Performance Analysis of Wide Band Microstrip Patch Antenna for 5G Communication

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Abstract - A wideband microstrip patch is proposed for 5G communication. Two rectangular slots are etched both from the highest and bottom of the oblong radiator to offer it the form of W and inset-cut feed line respectively. Antenna structure is radiating over wide frequency bands including 4.25 GHz, 7.055GHz, 12.48GHz and 15.26GHz bands. The directivity of the antenna is maximum at frequency 12.48GHz frequency which is used for satellite communications. VSWR obtained at these frequencies are 1.157, 1.052, 1.121 and 1.066. The overall antenna size is 30 X 25 mm2 with a substrate as FR4. Computer Simulation Technology Microwave Studio Version (CST MWS) tool is employed to style and simulate the proposed antenna structure. Consequently, this antenna has a plus of covering a good range of wireless applications.

Keywords – Antenna, VSWR, Frequency.

1. Introduction
In the transmission of information, the antenna plays a major role in wireless communication. The concept of microstrip antenna was first introduced within the 1950s. Though there are many types of antennas available, the microstrip antenna plays a major role. Microstrip antenna is very demanded in today’s scenario because of various advantages like easy to feed, light weight, ease of fabrication, superior portability, easy integration with external circuitry like microwave monolithic integrate circuits (MMICs), and their attractive radiation characteristics. One of the drawbacks of Microstrip antennas (MPA) is narrow bandwidth which can be overcome by using various techniques. Microstrip antenna comes under the category of wideband antenna; this antenna is differed from broadband antenna because its pass band is higher. It is also known as printed antenna. The basic structure of microstrip antenna is shown below in Figure 1

![Fig. 1: Basic structure of microstrip antenna](image)

This type of configuration provides a narrow bandwidth and low gain, reducing the permittivity, the bandwidth will be widened. But by means of increasing the thickness of the substrate, the probe length will be increased, due to that probe inductance will also be increased, which may lead to impedance matching problem and the efficiency of the antenna will be reduced [1].

There are different shapes with different parametric calculations. The length and the weight of the ground plane and the length and the width of the patch are more essential parameters [2]. They are mostly depending on the centered frequency. Different feeding mechanisms are used in antenna designing. Microstrip feeding is considered to be easiest among all the types of feeding mechanisms [3].

2. Antenna Design
A super wide-band microstrip patch antenna of W-shape with its view is depicted in Figure 4 and Figure 5. It is designed with the dimensions of 30.9 X 25.7 mm2 covering a wide frequency range of 1.61 to 17 GHz supporting numerous applications [4].

The proposed antenna consists of a rectangular shaped patch loaded with four slots on a FR4 substrate with thickness of 1.56 mm [5]. For exciting the radiating patch, a 50-ohm microstrip line is used. It is also shown in Figure 1 that the four slots on the patch namely 1, 2, 3 and 4 where slot 1 size is equal to slot 2 and that of slot 3 size is equal to slot 4. Length as well width of the ground plane is considered as 8mm x 8mm with feed length of 0.4mm and feed width of 3.25mm [6].

![Fig. 2: Proposed antenna design view-front](image)
CST MWS Studio software is utilized to design and simulate the proposed antenna structure and various antenna parameters are observed as shown in Figure 2 and Figure 3. Ultimately, the optimal dimensions were acquired as follows: \( L_s = 30.9 \text{ mm} \), \( W_s = 25.7 \text{ mm} \), \( L_g = 1 \text{ mm} \), \( W_g = 12.8 \text{ mm} \), \( L_p = 23.5 \text{ mm} \), \( W_2 = 8.9 \text{ mm} \) and \( W_4 = 2.55 \text{ mm} \). The width of slots 1 and 2 is 2mm and of slots 3 and 4 is 1mm.

3. Simulation Results
The microstrip antenna operating at the frequencies of 4.25GHz, 7.055GHz, 12.48GHz, and 15.26GHz provides better impedances of 57.16Ω, 47.495Ω, 45.337Ω, 46.92Ω and a VSWR of the antenna are 1.157, 1.052, 1.121, and 1.066 respectively.

The designed antenna provides better bandwidth and directivity of 6.025dBi, 6.114dBi, 8.076dBi, 7.949dBi at the frequencies of 4.25 GHz, 7.055GHz, 12.48GHz and 15.26GHz respectively.

**S-Parameter curve**
Input-output relationship of the ports in an electrical system is defined by S parameter. The magnitude of S-parameter is -22.773 for 4.25GHz, -31.80 for 7.055 GHz, -24.843 for 12.48 GHz, and -29.83 for 15.26 GHz. The multiple frequencies obtained are 4.25 GHz, 7.055 GHz, 12.48 GHz, and 15.26 GHz. These multiple frequencies make the antenna to work in larger bandwidth and provide the better gain and directivity [7]. The Figure 4 shows the S-Parameters curve of antenna.

The various magnitude curves obtained at multiple operating frequencies are represented in the following figures: The S-parameter magnitude value obtained at the operating frequency 4.25GHz is 22.773 dB as shown in Figure 5.

**VSWR Measurement**
The power reflection of the antenna is determined by the reflection coefficient. The ratio between the maximum voltage and the minimum voltage of the transmission
The VSWR is always a real and positive number for antennas. The antenna operational frequency of 3.044 GHz, 8.252 GHz, 10.995 GHz and 12.382 GHz VSWR bandwidth is experimented [9]. The minimum VSWR value is 1.0. In this case the antenna is idle. The VSWR achieved at the operating frequency of 4.25GHz is 1.157 as shown in the Figure 5 (a).

**Fig. 5:** VSWR at 4.25 GHz

The VSWR achieved at the operating frequency of 7.055GHz is 1.052 as shown in the Figure 5 (b).

**Fig. 5:** (a) VSWR at 7.0 GHz

The VSWR achieved at the operating frequency of 12.48GHz is 1.121 as shown in the Figure 5 (c).

**Fig. 5:** (c) VSWR at 12.48 GHz

The VSWR achieved at the operating frequency of 15.26GHz is 1.066 as shown in the Figure 5 (d).

**Fig. 5:** (d) VSWR at 15.26GHz

**Input impedance**

It is an important parameter in determining the maximum power transfer between the antenna and the transmission line [10],[11]. Input impedance is a combination of real and complex parts and its general form is: $Z_{in} = R_{in} + jX_{in}$

The Figure 6 shows the above measure.

**Fig. 6:** Input impedance

The input impedance obtained at the operating frequency of 4.25GHz is 57.16 ohms as shown in Figure 6 (a).
The input impedance obtained at the operating frequency of 7.055GHz is 47.495 ohms as shown in Figure 6 (b). The input impedance obtained at the operating frequency of 12.48GHz is 45.337 ohms as shown in Figure 6 (c).

The smith chart for the S-Parameter of desired multiple frequencies has been obtained as shown in the Figure 7.

Table 1 shows the Comparison Result Table

| Parameter | Specification | Frequency (GHz) |
|-----------|---------------|-----------------|
| S11(dB)   | <-10dB        | 4.25 7.05 12.48 15.26 |
| Z11(ohm)  | Inversely proportional frequency | 57.16 47.49 45.3 46.9 |
| VSWR      | Approximately between 0 and 2 | 1.15 1.05 1.21 1.06 |

4. Conclusion
The designed antenna is operating at frequencies in desired bands (4.25GHz, 7.055GHz, 12.48GHz, and 15.26GHz) with the maximum directivity of 8.076 dBi at 12.48 GHz. Moreover, they provide multiband and narrowband features simultaneously. These antennas can be used in any medium related to wireless communication that is supposed to operate in all frequencies.

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