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Design of Logarithmic periodical Di-electric Resonator Array for Wide Band Implementations

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Abstract: ***In this publication, L.P.D.R.A is fabricated in logarithmic periodical fashion employing Teflon based di-electric material for 3,5,7 elements. These L.P.D.R.A resonators are gratified with source employing micro strip feed line technique to accomplish better coupling between elements and feed line. H.F.S.S tool is used to resolve the return-loss and gain factor by simulating L.P.D.R.A elements. L.P.D.R.A Fabricated with 7elements furnishes better return-loss of -40db at 13.54GHz and at gain factor of 5.83db at 15.4Ghz.***

Index Terms: Di-electric Resonator Antenna (D.R.A), Logarithmic periodical D.R.A, Micro strip Line Feeding, Broadband Implementations.

I. INTRODUCTION

As an ultimatum, high speeds data transmission in communication systems like wireless products including mobiles and services comprising wireless LAN, Bluetooth etc. These devices are mostly portable and run on batteries which tend to go down once the charge is empty. That indicates the components in these devices should be minute in size and simultaneously consume the lease possible power [1]. In par with these equipment a few wireless accessories are required to support numerous wireless fixtures and very high data rate. As an antenna is the critical part of any wireless device, the expansion of highly efficient, low-contour, small-size, poly-band and wide band probes that can be modified to form wireless products are very much necessitated. During the last decades, two classes of antennas have been extensively investigated. They are the micro strip spot antenna patch and the di-electric resonator antenna (D.R.A)[1]. In this suggested Aerial Antenna Design of Logarithmic periodical Deictic Resonant Aerial Antenna is used for High Frequency rate Broad band implementations [8].H.F.S.S software has been used to investigate the performance such as Return-loss, Enhance Gain and V.S.W.R. The design Methodology of the D.R.A employing Logarithmic periodical Structures Discussed in Detail and the outcome of the Suggested aerial Antenna are Presented in this publication[3]. Rectangular D.R.A can be fabricated with greater flexibility over other structures .L.P.D.R.A aerial Antenna can play Important role in Modern Satellite Communication and Radar technology Di-electric Resonator Aerial Antennas (D.R.As) possess some peculiar properties which render them very promising, especially for millimeter wave implementations. D.R.As can be fabricated with different shapes to accommodate various design requirements [4]. Rectangular D.R.As can be fabricated with greater flexibility since two of the three of its dimensions can be varied independently for a fixed resonant frequency rate and known di-electric constant of the material [5]. In case of rectangular D.R.A, the availability of one degree of freedom more than cylindrical and spherical D.R.As can be used to control the bandwidth of the aerial Antenna. The design of Logarithmic periodical Di-electric Resonator Aerial Antenna. (L.P.D.R.A) is suggested here for elevated frequency rate (H.F) broadband implementations H.F.S.S software has been used to investigate the performances such as return-loss, radiation configurations, V.S.W.R and advancement of the fabricated aerial Antenna and the comprehensive outcomes of the suggested aerial Antenna are presented in this publication[8]. This suggested logarithmic-periodical di-electric resonator array assortment (L.P.D.R.A) aerial Antenna can play an important role in the modern satellite communication and radar technology[6].

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II. THEORY/CALCULATION

The encouraging evolution in high speed information transfer at elevated frequencies upsurges the necessity of flexible satellite communication systems. In modern satellite communication systems for IEEE Radar band implementations, multi resonant wide frequency rate operation is highly desirable, which require small and light weight aerial Antenna with less metallic losses and broadband facilities. The use of multi single frequency rate resonant aerial Antennas can be avoided by employing a single D.R.A array assortment which can support a wideband.

A three, five, seven elemental Logarithmic periodical D.R.A array assortment is fabricated and fabricated. The elements of the P.D.R.A array assortment are arranged in a logarithmic periodical fashion. The suggested array assortment is excited by logarithmic periodical branched micro strip feed line which outcomes in a better coupling of energy between the elements and the feed line.

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This feed line technique enables a much more precise amplitude control for elevated frequency rate. The physical structure of the L.P.D.R.A array assortment aerial Antenna is repetitive, which outcomes in repetitive behavior in its electrical characteristics. The design of frequency rate independent array assortment consists of a basic geometric pattern that repeats, except with a different size pattern. In this array assortment design, seven different sized rectangular shaped resonators are arranged in a logarithmic periodical fashion. The di-electric resonator of rectangular cross-section offers a second degree of freedom making it a versatile and flexible D.R.A. The length (L), width (W), height (H) and spacing (S) of L.P.D.R.A element upsurges logarithmically from one end to other end. The schematic view of the L.P.D.R.A array assortment is illustrated as in Figure. The array assortment is excited by 50Ω branched micro strip line feeding which offers an advantage of cost effective and easy fabrication of aerial Antenna. In the resonant approach, the feed line is terminated in an open circuit, which creates a standing wave on the line where the voltage maxima or minima of each wave are located multiples of λg/2 from the open-circuit location. The guided wavelength λg can be approximated employing Equation where €r is the relative permittivity of the di-electric Resonator and λo is the free space wave length of vacuum.

For this L.P.D.R.A design, a di-electric resonator with relative permittivity ϵ_r=2.1 (Teflon) is used. Teflon based di-electric components are appropriate for D.R.A array assortment design. The di-electric resonators along with the feed line elements are mounted on one side of inexpensive FR4 substrate (250mm long by 130 mm wide with a thickness (h_s) of 1.6 mm). The substrate has a relative di-electric constant (ϵ_r) of 4.4 with a loss tangent (tan δ) of 0.001. A partially printed ground plane (195× 130) (L_g × W_g)) is designated in the form of layered sheets on the opposite side in order to enhance the ensured bandwidth with full ground plane. The value of this L.P.D.R.A array assortment design is chosen as 1.05. The value of σ can be obtained by employing Equations, where σ_i is the ideal value of relative spacing

$$\sigma_i = 0.258\tau - 0.066$$
$$0.05 \leq \sigma \leq \sigma_i$$

The design parameter αd, can be designated by

$$\alpha_d = \tan^{-1}\left[\frac{1-\tau}{4\sigma}\right]$$

The preferred bandwidth of the array assortment,

B_o is the ratio of the highest (f_H) to lowest (f_L) range of frequency rate illustrated by

$B_d = B_o B_r$

$B_d = B_o\, 1.1 + 7.7(1- T)^2 \cot\alpha$

Br is designated as the active region bandwidth of logarithmic periodical D.R.A.

The number of di-electric resonators (N_R) required to fabricate the logarithmic periodical D.R.A array assortment can be obtained implying

$$N_R = 1 + \left[\frac{\ln Bd}{\ln\frac{1}{\tau}}\right]$$

Among all the basic shaped (hemispherical, cylindrical, and rectangular) D.R.A, rectangular shaped D.R.A is more flexible as it is has only single degree of freedom compared to cylindrical shaped D.R.A and two degrees of freedom more than hemispherical D.R.A. The length (L) of the di-electric resonators and their spacing (S) are graduated to allow a constant ratio to each other. The design ratio is illustrated by τ.

$$\tau = \frac{Lm+1}{Lm} = \frac{Wm+1}{Wm} = \frac{Sm+1}{Sm}$$

If the dimension of the array assortment is multiplied by η, it scales into itself with element m become element m+1, element m+1 become element m+2 etc.. This self-scaling property implies that the array assortment will have the same radiating properties at all those frequencies which are related by a factor of η. The values of L, W and S will be scaled into logarithmic periodical elements.

k-β diagram and its analysis:

The basic geometry of logarithmic periodical aerial Antenna having infinite periodical structure is illustrated in Figure. The aerial Antenna consists of 'n' number of elements arranged side by side on a plane and forming a planar array assortment.

S= Spacing between two adjacent elements

Z0 =characteristic impedance

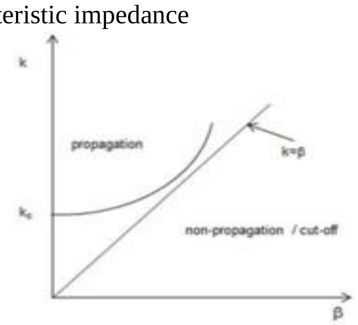

figure 1: 3 k-β diagram for an infinite periodic structure.

For the illustrated infinite logarithmic periodical structure the propagation constant is designated as

Y=∞+jß

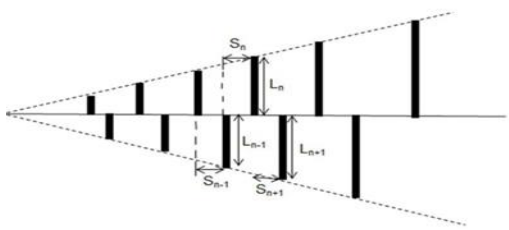

figure 2: Basic Geometry of Logarithmic periodical Aerial Antenna.

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∞ denotes attenuation constant (Np/m)
ß denote phase constant(rad/m)
we have,

$$Y=\sqrt{(R+jwL)(G+jwC)}$$

$$Z_o=\frac{R+jwL}{Y}=\frac{R+jwL}{G+jwC}$$

The equation designated above are the general elucidations which embrace variable loss effects, and thus the propagation constant and characteristic impedance were determined as complex quantity. During some practical cases, the loss in the periodic structures incurred is very small or meager, so it can be neglected. For a lossless case, the attenuation constant ∞ is zero.

So,R=G=0 in the illustrated equation.

$$Y=\alpha+j\beta=jw\sqrt{LC}$$

$$\beta=w\sqrt{LC}$$

which is a real and the propagation constant for a loss less periodic structural element becomes

$$Y=\beta$$

This equation is purely real. When ∞=0 and ß=0.6,this case corresponding to a non-attenuating, propagating wave on the periodic structure. In logarithmic periodical aerial Antenna array assortment, it is advantageous to plot the propagation constant ,ß versus the free space wave number ,k to study the propagation Characteristics features of a periodic structure. Such a graph is called as a k-ß diagram, Brillouin diagram.

Where ß= the propagation constant,
k= the free -space wave number,
for free space propagation

$$K=\beta=\frac{2\pi\pi}{c}$$

The Value of ß is greater than k upto certain frequency rate increased, the wave becomes fast i.e. ß becomes less than k(ß<k)

$$K=\sqrt{k^2c+\beta^2}$$

Where, Kc is the cutoff wave number of the mode The K-ß diagram can be plotted as illustrated as in Figure

III. RESULTS AND DISCUSSION

A branched micro strip line element fed L.P.D.R.A array assortment for Ku set of band has been fabricated and investigated. The outcomes of these three, five, seven elemental L.P.D.R.A array assortment are conferred in terms of bandwidth response, input impedance, radiation pattern, gain and propagation characteristics. The simulation explorations for the recommended L.P.D.R.A array assortment have been conducted by employing H.F.S.S.

The impedance bandwidth of the L.P.D.R.A from 10 - 18 GHz is the preferred beneficial frequency rate range for Ku set of band implementations. The gain, band-width, and radiation performance characteristics of D.R.A can be reformed by employing a logarithmic periodical array assortment proactively modify the basic shaped D.R.A. element.

3.1 3 Elemental Logarithmic periodical D.R.A array assortment

3 Elemental Logarithmic periodical D.R.A array assortment design as illustrated as in figure

Table 1: 3-elemental L.P.D.R.A design

Element	Length		Width		Thickness
	D.R.A	Feed	D.R.A	Feed	
1	25.01	3.718	23.82	4	2.85714
2	26.2605	3.9039	25.011	4. 2	3
3	27.5735	4.099095	26.26155	4.41	3.15

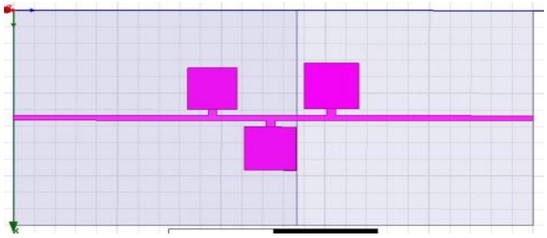

figure 3:Fabricated 3 element array assortment

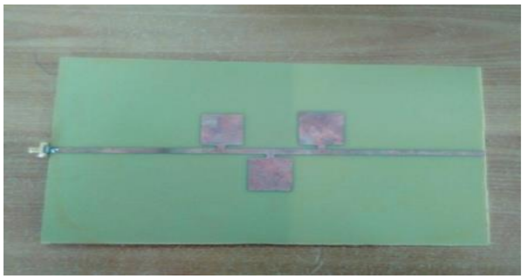

figure 4:Fabricated 3 element array assortment

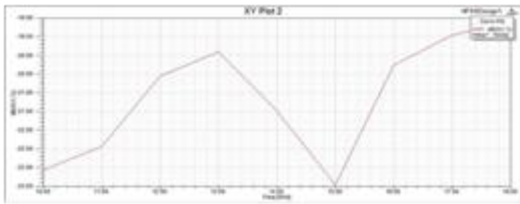

figure 5: Return-loss curve for 3 elemental L.P.D.R.A

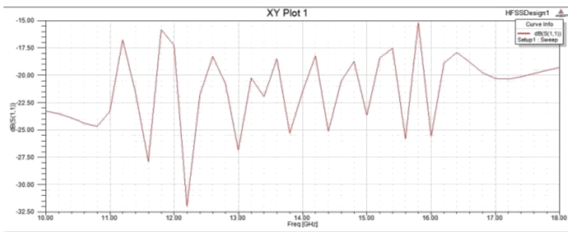

figure 6: Return-loss curve for 3 elemental LPA

As designated above the aerial Antenna has been fabricated for the frequency rateof 10 to 18GHz. Though the preferred return-loss is -10dB the aerial Antenna is DISPLAYING a return-loss greater than -10dB which is very advantageous. The D.R.A exhibited a return-loss of -23.5dB at 15GHz.

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Practical aerial Antenna Outcome

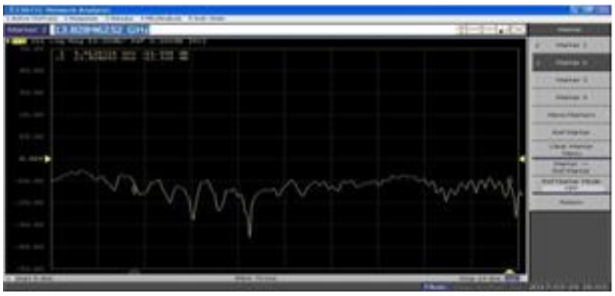

figure 7: Practical return-loss plot

As designated above the aerial Antenna has been fabricated for the frequency rate of 10 to 18GHz. Though the preferred return-loss is -10dB the aerial Antenna is displaying a return-loss greater than-10dB which is very advantageous. The L.P.A exhibited a return-loss of - 30dB at 12GHz.

Practical aerial Antenna outcomes:

The bandwidth obtained for practical aerial Antenna is about 8GHz which is similar to that of theoretically obtained outcome.

Practical return-loss plot

The 3D gain obtained for the D.R.A designated above is illustrated as in.

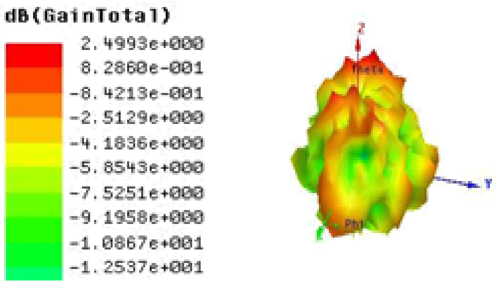

Figure 8: Gain plot for 3 elemental L.P.D.R.A

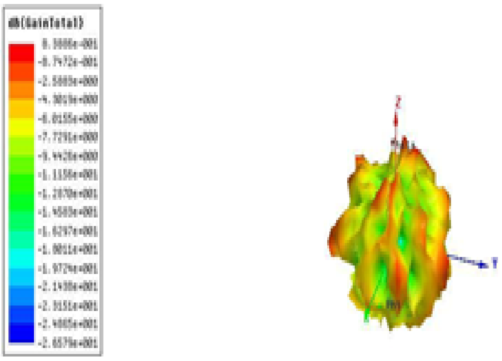

Figure 9:Gain plot for 3 elemental LPA

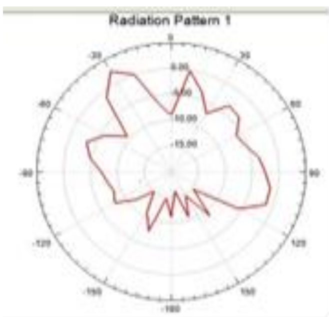

figure 10: Radiation pattern for 3 elemental L.P.D.R.A

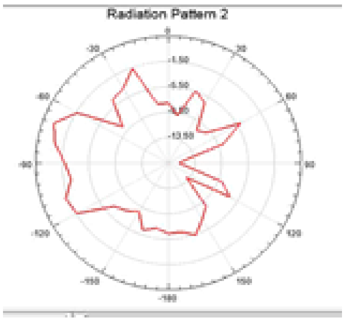

figure 11: Radiation pattern for 3 elemental LPA

3.25 elemental Logarithmic periodical D.R.A array assortment:

The dimensions like length of the D.R.A, length of feed, width of D.R.A, width of feed and the DR thickness in the H.F.S.S are illustrated as below,

Table 2:Dimensions of 5-elemental L.P.D.R.A design

Element	Length		Width		Thickness
	D.R.A	Feed	D.R.A	Feed	
1	25.01	3.718	23.82	4	2.721086
2	26.2605	3.9039	25.011	4. 2	2.85714
3	27.5735	4.099095	26.26155	4.41	3
4	28.95218	4.30405	27.51463	4.6305	3.15
5	30.39979	4.519252	28.95336	4.862025	3.3075

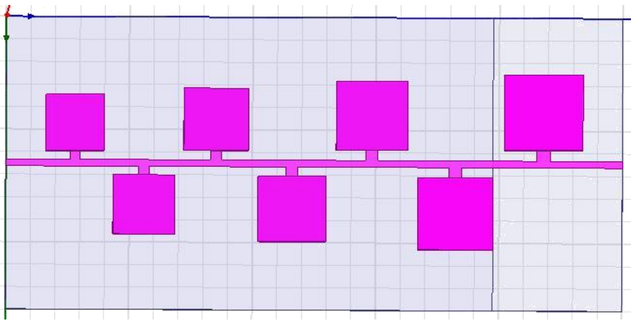

figure 12:5 element array assortment diagram

figure 13:fabricated 5 elemental L.P.D.R.A

return-losses of the 5 elemental L.P.D.R.A and L.P.A illustrated as in bellow figure from H.F.S.S

The Return-loss acquired for the D.R.A designated above is illustrated as in Figure As designated above the aerial Antenna has been fabricated for the frequency rateof 10 to 18GHz. Though the preferred return-loss is -10dB the aerial Antenna is presenting a return-loss greater than -10dB which is very advantageous. The D.R.A exhibited a return-loss of - 27dB at 15GHz.

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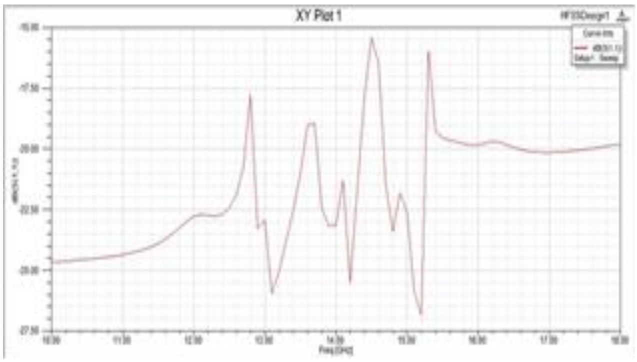

figure 14:Return-loss curve for 5 elemental L.P.D.R.A

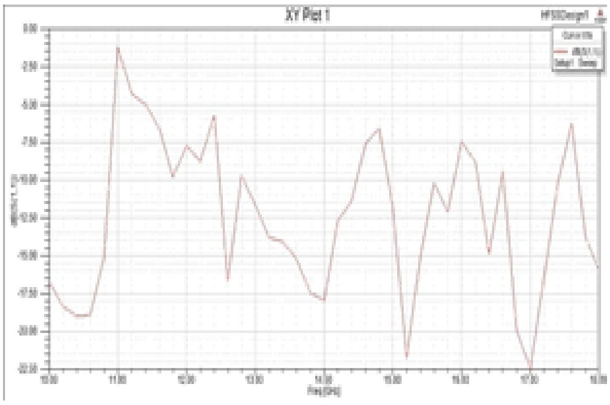

figure 15: Return-loss curve for 5 elemental LPA

The bandwidth obtained for practical ntenna is about 8GHz which is similar to that of theorically obtained outcome.

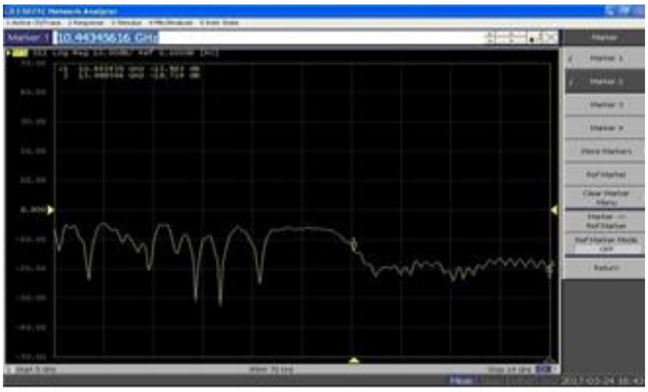

figure 16:practical return-loss es curve

The 3D gain obtained for the D.R.A designatedabove is illustrated as in Figure

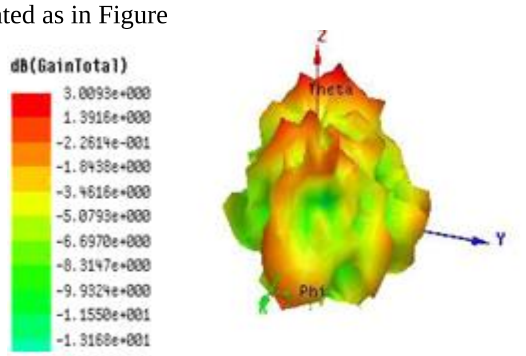

figure 17: Gain plot for 5 elemental L.P.D.R.A

The gain acquired for 5 elemental L.P.D.R.A is 3.009dB at 15GHz

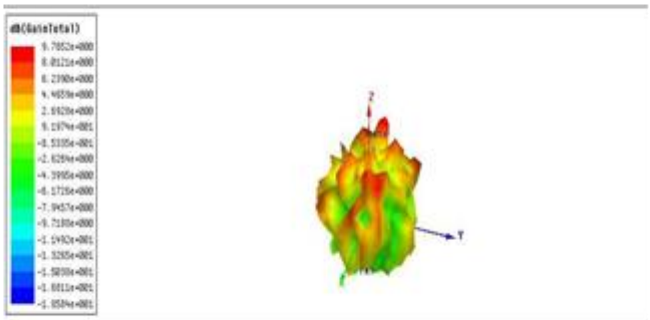

figure 18: Gain plot for 5 elemental LPA

L.L.P.A The achievement accomplished with 5 elemental gain accomplished for 5 elemental L.P.A is 9,7dB at 15GHz. The radiation pattern for 5 elemental L.P.D.R.A is illustrated as below

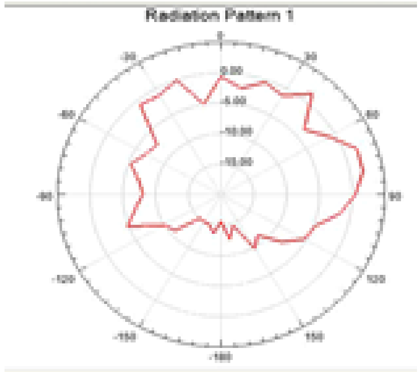

figure 19: Radiation pattern for 5 elemental L.P.D.R.A

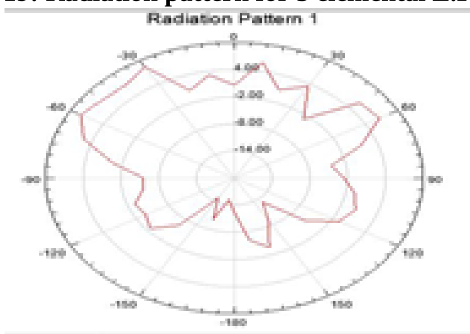

figure 20:Radiation pattern for 5 elemental LPA

3.3 7 elemental L.P.D.R.A

The dimensions like length of the D.R.A, length of feed, width of D.R.A, width of feed and the DR thickness in the H.F.S.S are illustrated as in figure

Table 3: Dimensions of 7-elemental L.P.D.R.A design

Element	Length		Width		Thickness
	D.R.A	Feed	D.R.A	Feed	
1	25.01	3.718	23.82	4	2.59151
2	26.2605	3.9039	25.011	4. 2	2.721086
3	27.5735	4.099095	26.26155	4.41	2.85714
4	28.95218	4.30405	27.51463	4.6305	3
5	30.39979	4.519252	28.95336	4.862025	3.15
6	31.91978	4.745215	30.40103	5.105126	3.3075
7	33.51577	4.982476	31.92108	5.360382	3.4728

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7 elemental L.P.D.R.A strcture as illustrated as in figure

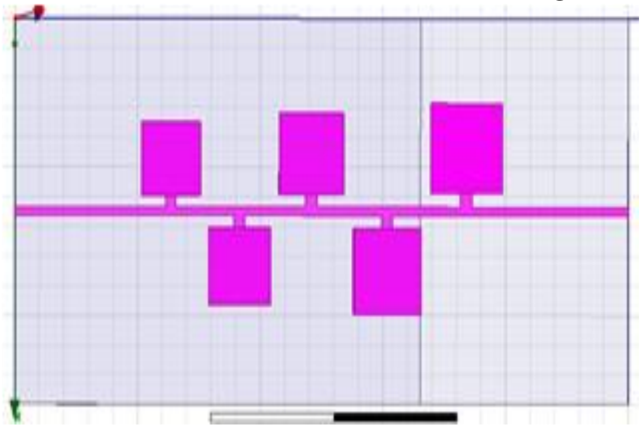

figure 21 :7 elemental L.P.DR

figure 22:fabricated 7 elemental LPA

As designated above the aerial Antenna has been fabricated for the frequency rate of 10 to 18GHz. Though the preferred return-loss is -10dB the aerial Antenna is DISPLAYING a return-loss greater than -10dB which is very advantageous. The D.R.A exhibited a return-loss of -40dB at 13.5GHz.

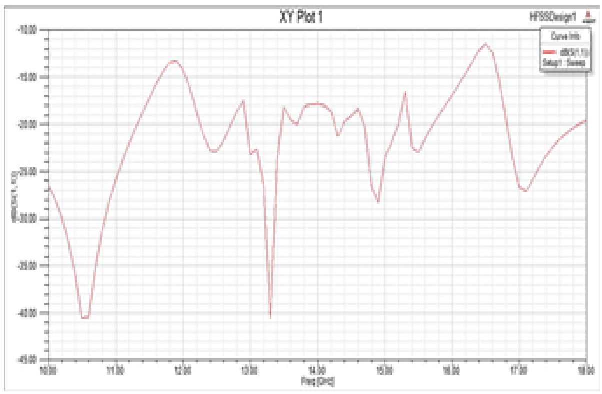

figure23: return-loss of the 7 elemental L.P.D.R.A

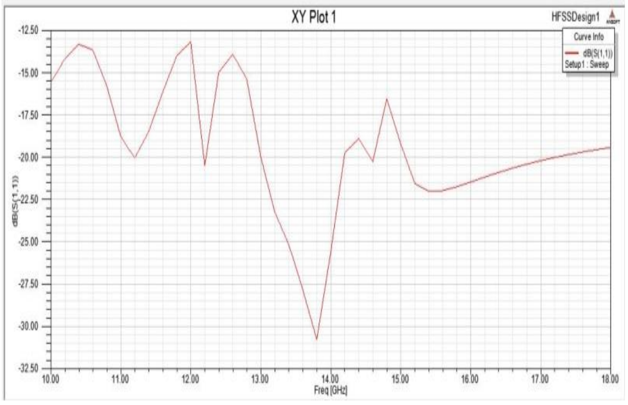

figure 24:return-loss of the 7 elemental LPA

suggested 7 elemental L.P.D.R.A practical return-loss

As designated above the aerial Antenna has been fabricated for the frequency rate of 10 to 18GHz. Though the presumed return-loss is -10dB the aerial Antenna is propagating a return-loss greater than -10dB which is very much advantageous. The D.R.A exhibited a return-loss of -30dB at 14GHz.

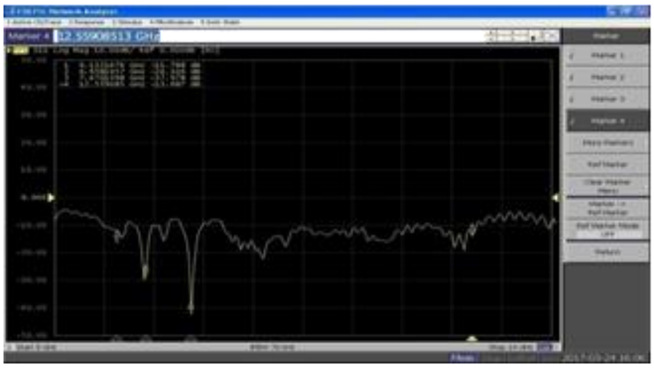

figure 25:practical return-loss es curve

The bandwidth accomplishedfor practical aerial Antenna is about 8GHz which is similar to that of theatrically accomplishedoutcome.

The 3D gain accomplishedfor the D.R.A designatedabove is illustrated as in Figure

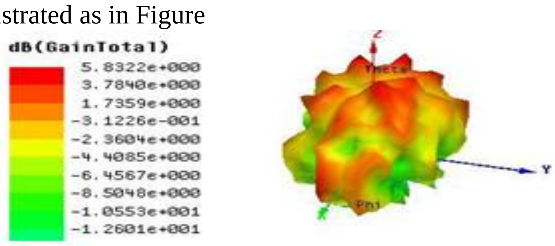

figure 26: Gain plot for 7 elemental L.P.D.R.A

The gain accomplishedfor 7 elemental L.P.D.R.A is 5.83dB at 15GHz.

The 3D gain accomplishedfor the L.P.A designatedabove is illustrated as in Figure

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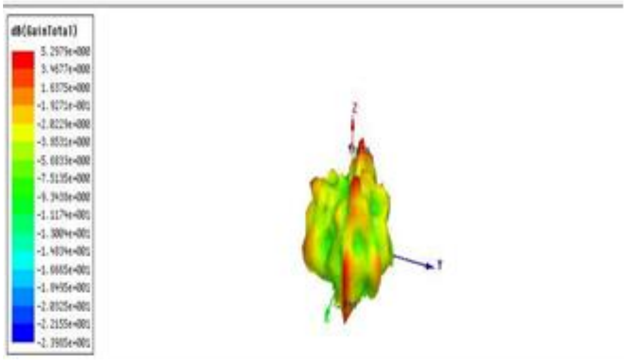

figure 27: Gain plot for 7 elemental LPA

The gain accomplishedfor 7 elemental L.P.A is 5.29dB at 15GHz

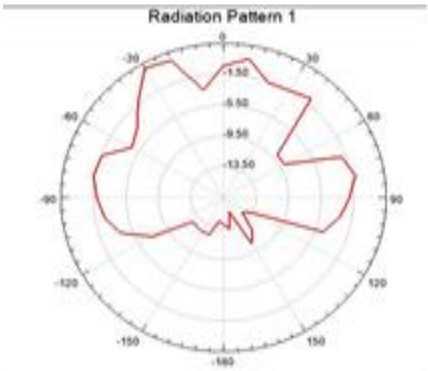

figure 28: Radiation pattern for 7 elemental L.P.D.R.A

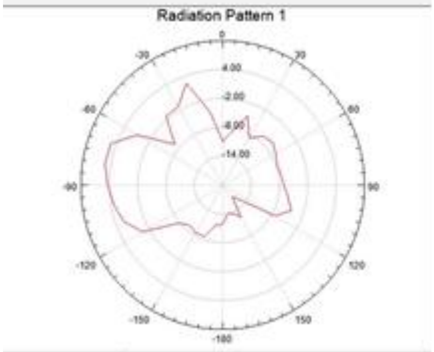

figure 29:Radiation pattern for 7 elemental LPA

From the outcomes above, it is clear that the bandwidth accomplishedfor L.P.D.R.A is more and efficient than that of LPA

Comparison of gain between different array assortment elements:

A seven elemental L.P.D.R.A array assortment compared to five elemental and three elemental L.P.D.R.A array assortment outcomes in a wide impedance bandwidth. A assessment in enactment of the array assortment in terms of bandwidth and gain on the grounds of the quantity of resonators is illustrated as in Table.

Table 4: Comparison of gain between different L.P.D.R.A's

No of elements	Gain		
	ε_{r1}=2.2	ε_{r2}=10.2	
3	1.2		2.4
5	1.8		3.04
7	3.62		5.35

IV. CONCLUSION

In this implementation, diversified shapes of di-electric resonator aerial Antennas are intended and fabricated for wide band frequencies. A single element square D.R.A is fabricated and this has illustrated as a return-loss of -30dB, gain of 8.3dB and bandwidth of 1.35GHz. E-shape asymmetric D.R.A is fabricated and this has illustrated as a return-loss of -41dB, gain of 4.7dB and bandwidth of 0.63MHz. E-shape symmetric D.R.A is fabricated and this has illustrateda return-loss of -24.9dB, gain of 7.14dB and bandwidth of 1.7GHz. P-shape D.R.A is fabricatedand this has illustrateda return-loss of -17.5dB, gain of 4.12dB and bandwidth of 3.93GHz. Stacked D.R.A is fabricatedand this has illustrateda return-loss of -29dB, gain of 4.6dB and bandwidth of 1.5GHz. Stair case D.R.A is fabricatedand this has illustrateda return-loss of -27dB, gain of 5.14dB.Apart from these single element D.R.As branched fed logarithmic periodical D.R.A's are also designed. A 3-elemental L.P.D.R.A is fabricatedand this has illustrateda return-loss of - 23.5dB, gain of 2.4dB. A 5-element D.R.A is fabricatedand this has illustrateda return-loss of -27dB, gain of 3dB. A 7-element D.R.A is fabricatedand this has illustrateda return-loss of -40dB, gain of 5.8dB. The bandwidth accomplishedform these D.R.A's is about 9-10GHz. In these L.P.D.R.As wide bandwidths are accomplishedbut the gain is less. By changing the scaling factor, the thickness of DRs will be increased and thereby gain can be enhanced.

REFERENCES

1. A.Petosa, "Di-electric Resonator Aerial Antenna Handbook", Artech House Publishers, 2007. R. K. Mongia and P. Bhartia, J. Microwave Millimeter-Wave Eng., pp. 230–247, Jul.
2. A.Petosa, A. Ittipiboon, and M. Cuhaci, ―Recent advances in di-electric resonator aerial Antenna technology‖, IEEE Aerial Antennas Propag. Mag., vol. 40, no. 3, Jun. 1998, pp. 35–48.
3. Chair, R., Kishk, A.A., and Lee, K.F., ―Wideband di-electric resonator aerial Antennas‖, IET Microw, Aerial Antennas Propag., 2007, 1, (2), pp .299 – 305.
4. Kishk A. A, Zhang X, Glisson A.W, and Kajfez D, ―Numerical analysis of, stacked di-electric resonator aerial Antenna excited by a coaxial probe for wideband implementations‖, IEEE Trans Aerial Antennas Propag., vol. 51, no. 8, Aug. 2003, pp. 1996–2005.
5. Cooper, M.: ―Investigation of current and novel rectangular di-electric resonator aerial Antennas for broadband implementations at L-ban‖. Master thesis, Department of Electronics, Carleton University, 1997.
6. Kishk, A.A., and Kajfez, D.: ―Broadband stacked di-electric resonator aerial Antenna‖, Electron. Lett., 1989, 25, (18), pp. 1232 – 1233.
7. Runa Kumari, Santanu Kumar Behera, ―Investigation on Logarithmic periodical Di-electric Resonator Aerial Antenna Array assortment for Ku band Implementations‖, Taylor Francis,Electromag-netics, 34(1):19-33, 2014

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