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L-Shape rectangular patch antenna for wireless communication application

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***Abstract*— A rectangular patch is designed and simulated on CST studio suite software for wireless communication with slots cut out in the shape of "L". It is designed on the operational frequency of 2.4 GHz. The design of the proposed antenna involves a rectangular patch and slots cut in the shape of "L" which indeed enhances the result. The antenna is the size of 60 mm x 60 mm x 1.6 mm and obtained peak gain of 6 dBi and maximum directivity of 6.40 dB at 2.4 GHz. The antenna achieves a radiation efficiency of 90% and a VSWR of less than 2 on the frequency of 2.4 GHz. As a result of its wide bandwidth, compact size, and stable radiation characteristics, so the proposed antenna is perfect for wireless communication.**

Keywords: rectangular patch antenna; wireless communication; wireless application; gain; directivity; VSWR

I. INTRODUCTION

Antennas are essential components of modern communication systems because they allow electromagnetic waves to be transferred between devices. Antennas act as the interface between electromagnetic wave transmission and reception, allowing for efficient and dependable communication between devices. The increasing need for high-speed data transfer and connectivity in various industries has resulted in a significant increase in demand for high-performance antennas in recent years. To meet these demands, antenna technology has advanced rapidly, with advancements in design, fabrication, and testing methods. Antennas have become an essential component of modern communication systems, allowing for seamless connectivity and communication across multiple devices and networks.[1]

A CN (computer network) known as a wireless network is one that connects network nodes via wireless data links. In residences, telecommunications networks, and business settings, wireless networking is a way to bypass the pricey procedure of installing cables across a building or connecting various equipment locations.[2] In the development and administration of administrative telecommunications networks, RC (radio communication) is frequently employed. According to the OSI model network topology, this occurs at the physical (layer) level.

The term "wireless communication" is broad and refers to all connections and communication techniques between two or more devices that make use of a wireless signal and wireless communication equipment. There is no distance barrier between two communication ports, which is one of the few features of wireless communication. Additionally, it can be used for wireless internet access, wireless home networking, cellular telephony, and many other things. It can travel for a few meters up to thousands of kilometers.

Wireless communication is preferred of any other mode of communication because it is flexible, cost-effective, has a better speed than any other mode of communication, it provides a better and constant connectivity, it is accessible to anyone, moreover it is convenient to use. [11]

The rectangular patch is the most prevalent, and this is because it is easiest to analyze using the cavity and transmission line models, which are the most accurate for this substrate.[3]

A kind of antenna that comprises of a rectangular patch is called a rectangular microstrip patch antenna (MPA). On one side of the dielectric substrate, this patch has a planar or non-planar shape, and on the other, a ground plane. MPA has a low-profile design, small bandwidth, also the ability to operate on two or three frequencies. The patch is made of metals that carry electricity, such as gold, tin, and nickel. The transmission line model and cavity model make it simple to analyze the rectangular patch. Less versatile and producing less accurate results is the transmission line model. In the cavity model, the interior of the substrate is modelled as a cavity that is enclosed on all sides by electric walls.

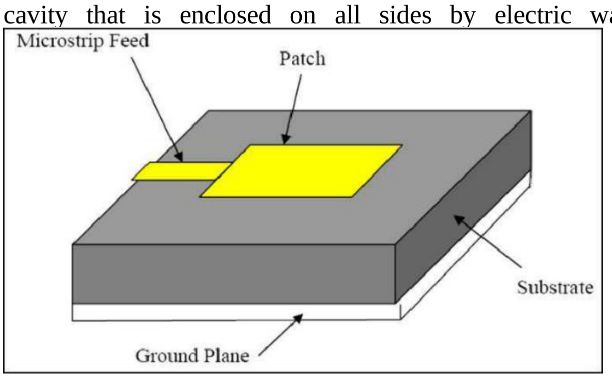

Fig. 1. Microstrip patch antenna

Few of the important applications of an RPA includes:

TABLE 1 Application of RPA

Application	Frequency of operation
GSM Application	900MHz,1800MHz,1900MHz
Microwave Application	6.19GHz to 10GHz
Indoor Application	60GHz
C-band Application	4GHz to 6GHZ

and many more.

In the following paper, RPA is designed for the application of wireless communication. As discussed before a rectangular patch is very common for designing and manufacturing. The designed RPA is with four slots within it. The slots are cut so that the results and performance are enhanced of the antenna.

II. Litrerature Survey

Due to its analysis being the easiest to understand the RPA is by far the most widely used antenna. The rectangular patch antenna has various advantages over the other antennas. The main radiator is an RPA. This type of broadband antenna has several advantages, i.e., low in cost, simple in construction, small in size, being planar, and quick for fabricating, making it appealing for practical applications.

By the survey of studies, it is clear that RPA for the use of wireless application is forever evolving process. Since there is a room for better and more efficient design all the time.

In one of the many studies, it is shown that a rectangular patch antenna is designed and fabricated of the dimension of 80 mm x 50 mm with the feedline of resistance of 50 ohm working on the operational frequency of 2.4 GHz and 5 GHz.[4]

Various researchers' work demonstrates the simulation and design of rectangular MPAs for many applications. In summary, RPAs are suitable for practical applications because they are planar, tiny in size, easy to manufacture, inexpensive in cost, and rapid to produce.[5]-[8]

So, the proposed RPA is with "L" shaped slots and is operating on the frequency of 2.4 GHz which makes it perfectly suitable for wireless communication application.[11]

III. Antenna Design And Geometrical Details

The suggested rectangular microstrip patch antenna is printed on a lossy substrate made of FR-4 (flame retardant material). Following formulas of width, length and effective dielectric constant helps to calculate the values of length and width of ground and substrate.

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right]$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

The dimensions of the ground that was taken for designing is 60mmx60mmx0.035mm. The substrate has the dimensions of 60mmx60mmx1.6mm and the material being FR-4 (lossy), a material which does not destroy from fire or places with higher temperature.

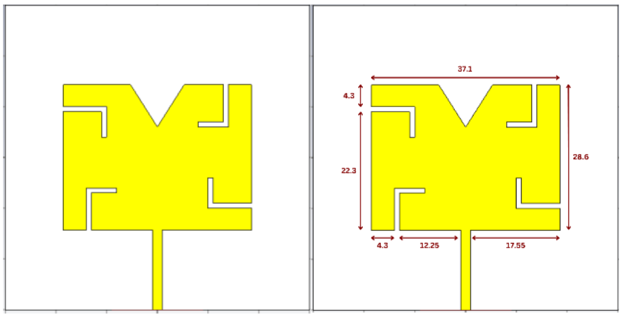

Fig. 2. (a) RPA with slots (b) RPA with "L" shaped slots and dimensions

The patch and the feedline are further created with Copper (Annealed). This material is used for creating because of its high conductivity and low resistivity also it is resistant to corrosion. The dimensions of the patch are 37.1mmx28.6mmx0.035 mm and the width of the feedline is 20 mm. Below figures show the dimensions and the shape of the "L" shaped slots. Further "L" shaped slots with the given dimensions are cut in the patch which results in enhancing the results and performance of the antenna. By feeding the parameters perfectly best results of the antenna is gained.

The design parameters for the shown antenna are determined using the aforementioned technique, and their values are displayed in tabular form below.

TABLE 2 Dimensions for the proposed design

Name	Value
x	60
y	60
t	0.035
h	1.6
x1	37.1
y1	28.6
xf	2
yf	-20
k	5
r1	1.9
r2	1
yl	0
rad	2.4

IV. Result and Discussion

Using the CST (Computer Simulation Technology) Studio Suite software, the proposed L-shaped rectangular patch antenna is designed and simulated and are listed below:

A. *Return Loss*

The percentage of radio waves that arrive at the antenna input that are rejected as opposed to those that are accepted is represented by the antenna's return loss as a number.

$$Return\ Loss\ (dB) = 10\log_{10}\frac{P_{out}}{P_{in}}$$

The plot of return loss is between reflection coefficient in dB and frequency in GHz. In the resultant graph it is observable that the designed antenna resonates under the frequencies that are 2.40GHz, 2.38GHz and 2.42GHz with RL of -17.24dB, -10.02dB and -10.00dB respectively as obtained after simulation:

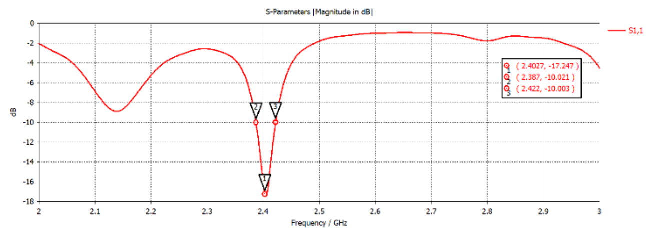

Fig.3. s11 of the proposed work

B. *VSWR*

The ratio of the highest voltage along a transmission line is known as VSWR.

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

For an ideal antenna, VSWR must lie between 1 to 2. The value of VSWR in the designed antenna is 1.43 with the frequency of 2.38 GHz. The VSWR plot obtained post simulation is as follows:

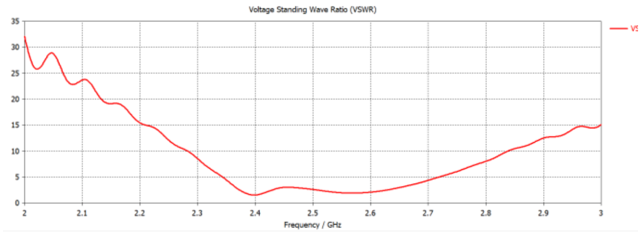

Fig.4. VSWR plot of the proposed work

C. *Gain and Directivity*

The difference between the power density an antenna produces in one direction and the power density an isotropic radiator would emit if the same total power were applied to both is known as gain. It measures power in logarithmic terms based on isotropic antenna, and its unit is dBi.

The ability of an antenna to emit electromagnetic waves in a specific direction, as opposed to an ideal isotropic radiator that emits radiation equally in all directions, is measured as directivity. Decibels (dB) are typically used to express it, and D or D_0 are commonly used.

The G & D of the designed antenna on the frequency of 2.4GHz are 6.00dBi and 6.40dB respectively. The gain & directivity plot obtained post simulation is as follows:

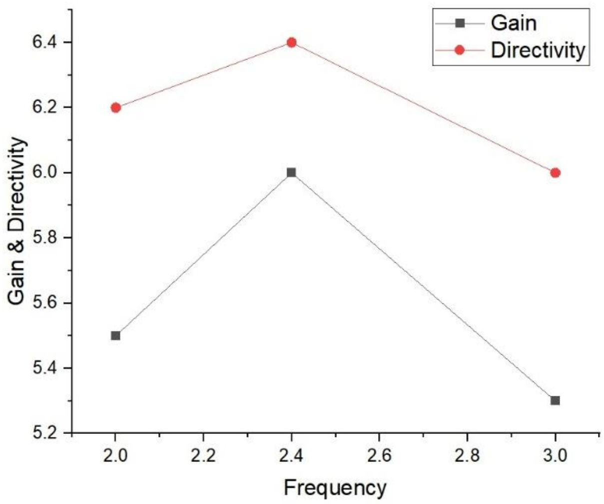

Fig.5. Gain & Directivity plot of the proposed work

D. *Radiation and Total Efficiency*

Total efficiency (TE) measures how much power is delivered to the antenna overall and how much is lost in the transmission line and any matching networks. Whereas, RE (Radiation efficiency) measures the power radiated by antenna in relation to power input to antenna. The RE and TE of the antenna on the frequency of 2.4GHz are 0.90 and 0.89 respectively. The radiation & total efficiency plot obtained post simulation is as follows:

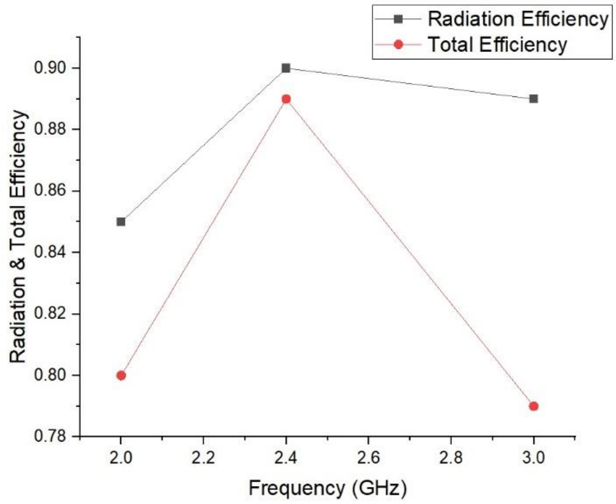

Fig.6. RE and TE plot of the proposed antenna in CST studio suite

E. *Radiation Pattern*

Electromagnetic field that the antenna emits in various directions as a function of angle or proximity to the antenna is depicted by the radiation pattern, which also indicates the relative strength and direction of the electromagnetic field. Below is a diagram of the phi=0deg proposed antenna's simulated far-field radiation pattern at resonant frequencies

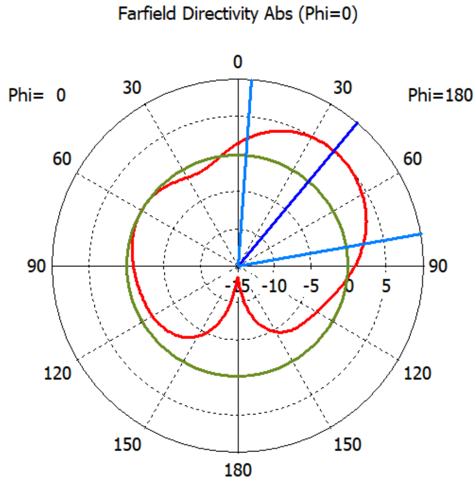

Fig.7. RP of the antenna

V. Conclusion

This study presents a design of an RPA with "L" shaped slots for the use of wireless communication at frequency of 2.4GHz. The simulated antenna has a peak gain of 6dBi, maximum directivity of 6.40dB, and 90% RE at 2.4GHz, according to the results produced via the CST program. The antenna also has a good radiation pattern with an omnidirectional structure.

Thus, this design is suitable for various applications in the field of wireless communication. Although the microstrip antenna has been intensively explored as one of the standard planar antennas over the last few decades, it still offers enormous potential for further development if a better result can be obtained.

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REFERENCES

[1] https://en.wikipedia.org/wiki/Antenna_(radio)

[2] https://en.wikipedia.org/wiki/Wireless_network

[3] Madhuri Garg, Nisha Singh, Rectangular Microstrip Patch Antenna, 4th ed., vol. 6. Dept. of Physics, Sri Sai University.

[4] S.-H. Hwang, J.-I. Moon, W.-I. Kwak, and S.-O. Park, “Printed compact dual band antenna for 2.4 and 5 GHz ISM band applications,” Electron. Lett., vol. 40, no. 25, pp. 1568–1569, 2004.

[5] Y.-J. Cho, S.-H. Hwang, and S.-O. Park, “Printed antenna with folded non-uniform meander line for 2.4/5 GHz WLAN bands,” Electron. Lett., vol. 41, no. 14, pp. 786–788, 2005.

[6] J. Park, H.-g. Na, and S.-h. Baik, “Design of wideband aperture stacked patch microstrip antennas,” IEEE Antennas Wireless Propag. Lett., vol. 3, pp. 117–119, 2004.

[7] C.-L. Mak, H. Wong, and K.-m. Luk, “High-gain and wide-band singlelayer patch antenna for wireless communications,” IEEE Trans. Veh. Technol., vol. 54, no. 1, pp. 33–40, Jan. 2005.

[8] David M.Pozar, "Microwave Engineering",4" edition, Jhon Wiley & sons inc 2012, pp.135-152

[9] Neto.A, Llombart.N, Gerini.G, and Maagt De P, "On the optimal radiation bandwidth of printed slot antennas surrounded by EBGs," IEEE Trans Antennas Propag., vol. 54, no. 4, pp. 1074-1082, April. 2006

[10] Sivakuma FSrinivasa Rao O and Manikandan AVM, "Bandwidth Enhancement of Rectangular Microstrip Patch Antenna using Slots", JOSR, Vol. 6, Iss 1, 2013

[11] https://www.tutorialspoint.com/wireless_communication/wireless_communication_overview.htm

[12] H. F. Pues and A. R. van de Capelle, “An impedance matching technique for increasing the bandwidth of microstrip antennas,” IEEE Trans. Antennas Propag., vol. 37, no. 11, pp. 1345–1354, Nov. 1989.

[13] Y.-X. Guo, K.-W. Khoo, and L. C. Ong, “Wideband circularly polarized patch antenna using broadband baluns,” IEEE Trans. Antennas Propag., vol. 56, no. 2, pp. 319–326, Feb. 2008.

[14] C. L. Mak, K. M. Luk, and K. F. Lee, “Microstrip line fed L-strip patch antenna,” Proc. Microw. Antennas Propag., vol. 146, no. 4, pp. 282–284, 1999.

[15] P. M. Bafrooei and L. Shafai, “Characteristics of single and double layer microstrip square-ring antennas,” IEEE Trans. Antennas Propag., vol. 47, no. 10, pp. 1633–1639, Oct. 1999.

[16] Y.-X. Guo, K.-M. Luk, and K.-F. Lee, “L-probe proximity fed annual ring microstrip antennas,” IEEE Trans. Antennas Propag., vol. 49, no. 1, pp. 19–21, Jan. 2001.

[17] R. Garg and V. S. Reddy, “Edge feeding of microstrip ring antenna,” IEEE Trans. Antennas Propag., vol. 51, no. 8, pp. 1941–1946, Aug. 2003.

[18] V. P. Sarin, Nisha Nassar, V Deepu, C. K Aanandan, P Mohanan, “Wideband Printed Microstrip Antenna for Wireless Communications,” IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, vol. 8

[19] Yi-Chieh Lee, Student Member, IEEE, Jwo-Shiun Sun, Min-Hsiang Hsu, and Ren-Hao Chen, “A New Printed Slot Loop Antenna With Tunable Strips for 2.4- and 5-GHz Wireless Applications,” IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, vol. 8, 2009