# A 28 GHz Rectangular Micro strip Patch Antenna for 5G Applications

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**Abstract:** In this paper, a 28GHz micro strip patch antenna (MSPA) design and performance analysis for fifth-generation (5G) communication systems is presented. The antenna is designed using FR4 substrate material with thickness of 0.244 mm, and and analyzed using HFSS (High frequency structure simulator) simulator. The simulated results show that, the beam-gain of 7.587 dBi, directivity of 7.509 dBi, the radiation efficiency of 98.214 %, and bandwidth of 1.046 GHz, compared to other similar designs suffers from losses are gained from the antenna significantly better bandwidth, beam-gain, return loss, and radiation efficiency. Therefore, the proposed antenna gives a highly competitive performance as related to other works, and also, it is a potential candidate antenna type for 5G communication systems.

**Key Words:** Antenna, Bandwidth, Beam-gain, Directivity, Fifth-Generation.

## INTRODUCTION:

Over the past few decades, wireless communication systems have brought a significant impact on the daily lives of human beings. Consequently, nowadays, more and more users connect their devices to the existing networks which are causing a constant increase in data increasing in the upcoming years. To deal with the ascension of wireless data traffic, the next deployment of wireless communication networks is at a nascent phase, which is stated to be a fifth generation wireless network [1-3]. The emerging 5G communication systems are high capacity by exploiting enormous unlicensed bandwidth millimeter wave band. It is also expected to be ready to provide and support very high data rates which in turn to a rep laced challenge on network requirements as well as in the designs to satisfy the expected data rate and capacity [4- 6]. The advancement of wireless communication systems require low-profile antenna types that are capable of delivering astonishing performance over a wide

frequency band. With this regard, the MSPA represents a lucid choice for volume, and a low-profile

configuration as compared to the other bulky types of antennas. The MSPA is easy and multi- purpose in terms of the directivity, gain, return loss, BW measuring techniques, and tuning dimensions of the antenna. polarization, resonant frequency, pattern, and input functions [7-10].

## 2. MATERIAL SPECIFICATION AND METHODOLOGY:

The performance characteristics of the antennas are mainly structures, and the material properties from which they are made. In this study, the rectangular patch shape selected because it is easy to angular patch shape selected because it is easy to design and analyze and it has wide bandwidth by reason of its broader shape as compared to other types. The physical structure of the examined MSPA is given in Fig - 1.

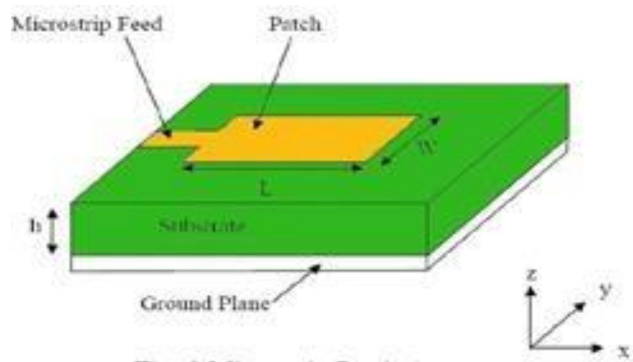


**Fig1: A rectangular MSPA design**

MSPA bandwidth and radiation efficiency by boosting surface laterally through the feed line. Consequently undesired cross-polarized radiation is directed ed by feed radiation such as conductor, dielectric and radiation which mainly results in narrowing the bandwidth and lowering the gain [7-10].

## 3. GOVERNING EQUATIONS AND DESIGNOF THE PROPOSED MSPA:

Various governing equations are employed to determine to calculate dimensions of rectangular MSPA. Some of the major governing equations are presented as follows:

### 3.1. Height of the Substrate:

The micro strip antenna height is related to substrate thickness or height (SH). The substrate height is calculated by:

$$SH = \frac{0.3C}{2\pi F\sqrt{g}}$$ where C= speed of light

in vacuum, F=solution frequency of antenna, $\epsilon$ = permitivity of the material.

### 3.2. Patch Width:

The patch width (PW) has significant effect on the bandwidth and radiation efficiency of antenna.

The PW is calculated by:

$$PW=\frac{C}{2F\sqrt{\frac{\epsilon+1}{2}}}$$

### 3.3. Patch Length:

During patch antenna design, the particular length of the patch is a critical parameter. Because of its inherent narrow bandwidth of the patch, it controls the resonant frequency. The patch length is sometimes selected within the range of 0.3333 $\lambda 0 < PL < 0.5 \lambda 0$ [6]. Therefore, the actual patch length (PL) is found by:

$$PL = PL_{eff} - 2\Delta PL$$

Where $PL_{eff}$ = effective patch length, $\Delta PL$= difference between PL and $PL_{eff}$.

### 3.4 Ground Plane Dimension:

The ground plane dimensions are often calculated using the equation given below [6-13]:

$$GL = PL + 6SH$$
$$GW = PW + 6SH$$

**Table1: values of the design parameters of the proposed antenna:**

| Design Parameters | Calculated Values(mm) |
|---|---|
| Width of the patch | 3.6025 |
| Length of the patch | 2.47818 |
| Length of micro strip Feeder | 1.27696 |
| Width of micro strip Feeder | 0.4785 |
| Width of the substrate | 4.7245 |
| Length of the substrate | 3.942177 |
| Width of a ground Plane | 4.7245 |
| Length of a ground plane | 3.942177 |
| height of the substrate | 0.244 |



### 4. RESULTS ANALYSIS AND DISCUSSION

In this section, the simulation results and discussions of the proposed rectangular MSPA is presented. To analyze the designed antenna, we simulated the proposed design of MSPA using HFSS software. The return loss is calculated with respect to solution frequency of 28 Ghz. The antenna is matched to 50Ω feed-line.

On the other side, the magnitude of VSWR is also used to quantify the reflection of the power from the antenna to the source. The simulated VSWR plot of the designed MSPA is revealed in Fig - 3. Therefore, between 27.397 GHz - 28.507 GHz, the magnitude of VSWR is less than two, which is in the acceptable range and 1.023 at 28 GHz. Another parameter that is often used to characterize the MSPA radiation pattern as drawn in Fig 4. And all the simulations are done in HFSS software with respect to the solution frequency (28 GHz). The simulated parameters which have calculated through graph are S11 i.e. return loss of the antenna, VSWR (voltage standing wave ratio, gain, directivity with respect to impedance 50 ohm. The initially calculated and optimized dimensions of the MSPA are summarized in Table1 and the simulation results are summarized in Table 2 respectively. And all the simulations are done In HFSS software with respect to the solution frequency (28 GHz).

| Parameters | Output Values |
|---|---|
| S11(dB) | -20.5949 |
| Gain(dB) | 7.587 |
| VSWR | 1.023 |
| Efficiency (%) | 98.214 |
| Bandwidth(GHz) | 1.046 |

**Table 2 :** Summarization of all outputs of the MSPA parameters

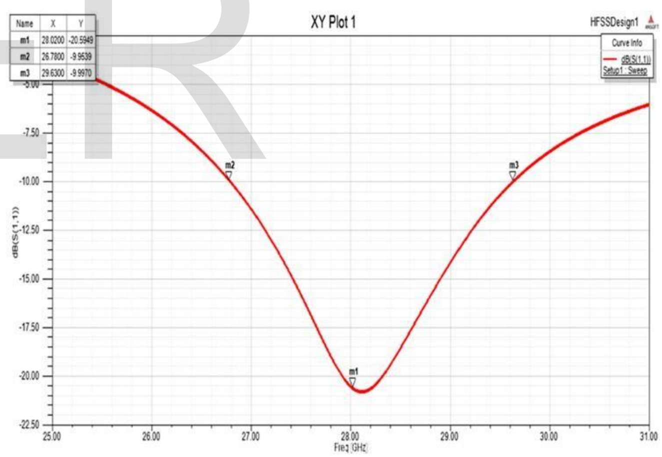


**Figure 2: Return loss vs. frequency plot for Patch antenna**

Here from the S11 vs frequency graph it is clearly shown that the proposed micro strip patch antenna has a return loss of -20.5949 dB at its solution frequency i.e. at 28 GHz which shows a much higher value which is desirable for better performance.

Now, the change of VSWR (voltage standing wave ratio) with frequency is shown in Fig 3.

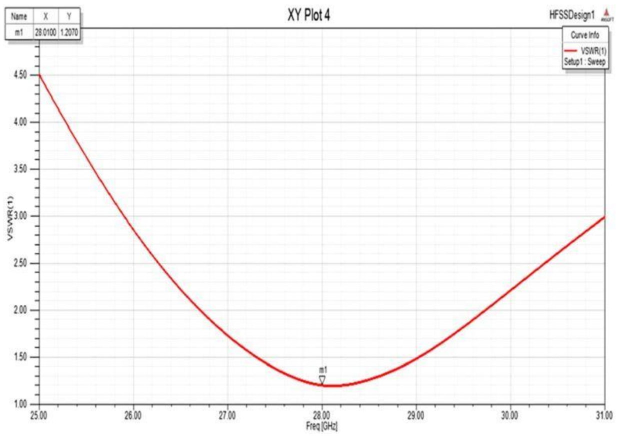


**Fig 3: VSWR graph of Patch Antenna**

As we know that an antenna should have a VSWR value between 1 to 2 as high VSWR value results noise in antenna. So from the above graph the VSWR value of the proposed antenna has 1.023 at its solution frequency i.e. at 28 Ghz which is quite desirable.

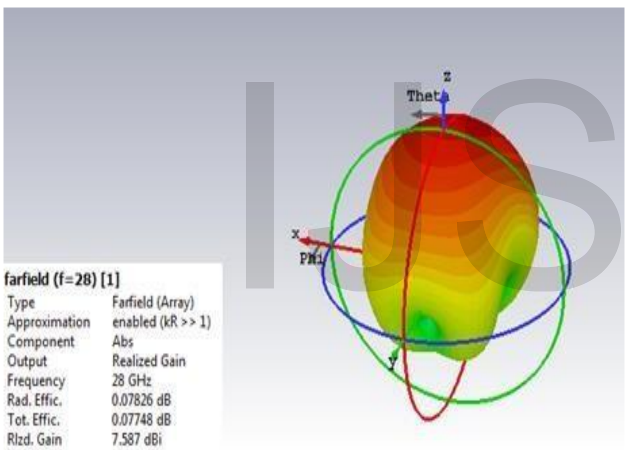


**Fig 4: 3D radiation pattern of patch antenna**

Here the 3D radiation pattern of the proposed patch antenna shows the value of different parameters of the antenna i.e. efficiency, gain which value at 28 GHz is 98.214% and 7.587 dB respectively.

## Conclusions:

In this paper, design and performance analysis of a 28GHz rectangular MSPA for 5G applications is presented. The proposed MSPA simulation result shows that the return loss, directivity, beam gain, and bandwidth of; -20.5949 dB, 7.509 dBi, 7.587 dBi, and 1.046 GHz respectively. As compared to existing designs reported in the scientific literature, the proposed antenna shows significantly better performance. In this paper, better performance has been achieved because of the introduction of the combined optimizations of parameters. Therefore, the designed antenna in this paper is a good candidate antenna type for the 5G millimeter-wave wireless applications. The high-gain antenna provides a wide coverage area for data exchange.

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