Survey on MIMO Antenna for 5G Applications.

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Article Info
Page Number: 2181 - 2191
Publication Issue:
Vol 71 No 3 (2022)

Article History
Article Received: *12 January 2022*
Revised: *25 February 2022*
Accepted: *20 April 2022*
Publication: *09 June 2022*

Abstract: In this paper MIMO antenna for 5G applications is studied. In the wireless communication technology, 5G is developed in this new generation. One of advanced technology in 5G communication systems is MIMO. By using more than one pattern and polarization is utilized in Multiple-Input-Multiple-Output (MIMO) antennas in present generation. These are mostly used in the modern telecommunication system applications. In this survey different MIMO antennas systems in detailed manner along with limitations also. Hence this survey will provide effective outcomes.

Key Words: 5G Wireless Communications, Multiple-Input-Multiple-Output (MIMO), Fifth Generation (5G) Antenna.

I. Introduction

MIMO is the system which is used in advanced technology for multiplying the capacity of radio link. This achieves multipath propagation multiple transmitting and receiving antennas are achieved. To send and receive the multiple independent channels MIMO systems are most widely used specifically. Multiple antenna topologies doesn’t have any power loss and uses same radio channel in rich scattering environment [1]. Next generation wireless communication technology using multiple antennas is capable of reliability improvement and channel capacity.

In early 90’s MIMO antennas are introduced to overcome the limitation of data rate in Single-Input-Single-Output (SISO) systems. To improve the transmission speed of data and system reliability MIMO system is introduced. In wireless communication systems transmission speed and system reliability plays very important role to improve the capacity [2].

The mobile wireless communication system plays very important role in last few decades rapidly. Systems reach high rates in past few decades they are like Wireless Local Area Networks (WLAN), Long-Term Evolution (LTE), Global System for Mobile Communication (GSM), Universal Mobile Telecommunication System (UMTS), and the data transfer rates.

Hence, mobile terminals requirements plays vital role in present generation. To increase the system capacity and guarantee data rate, multiple antennas are utilized in Multiple-Input Multiple-Output (MIMO). While designing MIMO antennas, for compact size there was a demand and different types of functions are utilized in terminals of mobile. The open issue in SISO antennas has low mutual coupling and covering wide operating band.

By 2020 the emerging wireless technology is 5G (Fifth Generation). This technology is commercialized in present generation. Both company's academia and commercial pays vital research in developing 5 wireless systems like Huawei Technologies. In 5G technology the major components used are LTE-advanced wireless systems. 100 time's bandwidth is obtained in the MIMO antenna system compared to current 4G. Hence in transmitter and receiver section, wireless system multiple antennas are used.

In MIMO systems the mutual coupling between elements is the major challenge. In MIMO systems the systems performance will be affected by the Mutual coupling. Mutual coupling is maintained by isolation of antenna. Hence in presented design the isolation of antenna should be maintained high to overcome the problem of mutual coupling. It is very difficult to design the small antennas when isolation becomes high and it becomes very difficult for hand held devices with MIMO element.

Since, with the MIMO system designing the multiple antennas became famous and popular, the modern devices are portable and small. Between the antennas, the spacing must be as less as possible. In MIMO antennas, this is the main implication. In mutual coupling, this results a problem between the elements of antenna. Different techniques were introduced to increase the isolation like as decoupling structure, quasi-complementary structure, to each other antenna elements are inserted orthogonally, and placing neutralization line. The radiating elements as per the above description, are fed with feeds and interested orthogonal to one another [3]. By the CPW feed the more area is occupied. This process increases the isolation, there is a current to remove the ground plane coupling, between the radiating elements antenna the neutralization line is inserted.

Antenna having quasi-complementary structure that was reported because it fed's orthogonally. In complementary structure, inheriting the polarization diversity's exhibiting characteristics property. Respectively, in ground plane and L shaped plane the rectangular slots and radiators are used, in between elements the problem of mutual coupling which occurred was reduced, to each other they are placed orthogonally. The T shaped stub combination increases the isolation and in radiating antenna element line feed was meandered. The isolation was enhanced on a co-shaped radiator and on ground plane with the help of F and I shaped stubs.

There has a circular micro strip elements data to the co-planar antenna that was suggested to get band rejection and between the radiating antenna elements there was a T shaped slot. The maximum numbers of antennas those are reported above are 2×2 multi band MIMO antennas. Conversely, 4 × 4 multi band MIMO antennas are also reported. There has a four radiating elements to an antenna, with increased isolation that was reported with the help of metal strips and to ground plane that was shorted and metalized the junctions. In 4-element antenna the mutual coupling problem was minimized, the radiating elements orientation is orthogonal to one another.

To attain notch characteristics, on ground plane the band stop design is etched. At octagonal monopole's edge, the miniaturization and wideband phenomena are achieved by using Koch fractal. Ground stubs are used to make the isolation enhancement. It is clear that from the above discussion the reported structure will either have small size less isolation with or high isolation with large size, hence, with higher isolation a compact multi band MIMO antenna design is a difficult task for portable devices. Due to this reason, with planer shaped antenna the introduced antenna was employed, to multi-band frequencies it satisfies the requirements in wireless communication.

Ii. Related Work

The frequency distribution is insufficient because of the low bandwidth of the channel as the number of user's increases. The number of users cannot exceed certain limit within the same frequency bandwidth. The interference with co-channels increases as the number of users increases. The large volume video sending and receiving is most difficult task using 3G and 4G frequency channels because of the advancement of Quadruple High Definition (QHD) and High Definition (HD) video resolutions.

This needs to create a necessity for having a faster data rate and large bandwidth for high speed reception or transmission of high resolution multimedia through wirelessly from one place to the other place. The introduction of a 4G mobile communication network quickly raises people's demands for the mobile communication speed. 5G frequencies are researched for a wider bandwidth to overcome this problem [4]. Comparing with the more frequency channels like 3G and 4G, 5G provides a greater bandwidth, which means it is ideal for increasing the more users requiring fast data rate when moving.

Development and investigation of the Fifth Generation (5G) antenna was carried out to satisfy these needs. Multi-cell and miniaturization antennas provide the ability to transmit data at high speed, but are difficult in developing antennas for cell phones. Recently, research on the 5G device antenna has been increasing day by day.

The Fifth Generation (5G) mobile communication technology has been considered to be in demand. Multiple-Input Multiple-Output (MIMO) technique can effectively increase spectrum efficiency and data transmission rate. It is identified that certain 5G frequency spectrum. It was widely accepted that MIMO antennas to be used in communications terminals for 5G operations to increase channel efficiency and increase transmission rates.

Today, to increase the data transfer rate there has been a huge demand in handheld/portable wireless communication devices. A better connectivity is also offered. A short range of electronic devices are connected currently using some wireless networks like Bluetooth and WLAN (Wireless Local Area Network). Nonetheless, in areas like office building, public places, school, supermarkets, there the WLAN (Wireless Local Area Network) is used mostly. In limited area, the WLAN work's based on wireless distribution method. Small size, high efficiency, operation on multiple frequencies and low cost, the modern wireless antenna's communication system is being forced to techniques due to new challenges.

To wireless systems the satisfying needs are provided by micro strip antennas due to the advantage, in employing micro strip the antenna's designers have been shown their interest in WLAN systems. Additionally, to minimize the antenna size the fractal geometry surface path with combination could help and to do multi frequency operation it was allowed. In designing an antenna there has fractal technology advantages which are summarize in given ways:
1) To attain high directivity element arrays, under-sampled and low-side lobbies, the frontier and Mass fractals are useful.
2) In multi band antenna designing, used the self-similarity (fractal tree, cantor set)
3) Because of meandering the overall dimension was minimized by the structures of Self-filing fractal like the Peano, Koch/Minkowski, Hilbert, and in small antennas designing it is helpful such as, monopole antennas, loops, or patch.

The demand for wireless system throughput is enhanced these days. To reach the needs, the technology of Multi Input Multi Output (MIMO) has been launched. In between the antenna elements, an efficient isolation was needed by the Multiple Input and Multiple Output antennas practical implementation. Here, with multi band, the MIMO antenna is designed. If we are using multi band technology, over the wide frequency bands the wireless systems communication devices are able to transmit with low power consumption. In the devices, included the other merits based on multi band, which are being low cost; high data rates and bandwidth has increased.

In multi band devices, the front end antenna plays a major role. For the antenna applications the promising solution is planar, because of its simple design, performance, and low cost [5]. This paper presents a hybrid fractal shape planar multi band CDRA antenna utilizing multiband MIMO wireless communications at multiband Applications to achieve good performance.

Dielectric Resonator Antenna (DRA) plays very important role in present generation for the purpose of growth in direct communication systems. For multi band antennas, Dielectric Resonator Antenna (DRA) is used for better performance. There will be reduction in size and in the same way complexity of system will be very low and has very high radiation frequency. Degree of freedom is provided for the antenna which uses the Dielectric Resonator Antenna (DRA), this will provide the separation between ports.

Iii. Literature Survey

Z. Yang, H. Yang, and H. Cui.et.al [6], for Mobile Terminals, presented an Inverted C-Shaped Ground Branches with Compact MIMO Antenna. The proposed antennas geometry was shown in figure 1. FR4 is the substrate, with a loss tangent of 0.02, a thickness of 0.8 mm, and a dielectric constant of 4.4. The overall antenna size is 100 × 65 mm^2. By 50 Ω impedance micro-strip feed line, with size of 15 × 20 $mm^2$the two printed planar elements of antenna are fed, at the top layer they are placed symmetrically. Each element of antenna has driven a shorted strip with a dimension of $W1$, $L4$, $L5$, $L6$ and strip with a dimension of $W1$,$W2$, $L1$, $L2$, and $L3$. Between the two elements, on the ground plane, located the two inverted C-shaped branches, which have a dimension of $L7$, $L8$, and $W1$, and by $W3$ the two branches gap is denoted.

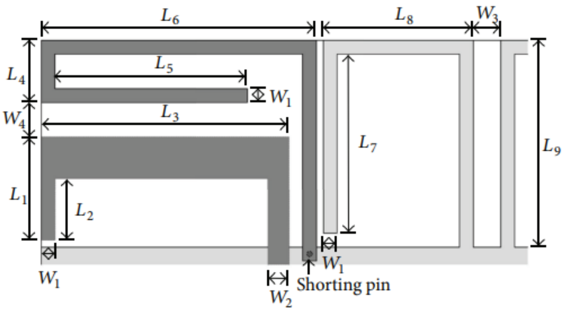

Figure 1: Geometry Of The Proposed Antenna

From 1.3 to 2.0 GHz without the ground branches the values of $S21$ are greater than −15 dB, especially around 1.5 GHz, and almost reach −5 dB. However, between the elements of antenna introduced the inverted C-shaped ground branches to greatly enhance the isolation. As a result, at all frequencies the $S21$ values are less than −16 dB. Meanwhile, by the branches improved the performance of impedance from 2.5 to 3.3 GHz.

At the operating bands, the efficiency of radiation is above 60% and the peak gains are from 1.5 to 3.4 dB. It also can be seen that, the efficiency and gains are more at the frequencies with lower return loss value compared to the frequencies, where the impedance of the antenna is better. The proposed antenna's structure is simple and it can be optimized easily. For mobile terminals of MIMO system the correlation coefficients envelop is less than 0.01 and also obtained the good radiation performances, it was making it suitable.

L. Guo, J. Deng, J. Li, and L. Zhao, et. al. [7], for WLAN applications with the Enhanced Isolation, a Dual Band Inverted-F MIMO Antenna was presented. From meandering inverted F- antenna, evolved the antenna system. A WLAN bandwidth is achieved by involving two meandering monopoles. Between two elements of antenna a high isolation was obtained by etching on the ground with an inverted T-slot and resonant branch was meandered. Figure 2 shows proposed geometry of dual-band inverted-F WLAN MIMO antenna's initial design. For different coupling circumstance (where between two elements of antenna the distance was represented by D) investigated antenna pairs with about D = 0.1 λ0 and D = 0.2 λ0, in this case D equals to 0.115 λ0, which is about 1/8 λ0 (where the wavelength at 2.4 GHz) the overall antenna system's size will be reduced. With a low-cost FR4 substrate the antenna is printed with the dimension of 77.5 mm (L) × 52 mm (W) × 1.6 mm (T) on the top layer (tan δ = 0.02, εr = 4.4). By the 50 Ω micro-strip lines the two elements of antenna are fed with the width of 2.5 mm.

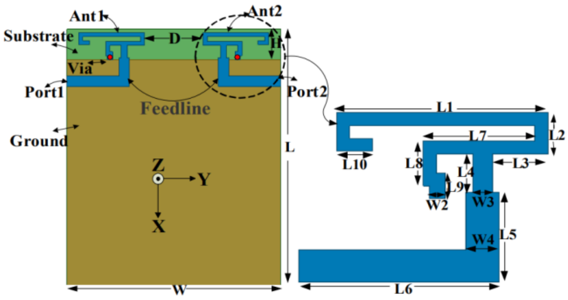

Figure 2: Geometry Of The Original Mimo Antenna

Two decoupling devices are build to achieve high isolation, respectively, for lower band and higher band an inverted T-shaped slot and meandering resonant branch was etched on the ground. Furthermore, to broaden the high band's bandwidth a better impedance matching was achieved by two U-shaped slits that is etched on the 50 Ohm feeding lines. The proposed antenna's impedance bandwidth (S11<-10 dB) that covers 5.15 GHz to 5.825 GHz in the upper band and 2.4 GHz to 2.48 GHz in the lower band and the proposed configuration obtain the 5 GHz WLAN bands and 15 dB isolation within the 2.4 GHz, a significant improvement was shown compared to the MIMO antenna's initial design. The proposed inverted-F-MIMO antenna system was indicated by the measurement and simulation results, for WLAN applications it is quite suitable.

X. Shi, L. Kang, H. Li, and X. Wang, et. al. [8] for Band-Notched UWB Applications, a Compact Offset Micro-strip-Fed MIMO Antenna was explained. The proposed band-notched UWB MIMO antenna's geometry was illustrated in figure 3. With a relative dielectric constant of 4.4 and a thickness of 1.6 mm, on a FR4 substrate with an overall size of 38.5 × 38.5 mm^2 the designed antenna is printed. A parasitic T-shaped strip, two orthogonal microstrip-fed lines are consisted, and with an L-shaped slits pair and a rhombic slot a ground plane was etched. Both the micro-fedlines have three stages from the center at an offset distance for impedance transforming. Between the elements of antenna the parasitic strip placed, in isolation improvement an important role was played. Two major parts are consisted: a strip is perpendicular to the diagonal and the other is along the diagonal. On the other side of the substrate, designed the ground plane. At 5.5 GHz to produce a notched band, used the etched slits on the ground.

An L-shaped slits pair by etching on the ground realized the notched band at 5.5 GHz. With a compact size of 38.5 X 38.5 mm^2, the prototype of antenna has been fabricated and measured. Except sharp rejection band of 5.03-5.97 GHz, an impedance bandwidth is larger than 3.1-10.6 GHz that was achieved by the proposed antenna which were shown in the measured results. Besides, through the whole UWB band a low correlation coefficient envelop is less than 0.02 and low mutual coupling is better than -15 dB can also be obtained. For diversity/MIMO systems the proposed antenna with the compact size and features as mentioned above can be a promising candidate.

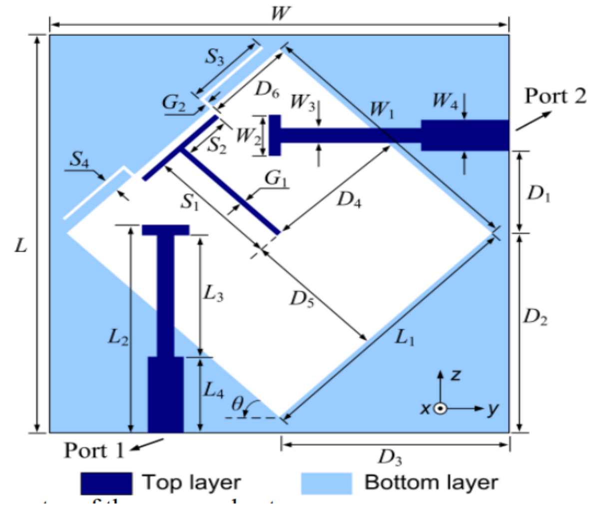

Figure 3: Geometry Of The Proposed Antenna

R. Fan, Y. Yin, J. Ren, and W. Hu, et. al. [9] for UWB Applications there has Compact Printed MIMO Antenna. The proposed UWB MIMO antenna's geometry, with a small size of 32 X 32 mm^2 is shown in Figure 4. With a thickness 0.8 mm and relative permittivity 4.4, on FR 4 substrate it has printed. Two L-shaped slot antenna elements are consisted by the proposed MIMO antenna, it was denoted as LS2 and LS1. To achieve good isolation the two LSs are perpendicularly placed to each other between the two elements of antenna. By a 50 Ω micro-strip line, a rectangular patch and an L-shaped slot was consisted in the antenna's element that is fed. For UWB applications to obtain the bandwidth enhancement, attached a T-shaped stub to the rectangular patch, which consists of a vertical stub and horizontal stub a L3. At low band on the bottom of the ground plane a narrow rectangular slot is cut, in between the elements of antenna to enhance the isolation.

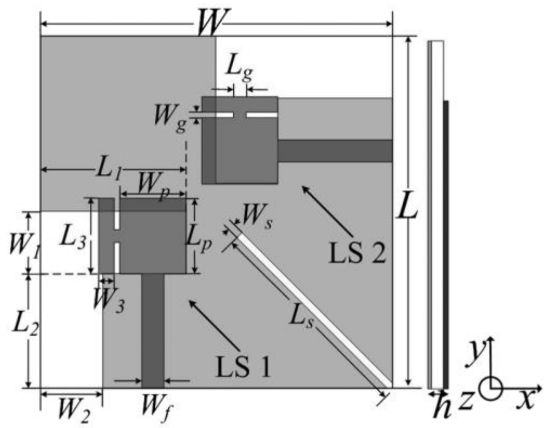

Figure 4: Geometry Of The Proposed Antenna, Top View And Side View

To obtain high isolation the elements of antenna are placed perpendicularly to each other, and to reduce the antenna elements mutual coupling the narrow slot is added in the low frequency band (3-4.5 GHz). There has a compact size of 32 X 32 mm^2 to a proposed MIMO antenna, and the antenna prototype is measured and fabricated. An impedance bandwidth is larger than 3.1–10.6 GHz that was achieved by the proposed antenna which was shown in measured results and through the whole UWB band the low mutual coupling is less than 15 dB. The measurements prove that the proposed antenna is suitable for portable UWB applications.

Z. Ma, H. Zhai, R. Yu, C. Liang, S. Liu, and G. Li, et. al. [10] Dual-Band MIMO Antenna Array was improved by the developed Isolation for Worldwide Interoperability for Microwave Access (WiMAX)/long term evolution (LTE) Mobile Terminals. Eight elements were comprised by MIMO system, two types of planar inverse-F antennas (PIFAs) are included. To achieve dual band property the U-slit was introduced by one type of PIFA, and for the dual resonances an L-slit was introduced by another type of PIFA. To provide polarization diversity placed the two types of PIFAs orthogonally for coupling reduction. Proposed many decoupling methods between different element ports to achieve better isolation performance in a small mobile handset. First, for the various U-slit etched PIFAs (USEPIFAs) ground a disconnected dispose is presented to break the electric current flowing on the shared ground from one USEPIFA to another. Second, on the main MIMO system substrate, utilized a pair of metallic strips for the operation to provide a resonance, which can act as an insulator to avoid inherent edge coupling between the elements around the resonant strips. In addition, on the L-slit etched PIFAs (LSEPIFAs) a deformation series was proposed to improve the mutual coupling further between the adjacent LSEPIFAs, which includes removing three triangle corners from radiator, etching a narrow slit in radiator, and employing an L-corner feedline.

With eight-element, the symmetrical WiMAX/LTE MIMO array configurations were proposed that was shown in Figure 5, where LSEPIFAs and USEPIFAs are the two types of PIFA antennas. For ease integration the eight elements of upper surface (along z axis) are in the same plane. All the above structures are utilized, dual-band MIMO antenna array was improved to achieve an eight-element isolation in a compact dimension of 140 mm×70 mm×9.55 mm^3 for a practical mobile terminal.

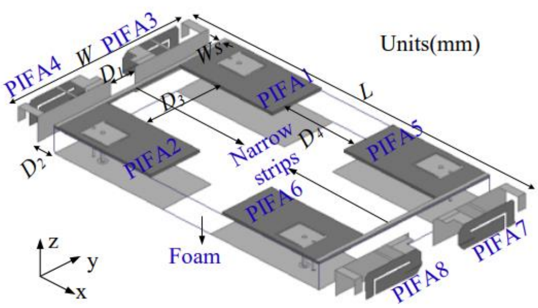

Figure 5: Configurations Of The Proposed Eight-Element Mimo Array

The parasitic resonant strips, the ground plane disconnection, the excellent element isolation (above 20 dB), also the modified PIFAs, and achieved other good MIMO performance with the presented decoupling methods which are included in the design. The overall the MIMO system's dimension is only 140×70×9.55 mm^3, and across the operating bands (3.4-3.6 GHz and 2.6–2.8 GHz) achieved a good return loss (above 10 dB) for all the PIFA elements. Studied the MIMO system's correlation coefficients envelope and radiation patterns, for mobile communications an accepted correlation coefficient and quasi omni-directional radiation were shown across the dual-band operation.

J. Rodriguez, A. S. Hussaini, R. A. Abd-Alhameed, I. T. E. Elfergani, C. H. See2, M. and B. Child, et. al. [11] explained design of a compact tuned antenna system for mobile MIMO applications. The schematic of proposed MIMO antenna systems geometry was shown the in figure 6. In a symmetrical configuration, arranged the radiators of two printed F-slot which was consisted in a structure. The structure is printed on a FR4 substrate with 50.0 X 37.5 X 1.6 mm^3 block, with a loss tangent of 0.02, and a dielectric constant o f 4.4. The slot on the ground has a 15 mm height and a width of 1.75 mm. Each radiator located on the FR4 block's right and left hand sides which had a footprint of 15.0 X 18.0 mm^2. By capacitive compensation achieved the tuning, and realized to accommodate the varactor on the ground by an F-slot. By 50 Ω micro-strip lines (with dimensions 17.0 X 1.5 mm^2) the radiators are fed. With in the design there has additional functionality by the feeding arrangements, and for the GSM1800/1900 band it acts to generate a proper resonant mode.

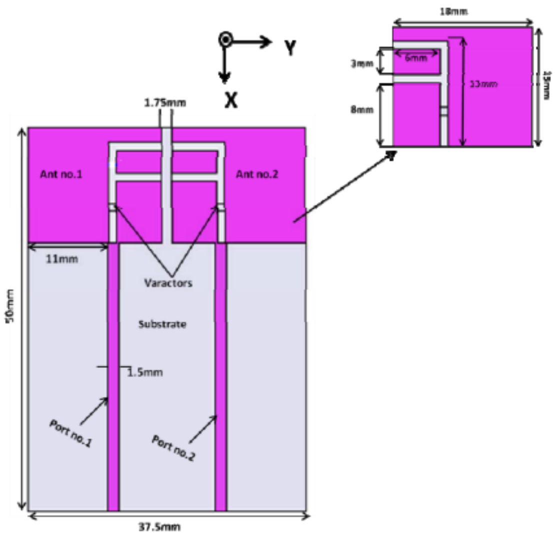

Figure 6: Geometry Of Proposed Antenna

At 2.2 GHz, the MIMO system resonates are unloaded, and approximately, there has a -7 dB (in terms of S21 it was observed) of mutual coupling. The compensation strip's introduction was seen by the next iteration onto the ground plane, on mutual coupling this has the reducing effect approximately to -13 dB, whilst the resonant frequency was left unalteredly.
In a decreased mutual coupling, on the ground plane the slot with the structure of loaded antenna results were presented; in terms of the s-parameters this may be observed. Resonates at 1.72 GHz (S22), and 1.9 GHz (S11) are arranged. Due to the capacitive loading, in the loaded structure there is an asymmetry over the radiating elements. The peak shifts of S22

from 1.82 GHz to 1.90 GHz, and the peak shifts of S11from 1.65 GHz to 1.72 GHz, again observes the reducing level of mutual coupling.

The performances of antenna has predicted without and with decoupling mechanism that have been presented. A mutual coupling should be provided by this tunable MIMO antenna across the full bandwidth, it is better than -13 dB that was indicated by the preliminary results.

IV. Conclusion

In this paper MIMO antenna for 5G applications was studied. In the area of wireless communication an important role was played by the MIMO antenna in the current generation. For 5G wireless technology a specific standard has not been established up to now. However, to put the base several researchers have started for that standard. MIMO is one of the 5G technology basis. From the MIMO technology advantages it was benefitted, for mobile communication an arrays configuration with MIMO antenna system's integration can be provided at mm-wave frequencies. This survey explains the geometrical analysis of different MIMO antennas with several advantages and limitations. Therefore this paper is very useful for researchers while selecting the suitable antennas for specific applications efficiently.

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