Reflect array Antenna based on Torus ring Unit cell for X –Band Application

[1]S. Chitra, *Research Scholar, Department of ECE, Bharath University, Chennai.India.*

[2]Dr H. Umma Habiba, *Professor, Department of ECE, Bharath University, Chennai, India.*

[3]L.K. Aishwaryaa, *Research Scholar, Department of ECE, Bharath University, Chennai, India.*

[4]S.Venkatraman, Electronic Engineer,*Bharath Dynamics Limited, Hyderabad, India.*

Abstract – A single layer tiny reflect-array antenna is presented here based on Torus ring patch for X band applications which operates at the frequency band from 8 GHz to 12 GHz. The linear phase range of 0 to 350° is obtained. A 10*10 reflect array antenna is designed using single layer micro strip array with the size of 25 mm * 25 mm .The computer simulation technology(CST) software is used for simulation of the whole reflect array antenna on the Rogers 5880 substrate with dielectric constant of 2.2 and a thickness of 1.6 mm . The designed reflect array antenna is validated by analysing 2-D and 3-D radiation pattern and gain.

Keywords - Reflect array, Single layer , Torus ring patch, CST.

I.INTRODUCTION

The reflect array antenna is a combination of reflector and phased array with some features of both antennas. Micro strip reflect arrays are flat reflector antennas consisting of a planar array of micro strip patches illuminated by a feed . Reflect arrays are an innovative and attractive alternative to the conventional reflector antennas[1] . Printed RA antennas have widely been used for smart arrays and beamforming is achieved by regulating amplitude and phase of each element [2] Advances in Wireless technologies and Telecommunication require the deployment of low cost, light weight, high gain and easy to install micro strip antennas reflect arrays is largely diffused in many application fields such as remote sensing and satellite communications [3] .The reflecting surface is irradiated spatially using a suitable feed antenna. One important issue in the design of microstrip reflect arrays is obtaining wide phasing range and slow phase variations(slope) as a function of the phasing element's variable size. A wide phase range gives the designer more flexibility in selecting proper element sizes for a given phase value [4]. A horn antenna for feeding purpose along with an array of radiating elements together constitutes the general structure of reflectarray antenna.Due to nature of spatial illumination of the incident wave onto elements by the horn, path differences exists and hence phase differences exists which need to be compensated for each element by varying their resonant dimensions[5]. Recent developments in cubesat satellite technology have enabled easier and relatively inexpensive access to space One of the major requirements of cubesats is small size which hinders the use of large high gain antennas[6]. An antenna consisting of a feed and an array of reflecting elements arranged on a surface and adjusted so that the reflected waves from the individual elements combine to produce a prescribed secondary radiation pattern. The incident spherical wave is transformed into linear wave fronts in a parabolic reflector, the phase necessary to produce collimated beam is compensated by the parabolic form[7]. The high gain feature of the RA antenna becomes inherent due to large number of elements. on the array. This high gain has made RAs suitable and attractive for space and sat-com applications. RAs can be installed flexibly and have a low cost. The linear phase shift is achieved by varying geometrical parameters of the unit cell element. On this reflecting surface, there is an array of passive printed elements each with it’s own specific dimension in order to compensate the phase difference caused by the feed to element path and thus produce a co-phased plane and hence the directive pattern at the antenna far field region[8] .

II.UNIT ELEMENT DESIGN AND ANALYSIS

The reflectarray unit cell element is designed using a microstrip Torus ring patch which resonates at 10 GHz. However, a compact single layer elements with large linear phase range are the desirable characteristics. This has been achieved by varying radius of the unit cell element .The unit cell consists of torus ring patch for lower band on the Rogers substrate with permittivity 2.2 and thickness 1.6 mm. The performance of the proposed unit cell is determined in terms of phase range and effect of incident angles, different frequencies, Substrate thickness have been discussed , The incident angle does not have any change in the phase range.

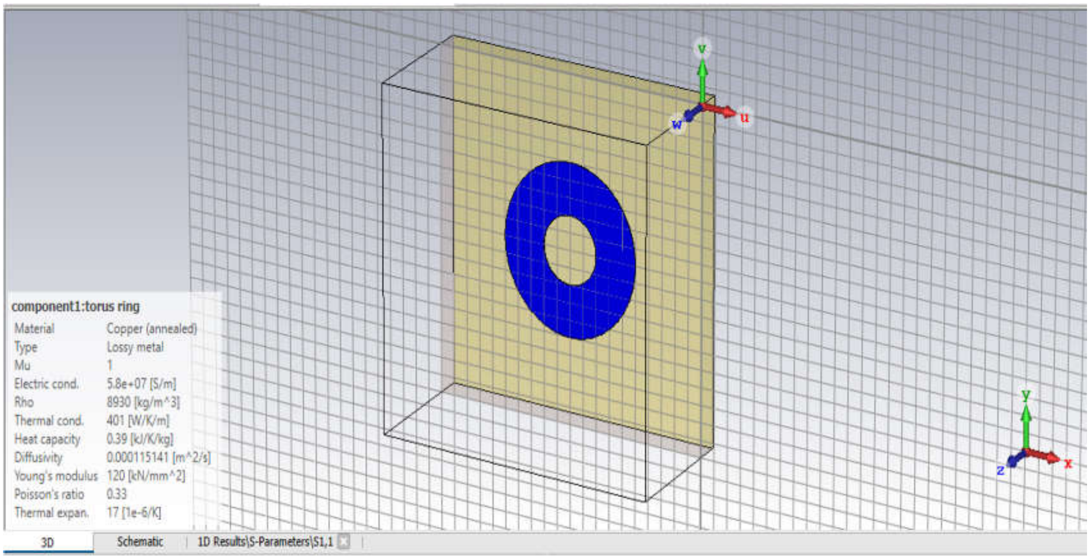

Fig 1.Single Unit cell Structure

Dimension: Outer radius – 5 mm , Inner radius – 3 mm

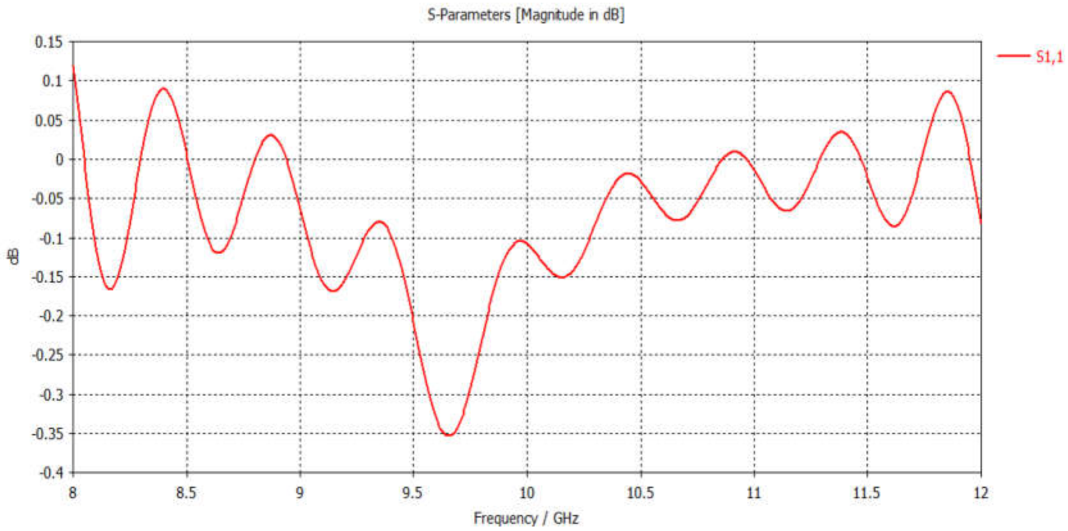

Fig 2. Return loss parameter S11

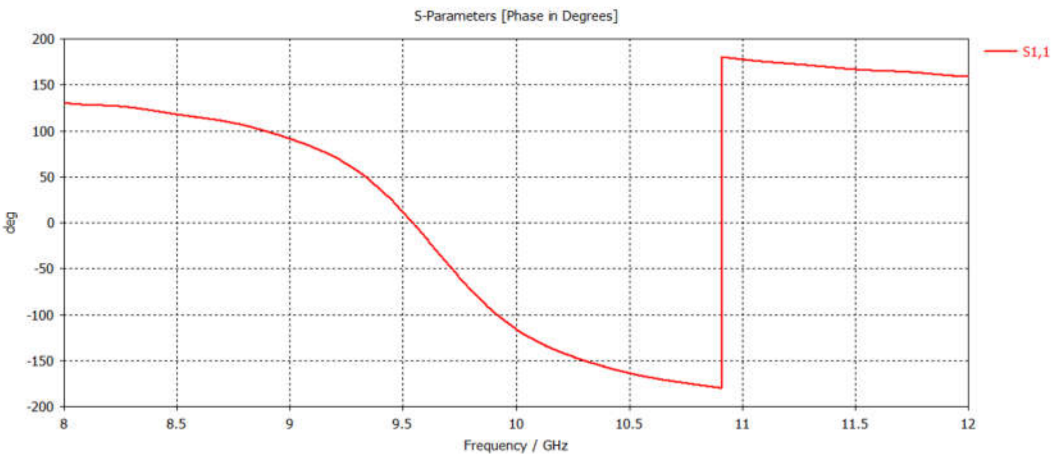

Fig 3. Phase Reflection Curve

III. FULL REFLECTARRAY CONFIGURATION

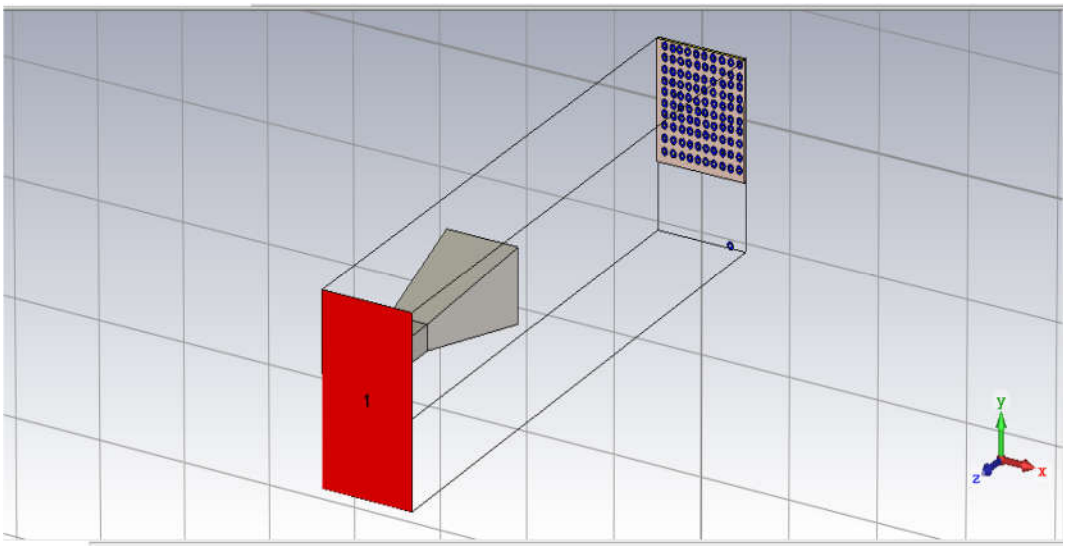

Fig 4. Perspective Layout of Reflectarray Antenna

A ten * ten elements centre-fed reflectarray is simulated and measured on Rogers 5880 substrate as shown in Figure. At the bottom layer, Ground plane is constructed then substrate of Rogers 5880 of dielectric constant 2,2 with a thickness of 1.6 mm is kept over the ground plane and then torus ring patch is etched on the substrate. Uniform spacing of 0.5 ƛ is provided between 100 elements. The complete reflectarray system simulations are carried out CST software. The reflectarray model consists of finite number of elements. These elements have uniform sizes according to phase distribution of array aperture.

IV.RESULTS AND ANALYSIS

The simulations are carried out in Time domain solver and E field, H field and far fields are added in field monitors to generate output of far field radiation pattern at 8 GHz,10 GHz and 12 GHz respectively. The gain is measured with E_{max}, H_{max} and power flow.S11 is -0.35 db at 9.7 GHz. Realized gain at 8 GHz is 57.36 db and at 10 GHz is 132.2 db and at 12 GHz is 193.9 db. The power distribution curve is also plotted. Full reflect array configuration with 100 torus elements in a 10*10 array is shown in Fig 4. excited by the horn antenna working in X band.

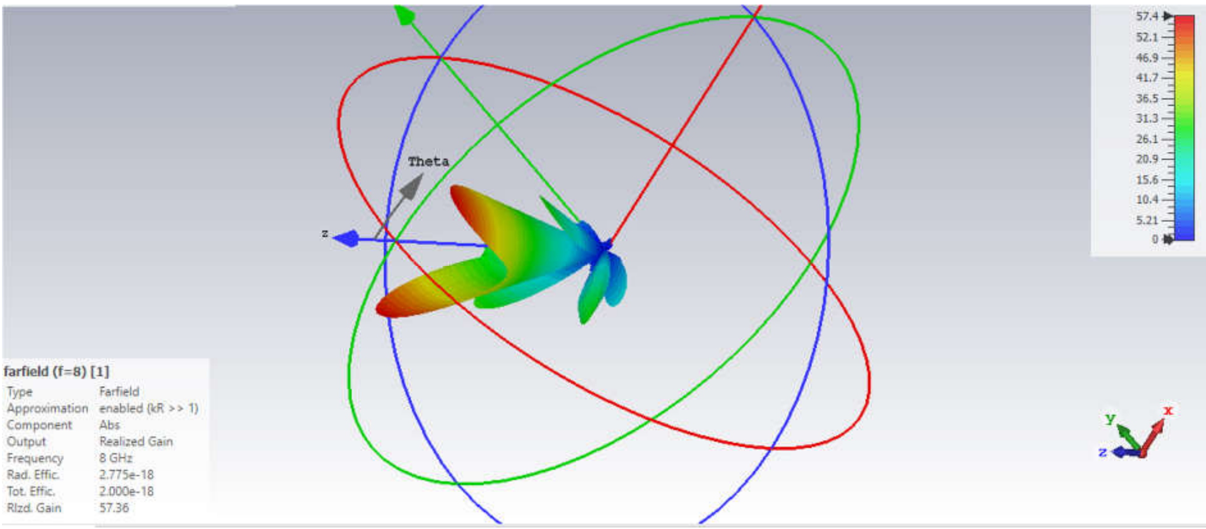

Fig 5. Radiation pattern for the proposed Reflectarray antenna at 8 GHz

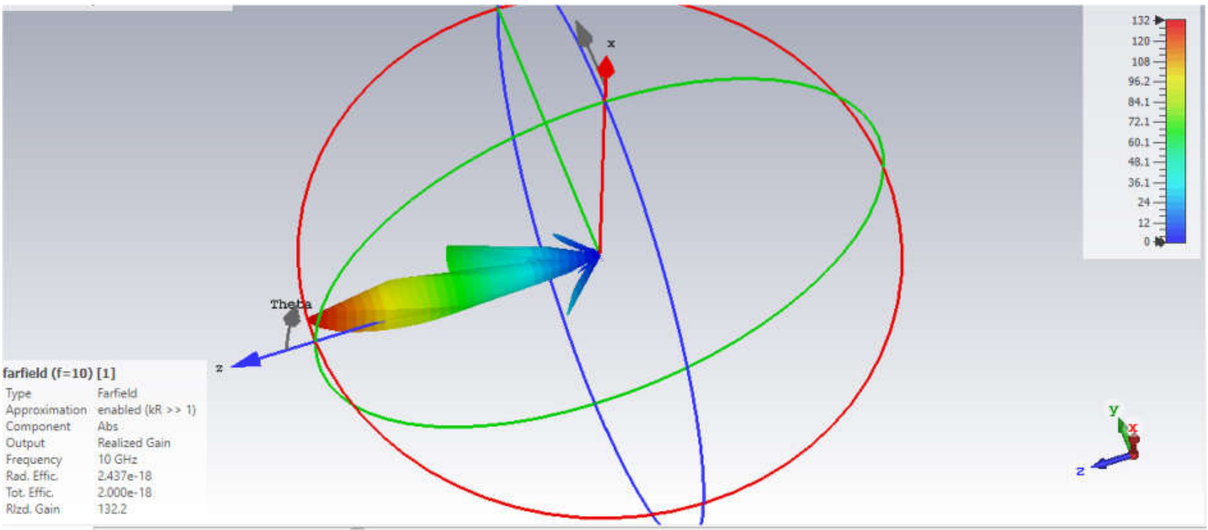

Fig 6. Radiation pattern for the proposed Reflectarray antenna at 10 GHz

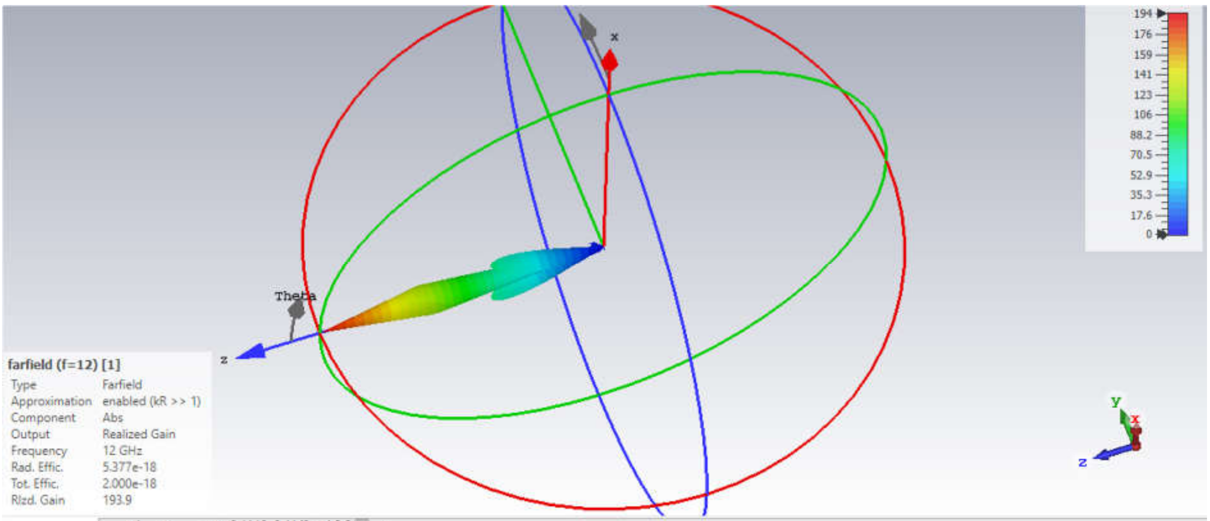

Fig 7. Radiation pattern for the proposed Reflectarray antenna at 12 GHz

Fig

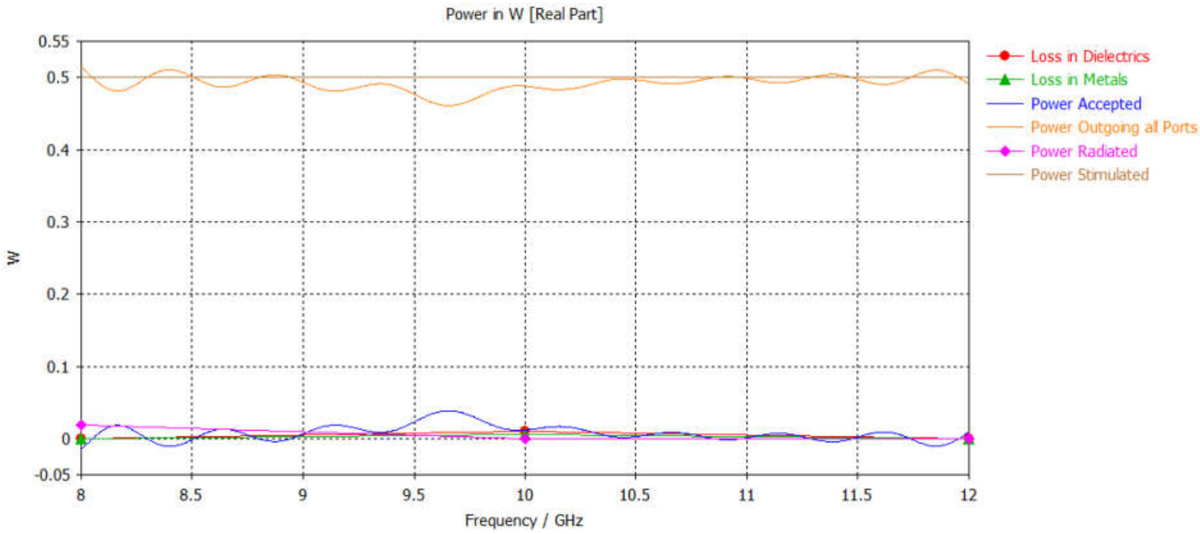

Fig 8. Power Distribution curves

V. CONCLUSION

A novel torus ring patch reflectarray element and a 10*10 reflectarray antenna has been proposed in this paper. A 10*10 reflectarray antenna has been designed using a proposed element and it's return loss, phase performance is plotted. The proposed antenna provides maximum gain of 132.2 db at centre frequency of 10 GHz. The future scope of the antenna lies in satellite communication applications like DBS, Disaster management, radar system, remote sensing and endless applications which require high gain antennas.

ACKNOWLEDGMENT

The authors would like to thank her guide, family members, and friends for their fullest cooperation.

REFERENCES

[1] Finich, Sanaâ, N. Touhami, and Abdelkrim Farkhsi. "Comparison and analysis of unit-cell environment behavior of reflectarray antenna." *ARPN Journal of Engineering and Applied Sciences* 11 (2016): 1421-1424.

[2] Bhaskaran, Rahul, et al. "Design of ku band reflectarray antenna using novel half ellipse elements." 2018 6th Edition of International Conference on Wireless Networks & Embedded Systems (WECON). IEEE, 2018.

[3] Finich, Sanaâ, Naima Amar Touhami, and Abdelkrim Farkhsi. "Design and analysis of different shapes for unit-cell reflectarray antenna." Procedia Engineering 181 (2017): 526-530.

[4] Bialkowski, M. E., and K. H. Sayidmarie. "Phasing characteristics of a single layer microstrip reflectarray employing various basic element shapes." 2008 International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials. IEEE, 2008

[5] Venkatraman, S., et al. "Design of a Single Layer Ku Band Reflectarray Antenna based on Hexagonal Unit Cell for Satellite Applications." 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS). IEEE, 2022.

[6] Rubio, Antonio J., et al. "A deployable hexagonal reflectarray antenna for space applications." 2021 United States National Committee of URSI National Radio Science Meeting (USNC-URSI NRSM). IEEE, 2021.

[7] P. Jothilakshmi, C. G. Preethika, R. Mohanasundaram and S. S. Kumar, "Design of Reflectarray Unit Cell for Ku Band Satellite Communication," *2022 IEEE 6th Conference on Information and Communication Technology (CICT)*, Gwalior, India, 2022, pp. 1-6, doi: 10.1109/CICT56698.2022.9997910.

[8] Hemalatha, M. C., et al. "Reflect array Antenna based on Vertical polarized Square Patch Unit cell for Ku-Band Application." 2019 IEEE International Conference on Innovations in Communication, Computing and Instrumentation (ICCI). IEEE, 2019.

BIOGRAPHY

S. Chitra was awarded M. Tech by National Institute of technology, Trichy Tamil Nadu India in the year of 2006. She is having concurrent teaching and industrial experience of more than twenty years. Currently, she is working as Assistant Professor of ECE department at Bharath University, Chennai and pursuing her research in Reflectarray antennas. Her area of interest includes RF and Microwave communication and RF Mems. She is the life member of IAENG and annual member of IEEE

H. Umma Habiba was awarded Ph.D. degree in Electronics and Communication Engineering from Anna University, Chennai, Tamil Nadu, India. she was specialized in RF and Microwave Communication. She has two decades of teaching and Research experience. Currently she is working as a Professor in the Department of Electronics and Communication Engg, Bharath University, Chennai. She has a strong background in RF and Microwave Communication.

L.K. Aishwaryaa received her Master’s degree in Electronics and Communication Engineering department from Anna University, Chennai, Tamil Nadu, India. She is specialized in Communication Systems under the discipline of Electronics and Communication Engineering. She has three years of teaching experience. Currently, she is working as Assistant Professor in A.C.S College of engineering, Bangalore, Karnataka

S Venkatraman, India, received his Master's degree in Electronics and Communication Engineering from Anna University, Tamil Nadu, India. He specialized in Communication Systems under the discipline of Electronics and Communication Engineering. He has experience as Patent Analyst. Previously, he was an Assistant Professor with the department of Electronics and Communication Engineering at Sri Sai Ram Institute of Technology, India.