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Characteristics MIMO 2x4 Antenna for 5G Communication System

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Abstract

This paper presents the characteristic MIMO 2x4 antenna for 5G communication system. The proposed antenna works at 28 GHz and simulated by using CST simulation software. The antenna uses RT Duroid 5880 substrate with dielectric constant of 2.2. The MIMO antenna consists of eight elements with rectangular patches and inset feeding. Thedimension of patch (Wp x Lp) is 6 mm x 8 mm. There are three (3) antenna configurations derived in this paper such as; single element, 1x4 elements and 2x4 elements. The MIMO 1x4 elements antenna configuration is designed based on the single element antenna with the distance between center to center elements antennas of 5 mm. The MIMO 2x4 antenna is formed from the MIMO 1x4 element configuration with the opposite direction. The 2x4 element antenna, a distance between opposite antenna elements is 10 mm. From the simulation results, it is shown that by increasing the number elements of antenna affect to the directivity and the return loss. Antenna with 2x4 elements has 14 dBi of directivity with the return loss of -19 dB. While antenna with 1x4 elements, the directivity obtained is 14.3 dBi with return loss of -18 dB.

Keywords*: MIMO Antenna; 5G Antenna; 28 GHz; Microstrip Antenna*

1. Introduction

Future fifth generation (5G) wireless communication networks will make an important difference and will add more services and benefits to the world over 4G [1].Requirement of large bandwidth is the key problem of 5G wireless network which can be fulfilled by huge bandwidth in mm wave band 30 GHz to 300 GHz [2]. 5G requires a high efficiency antenna system with wide bandwidth for growing high speed media [3]. In the 5G era, many things like electronic devices, vehicles and equipment in offices and homes will connect wireless via the Internet. Compared to the 4G system, one of the major differences in the 5G cellular system is a higher frequency shift where it is easier to get wider bandwidth [4].

MIMO technology makes a major breakthrough by satisfying the demand for high quality mobile communications services without the use of additional radio resources and has significant capability to increase data throughput without additional bandwidth or power transmitter. For optimal performance, the patch antenna topology typically need to be integrated on the substrate with active circuits using low-loss interconnects and feed-lines [5]. Since millimeter wave bands have relatively higher propagation loss in air, high-gain antennas are required with narrow beam-width and beam-steering control [6-7]. Therefore, tominiaturize the antennas capable of providing wide bandwidth or impedance matching and acceptable gain will be challenging task [8]. Notably, in usual sparse array architectures, the quest for low sidelobes, which is indeed of interest in multibeam applications, leaves empty a large portion of the aperture plane. Such feature results in a reduction of the antenna directivity (and gain) with respect to the theoretical maximum performance [9].

Researchers around the world have published their papers on antenna for 5G Wireless communication [3,6,10]. In paper [3], a design procedure of phase controlled linear adaptive array antenna operating at 38 GHz for 5G application was presented. The Wilkinson equal power divider/combiner feeding network is loaded with the antenna elements for equal power distribution. The Obtained gain of.the antenna is 12 Bi.at.the.operating.frequency of 38 GHz, -15 dB of isolation is observed between the array antenna elements at the operating frequency.

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Paper [10] described a printed patch antenna array for 37 GHz point-to-point wireless links. The antenna array consists of five elements with rectangular patch and uniform distribution. It has a compact size of 30.25 x 9.5 mm with operating frequency at 37 GHz that covers future 5G applications. The designed antenna used a substrate with a relative dielectric permittivity of 2.2 and a thickness of 0.508 mm with 50 Ω Paper [6] presented high-performance and ultra-miniaturized mm-wave building block structures on panel-scale processed 3D glass packages for high-speed 5G communication standards at 28 and 39 GHz bands. To demonstrate the benefits of glass for 5G communications, various topologies of microstrip-fed patch antennas for different resonant frequencies and compact conductor-backed co-planar waveguides were modeled and designed for high bandwidth and efficiency in the mm-wave bands. The fabricated conductor-backed coplanar waveguides show insertion losses of 0.2-0.3 dB/mm with a channel length of 1.86 mm, and the fabricated antennas have more than around 6% bandwidth in the frequency range of 35 to 39 GHz.

This paper describes the characteristics of MIMO 2x4 antenna for 5G communication system. The proposed antenna works at frequency of 28 GHz. The antenna is designed by adding slot on patch and inset feeding technique.This technique is more efficient to get the desired characterization. The structure of this paper as follows: starting with the introduction then followed by the antenna design for single, 1x4 and 2x4 configurations in section 2. Results and analysis provides in section 3. Last, all the results are concluded in conclusion section.

2. 5G Antenna Designs and Methods

In this section, three (3) configurations antennas, single element; 1x4 elements; and 2x4 elements will be described. First, single element antenna is designed to meet the desired requirement such as frequency (28 GHz) and return loss. Then, this single element is used to form the MIMO configurations, 1x4 elements and 2x4 elements.

2.1. Single Element Antenna

This antenna uses RT Duroid 5880 as a substrate. The substrate parameters are summarized in Table 1. The basic design of rectangular antenna is derived from [3] with adding slot on patch.The slot gives significant shifting in working frequency. Figure 1 presents the geometry of 28 GHz antenna design. The inset feeding is used to provide good impedance matching. Table 2 lists the dimensions used in the antenna design. The patch width (Wp) is 6 mm with patch length (Lp) of 8 mm. The feeding line is 5x0.3 mm.

Table 1. RT Duroid 5880 Parameters

Parameters	Value
Dielectric constant (εr)	2.2
Substrate thickness (h)	0.254 mm
Loss tangent (δ)	0.0009

Table 2. Dimensions of antenna

Parameter	Value(mm)
W	10
L	10
H	0.254
Wp	6
Lp	8
Wf	0.3
H	5
Lf	1
Wa	1
La1	2.5
Wb1	4
Wb2	0.6
Wc	2
Lc1	1
A	1
C	1

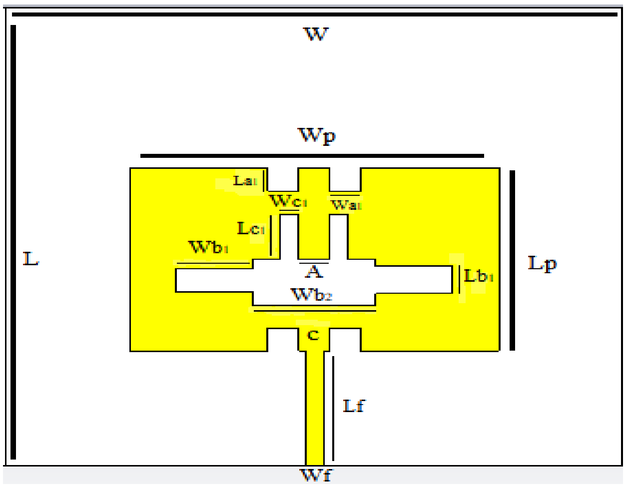


Figure 1. The geometry of single element antenna design

2.2. 1x4 Elements Antenna

The MIMO1x4 elements antenna configuration is designed based on the previous single element antenna with the distance between center to center elements antennas of 5 mm as shown in Figure 2. This is the optimized distance that provides the desired working frequency of 28 GHz. In fact, decreasing or increasing the distance gives the frequency shifting.

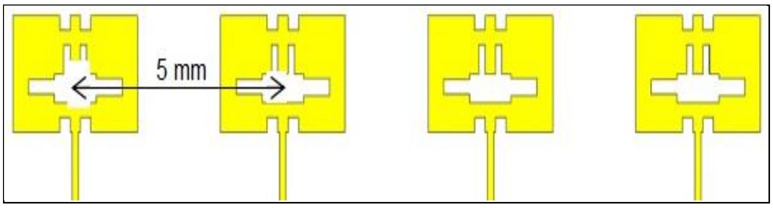


Figure 2. MIMO 1x4 elements antenna

2.3. 2x4 Elements antenna

Figure 3 shows the 2x4 MIMO element antenna configuration. The MIMO antenna is formed from the previous MIMO 1x4 element configuration in the opposite direction. The 2x4 element antenna, a distance between opposite antenna elements is 10 mm.

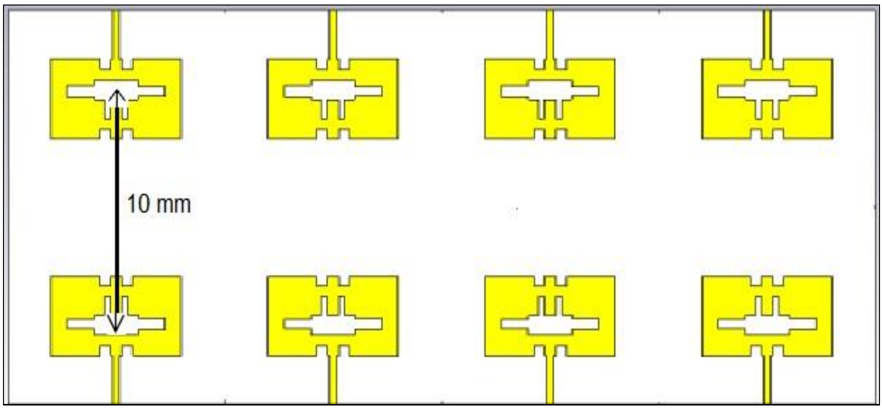


Figure 3. MIMO 2x4 elements antenna

3. Results and Analysis

3.1. Single Element Antenna

The simulated return loss is illustrated in Figure 4. It provides -18 dB at 28 GHz and bandwidth of 500 MHz with respect to -10 dB. Figure 5 shows 2D and 3D simulated radiation patterns at 28 GHz. As shown in Figure 5, this antenna has directivity of 7.82 dBi.

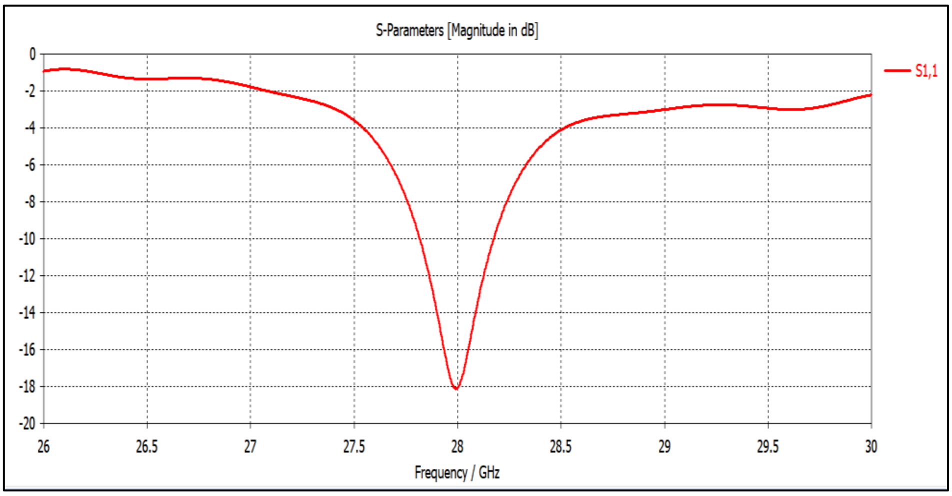


Figure 4. The simulated return loss of single element antenna

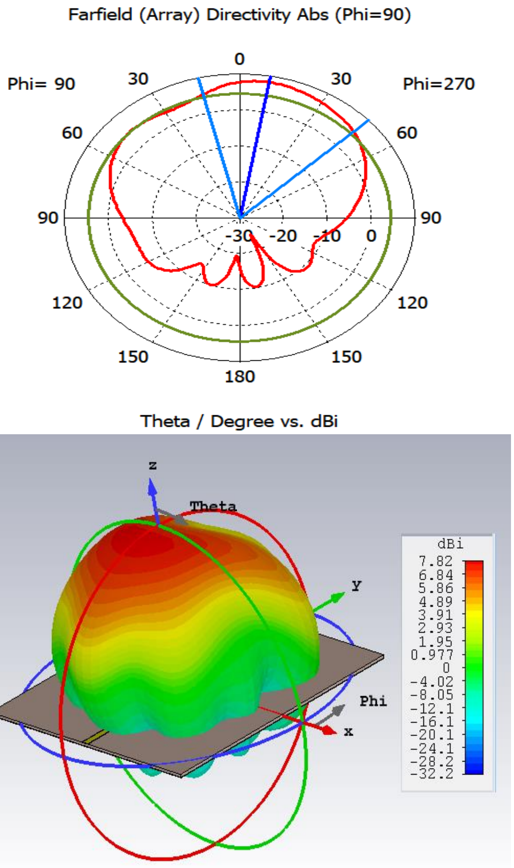


Figure 5. Radiation patterns of a single element antenna at 28 GHz

3.2 1x4 Elements Antenna

The simulated return loss is presented in Figure 6. The return loss slightly increasesto-16.381 dB compared to the previous single element. The isolation between the consecutive ports, S21, S32, S43 etc are well below -20 dB showing a lesser mutual coupling between them. The simulated radiation pattern is presented in Figure 7. It was observed that there was an increase in antenna directivity from 7.82 dBi to 14.3 dBi.

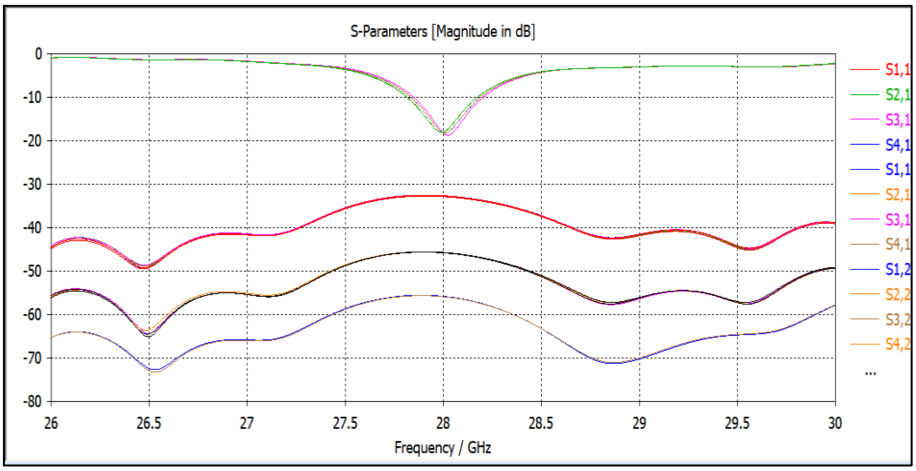
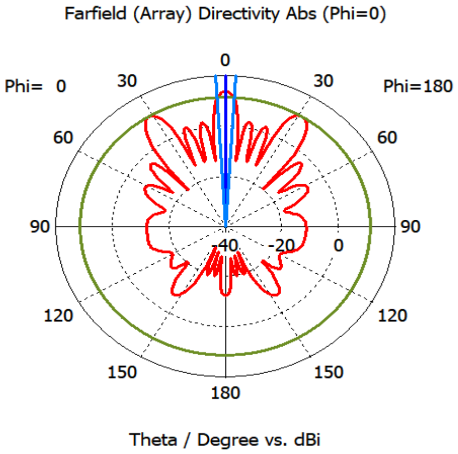


Figure 6. The simulated S-parameters of 1x4 elements antenna



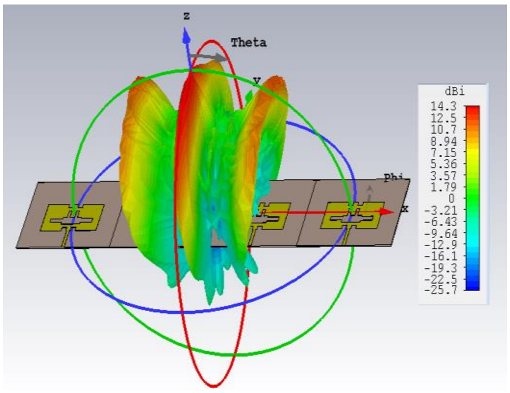


Figure 7. Radiation pattern of 1x4 elements antenna at 28 GHz

3.3. 2x4 Elements Antenna

The simulated S-parameter of the 2x4 elements antenna is illustrated in Figure 8. From the result, the simulated return loss of-19 dB is obtained at the desired frequency. There is an decrease in return loss compared to 1x4 elements. The isolation between the consecutive ports, S21, S32, S43 etc are still well below -20 dB showing a lesser mutual coupling between them. The simulated radiation pattern is presented in Figure 9. It was observed when elements were assembled in the form of eight elements antenna linear array, there was slightly an decrease in antenna directivity from 14.3 dBi to 14 dBi.

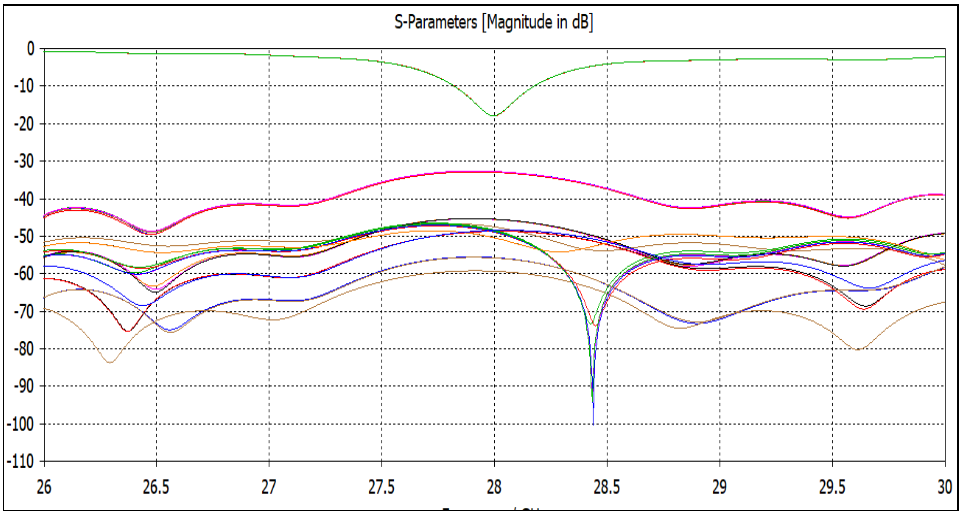


Figure 8. The simulated S-parameters of 2x4 elements antenna

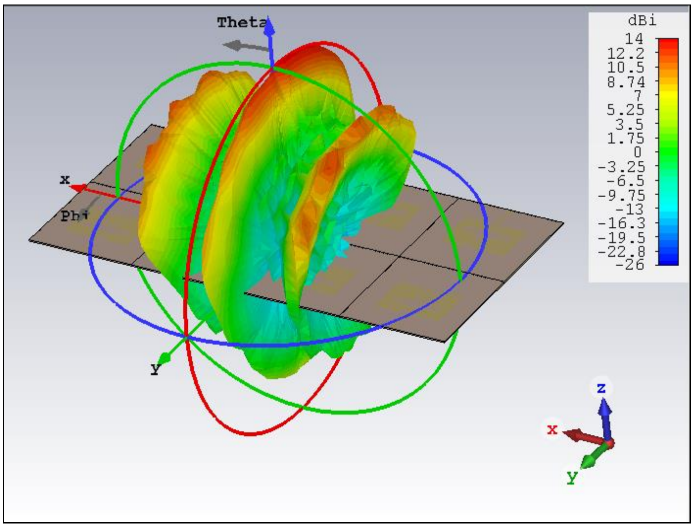


Figure 9. Radiation patterns of 2x4 elements antenna at 28 GHz

4. Conclusion

This paper presents the simulation designs of single element, 1x4 elements and 2x4 elements antenna for 5G communication system. The proposed antennas work at 28 GHz. The MIMO configurations are formed from the single elements antenna. From the simulation results, it is shown that by increasing the number elements of antenna affect to the directivity and the return loss. Antenna with 2x4 elements has 14 dBi of directivity with the return loss of -19 dB. While antenna with 1x4 elements, the directivity obtained is 14.3 dBi with return loss of -18 dB.

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