



Article Title: **Design and Analysis of Rectangular Microstrip Patch Using Simple Single Layer Geometry**

Design and Analysis of Rectangular Microstrip Patch Using Simple Single Layer Geometry

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ABSTRACT

This study suggests a 5G mmW wireless network, device, and application-specific low profile multiband micro strip patch antenna. A patch antenna is appropriate for usage in portable smart devices and has a ground plane with a slotted insert. Its compact rectangular design is 9.2 x 8.6x 0.6 mm³. An antenna's operating frequencies are 93.9 GHz, 81.9 GHz, 39.4 GHz, 66.2 GHz and 23.8 GHz. It has the following bandwidths: 12.5 GHz, 8.341 GHz, 2.7634 GHz, 5.9609 GHz and 1.5663 GHz. The suggested design produces gains at resonance frequency of 6.5805 dBi, 6.925 dBi, 7.6845 dBi, 7.6768 dBi, and 8.1006 dBi. Utilizing Micro Strip Feeding technology, the benefits of 5G multiband antenna's design are low cost, light in weight, high gain, efficiency and low profile. Since the antenna was made for the 2.4 GHz frequency band, it is ideal for a wide range of wireless systems, including satellite communication, radar, and medical applications. The Ansoft HFSS software is used to carry out this job.

1 Introduction

Increasing user density, capacity demand, and data speeds on a daily basis lead to a significant advancement in wireless communications. This exceptional development requires more action in the direction of new spectrum and the reallocation of key operating bands at higher frequencies. The 3.3–3.8 GHz dual polarisation, suspended patch antenna design for 5G base stations is affordable and makes fabrication easier [1]. This 5G mm Wave Antenna Module Dual Polarized Broadband Microstrip Patch Antenna on FR4 Substrate is suitable due to its inexpensive and simple mass production [2]. A microstrip antenna array for orbital angular momentum with dual polarisation and dual modes (OAM) The low profile and compact design of this concept make it appropriate for OAM applications [3]. Millimetre wave spectrum applications benefit from the capacitive coupled microstrip comb line array (CCMCA) antenna's low cost, ease of manufacture and low profile [4]. With a based on probability ranging of 1.68 to >50, Due to its capacity to continuously transition between MW and MMW operational bands, this type of antenna is known as a Single Fed Dual Band Micro Strip Antenna for 5G Wireless Transmission [5]. To operate in the 3300-4200 MHz MIMO range, three wideband MPAs have been merged into a Y-shaped architecture for 5G access points. With measured antenna effectiveness of over 88%, the 5G spectrum is in good condition [6]. This liquid crystal (LC)-embedded reconfigurable microstrip antenna operates at 28 GHz, and

it has a lower loss tangent, suggesting that the LC's enhanced RF performance may allow the adoption of reconfigurable resources for cutting edge antenna uses like 5G communication [7]. A Broadband mm-Wave Microstrip Array Antenna for Various 5G Applications with Improved Radiation Characteristics. With SLL less than -12 dB, it has a high space coverage of more than 100 in the H-plane [8]. Because it has a high gain and is affordable, the Bandwidth Proximity Coupled Microstrip Planar Antenna Array for 5G Cellular Application is the ideal choice [9]. The 0.1THz arrays being tested by Liquid Crystalline Polymer Substrate Based THz Microstrip Antenna Arrays for Medical Applications respond well [10]. For millimetre wave approaches, a dual-band, dual-polarized microstrip antenna array can be employed to enhance input impedance, radiation effectiveness, and scanning capability [11]. For millimetre wave applications, a dual band, dual polarisation microstrip antenna array with broadside beam scanning capabilities can enhance input impedance, radiated efficiency, and scanning capability [12]. The Empty Substrate Integrated Waveguide is a low loss and extremely effective feeding arrangement that powers the microstrip patch antenna array (ESIW). The suggested antenna array is made for 5G wireless communication systems that operate at 28 GH, and it is incredibly efficient and affordable [13]. The Empty Substrate Integrated Waveguide (ESIW) microstrip patch antenna array offers a low loss and highly effective feeding structure, low cost of production, and great effectiveness [14]. A 5G wideband patch antenna with anti-symmetric L-shaped probe feeds has sufficient isolation of more than -30dB between the two input ports, a broad bandwidth of 54% (SWR 2), and acceptable directional radiation patterns in the vertical and horizontal planes [15]. The fifth generation mobile network would take advantage of the massive quantity of spectrum in the millimetre wave (mm Wave) bands to considerably enhance communication capacity in response to the rapidly increasing demand for mobile data.

2 Proposed System

Multiband low profile micro strip patch antenna designs are advised for usage with 5G millimetre wave wireless networks, services, and products. The proposed patch antenna has a ground plane and a slotted inset feed line, and it has a small rectangular shape measuring 8.6 x 9.2 x 0.6 mm³. It is appropriate for mobile smart devices.

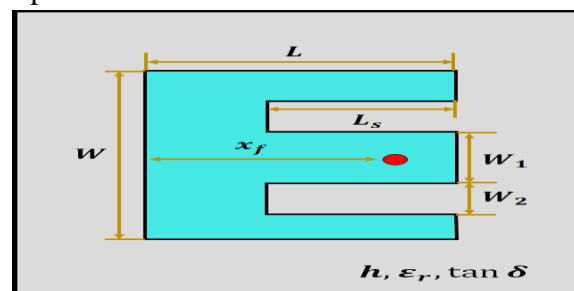


Figure 1: Proposed diagram

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In theory, multi band planar antennas need to function at least two different frequencies with characteristics that are comparable in terms of matching impedance and radiation.

It is possible to think of a straightforward rectangular microstrip patch as a hollow with magnetic walls on the radiating edges. Size and bandwidth of the microstrip antenna are highly correlated with the substrate's electrical resistivity. An antenna with a high dielectric constant has a smaller size, while a substrate with a low dielectric constant has a higher bandwidth. Bandwidth and antenna size are subject to trade-offs. As a higher awarding full wave electromagnetic (EM) field simulator for random 3D volumetric inactive device model, HFSS makes advantage of the well-known Microsoft Windows graphical user interface.

With measured bandwidths of 1.5663 GHz, 2.7634 GHz, 5.9609 GHz, and 12.5 GHz, it operates in the mm-wave spectrum at 23.8 GHz, 39.4 GHz, 66.2 GHz, 81.9 GHz, and 93.9 GHz. At resonance frequencies of 6.5805 dBi, 6.925 dBi, 7.6768 dBi, and 7.6845 dBi, gains are attained using the fundamental approaches.

2.1 Feeding Techniques

Many different methods can be used to feed a microstrip patch antenna. Techniques using contact and those without contact are both used. RF power is directly delivered to the radiating patch in contacting technique using a connecting element, such as a Microstrip line. Through electromagnetic field coupling, the radiating patch transfers power to the Microstrip line in a non-contacting system. Four of the most popular feed techniques are proximity coupling, aperture coupling, coaxial probe, and microstrip line (both contacting systems). There was one coaxial feed used for this project.

2.1.1 Coaxial Feed

The probing feed method, sometimes known as coaxial feed, is a widely used method for feeding Micro strip patch antennas. An outer conductor of a coaxial connector is wired to ground, and the inner conductor which travels through the dielectric is wired to a radiating patch. The flexibility with which the feed may be placed inside the patch to best match the input impedance is the main benefit of employing this type of feeding system.

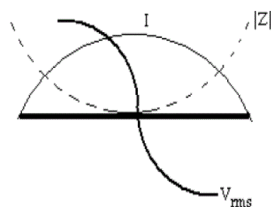


Figure 2: Impedence Variation of the patch

The inputs resistance of a rectangular Micro strip antenna changes from zero at its centre to its maximum priority at its radiating edges for the basic TM₁₀ mode since the voltage is highest and the current is lowest. This feed system is simple to construct and emits little extra radiation. Due to the need for drilling a hole in the substrate and the connector extending past ground

plane, which prohibits thick substrates from being flat, its principal shortcomings are a poor bandwidth and difficulties in copying.

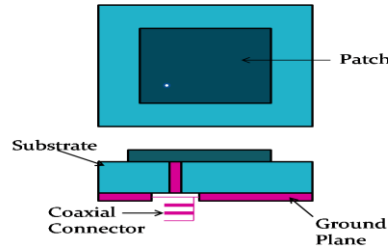


Figure 3: Probe Feed Microstrip patch Antenna

Furthermore, the longer probe results in a more inductive input impedance for thicker substrates, which poses problems with matching. Coaxial feed and Micro strip line feed both have a number of drawbacks when used with a thick dielectric substrate that provides a large bandwidth.

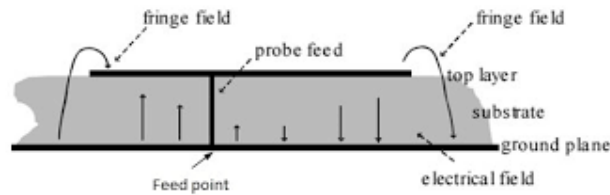


Figure 4: Feed Line Connection Techniques

2.1.2 Microstrip Line Feed

The illustration demonstrates how the suggested feed method immediately bonds a conductivity strip to the Micro strip patch's edge. The advantage of this specific feed arrangement technique is that it makes it possible to etch the feed on the same substrate, resulting in a flat structure. The patches are bigger than the conducting strip.

Figure 5: Without the use of any extra equalising components, the Small Strip Line inset balances the resistance of the signal source to the patch. To do this, the inset position must be properly managed.

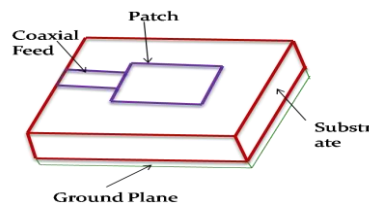


Figure 5: Micro strip Line Feed

This feeding technique is straightforward because to its ease of production, ability to match impedance and simplicity. Nevertheless, when the dielectric substrate's thickness increases, an

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antenna's bandwidth decreases along with erroneous feed radiation and surface waves. Feed radiation give rise for unwanted cross polarized radiation.

2.1.3 Aperture Coupled Feed

In this kind of feed mechanism, as seen in figure 6, the ground plane acts as a partition between the Micro strips feed line and radiating patch. The feed line and patch are connected by a hole or slot in the ground plane.

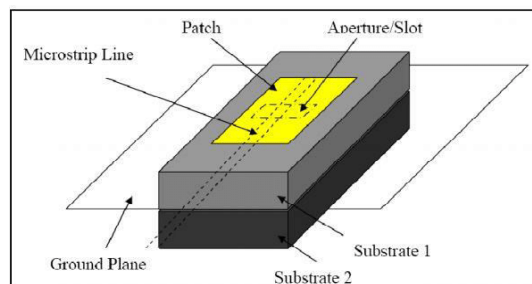


Figure 6: Coupled Aperture Feed

The coupling aperture is often found centred below the patch because of the symmetry of the design, which minimises cross polarisation. The amount of coupling between the feed line and patch depends on the aperture's size, location, and shape. The ground plane's function of isolating Patch from the feed line results in decreased spurious radiation.

The upper substrate is usually made of a thick, low dielectric constant material to maximise radiation from the patch, while the foot substrate is usually made of a thick, high-dielectric constituency material. This feed method's primary drawback is the complex assembly required by the various layers that thicken the antenna as well. The particular feeding technique also has a constrained bandwidth.

2.1.4 Proximity Coupled Feed

The particular kind of feed mechanism is also referred as an electromagnetic coupling system, as displayed in figure 7. The radiating patch is positioned above the lower substrate and feed line is positioned among two dielectric substrates.

Primary benefits of a proposed feed strategy is that, it provides a very high bandwidth (as high as 13%) and avoids spurious feed radiation that is caused due to a general rise in a thickness of the Micro strip patch antenna.

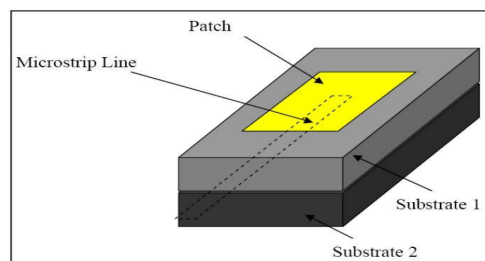


Figure 7: Proximity Coupled Feed



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This method allows users to choose among two distinguished dielectric media, one for the feed line and one for the patch, to enhance each user's performance. This feed scheme's primary drawback is that it requires careful fabrication because it has two dielectric layers that must be aligned. The antenna's overall width has also increased.

A traits of the various feed strategies are outlined in the table below.

Table 1: Different feeding techniques

Characteristics	Micro strip Line Feed	Coaxial Feed	Aperture coupled Feed	Proximity coupled Feed
Spurious feed radiation	More	More	Less	Minimum
Reliability	Better	Poor due to soldering	Good	Good
Ease of fabrication	Easy	Soldering and drilling needed	Alignment required	Alignment required
Impedance matching	Easy	Easy	Easy	Easy
Bandwidth (achieved with impedance matching)	2-5%	2-5%	2-5%	2-5%

2.2 Design of Rectangular Patch Antenna

In the microwave frequency range, micro strip antennas are the most common type of antenna. They are also widely utilised in the millimetre wave frequency range. (Lower about 1 GHz, other types of antennas, such as wire antennas, predominate since a microstrip antenna's size are mostly outsized to be applied in the real world.)

The fundamental procedures for creating a RPA (Rectangular Patch Antenna) are as follows:

STEP 1: a variable from this equation, the width of the radiating RPA is calculated.

$$W = \frac{C}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

Where,

C = velocity of light, 3×10^8 m/s

ϵ_r = dielectric constant of the substrate.

f_r = resonant frequency of antenna

STEP 2: PRA's efficient dielectric constant can be calculated with the help of,

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[\frac{1}{\sqrt{1 + \frac{2h}{W}}} \right] \quad (2)$$

STEP 3: At the resonance frequency, the effective length is given,

$$L_{eff} = \frac{C}{2f_r \sqrt{\epsilon_{eff}}} \quad (3)$$

STEP 4: Elongated length of PRA calculated using the following equation,

$$\Delta L = h * 0.412 * \frac{(\epsilon_{eff} + 3) \left[\frac{W}{h} + 0.264 \right]}{(\epsilon_{eff} - 0.258) \left[\frac{W}{h} + 0.8 \right]} \quad (4)$$



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The PRA's length "L" is calculated as follows:

$$L = L_{\text{eff}} - 2\Delta L \quad (5)$$

- Dimension of the patch are $W = 22.26\text{mm} * L = 16.95\text{mm}$.
- The dimension feed are $W_L = 3.1\text{mm} * L_L = 10.4\text{mm}$.
- Ground plane dimensions has been computed as $W_g = 31.86\text{mm}$ and $L_g = 26.55\text{mm}$.

In many communication systems, micro strip antennas are commonly employed as effective radiators. Microstrip antennas are appealing due to their pocket friendly cost, compact size and simplicity of integration including networks of printed feeds and active circuits. Microstrip antennas saw rapid development and significant growth in popularity. The 2.4 GHz frequency band is where the antenna was constructed.

As a result, this antenna is ideal for a variety of uses, including wireless systems, radar, medical applications, and satellite communication. There are several uses for radar systems, including monitoring and remote sensing. Researchers are becoming interested in radar remote sensing methods. System for ultra-wideband radar that transmits pulses with a brief duration. This radar works on the premise of sending brief pulses, then receiving the response from reflected pulses.

4.3 Design Aspects

The HFSS tool is used to design the structures of various micro strip patch antennas for a variety of applications. These dimensions are presented below in their appropriate tabular form. These measurements were utilised to create the E-Slot tiny strip patch antenna.

Table 4 Dimensions of E-Slot Antenna

Parameter	Size(mm)
Substrate (ROGERS 3210)	22*31*2.6
Infinite Ground	22*31
Patch	16*23*2.6
Corner cut	2*3
Air	22*31*2.6
Feed	3*2
E-Slot	12*366

3 Result and Discussion

Ansys Electronics Desktop student programme 21 has been used to design and simulate the suggested antennas.



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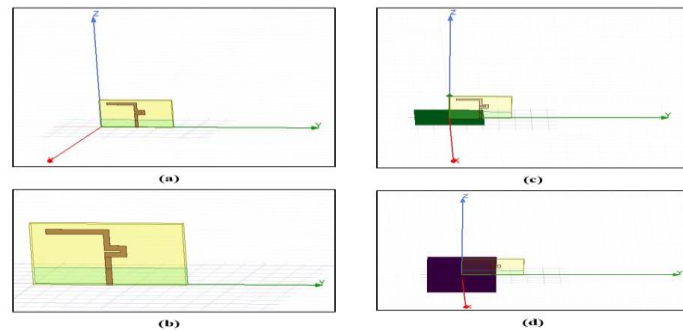


Figure 8: Micro strip Patch Antenna's

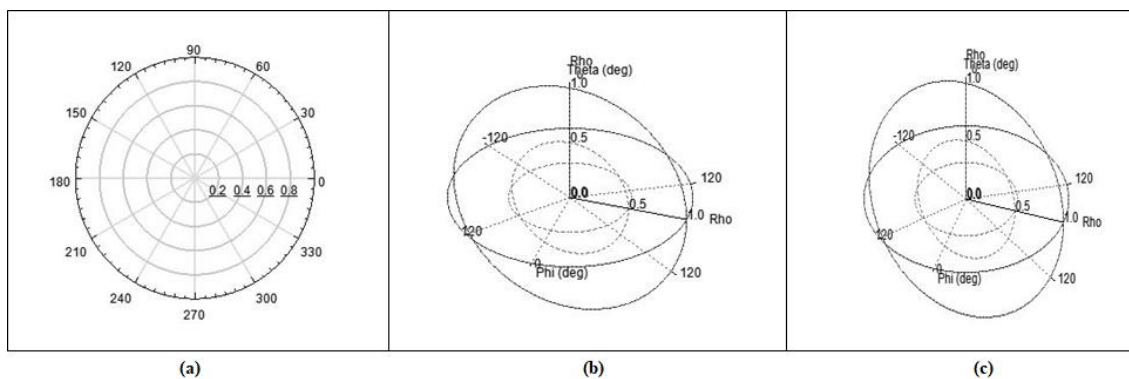


Figure 9: (a) S Parameter (b) S Parameter Plot (c) S Parameter 2

4 Conclusion

It advocates the use of form Wave wireless networks, equipment and applications with multiband low profile micro strip patch antennas. Patch antenna is $0.6 \times 8.6 \times 9.2 \text{ mm}^3$ in size and is rectangular in shape. It is ideal for use in smart portable devices. It consists of a slotted inset feed line and the ground plane. A straightforward single layer design is used to create a multiband rectangular Micro strip patch antenna. Through the addition of a slot to the radiating patch's feeding line, it can operate across different frequency bands. We get high gain and impedance using an E-Slot Micro strip antenna. Since this project was created for the 2.4 GHz frequency band, the antenna is ideal for a wide range of wireless devices, including satellite communication, radar, and medical applications.

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