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Review of Microstrip Patch Antenna for Wireless Applications

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ABSTRACT

This review research paper examines the evolution of the microstrip patch antenna (MPA) in the field of wireless communication technology. Distinguished researchers have made several efforts to develop MPA in order to meet market demands. To begin, this paper provides a quick overview of wireless technology and MPA. Following that, a literature review is provided in order to better comprehend the concept of a patch antenna that is small in size, has multiband and wideband functionalities, and is widely used in wireless communication. Reported antennas simulation have been accomplished with the help of CST, HFSS, and other tools. Return loss, VSWR, directivity, gain, efficiency, and radiation pattern are all examined with this software. The end result of numerous investigations has been mentioned which can be primarily based on antenna performance factors like patch slot, antenna dimensions, substrate material, and feeding techniques. For their better understanding these findings delineated within the tabular form and finally conclusion of the overview paper is discussed.

Keywords: - Microstrip patch antenna, Feed Techniques, Substrate, Return loss, Gain.

1. INTRODUCTION

Satellite and wireless communication have advanced rapidly in recent decades, and they have already had a significant impact on human life. Many applications in communications and local area network require a means for transmitting and receiving electromagnetic waves. Microstrip antenna technology's adaptability has resulted in a wide range of designs and ways to meet this need. A small monopole antenna for multiband applications was presented in this paper. For DCS, PCS, and Bluetooth wireless applications, two stubs were created, while three rectangular slots were created for WiMAX, WLAN, and the X-Band Downlink system [1-5].

The demand for small mobile phone handsets has increased in recent years. Pocket-sized handsets have begun to come on the market. As demand grows, the demand for compact handsets will grow as well. One of the most essential variables in portable communication systems is the antenna size. Because of its modest volume and small profile, the MPA is commonly used. MPA's size is mostly influenced by the length and width of its resonance. This research examines three multiband MPAs that operate in the WiMAX (3.5/5.5 GHz), WLAN (5.2/5.8 GHz), and C frequency bands [6-10]. The patch size can be reduced by utilizing a patch substrate material with a high permittivity and a short substrate height. In current scenario of communication systems role of microstrip antenna is very much useful. A RF-MEMS switch is used to reconfigure a new CPW-fed elliptical shaped reconfigurable antenna for wireless applications. Four uniform sinusoidal flexure RFMEMS switches are loaded into the proposed CEP antenna [11-17].

2. FEED TECHNIQUES

There are different types of methods for feeding Microstrip patch antenna. Antenna has two sides, one side has dielectric substrate and other side has radiating patch. There are two types of feed techniques one is contacting and another one is non-contacting. In Contacting feed technique power is coupled to the radiating patch directly through radiating element. The impacts of conductive material thickness on a single element rectangular microstrip patch inset supplied antenna operated at 28 GHz resonance for 5G wireless communication applications were given, as well as the construction of a mathematical model [18-25].

In non-contacting technique there is electromagnetic coupling between feed line and radiating patch. The effect of the radiation loss on the radiation pattern of the antenna is one of the most important aspects for the evaluation of the feed. The impedance bandwidth remains same as strip width increases, but return losses increase due to impedance mismatch between the microstrip line and the monopole. Due to the monopole's less effective current distribution, the AR bandwidth decreases as the parasitic strip dimension grows [26-33]. The star shape slotted dual band MPA working at 2.4 and 5 GHz frequencies has size reduction due to a combination of high permittivity substrate, slot, and DGS methods [34-37]. Following are the used techniques:

i. Contacting feed
a. Microstrip line
b. Coaxial probe
ii. Non- contacting feed
a. Aperture coupling
b. Proximity coupling
c. Co- planar wave guide feed.

TABLE 1. Comparison of different feed techniques and their characteristic

Characteristics	Co-axial probe feed	Radiating Edge coupled	Non-radiating Edge coupled	Gap Coupled	Insert Feed	Proximity coupled	Aperture Coupled
Design Aspects	Non planar	Coplanar	Coplanar	Coplanar	Coplanar	Planar	Planar
Feed Pattern	More	Less	Less	More	More	More	More
Polarization Quality	Poor	Good	Poor	Poor	Poor	Poor	Excellent
Manufacturing Process	Mount component	Simple	Simple	Simple	Simple	Alignment required	Alignment Required
Consistency	Not reliable	More reliable	More reliable	More reliable	More reliable	Less reliable	Less reliable
Impedance Matching (50 Ω)	Simple	Poor	Simple	Simple	Simple	Simple	Simple
Bandwidth in GHz (%)	2-5%	9-12%	2-5%	2-5%	2-5%	12%	21%

3. DIMENSION PARAMETERS

The dimensions of the Microstrip patch antenna are calculated as given below

3.1 Length

The rectangular patch antenna length decides the resonate frequency. For a rectangular patch the resonate frequency is λ/2 in its fundamental mode. Practically it is observed that due to the fringing field effect the patch is a some larger than the theoretical dimensions.

The length is calculated by the by equation (1).

$$L \approx 0.49\,\lambda_d = \frac{0.49\,\lambda}{\sqrt{\varepsilon_r}} \tag{1}$$

3.2 Width

The dimensions of the patch antenna have main role to affect in the results, especially length (*L*) and the width (*W*). The width of the patch can be calculated by equation (2).

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

c is speed of light

f_r is the resonant frequency

3.3 Length of Extension (ΔL)

The normalized expansion of the length is calculated by equation (3).

$$\Delta L = \quad 0.412h\frac{(\varepsilon_r + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 8\right)} \tag{3}$$

Where:

h- Height of the patch.

w- Width of the patch.

ε_{reff} - Effective Dielectric Constant.

TABLE 2. Comparison of different parameters of reported MPAs

Ref. No.	Antenna Resonate Slot	Antenna Area (mm^2)	Substrate Material	Gain (dB)	Feeding Technique
[1]	L-Shaped Slot	18×16	Duriod	7.8	Microstrip line
[2]	DGS Structure	37×47	FR4	10.13	Microstrip line
[3]	Rectangular Shape	6.2 ×7.3	FR4	5.62	Microstrip line
[4]	Square Shape	9 ×9	Si	5.13	Coplanar Wave- guide
[5]	Rectangular Shape	78 × 45	Duriod	4.7	Microstrip line
[6]	Elliptical	21×21	FR4	8	Coaxial
[7]	Square Shape	21×21	FR4	2.61	Microstrip line
[8]	DGS Structure	104 ×104	Duriod	11	Microstrip line
[9]	L-Slot	54.4 × 46.7	FR4	4	Microstrip line
[10]	Diamond Slot	66 ×66	Duriod	1.31	Coaxial
[11]	Rectangular U-Shaped Slot	54 × 59.5	Rogers TMM4	6.9	Inset Feed
[12]	U-Shape Slot	61×38	FR4	3.5	Inset microstrip feed line
[13]	U-Slot	18 ×22	Air	8	Coaxial
[14]	Two L-Shaped Slots	4.3 ×10	FR4	4.93	Inset feed
[15]	Elliptical Ring Slot	33×40	FR4	6.42	Coplanar waveguide
[16]	Elliptical Slot	16×20	FR4	6.65	Coplanar waveguide
[17]	Rectangular Shape	6.2 ×7.2	RT Duroid 5880	6.63	Inset microstrip feed line
[18]	Rectangular Shape	3.4×4.3	Rogers 5880	7.3	Microstrip feed line
[19]	Rectangular Shape	5.4×4.5	Air	9.47	Microstrip feed line
[20]]	Rectangular Shape	7.9×8.9	FR4	7.42	Microstrip feed line
[21]	Square Shape (Surface Edge Cut)	28.9×28.9	FR4	4.83	Inset Feed
[22]	I-Shape Slotted Antenna With Dumbbell Shape	29×38	FR4	3.61	Microstrip feed line
[23]	Φ-Shaped Patch Antenna	55×55	FR4	4.41	Microstrip feed line
[24]	Rectangular Shape	6×6	Duroid	10	Microstrip feed line
[25]	Dual Circular Slot Ring	50×50	FR4	7.8	Microstrip feed line
[26]	Rectangular Shape	48×29.5	FR4	3.5	Microstrip feed line
[27]	Annular-Ring Slot	25×24	FR4	4.59	Microstrip feed line
[28]	Square-Slot Antenna	26×26	FR4	4.42	Microstrip feed line
[29]	Monopole Antenna	24×24	FR4	2.8	Microstrip feed line
[30]	Rectangular Shape	20×30	FR4	4	CPW feed line
[31]	Circular Shape	25×25	FR4	3.5	Microstrip feed line
[32]	Square Slot Antenna	116×116	FR4	3.4	Microstrip feed line
[33]	C-Shaped Slot Antenna	55×40	FR4	6.8	Microstrip feed line
[34]	Rectangular Shape	18×20	FR4	5.30	Microstrip feed line
[35]	Arc-Shaped Tuning Stub	70×70	FR4	5.1	Microstrip feed line
[36]	Star-Shape Slotted Antenna	28.5×37	FR4	4.27	Microstrip feed line
[37]	Square Shaped Antenna	19×19	Duriod	6.7	Microstrip feed line

4. RESULT DISCUSSION AND COMPARISON

For improving the performance many different techniques are used in microstrip patch antennas. This section provides a contrast between the different investigations of the antennas, taking into account various technical parameters such as antenna gain, substrate material and feeding techniques. The comparison of investigations done using various techniques revels that:

- Design of multi-band frequency reconfigurable antenna with defected ground structure for wireless applications is provided maximum gain. The value of 10.13dB is reported in M. Lenath Sathikbasha and V. Nagarajan [2].
- Design and implementation of microstrip patch antenna for 5G applications is provided 2nd maximum gain. The value of 10 dB is reported in John Colaco and Rajesh Lohani [24].
- Mathematical model on the effects of conductor thickness on the center frequency at 28 GHz for the performance of microstrip patch antenna using air substrate for 5G application is provided a gain of 9.47dB in Abdullahi S.B. Mohammed, Shahanawaz [19].

In this article [2] antenna has maximum gain of 10.13dB. It has return loss of 15.47dB at 6 GHz and 13.57dB at 3.2 GHz. With defected ground structure having PIN diode has an approximate return loss of 33 dB. In this article [24] microstrip patch antenna has second maximum gain of 10 dB for 5G applications. It has better return loss of 33 dB, VSWR is 1.04 and radiation efficiency is 99.5%.

It shows that maximum value of gain is achieved by using different geometry and maximum value of bandwidth is achieved by using insertion of slots on the patch. It may be because the fractal geometric process and the insertion of slots will adjust the current distribution and provide a higher impedance alignment.

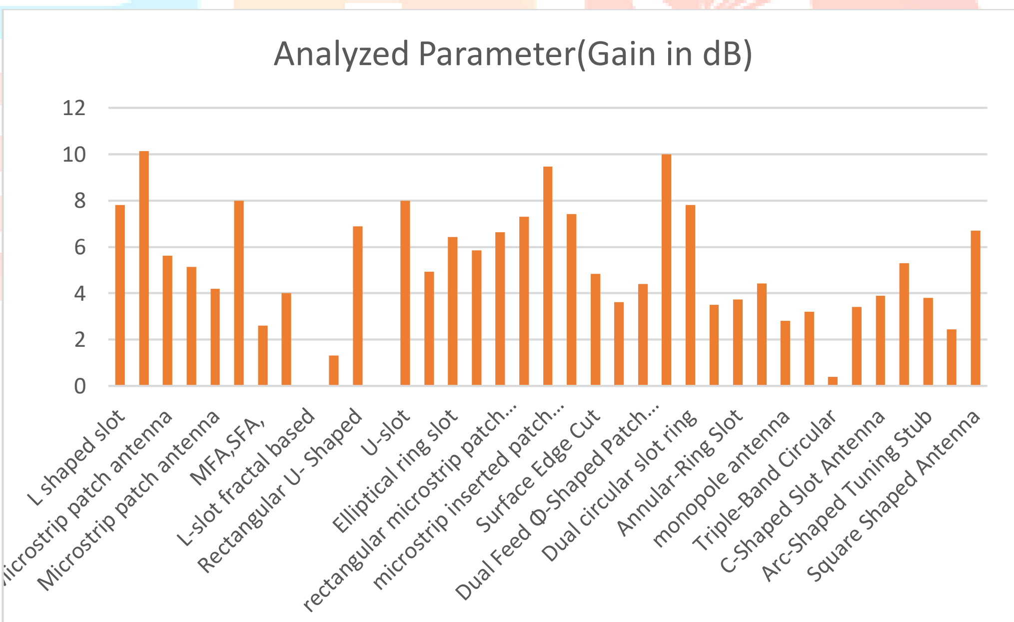

FIGURE 1. Graph between Gain and different shape of antenna

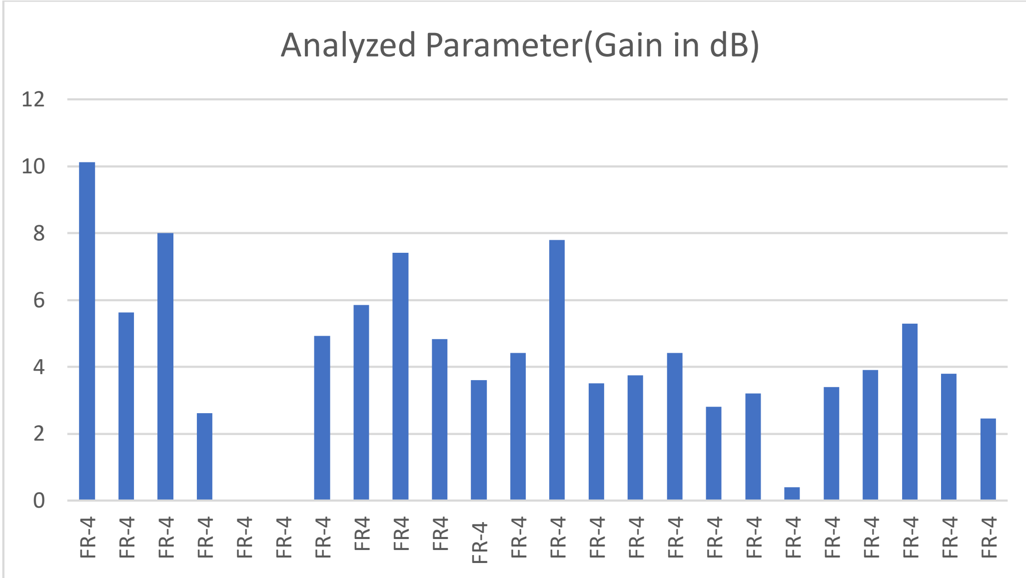

FIGURE 2. Graph between gain and same dielectric material with different slots

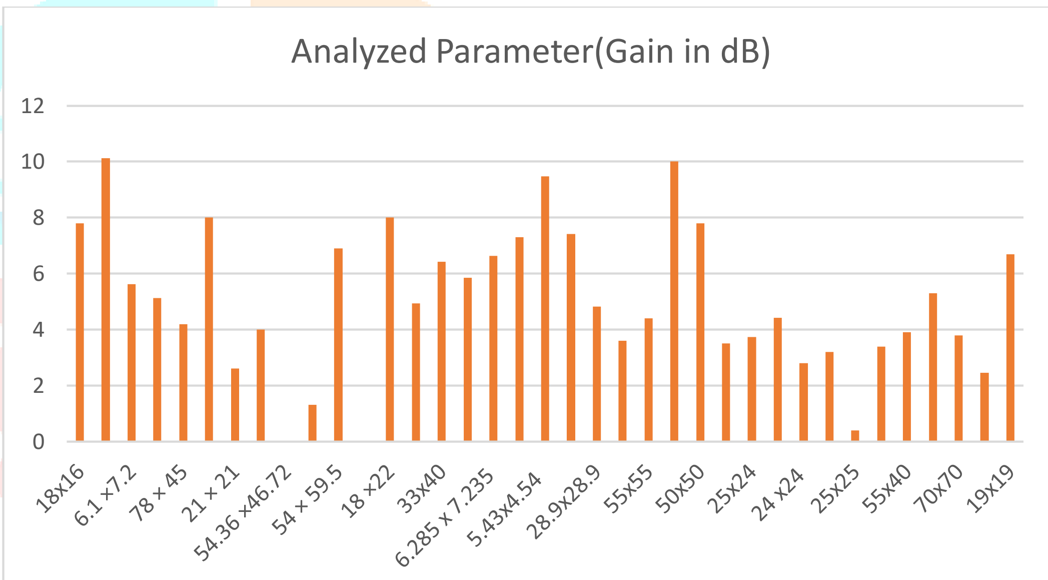

FIGURE 3. Graph between gain and antenna area

5. Conclusion

A detailed overview of the research work to be done to improve the performance parameters of micro strip patch antennas is presented in a comprehensive review of the literature. Various experimental and simulated studies are compared and presented. It has been concluded that using techniques like fractal geometry and insertion of slots different performance parameters like bandwidth, gain and return loss of desired values may be achieved. For future improvements some suggestions are given like in order to obtain better results, improvements in the geometry of the fractal structure can be further explored. Different techniques, such as by using parasitic patches and reflecting layer, replacing conventional substrate with air substrate etc. can be a great benefit in achieving the performance parameter of microstrip antenna. The future scope is to get higher bandwidth, best return loss and high gain by using array elements.

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