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A Patch Array Antenna for 5G Mobile Phone Applications

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ABSTRACT

Due to increase in the smart phone users the capacity demand also increases, the fifth generation (5G) mobile technology would be able to greatly increase communication capacity by using the large amount of spectrum in the millimeter wave (mm wave) bands. The references shows that in addition to capacity boosting technologies 5G needs to offer ultra-reliable communications, low latency and massive connectivity. In this paper, we present the motivation for future antenna for 5G mobile communications, methodology, and offer a variety of simulation results that show 28.5 GHz frequency can be used when employing steerable directional antenna. The proposed idea is implemented by using HFSS software.

Keywords: Patch array, rt-duroid and 5G mobile phone application.

1. INTRODUCTION

Due to rapid increase of mobile data growth and the use of smart phones are creating unprecedented challenges for wireless service providers to overcome a global bandwidth. In the last few years a large technological improvement has taken place in the field of mobile communications due to the introduction of new mobile in communication networks are GSM and PCN. The number of subscribers in worldwide has been raised over 150 million. The existing 4G systems can provide over 1 Gbps maximum data rates hence the proposed system provides the data rate more than that. Furthermore, it is predicted that the fifth-generation (5G) systems will be approximately implemented in the year of 2020s. Compared with 4G systems, one of the main differences in 5G cellular systems the frequency is shifted to higher frequency where is easier to obtain wider bandwidths.

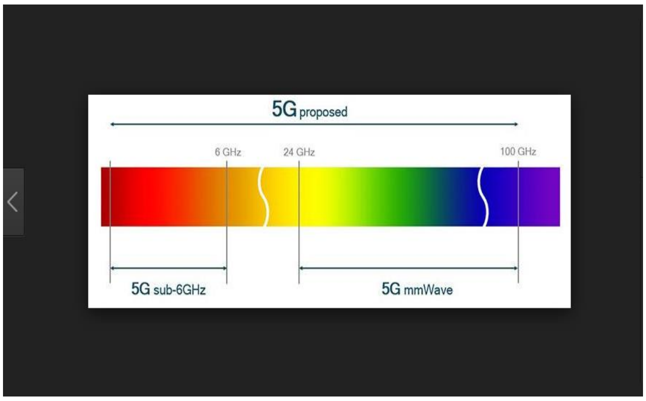

Fig.1. Frequency bands of 5G application

Low-profile antennas are required for communication systems where the antenna installation space is limited. Bandwidth enhancement is also a requirement. Particularly for ultra-wideband (UWB) applications. Patch array antenna meet these requirements. Hence here the two patches are connected by using stub. According to the friis transmission equation, by increasing the operation frequency, the path loss increases. The proposed antenna is designed by using rt-duroid substrate. The dielectric constant of these high frequency laminates is the lower for all products, and low dielectric loss make them it's well suited for high frequency applications where dispersion and other losses are to be minimized. Because it has very low water absorption characteristics, hence the rt-duroid laminates are ideal for applications in high moisture environments.

Table 1. Substrate specifications table

Properties	Values
Dielectric constant	4.4
Loss tangent	0.0009
Substrate thickness	1.6mm

This paper proposes a new design of patch array antenna in a standard rt-duroid PCB technology for millimeter-wave 5G mobile applications. The analysis and performance of the antenna are obtained by using HFSS software.

2. CONCEPTUAL DESIGN

The proposed antenna package operates in 28.5 GHz which is required for 5G communications. The design consists of two patch antennas and it is connected by using stub. The proposed design has > 7.5db gain with good directivity and efficiency. The Antenna is designed by using an rt-duroid substrate with thickness (hsub) of 1.6 mm, permittivity (εr) of 4.3, and loss tangent (δ) of 0.0009. To design an array of antenna the first step is to design a single micro strip patch antenna.

Because patch antenna is less in weight ,easy to implement, very low fabrication cost and it supports both linear and circular polarization additional benefits of patch antenna is they are easily fabricated and are cost effective. Because of their low profile design, the patch antenna is often square or rectangular in shape that allows them to be mounted on flat surfaces. While the challenge is to cover half of the space for 5G mobile phones with high gain radiation beams. This is achieved by using arrays of patch antenna used at the PCB.

Table 2. Final Dimensions of the 5G Antenna Parameters

Parameters	Values (mm)
H(sub)	1.6
Feed width	4.93
Patchx	4.16
Patchy	2.37
Edge feed width	1.915
X(sub)	15.8
Y(sub)	13.36
Feed length	3.206

Based on the above table the antenna is designed and stimulated by using HFSS software. The above parameters are calculated based on the standard formulas.

Top View of the Proposed Antenna

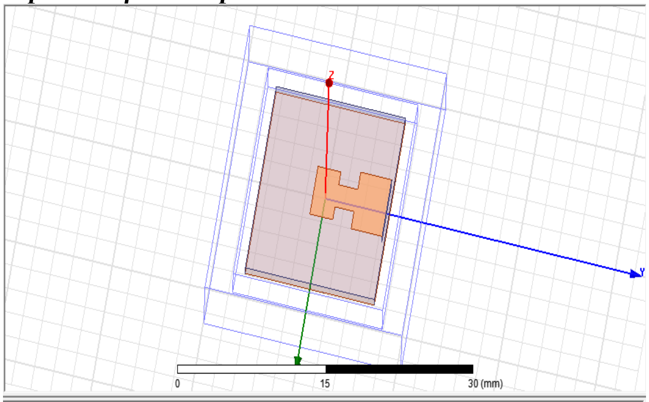

Figure 1.1: Top view of proposed antenna

3. STIMULATED RESULTS

3.1 Return Loss/VSWR

The VSWR is the function of reflection coefficient which shows power reflected from the antenna and the reflection coefficient is also known as S11 or return loss. The smaller the VSWR is the better the antenna matched to the transmission line and power delivered to the antenna. Return loss is generally the amount of power lost in the load. Return loss is commonly expressed in decibels. An impedance of exactly 50 ohm can be practically achieved at one frequency. The VSWR shows how far the impedance differs from 50 ohm with a wide-band antenna.

The power delivered from the transmitter cannot be longer radiated without loss because of this incorrect compensation. Some of this power is reflected at the antenna and is returned to the transmitter. The forward power and return power forms standing waves with corresponding voltage minima and voltage maxima (umin/umax). This voltage standing wave ratio defines the level of compensation of the antenna and it was measured by sensor measurements previously. The VSWR of 1.5 is standard for mobile communications. In this case the real component of the impedance may vary between the following values:

Maximum value: 75 ohms
Minimum value: 33 ohms

The term return loss attenuation is being used often in recent times. The reason for this is the voltage ratio of the return loss of the forward-wave and reverse wave ur/uv can be measured by directional coupler. Return loss is related to both standing wave ratio (SWR) and reflection coefficient (γ).

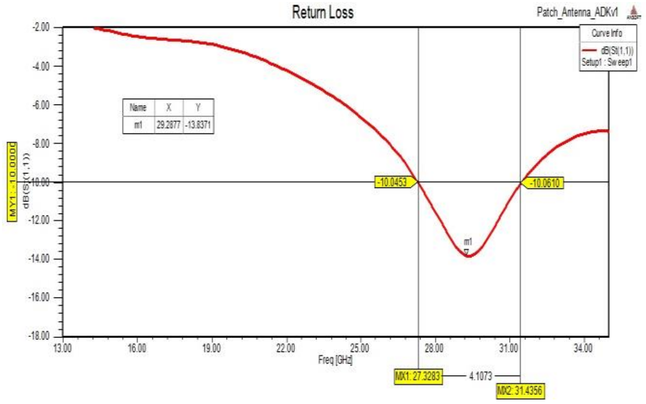

Figure 2.1: Return loss

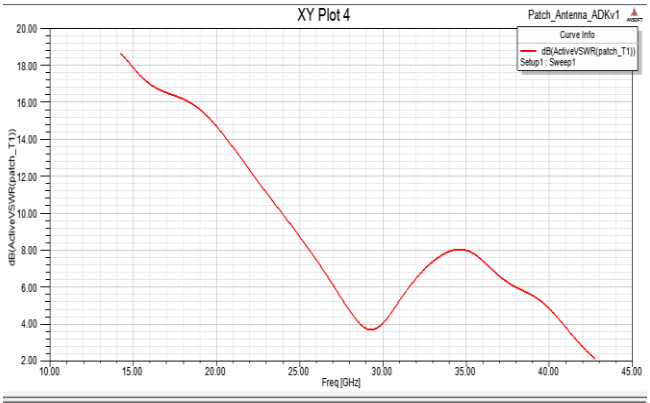

Figure 2.2: VSWR

3.2 Gain and Directivity

Gain of an antenna is defined as the ability of the antenna to concentrate the radiated power in a given direction or conversely to absorb effectively the incident power from that direction. The term gain describes how much power is transmitted in the direction of peak radiation of an isotropic source. A transmitting antenna with gain of 3db means the received power far from antenna will be 3db higher than the received power from a lossless isotropic antenna with the same input power. The antenna gain is related to the directivity and efficiency,

$$G = \epsilon r d$$

The directivity d of an antenna is defined as the ratio of maximum radiation intensity to the average radiation intensity. The directivity of isotropic antenna is defined as a lossless antenna having equal radiation in all direction. The gain and the directivity is calculated based on the formula given below,

Directivity (D): The directivity (D) of the proposed antenna can be calculated as

$D = Ae4\pi / \lambda^2$, where Ae (effective area) = 7.5299db

Gain (G):
Gain (with reference to the isotropic radiator dbi) = gain (with reference to l/2-dipole dbd) + 2.15 db
The gain of the proposed system is 7.4040

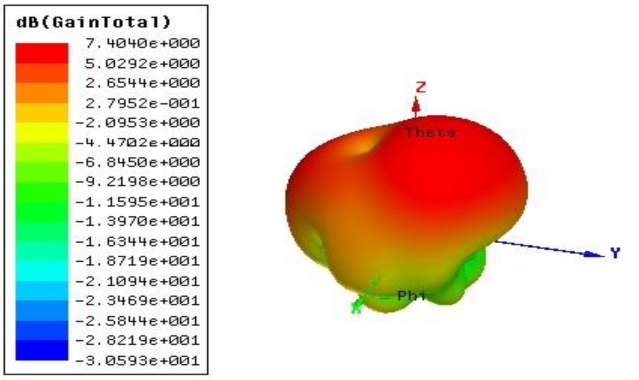

Figure 2.3: The 3-D pattern of gain

The above figure 5 shows the 3-D pattern gain of the proposed antenna and figure 6 shows the 2-D pattern of the proposed antenna.

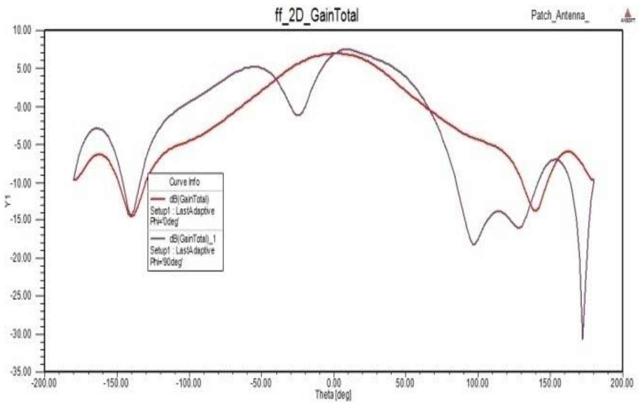

Figure 2.4: The 2-D pattern of gain

The above diagram shows 2-D pattern of gain in which the gain of patchX and patchY are given in different color.

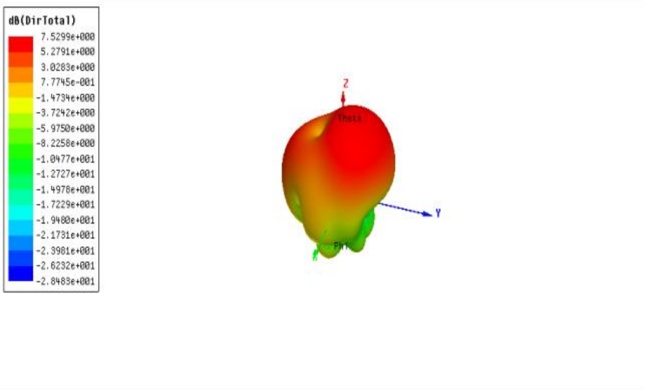

Figure 2.5: The 3-D pattern of directivity

3.3 Radiation Pattern
In the field of antenna design the term radiation pattern refers to the directional strength of the radio waves from the antenna.

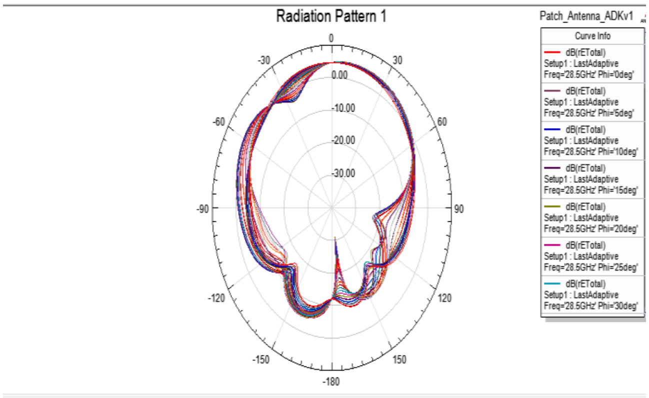

Figure 2.6: Radiation pattern

The radiation pattern of the proposed antenna is shown in the figure 8.

4. CONCLUSION
In this paper, a new patch array antenna aiming for 5G mobile communications is presented. The antenna is designed on an rt-duroid to operate at 28.5 GHz. The proposed antenna has good performance in terms of S-parameter, gain, efficiency, and beam steering characteristics. Experimental and simulated results are presented to validate the usefulness of the proposed patch array antenna for 5G applications. The efficiency of the proposed antenna is 100% and the gain of an antenna is 7.404db.the antenna is designed and stimulated using HFSS software.

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