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Review on Microstrip Patch Antenna forMobile Communications and 5G Satellite

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Abstract: *Human development is constantly being heavily influenced by connectivity. Human history has been shaped by it since many years, and the future is now beginning to imagine. Wireless communication has evolved over the years because it wants speed and perfection. All updates to communication generation will accelerate the electronics industry for decades. Just a few years after it was introduced, 4G has been taking over. Furthermore, there are strong advances in meeting the demand for fifth generation communications networks. This article designs and simulates microstrap patch antennas compatible with 5G communication. The antenna operates on a very high frequency spectrum (EHF) of 43.7 GHz. The substrate material used is fire-resistant 4 (FR4) poxide with a relative perpetrator of 4.4. We also examined radiation patterns, electrical distribution, reinforcement, VSWR, and loss of yield of the antenna. The results are checked to meet the requirements and are discussed for many applications.*

Keywords*:* 5G, Microstrip Patch Antenna, Feeding Techniques, FR4, High Frequency, MIMO, Gain

I. INTRODUCTION

The purpose of this paper is to describe the systematic and experimental design approaches of microstrips and to imple ment a comprehensive overview of the state of microstrip techniques. The transition from 4G to 5G leads to a paradigm shift in wireless communications. This highlights ultrahigh speed data transmission, large device connections, and ultra reliable communication with low latency. Antennas play an important role in enabling these functions. Microstrip patch antennas are known for their compact size and compatibility with printed circuit boards, but are widely popular in 5G mobile parts, base stations and IoT applications. In other words, the antenna becomes an increase system of conductors that correspond or match the recipient with free space in the transmitter or recipient. The main categories include micro stripe dipole, printed slit antennas, and microstrip transmission wave antennas. Design Microstrip Patch Antenna Micro strip Patch Antenna for wireless applications including the following goals: Selectionof substrate material between the f our: FR4, RO4003, GML 1000, RT/Duroid5880. antenna. The designed antennas are examined for several feeding tech niques, and results are compared and introduced in further sections. Finally, this paper provides a brief overview of the l atest developments in patch antenna development technology and real world applications. This paper closes with comparative testing of various feeding techniques and improvements using antenna arrays.

II. DESIGN OF MICROSTRIP PATCH ANTENNA

The microstrap patch antenna consists of thin metal spots of each shape on a dielectric plate, with the opposite side grounded. The thickness of the dielectric plate is 0.03î»-0.05î»

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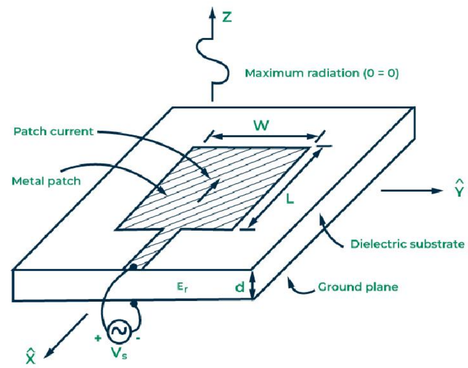

To calculate a rectangular patch antenna, calculate parameters such as dielectric constant (ε_r) resonant frequency (f_r), and substrate height (h). For efficient widths lead to good radiation efficiency

$$W = \frac{c}{2f_r}\sqrt{\left(\frac{2}{\varepsilon_r + 1}\right)}$$

Here, c is the speed of light. To calculate the length of the patch, you need to calculate the effective dielectric constant of the substrate.

Parameters	Fr4	RO-4003	RT-Duroid
Dielectric constant	4.36	3.4	2.2
Loss tangent	0.013	0.002	0.0004
Water absorption (%)	<0.25	0.06	0.02
Tensile strength (MPa)	310	141	450
Volume resistivity (M-Ohm.cm)	8×10^7	1700×10^7	2×10^7
Surface resistivity (MOhm)	2×10^5	4.2×10^9	3×10^7
Breakdown voltage	55 kV	–	>60 kV
Peel strength (N/nm)	9	1.05	5.5
Density (kg/m^3)	1850	1790	2200

The above table represents properties of commomly used dielectric materials.

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

The final length of the patch can be determined by using the formula,

$$L = \frac{1}{2f_r\sqrt{(\varepsilon_{reff})}\sqrt{(\mu_o\varepsilon_o)}} - 2\Delta L$$

where ΔL is the extension of the length of the patch and can be determined using formula,

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

With the above equation, the width and length of the rectangular pavement can be calculated for the 2.1 GHz frequency. For calculations, both W and L are about 29.2 mm. Patches with specified dimensions can be created with any EDA

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tool used for antenna development. 3.The black part is the substrate material, FR4, which surrounds the actual patch. The rectangular patch is shown in brown on top of the substrate material. The patch dimensions are 29.2 mm 9 29.2 mm according to previously performed calculations. The point marked with the red arrow is actually port 1 where the rectangular microstrog pavement for the transmission of electromagnetic waves is fed into the open space. The next important part of antenna design is feeding the antenna. There are several feeding techniques discussed in the next section.

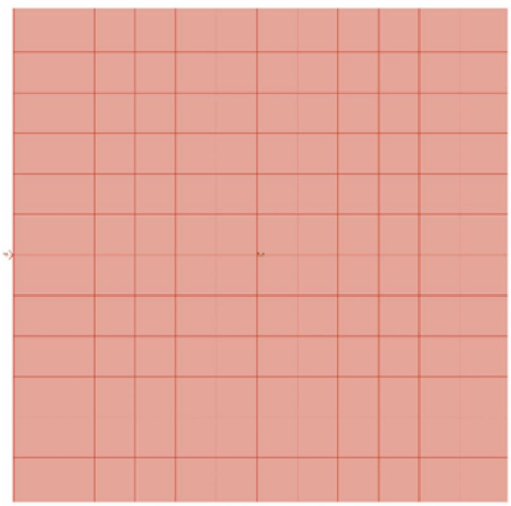


Figure 2: Layout designed under ADS 2016.01

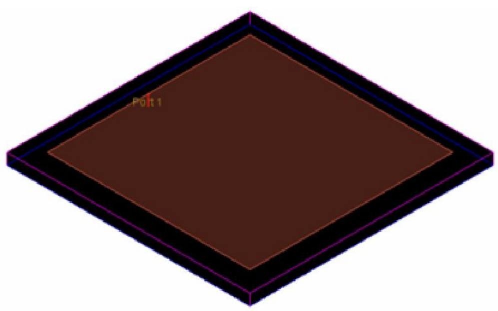


Figure 3: Three dimensional view of rectangular patch

III. FEEDING TECHNIQUES

The role of feeding is extremely important for efficient antenna associations to improve antenna input impedance adjustment. [7] The different types of feeding techniques are as follows:

Microstrip line Feed:-

This type of feed technology allows the conductive strip to be connected directly to the end of the microstrip patch. The conductive strips are smaller than patches, and this type of feed arrangement has the advantage that feeds can be etched onto the same substrate to provide a planar structure. [8]

Inset Feed

In is a kind of microstripe making feeding technique that has the advantage that the line strip width is lower compared to patches and that the feed can provide a planar structure. [2] The purpose of bullets in a patch is to accommodate the impedance of the feedline of the patch input impedance, without the need for additional matching elements. This can be achieved by adjusting the position and dimensions appropriately to set the toggle. [6]

Co-axial Feed

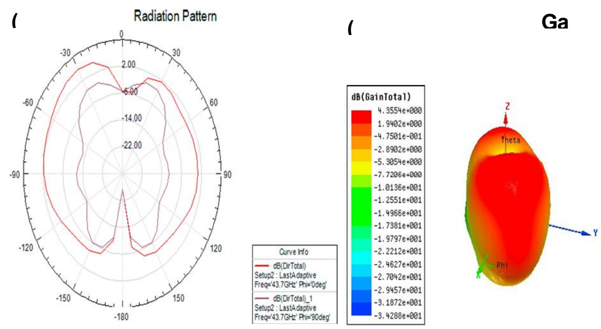
Coaxial probe feeding is a very common technique used to feed microstrip patch antennas. The inner head of the coaxial cable extends over the dielectric, soldered to the radiation metal pavement, and an outer ladder connected to the ground level. The advantage of this feeding scheme is that the feed can be placed in patches anywhere to accommodate the cable impedance to the antenna input impedance. [5] The main goal of using probe intake is to improve reinforcement and provide narrow bandwidth and impedance contracts. [6]

Aperture coupled Feed

In this type of feed technology, the radiation field and the microstrap advance line are separated at the ground level. The coupling between the pavement and the supply line is produced by ground level slits or panels.

Proximity coupled Feed

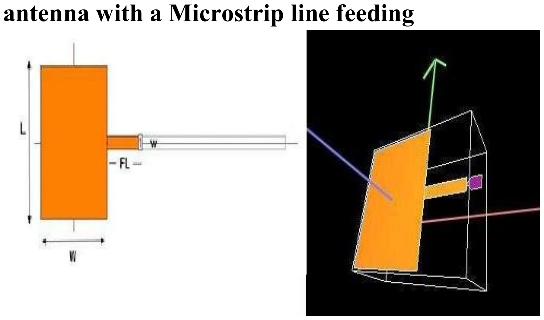
This type of feed technology is also known as an electromagnetic coupling scheme. Because two dielectric substrates are used, the preshed line is between the two substrates and the radiating patch is at the top of the top substrate. The main advantage of this feeding technique is that it eliminates false feed radiation and provides very high bandwidth due to the general increase in microstrip patch thickness (up to 13).



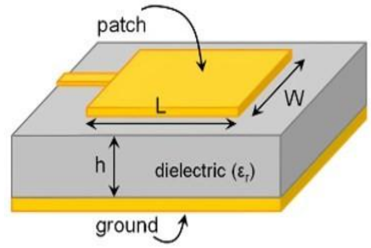
Feed techniques

Here are various types of methods for feeding microstrip patch antennas. The antenna has two sides, one side with a dielectric substrate and the other side with a radiant patch. There are two types of contact feeding techniques, and do not contact other types. When contacting feeding techniques, performance is linked directly to the radiation patch by the radiation element. The thickness of the conductive material is influenced on a single element of a rectangular microstrip patch delivered for 5G wireless communication applications with 28 GHz resonance, withelectromagnetic coupling between the supply line and the radiating plow. The effect of radiation loss on the radiation pattern of the antenna is one of the most important aspects of evaluating feed. The impedance bandwidth remains the same as the strip width increases, but the yield loss due to impedance does not match between the microstripe line and monopoly. Due to the low effective power distribution of monopoly, AR bandwidth decreases with increasing parasitic strip dimensions [26-33]. The dual band-MPA in the Starform lot operating at 2.4 and 5 GHz frequencies is reduced in size due to the combination of methods with the high slope substrate, slot, and DGS [34-37]. The techniques used are listed below:

Rectangular Microstrip patch antenna with a Microstrip line feeding



A Microstrip Patch Antenna



Using an antenna array to increase efficiency

Another technique to increase bandwidth and improve antenna magnitude responsiveness is to use an antenna array. A microstrip line can be used to connect two or more antennas. The performance of the entire patch design can be optimized by the designer by allowing all of the antennas to use the same or alternative feeding mechanisms. High gain, adjustable beam-width, return loss characteristics, and other special qualities can be obtained at a minimal cost with antenna arrays. Nearly all of the drawbacks of a microstrip patch antenna are mitigated by an array of patch antennas. Additionally, once a single antenna is ready, creating an array is not too difficult.A Microstrip wire of nearly identical dimensions with a 50 ohm impedance running the length of it connects two inset fed rectangular patch antennas in Figure 11. When compared to a typical inset-fed antenna, the array displayed above offers a far greater response.

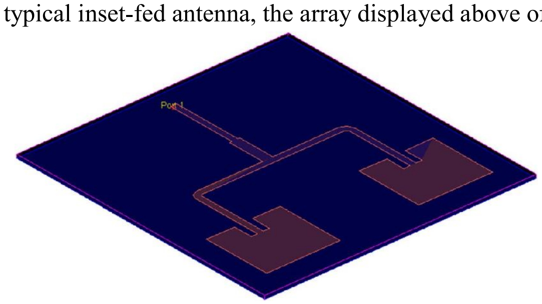
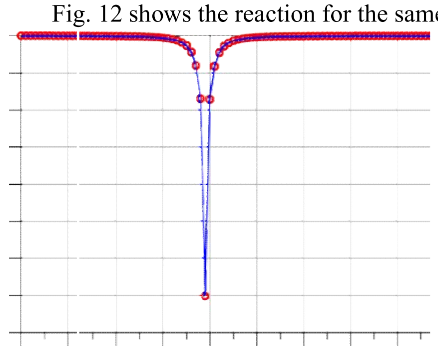
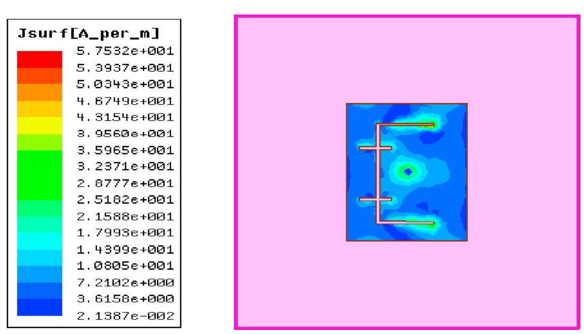


Fig. 12 shows the reaction for the same.





The two antenna arrangement can provide a better size point when the resistance of the printed board is compared to typical supply supply results [9]. In this particular area, a coaxial plug is mounted vertically on the patch surface to allow delivery to the patch antenna. The coaxial FED structure of the antenna is shown above. A return loss of -23,3656 was recorded at 43.7 GHz.

To visualize the antenna radiation field, radiation patterns are shown at electrical and H levels. Furthermore, the positive value of profits is always predicted. The following diagram shows that the constructed antenna creates an accurate radiation pattern and an appropriate reinforcement of 4.35 at the resonance frequency. Figure 6 shows the surface current distribution seen throughout the patch and is used for the resonance frequency. The fact that all slots created with the antenna patch affect the behavior of the antenna. Slot adaptation is usually used to take into account the trends of designed antennas and focus on the theoretical expectations when simulated. Designers need to modify several slot strategies to achieve the desired result, usually achieved by experiments and errors.

If the world is excitedly waiting for the arrival of 5G, it is essential to recognize the meaning of 5G antennas. The antenna is compact and can be changed to use it as a 5G communication antenna on mobile phones. Because it operates at a very high frequency (EHF) in this area, the antenna is also applicable to use in satellite applications. As a result, all artificial things will disrupt 5G signals [21] [22]. The use of large MIMO antennas can help prevent this problem. The idea behind Massive MIMO is to use many antennas of the same type for a single application, so that multiple input multi-output (MIMO) antennas cover the barrier. It also needs to adapt small cell cell networks containing small base stations with minimal power requirements [24]. Small network cells are processed by this compact base station, and also improve local signal strength. Due to its good radiation patterns and legitimate interest, the developed antennas can also be used in these small stations.

IV. CONCLUSION

In this work, microstrip patch-slot antennas and 5G communication were built for the satellite. This design was simulated using the ANSYS HFSS v.15.0 simulation tool. The results obtained are determined to meet the criteria for 5G communication antennas.

43.7 GHz is the resonance frequency at which the antenna works. Small antennas can be used in microbial stations and communication devices. Since 5G requires large MIMO antennas, it is recommended to use several antennas of comparable types. The antenna impedance problem is reduced by using coaxial feeds. Future projects include the production of the intended antennas for the 5G-Echtzeitlendungen. Low efficiency, low performance, and a limited range of microstrip antennas should be considered. Nevertheless, additional antenna improvements are required and installed to adapt to real-time application scenarios.

V. ADVANTAGES OF MIMO SYSTEMS

The growth area of mobile applications has led to demand for gigabit data rates to meet users at various mobility levels with lower mobility levels and lower mobility scenarios. To meet this requirement, traditional individual antennas on mobile devices are replaced by MIMO antennas. By implementing MIMO technology, mobile devices can provide improved service quality, providing uninterrupted signals, high data rates, increased capacity and improved spectral efficiency. Some of the benefits are listed below.

4.1. Increased Data Rates

MIMO technology enables several data flows to be transmitted simultaneously over the same frequency band, enabling higher data rates compared to traditional single-input single-output systems. The increased number of MIMO layers also increases the overall system throughput.

4.2. Improved Signal Quality

MIMO technology helps improve signal quality by reducing the effects of fade, interference and noise. As a traditional SISO (single input - individual output), a single data stream is transmitted between the transmitter and receiver. This

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results in more interference and fade effects with the cover limit, as the large jet width of the base station antenna is shown in Figure 7 for MIMO or MIMO at Gnodeb (base station antenna). With cover restrictions as shown in Figure 8.

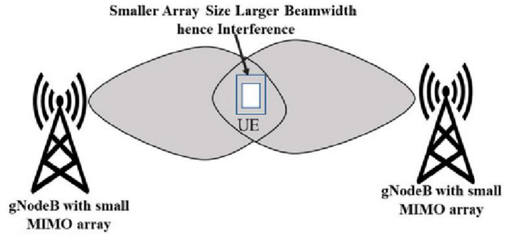

Figure 7. The smaller the array size and large beamwidth, the more interference at the coverage boundary.

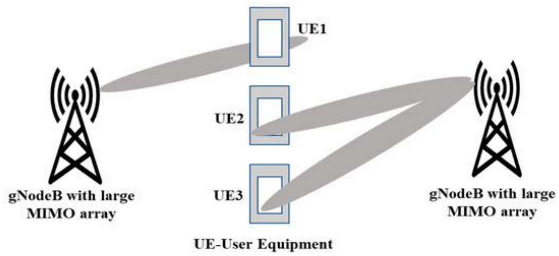

Figure 8. Larger array size sharper beam low interference.

4.3. Increased Range and Coverage

MIMO technology can expand the realm and reporting of your wireless network by improving connection quality and reducing the likelihood of signal dropouts. Figure 9 shows that a larger MIMO array or larger MIMO creates a more directional beam that can improve coverage compared to traditional SISO systems.

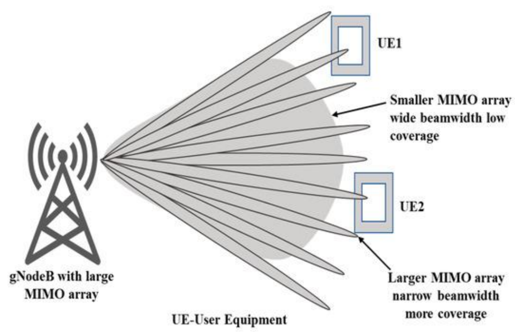

Figure 9. Directional beams have a stronger coverage area and improved signal-to-noise ratio

Design Challenges for 5G MIMO Antennas

MIMO antennas have several challenges to design and integrate into a real environment. MIMO's biggest challenge is mutual coupling that reduces antenna performance. Electromagnetic coupling between different antenna connections reduces performance with narrow spacers. Apart from mutual coupling, the size of the Mimo antenna is also an issue in terms of portable devices that are carefully guaranteed. Some antennas require more HF chains along with each antenna element, which increases the size and cost of the antenna. Therefore, technologies such as polarization diversity are effective in situations where systems can be reduced to some extent in size and cost. Therefore, researchers need to carefully address different types of single MIMO systems to achieve optimal performance. Some of the design challenges are explained below.

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Coupling

In MIMO antennas, several antennas are tightly packed into the transmitter and recipient side, leading to mutual coupling between the antenna elements. If some antennas are located close by, electromagnetic energy can be combined to affect the performance of the mimo antenna. Coupling can affect the radiation pattern and reduce insulation between the antenna elements. The literature proposes various methods to reduce mutual bonding and improve separation between different ports. Parasitic elements, neutralization lines, slots/stubs, separation structures, poor soil structures, slit mulching, metametals, unit cells, etc. It is the most frequently used thermal insulation technology [85,86,87,88,89,90]. A parasitic element approach is when an insulating element is placed between the antenna elements to reduce the effect of coupling. [91], the authors explain that inserting parasitic structures reduces the correlation effect between ports. Parasitic structures are designed to reduce binding effect on all pass straps. Neutralization, slots, and stubs are methods used between radiant spots that reduce the effect of coupling with ground level or with another antenna. [92,93,94], the paper explains reducing separation along with neutralization techniques along with SIW, slots, or isolation networks. As the literature shows, neutralization lines, slots and stubs are easily integrated into the structure, providing significant improvements in separation between different ports. Furthermore, practical applications require community level for practical applications, as ground level electricity causes antenna performance with respect to other antenna elements and the effects of radiation patterns and efficiency. Thus, ground level ground structures or slot defects significantly reduce surface currents to excite other antennas, providing greater separation between ports [95]. Metallurgical structures developed between radiation elements, floor levels, or antenna elements greatly improve insulation. [96,97,98], the authors described significant improvements in metametal and DGS-based insulation techniques.

The Compactness of Portable Devices

To meet the growing need for an increase in mobile data volume, the capabilities of radio mobile radio networks need to be improved. While networking and new frequency integration are potential solutions, including higher-order MIMO functions in existing wireless networks provides the option to significantly improve top data rates and increase total network capacity. Polarized antennas are typically used in traditional 2-2 MIMO networks. A second transverse antenna can be used to insert additional independent antennas into the system (e.g., 4 Raw 4 Mimo on a smartphone) [99]. To prevent the antennas from correlated, either the horizontal or vertical distance between them must be in the handheld device between them. It is a challenge for researchers to design such a configuration. Currently available mobile phones on the market currently support 2-Roh-Mimo antenna 2 or up to 4 Å4 Mimo in the best segment of smartphones. MIMO antennas must be compact to integrate into portable devices. However, small antennas can affect performance. Designers need to make up for compromises between size, efficiency and bandwidth.

Polarization Diversity

In reality, large antenna distances are often required to achieve a large multiplex or diversity gain. The use of bipolarized antennas (polarized diversity) is a promising cost and spatially effective alternative, with two spatially separated university polarized antennas being replaced by a single antenna structure using orthogonal polarization. This can be achieved by using antennas with different polarization directions or using two polarized antennas. Designers need to carefully select the type and orientation of the antenna for optimal performance.

Frequency Band Coverage

5G wireless networks operate on MMWave with frequency bands below 6 GHz for 5G communication. Both the Sub 6 and MMWave bands have their advantages and disadvantages. MMWAVE technology has a higher data rate due to its large bandwidth, but has a small coverage area due to its strong attenuation at high frequencies. Due to limited availability of bandwidth, the 6 GHz sub-GHz gang has lower losses of weakening due to higher coverage area and lower data rates [101]. Therefore, the greatest need is to design MIMO antennas that support the multiband modes of FR-1 and FR-2. Therefore, the antenna range and radiation characteristics should be consistent with the frequency band of interest.

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