properties of a 4 linear array composed of aperture-coupled elements embedded in a mobile terminal are studied.The various finger configurations as well as the terminal casing of the user with the terminal are takenintoaccount.Wireless devices that are small and integrated, a 5G antenna system with a common aperture was suggested by IKRAM., et. al., [32].An integrated antenna structure that operates in various bands, such as at 3:6 GHz sub-6 GHz and at 28 GHz mm-wave, has been validated utilizing a dipole and tapered slots.A dipole 3:6 GHz was restyled balloon consisting of a tapered slot and a microstrip line.In this scenario, the tapered slot serves two purposes: it stimulatesand provides at 28 GHz a tapered slot antennaat 3:6 GHz the dipole.The design is distinctive and offers an extremely high frequency ratio because only one feeder has been optimized and is used in both structures.Tsakyridis., et. al., [33] have experimentally demonstrateda fronthaul bus topology based on millimeter wave Fiber Wireless with bandwidth reconfigurability for 5G Centralized-Radio Access Networks(C-RAN) that are spectrally efficient and easily reconfigurable. The suggested fronthaul structure contains 4 1 Gb/s Intermediate Frequency placed above a white Fiber (IFoF) channel that was allocated flexibly among two nodes integrated Reconfigurable Optical Add/Drop Multiplexer (ROADM) in series, MO is assisting 32-element Phased Array Antenna (PAA) terminals8 Vband, et. al., [34] a new and efficient data-driven technique for creating a beam codebook to improve themillimeter wave terminal spherical coverage was proposed. The technique accepts measured or simulated electric fields as inputs response data for every antenna and offers the codebook in accordance with the codebook requirementsspherical coverage, size, and other factors. The technique is simple to apply to different situations. The antenna type, antenna placement, antenna array configuration, and terminal housing design are all important considerations. A practical millimeter-wave phased array design that is distributed and simple5G mobile handset arrays was introduced by LI., et. al., [36].In terms of coverage efficiency and map coverage, three distinct antenna array types and 4 main arrangements are researched.The feeding network's purpose is to evaluate the arrays' beam shaping capability, and a prototype was constructed and tested.The entire arrays have greater than 35 dB isolation and encompass a 27.85 GHz to 28.62 GHzfrequency range. Millimeter wave frequency bands appear to be promising candidates for 5G mobile communication systems; however, the base station'shigh directional antenna systems and user equipment (UE) are required to compensate for high path loss. In ZHAO., et. al., [37] the millimeter wave UEs' spherical coverage is describedbased on 3GPP specifications was researched, where antenna topologies, device integration, and user interaction all come together using simulation and measurement results, the effect of body obstruction on UE's spherical coverage was studied.

SHIM., et. al., [38] have presented a phased array antenna of wideband was created for mm-wave mobile terminals of 5G.In order to obtainbroadband impedance matching and low profile, the tightly coupled dipole was employed to construct the suggested array antenna based on array (TCDA).The maximum beam direction of the suggested 1D array antenna was aligned with the ground, trying to make It is suitable for mobile terminal implementations.Making use of a electromagnetic simulation software of full-wave, on a multilayer substrate, a 1× 8 TCDA was established, with such a central reflector surface to take the place of a vertical ground plane.In the case of applications for mobile terminals for 5G millimeter wave,the user's body has an increased probability of causing a blockage or shadow in the radiation pattern of the handset antenna array.Inthis research article. Syrytsin., et. al., [35], when user effects are taken into account, in terms of spatial coverage, for the 5G mm-wave array framework, the handset chassis' corner positions offer the good performance.To demonstrate this claim, Using SIW lenses and MMPX connectors, a prototype 5G mm-wave antenna system was developedand evaluated by comparing with the more general case.

3. Millimeter-Wave Antenna Design for 5G challenges

It is difficult to generate and receive millimeter waves, but the travelling media is the most difficult factor with these high frequencies.The most difficult challenges are path loss in the atmosphere and in free space.To combat severe propagation loss, directional antennas with increased antenna gain are used at both the transmitter and receiver.

4. Conclusion

The goal of this research was to discuss the design of 5G wireless system's mm-wave antennas. It was found that the 5G of wireless communication technology will be used for a wide range ofapplications including mobile communications, Internet of service (IoT), wirelesslocal area network, industrial, scientific, and medical, virtual reality, smart energy,and smart vehicles.5G antennas with wider bandwidth and high gain will be required for theconcurrent functioning of various system services, and to reduce attenuations andabsorption in the atmosphere at the mm-wave spectrum.Multiple-input multiple-output (MIMO) antenna solutions will be established for 5Gcommunication applications, allowing multi-antennas to operate simultaneously.The goals and specifications of 5G mm-wave antennas were investigated.The latest developments in mm-wave antenna framework were discussed, as well as design guidelines. Severaldistinct designs have recently been discussed in the research was focused on their appealing qualities that support 5G applications and requirements.

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