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RECENT TREDS IN ANTENNA DEVELOPMENT FOR 5G WIRELESS NETWORK

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Abstract-

Fifth generation (5G) is the next major phase of mobile telecommunications standards beyond the current 4G, which will operate at millimeter-wave frequency band. The design of an efficient antenna plays a very important role in the performance of radio communications in any wireless device . 5G is considered beyond 2020 mobile communications Technologies. Improving the capacity of the networks with better coverage at a lower cost is the main objectives of 5G. The general agreement among different research groups working on the futuristic 5G technologies is a peak data rate of 10 Gb/s for static users, 1 Gb/s for mobility users and no less than 100 Mb/s in urban areas led to the study of using advanced multiple-input multiple-output (MIMO) architecture as well as adaptive beam-forming. These antenna technologies may be among the key factors for overcoming some of the challenging propagation characteristics of mm-waves and could increase the spectrum efficiency, provide higher data rates, and adequate reasonable coverage for mobile broadband services. With the potential for higher frequencies as well as mm waves deployment, most 5G frequency bands are predicted to be in the range of 20-50GHz.: Extension of multi-user MIMO concept to hundreds of antennas at the base station is a promising solution to significantly increase user throughput and network capacity by allowing beamformed data transmission and interference management. Moving to the mm-Wave frequencies for 5G mobile stations, requires new techniques in the design of antennas for mobile-station (MS) and base-station (BS) systems.

Keywords— MIMO, mm-Wave, 5G Communication Systems,

INTRODUCTION

The aim of 5G is to provide connection to any kind of device and for kind of applications that may benefit from being connected, including cellular communication for people and various objects in user's environment. 5G can achieve high data rate (10-50 Gbps), low latency, and very high device density must be accommodated. The FCC allocated the frequency band for 5G Wireless Communications are listed as 5GHz (5.1-5.85GHz), 28GHz (27.5-28.35 GHz), 37GHz (37-38.6GHz), 39GHz (38.6-40 GHz), 64-71 GHz band include traditional cellular licensing, Wi-Fi, mixed licensing that allow for both local and wide area network [2] [7]. Multiple–Input Multiple-Output (MIMO) antennas have multiple antennas in a single layer and are designed for Fifth Generation network. By Installing multiple antennas, which improves data rate and coverage area and the multiple antenna are excited with same radio transmit power as compared to a single antenna. MIMO antennas improve link reliability which experiences less fading than a single antenna system. Using MIMO technique, the single data stream is breaks down into several separate data streams and it is sent out over multiple antennas which improve wireless performance and capacity. due to its capability to access a large amount of available spectrum resources. Millimeter-wave (mm Wave) communication is one of the most promising technologies in the fifth generation (5G) mobile networks Hence, for developing 5G wireless communication systems accurate and reliable knowledge on mm Wave channel propagation characteristics is essential.

Traditional antennas are passive devices that use metal rods, capacitors, and conductors. Active antennas and MIMO are key to differentiating 5G from previous wireless networks.
Technologies such as multiple input multiple output (MIMO), and scanning antennas are being considered of mobile network capacity to accommodate higher capacity and larger number of connected devices, The concept of using a phased array or steerable antenna for dynamic beam forming is not new, but its implementation in a mobile network has become possible now a days ,thanks to the new advanced signal processing in modern, highly sophisticated handsets.

The new 5G cellular technologies will provide consumers with data rates of up to ten times that of previous 4G/LTE. A similar trend towards higher data rates by using higher frequencies is visible for Wi-Fi implementations exploiting the 60 GHz band with standards 802.11ad and 802.11ay. For these new technologies, achieving the desired network performance in urban and indoor environments creates new challenges. Performance will depend strongly on the radio channel (and the associated frequencies used) which the urban and indoor building structures will impact. High-accuracy wave propagation models are required, for channel statistics as well as for predicting and optimizing radio coverage. Coverage needs to be analyzed for different base station deployment scenarios, different frequencies and different environments and along different test drives.

RECENT ADVANCES AND CHALLENGES IN DESIGNING ANTENNA

With the development of wireless communication system has demanded compact wireless devices that allow more space to integrate the other electronics components. Advancement in technology creates challenges in implementing antenna for multiple RF band with a wide range of frequencies. With the advancement of optimization technique, we can improve the antenna design as well as provide us the motivation of analyzing the existing studies in order to categorize and synthesize them in a meaningful manner. The research and development trends and novel approaches in design of multiband MIMO, smart reconfigurable and defected ground structure (DGS) antenna techniques for wireless system. The development of wireless communication technology such as computer, cellular technology, Person Area Network for remote regeneration and observing of surroundings information has demanded for antenna suitable to operate with dual or multiband characteristics in wireless communication devices.

Broadband Antenna in wireless communication area has demanded the design of antennas that must operate effectively over a wide range of frequencies. Concurrently, Multiband antennas are required for mobile communication technology which operates in different frequency ranges. The design and development of antenna should be in the compact size in order to offer more space to integrate other electronics components for reduction of volume of the wireless communication system. The integration of broadband, Multiband antennas with frequency reconfigurability is based on P-I-N diode, Material, Optical switch, Mechanical movement based. This is the most challenging scenario for deploying the antenna for desired frequency. In addition, use of defected ground structure, Use of Metamaterial with high quality factor for antenna miniaturization is required. The new frequency band are requiring covering some communication system with improved data rate as they need to operate on a new band multiband MIMO antenna are required. To overcome the global bandwidth shortage in today's wireless cellular networks, the fifth generation (5G) communication system is expected to utilize millimeter-wave bands, which have a large amount of available spectrum. Several measurements have demonstrated the promise of orders of magnitude greater bandwidths combined with further gain via beam forming and spatial multiplexing from multi-element antenna arrays. As a result, designing an optimal antenna for millimeter-wave beam forming could be an important step for realizing 5G wireless cellular networks.

Generating and receiving millimeter wave is a challenge ,but the biggest and most challenging factor with these higher frequency is the travelling media, the biggest challenges are atmospheric and free space path loss.to combat severe propagation loss ,directional antenna are employed at both transmitter and receiver to achieve high antenna gain .

ANTENNA DESIGN TECHNIQUES

Multiband MIMO Antenna :

Due to requirement of multiband antenna to cover number of applications for wireless system in less space the multiband MIMO Antenna Technology demand is getting increased for current 4G and future 5G. To design the antenna is not the easy task, but always special modification or shape combination should be implemented, or proper optimization is required to get the multiband frequency range. 5G network will highly depend upon MIMO systems as it demands limited space as well as less cost. To meet all these requirement multiband MIMO antennas can be obtained by these methods.

Insertion of Parasitic elements

Parasitic elements can be used to enable virtual rotation of the antenna. The insertion of parasitic elements in MIMO array antenna will reduce the mutual coupling. The parasitic element is placed at distance $\lambda/64$ to the active element to avoid power loss.

ii) Use of Slots

In Multiband MIMO with the use of slot the Slot is a cut in the patch antenna to improve the bandwidth. As the current flow in the circuit the patch can be represent as the LC circuit. As the current flows around the slot, the length of the current path is increased. The two resonant circuits couple together and form a wider bandwidth.

iii) Use of Fractal

Such antenna could be used to improve the functionality of modern wireless communication system. Fractal can be used in two ways to enhance antenna design. The first method is in design of miniaturized antenna elements. The second method is to use the self-similarity in the geometry to blueprint antennas which are multiband or resonant over several frequency bands. Small antennas are of prime importance because of the available space limitation on device and the oncoming deployment and multi input multi output (MIMO) system. However, the classical small antenna suffers from insufficient performance. Fractal geometry provides the solution by designing compact and multiband antenna in most efficient and sophisticated way. There are many fractal geometries available like Stephanie Carpet, Stephanie Gasket, Koch Fractal Loop, Hilbert Curve and Contort Set.

iv) Feeding Methods

Selection of feeding techniques depends upon how much power is transferred by feed line to the radiating patch. Power transferred depends upon the impedance matching. Feeding technique can be classified into two techniques one with contacting and other with non –contacting. In contacting, radiating patch is directly given the feed as by Microstrip line. In non -contacting, power is transferred by electromagnetic coupling between radiating patch and the feed line.

Smart Reconfigurable:

Smart Reconfigurable technique improves the previous approaches by modifying dynamically its frequency and radiation pattern properties in a controlled and reversible manner so that its behavior can be changed by reconfiguration and it allow to operate on multiple frequency bands. Polarization reconfigurability or hybrid antenna received much attention as it can fulfil demand for low profile antennas for different services in just single terminal. The techniques that can be used for reconfigurability in antennas are many such as by using active switches based on micro electromechanical systems (MEMS), PIN diodes, varactor diode, using photoconductive switch, doing some change in structure and alteration in material.
Reconfigurable antenna various techniques.

i) Electrically Reconfigurable Antennas

RF MEMS are new revolution in microelectronics. RF MEMS, PIN diode and varactor diode work in the form of open and closed switch in the antenna structure and redistribute the surface current path.

ii) Optically reconfigurable Antenna

An optically reconfigurable antennas uses lasers which incident on semiconductor materials like silicon, gallium arsenide. An optically shorted stub frequency reconfigurable antenna achieved multi frequency switching of the patch by using three photoconductive switches.

iii) Physically Reconfigurable Antennas

By physical alteration of the radiating structure of the antenna, reconfigurability can be achieved. It has some disadvantages like antenna size increases, the tuning speed is very less, and that is why it cannot be used in cognitive radio system. frequency reconfigurability is achieved by the three antennas which reconfigures based on its operating frequency or radiation pattern based on a physical movement of some of its radiating parts. The antennas vary from a frequency reconfigurable quadrifocal helix to a frequency reconfigurable sector monopole as well as a radiation pattern reconfigurable patch.

iv) Smart Materials Based Reconfigurable Antenna

Materials for example liquid crystals or ferrites are used in making substrate which can change its characteristics. A Double Negative (DNG) material with negative permittivity and negative permeability is used for this reconfigurable antenna. The met surface design is proved to be a meta-material with negative refractive index, as both relative permittivity and relative permeability are observed to be negative in the desired frequency range to achieve frequency reconfigurability.

Defected Ground Structure:

Defected Ground Structure referred to Slots or defects integrated on the ground plane of microwave planar circuits. Using DGS in antenna design leads to size reduction, gain or bandwidth enhancement. DGS opens a door to microwave researchers of a wide range of applications like miniaturization, multiband performance, bandwidth and gain enhancement, mutual coupling suppression between two elements, higher mode harmonics suppression, cross-polarization suppression, notched band creation, and circular polarization achievement.

There are different configurations have been explored below:

i. Multiband Circularly Polarized DGS Antenna

Multiband frequency operations can be achieved by Circular polarized antennas. The multiband circular polarized antenna can integrate various frequency bands in a single antenna and cover many wireless applications on single platform. The multiband

circular antenna can also be used with microstrip antenna in order to achieve small size, less weight and low cost.

ii. Fractal Defected Ground Structure (FDGS)

Fractal DGS is used to reduce the mutual coupling between microstrip antenna elements, but it has never been used to design CP microstrip antenna. FDGS will increase the Cross-polarization XP level furthermore compared to the conventional DGSs. The increased XP level has almost the same magnitude as that of the main polarization level, which contributes to the design of the CP microstrip antenna. DGS provided more efficient size-reduction of the microstrip structure and better bandgap characteristics than the dumbbell shaped DGS.

Dual band MM wave antenna:

This design employs a dual-band slotted patch antenna operating at 28 GHz and 38 GHz. The antenna has circular polarization and is excited by a single feed microstrip line. The present design is desirable for high-gain antenna array implementation in the mm-wave band, in order to compensate for the mm-wave propagation loss.

Compact Planar Inverted F Antenna:

Another successive application that utilizes mm wave antenna is based on a compact planar inverted-F antenna (PIFA) with single layer dielectric load of a superstrate to enhance the gain and achieve a wide impedance bandwidth resulting in high efficiency.

T shaped patch antenna:

Another design that operates in the mm-wave band is a T-Shaped patch antenna. The proposed antenna a wideband range from (26.5 GHz-40 GHz) of the Ka band. The PFT substrate was used as it offers some advantages; low cost, high flexibility, harmless to human body and resistive towards environmental effects.

MIMO antenna array for MM wave:

This mm-wave antenna design employs two MIMO arrays each composed of 2×2 antenna elements. It utilizes concept of antenna array and beamforming. The two MIMO array configurations are spatially orthogonal to each other which results in polarization diversity. The trend in future mobile networks (5G) has shown a different pattern from that of existing networks, because the main objective has changed from enabling users to connect wirelessly to the Internet to enabling massive numbers of users and devices to seamlessly connect in smart cities (IoT) by 2020 and beyond (www. itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx). At WRC 2015, the main objective focused on adding extra spectrum for mobile communications below 6 GHz. However, the massive growth in global mobile traffic cannot be fulfilled by this addition alone. 5G will need to access and extend its operation to the millimeter-wave band to enable multi-Gbps data rates. Therefore, it was decided that at WRC in 2019, the identification of bands above 6 GHz will be included.

The ITU-R Working Party 5D will define the technical performance requirements for next generation systems and develop an evaluation process to occur between 2016 and 2017. According to the ITU timeframe, standardization and proposals will be studied in 2018. From 2018 through 2020, an evaluation will be held by external groups, and the definition of new radio interfaces will be included in the most recent International Mobile Telecommunication system (IMT-2020), like what happened for IMT-2000, and IMT-Advanced

FUTURE SCOPE (ON THE WAY TOWARD 6G)

The next-generation wireless technology sixth generation can utilize waves in the >0.1 THz frequency range, As 5G fully deploys, research into terahertz communication will increasingly demand fully operational

communication systems ,there are many scientific and engineering challenges, as well as opportunities, that will need to be addressed. In this review we focus on three broad classes. First, there is the terahertz channel. This encompasses the new challenges of working with terahertz frequency waves as they propagate from transmitter to receiver, in predominately terrestrial communication links. While terahertz waves are like radiofrequency (RF) waves in many respects, their shorter wavelength affects beam directivity, diffraction, and antenna properties. In addition, the reflectivity, transmissivity, and absorption of materials, especially the atmosphere, are quite different. Second, we consider terahertz devices. The generation, reception, and conversion of terahertz waves in mobile devices require cutting-edge electronic, photonic, or hybrid approaches that push the limits of material properties and device capabilities, while simultaneously enabling cost-effective fabrication and device integration. Third, we consider space-based terahertz opportunities, since these applications may be uniquely suited to terahertz communications, and since they demand system-level solutions that will be common to terrestrial systems and space systems alike, with probably greater restrictions arising from the latter. In other words, space-based terahertz communications may be excellent development surrogates for future terrestrial systems. terahertz communications will require a large and dedicated effort in system-wide channel sounding. The key requirements for accurate terahertz channel sounding are high dynamic range (within a narrow frequency range) while maintaining wide tunability, fast detection (to capture real-time dynamics), and a long enough measurement window to capture power delay profiles. Antenna array technologies will need to exploit new approaches and physical architectures, such as spatial noise shaping, beam-forming, hybrid beam-forming, and the cones of silence, as these were shown to provide significant performance benefits and will solve design constraints such as the physical size of RF components with a vast number of antenna elements .Challenges such as power-efficient devices, cost-effective integrated circuit solutions, and practical phased arrays that may be interconnected with minimal loss loom as impediments to 6G and THz product development, and offer open research and development problems that are being investigated by DARPA and other global research agencies.
As the world begins to look to 6G and beyond, at frequencies above 100 GHz, there should be careful studies to determine the impact that THz radiation has on the biological effects of humans and animals, and to see if such radiation could be used as a safe and effective replacement for more dangerous ionizing imaging methods such as X-rays and CT/PET scans.

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