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Multi-Array Wideband Slotted MIMO Microstrip Patch Antenna

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Abstract: ***As per the advancement of wireless technologies, 5G will be the next break-through which will be capable to taking data rate in Gbps speed. But to sustain such higher bandwidth as well as reducing signal blocking at such high frequencies, MIMO antenna must be implemented. MIMO antenna is capable of high speed transmission with lesser interference. In this paper, Different MIMO antenna with slots and wideband antenna designs has been discussed. It is found that multi-Array MIMO antenna designs performs better at high bandwidth and show lesser attenuation.***
Keywords: Multiband Antenna, MIMO (Multiple Input Multiple Output), 5G, Wideband, MSA (Microstrip Antenna), VSWR (Voltage Standing Wave Ratio), FR-4.

I. INTRODUCTION

The 5G architecture has been implemented now with the increase in rate of data transmission which will be increased by 5000 time upto 2030 and this will create systems which will work on Gbps speed with latency reduced to less than 1 ms. With the implementation of 5G, the large networks will be converted into a group of small cells which are capable of providing high data rate with better services. This will also leads to reduction in transmission power because now millimeter waves will be used with new high tech modem which provides higher bandwidth, but there is only one problem of signal blocking and attenuation due to higher frequencies [1]. This lead to the requirement of multiple antenna systems like Antenna based on MIMO as they are capable of adjusting transmission parameters to reduce the effect of the wave's millimeter. By 2020, it is expected to launch 5G modem as a wireless technology. The main factor of these 5G antennas is the implementation of MIMO to increase the speed by 10-100 times as compared to 4G. Interference alignment and multi-cell processing can be used with MIMO to reduce interference [6].Using these techniques (multi-cell processing and interference alignment) the cell size is reduced by fixing fimto cells or small cells but this will increase the cost of additional equipment in addition to increasing interference, therefore, the most appropriate option is to use MIMO technology.

5G technology uses millimeter & centimeter wave spectrum that is 3 to 300 GHz, this can increase the bandwidth as well as very high speed of Gigabit-per-second (Gbps) can be attained with it [2]. Since the lower spectrum has been used for other wireless services and wireless applications like Wi-Fi, Bluetooth, Wi-Max etc, therefore higher spectrum is left and can be used for 5G [8]. But using such a high frequency spectrum for 5G also leads to some issues. Free space propagation is one issue at such higher frequencies because lower frequencies can travel more miles and can pass through tress & buildings. While the higher frequencies has problem in passing through tress & buildings like high density material as well as can travel shorter distances creates small coverage area. Nevertheless, such properties are not always an issue. Frequency reuse technique can be used to utilize losses due to propagation and this can be done by making small cell base stations which are also called as pico-cells & femto-cells. The environmental conditions like rains also creates problem in propagation of higher frequencies. Snowfall, fog, rain etc leads to bad transmission. This also leads to bad strength and bad signal quality due to attenuation by atmosphere. This issue can be solved by introducing directional antenna with high gain.

The change in requirements of wireless technologies and its applications leads to requirements of new models of antenna which can be used for such change in dynamic requirements. The newer wireless applications required mostly high speed and high bandwidth. It is found that antenna models which can support multimedia services and can work on higher channel capacity, system reliability and high data rate are used for 4^{th} generation communication system [3]. This can be achieved by using latest technology antenna that is MIMO antenna. The biggest advantage of this antenna is that it can work as a multi-channel trans-receiver without requiring additional bandwidth and extra radiation power. It is hard to design MIMO antenna with multiple arrays because these designs are very small and also share same substrate. This also leads to very small space between two elements inside the antenna and creates high mutual coupling in between antenna elements. This leads to a challenge of designing an antenna with has better isolation to remove coupling effect [9].

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II. MIMO SYSTEM

Any trans-receiver system has one oscillator, one band pass filter (BPF), one low noise amplifier (LNA) and an antenna. Slotted microstrip antenna is designed out of microstrip patch antenna. In MIMO technology, several antenna elements in the single unit is used at both source and destination units. These multiple antennas are used together to reduce errors as well as increase data rates. MIMO is a smart antenna model which is used for 5G, other such smart models are MISO (Multiple input, Single output) and SIMO (Single input, Multiple output). While conventional systems make use of single antenna at both source and destination. Multipath effects creates a problem in MIMO system. Scattering of EM signal occur due to high density obstacles like valley, trees, buildings, cables etc, this leads to problems like delay in signal, signal fading, cut off of signal etc. Such issues leads to problems in communication system like decrease in data rate and errors in signal [7].

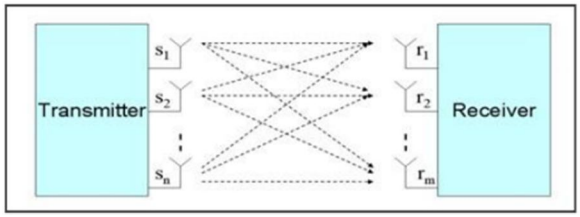

Fig. 1: MIMO System

The use of multiple antennas in MIMO system reduces the effect of delay of signal because of multipath or missing signal since multiple signals can be sent at once. Television, Wireless local area network, mobile communication systems uses MIMO systems for better transmission [4].

III. ADVANTAGES OF MIMO SYSTEM

There are following benefits of MIMO system,

A. High Data Rate

Multiple antennas can transmit multiple data together and thus increase the speed of communication as well as enable multi user transmission.

B. High Reliabillity

Due to multiple antenna, there are many path of propagation for signal to travel and thus enhances the reliability.

C. Increase Efficiency

Since these antennas are unidirectional therefore transmission station emits all the radiations in single directional and thus increases energy efficiency.

D. Deceases Interference

Spreading interference can be reduced because now antenna is not transmitting in multiple directions. According to Shannon's Law, channel capacity is equated as,

$$C = B\ log_2(1 + \frac{S}{N}) \qquad (1)$$

As per the above equation, it can be seen that the main parameter to achieve maximum speed of communication is bandwidth because it is directly proportional to capacity while SNR defines the signal transmission quality. One of the advantage of MIMO systems is that it can increase channel capacity without changing the bandwidth. Another advantage of MIMO is its linear increase in channel capacity with respect to increase in antenna counts while for all others like SISO, SIMO & MISO channel capacity increases logarithmically. There is only one path in between each of the source & destination pairs, it indicates the transmission of same information in multiple directions and thus multiple copy of same information will be received at destination end which indicates reliability.

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IV. LITERATURE SURVEY ON MIMO ANTENNA

Arwa Abdulkareem, Malik Jasim Farhan are proposed a new design of MIMO microstrip patch antenna. The antenna is developed with FR-4 top dielectric layer and one ground plane while it is fed by microstrip feed line of characteristics impedance of 50 Ohm. The bandwidth of 4.337 GHz with 3.86 dBi gain and thus it is suitable for 5G applications.
Gain and bandwidth is achieved by modifying ground plane and slots on patch. Sweep parameter method is used to calculate the dimensions. CST simulation software is used [1].

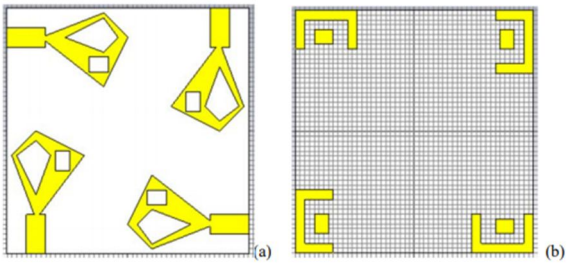

Fig. 2: Four Array MIMO antenna [1]

Daniyal Ali Sehrai, Mujeeb Abdullah, Ahsan Altaf, Saad Hassan Kiani, Fazal Muhammad, Muhammad Tufail, Muhammad Irfan, Adam Glowacz and Saifur Rahman have proposed a 5G MIMO antenna with a tree shape planer 4 array elements to achieve wide bandwidth. This wide bandwidth has been achieved by using 4 different arcs in the radiating element. Thicker Rogers-5880 substrate material of 1.57 mm is used with loss tangent & relative dielectric constant of 0.0009 and 2.2 respectively. They have achieved an impedance bandwidth of 17 GHz with isolation of more than 20 dB. These parameters helps in lesser attenuation occurs due to atmosphere at higher frequencies. 70% efficiency is achieved. The achieved performance parameters of MIMO are MEG less than 3dB and ECC less than 0.5dB. CST software is used for simulation [2].

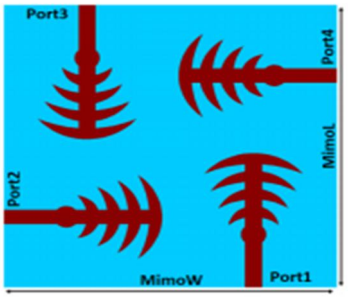

Fig. 3: Wideband MIMO antenna [2]

BanothuYVNRSwamy, Polepalli Siddaiah presented a multiband antenna based on MIMO for wireless applications. This antenna consists of 2x2 array of MIMO and has both vertical and horizontal radiating elements. Polarization diversity is achieved in this design. Here stepped ground with slots and orthogonal placement of elements in the design of antenna helps in reducing coupling effect. Substrate used is FR-4. The antenna resonating frequency covers three bands 2.11GHz-2.23GHz, 3.24GHz-3.32GHz and 3.92GHz-4.42GHz with a VSWR value less than 2. -10 dB isolation is achieved for all resonating frequencies. Optimized gain has been achieved at center frequencies of 2.18GHz, 3.28GHz and 4.17GHz. It can be used in applications like WLAN, WiMAX and LTE bands [3].

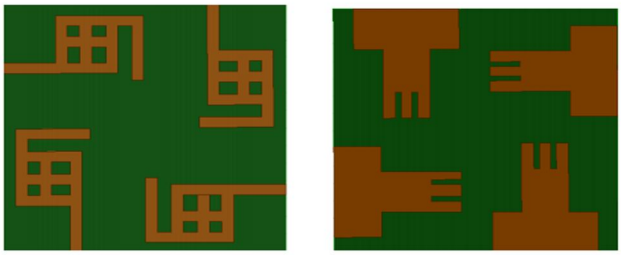

Fig. 4: 2x2 MIMO antenna [3]

Nuhung Suleman and Rahmat has discussed that multiple antennas are used to create a single MIMO system to increase channel capacity. They have used slot method to achieve desired frequency with MIMO of 2x2 array. Advanced Design System 2009 software (ADS 2009) software is used for simulations. FR-4 is used as a substrate. They have achieved a fc (single / MIMO 2x2) with f1 of 0.9 GHz / 0.9 GHz, f2 of 1.8 GHz / 1.8 GHz, f3 of 2.4 GHz / 2.38 GHz, f4 of 3.5 GHz / 3.52 GHz, and f5 3.8 of GHz / 3.79 GHz [4].

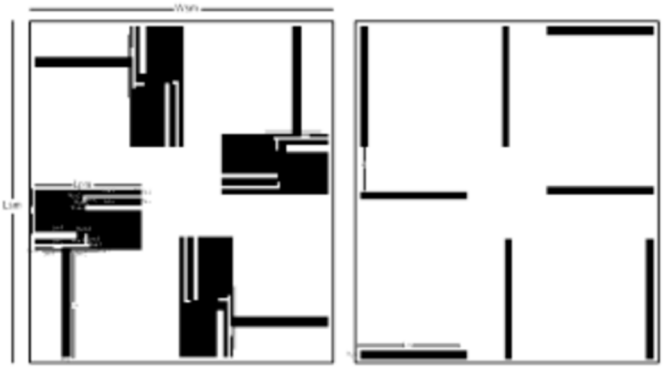

Fig. 5: Antenna with slot and 2x2 MIMO [4]

Mousami Soni, Prof. Mahesh Goud discussed that sue to compactness and low profile, micro strip patch antenna is very good for low profile applications. They have created a design consists of 2 element slots which are transformer coupled with both full and slotted ground. Their deign achieved a center frequency of 5.2Ghz with -21dB return loss. With full ground design, achieved center frequency is 4.3 GHz with -17 return loss and -10 dB isolation. It is found that better isolation can be achieved by using slots in ground plane [5].

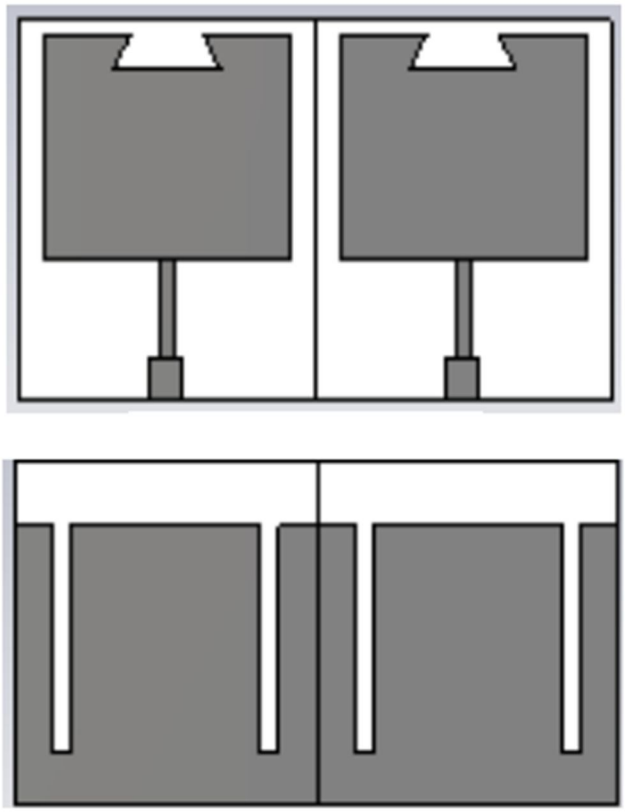

Fig. 6: 2x1 Slotted Patch Antenna [5]

V. CONCLUSION

Multi-array with slots MIMO antenna is very effective with 5G technology. In the literature survey, it is found that MIMO antenna is capable to work at higher transmission rate of Gbps with very less attenuation. Researchers have created designs to reduce coupling effect in MIMO system by using multiple array and slots. MIMO antenna increases the overall capacity of the system by increasing signal to noise ratio. So it can concluded that Multiple array slotted MIMO antenna is very suitable for high speed 5G technology.

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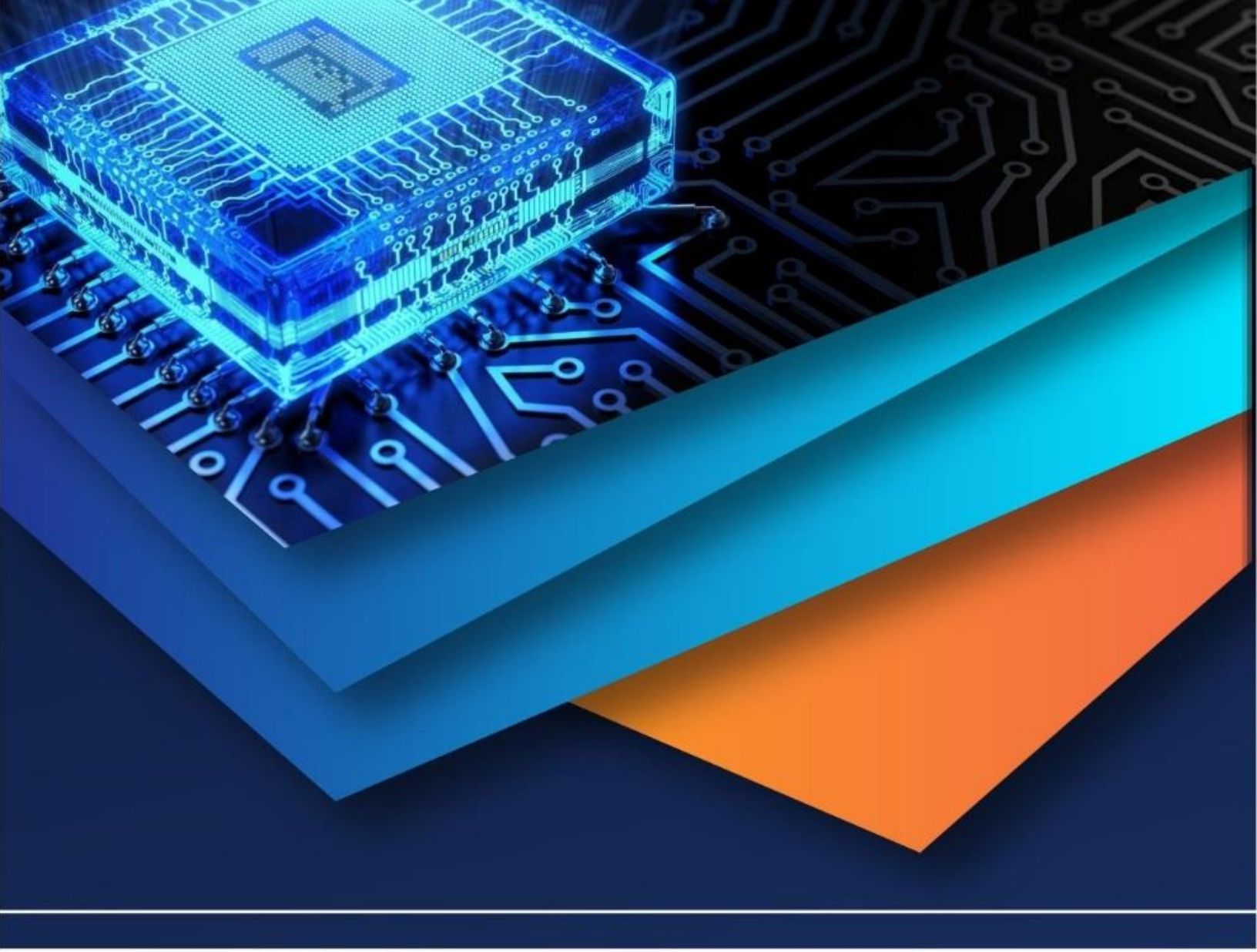

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