Rectangular Patch Antenna Array with microstrip line Designed for 5G Applications

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Abstract : The antenna must be properly designed for improved communication. This paper focuses on millimetre wave antenna design for future 5G wireless systems. Antennas for modern wireless communications systems must be low-profile, high-gain, and simple-structured. These requirements, such as simplicity and compatibility, are met by microstrip antennas. The proposed model calls for the creation of a patch antenna array with multiple arrays such as 4x1 and 8x1 to increase bandwidth, gain, directivity, and return loss. CST Microwave Studio 2017 is used to design and simulate the proposed model.

***Keywords* - Milli-meter wave antenna, 5G, Microstrip antenna, Multiband**

I. INTRODUCTION

As the generation moves toward 5G technology, much research is being conducted in the field of antenna design in terms of compact antenna designs, bandwidth and gain improvement, and high radiation efficiency. 5G standardization is underway, with the first deployment scheduled for 2020 [1]. Furthermore, data volumes exchanged and used for millimeter bands with low propagation capacity will skyrocket [2]. Several trends can be identified in 5G specifications. Because no standard will be available until 2019, these specifications may change. However, they continue to be a predictor of what mobile networks will look like in the future. Here are the main specifications that have been established thus far: Any system that operates in real time, such as autonomous vehicles and remote surgery, requires a latency time of between 1 and 5 milliseconds [3]. The goal is also to give the user a sense of instant access to relevant content. This paper focuses on patch array antennas for increased gain and bandwidth. It discusses how to enhance the performance of a single rectangular patch antenna and a rectangular patch antenna array at 28 GHz for future 5G applications fed by a microstrip feed line. The proposed design of an 8x1 rectangular patch array antenna at 28 GHz is discussed, and the necessary calculations of the antenna's radiation parameters (return loss, radiation pattern, gain) are performed. The simulation results are compared between the 4x1 and 8x1 linear rectangular patch array antennas using CST Studio

II. RECTANGULAR PATCH ANTENNA ARRAY

To achieve the resonant frequency requirement of 28 GHz, the theoretical characteristics of a single rectangular patch were optimized for the microstrip. The performance of the developed feeding approach may be seen using the optimized settings.

i)Rectangular Patch antenna

The first step was to investigate the effect of substrate thickness on antenna performance. The antenna bandwidth was shown to improve when h was raised. The rectangular patch antenna with microstrip line feed. y1 gap parameter (see fig.1) was tuned to satisfy the minimal return loss criterion at the resonant frequency of 28 GHz. When the patch length was L = 10 mm, the width was W = 14 mm, and the gap y1 was 1.1 mm, we achieved the lowest return loss.

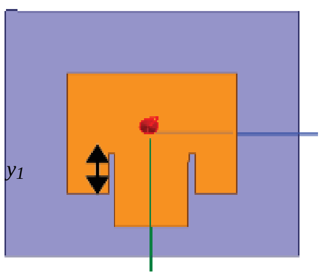

Fig.1 Geometry of the rectangular patch antenna with Inset Microstrip feed line

i) *Rectangular 2*1Patch array antenna.*

Before creating a four-element patch antenna array, we investigated a 2*1 rectangle patch antenna array driven by a microstrip line. The fundamental goal is to have appropriate impedance matching and a wide bandwidth. The antenna must be adjusted to 50 Ω to operate effectively. A T-junction is used to provide power to a two-element antenna array. There are multiple T-junction configurations with various calculating methodologies.

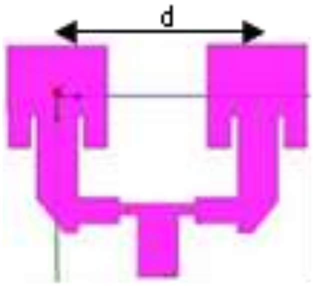

Fig.2 Geometry of the rectangular 2*1 patch antenna array

To maximize the radiated gain, the distance d was optimized. The optimal value equals 7.4 mm. Figure 2 shows the simulated gain of a 2*1 patch array antenna supplied by a microstrip line.

ii) Patch Antenna array 4x1 and 8x1 with microstrip line feed

The radiating elements are mounted on the surface of the dielectric substrate with a thickness of *h* = 0.2 mm and a relative permittivity of ε_r = 2.2 We take the optimized distance d of the 2*1 rectangular patch antenna array and we optimized the distance between the internal patchs d_2 (see *fig.3*). We must take into account in the design of a patch array antenna the spacing between the elements of the array which directly affects the radiation pattern and the gain. The maximum gain is obtained when the spacing is between 0.4 λ_0 and 0.9λ_0 . If the elements are too close to each other, a coupling phenomenon reduces the gain value and when they are too far apart, secondary lobes appear and consequently reduce the directivity.

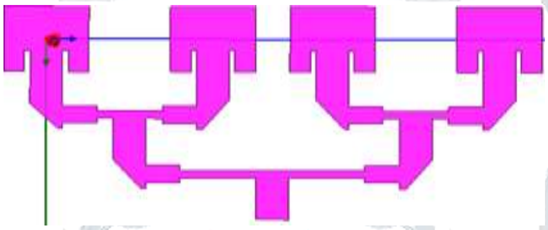

Fig.3 Geometry of the rectangular 4x1 patch antenna

Fig. 3 shows a 4x1 rectangle patch antenna with the same parameters as the 8x1 rectangle patch antenna shown in Fig. 4

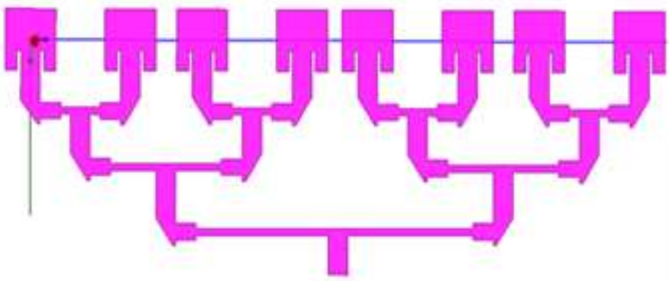

Fig.4 Geometry of the rectangular 8x1 patch antenna

Table-1 Dimensions of 4x1 and 8x1 Rectangular patch array antennas

Parameter	4*1 antenna	8*1antenna
h(mm)	0.2	0.2
W(mm)	14	14
L(mm)	10	10
tp(mm)	0.0256	0.0256
W1stub(mm)	1.57	1.57
W2stub(mm)	0.89	0.89
L1stub(mm)	1.95	1.95
L2stub(mm)	3.97	3.97

III. SIMULATION RESULTS AND DISCUSSIONS

The simulation Results for 4*1 and 8*1 rectangular array patch antennas are obtained by using CST studio software and the results are compared.

3.1Return Loss

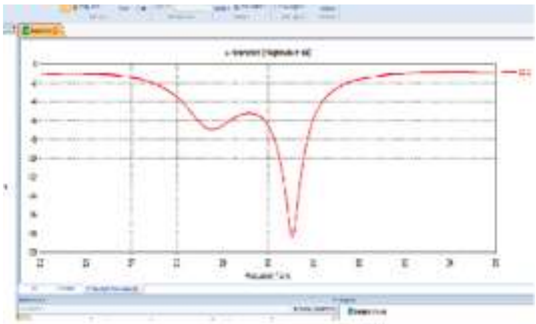

Fig.5 Return loss of the rectangular 4x1 patch antenna array

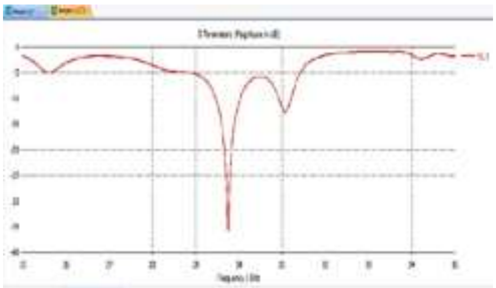

Fig.6 Return loss of the rectangular 8x1 patch antenna array

3.2 Gain

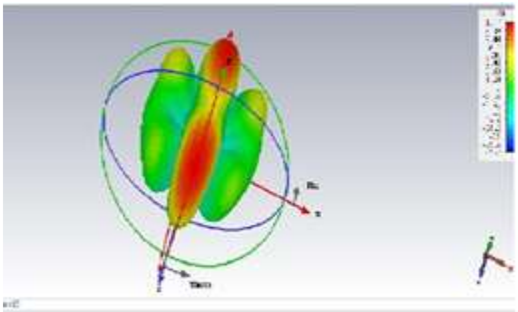

Fig.7 3D Gain pattern of the rectangular 4x1 patch antenna

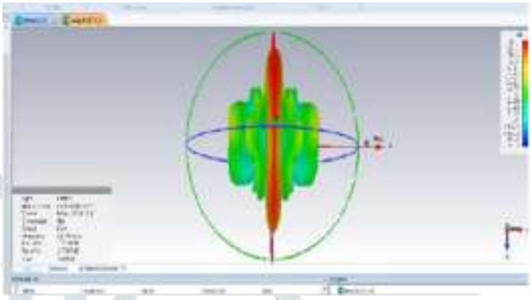

Fig.8 3D Gain pattern of the rectangular 8x1 patch antenna

3.3 VSWR

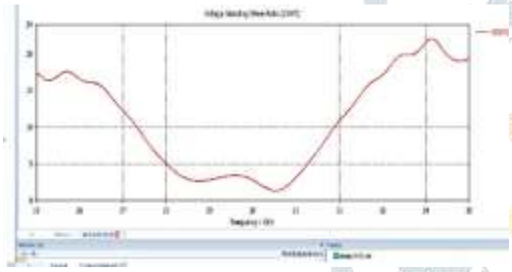

Fig.9 VSWR of the rectangular 4x1 patch antenna

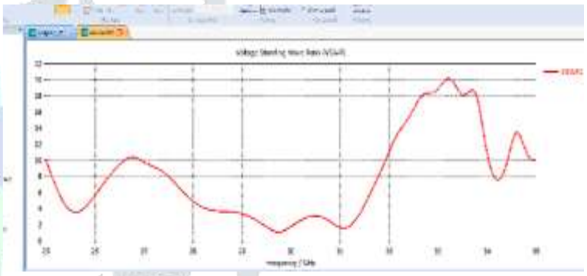

Fig.10 VSWR of the rectangular 8x1 patch antenna

Table-2 Comparison between 4*1 and 8*1 Rectangular patch array antennas

Parameters	4*1 rectangular Patch array antenna	8*1 rectangular Patch array antenna
Minimum return loss(dB)	-18.38	-35.7
Gain(dBi)	10.73	14.09
BW(GHz)	0.569	0.591
Directivity(dBi)	11.38	14.88

IV. CONCLUSION

CST was used to successfully design and analyze a rectangular patch antenna, as well as a 4*1 and an 8*1 linear rectangle patch array antenna supplied by a microstrip line. The return loss of -18.38 dB, bandwidth of 0.569 GHz, and gain of 10.73 dB at 30.5 GHz were obtained for the microstrip 4*1 rectangular patch array antenna. We get a return loss of 35.7 dB, a bandwidth of 0.591 GHz, and a gain of 14.88 dB at 29.5 GHz from the microstrip 8*1 rectangle patch array antenna. The suggested designs are suitable for a variety of mm-wave phased array applications, as well as future 5G networks. The array's gain will be increased by accounting for mutual coupling effects between components as well as reflection in the feed network.

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