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Different Methods of Reducing Mutual Coupling between Microstrip MIMO Antenna: A Review

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Abstract

Now a day's the MIMO (Multiple Input Multiple Output) antennas are turn out to be a hot subject of study. The most common necessity of today's wireless communication system is high data rate along with to neutralization of the effect of fading when signal propagates through various surroundings, thus MIMO antenna system is turn out to be solitary solutions of this. For augmentation of range and dependability of the wireless system mainly used technology is MIMO antenna system. The main problem with MIMO antenna is strong mutual coupling stuck between antenna elements due to which there is signal interference between them and hence there is significant decrement in antenna's performance by the higher value of mutual coupling. Therefore the value of mutual coupling should be low as much as possible. This paper shows different procedure projected for reducing the value of mutual coupling among antenna elements.

Introduction

Microstrip patch Antenna is a low profile, conformable to planner and non-planner surfaces, uncomplicated and economical to construct via contemporary printed circuit tools. It can be grown on a flat plane. In general the patch is in the rectangular type in addition it is also available in spherical, cylindrical or in other shapes. The sheet on which it is grown, which is of metal, is called "ground plane". The length of the patch is half of the wavelength i.e. "λ/2". The foremost disadvantage of this antenna is their inefficiency along with very narrow bandwidth, low power, high Q, poor diversity, low gain. To rise above these problems multiple patches are designed on a same ground plane on receiver as well as on transmitting end, this structure of design is known as MIMO. To increase the capacity of radio links MIMO technology is used. In MIMO technology multiple transmit with receive antennas are used en route for make use of multipath propagation (fig. 1).

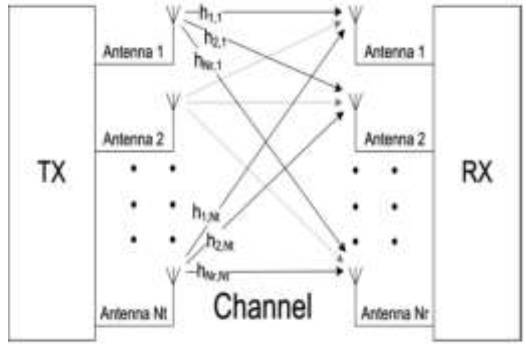

Fig.1 MIMO system

The schema of MIMO antennas exist for high data rate as well as it counteracts the effect of fading during signal propagation through various environments. When we use MIMO antenna system the probability of reception and reliability is more as compare to single radiating patch [1]. The main advantage of MIMO antenna system is higher data rate which is accomplished by without increase in the transmission power or bandwidth [2].

The main weakness of MIMO antenna is mutual coupling (MC) between the near antenna elements due to this the antenna factors are decreased [3]. In recent years there are many studies are proposed for reducing the mutual coupling between the antenna elements. Here we present assess on different MIMO antenna technologies used for reducing the mutual coupling.

Techniques to improve mutual coupling (MC) in MIMO antenna system

In microstrip patch antenna when we are using multiple patches on a single plane to form MIMO antenna, the space between these patches are very narrow it is mostly of $\lambda/4$ order, then there is more chance of having MC. MC in antenna illustrates energy absorbed by one antenna's receiver when a further nearby antenna is operating. In the transmitting mode energy that should be radiated away is absorbed by nearby antenna in the similar way in receiving mode energy that could have been captured by one antenna is instead absorbed by a nearby antenna. It causes the antenna factors to be decrease and hence the efficiency of the antenna is reduced at very significant level. In past few years there are so much work is proposed to reduce MC between the closely spaced patches of antenna. Here we discussed some techniques which show reduction in MC and hence once the MC is reduced the antenna factors are also increases.

a) Resonators
b) Defected Ground Structures
c) Parasitic element

a) Resonators

A resonator is a type of radio antenna typically used at microwave frequencies. It consists of chunks of clay substance of different shapes. These are mounted on dielectric substrate or on a ground. These antennas have lower losses and high efficiency than metal antennas. It has no inherent loss and high radiation efficiency and hence effective in reducing MC.

A MIMO dielectric resonator (DR) antenna with superior isolation was projected in [4] for the future 5G mm-wave applications. Two rectangular DRs were accumulated on a substrate energized by rectangular microstrip-fed slots beneath DRs. Each DR had a metal strip printed on its upper surface affecting the strongest part of the coupling field away from the stimulating slot to get better isolation among two antenna elements. The proposed antenna design is shown in fig. 2.

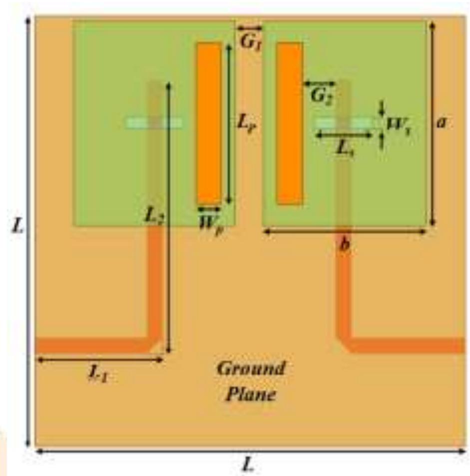

Fig. 2. Geometry structure of the proposed MIMO DRA

The projected antenna attains utmost enhancement of 12 dB on the isolation over 27.5 - 28.35 GHz frequency band.

b) Defected Ground Structures

The current formed on the ground plane is be able to be coupled to neighboring elements causing high coupling which worsen the MIMO antenna system isolation and correlation. The coupling between neighboring antenna elements can be minimized by the change in the ground plane [5]. Changes can be established as slits [6], [7] or it can be of dumble-shaped, defects etc [8], [9].

It operates as band stop filter also provide limit to the coupled fields among the nearest antenna elements by diminishing the current on the ground plane. A DGS is sorted by its band stop uniqueness among which it avoids the transmission of electromagnetic waves. A DGS is placed underneath a transmission line which withdraws the EMF fields around the defect. Electric fields near the DGS gives ascend to the capacitance effect and the superficial currents around a defect cause an inductance consequence. DGS operates as band stop filter and suppresses the higher harmonics [10].

A novel dual-band two port Multiple-Input-Multiple-Output (MIMO) antenna at 28/38 GHz bands for the approaching 5G wireless applications was configured and manufactured in [11]. The MIMO antenna takes in identically positioned two rectangular slotted patches with inverted I-shaped slots at the lower border of the mobile substrate. The system had an overall size of 55 x 110 x 0.508 mm^3 (fig.4). The antenna works in a 1.0683 (27.58–28.649) GHz bandwidth at 28 GHz and 1.4306 (37.213-38.643) GHz 38 GHz. A defected ground construction (DGS) to raise the isolation among the two ports and magnify the antenna radiation was introduced. The isolation was further desirable than -29.4 dB and -27.3 dB for the higher and lower frequencies, respectively among antenna elements.

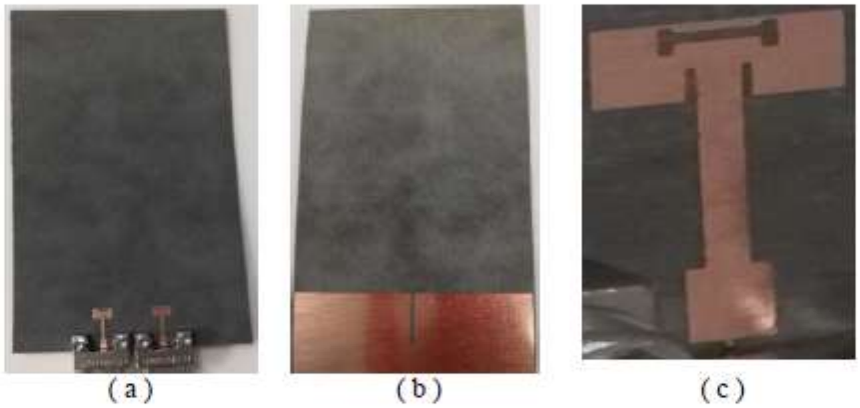

Fig. 4Introduced (a) 5G MIMO Antenna,(b) Ground plane and (c) Single element

c) Parasitic element

Parasitic elements are not truly coupled with the antennas. These elements are utilized in the middle of the antennas to finish element of the coupled fields connecting them by creating an opposite coupling field thus minimizing the total coupling on the target antenna. Also parasitic elements are designed to control the bandwidth, range of isolation and the amount of coupling [12].

The design of MIMO antenna with beam steer-ability was projected for 5G communication structure, which works at 38 GHz frequency. In [13], the projected antenna was developed from a driven element through coaxial probe, even as four parasitic elements enclosed the driven element through shorting pin. The 4 parasitic elements perform as either reflector or director depending on the shorting pin configuration as replicate to Yagi-Uda patch antenna concept. By altering the status of shorting pin location either ON or OFF mode concurrently on the parasitic elements, the radiation pattern can be varied, as a result achieving the radiation configurability (fig. 5).

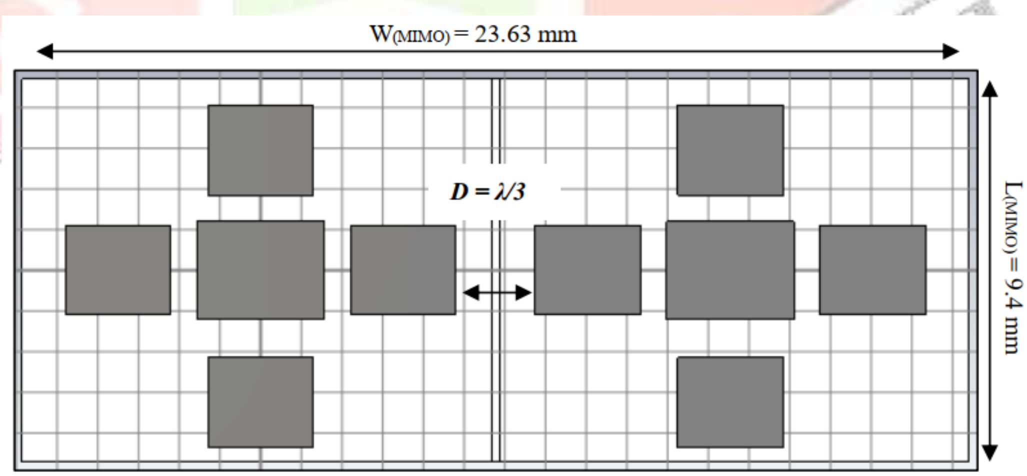

Fig. 5 2-Element MIMO Antenna

This shorting pin contributes to the antenna's electrical dimensional changes that manage to control the beam steering and return loss performance. By managing the ON and OFF state condition of the integrated shorting pin, nine beam steering angles can be achieved. The proposed Multiple-Input Multiple-Output (MIMO) antenna consists of two identical patch elements with certain D separation distance on the Rogers RT5880. The significant parameters performance such as mutual coupling and correlation coefficient are been observed. The 2x2 MIMO antenna provides the most optimum results with bandwidth impedance of 1.783 GHz (4.7%) and achieve the reflection coefficient of -20 dB at 38 GHz application. The efficiency of the presented antenna has successfully achieved more than 80% with high gain of more than 7dBi.

Conclusion

Many investigators have contributed towards the improvement of channel capacity, Bit Error Rate (BER), diversity and gain of the multi element antennas for MIMO systems. However there are still plenty of opportunities for the researchers to work on various reduction techniques in MC. In this review paper various MC reduction techniques are discussed. Along with the above discussed methods there are also having other methods for reducing the MC.

MC degrades the system performance in terms of pattern diversity and hence MC reduction is a vast and an interesting area of research which has direct application for next generation wireless communication.

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