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REGULAR ARTICLE

Transit to 6G Spectrum with MIMO Antenna Model – A Review

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The Sixth Generation (6G) is a promising concept in the current era for various Wireless Communication (WC) Systems. Recently, the Multiple Input and Multiple Output (MIMO) Antenna has been supported in different aspects by strongly evolving in the 6G application. Firstly, the 6G is involved very deeply by many sincere specifications, which are built for high-speed transmission in the MIMO Antenna. Mainly, 6G demands on the frequencies in the ranges from 100 GHz to 3 THz. Embedding the MIMO antenna onto the spectrum in the WC system will lead to a high data rate, increasing the baseline capacity of each Cell. Also, 6G has hit the challenges of energy consumption in many electronic devices with abundant protection. Nowadays, the Terahertz (THz) and millimeter (MM) wave consist of the MIMO antenna by the usage of 6G application. The frequency ranges between 30 – 300 GHz for MM wave and 300 – 3000 GHZ for terahertz exist in mobile technology with the enhancement of the 6G parameters. This survey speaks about the different types of MIMO antenna implemented by using the 6G, to enable various parameters to be executed. With this analysis, the techniques to implement from SISO to massive MIMO which fits into Millimeter-wave, and THz are determined. It proves a better performance than the conventional method (5G) in the MIMO antenna by using HFSS software.

Keywords: Wireless communication (WC), Sixth generation (6G), Multiple input and multiple output (MIMO), Terahertz (THz) and millimeter (MM) wave.

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1. INTRODUCTION

The First Generation (1G) of wireless communication networks debuted in the early 1980s Audio communication via analog cellular phone technologies. As a result, to address the disadvantages of conventional analog communication systems, Second Generation Technology (2G) introduced an electronic system network that established a standard component of all mobile communication networks. Short message services (SMS) are examples of telecommunications implications that began to be offered in the 1990s. Third Generation (3G) mobile broadband networks were developed, enabling new applications that include multimedia messaging services, video calls, and mobile TV. Fourth Generation (4G) enabled faster mobile broadband services, high-resolution video streaming, and smooth changeover. The widespread implementation of telecommunication methods that depend on the Internet Protocol (IP) provided numerous quality excellence of service (QoS) standards to enhance the fulfillment of the various types of users' requests [1].

The fifth type generation technology (5G) of modern wireless telecommunication technology provides greater data speeds, lower latency, and more network capability, as well as an improved user interface than previous generations (3G and 4G). 5G new radio(NR) constitutes one of the most-discussed technologies in recent years. Due to the inadequate bandwidth accessible in the microwave sector, as well as significant delay as well as low data rates, there is a fast-expanding demand for better utilization of this technology. 5G NR makes extensive use of millimeter-wave (mm-wave) technology, particularly in the (24 – 100 GHz) frequency range.

Smart factories, smart cities, smart homes, virtual reality, seamless integration in self-driving vehicles, and remote healthcare are all part of Te5GNR [1, 2]. 5G mm-wave electromagnetic channel bandwidths are expected to be several times greater than today's 4G LTE 20 MHz cellular channels.5G networks are dependable, having a wide variety of antennas to better satisfy the massive expansion in enormous data rate requirements and minimal power consumption devices [3]. Several multiple-input multiple-output (MIMO) antennas that operate in the FCC-designated band for 5G communication are currently being proposed [4].

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2. LITERATURE REVIEW

As a result of the ongoing expansion of wireless technology, the number of linked devices has increased exponentially. As a result, the Fifth Generation technology (5G) of mobile-based telecommunication system networks constitutes a major advancement forward in meeting this requirement. With this type of 5G technology, the systematic network must be able to meet severe standards for data throughput (up to 10 – 15 GBPS), latency (up to 1 ms – 2 ms), network connectivity (up to 1 million/km^2), system dependability (up to 105), as well as the power usage [5]. Thus, the design and functioning components of the anticipated Sixth Generation (6G) remained mostly unknown. Nevertheless, numerous new developments are required to achieve the predicted bold key performance indicators (KPIs), which include technologies involving several antennas that include massive Multiple (Various) Input Multiple (Various) Output (m MIMO) [6], extraordinarily maximum MIMO (XL-MIMO) [5,6] as well as non-cellular massive MIMO (CF-m MIMO) telecommunications [7].

A different approach and an interesting method for 6G wireless communication networks includes the CF-based massive MIMO approach, which exhibits that the lack of clearly-defined network cell borders decreases that is not merely the challenges that accompany the procedure for handover, but additionally the constraints of cell-edge users along with Intercellular communication [11]. Furthermore, The IRS has lately suggested as well as represents a novel idea of technology capable of achieving intelligent and programmable radio transmission settings. The wireless channels could be consciously as well as deterministically regulated to enhance the quality of signal within the receiver, thereby improving network strength and also durability, by heavily deploying IRS next-generation 6G Networks whilst intelligently coordinating the phase and amplitude of the respective elements [5, 6].

Various recent publications [4] give evaluations of the key principles, benefits, limitations, and problems with any one of the aforementioned multiple (Various) antenna techniques, however, they do not concentrate on 6G Network topologies or needs. Furthermore, several additional studies [9] give a future 6G system network scenario as well as outline the principles of various system technologies that are critical to meeting the expected needs. These studies, however, do not go into depth into the role of upcoming MIMO approaches. Notably, the authors explore multiple (various)antenna techniques which would very certainly involve important responsibilities in 6G networks, especially m MIMO, CF-m MIMO, as well as IRS. This article describes the underlying reasons, important qualities, and current technical advancements, as well as potential future research prospects.

They do not, however, contextualize the issue in terms of new 6G system Networks utilized scenarios as well as needs. This article provides a comprehensive overview of the most important developing MIMO techniques used for the 6G system networks, including XL-MIMO, m MIMO, CF-MMIMO, as well as IRS telecommunications. Furthermore, unlike [9], this type of article discusses in depth certain unique utilized such type of cases which will be enabled by 6th type Generation networks as well as provides a critical explanation of the major needs for fully implementing every scenario based on its characteristics. Furthermore, we expand our research by demonstrating just how these key performance indicators KPI are calculated so innovative 6G system network scenarios may be satisfied along with the advancement of each type of MIMO technology.

The concept of a microstrip-based antenna (MSA) dates back to the early 1950s and was presented and produced as a microstrip-based antenna. Despite MSA's proliferation, there was very little action in its growth for the next 15 years. This was partially owing to a lack of excellent microwave substrates, as well as increased emphasis that has been placed on microwave striped line circuitry along with the antennas as the most affordable, concealed alternatives for waveguide elements. Aircraft as well as projectiles must have conformal, narrow antennas are prompted the creation of MSAs at the beginning of the 1970s. Furthermore, MPA is the most basic form of antenna, with only three layers.

The first is a patch, which is in charge of radiation. It is engraved on the subsequent (medium) layer known as the dielectrics substrate, which is made of a thin conducting material such as the metal copper (Cu) or gold as a material (Au). The third layer comprises the ground plane, which is the substrate's corresponding side with a small conducting material [9]. The limited band is MSA's biggest drawback. As a result, numerous experimental techniques have been used to solve this issue. There are three methods for increasing the impedance bandwidth of MSA. In this article, we might look at a novel MIMO multiport antenna that performs in Mm-Wave frequencies, and this is common for almost 6G wireless systems. Hence, the second aim is to concentrate on having such type of antenna perform across a broad range of frequency bands because of that it may be extensively employed in different current wireless communication systems. Thus, the third objective is enhancing to and develop many designs until the antenna produces satisfactory results regarding effectiveness, power gain, performance, reflection coefficient, efficacy, diversification gain, as well as the ECC of the isolation ratio among the inputs and outputs in the MIMO configuration. The most effective layout yields the best outcomes. The fourth and last element is to concentrate on precisely developing the antenna and employing cutting-edge ways so that its compact size matches with the diverse locations of smart communication systems [10].

3. CHARACTERISTICS AND PARAMETERS OF SIXTH GENERATION (6G)

Nowadays, 6G demands many technologies to link Artificial Intelligence (AI) and Machine learning (ML) enabled with unique features. Mostly, it merges to empower with benefits in smart cities, virtual reality, augmented reality, etc. The International Telecommunication Union (ITU) did not state the finishing specification of the 6G, but the frequency ranges can work out from hundreds of gigahertz (GHz) to terahertz(THz) to transmit the data speeds. The parameters cover [15, 21],

i) Spectrum focuses on mid-band 7 – 20 GHz, low bands as 460 – 694 MHz, and high-band for sub THz spectrum from 90 GHz to 300 GHz based on the data speed as 100 Gbps.

ii) Data rate is available maximum of 100 Gbps to 1 Tbps and spectral efficiency is double that of 5G.
iii) Latency decreases very less than 0.1 msec
iv) 100 million of machine to machine devices are connected
v) 10 GHz – 100 GHz bandwidths
vi) Efficiency – 1 TBPS, Jitter – 10 msec
vii) Peak Spectral Efficiency – 30 bits/sec
viii) Mobility – 1000 kmph
ix) Reliability (Bit Error Rate) – 1 – 10^{-9}

The following are some of the important characteristics of 6G technologies: **(i)** Higher data rate communication: 6G has an average data rate of 20 GBps, which is approximately 20 times higher than 5G. **(ii)** Low latency: Because 6G has a latency of less than 1 millisecond, there is a small delay in transmitting and receiving data. **(iii)** Extensive network capability: 6G may link greater numbers of gadgets per unit area than 5G, allowing it to accommodate an expanding number of linked devices. **(iv)** Increased user interface: 6G provides an improved user experience than earlier generations of mobile communications due to faster data speeds, less latency, and more network capacity. **(v)** 6G uses modern methods of encryption to safeguard data communications, rendering it substantially safer than 5G. **(vi)** Multigigabit wireless connection: 6G provides a multigigabit wireless connection for appliances, which makes it perfect for transmitting data quickly in applications that include virtual reality (VR) along with augmented reality (AR).

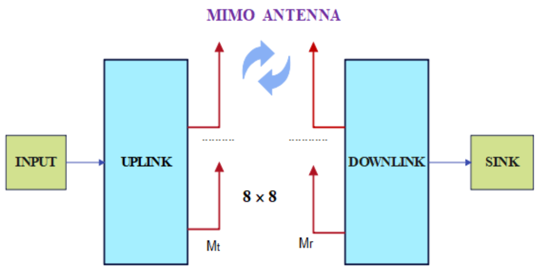

Fig. 1 – Block Diagram of MIMO Antenna

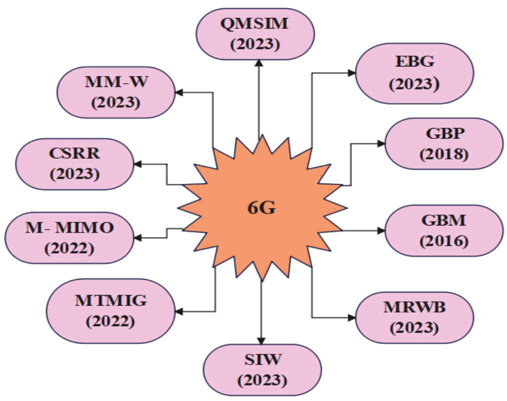

Fig. 2 – Study of Various MIMO Antennas by using 6G

The block diagram of the MIMO antenna is shown in Fig. 1, how the wireless communication works from uplink to downlink through the MIMO antenna in the system. The various antenna implemented by using 6G is shown in Fig. 2 with the abbreviation below, **(i)** QMSIW - Quarter-Mode Substrate Integrated Waveguide, **(ii)** EBG – Ultra-Wideband Microstrip MIMO Antenna with Electromagnetic Bandgap, **(iii)** GBP – Graphene-based patch, **(iv)** GBM- Graphene-based miniaturized, **(v)** MRWB- Multi-Resonant Wide Band, **(vi)** Substrate Integrated Waveguide, **(vii)** MTM-Inspired Graphene-Based THz, **(viii)** M-MIMO – Massive MIMO, **(ix)** CSRR - Complementary split-ring resonator Loaded Graphene Inspired EBG, **(x)** MM-W – Millimeter Wave. Table 1 determines the study of different parameters of the MIMO Antenna obtained.

Table 1 – Performance Evaluation of Existing MIMO Antenna in 6G (11-20)

S.No	MIMO	Bandwidth (GHz)	Return Loss (dBi)	Gain (dB)	Wavelength (GHz)	Efficiency (%)	Frequency (GHz)
1	QMSIM	28	10	6.5 - 6.6	5.5	92	5.5
2	EBG	15	-10	5.5 GHz	6	90	2.4 - 6.5
3	Graphene based patch Antenna	79.1	-39.19	5.0	-	66.71	1.0THz
4	Graphene based miniatured THz antenna	270	-26.71	5.0	-	-	2.67 - 2.92
5	Multi Resonant Wide Band	11.34	-10	5	-	34.90	28/28
6	SIW	10.38/11.86	100	26.9 - 25.21	0.1	73.86 - 77.85	9.-140
7	MTM-Inspired Graphene based THz	0.6 THz	-35	7.23	Quarter	-	3.5
8	8´8 Massive MIMO antenna	38.49	-25	9	-	-	46
9	CSRR loaded Graphene Inspired EBG	6.0 -12.5 THz	7.3	7.3	3mm - 0.33mm	70.76	6.5 -11.5
10	mm-wave & Sub 6 GHz Antenna	5.8 to 38.2	15	5 &32	-	65	11 - 27

Several important parameters, together with the core single antenna parameters such as bandwidth, gain, and radiation efficiency, need to be evaluated to fully characterize a MIMO antenna system. For a multiantenna system, performance indicators are of major importance. The design procedure and evaluation of the MIMO system are given in Fig. 3.

4. PROBLEM IN MIMO ANTENNA SYSTEMS

MIMO antenna systems consist of several antennas positioned inside a single substrate that shares a ground plane. Consequently, the antenna elements in the MIMO antenna system develop mutual coupling. Within a multiport antenna system, mutual coupling illustrates how power coupling interacts between neighbouring antenna parts. The coupling between radiation patterns is not covered by the mutual coupling. "Isolation" is another word used in MIMO antenna that is closely related to mutual coupling. S-parameters are used to represent mutual coupling and isolation.

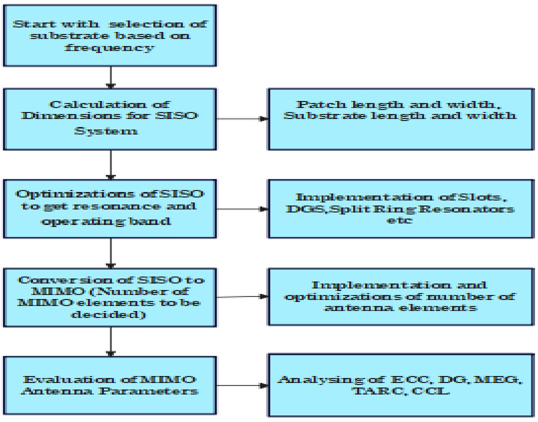

Fig. 3 – Design Procedure and Evaluation of MIMO system

This component is measured by the transmission coefficient (S_x >) between two antenna elements, which are denoted by the symbols *x* and *y*, respectively, for antenna-1 and antenna-2.

A high mutual coupling is created between the antenna if they are positioned closer together than XI4. A route, USB dongle, and cell phones are examples of medium to small-sized communication devices with relatively compact device dimensions that have their antenna elements positioned relatively close to one another. As a result, there is low isolation and strong mutual coupling between the antenna elements. Both the channel capacity and MIMO antenna's efficiency would be impacted by the low isolation level. A high level of isolation between the antenna's elements is necessary to enhance its MIMO performance. The literature contains several isolation improvement strategies for reducing the reciprocal coupling impact between the antenna parts.

5. CONCLUSION

Thus this review paper suggests the way of transit to 6G from 5G spectral bands. Due to its latency and effective short-range communication 6G spectra are suggested by the International Telecommunication Union to be implemented beyond 5G. With MIMO systems on to 6G, a new era of Communication systems would be designed with very low latency and deplorability over the horizon. This paper suggests the importance of the 6G spectrum with the important key parameters to be measured and satisfied for a MIMO system. In the future, we plan to design and implement the THz MIMO antenna by using the 6G parameter which is utilized in the wireless communication system. In this review, we search the difficulties focussed on various devices that are utilized in the 6G applications. Also, mainly observed the spectrum ranges between 30 – 300 GHz for MM wave and 300 – 3000 GHZ for terahertz in many industrial applications.

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Перехід до спектру 6G за допомогою моделі антени MIMO

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Шосте покоління (6G) є багатообіцяючою концепцією в поточну епоху для різних систем бездротового зв'язку (WC). Нещодавно антена з декількома входами та декількома виходами (MIMO) була підтримана в різних аспектах завдяки значному розвитку в програмі 6G. По-перше, 6G дуже глибоко задіяний у багатьох щирих специфікаціях, які створені для високошвидкісної передачі в антені MIMO. В основному 6G вимагає частот в діапазоні від 100 ГГц до 3 ТГц. Вбудовування антени MIMO в спектр системи WC призведе до високої швидкості передачі даних, збільшуючи базову пропускну здатність кожної комірки. Крім того, 6G впорався з проблемами енергоспоживання в багатьох електронних пристроях завдяки значному захисту. Зараз терагерцові (ТГц) і міліметрові (ММ) хвилі складаються з антен MIMO за допомогою програми 6G. Діапазони частот між 30–300 ГГц для хвилі ММ і 300–3000 ГГц для терагерц працюють в мобільних технологіях із покращенням параметрів 6G. У даній статті розглянуті різні типи антен MIMO, реалізованих за допомогою 6G, щоб забезпечити виконання різних параметрів. На основі аналізу визначено методи реалізації від SISO до масивного MIMO, який відповідає міліметровому діапазону та ТГц. Це підтверджує кращу продуктивність, ніж звичайний метод (5G) в MIMO-антені за допомогою програмного забезпечення HFSS.

Ключові слова: Бездротовий зв'язок (WC), Шосте покоління (6G), Множинний вхід і вихід (MIMO), Терагерцові (ТГц) і міліметрові (ММ) хвилі.