Designing Of a Slotted Square Shaped Novel Multiband Antenna For 4G, S-band, Radar And Satellite Applications

Adil Imtiyaz Bhat[1], Vikas Kumar[2]

[1]M.Tech Scholar, ECE Department, Galaxy Global Group of Institutions, Ambala,
[2]Assistant Professor, ECE Department, Galaxy Global Group of Institutions, Ambala.

Abstract- **In this work we have developed a new study concerning the single-band and multiband microstrip patch antenna by using square shaped slot loaded patch resonating at frequency 1.8 GHz which providing a single band and multiband (having many wireless bands). The goal from this work was to get more number of bands to design a better multiband antenna. A multiband microstrip patch antenna has been developed, analyzed and validated for 4G and other wireless applications.**

So in this dissertation, different iterations of square geometry are applied to form self-similar structures. Initially a square patch of antenna is taken. In this attempt, a square shaped slot based microstrip patch antenna is proposed and designed. The functional characteristics of the proposed antenna namely return loss, VSWR and radiation pattern are investigated. The designed antenna is resonating at 1.8 GHz, and the return loss and VSWR about, -47.66 dB and 1.0083 respectively. The overall size of the proposed antenna is 38 mm × 48 mm. The size of the proposed antenna is small and meets the requirements for 4G applications. Hence it could be incorporated for 4G applications.

Keywords- *4G, Square Shape Slots, High Frequency Structure Simulator, Microstrip patch antenna, Return Loss, Impedance Matching, VSWR, resonant frequency,HFSS Software.*

I. INTRODUCTION

The field of antennas is overwhelming and vigorus, and in the course of the past 70 years this field has been making a great deal of enhancements and has become an indispensable part of communication revolution.[1] Antenna technology witnesses various advancements by designing different antennas with suitable parameters i,e, most conventional antennas are made with conducting metals and dielectrics that allow electric charge to vibrate at different radio frequencies. For example, in modern communications equipment such as cell phones, the electric charge vibration frequencies (GHZ radio frequencies) can be several billion cycles per second. [2] The antenna structure establishes a path to which the vibrating electric charges are confined and further define the antenna pattern they produce. [3] However, when a very low-profile antenna is desired, the close proximity of metal structure to a conventional antenna causes poor performance unless cavities or other bulky structures are allowed .[4]

MSA Antennas do not utilize electric charge to achieve radiation [5]. Instead, the magnetic flux that resides in the MSA core shapes and supports an efficient form of magnetic polarization current in a specially designed flux channel**. [6]** The MSA core is an non-homogeneous and anisotropic construction which allows for closer proximity and integration within conductors, which cannot be achieved by conventional antennas .[7]

Unlike conventional antennas, the MSA may be placed directly on, or even within, conducting structure with no ill-effects on radiation or impedance match performance. For communications in the VHF/UHF bands (30 MHz to 3 GHz) MSA antennas can provide equivalent performance to conventional [8].

An antenna is the integral part of wireless communication system. Designing of better performance antennas leads to better quality of communication network. [9]TV can be visualized as specific model where broadcast quality could be enhanced by utilizing modified effective antennas. The antennas play a same role in communication as that of eyes and eyeglasses in the human being’s life. [10]

The microstrip patch antenna apparatus that offers a wide scope of utilizations in remote or satellite correspondences because of marked down size, cost, and power utilization, offering a significant favorable position over customary or traditional ones [11]. Execution of ultra-wide band frameworks

(UWB) has become an exceptionally focused point in the modern broadcast communications networks. [12] Specifically, ultra-wide band antennas are one of the principle parts of the UWB framework and have pulled in a great deal of consideration for a long time .[13] By its transfer speed and high information rates, ultra-broadband (UWB) framework have been generally utilized in radar and satellite applications. [14] To decrease the multipath fading and enhancing data transmission MIMO technology at transmitter and receiver terminals becomes an interesting area for industries. Ultra-wideband technology along with MIMO is used for short distance communications.

In high performance aircrafts, spacecraft's, satellites we require low-profile antennas because of various constraints like weight, cost, size etc. In order to meet these required conditions and standards microstrip antennas are used. [15] These antennas are low profile, comfortable to planer and non-planer surfaces, simple and inexpensive to manufacture.[16] Adjusting their resonant frequency, polarization, pattern and impedance decides their applications. Apart from the advantages, there are few disadvantages as well e.g. low efficiency, low power, high Q [17]. But there are a number of methods by which the performance of microstrip antenna can be improved. These methods include defected ground structure, variation in ground height,cutting slots in patch.[18] One of the latest trends in modern wireless mobile communication is a reduction in physical size and multiband capability. [19] The geometry of fractal antenna solves this purpose in a number of ways .[20] By applying fractal geometry on the patch, the size decreases but resonant frequency increases with frequency bands. [21]

II. STRUCTURE OF MICROSTRIP PATCH ANTENNA

The patch may have many shapes and generally made of conductive materials such as gold or copper. The microstrip antenna maybe square shaped, rectangle shaped, circle shaped and elliptical[22].Certain patch antennas may not have dielectric substrate rather they are made of metal patch placed over ground plane. The patch and ground plane are separated by dielectric spacers [23]

i) Patch: Patch is a very thin, radiating metal strip located on one side of a thin no conducting substrate. The metallic patch is made of thin foil plated with a corrosion resistive metal, such as gold, tin, nickel.

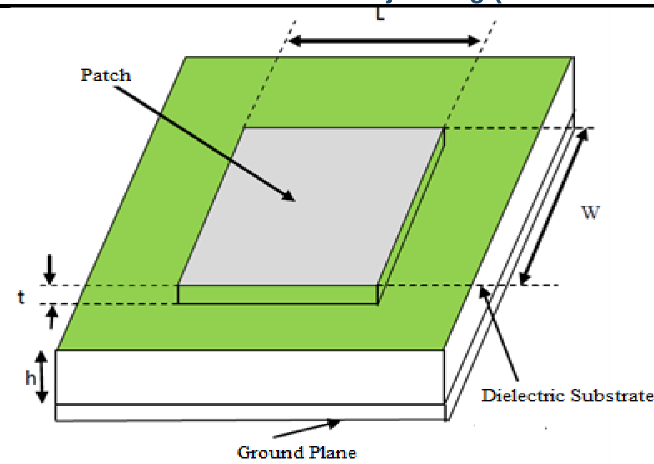

Figure 1: Structure of microstrip patch antenna

ii) Ground: Ground is a metallic surface located on the other side of the substrate. The size of the ground should always be more for practical considerations. It should be greater than patch of six times substrate thickness.

iii) Substrate: For MSA applications, thicker substrates with low dielectric substrates are favored for upgraded radiation. This is the dielectric that builds the recurrence. For better reception, substrates with low dielectric ought to be utilized. The most widely recognized substrates are Teflon (PTFE, Polytetrafluoroethylene), Polypropylene and Polystyrene. Epoxy substrate, mostly utilized in PCB is called FR4. It is perhaps the least expensive substrate.Substrate is chiefly used to give separation and mechanical help among fix and ground plane. It is utilized ordinarily with steady dielectric material to fix and diminish the size.

According to the surface dielectric constant ε_r can be divided into three categories: -

- There is a relative dielectric constant ε_r in the range 1.0 to 2.0. This material can be air, polystyrene foam or dielectric honeycomb
- There ε_r of about 2.0 to 4.0 with material consisting mostly of fiberglass reinforced Teflon.

With ε_r between 4 to 10 the material may include ceramic, quartz, or aluminum

III. DESIGN & RESULT ANALYSIS

Design of proposed single band antenna using square ring slots:

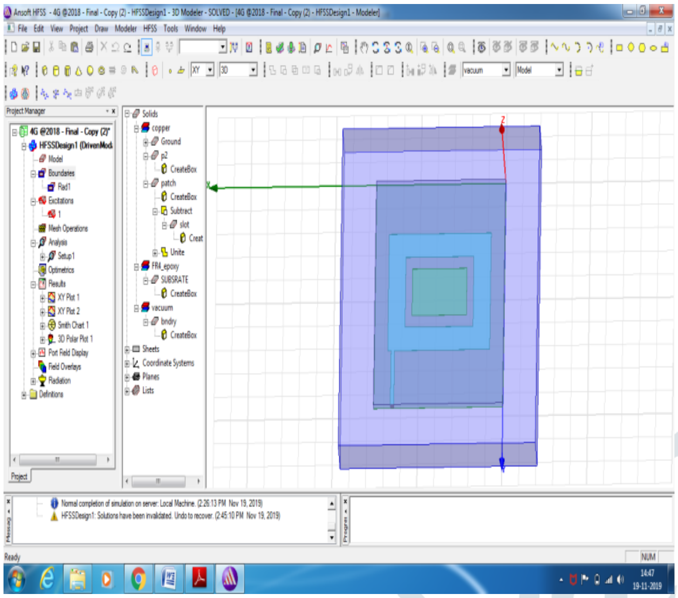

Figure 2: Design of proposed single band antenna using square ring slots

RESULTS:

The return loss plot for the designed antenna at -10 dB bandwidth using microstrip line feed is shown in figure 3 as below.

a) Observation from -10dB return loss

- Resonate at frequency = **1.8 GHz**
- Return Loss (S- Parameters) = **-47.66 dB**

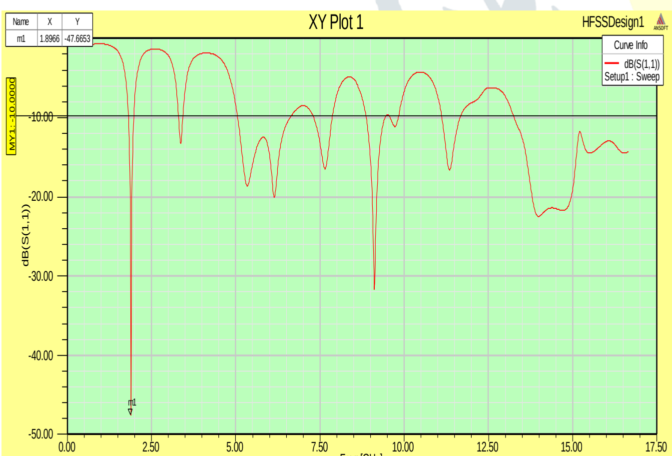

Figure 3: Simulated return loss

b) Observation from VSWR

VSWR at resonant frequency 1.8 GHz=1.0083

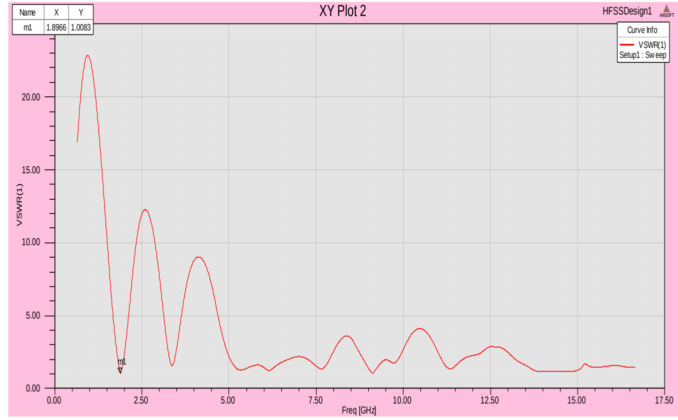

Figure 4: VSWR plot

c) Smith Chart

It is observed from the smith chart that the value of impedance in this smith chart is 0.9918×50 (characteristic impedance) = 49.59 ohm at resonant frequency.

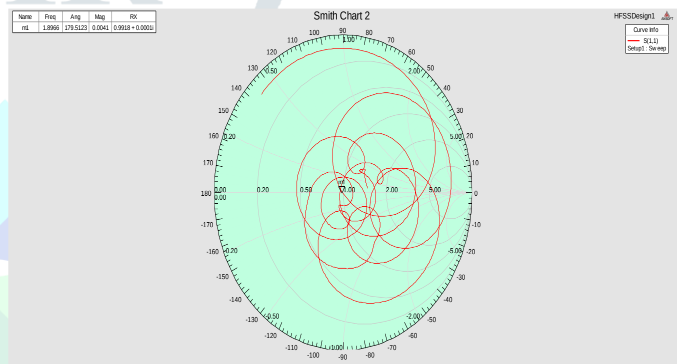

Figure 5:Smith Chart plot

Conclusion between Reference Antenna and Proposed Antenna:

Hence I have designed a slotted square shaped antenna for 4G and other wireless applications & thus a compact microstrip patch antenna has been designed for full filling the requirements of 4G applications at 1.8 GHz frequency. The measured and simulated results are in good match. To meet the miniaturization requirement microstrip patch antennas has been designed.

Table 1: Difference Table between Reference and Proposed antenna

ANTENNA	Resonant Frequency (GHz)	Return Loss	VSWR
Reference Antenna	1.8	-29.19 dB	1.07
Proposed Antenna	1.8	-47.66 dB	1.0083

IV. CONCLUSION

In this dissertation, different iterations of square geometry are applied to form self-similar structures. Initially a square patch of antenna is taken. In this attempt, a square shaped slot based microstrip patch antenna is proposed and designed. The functional characteristics of the proposed antenna namely return loss, VSWR and radiation pattern are investigated. The designed antenna is resonating at 1.8 GHz, and the return loss and VSWR about, -47.66 dB and 1.0083 respectively. The overall size of the proposed antenna is 38 mm × 48 mm. The size of the proposed antenna is small and meets the requirements for 4G applications. Hence it could be incorporated for 4G applications. Parametric analysis has been applied to obtain antenna characteristics. Characteristics of antenna are analyzed by changing substrate thickness, changing feeding technique, change of substrate. Different designs have different application areas. By applying iterations of square geometry antenna resonated at 1.8 GHz, 3.34 GHz, 6.10 GHz, 7.61 GHz, 9.09 GHz, 11.30 GHz and 13.95 GHz with good bandwidth. By changing feed to microstrip feed, antenna can be useful for many wireless applications.

VI. REFERENCES

[1] Yogesh Kumar Choukiker, Satish K. Sharma and Santanu K. Behera, 2014. "Hybrid Fractal Planer Monopole Antenna Covering multiple Wireless Communication with (MIMO) Implementation for Handheld Devices," IEEE transactions on antenna and propagation, Vol 62, No. 3, March 2014.

[2] V.V. Reddy and R.S.V.N. Sharma, "Compact Circularly Polarized Asymmetrical Fractal Boundary Microstrip Antenna for Wireless Applications," IEEE antenna and wireless communication letters, Vol 13, No. 9, May 2014.

[3] V.V. Reddy and R.S.V.N. Sharma, "Triband Circularly Polarized Kotch Fractal Boundary Microstrip Antenna," IEEE antenna and wireless communication letters, Vol 14, No. 4, March 2014.

[4] Wei-Chung Weng and Chia Liang Hung, "An H-Fractal Antenna for Multiband Operations" IEEE antenna and wireless communication letters, Vol 16, No. 8, March 2014.

[5] Sangeetha Velan, Ester Florence Sunder Singh, Malathi Kangasabai, Member,Aswathy K. Sarma, Chinnambeti Raviteja, Ramprabhu Sivasamy and Jayaram Kizhekke Pakkathillam, "Dual-Band EBG Integrated Monopole Antenna Deploying Fractal Geometry for Wearable Applications," IEEE antenna and wireless communication letters, Vol 5, No. 9, March 2015.

[6] Amrollah Amini, homayoon Oraizi, Mohammad Amin Chaychi Zadeh, 2015. "Miniaturized UWB Log-Periodic Square Fractal Antenna," IEEE antenna and wireless communication letters, Vol 14, No. 3, March 2015.

[7] Shrivishal Tripathi, Akhilesh Mohan, Sandeep Yadav, 2015. "A Compact Kotch Fractal UWB MIMO Antenna With WLAN Band-Rejection," IEEE antenna and wireless communication letters, Vol 11, No. 7, March 2015.

[8] T.Shanmuganantham, S.Raghavan, "Design of a Compact Microstrip Patch Antenna With Probe Feeding for Wireless Applications," International Journal for Electronics and Communication, Vol 2, No. 3, August 2008, pp. 653-659.

[9] S. Chaimool, C. Chokchai and P. Akkeraekthalin, "Multiband Loaded Fractal Loop Monopole Antenna For USB Dongle Application," Electronics letters, Vol 48, No. 23, December 2012.

[10] Xue-Xea Yang, Bing-Cheng Shao, Fan Yang, Atef Z. Elsherbeniamd Bo Gong, "A Polarization Reconfigurable Patch Antenna With Loop Slots On Ground Plane," IEEE antenna and wireless communication letters, Vol 11, No.6, Jan 2012.

[11] R.K. Sharan, S.K. Sharma, " A .Gupta, R.K Chaudhary, An Edge Tapered Rectangular Patch Antenna with Parasitic Stubs and Slot for Wideband Applications, Wireless Pers Commun Vol 86, pp 1213–1220, 2016.

[12] M. Tarikul Islam, M. Samsuzzaman, M. Z. Mahmud, M.T. Islam, "A Compact Spectacles Shaped Patch Antenna for UWB Applications", 9th International Conference on Electrical and Computer Engineering, IEEE, 20-22 December, 2016, Dhaka, Bangladesh.

[13] P.Surendra Kumar, B.Chandra Mohan, "Dual-Frequency Vertex-Fed Pentagonal Slot On Rectangular Patch For WLAN/WiMAX Applications", 978-1-5090-3646/ 2016 IEEE.

[14] Ranjan Mishra, Raj Gaurav Mishra, Piyush Kuchhal, "Analytical Study on the Effect of Dimension and Position of Slot for the Designing of Ultra Wide Band (UWB) Microstrip Antenna", Intl. Conference on Advances in Computing, Communications and Informatics (ICACCI), Sept. 21-24, 2016, Jaipur, India, 978-1-5090-2029-4/16/IEEE.

[15] Jagori Raychaudhuri, Jayjit Mukherjee and Sudhabindu Ray, "Compact Circularly Polarized Suspended Microstrip Antenna with "*Swastika*" Shaped Slot", IEEE, International Symposium on Antennas and Propagation (APSYM), 2016.

[16] Amit A. Deshmukh, Priyal Zaveri, Sanjay Deshmukh and Anuja Odhekar, "Analysis of Circularly Polarized E-shaped Microstrip Antenna", IEEE 2016 International Symposium on Antennas and Propagation (APSYM).

[17] B. Zoubiri, A. Mayouf, F. Mayouf, S. Abdelkebir and T. Devers, "Rectangular Microstrip Antenna Gain Enhancement Using Elliptical EBG Structure", IEEE 2016 7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT).

[18] Divesh Mittal and Aman Nag, "High Directivity FR4 Substrate Slotted Defected Ground Microstrip Patch Antenna for X-Band Applications" IEEE 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication.

[19] Jaiverdhan, Deepshikha Lodhi, M. M Sharma, R. P Yadav, "Analysis of Dual Band Double Slot Loaded Microstrip Patch Antenna",International Conference on Computer, Communications and Electronics (Comptelix) Manipal

University Jaipur, Malaviya National Institute of Technology Jaipur & IRISWORLD, July 01-02, 2017.

[20] Anamika Banwari, Nagraj Acharya, Manish Kumar Sharma, Sanjeev Sexsena, "Low Loss Semicircular Slotted Microstrip Patch Antenna for ISM Band Application" Next Generation Electronics (ISNE), 2017 6th International Symposium IEEE, Keelung, Taiwan, **ISSN:** 2378-8607, 23-25 May 2017

[21] K.L.Naga Kishore, "Wide Band Slotted Rectangular Micro-strip Patch Antenna for Space Applications", Proceedings of the Second International Conference on Inventive Systems and Control (ICISC 2018) IEEE Xplore Compliant - Part Number:CFP18J06-ART, ISBN:978.

[22] S. P. Gangwar, K. Gangwar and A. Kumar, "A compact microstrip patch antenna with five circular slots for wideband applications," *2018 3rd International Conference on Microwave and Photonics (ICMAP)*, Dhanbad, 2018, pp. 1-2. ICMAP.2018.

[23] Bhanu Ashika and S. Robinson, "Design and Analysis of Microstrip Patch Antenna for 4G Communication," *2018 International Conference on Current Trends towards Converging Technologies (ICCTCT)*, Coimbatore, 2018, pp. 1-5, IEEE conference.