International Journal Of
Recent Scientific Research
ISSN: 0976-3031
Volume: 7(3) March -2016

LOG-PERIODIC WANING CRESCENT PATCH ANTENNA FOR X-BAND APPLICATIONS

Ribhu Abhusan P and Debasis Mishra

THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 7, Issue, 3, pp. 9483-9487, March, 2016

International Journal of Recent Scientific Research

RESEARCH ARTICLE

LOG-PERIODIC WANING CRESCENT PATCH ANTENNA FOR X-BAND APPLICATIONS

Ribhu Abhusan P* and Debasis Mishra

Department of Electronics and Telecommunication Engineering, Veer Surendra Sai University of Technology, Burla, Sambalpur, Odisha, India

ARTICLE INFO

Article History:

Received 05th December, 2015
Received in revised form 08th January, 2016
Accepted 10th February, 2016
Published online 28st March, 2016

Keywords:

CST, Frequency Scaling, Log-Periodic, Rotman Lens, Waning Crescent,X-band

ABSTRACT

In this paper the circular patch structure is modified in accordance to the Rotman Lens to operate in the X-band whose frequency range is defined by the IEEE as 8 GHz to 12 GHz. The antenna is designed on a FR4 epoxy substrate having a relative permittivity of 4.4 and then patch structure is found out using MATLAB program. To operate all over the frequency range of X-band the log periodic implementation of the antenna is done by the frequency scaling method .All the simulation work is carried out by the CST software. The return loss, VSWR, directivity and gain of the proposed antenna are analyzed from the simulation results.

INTRODUCTION

Many applications in current age have been developed to exploit the advantages of small size and wide band. A Beam forming lens antenna on a high resistive silicon wafer was developed for 60GHz WPAN taking the Rotman Lens structure into account [1]. The lens structure has two arc, one is circular and another one modified as elliptical in order to reduce aberration [2]. In this paper both the arc are taken as circular and the maximum distance between the two arc is taken as the value of half the wavelength which corresponds to the design frequency 10GHz which is in the range of 8GHz to 12 GHz corresponds to the X-Band. Combination of multiple patch as a log periodic array will give a wide band radiation from a low profile antenna structure [3]. In this papers the log periodic implementation of waning crescent patch antenna is done as to operate over a wideband which includes the X-band Frequency range.

Mathematical formulation of patch geometry

The actual lens geometry parameters depend upon the positions of the beam ports, receiving ports and the transmission line lengths. The design of the lens is governed by the Rotman-Turner design equations that are based on the geometry of the lens, shown in Fig 1[4] The left contour of the lens is a circular are. Based on Gent's equations for optical path length equality the co-ordinates of the points of positions of the antenna ports on right inner ' array curve' are derived with respect to three perfect focal points (G, F1 and F2)[4] . The lower case letters represent their upper case variable normalized to the focal length F and w is the phase delay in wavelengths between the antenna port on inner lens contour∑1 and antenna on outer contour∑2. Some of the predefining parameters of the Rotman lens are the internal scan angle a, focal length F, distance of on axis focal length from origin G.From Fig.1 the two symmetrical off-axis focal points F1 and F2 have coordinates (-Fcos α, Fsin α), (-Fcos α, -Fsin α) and on-axis focal point G has (-G,0) relative to point O_1 All parameters of Rotman lens are defined as n=N/F, w=(W-W_0)/f, x=X/F, y=Y/F, g=G/F, a_0= cos α, b_0=sin α.[4]

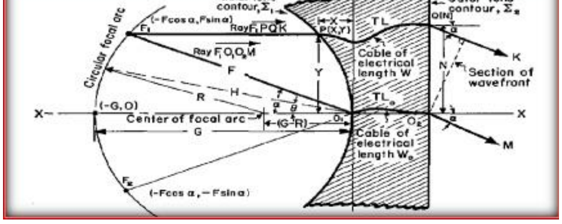

Fig 1 Geometry of a Rotman Lens[4]

Corresponding author:* **Ribhu Abhusan P
Department of Electronics and Telecommunication Engineering, Veer Surendra Sai University of Technology, Burla, Sambalpur, Odisha, India

Final design equations of the array curve of the lens can be summarized as

$y = \eta(1-w)$ ……………………………………..(1)

$x^2+y^2+2a_0x=w^2+b^2_0\,\eta^2-2w$ …………………...(2)

$x^2+y^2+2gx=w^2-2gw$ …………………………(3)

To determine the value of 'w' we can solve the quadratic equation as

$aw^2+bw+c = 0$ ………………………………… (4)

The equation 3 can be modified as the centre of circle having centre at '-g' and radius 'g + w' .The intersection of such two circles leads to a biconvex lens structure. The maximum distance between two sides of the lens is taken as the value half of the wavelength which corresponds to the frequency 10 GHz which is taken for the design and which lies in 'X' band. The layout of the shape was determined using MATLAB. The shape resembles the structure of the moon in the lunar cycle where the moon is illuminated less than its half. It is called as "Waning Crescent".The word "crescent" refers to the phases where the moon is less than half illuminated and waning means decreasing .[12]

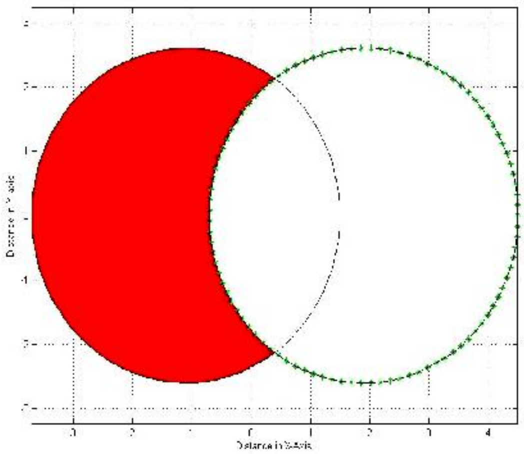

Fig 2(a) The layout of the shape using MATLAB**Fig 2(b)** Waning Crescent Moon[12]

Design of single waning crescent patch antenna

The shadowed region of the layout of the shape using MATLAB is the patch having maximum distance between two arcs is half of the wavelength corresponds to the desired frequency 10GHz.Most of the electromagnetic waves in microstrip line propagates within a substrate under quasi TEM mode. Because of the increased thickness spurious surface waves will be produced which will lead to significant losses [1]. Therefore thickness should be reduced. The cutoff frequency of the dominant mode is given by [5]

$f_t = \left(\frac{150}{h\pi}\right)\left[\frac{\sqrt{2}}{\sqrt{\epsilon r-1}}\right]\tan^{-1}\epsilon r$ ………………..(5)

Where f_t is the cut off frequency, 'h' is the height of the substrate and Єris the relative permittivity of the substrate which is 4.4 for FR4 Epoxy.The values for the parameters are shown in the following table.

Table I

Design Parameters	Value
Design frequency f	10GHz
Wavelength λ	30 mm
Length of the substrate	60 mm
Width of the substrate	60 mm
Height of the substrate	2.83 mm
Maximum distance between two arc of the patch λ/2	15 mm

The design and simulation is done using Computer Simulation Technology CST software.

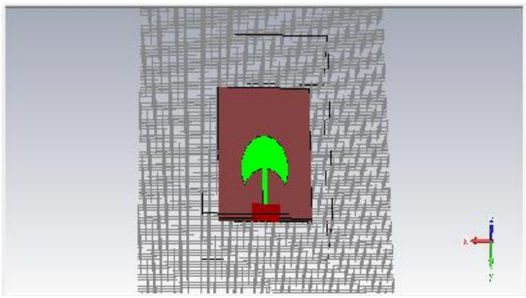

Fig 3 Perturbed Circular Patch Antenna using CST

After the design the parameters like S-Parameter which gives the return loss, VSWR, Gain and Directivity of the proposed antenna are found out using CST software. The results are shown in figures below. The frequency range has given from 7GHz to 14GHz in which the results of the X-band frequency range (8GHz to 12GHz) are analysed.

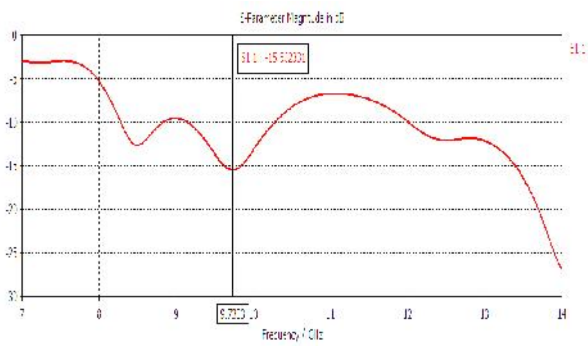

Fig 4 S_{11}-Parameter in dB

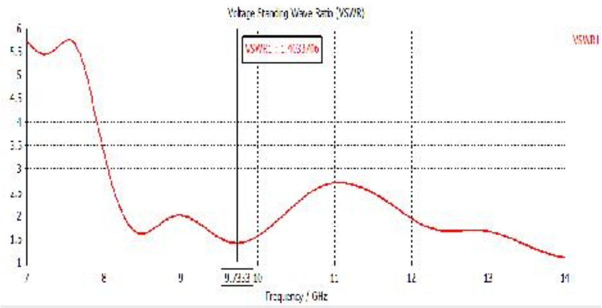

Fig 5 VSWR (Voltage Standing Wave Ratio)

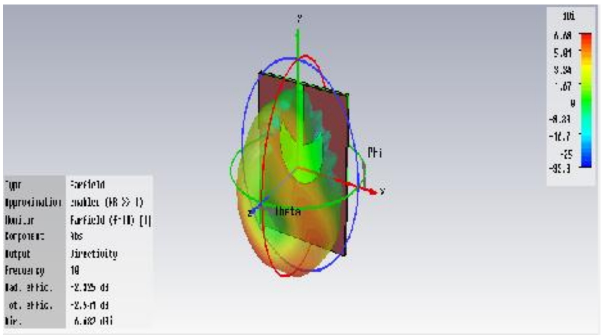

Fig 6 3D Far field radiation pattern

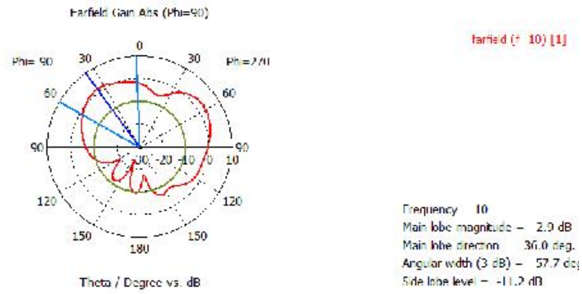

Fig 7 Gain at Phi=90^0

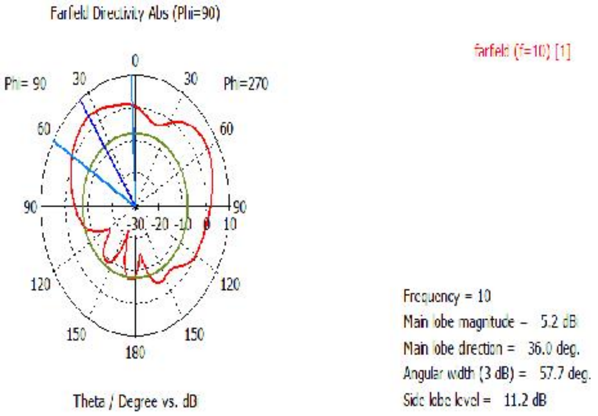

Fig 8 Directivity at Phi=90^0

Design of 4 element log-periodic waning crescent patch antenna

In log periodic antennas the electrical property varies periodically with logarithm of frequency [6] and the frequency scaling property leads to the determination of the dimensions. Here the 4 element log periodic antenna has been designed to operate in the X band (8GHz to 12GHz) entirely. The patch length and width are dependent upon the scaling factor "τ" [7].

$\tau = L_{n+1}/L_n = W_{n+1}/W_n$ ………………………… (6)

Where "L" indicates the length of the patch and "W" indicates the width and 'n' indicates the no of element.

In log periodic antenna array the frequencies are logarithmically periodic. [8] So

$\tau = f_{n+1}/f_n = \lambda_n/\lambda_{n+1}$ ……………………………. (7)

Where "f" indicates the frequency of the patch and "λ" indicates the wavelength of the corresponding frequency.

The maximum distance between two arcs of the perturbed circular patch was taken as λ/2.At the design frequency the half-wavelength λ/2 is 15 mm .If the value of τ nearly equal to 1 then the antenna frequency will reach continuous variation [9]. So the τ value is taken as 1.1 For the design of biconvex patch the λ is taken as the maximum distance between two sides of the patch so considering the scaling factor τ , the values of $\lambda_2/2$,λ3/2and $\lambda_4/2$are calculated for the 2^{nd},3^{rd} and 4^{th} element respectively. The values of $\lambda_2/2$,$\lambda_3/2$and $\lambda_4/2$are found out to be 16.5 mm and 18.15 mm and 19.965 mm respectively. Then the design and simulation has been done using CST. The frequency range has given from 7GHz to 14GHz in which the results of the X-band frequency range (8GHz to 12GHz) are analysed.

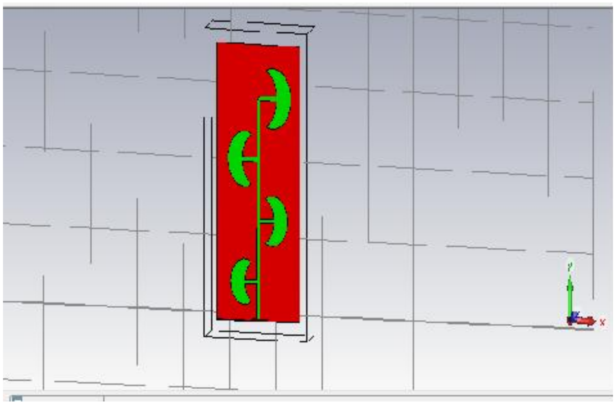

Fig 9 Log-Periodic Perturbed Circular Patch Antenna using CST

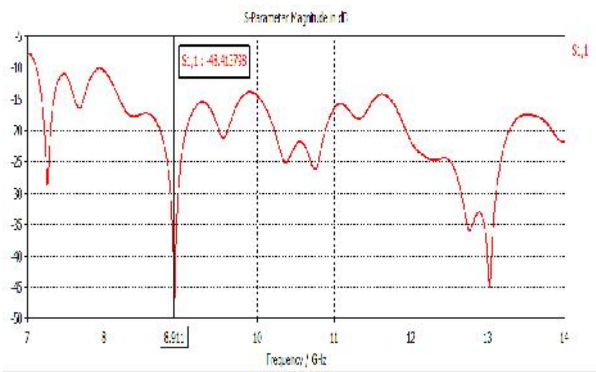

Fig 10 S $_{11}$ Parameterin dB of Log-Periodic Perturbed Circular Patch Antenna

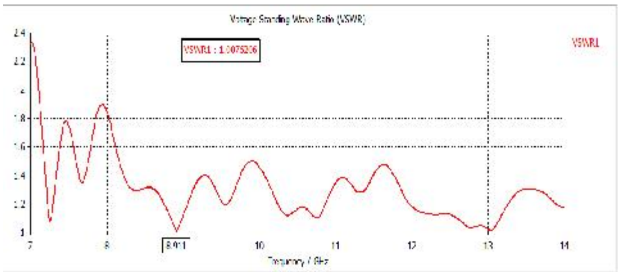

Fig 11 VSWR of Log-Periodic Perturbed Circular Patch Antenna

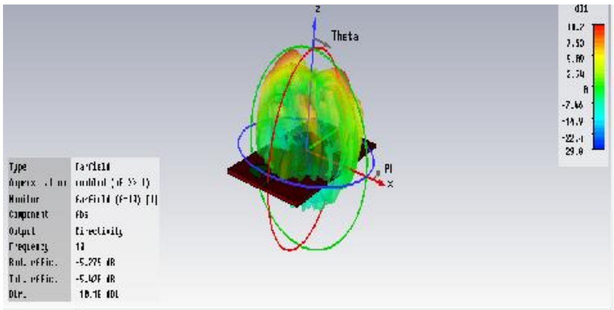

Fig 12 3D Far field radiation pattern of Log- Periodic Perturbed Circular Patch Antenna

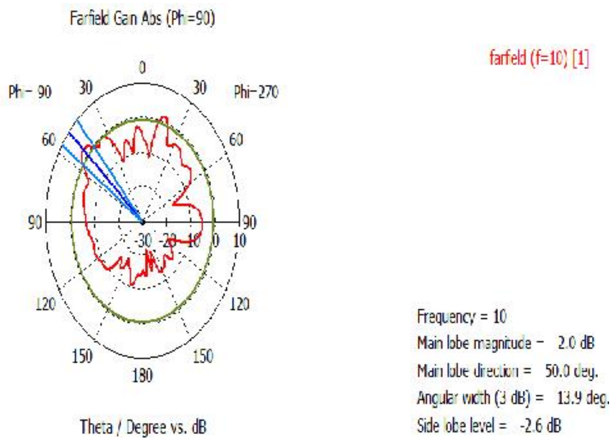

Fig 13 Gain at Phi=90^0 of Log- Periodic Perturbed Circular Patch Antenna

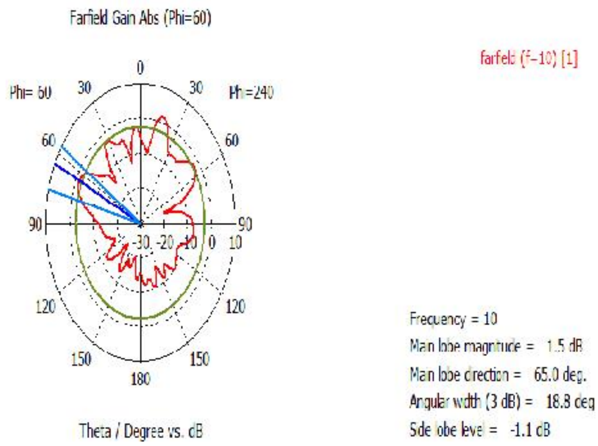

Fig 14 Gain at Phi=60^0 of Log- Periodic Perturbed Circular Patch Antenna

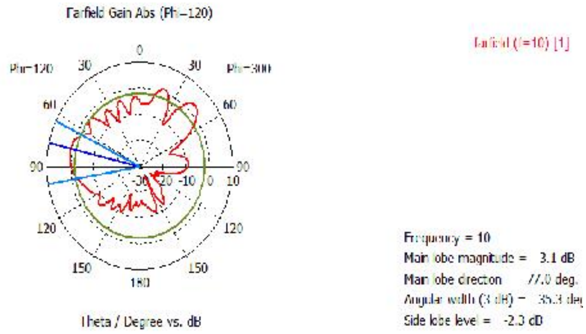

Fig 15 Gain at Phi=60^0 of Log- Periodic Perturbed Circular Patch Antenna

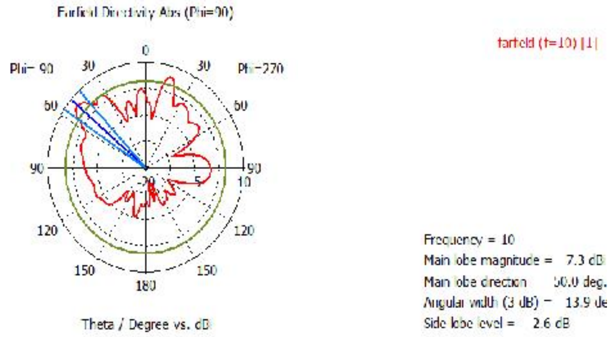

Fig 16 Directivity at Phi=90^0 of Log- Periodic Perturbed Circular Patch Antenna

Comparison of results

From the simulated results of both single element perturbed circular patch antenna and the 4 element log periodic perturbed patch antenna it is clearly observed that the log periodic structure has more bandwidth compared to the single element structure .Taking the -10 dB line as reference in S_{11} plot it is determined that the single element structure has a 2 bands between 8 GHz to 12 GHz and the very narrow bandwidth of those two bands are 1.16 GHz and 0.561 GHz .Whereas the Log periodic structure has a much wider bandwidth covering from 8 GHz to 12 GHz entirely. Also the antenna is resonating at 8.91 GHz which is in the desired range having a VSWR of 1.0076 which is nearly equal to 1 leading to a very nice result as VSWR equal to 1 corresponds to reflection coefficient 0 [10] which means no reflection .The comparison table is given below.

Table II

Parameters	Single element Perturbed Circular Patch Antenna	Log Periodic Perturbed Circular Patch Antenna
S_{11}	-15.505	-48.414
VSWR	1.4032	1.0076
Directivity	6.682 dB	10.18dB
Gain	4.356dB	4.901dB

The comparison plots of S_{11} is shown below

Fig 17 Compared Plots of S_{11} between single element and log periodic perturbed patch antenna

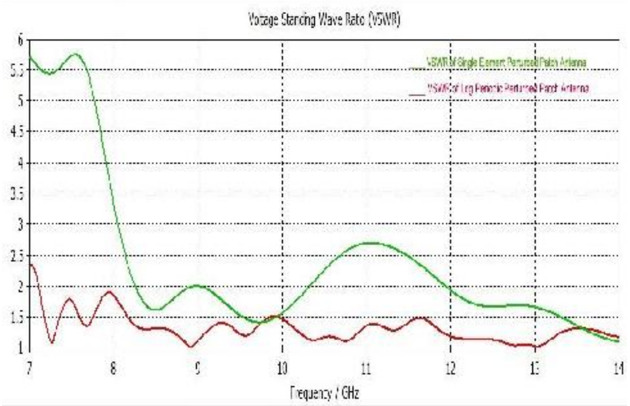

Fig 18 Compared Plots of VSWR between single element and log periodic perturbed patch antenna

CONCLUSION

From the results it is observed that for X-Band applications such as radar, terrestrial communication and networking, space communication and amateur radio [11] the log periodic implementation of perturbed circular patch antenna is best suited as it has a broadband property and covering the entire band from 8 GHz to 12 GHz having a desirable value of return loss and VSWR with high directivity.

References

1. W.Lee, J.Kim, C.S.Cho and Y.J.Yoon "Beam Forming Lens Antenna on a high resistive silicon wafer for 60GHz WPAN," IEEE Transaction Antenna Propagation., vol. 58, Mar. 2010. 706–713
2. Nelson Fonseca , "An improved design method for two dimensional Rotman Lens with reduced phase aberrations." Antennas and Propagation Society International Symposium (APSURSI), IEEE,7-13 July,1162-1167
3. Peter S. Hall "New wideband microstrip antenna using log periodic technique." IEEE Electronics Letters, vol 16, issue 4,Feb 14, 1980, 127-128
4. W.Rotman and R.Turner, "Wide angle microwave lens for line source applications.", IEEE transaction, Antenna Propagation, 1963, 623-632
5. K. C. Gupta, R. Garg, I. Bahl, and P. Bhartia, *Microstrip Lines and Slotlines*. (Norwood, MA: Artech House 1996), chapter. 2.
6. C.A.Balanis, *Antenna Theory :Analysis and Design* ,(3rd edn., Wiley, New York , 2005)
7. M.K.A.Rahim , "Active Log Periodic Antenna", Jurnal Teknologi , vol. 46 (D) , June 2007,17-34
8. R.K.Mishra , "Transmission line model for Log Periodic microstrip antenna" ,IEEE Antennas and Propagation Socity International Symposium (APSURSI), July 2013,68-169.
9. Zhen Yu, Xiaoying Ran and Jianguo Yu , "Design of a Broadband Planar Equiangular LPDA", Fourth International Conference on Communication systems and Networks (CSNT), April 2014,41-44 .
10. www.rfcafe.com
11. www.wikipidia.com
12. www.moonconnection.com

****

How to cite this article:

Ribhu Abhusan Panda and Debasis Mishra., Log-Periodic Waning Crescent Patch Antenna For X-Band Applications. *Int J Recent Sci Res.* 7(3), pp. 9483-9487.

ISSN 0976-3031

9 770976 303009 >