Simulation of Hexagonal Patch Antenna with three Parasitic Artifacts

G. Ahmad, S.W.Shah, S. Ali, F. Ali
Department of Electrical Engineering, UET Peshawar, Pakistan

***Abstract*—In satellite communication applications, patch antennas design faces the challenge of lower bandwidth and small gain. Many design approaches are proposed in the literature to overcome this limitation. Furthermore, future developments/trends in the field of satellite communication also focus on the design of more efficient patch antennas. This research work is focused on the enhancement of bandwidth, efficiency and gain of patch antenna. Various techniques are proposed and analyzed using computer based simulations to improve such design requirements. The investigated design is based on a hexagonal structure with a rectangular defect. Further in order to investigate the design performance, three parasitic patches were employed in its vicinity and defects were also created in the ground plane. Preperm L380 substrate (with a dielectric constant: 3.8) was selected, and for bandwidth expansion air hole was employed in the substrate. Proposed design of antenna with dimensions of 24mm in length, 28mm in width and a thickness of 1.64mm was simulated and analyzed for several parameters including return loss, SWR with respect to voltage, efficiencies, Gain and directivity. Proposed design bandwidth was enhanced from 3.74GHz to 4GHz in X and Ku band for satellite military applications. Simulation results show an overall efficiency of 0.98 prior to and after the structural amendments in the proposed design with a maximum gain of 6.46dB which make it suitable for use in X and Ku band in satellite military applications.**

***Index Terms*—Return Loss, Bandwidth, Gain, VSWR, Military Applications and Satellite Applications.**

I. Introduction

Currently, several printed monopole antennas have been suggested through implementing several favorable excitation arrangements. Major factors behind the exponential growth in the use of microstrip patch antennas, are light weight, compactness and ease of fabrication. These patch antennas are very cost effective. This steep growth is evident from their enormous use in the areas of aircraft industry, space technology, mobile/cellular communication and biomedical engineering at a rapid rate. Researchers have been carrying out research to build up a high speed data rate satellite communication system [1, 2, 3]. Satellite communication is a type of wireless communication system. C, X, Ku and K bands have been dedicated to various types of satellite wireless communication systems and antenna is its integral component. For the applicationof the patch antenna in military satellite communication, the scientists need to analyze and fabricate a microstrip patch antenna that will operate in the above mentioned high frequencies bands with sound characteristics such as large bandwidth, large gain and high efficiency. Microstrip patch antennas are cost effective and can be easily fabricated using electronic printed circuits [4, 5]. A lot of advantages of patch antennas have been discussed in the relevant literature but the researchers are still working to surmount its narrow bandwidth. [6-8] were presented to highlight the mechanisms for the expansion of the bandwidth of patch antennas. Similarly, various structures of patch were highlighted in [9-14], to improve the performance of the patch antenna in the field of wireless communication. The bandwidth of the patch antenna was expanded using a novel patch structure for Ku-band satellite communication [15]. The patch antenna in [16] has got good characteristics and its bandwidth was reasonably improved. [17] Presented a square antenna which was 15mm long and 15mm wide and it was recommended with a bandwidth of 0.95GHz for Ku-band military applications. The bandwidth in [18] was expanded to 2.1GHz. A fractional bandwidth of 13.3% was attained in [19] at resonant frequency of 12.57GHz. The bandwidth of this antenna is in the Ku-band that is used for satellite applications. The author in [20] improved the efficiency of the patch antenna using the efficient dielectric material of Preperm in the substrate. The total efficiency of 99% was attained in [21] with the help of Preperm material. Similarly, total efficiency of 98.85% was got in [22] using the same above mentioned material in the substrate of the antenna. A bandwidth of 0.96GHz and a reflection coefficient of -22dB were attained by the patch antenna discussed in [23]. Evidently the bandwidth and the reflection coefficient of this antenna at the central frequency are less than the proposed antenna of this article. Similarly, a patch antenna was dedicated to X and Ku applications in [24] but its bandwidth was also less than the proposed antenna. Its bandwidth was 2.5GHz and its reflection coefficient was -22dB. An antenna having a bandwidth of 2.1GHz for 28GHz applications was presented in [25] and its bandwidth was also less than the proposed antenna. Its reflection coefficient was -26dB. Similarly, the bandwidth of the antenna in [26] was 1.24GHz. Its efficiency was 0.88 and its reflection coefficient at the center frequency was -25dB.A patch antenna was recommended for satellite applications using Ku-band in [27]. This antenna with a substrate material of

Rogers RT/Duroid 6010 demonstrated an impedance bandwidth of 0.576 GHz. A comparison has been made in Table 1, which shows that the bandwidth, reflection coefficient and efficiency of the proposed antenna are far better than the remaining designs mentioned in the table.

TABLE I
COMPARISON OF SIMILAR WORK WITH PROPOSED DESIGN

Papers	Bandwidth	Efficiency	Reflection Coefficient
[17]	0.95GHz	Not Mentioned	-20dB
[18]	2.1GHz	Not Mentioned	-27dB
[23]	0.96GHz	Not Mentioned	-23dB
[24]	2.5GHZ	82-86%	-22dB
[25]	2.1GHz	Not Mentioned	-26dB
[26]	1.24GHz	84.8%	-25dB
This Work	4GHz	98.9%	-31dB

The Problem is that the patch antenna for satellite and other applications needs to have a wide bandwidth, large gain and high efficiency to cope with the future demands. In this article a new shape of patch antenna for its application in X and Ku-band is investigated. Structural changes, such as the addition of parasitic patches, introduction of slots in the patch as well as ground and creation of holes in the substrate, will be made to improve its bandwidth, gain and efficiency for its application in the satellite bands. The antenna will have a large bandwidth, its efficiency will be very high and its gain will be reasonably large to support the future wireless mobile communication in the mentioned bands. In order to achieve an efficient patch antenna having a large bandwidth and large gain for satellite applications, the material of Preperm L 380 was investigated in the substrate of the proposed antenna presented in this article.

II. Structure of Antenna

Rectangular defects (slots) were formed in the hexagonal patch, ground and the dielectric substrate of the patch antenna as shown in Fig.1 and Fig.2. Three parasitic elements were placedon top of the substrate in neighborhood of the hexagonal patch. Radius of the initial hexagonal structure was 6×10^{-3}m. Defect in center of the substrate was in form of a rectangular hole andthe area of this hole is mentioned in Table 2. The Hexagonal patch was created at the center of the substrate. The antenna was 24mm long and 28mm wide. Coaxial Probe was employed to energize this antenna and it was placed at ahorizontal distance of 4.35mm from the center of the antenna on the x-axis.The three parasitic patches are represented by PP_1, PP_2, and PP_3 in this article.PP_1wascreated at a horizontal distance of 2.45mm from left side of the design and a vertical distance of 9mm from the bottom side. PP_2 was designed at a horizontal distance of 8.9mmfrom left side of the antenna and a vertical distance of 5.5mm from the top side. Similarly, PP_3 was placed at a horizontal distance of 2.45mm from right side of the design and a vertical distance of 9mm from the top side. The patch view is shown in Fig.1.

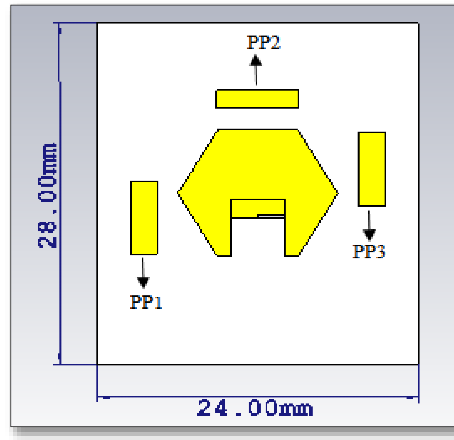

Fig. 1. Patch View before Structural Changes

The view of the ground is shown in Fig.2.It is evident from the ground view that seven rectangular defects were created in the ground to observe its effects on the performance of the antenna and these rectangular defects were represented by D_1, D_2, D_3, D_4, D_5, D_6 and D_7.

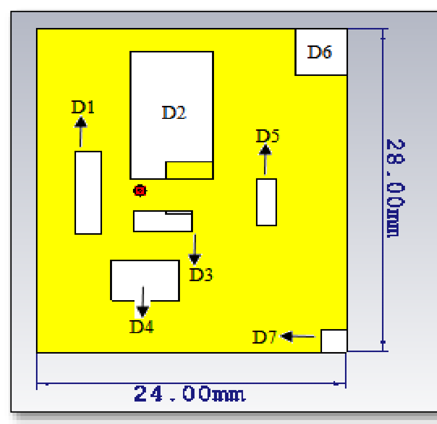

Fig. 2. Ground View before Structural Changes

D_1 was produced at a horizontal distance of 3mm from left side of the ground and a vertical distance of 10.6mm from the top side. D_2 was etched at a horizontal distance of 7.2mm from left side of the ground and a vertical distance of 2mm from the top side. D_3 was created at a horizontal distance of 7.5mm from left side of the design and a vertical distance of 10.5mm from bottom side. D_4 was shaped at a horizontal distance of 5.8mm from left side of the design and a vertical distance of 4.5mm from bottom side. Finally, D_5 was etched at a horizontal distance of 17mm from left side of the antenna and a vertical distance of 11mm from the bottom side. The remaining two defects D_6 and D_7 are located at right corners of the antenna. These defects in the ground improved some characteristics of the antenna. The dimensions to reproduce this structure are given in Table 2 and the dimensional view of the patch is presented in Fig.3.

TABLE II
DIMENSIONS OF ANTENNA

Parameters	Values
Size of antenna	$24×28mm^2$
Radius of Hexagonal Patch	6mm
Rectangular Defect on the Hexagonal Patch	$4× 4.6966mm^2$
Dimension of PP_1	$2×6\ mm^2$
Dimension of PP_2	$6.1×1.5mm^2$
Dimension of PP_3	$2×6mm^2$
Dimension of D_1	$2×7.2\ mm^2$
Dimension of D_2	$6.4×11\ mm^2$
Dimension of D_3	$4.5×1.7mm^2$
Dimension of D_4	$5.2×3.5\ mm^2$
Dimension of D_5	$1.5×4\ mm^2$
Dimension of D_6	$4×4\ mm^2$
Dimension of D_7	$2×2mm^2$
Dimensions of Substrate's hole	$4.5×4.5mm^2$
Location of feed from the center	4.35mm on x-axis

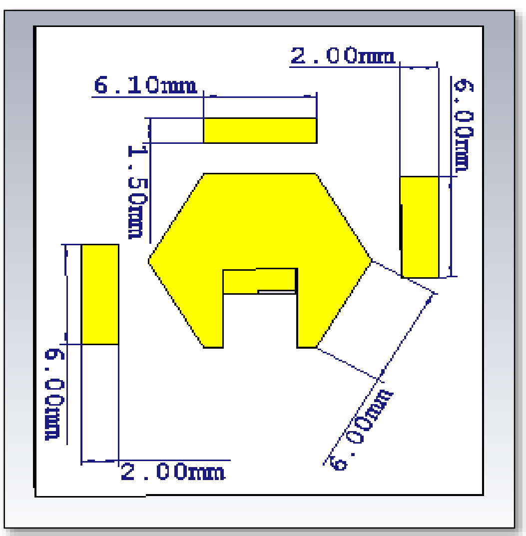

Fig. 3. Dimensional View of Patch

III. Results and Discussion

The symbol for coefficient of reflection is S_{11} dB and its graphical relationship with frequency is shown in Fig. 4. -10dB bandwidth of this new structure was 3.74GHz and it occurred in X as well as Ku band. Its Initial frequency (10.98GHz) was in the X band while its final frequency (14.73GHz) was in the Ku Band. The minimum value of S_{11}in dB took place at 14.2GHz and it was -53.36dB.

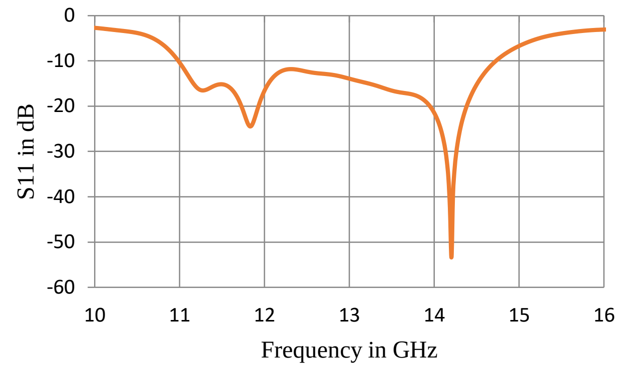

Fig. 4. S_{11} dB before Structural Changes

Voltage Standing Wave Ratio was sketched in Fig. 5 as a function of frequency. This ratio was in the desirable slot between 1 and 2 and its minimum value at the center frequency of the bandwidth was 1.004. The minimum value of this ratio at the center frequency of 14.2GHz shows that the impedance of this design is properly matched.

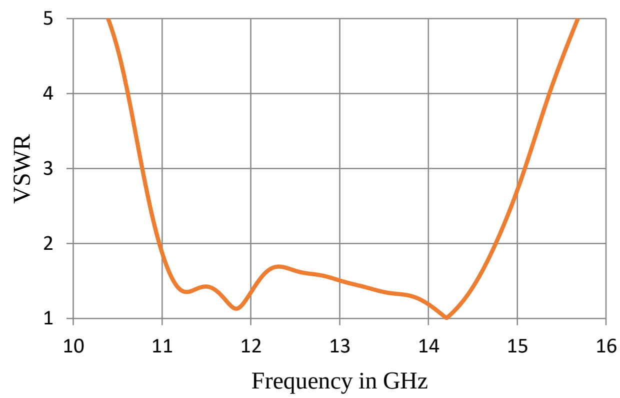

Fig. 5 VSWR before Structural Changes

Total efficiency was sketched in Fig. 6. This efficient antenna demonstrated maximum efficiency of 0.982 at 14.2GHz. The efficiency of this structure was greater than 88% in the above mentioned bandwidth. The efficiency of the patch antenna is very high as compared to the antennas cited in this article. Efficiency of the antenna can be computed with the help of gain and directivity as the ratio of the gain to the directivity of an antenna defines its efficiency.

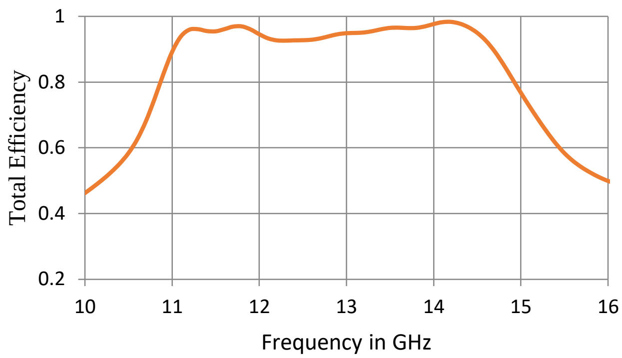

Fig. 6. Efficiency before Structural Changes

Gain of this antenna was sketched in Fig. 7. A gain of 6.92dB was attained at 11.7GHz and its minimum value in the whole bandwidth was 5dB.The gain of the antenna is large and this antenna can be employed successfully in the mentioned bands for satellite applications.

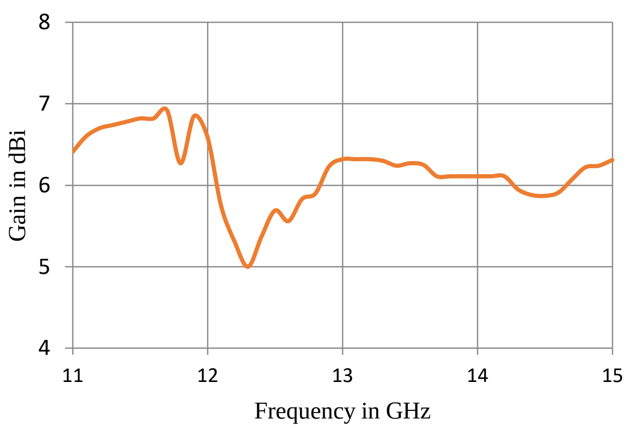

Fig. 7. Gain before Structural Changes

IV. Structural Changes for Bandwidth Improvement

Trivial alterations were induced in the antenna to expand its bandwidth. Size of the rectangular slot (defect) in the hexagonal main patch was changed. The three parasitic artifacts represented by PP_1, PP_2 and PP_3 were repositioned as shown in Fig.8.

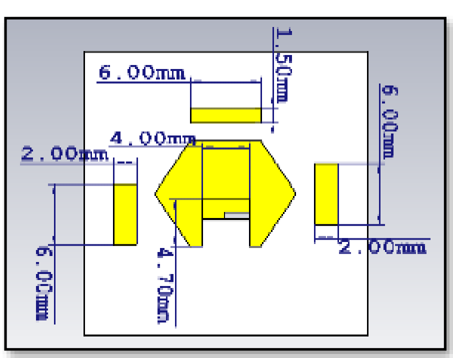

Fig.8. Dimensional View of Patch after Structural Changes

Length of PP_2 was reduced to 6mm. PP_1 was placed at a distance of 2.5mm from left edge of the antenna and a distance of 9mm from the bottom edge. PP_2 was placed at a horizontal distance of 9mm from left side of the antenna and a vertical distance of 5.5mm from the top edge. Similarly, PP_3 was placed at a horizontal distance of 2.5mm from right side of the design and a vertical distance of 11mm from the top side. D_4 was repositioned as its distance from left edge of the antenna was maintained at 5.8mm and its distance from the bottom edge was made equal to 5mm.Width of D_4 was reduced from 3.5mm to 3mm. The rectangular hole in the Substrate was expanded from 4.5×4.5mm^2 to 5×5mm^2 and it was located at the substrate's center. Substrate's height was changed from 1.5×10^{-3}m to 1.64×10^{-3}m. Dimensional view of Patch after structural changes is presented in Fig.8.Coaxial Probe was employed to energize this antenna and it was placed at a horizontal distance of 4mm from the center of the antenna on the x-axis. Dimensions of the antenna after the mentioned changes are given in Table 3.

TABLE III
DIMENSIONS OF ANTENNA AFTER CHANGES

Parameters	Values
Size of antenna	24×28mm^2
Radius of Hexagonal Patch	6mm
Rectangular Defect on the Hexagonal Patch	4× 4.7mm^2
Dimension of PP_1	2×6 mm^2
Dimension of PP_2	6×1.5mm^2
Dimension of PP_3	2×6mm^2
Dimension of D_1	2×7.2 mm^2
Dimension of D_2	6.4×11 mm^2
Dimension of D_3	4.5×1.7mm^2
Dimension of D_4	5.2×3 mm^2
Dimension of D_5	1.5×4 mm^2
Dimension of D_6	4×4 mm^2
Dimension of D_7	2×2mm^2
Dimensions of Substrate's hole	5×5mm^2
Substrate's height	1.64 mm
Location of feed from the center	4mm on x-axis

The results of this antenna are discussed in the following section. The bandwidth was augmented from 3.74GHz to 4GHz with the help of this parametric optimization. The center frequency was shifted from 14.2GHz to 14.5GHz with the help of this parametric optimization. S_{11} dB of this new antenna after the above mentioned alterations is shown in Fig.9.

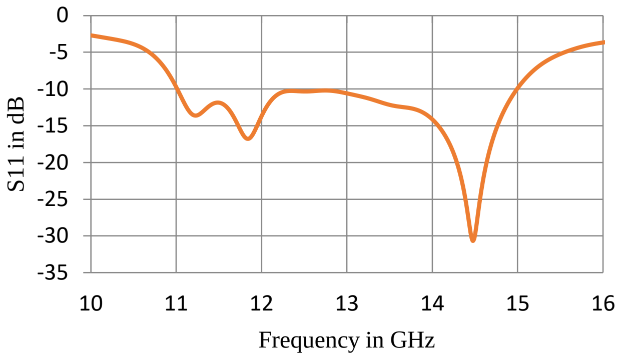

Fig.9. Bandwidth of the Antenna after Alteration

The minimum value of the reflection coefficient of the first design was -53.36dB while the minimum value of the reflection coefficient of this optimized design was -30.67dB at the center frequency. The initial frequency of the bandwidth shifted from 10.98GHz to 11GHz which was in the X band while the final frequency shifted from 14.73GHz to 15GHz which was in the Ku Band. The minimum value of Voltage standing wave ratio was 1.06. This ratio of 1.06 took place at 14.5GHz as shown in Fig. 10. Minimum value of this ratio indicates that antenna was matched properly at the center frequency.

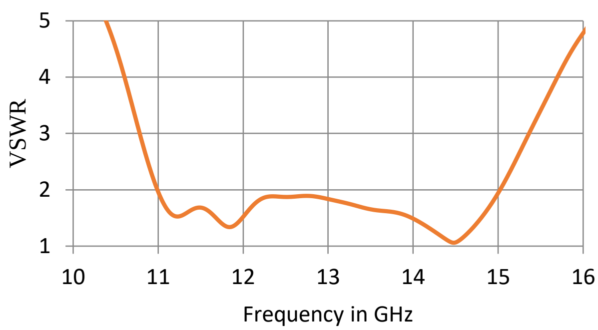

Fig.10. VSWR of the Antenna after Alteration

This efficient antenna demonstrated total efficiency of 0.9822 at 14.5GHz while the minimum value of the total efficiency was 88% in the above mentioned bandwidth. The sketch of the total efficiency is shown in Fig.11.

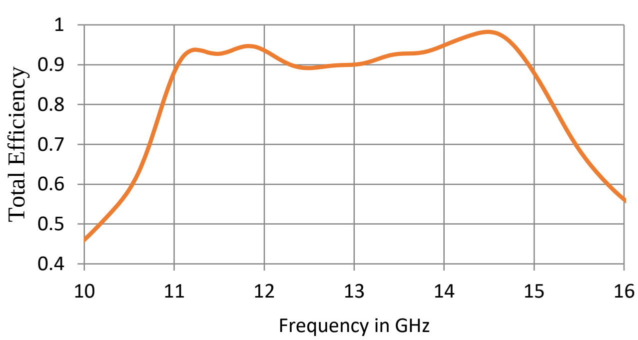

Fig. 11. Total Efficiency of the Antenna after Alteration

The high efficiency was maintained even after making changes in the structure. The efficiency of the antenna is very high and this efficient antenna can be successfully engaged in the satellite applications.

Finally, Gain was sketched in Fig. 12. Gain varied from 4.98dB to 6.98dB in the entire bandwidth. A slight drop in Gain was recorded due to the mentioned changes in the antenna. The mentioned values of gain in the working bandwidth justify its engagement in satellite as well as other wireless communication in future.

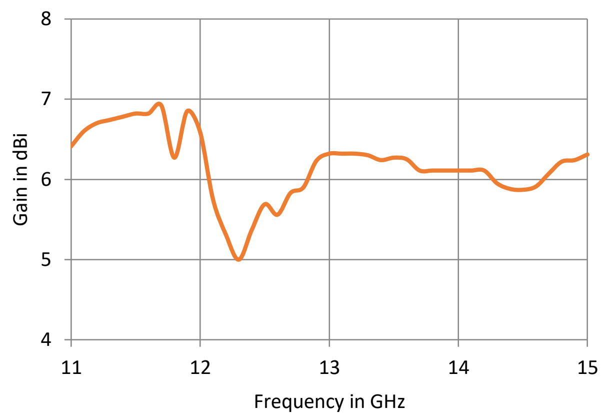

Fig. 12. Gain of the Modified Antenna

V. Radiation Patterns

2D radiation pattern elaborated in Fig.13a had a 3dB angular width of 56^0. Its main lobe level was 5.06dB and its side lob level was -1.9dB.

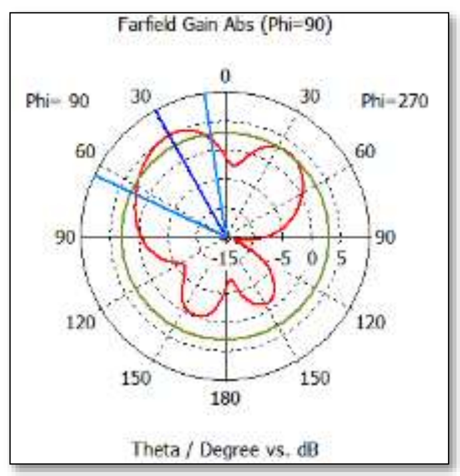

Fig.13a. Radiation pattern at 12GHz

2D radiation pattern of Fig.13b was sketched at frequency of 13GHz. Its 3dB angular width was 43.8degree, its main lobe level was 5.65dB and its side lob level was -1.9dB.

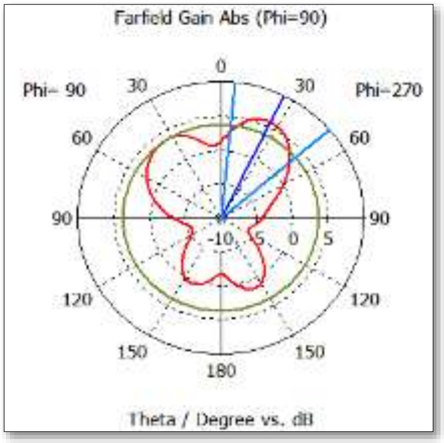

Fig.13b. Radiation pattern at 13GHz

The radiation pattern at the frequency of 14GHz was displayed in figure 13c. Its angular width was observed as 37.5 degree and its main lobe level was recorded as 6.02dB while its side level lobe was recorded as -2dB.

Finally, Fig.13d represents the 2D radiation pattern of this antenna at 14.8GHz. Its angular width was observed as 83.5 degree and its main lobe level was recorded as 6.07dB while its side level lobe was recorded as -2.1dB.

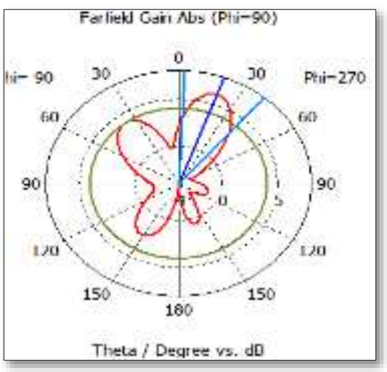

Fig.13c. Radiation pattern at 14GHz

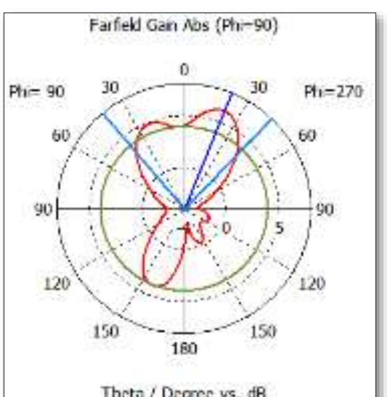

Fig.13d. Radiation pattern at 14.8GHz

The 2D radiation patterns of this patch antenna have narrow half power beamwidth and they have large values of gain that guaranty the application of the antenna in the satellite communications.

The real part of the impedance is sketched with respect to frequency in Figure 14. The real part of the impedance is 50Ω for the best matching. The real impedance is 50Ω at 14.5GHz which is the center frequency of the bandwidth.

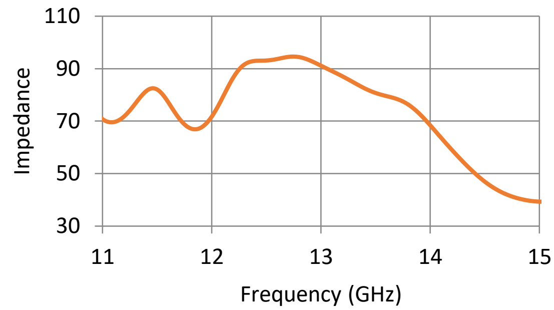

Fig. 14. Real Part of the Impedance

The maximum value of gain and directivity are given in Figure 15. The ratio of the gain to directivity defines the efficiency of the antenna as well that comes out to be 98.93%. The antenna is very efficient antenna. The radiation efficiency of the antenna is shown in Figure 16. The minimum value of the radiation efficiency is 96.65% and the maximum value is 99.22%. The radiation efficiency of the antenna is very large.

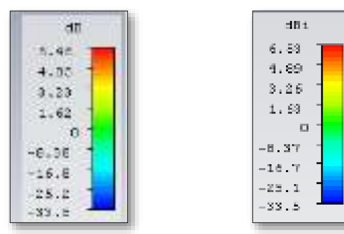

Fig. 15. Gain and Directivity for the calculation of efficiency

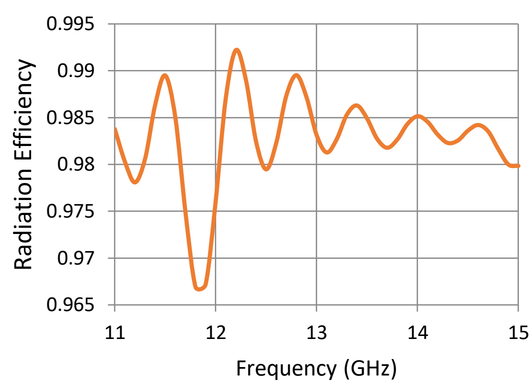

Fig. 16. Radiation efficiency

The 3D radiation pattern at the center frequency of 14.5GHz has been shown in Figure 17. The directivity of the antenna at the mentioned frequency is 6.04dBi, while its efficiency is 98.14%.

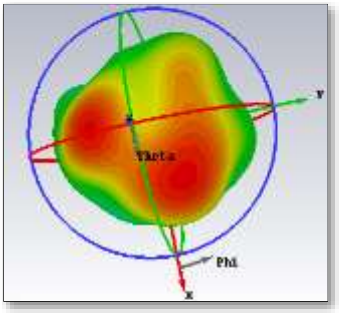

Fig. 17. 3D Radiation Pattern at 14.5GHz

VI. CONCLUSION

This research analyzes the simulated results of a novel design of patch antenna suitable for satellite military application in X and Ku band. The initial design bandwidth of the antenna was 3.74GHz with a center frequency of 14.2GHz. The gain of antenna was in the range of 5dB to 6.98dB with an overall efficiency of 0.98. The minimum value of standing wave ratio was 1.004. Further, in order to enhance the bandwidth of the antenna, slight modifications in the design were introduced which enhanced its bandwidth to 4GHz. The results showed no change in the overall efficiency even after the modifications in the design structure. A slight decline in the gain of the modified design was observed due to bandwidth enhancement, the gain was in the range of 4.98dB to 6.46dB. Detraction in the coefficient of reflection was observed (from a value of -53.36 dB to -30.67dB). The dimensions of the proposed antenna were 24mm × 28mm. The simulation results show an improvement in the antenna bandwidth of 4GHz, high efficiency of 0.99 and large gain of 6.46dB in comparison to the designs proposed in the available literature. These improvements in the parameters make this novel design of patch antenna suitable to be implemented in the mentioned bands for satellite applications. Future work will be based on the further modification in the design to enhance bandwidth and gain of the antenna.

ACKNOWLEDGMENT

The author acknowledges the contributions made by Dr. Siddique Ali who extends his help in the research work.

REFERENCES

[1] Rao, S. M., D. R. Wilton & A.W. Glisson., Electromagnetic scattering by surfaces of arbitrary shape., IEEE Transactions on Antennas Propagation., vol. AP-30 , pp. 409–418. (1982)

[2] Gupta, K. C. & A. B. Norwood., Microstrip Antenna Design., Norwood, MA: Artech House, London,UK, (1988)

[3] Zhang, X.X. &F.Yang., The study of slit cut on the microstrip antenna and its applications., Microwave and Optical Technology Letters, vol. 18(4), pp. 297–300, (1998)

[4] Rahmat-Samii, Y. & E. Michielssen., Electromagnetic Optimization by Genetic Algorithms., New York, NY: Wiley,USA, (1999)

[5] Hodges, R. E. & Y. Rahmat-Samii., An iterative current-based hybrid method for complex structures., IEEE Transactions on Antennas Propagation., vol. 45, pp. 265–276, (1997)

[6] Rawat, S. & K .K. Sharma., A compact broadband microstrip patch antenna with defected ground structure for C-band applications., Central European Journal of Engineering, Springer, 287-292.(2014)

[7] Surjati,I.,Y. KN &Yuliastuti., Increasing Bandwidth Dual Frequency Triangular Micro-strip antenna for Wi-Max application., International Journal of Electrical & Computer Science, vol. 10 (06) , (2010)

[8] Papapolymerous, I., R. F. Drayton & L. P. B. Katehi., Micromachined patch antennas., IEEE Transations on Antennas Propagation, vol. 46, pp. 275–283(1998)

[9] Liu, L., S. W. Cheung, R. Azim, & M. T. Islam., A compact circular-ring antenna for ultra-wideband applications., Microwave and Optical Technology Letters, vol. 53, no. 10, pp. 2283–2288, (2011)

[10] Kaufmann, T., A. Verma, V.-T. Truong, B. Weng, R. Shepherd, & C. Fumeaux., Efficiency of a Compact Elliptical Planar Ultra-Wideband Antenna Based on Conductive Polymers., International Journal of Antennas and Propagation, vol. 2012, May (2012)

[11] Azim, R., M. T. Islam, N. Misran, S. W. Cheung, & Y. Yamada., Planar UWB antenna with multi-slotted ground plane., Microwave and Optical Technology Letters, vol. 53, no. 5, pp. 966–968,(2011)

[12] Sze, J.-Y., T.-H. Hu, & T.-J. Chen., Compact dual-band annular-ring slot antenna with meandered grounded strip., Progress In Electromagnetics Research, vol. 95, pp. 299–308, (2009)

[13] Song, Y., Y.-C. Jiao, G. Zhao, & F.-S. Zhang., Multiband CPW-FED triangle-shaped monopole antenna for wireless applications., Progress in Electromagnetics Research, vol. 70, pp. 329–336, (2007)

[14] Abu Tarboush, H. F., R. Nilavalan, T. Peter, & S. W. Cheung., Multiband Inverted-F Antenna With Independent Bands for Small and Slim Cellular Mobile Handsets., IEEE Transactions on Antennas and Propagation, vol. 59, no. 7, pp. 2636 –2645, Jul. (2011)

[15] Malisuwan, S., J. Sivaraks, N. Madan & N. Suriyakrai., Design of Microstrip Patch Antenna for Ku-Band SatelliteCommunication Applications., International Journal of Computer and Communication Engineering, Vol. 3, No. 6, November (2014)

[16] Chodavadiya, V.V. & S.S. Aggarwal., Microstrip Patch Antenna Design for Ku Band Application., International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 4, April (2014)

[17] Azim, R., M. T. Islam, & N. Misran., Dual polarized microstrip patch antenna for Ku-band application.,Journal of Microelectronics, Electronics components and Materials, Informacije MIDEM, 41(2), 114-117, (2011)

[18] Nor, N. M., M. H. Jamaluddin, M. R. Kamarudin& M. Khalily., Rectangular Dielectric Resonator Antenna Array for 28GHz Applications., Progress In Electromagnetics Research C, Vol. 63, 53-61, (2016)

[19] Qas Elias, B. B., A Wideband Microstrip Patch Antenna for KU-Band Applications., American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) ISSN (Print) 2313-4410, ISSN (Online) 2313-4402, (2015).

[20] Ahmad, G., M.I. Babar., M.I. Khattak., A Novel Wideband Microstrip Patch Antenna for Satellite Communications in Ku-Band., Journal of Engineering & Applied Sciences, Vol. 36, No.2, 17-22, (2017)

[21] Ahmad, G., M.I. Babar., An Efficient Patch Antenna with Improved Bandwidth for Future Applications, Journal of Engineering & Applied Sciences, Vol. 38, No.1, (2019).

[22] Ahmad, G., M. I. Babar., M. Irfan., M. Ashraf., T. Jan., and S. W. Shah., Bandwidth Enhancement of Patch Antenna through Various Techniques for Ku-Band Application., Proceedings of the Pakistan Academy of Sciences: Pakistan Academy of Sciences A. Physical and Computational Sciences 55 (1): 109–116 (2018).

[23] Azim, R.,M.T.Islam., and N. Misran., Dual polarized microstrip patch antenna for Ku-band application ,Journal of Microelectronics, Electronics

Components and Materials, Informacije MIDEM, volume 41(2), pp. 114-117(2011).

[24] Lakrit, S., Ammor, H., Matah, S., Karli, R., Saadi, A., Terhzaz, J., &Tribak,A., “A new small high-gain wideband rectangular patch antenna for X and Ku bands applications”, Journal of Taibah University for Science, vol. 12, no. 2, 202–207, 2018.

[25] Nor, N.M., M.H.Jamaluddin., M.R. Kamarudin., and M. Khalily., Rectangular dielectric resonator antenna array for 28GHz applications, Progress in Electromagnetics Research, C 63: pp. 53-61, 2016.

[26] Bhadouria, A.S., Kumar, M., “Wide Ku-Band Microstrip Patch Antenna Using Defected patch and ground”,IEEE International Conference on Advances in Engineering & Technology Research (ICAETR - 2014), August 01-02, Kota, India, 2014.

[27] Samsuzzaman, M., M.T. Islam.,B. Yatim., and M. M. Ali., Dual frequency triangular slotted microstrip patch antenna for Ku band applications. PrzeglądElektrotechniczny, 89(1), 275-279, (2013) (2013).

G.Ahmad graduated from UET Peshawar back in 1993. He did his master degree in Power Stream in 2000. He did another master in Communication Stream from George Washington University USA in 2002. He did PhD in Electrical Engineering in 2017;currently he has been serving UET Peshawar as Associate Professor and Advisor Students Affairs. He has published a book titled‘Basic Electrical Engineering’ in 2019.