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Design of a Wideband 8x8 MIMO Microstrip Patch Antenna for 5G Applications

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Abstract - *In the Recent technology development most of the used antennas are low-profile antennas elements with Multi-Input Multi-Output (MIMO) antenna array is presented for 5G devices. The paper focusses on the system that can operate at a wideband range that covers 4.9–6.2 GHz. Desirable antenna wideband capability is obtained by introducing slots in the patch where the overall antenna size is (46.42 mm × 46.42 mm). The technique of band enhancement of creating slots in the antenna is used so far. The simulated results of the presented paper of MIMO antenna array show that in the achieved wide band, the proposed design can achieve good antenna performances, with isolation >16 and return loss <-11dB are calculated. The antenna gain and radiation pattern are demonstrated. The proposed Multi-Input Multi-Output (MIMO) antenna system presents small size, simple design and wider bandwidth. This MIMO antenna parameters have been studied with the HFSS software to obtain a better output.*

***Key Words*: wideband, MIMO antenna, microstrip patch antenna, 5G mobile communication**

1.INTRODUCTION

Mostly the antennas are single element and it is difficult to achieve higher gains and channel capacity. Few designs are array-based being fed through single excitation have approximately the same channel capacity. That is why the frequency channels are busy most of the time, which reduces the data rate. Moreover, the bandwidths are very low to accommodate the greater number of users. Therefore, it is inevitable to use the MIMO technique for 5G bands to accommodate a greater number of users and provide them with a suitable higher data rate and better throughput performance.

Despite many desirable features, 5G has a serious low penetration power problem that signal fades away on the reaching to the receiver side from the transmitter side using one ante

In this paper, 8 x 8 antenna array with wide operating bandwidth that covers 4.9-6.2 GHz is proposed for 5G effective communication needed in 5G equipment. By multiplying the number of antenna elements at both the receiver and transmitter side, we can get a better data rate and channel capacity.

The microstrip slotted antennas are used for miniaturization, low profile, inexpensive, lightweight, simplicity, low profile and reproducibility.

By using open ended and closed ended slots band enhancement and compactness is achieved. It also helps in impedance matching, gain enhancement, isolation and for shifting the frequency at desired frequency.

The reflection coefficients of the antenna design is evaluated to be less than −11 dB across 4.9–6.2 GHz, with isolation greater than 16 dB. The S parameters, radiation performances (radiation pattern, total efficiency and gain) are investigated. ANSYS HFSS is used to obtain the simulated results.

2. ANTENNNA DIMENSIONS

The specific geometry that has been adapted in this paper for the antenna element can be seen in the figure shown below revealing the 8 element MIMO antenna array. The designed antenna uses FR-4 substrate with relative permittivity= 4.4 and loss tangent= 0.025 with the size 200 mm x 97 mm x 3 mm. The wideband (4.9–6.2 GHz) is obtained by introducing slots where the overall antenna size is (46.42 mm × 46.42 mm).

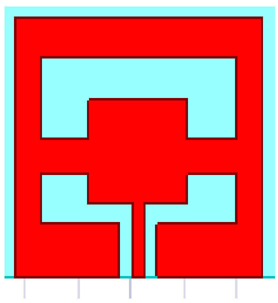

Fig -1: Single element of the MIMO antenna system

1.2 Design Equations for Patch

$$W = \frac{C}{2\,fo}\sqrt{\frac{2}{\varepsilon r + 1}}$$

$$\varepsilon eff = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2}$$

$$Leff = \frac{c}{2fr\sqrt{\varepsilon eff}}$$

$$L = Leff - 2\Delta L$$

$$\Delta L = h \times 0.412 \frac{(\varepsilon eff + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon eff - 0.258)(\frac{w}{h} + 0.8)}$$

Where, w =width of the patch

L =length of the patch

F =Resonant frequency

ε_r =Dielectric constant of substrate

3. DESIGN AND CONSTRUCTION

In the fig 1 the specific structure of the antenna element is shown. The overall square patch is 46.42 mm^2. A close ended and an open ended slot is etched of the shape revealed in the fig 1 which acts as the dipole to extend the band. The width of the feed line was designed to be 50 ohms for probe feeding. The antenna is inset fed.

The MIMO Antenna array is designed using the 8 single elements on FR-4substrate with relative permittivity of 4.4 and loss tangentof 0.025 as shown in the fig 2 below.

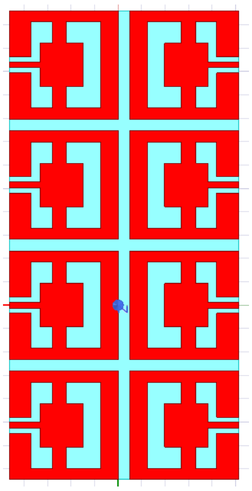

Fig -2: The proposed design of 8x8 MIMO Antenna

4. RESULTS AND DISCUSSION

4.1 S Parameter

Using the HFSS the results of the proposed antenna structure have been simulated. It can be seen in fig 3 that each element can cover the bandwidth from 4.9 to 6.2GHz with return loss less than -11 dB. A return loss of -11.5 dB and -13 dB is observed at 5GHz and 6GHz respectively. The isolation between the pair of the antenna elements is more than 16 dB.

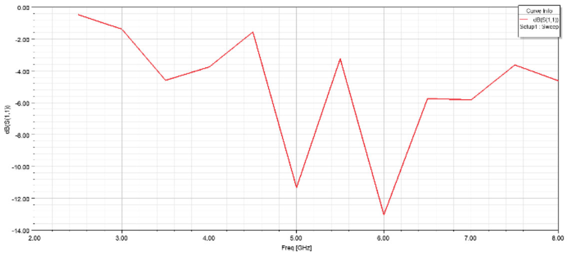

Fig -3: Simulated S11 parameter

4.2 Radiation Performances

The MIMO antenna is simulated with the HFSS software which shows the result in the x and y direction which can be shown in fig.4 at 3.5 GHz and fig.5 at 6 GHz. As can be seen from both the figures the radiation is almost unidirectional. . The simulated 3D patterns at the frequencies 3.5 GHz, 5 GHz and 6 GHz are shown in fig. 6, fig.7 and fig.8.

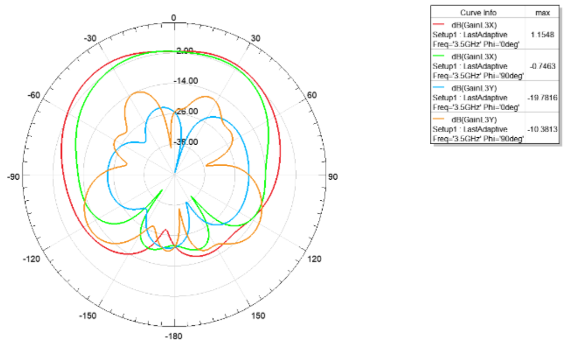

Fig -4: Simulated radiation pattern in the xy plane at 3.5 GHZ

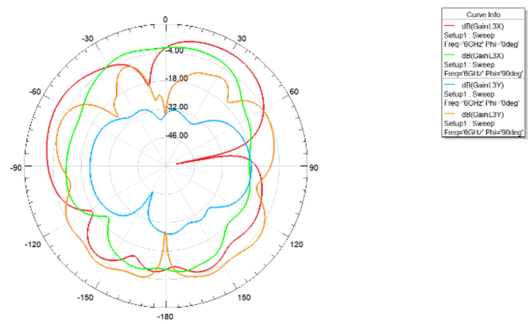

Fig -5: Simulated radiation pattern in the xy plane at 6 GHZ

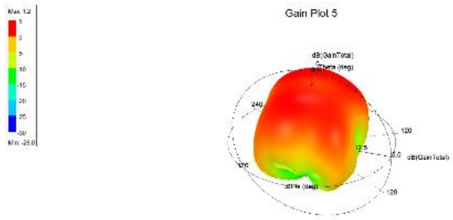

Fig -6: Simulated 3D Gain at 3.5 GHz

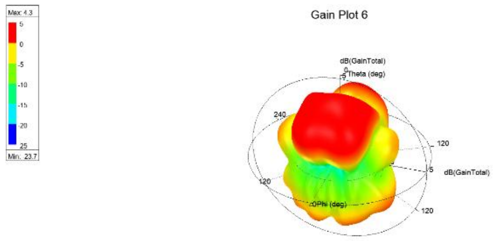

Fig -7: Simulated 3D Gain at 5 GHz

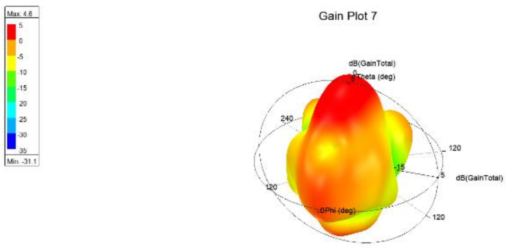

Fig -8: Simulated 3D Gain at 6GHz

Table -1: Simulated return loss and gain at different frequencies

Return loss and Gain at different frequencies		
Frequency	Return loss (dB)	Gain (dB)
3.5 GHz	-4.5 dB	1.2 dB
5 GHz	-11.5 dB	4.3 dB
6 GHz	-13 dB	4.6 dB

5. CONCLUSIONS

A 8x8 element wideband (4.9–6.2 GHz) MIMO antenna has been designed using 8 single 46.42 mm^2 slotted microstrip line fed planar patch antennas on FR-4 substrate of the size 200 mm x 97 mm x 3 mm. Impedance matching and close ended and open ended slot is used designing to achieve frequency adjustment, compactness and good performance. The bandwidth of 1.3 GHz, covering 4.9–6.2 GHz band with 4.6 dBi peak gain of the antenna, isolation >16 dB and return loss <-11dB is achieved. This antenna design of array can be used for 5G communication to various applications.

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