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# Design and Performance Analysis of Printed Square Log Periodic Array Microstrip Patch Antenna at 2.5 and 3.5 GHz

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***ABSTRACT***
*This Article defined the design, simulation, edifice and study of inset feed seven elements log periodic microstrip antenna at 2.5-3.5 GHz with the help of Agilent (ADS2009) and Tiny Cad. The antennas were etched/printed on a PCB board using iron on glossy method laser printer and $FeCl_3$, modeled using microstrip lines, the S and 3D parameters data for both shapes were obtained. The data is extracted from the momentum simulation was compared with the measured parameters which were obtained through measurements and simulation. The properties of the square log periodic printed microstrip antennas such as return loss, gain, efficiency, power radiated, cross polarization and the beam width have been investigated and compared. A Square log periodic gain of 3.47dB along with the directivity of 6.99dB, efficiency of 0.74% and resonant frequency of 2.75GHz.*

## INTRODUCTION

Printed Microstrip antenna are largely used in several applications as they show a very little profile, smaller size, light weight, little cost and easy method of fabrication and installation. Though, a restriction of microstrip antenna is the fine bandwidth of the basic element. The bandwidth of a basic patch element is typically 1-3%. The bandwidth of the antenna is well-defined [Enoh, 2014] as the range of frequencies, above which the performance of the antenna with admiration to certain features imitates to a particular standard. The bandwidth of the antenna rest on the patch form, resonant frequency, dielectric constant and the depth of the substrate.

Band-width of the antenna can be increased by reducing the substrate permittivity (Ɛr) or increasing its thickness (h). However, there are two problems associated with increasing the substrate thickness. One of the problems is the radiation and reactance associated with the feed junction.as given by [4]. The second problem is an upsurge in surface wave effects [3] in order to evade the complications, a number of dissimilar approaches have been examined to recover the bandwidth of the microstrip antenna.[10-14]

Dissimilar methods to improve the bandwidth of microstrip antenna have been examined. Most of the effort done for bandwidth improvement has been focused towards refining the impedance bandwidth of the antenna component. The bandwidth can be amplified by means of multilayer substrate structure antenna, parasitic elements [5,8,9], non-contact feeding procedure, diverse shapes slot [6] ort log periodic procedure by [7] and Rahim, *et al*, 2004], which we applied in this study.

## DESIGN OF LPA

The scheme principle for log periodic needs scaling of the magnitudes from period so that performance is periodic with the logarithm of frequency. This principle can be practical to a display of patch antennas. The patch length (L), the width (W) and the inset (I) are related to the scale factor τ by (Ogherohwo, *et al.* 2014).[1,2]

$$\tau = \frac{L_{m+1}}{L_m} = \frac{W_{m+1}}{W_m} = \frac{I_{m+1}}{I_m} \quad (1)$$

If we multiply all magnitudes of the array by τ its scales into itself with element m becoming element m+1 element m+1 becoming element m+2 etc. This self-scaling asset suggests that the array will have the similar radiating assets at all frequencies that are associated by a factor of τ. A single element of rectangular or square geometry as shown in Figure 1 can be designed for the lowest resonant frequency using transmission line model [4].

$$f = \frac{c}{2(L+2\Delta L)\sqrt{\varepsilon_{eff}}} \quad (2)$$

Where $c = 3\times10^8 m/s$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)}{(\varepsilon_{eff}-0.258)}\frac{(\frac{W}{h}+0.264)}{(\frac{W}{h}+0.8)} \quad (3)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\frac{1}{\left(1+12\frac{h}{W}\right)^{-\frac{1}{2}}} \quad (4)$$

For microstrip antennas the choice of the width of the patch radiator is very significant. Lesser values of (W) result in low antenna effectiveness while big (W) values lead to higher order modes. The optimal values of W are

$$W = \frac{\lambda_o}{2}\left(\frac{\varepsilon_r+1}{2}\right)^{-\frac{1}{2}} \quad (5)$$

The resonant input resistance can be calculated from

$$R_{in}(y=y_o) = \frac{1}{2(G_1 \pm G_{12}}\cos^2\left(\frac{\pi y_o}{L}\right) \quad (6)$$

$$G_1 = \frac{I_1}{120\pi^2}$$

$$I_1 = \int_o^{\pi}\left[\frac{\sin\left(\frac{k_o w}{2}\cos\theta\right)}{\cos\theta}\right]^2 \sin^3\theta \quad (7)$$

$$G_{12} = \frac{1}{120\pi^2}\int\left[\frac{\sin\left(\frac{k_o w}{2}\cos\theta\right)}{\cos\theta}\right]^2 j_o(k_o L\sin\theta)\sin^3\theta d\theta \quad (8)$$

$j_o$ = Bessel unction of the first kind order zero

The characteristic impedance of the line can be calculated from

$$Z_o = \left\{\frac{60}{\sqrt{\varepsilon_{eff}}}\ln\left[\frac{8h}{w_o}+\frac{w_o}{4h}\right]\right\} when \frac{w_o}{h} \le 1 \quad (9)$$

$$\left\{\frac{120\pi}{\sqrt{\varepsilon_{eff}}}\left[\frac{w_o}{h}+1.393+0.667\ln\left(\frac{w_o}{h}+1.444\right)\right]\right\} when \frac{w_o}{h} > 1 \quad (10)$$

The values of L, W and inset feed (*I*) *c*an be calculated using the above equations. This value will be scaled into log periodic element.

Calculation of the Square patch microstrip antenna is given in table 1. The substrate used is PCB with dielectric constant of 4.7 and thickness of 1. 06mm.The scaling factor τ =1.05. The loss tangent of the material is 0.019.

***Table 1:*** *Designed Parameters for Seven Elements Log Periodic Antenna.*

| Number of Element | L=W(Square Patch) | Im |
|---|---|---|
| *f1* | 35.54 | 15.50 |
| *f2* | 33.78 | 15.12 |
| *f3* | 32.31 | 14.24 |
| *f4* | 30.75 | 13.60 |
| *f5* | 29.23 | 13.00 |
| *f6* | 27.85 | 12.50 |
| *f7* | 26.52 | 12.12 |

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The circuit design was achieved using the Agilent software 2009(ADS) the plans were attained using the microstrip lines (MSUB, MLIN and MTEE) and the S parameters were simulated using the above stated parameters. Figure 3 show the diagram and the layout diagram for the Square patch antennas.

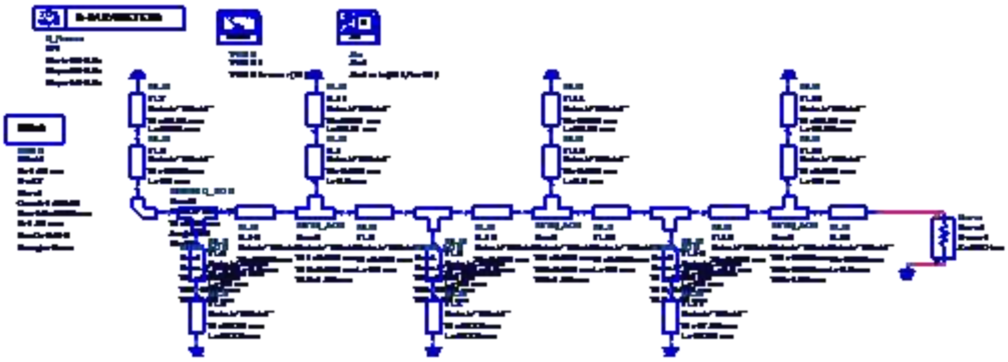

***Fig. 1:*** *Transmission Line Model.*

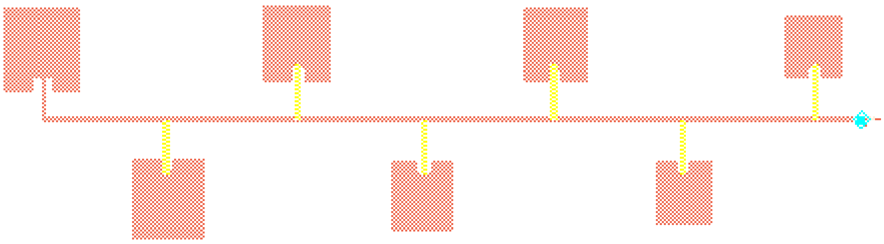

***Fig. 2:*** *Circuit Modeling Diagram for Seven Element Square Log Periodic Antenna.*

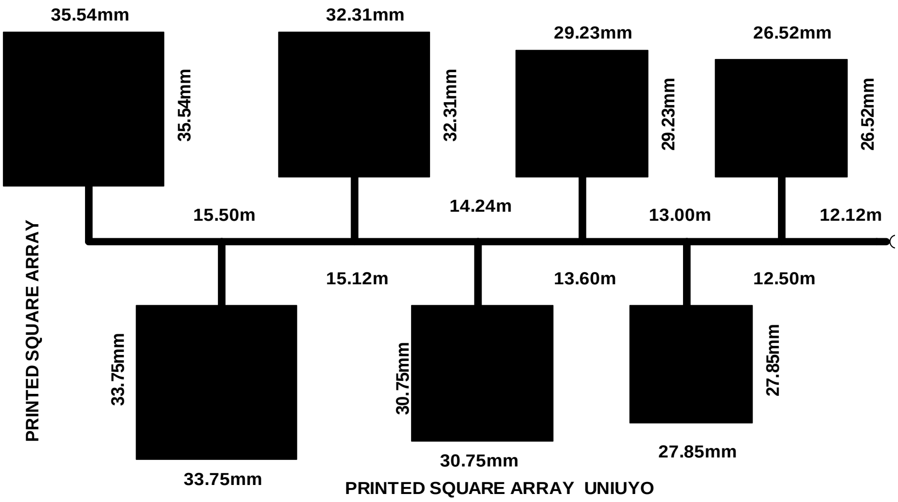


***Fig. 3:*** *Circuit and Layout for Seven Element Rectangular LPA.*

## CONSTRUCTION

The simulated antenna was constructed using a Printed Circuit Board and the the antenna shape was printed on the board following the procedures for etching of microstrip on pcb board using iron on glossy method,the pcb wizard was used to draw the simulated microstrip and printing on glossy paper using laser printer which was transferred to the pcb board by ironing and later washed using $FeCl_3$ to remove the copper part of the etching to remain the

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transferred patch and latter cleaned using pentone.The printed circuit was achieved as shown in figure 4.The obtained printed patch was tested to obtain the performance analysis of the antenna.Measurement was done by attaching the system the antenna to a signal analyzer ot obtain the parameters figure 5.

## MEASUREMENTS AND SIMULATION

The measurement of the constructed microstrip array patch was carried out using spectrum analyzer (Science laboratory dept. Ladoke Akintola University of technology), wireless router to produce wireless signal at 2.45 – 2.5GHz frequency,laptop ,stand and coaxial cable of 50 ohms .the set up is shown in figure below.The sweep measurement was taken with the frequency band stop and start of 2.0 GHz.

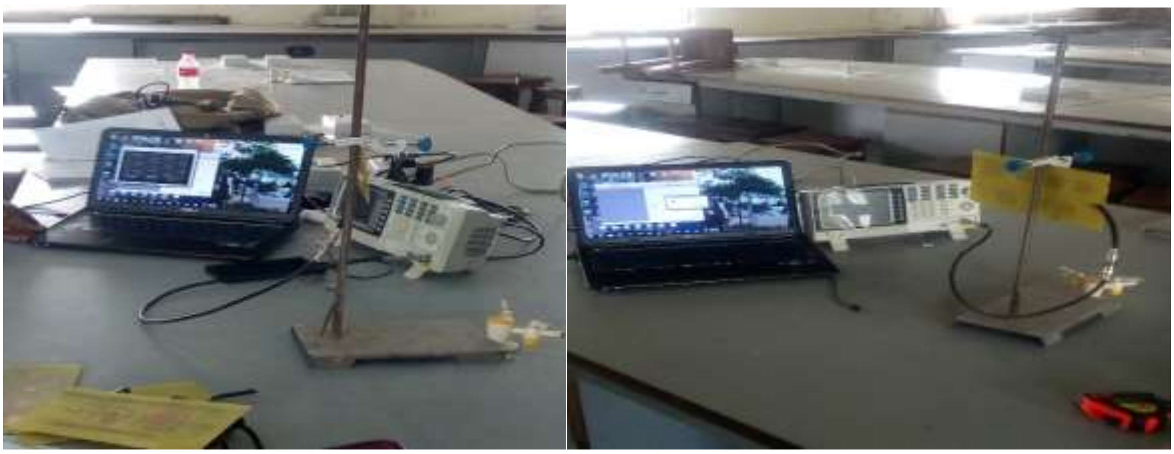

***Fig. 4:*** *Measurement Setup for the Antenna Measurement.*

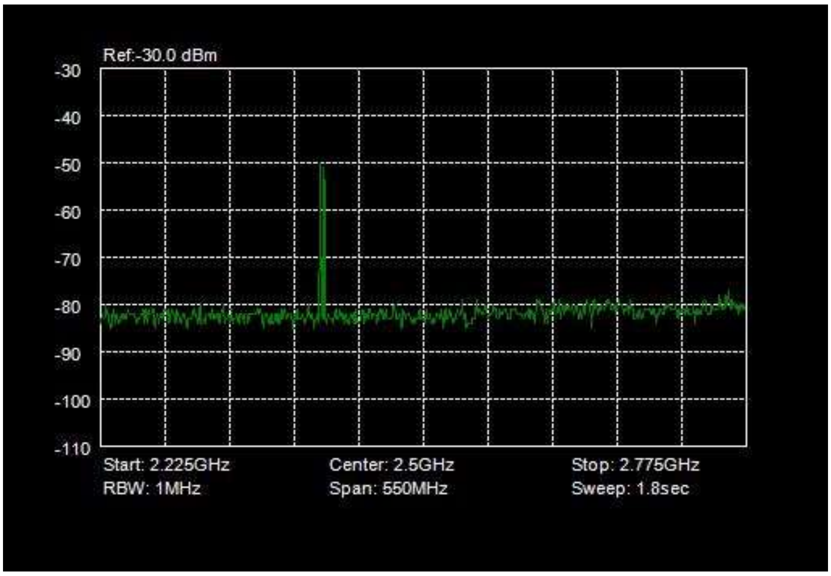


***Fig. 5:*** *Measured Return Loss for the Antenna.*

## RESULT AND DISCUSSION

The virtual results of the input and measured output return damage for the seven elements enthusiastic log periodic antenna is presented in the figures (6-11) and the relative values on Table 2 for square array shows a real performance ability of square log periodic array microstrip parameters.

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Square log periodic array Microstrip antenna: The broadband antenna of seven element array shown on Figures, the simulation with ADS2009 software package, the antenna shows a 3.3GHz and 2.35GHz as input and the output resonant frequency, gain and directivity of 7.06 and 6.038dB respectively with efficiency of 1.089%.

Square log periodic array Microstrip antenna: this show a resonant frequency of 2.

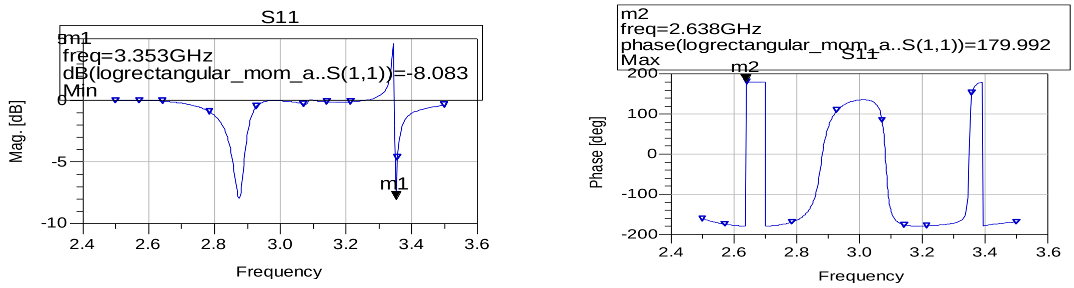
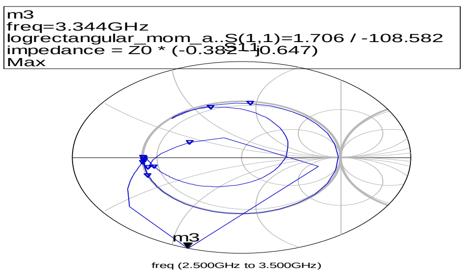



***Fig. 6:*** *The Input and Output Return Loss Return Loss for Square Log Periodic Array Microstrip Antenna.*



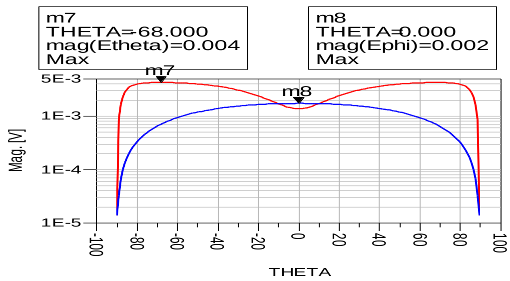
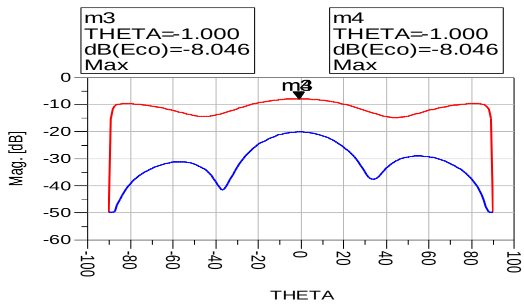




***Fig. 7:*** *Smith Chart for the Input Impedance.* ***Fig. 8:*** *The radiation Pattern for Square LPA.*



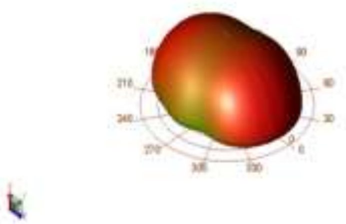



***Fig. 9:*** *The E-co and E-cross of Square LPA.* ***Fig. 10:*** *The 3D Radiation Pattern for Square LPA.*

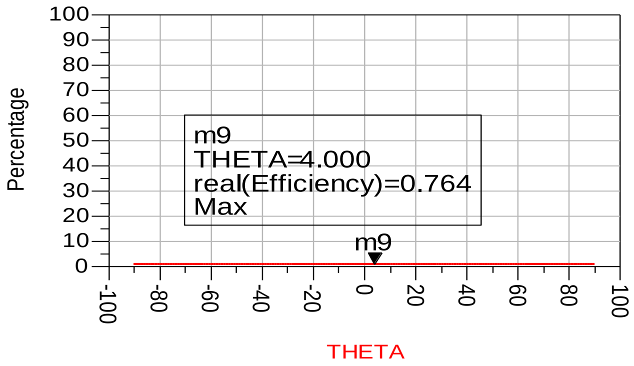



***Fig. 11:*** *Efficiency for Square LPA.*

***Table 2:*** *The Antenna Parameters for Rectangular and Square Array.*

| Array Types | Return Loss(input)dB | Return Loss(output)dB | Power Rad(Watt) | Directivity (dB) | Gain (dB) | Effective Angle | Efficiency |
|---|---|---|---|---|---|---|---|
| Square | -8.083 | -162.48 | 5.209E-08 | 6.99 | 3.471 | 2.04 | 0.74 |

## CONCLUSION

The seven elements log periodic rectangular and square array have been designed, etched and analyzed using Agilent electromagnetic simulator, TinyCad and iron on glossy method. The obtained results show a little difference from their performances in terms of resonating frequency 2.75 GHz and 3.35 GHz respectively, gain of 2.80 dB which is high compare to that of measured and directivity as well as power radiated, but with 51% bandwidth and are both efficient in performance. It can be deduced that square patch is appropriate for different purposes of wireless and 4G communication application.

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