ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

Design of Linearly Polarized Sinuous Antenna in the Range of 2.5-6GHz

Meera S[1], Prof. A K Prakash[2]

M.Tech (Wireless Technology), Dept. of ECE, Toc H Institute of Science & Technology, Kerala, India[1]

Professor, Dept. of ECE, Toc H Institute of Science & Technology, Kerala, India[2]

ABSTRACT: Sinuous Antenna, the most recent Frequency Independent Antenna, invented by R.H.DuHamel in the year 1987 is a derivative of spiral antenna. It hasN identical sinuous arms extending outward from a common point and arranged symmetrically on a surface comprising of bends and curves.Each cell is interleaved without connecting between adjacent cells of otherarm. The major advantages of sinuous antenna are in terms of polarization, bandwidth and its self-complementary structure. It can provide dual linear as well as dual circular polarization and is having a flexible bandwidth. It is also having a low profile geometry compared to other patch antennas for similar performances. These features make it suitable for various applications like surveillance for military and civil systems such as direction finding systems, radar warning receivers and reflector feeds due to their superior broadband characteristics and simultaneous polarization capability. In this paper, a 2- arm self-complementary sinuous antenna in the range of 2.5-6GHz is introduced. The sinuous antenna is fed with a Balun in order to provide unbalance to balance transformation. Tapered Balun also provides impedance transformation and matching in this realization. A cavity backing is provided in order to make the pattern unidirectional. This paper also describes how a loaded cavity backing improves the return loss with the help of relevant results. Andfinally the parameters of sinuous antenna like return loss, beam pattern and gain are compared over the frequency band. Stimulated design and analysis are carried out, to optimise the configuration. Hardware design and realisationare the final goals.

KEYWORDS: Sinous Antenna, UWB, Frequency Independent, Self-complementary structure,

I.INTRODUCTION

Ultra Wideband Antennas can cover wide range of frequencies. The key mechanism for radiation in UWB antenna is charge acceleration. The basic question that can arise is which kind of structures facilitates the charge acceleration over the very wide band. UWB radiation is based on certain principles.

A. Frequency Independent structure
B. Self-complementary structure
C. Multiple resonance Structure
D. Electrically small Antenna
E. Travelling wave structure

Frequency independent antennas exhibit constant electromagnetic properties along the frequency that is a scaled version of a radiating structure must exhibit the same characteristics like the original one, when fed with a signal whose wavelength is scaled by same factor. The radiating behaviour is expected to be independent of frequency. Self-complementary structure means the metal can be replaced by the dielectric and vice versa without changing the antenna structure. Multiple resonant antennas will be a combination of multiple, narrow band radiating element. Electrically small antennas are the antenna which is small in size. These antennas are equally bad in the frequency of operation because of their impedance mismatch. By giving a proper impedance transformation it can be made as UWB antennas, example hertizian dipole. Travelling wave antenna uses a travelling wave on a guided structure as the main radiating mechanism. Generally they are of two types. One is slow wave in which the guided wave is a slow wave and the second

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

one is the fast wave which uses fast wave as guided wave example Vivaldi Antenna. In this paper, a two arm, linearly polarized sinuous antenna is designed to work in the frequency range of 2.5 to 6GHz. The antenna should be designed in such a way that the VSWR should be less than or equal to 2 or return loss should be lea than -10dB. This means that, from overall input power, 89% is transferred and only 10% is reflected back.
Sinuous Antenna is invented R H DuHamal in the year 1987. He designed sinuous having N identical arms extending outward and it consists of bends and curves. In the year 2008, Michael C. Buck studies both 2 arm planar sinuous and conical sinuous. He concluded that planar 2 arm sinuous required cavity backing in order to make the radiation patter unidirectional where as in the case of conical 2 arm sinuous, cavity backing is not required and has superior impedance matching. In 2010 SandeepPalreddy compared the improvement in return loss in the presence of a loaded cavity with an unloaded cavity. HosseinEmami, NiushaSarkhosh, Elias Roberto Lopez Lara, and Arnan Mitchell in 2012, designed a reconfigurable photonic feed sinuous antenna.

II.FREQUENCY INDEPENDENT SELF COMPLIMENTARY STRUCTURE

Sinuous is a frequency independent self-complimentary structure which is a derivative of Spiral Antenna. Compared to spiral, the advantages of sinuous are

A. It can give dual linear as well as dual circular polarization whereas spiral antenna can give only circular polarization
B. Gain of sinuous is more compared to spiral.
C. Low profile geometry
D. Flexible bandwidth

III.DESIGN PRINCIPLE

Sinuous antenna is a type of log periodic antenna, defined based on angles and growth rate or the expansion rate. Its arms are generated using the equation

$$\varphi(r) = (-1)^p \alpha_p \sin\left[\frac{\pi \ln\left(\frac{r}{R_p}\right)}{\ln(\tau_p)}\right]$$

Where r and φ are the polar coordinates,‘p’ is the total number of arms of the sinuous antenna,$\alpha_p$is the angle which includes the effective radiating length and is the rotation angle. The curve swings between $\varphi = \pm(\alpha + \quad)$. ‘r’ denotes the inner radius and Rp is the radius of the pth cell.$\tau_p$is the growth rate with which the arms of the antenna grows. Radius of each cell of the antenna is related to the radius of the previous cell by the equation

$$(\tau_p = R_{p+1}/R_p)$$

The growth rate should be always less than unity. As the growth rate tends to infinity, the curve will be a straight line. The value of α and are taken as 45 and 22.5 respectively. In order to design sinuous antenna, different tools like CST, AutoCAD and Antenna Magus can be used. As the equation of the curve is in polar coordinates, it should be converted to Cartesian coordinate if CST is used. Using Auto lisp program, the curve can be generated. Antenna Magus is the powerful tool in order to design complex structures like sinuous. The design can be then exported to CST for further optimization.

IV.ANTENNA FEED AND IMPEDANCE MATCHING

By Brooker- Babinet principle the impedance of sinuous antenna is almost equal to 60Π = 188.5Ω. Two aspects should be considered while designing the sinuous antenna. One is, antenna is a balanced structure and the coaxial cable which is used to feed is an unbalanced structure. Second one is the impedance matching. Antenna is of 188.5Ω and coaxial

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

cable is of 50Ω, an impedance matching should be provided. So in order to provide impedance matching as well as unbalance to balance transformation, a linearly tapered balun is used.

V.ABSORBING BACK CAVITY

A cavity backing is provided to the antenna in order to produce a unidirectional radiation pattern. The cavity is filled with an absorbing material which can absorb back radiation or the reflected wave. A ground plane is also provided to the back of the cavity. If the cavity is made much smaller than λ/4, then it will add up the back radiation to the front lob and as a result the gain is increased. But it won't work in the case of wide band antennas as it is frequency sensitive. Hence a loss cavity is designed to work in the wide range of frequencies. The cavity should be designed in such a way that the antenna substrate should rest on the top of the cavity.

VI.SIMULATION RESULTS

Antenna is designed on a substrate called RT Duroid 5870 whose dielectric constant is 2.1 and tan is .00012. Thickness of the substrate is taken as 60mil ie 1.016 mm. Antenna is optimized by varying parameters like α, and τ_p. In this paper, α is taken as 50 degree, as 22.5 and $\tau_p = 0.786$. A linearly tapered balun is designed in the defined range.It is made on the same material as that of antenna substrate. Then the balun is inserted to the centre of the antennaAntenna structure and their respective return loss is as shown in Fig 3 and Fig 4.

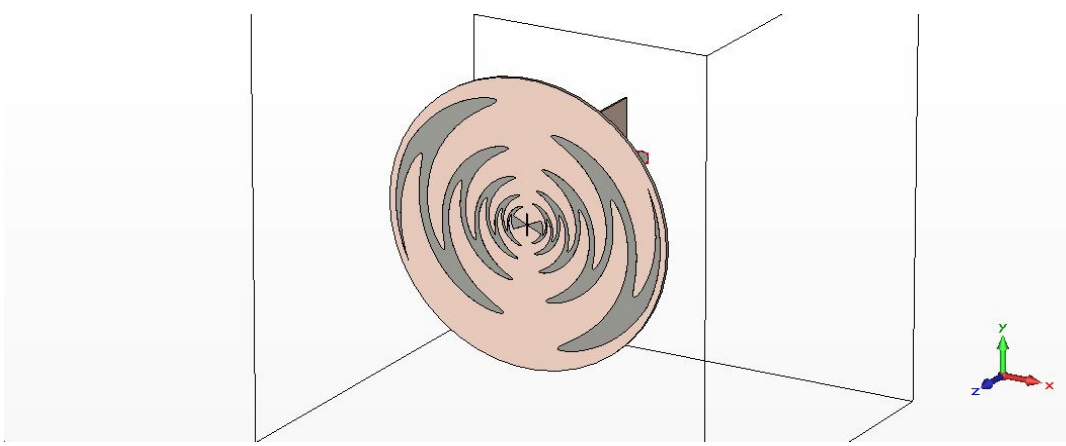

Fig 3. Antenna With linearly tapered Balun

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

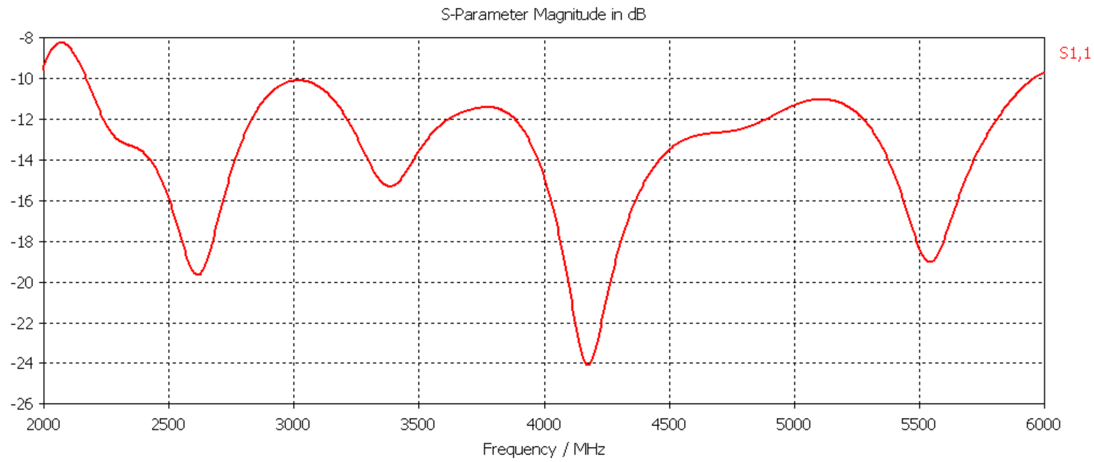

Fig 4. Optimized Return loss

The result shows a return loss of -10dB which means that from the total input power, only 11% is reflected and 89% is transferred

After optimizing the individual results, cavity backing is given to the antenna. The cavity is made up of metal with a thickness of 1mm. Then the cavity is filled with an absorbing material Eccosorb FGM- 40. It is a thin sheet type material. Fig 5 and 6 shows the perspective view and the side view of the antenna respectively.

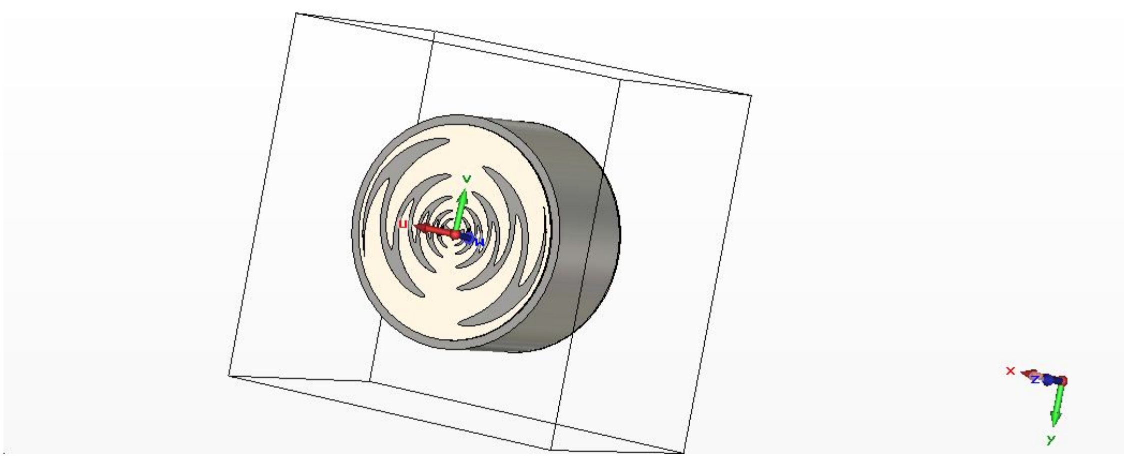

Fig 5. Perspective view

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

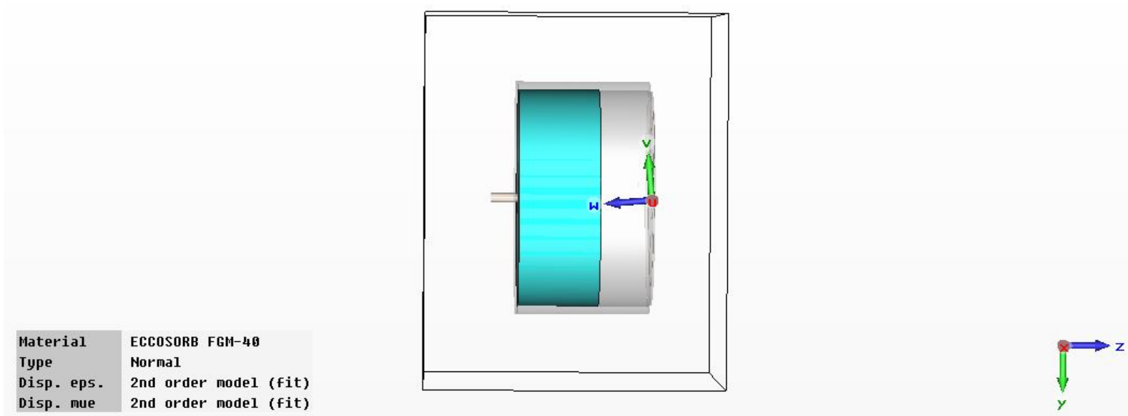

Fig 6. Side view of the cavity backed sinuous

The antenna is simulated and the return loss and unidirectional radiation pattern at high frequency is as shown below

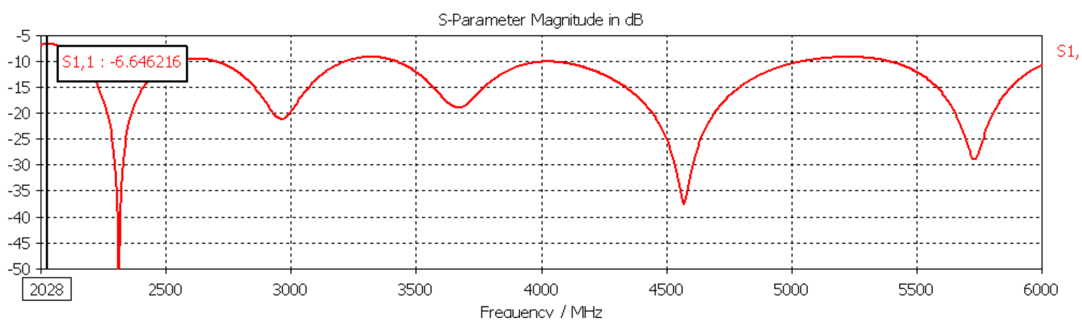

Fig 7. Return loss (with cavity backing)

The cavity backed sinuous is optimized by varying different parameters like thickness of the absorbing material, the metal thickness.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

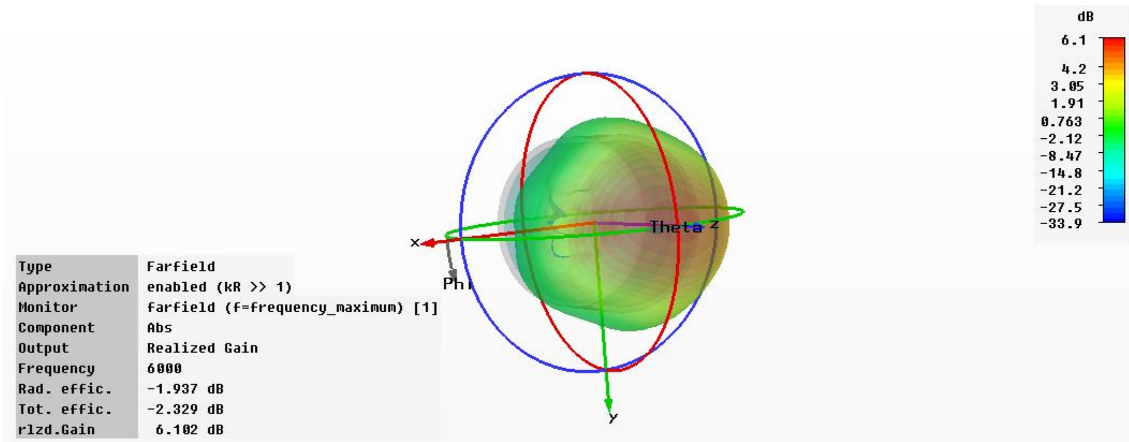

Fig 8. Radiation pattern at 6GHz

Finally a unidirectional radiation pattern is obtained with a realized gain of 6.102 dB at highest frequency of 6GHz.

VII.CONCLUSION

Sinuous Antenna is designed in the frequency range of 2.5 to 6GHz with an overall diameter of 80mm and thickness of 1.016mm is presented. The return loss is attained is 10dB at the entire frequency range. Still there is scope for optimization of the return loss by fine tuning of the balun. Comparisons of simulated and measured results are the future works.

REFERENCES

[1] A R Mahnad, "A tribute to a great inventor: Raymond H. DuHamel 1921-1993," IEEE Antennas Propagation Magazine, vol. 36, pp 54–56, June 1994

[2] Ehud Gazit, April 1988, IEE PROCEEDINGS, Vol. 135, Pt. H, No. 2, pp 89-92

[3] HosseinEmami, NiushaSarkhosh, Elias Roberto Lopez Lara, and Arnan Mitchell, Journal of Lightwave Technology, Vol. 30, NO. 16, August 15, 2012

[4] J. A. Kaiser, "The Archimedean Two-Wire Spiral Antenna," IRE Transactions on Antennas and, AP-8, May 1960, pp. 312-323.

[5] Johannes HendrikCloete and Thomas Sickel, "The planar dual-polarized cavity backed sinuous antenna a design summary" IEEE Transactions on Antenna Propagation, 2012, pp 1169-1172

[6] Li Ping, Yu Jia-ao. Research on printed Vivaldi antennas. JOURNAL OF XIDIAN UNIVERSITY. 2011, Vo1.38, No.2, pp.194-196.

[7] Michael C. Buck, IEEE Transactions on Antennas and Propagation, VOL. 56, NO. 5, MAY 2008, pp 1229-1235.

[8] M. N. Afsar, Y.Wang and R.Cheung, "Analysis and Measurement of a Broadband Spiral Antenna," IEE Antennas and Propagation Magazine, 46, 1, February 2004, pp. 59-64.

[9] Marc C.Greenberg," Performance Characteristics of the Dual Exponentially Tapered Slot Antenna (DETSA) for Wireless Communications Applications", IEEE Transactions on Vehicular Technology, VOL.52, N0.2, March 2003,pp.305-312.

[10] R H DuHamel, "Dual polarized sinuous antennas", US Patent 4658262, 14 April 1987,http://www.freepatentsonline.com/4658262.html.

[11] Sandeeppalreddy, Amir I. Zaghloul, Rudolf Cheung, "An Optimized Lossy Back Cavity Loaded Four Arm Sinuous Antenna", IEEE Trans. Antenna propagation, 2010

[12] S. Wang, X. D. Chen and C. G. Parini, in 2007, "Analysis Of Ultra Wideband Antipodal Vivaldi Antenna Design "IEEE Loughborough Antennas and Propagation Conference, pp 129-132

[13] T. H. Chio and D. H. Schaubert, "Parameter study and design of wide-band widescan dual-polarized tapered slot antenna arrays," IEEE Trans. Antennas Propagation., Vol. 48, pp. 879-886, 2000.

[14] Song Lizhong and Fang Qingyuan, in 2011," Design and Measurement of a Kind of Dual Polarized Vivaldi Antenna", IEEE Cross Strait Quad-Regional Radio Science and Wireless Technology Conference, July 2012, pp 494-497.

[15] XiaodongZhuge and Alexander Yarovoy, Design of Low Profile Antipodal Vivaldi Antenna for Ultra-Wideband Near-Field Imaging, May 2008

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

BIOGRAPHY

MeeraS, received her B.Tech in Electronics and Communication Engineering from SCMS School of Engineering and Technology, Cochin Kerala, in 2010. She is currently doing her M.Tech in Wireless Technology from Toc H Institute of Science and Technology, Cochin Kerala. Her research interest includes RF and Designing of UltraWideband Antennas.

A K Prakash,received his B.Tech in Electronics and Communication from IIT Madras and M.tech from IIT Mumbai. He is currently associated with Toc H Institute of Science And Technology. His research interest includes Radar , Sonar and communication systems.