Dual Band, High Gain Simple Structure in Microstrip Patch Antenna For X-band Application

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Abstract*—This article proposes a microstrip antenna for X-band communication. The suggested antenna is built on a FR4 dielectricsubstrate with a thickness of1.6 mm and a relative permittivity of 4.4, with a loss tangent of 0.02. The suggested antenna measures 13.5 x 18 x 1.6 mm^3 in dimension. Communication systems are the result of communications and space technology development, with the goal of achieving ever-increasing ranges and capabilities at the most affordable prices. The HFSS-18 simulator is used to construct and examine the proposed microstrip patch antenna. *The results demonstrate that it is suited for x band communication.

***Index Terms*—HFSS, Patch Antenna, feeding methods, X-band, High Gain.**

I. INTRODUCTION

In the modern era of wireless communication, frequencies greater than 10 GHz are attracting interest, resulting in new wireless systems, goods, and services.An antenna and a filter are critical and leading elements of both a transmission and reception system [1]. At higher frequencies, the system has more sub-system elements with independent performance and characteristics. Furthermore, high insertion losses were discovered at interconnected systems, resulting in much less polarised current being obtained in the radiating element.Modern communications systems necessitate the development of extremely small, minimally sized antennas with large gain and directivity. Antennas connect the sending and receiving devices to the propagation direction in space.Most satellite antennas are constructed to provide coverage over a specific, secured area, specifying antenna gain restrictions; on the other hand, load restrictions of weight and size lead to small, lightweight antennas.Planar antennas, in particular, could find widespread use on communications satellites due to these properties [2]. Researchers and engineers have paid close attention to microstrip antennas and arrays, which are widely used in RF and microwave system applications such as communications, radar, navigation, remote sensing, and biomedical systems.[3].Researchers and engineers have paid close attention to microstrip antennas and arrays, which are widely used in RF and microwave system applications such as communications, radar, navigation, and remote sensing.The term X-band was first applied to the extended AM broadcast band.. The International Telecommunication Union (ITU) has defined a portion of the X band or Super High Frequency (SHF) spectrum for satellite communication. The ITU designated the frequency bands 7.2 GHz to 7.7 GHz for downlink and 7.9 GHz to 8.4 GHz for uplink for government use.The X band frequencies have the advantage of being less affected by rain fade, providing maximum rain resilience when compared to other higher frequency bands used for satellite communication, such as Ku or Ka. As a result, connection accessibility is extremely high[4-7].

Two circular cuts at the top edge of the patch are used in the proposed antenna's design structure.. The proposed antenna measures 13.5 mm x 18 mm x 1.6 mm in total. The proposed antenna covers the dual-frequency bands of 10.2 to 11.0 GHz and 12.5 to 13.2 GHz, which are suitable for X-band satellite communication.following is the paper's orientation.Section III contains the results and discussion.Section II analyses antenna structure and factors influencing it. The simulation was carried out in HFSS. Section IV of this paper summarizes the conclusion.

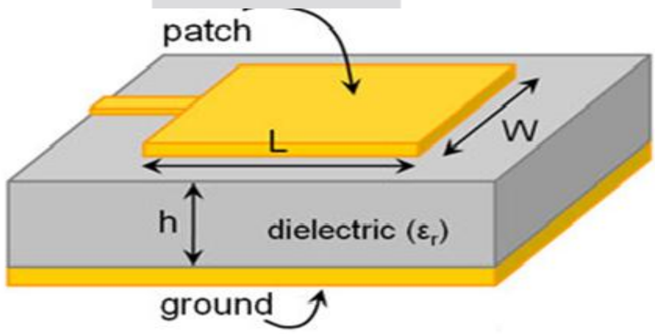


Fig.1 Antenna structure for Microstrip patch

II. DESIGN METHODOLOGY FOR ANTENNA

The three key factors for constructing a microstrip patch antenna are substrate permittivity (r), operating frequency (f), and substrate height (h.).for a rectangular patch, all measurementare entirely dependent on these factors. The three previously mentioned parameters can be used to determine the length and width of a microstrip patch[8].

A. The patch's height (h)equation:

$$h = \frac{0.3c}{2\Pi f\sqrt{\varepsilon_r}}$$ (1)C.= 3.0 x 108m/s

ε_r= dielectric substrate
h = height (mm),

B. The patch's width (W) eqation:

Patch width is calculated by using the given equation.

$$w = \frac{c}{2f}\sqrt{\left(\frac{2}{\epsilon_{r+1}}\right)}(2)$$

W =width (mm)

C. The effective dielectric constant equation (ε_{eff})

Effective dielectric constant is calculated by using equation:

$$\varepsilon_{\text{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} (3)$$

h= Patch height
w= Patch width

D. Extension of the patch length equation(Δ L)

The extra length at the patch's end created by the fringing field running down its length is referred to as length extension. The following is the equation for calculating it::

$$\Delta \text{L} = 0.412\frac{[\varepsilon_{eff}+0.3][\frac{W}{h}+0.264]}{[\varepsilon_{eff}-0.258][\frac{W}{h}+0.8]} (4)$$

E. Effective length of the patch (L eff).

The patch's effective le:ngth (L eff) equation.

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{eff}}} \qquad (5)$$

F. Calculation of the patch's real length (L);

The provided equations used to calculate real length L of the patch.

$$L = L_{eff} - 2\Delta \text{L} (6)$$

G. Calculation of the ground plane dimensions;

Equationfor calculating ground measurement

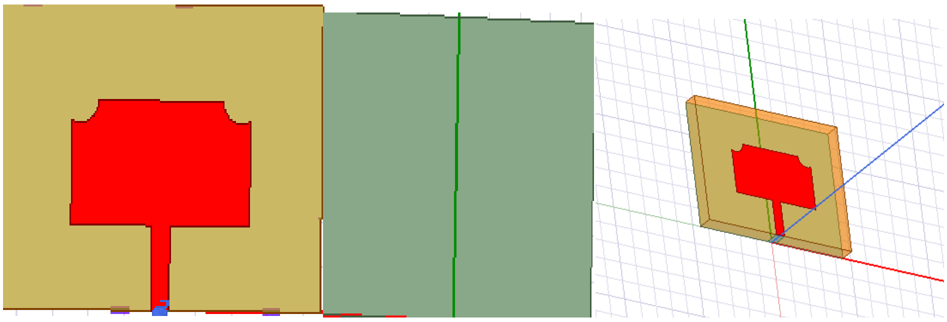
Lg= L + 6h(7)

Wg=W+6h (8)

L and W are the patch antenna's length and width, respectively.

Table1ANTENNA DESIGN MEASUREMENT

S. No	Measurement of the Structure	Value (Unit mm)
1	Wf	1.037
2	Wp	10
3	Ls	18
4	Ws	13.5
5	Wg	13.5
6	Lg	18
7	Lf	3.74
8	Lp	5.5



(a) (b) (c)

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Fig 2: Antenna Structure (a) Front view (b) Bottom View (c) inset View

III. DISCUSSION OF SIMULATION OUTCOME AND COMPARISON

The suggested structure is created, simulated, and optimized using the Ansoft HFSS version 18.0 simulator. Figure 1 shows the return loss plot, VSWR, and gain of the suggested microstrip patch antenna. The antenna resonates within the defined x band reference range.

1. Return Loss and VSWR of the Proposed structure

The amount of return loss determines how closely the antennas are aligned. The antenna insertion loss is provided by S11. The insertion loss is proportional to the input power of the antenna. Figure 3 depicts the simulated Return loss of the proposed antenna. Return losses of -15 dB and -16 dB are obtained at two resonant frequencies, 10.6 GHz and 12.6 GHz, respectively. This bandwidth includes the abovementioned X band frequency range.The impedance matching between antenna and transmission line is defined by the Voltage Standing Wave Ratio (VSWR). The ideal value of VSWR is one, and values up to two are acceptable. the value of VSWR at the operating frequency is l.6as shown in figure 3

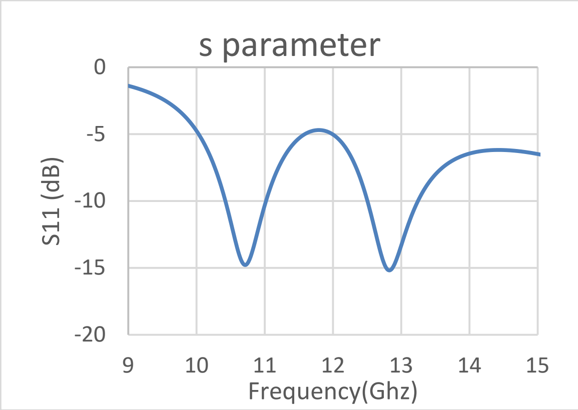

Figure3: Return Loss

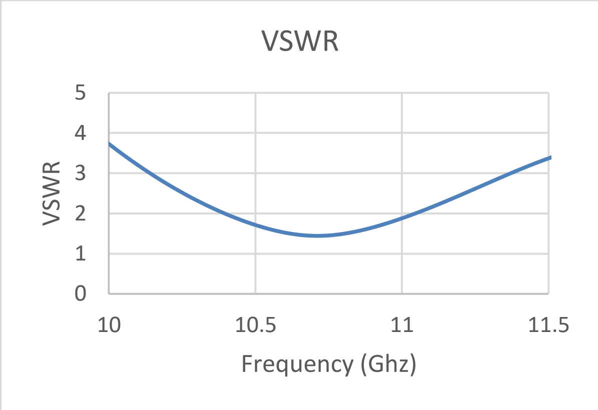

Figure 4: VSWR

2.Gain And Radiation Pattern of the Proposed antenna

Gain is a decibel-based unit of measure. As a result, the gain of an anisotropic area is referred to as the total amount of power delivered to it. At the resonance frequency of 10.5 GHz, proposed antenna has a gain of 6.1 dB, as shown in Figure.5.and 3d gain is shown in figure 6.The radiation pattern of the optimized patch structure is more uniformly distributed on the broader side in terms of the electric field strength as shown in figure 8

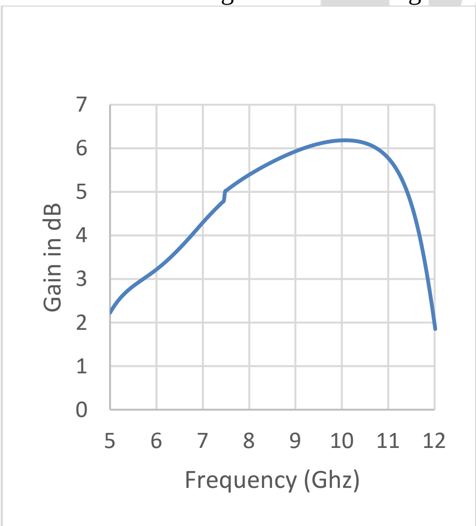

Figure 5: Gain of the Proposed patch antenna

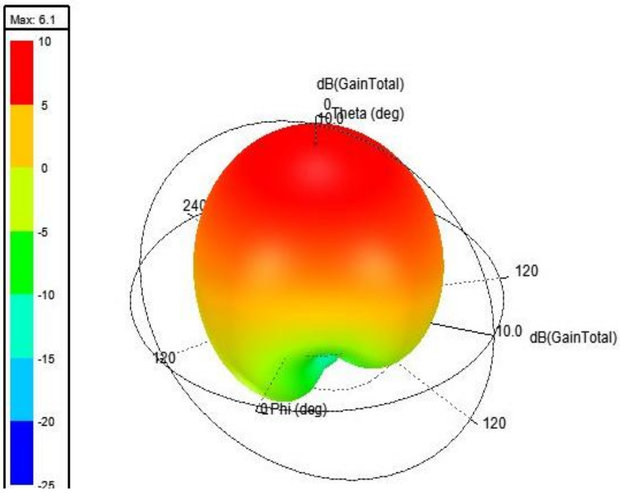

Figure 6: 3d gain of the proposed antenna

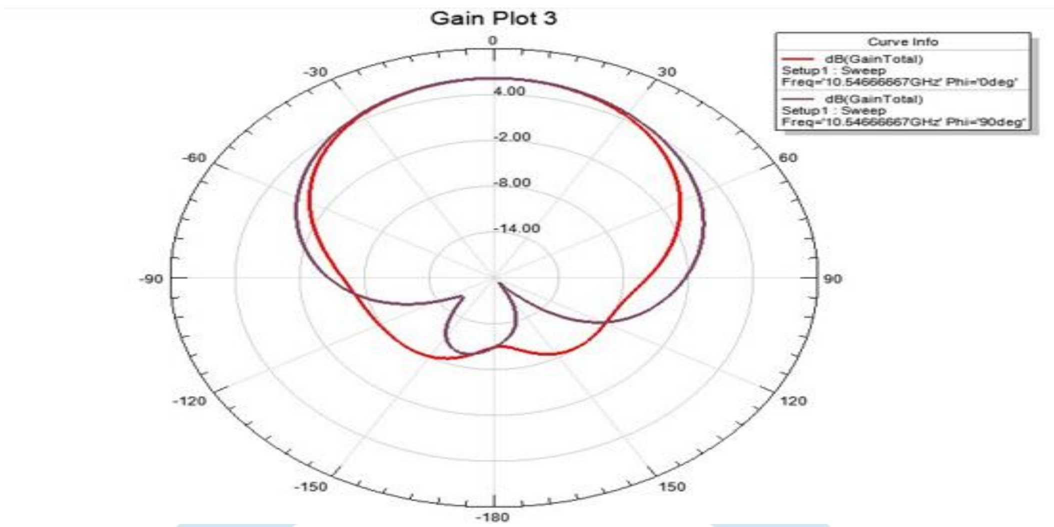

Figure8: Radiation Pattern of the proposed design

. ***3.Comparison of Results***

Table2: Comparison result of proposed antenna with previous work

SNO.	Frequency(Ghz)	S11(dB)	Gain (dB)	Measurement (in mm3)
[12]	10.5	-20	5.5	30x21x1.5
[14]	10.04	-42	1.06	30x35x1.58
[13]	10.5	-14	4	30x301.58
Proposed Antenna	10.5	-15	6.1	13.5 x 18 x 1.6

IV CONCLUSION

Based on the above results and observations, a simple antenna design is possible through the optimization of the patch measurement for having appropriate feed impedance matching, as well as the appropriate circular slot geometry on a substrate using FR4 substrate material.A simple circular slot of the proper size and at the proper matched distance on the radiating patch will also provide dual band and high gain at the antenna's working frequency. Dimension of the antenna is small13.5 x18 x 1.6 mm^{3}as a result, the proposed antenna is a strong contender for X-band wireless applications.

REFERENCES

[1] C. A. BALANIS, "ANTENNA THEORY ANALYSIS AND DESIGN," *WILEY SONS PUBL. NEW JERSEY*, 2005.
[2] Ara, S. ., and P. . Kumari Nunna. "ASIM Shape Wide Band High-Gain Patch Antenna Integrated With Frequency-Selective Surface As Superstrate for Sub-6GHz 5G Applications". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 2s, Dec. 2022, pp. 23-28, doi:10.17762/ijritcc.v10i2s.5908
[3]Ara, S., &Nunna, P. K. (2022). High Gain Inset Fed Rectangular Patch Antenna Design for Sub6 GhzApplication. resmilitaris, 12(5), 1385-1391
[4] J. H. Winters, "Smart antennas for wireless systems," Personal Communications, IEEE , vol. 5, no. 1, pp. 23-27, Feb. 1998
[5] Dr. Rahul G. Mapari and Rahul S. Parbat, "Design of 4X1 Microstrip Array Antenna for X-Band Satellite Communication Application," International Journal of Pure and Applied Mathematics, Volume 118 No. 24 2018. ISSN: 1314-3539
[6] W. L. Pritchard, "Satellite communication-an overview of the problems and programs," Proc. IEEE, vol. 65, no. 3, pp. 294-307, March 1977.
[7] B.Kishor Kumar, R.Mohanasundaram and Dr.P.Jothilakshmi, "Design of Multilayer Stacked Patch Antenna for C and X band Applications", International Journal of Scientific Research and Review, ISSN No:2279- 543X,Vol.8,issue3, pp.1103-1109, 2019. (UGC ISSN APPROVED: 64650)
[8]S. Ara and N. Prasanti, "Compact structure in patch antenna for X band application," *2021 10th International Conference on Internet of Everything, Microwave Engineering, Communication and Networks (IEMECON)*, Jaipur, India, 2021, pp. 1-5, doi: 10.1109/IEMECON53809.2021.9689077
[9] Imam, M. S., Ingle, S., & Ara, S. (2013). A review paper based on spectrum sensing techniques in cognitive radio networks. International Institute for Science, Technology and Education, 3(9), 14-21

[10]Design of MicroStrip Patch Antenna for 2.4GHz Application", International Journal of Science & Engineering Development Research (www.ijrti.org), ISSN:2455-2631, Vol.7, Issue 7, page no.121 - 127, July-2022, Available :http://www.ijrti.org/papers/IJRTI2207019.pdf

[11]M. Meloui and M. Essaaidi, "A dual ultra wide band slotted antenna for C and X bands application," *Prog. Electromagn. Res. Lett.*, vol. 47, no. May, pp. 91–96, 2014, doi: 10.2528/PIERL1405210

[12] Wide Band Microstrip Patch Antenna for X-Band Applications," Proc. - 2015 2nd IEEE Int. Conf. Adv. Comput. Commun. Eng.ICACCE 2015, pp. 296–300, 2015, doi: 10.1109/ICACCE.2015.135.

[13 I. B. Sharma, F. L. Lohar, R. K. Maddila, A. Deshpande, and M. M. Sharma, "Tri-band microstrip patch antenna for C, X, and Ku band applications," Lect. Notes Electr. Eng., vol. 472, pp. 567–574, 2018, doi: 10.1007/978-981-10-7395-3_63.