Multiband Microstrip Patch Antenna for 5G Wireless Mobile Phone

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Abstract: ***The scope of this paper is to design an array antenna for wireless communication 5G, firstly designed a single patch antenna with a DGS filter. The position of the DGS filter element in the ground plan, underfeed line and the slot in patch antenna from U&T and also add. The simulation of a single antenna gave: fr1=29. 22 GHz, Gain=1. 82dB, VSWR=1.073. To improve gain, the effective area of the antenna should somehow be increased using techniques like parasitic patches, the meandering of edges, etc. Also, you may use the EBG superstrate. in this paper use array antenna, the distance between patch constant 1.8mm: fr1=32.836and fr2=39Ghz, and the value of gain is 13.1dB and 8.95Db respectively .The designed and analysis is performed by using High Frequency structural simulator (HFSS version 13.0: frequency structural simulator) software and CST studio.***

Keywords: slot antenna, array antenna, DGS structure antenna, 5G communication

1. Introduction

Utilization of the millimeter wave (mmWave) band is a key technology for the development of heterogeneous networks (HetNets) that will be used for 5th generation wireless cellular networks (5G) [1]. The emergence of microstrip antennas has been a great development in the field of telecommunication and wireless technologies, as this generation of antennas helped to achieve good performances with a small size and low cost. In 5G wireless communication technologies require antennas that operate at mm-wave frequency while maintaining a small size [1]. Array antenna plays a key role in modern telecommunication for improves the performance of the small size antenna systems [2].

In [anouar] application of DGS for 5G mobile wireless communication.

The study of the normal array antenna precisely a long time ago, and also determine and analyze all the vectors necessary of found the optimal antenna for 5Gcommunication. In addition, the beam of an antenna device is scanned using them, Increase the directivity and perform various other tasks, which for any single feature will be difficult. In a feed network structure, the elements can be fed by a single line or by multiple lines, so we used an array to establish the output of this antenna in this article.

In this article, we present a new design of a DGS antenna and make them in array patch. This antenna can operate easily at two frequencies for array antenna. The desired antenna performances are increase because we add 8×elements of patch, and we also add a slot in grand plan.

2. Theory

a) Slot antenna

The slot antenna is popular because it can be installed on every surface and has radiation patterns that are estimated unidirectional. The polarization of the slot antenna is linear. The slot size, shape and what is behind its (the cavity) offer design variables that can be used to tune.

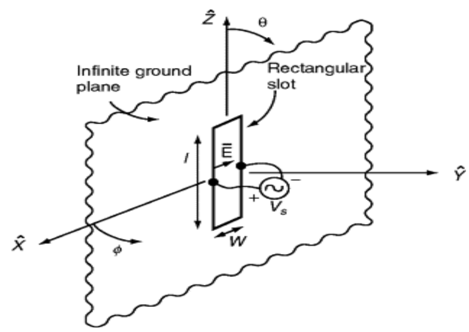

Figure 1: The equivalent circuit of the slot in ground plan.

We would first understand the Babinet principle in order to gain an understanding of slot antennas. This concept applies to the radiated fields and the impedance of an aperture or slot antenna to that of its dual antenna area. If the conductive material and air were exchanged, that is, the slot antenna was turned into a space metal slab, the dual of a slot antenna would be. An example of dual antennas is shown in figure 2.

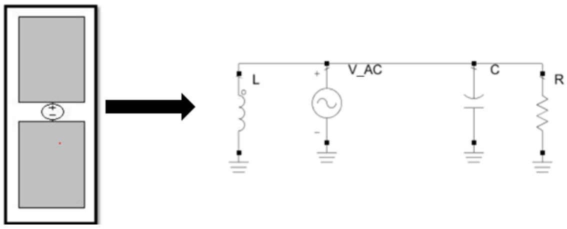

Figure 2: The equivalent of slot in patch antenna

b) DGS Fundamentals

Slots or defects integrated on the ground plane of microwave planar circuits are referred to as Defected Ground Structure. DGS is adopted as an emerging technique for improving the various parameters of microwave circuits, that is, narrow bandwidth, cross-polarization, low gain, and so forth. PBG and EBG. A basic concept behind the DGS technology and several theoretical techniques for analyzing the Defected Ground Structure are discussed. Several applications of

DGS in the field of filters, planar waveguides, amplifiers, and antennas are presented [3].

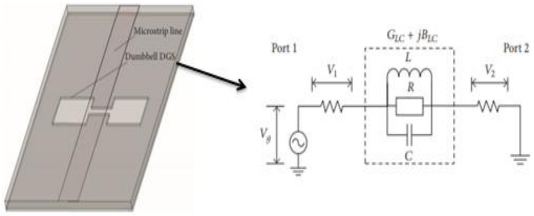

Figure 3: Equivalent circuit of the dumbbell DGS circuit

The capacitance C, inductance L, and resistance R can be calculated as [4]:

$$C = \frac{\omega_c}{2Z_0\left(\omega_0^2 - \omega_c^2\right)},$$

$$L = \frac{1}{4\pi^2 f_0^2 C},$$

$$R(\omega) = \frac{2Z_0}{\sqrt{1/\left|S_{11}(\omega)\right|^2 - \left(2Z_0\left(\omega C - 1/\omega L\right)\right)^2 - 1}}.$$

DGS is widely used nowadays in active and passive devices. Each DGS shape has its own characteristics and creates effect on the performance of the device according to its geometry and size [4]. DGS has been used in filters, coplanar waveguides, microwave amplifiers, and antennas to improve their performance. DGS is used for miniaturizing the size of component, enhancing the operating bandwidth and gain, reducing the mutual coupling between two networks, suppressing the higher order harmonics and unwanted cross-polarization, and also producing notched band to stop interference with any band. Several applications of DGS available in literature are discussed further.

3. Geometry of the Novel Patch Antenna

a) Geometry of the single antenna

The geometry of the new antenna is presented in figure (4). The size of this antenna is 5mm width and 6.33mm long, with dielectric constant epsilon=2.2 with thickness H=0. 8mm. The new patch antenna has T&U slotted and notches.50 ohm single microstrip line feeding with radiation patch, which is resonant with the dual band frequencies.

Before calculating the length of the patch it is necessary to calculate the effective dielectric constant, effective with and length extension of the resulting length by using the equation:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

$$L_{eff} = L + 2\Delta L$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}}$$

The dimensions of patch antenna presented in table.1, Where λ is the wave length, Fr is the resonant frequency; L and W are the length and width of the patch element respectively. In the following Figure.1 shows a single patch antenna that has been designed to cover operating frequency of 29.22 GHz with input impedance of 50 Ω, using FR-4 (εr = 2.2) and height (h=0.8mm)

Table 1: Dimensions of patch antenna

Parameters	Dimensions (mm)
L	5.33
W	6.67
L1	3.07
W1	2.9
NO	0.2

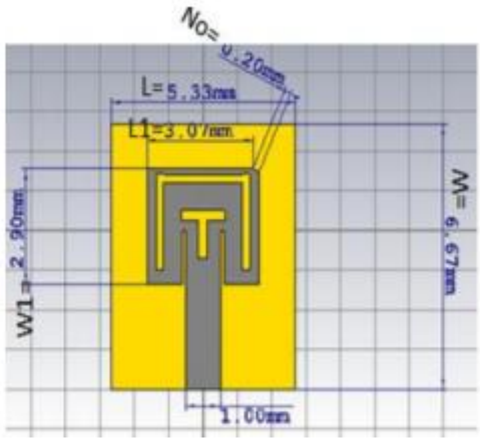

Figure 4: Geometry of proposed antenna with DSG unit cell and DGS filter by CST[5]

We present the geometry DGS filter in table.2.

Table 2: Dimensions of DGS filter

Parameters	Dimension (mm)
P	0.2
T	1
T1	0.5
T2	0.5
P1	0.2

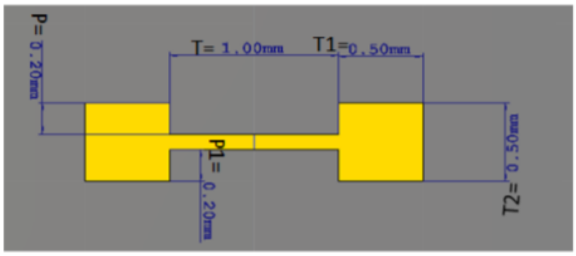

Figure 5: Geometry of proposed DGS filter

b) Simulation resultant of single antenna

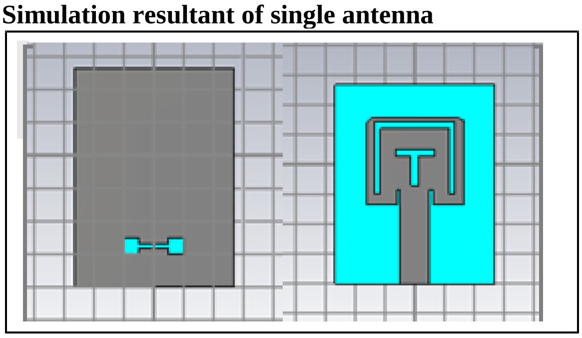

Figure 6: Antenna proposed with DGS filter by CST

Also, we design by HFSS to confirm our resultant.

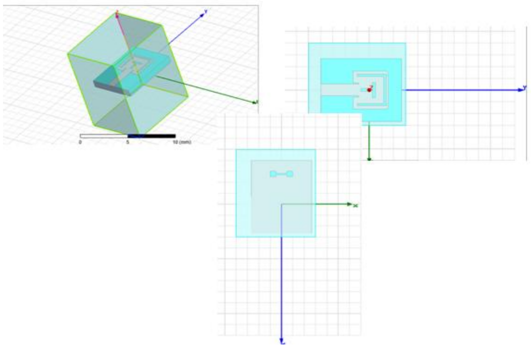

Figure 7: antenna proposed design by HFSS [6]

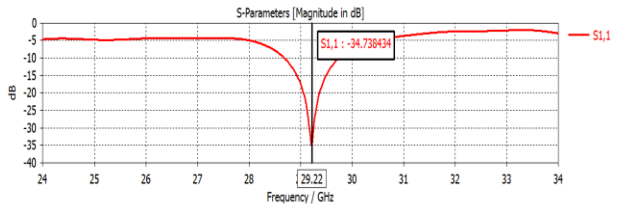

Figure.8: Parameters S11 by CST

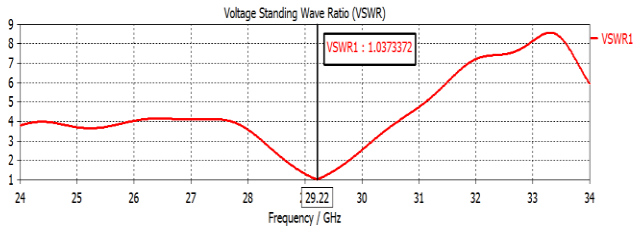

Figure 9: VSWR by CST

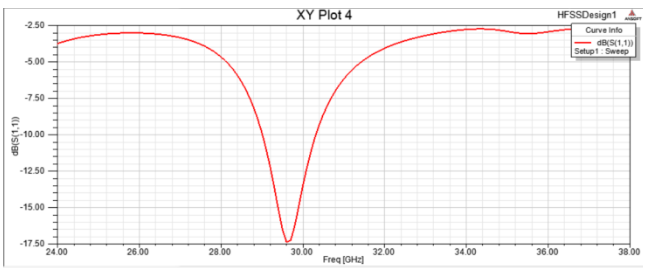

Figure 10: Parameters S11by HFSS

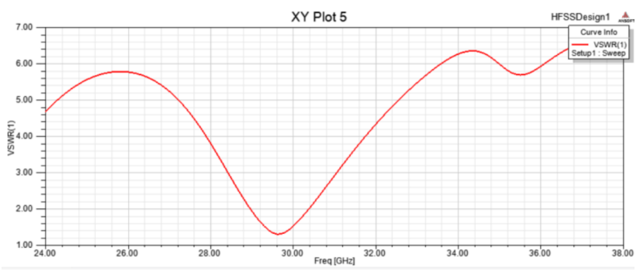

Figure 11: VSWR by HFSS

In the next figure we compare between simulation in HFSS and CST. It's clear we have a difference between both simulators but very few.

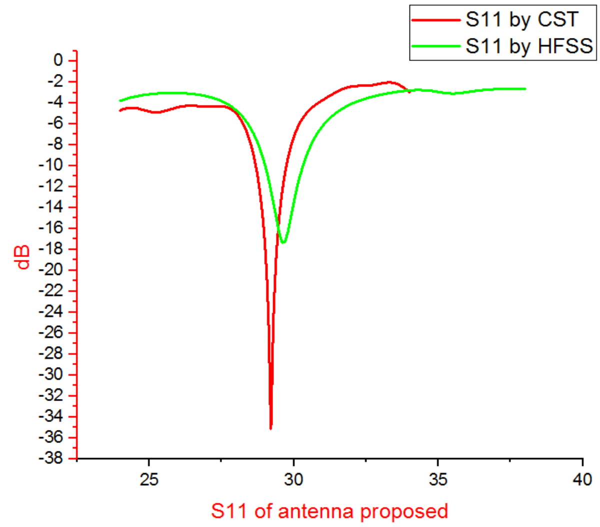

Figure12: Comparison between HFSS and CST.

c) Gain of antenna proposed

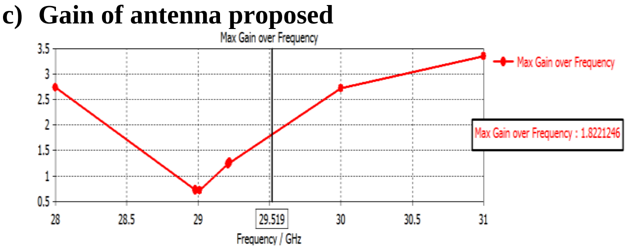

Figure13: Changes Gain in terms frequencies

This single antenna have a value of Gain= 2.5 dB so the objective of the next study is to increase antenna efficiency by using a linear array antenna.

d) Geometry of the array antenna

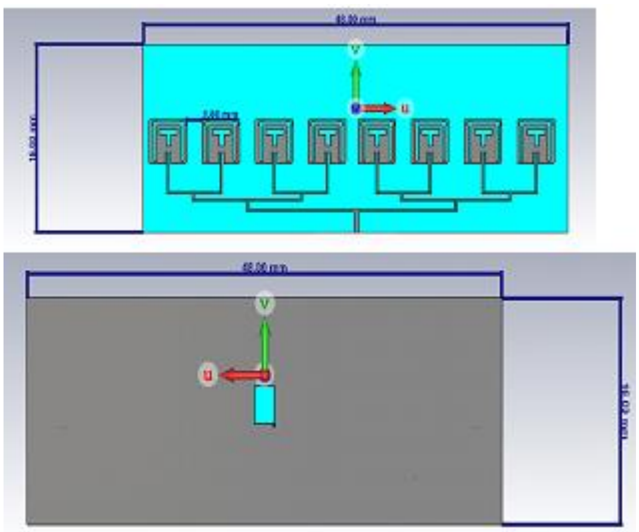

Figure14: Geometry of 1*8elements array microstrip antenna by CST

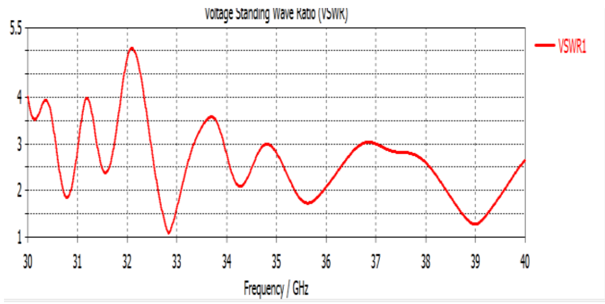

Figure15: VSWR parameters for linear array antenna

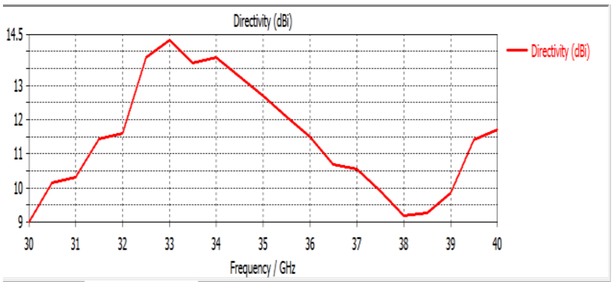

Figure16: Changes directivity in terms frequencies

It's clear our antenna more directivity in frequency of resonance. In the figure 21 we have the values of gain.

And we have also in table x the comparison between single antenna and array antenna.

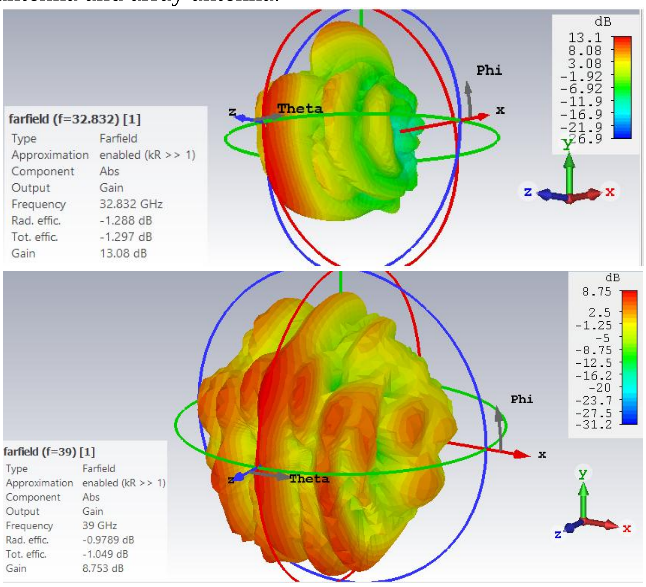

Figure 16: Changes gain in terms frequencies

The simulated antenna radiation patterns at the resonant frequency are plotted in Figures 17, 18,19 and 20.

The numerous planes in the resonant frequency radiation patterns are similar to omnidirectional. The omnidirectional estimated function of From the various horizontal and vertical shapes, you can see this new array antenna.

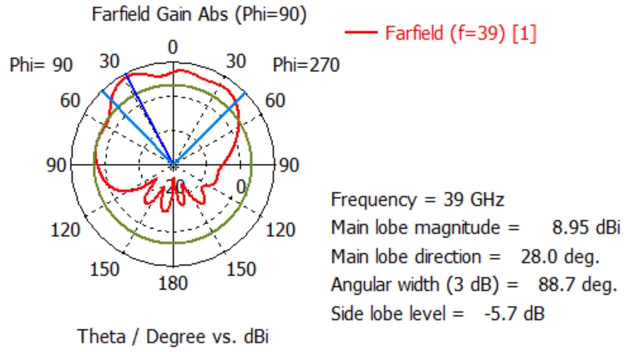

Figure 17: Simulated radiation patterns in dB (phi =90, x-z plane) at fr=39 GHz

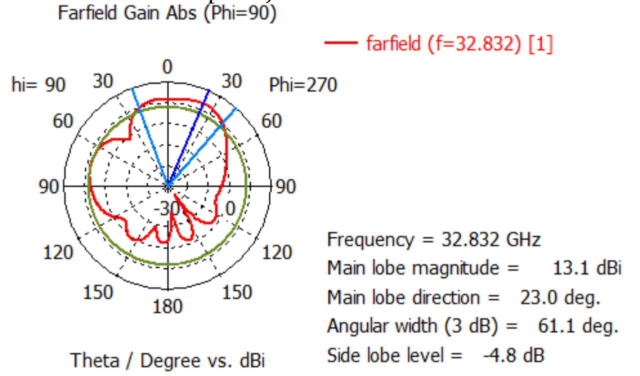

Figure 18: Simulated radiation patterns in dB (*phi* = *90*, x-z plane) at fr=32.832 GHz

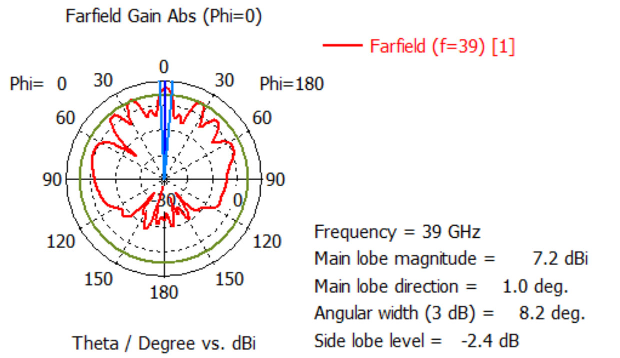

Figure 19: Simulated radiation patterns in dB (phi =0, x-z plane) at fr=39 GHz

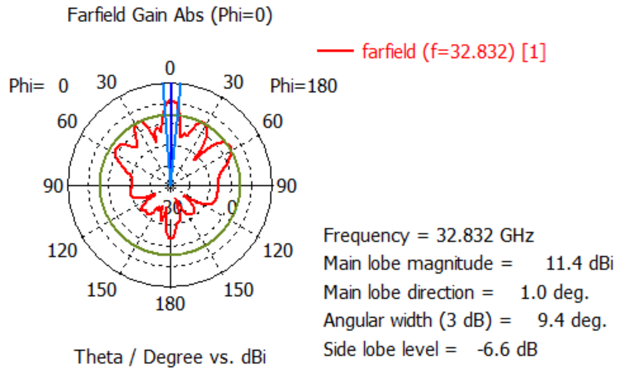

Figure 20: Simulated radiation patterns in dB (phi =0, x-z plane) at fr=32.832 GHz

Table 3: Attribute values of single and array antenna

	Frequency	VSWR	Gain	BW
Single antenna	29.22Ghz	1.0481	1.2459	1.09Ghz
Array antenna	Fr1=32.132	4.926	Gain_fr1=13.2dB	0.429Mhz
8*elements	Fr2=39Ghz	1.3241	Gain_fr2=8.5dB	1.079Ghz

4. Conclusion

Using computer simulation technology (CST) software, the array's simulated gain is more than 12 dBi between 32.5 and 39 GHz. for 5 G communication and mm-wave imaging, this range can be used. The impedance and gain bandwidth of the array is truncated due to the resonance between the neighboring components. The associated research will be submitted shortly to eliminate the resonance.

5. Acknowledgment

I would like to express my special thanks of gratitude to my professor Pr.Larbi Setti and also my friend .who gave me the golden opportunity to do this wonderful project ,which also helped me in doing a lot of Research and I came to know about so many new things I am really thankful to them.

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