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Design and Comparative Analysis of Rectangular and Square Log Periodic Array Microstrip Patch Antenna

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ABSTRACT

This paper described the design, simulation and comparative analysis of inset feed seven elements log periodic microstrip antenna at 2.5-3.5 GHz with the aide of Agilent (ADS2009).The antennas were modeled using microstrip lines, the S and 3D parameters data for both shapes were compared. The data is extracted from the momentum simulation. The properties of the antennas such as return loss, gain, efficiency, power radiated, cross polarization and the beam width have been investigated and compared with each other. A gain of 3.47dB using square over the gain of 2.8dB for rectangular, directivity of 7.44dB to 7.90dB, efficiency of 34 to 36 and resonant frequency of 2.75GHz and 3.35GHz respectively.

Keywords:- Square, Rectangular, Comparative, Seven Element Inset Feed, Microstrip

1.INTRODUCTION

Microstrip antenna has gain popularity because of their small size and light weight. However a limitation of microstrip antenna is the narrow bandwidth of the basic element. The bandwidth of a basic patch element is usually 1-3%.The bandwidth of the antenna is defined [3] as the range of frequencies, over which the performance of the antenna with respect to some characteristics conforms to a specific standard. The bandwidth of the antenna depends on the patch shape, resonant frequency, dielectric constant and the thickness of the substrate. The bandwidth of the antenna can be increased by reducing the substrate permittivity (□r) or increasing its thickness (h).How ever there are two problems associated with increasing the substrate thickness. One of the problem is the radiation and reactance associated with the feed junction.as given by [4].The second problem is an increase in surface wave effects[3].in order to avoid the problems, a number of different methods have been investigated to improve the bandwidth of the microstrip antenna. Different techniques to enhance the bandwidth of microstrip antenna have been investigated. Most of the work done for bandwidth enhancement has been directed towards improving the impedance bandwidth of the antenna element. The bandwidth can be increased using multilayer substrate structure antenna, parasitic elements [4], non-contact feeding technique, different shapes slot [6]ort log periodic technique by [7 and 4], which we applied in this research.

1.1 Design of LPA

The design principle for log periodic requires scaling of the dimensions from period so that performance is periodic with the logarithm of frequency. This principle can be applied to an array of patch antennas. The patch length (L), the width (W) and the inset (I) are related to the scale factor τ by.

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

If we multiply all dimensions 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 property implies that the array will have the same radiating properties at all frequencies that are related 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 [1].

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

Where $c = 3\times 10^{8}\, m/s$

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

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

For microstrip antennas the choice of the width of the patch radiator is very important. Small values of (W) result in low antenna efficiencies while large (W) values lead to higher order modes. The optimum values of W is

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

The resonant input resistance can be calculated from

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

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

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

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

j_o = Bessel unction of the first kind order zero

The characteristic impedance of the line can be calculated from

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

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

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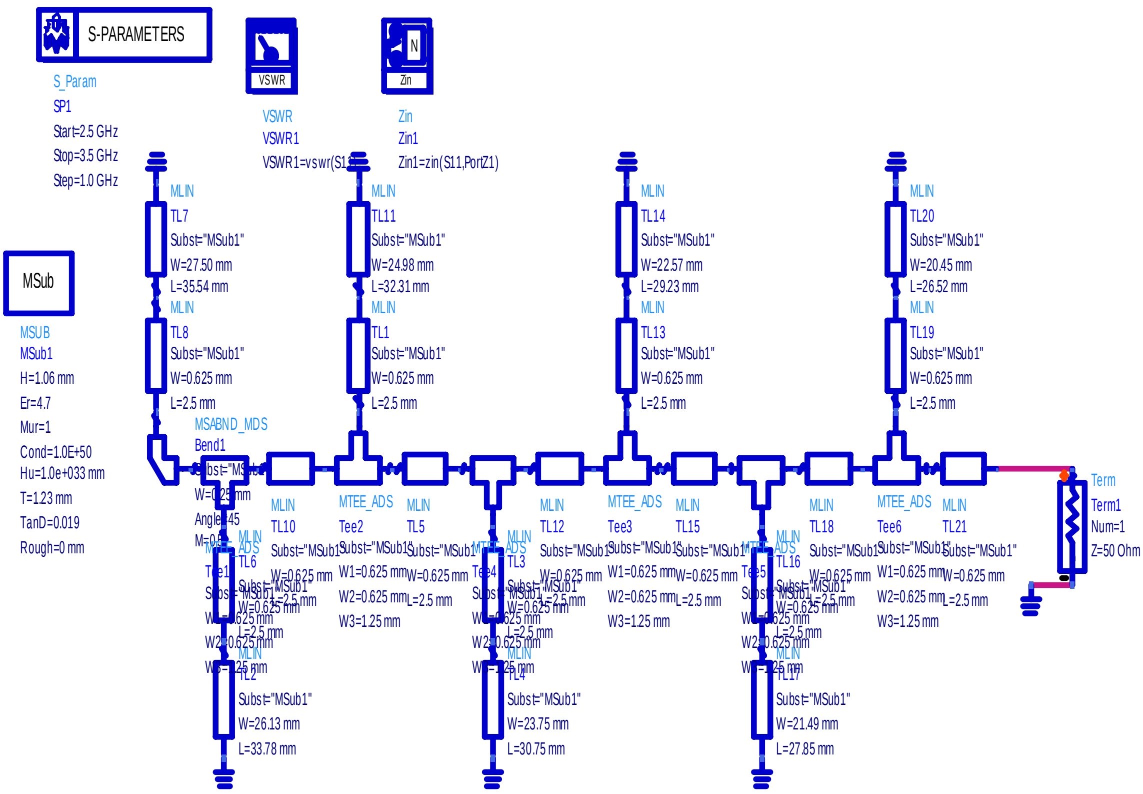
The values of L, W and inset feed (*I*) can be calculated using the above equations. This value will be scaled into log periodic element. Calculation of the length and width of rectangular and Square patch microstrip antenna is given in table 1.The substrate used is FR4 with dielectric constant of 4.7 and thickness of 1.06mm.The scaling factor τ =1.05.The loss tangent of the material is 0.019.

Table 1: Calculated Parameters for Seven elements Log Periodic Antenna

Number of Element	Frequency(GHz)	L(mm)	W(mm)	L=W(Square Patch)	Im
f1	2.5	27.50	35.54	35.54	15.50
f2	2.63	26.13	33.78	33.78	15.12
f3	2.75	24.98	32.31	32.31	14.24
f4	2.89	23.75	30.75	30.75	13.60
f5	3.04	22.57	29.23	29.23	13.00
f6	3.19	21.49	27.85	27.85	12.50
f7	3.35	20.45	26.52	26.52	12.12

The circuit design was obtained using the Agilent software 2009(ADS) the schematics were obtained using the microstrip lines (MSUB, MLIN and MTEE) and the S parameters were simulated using the above mentioned parameters. Figure 2 and 3 show the diagram and the layout diagram for the Rectangular and Square patch antennas.



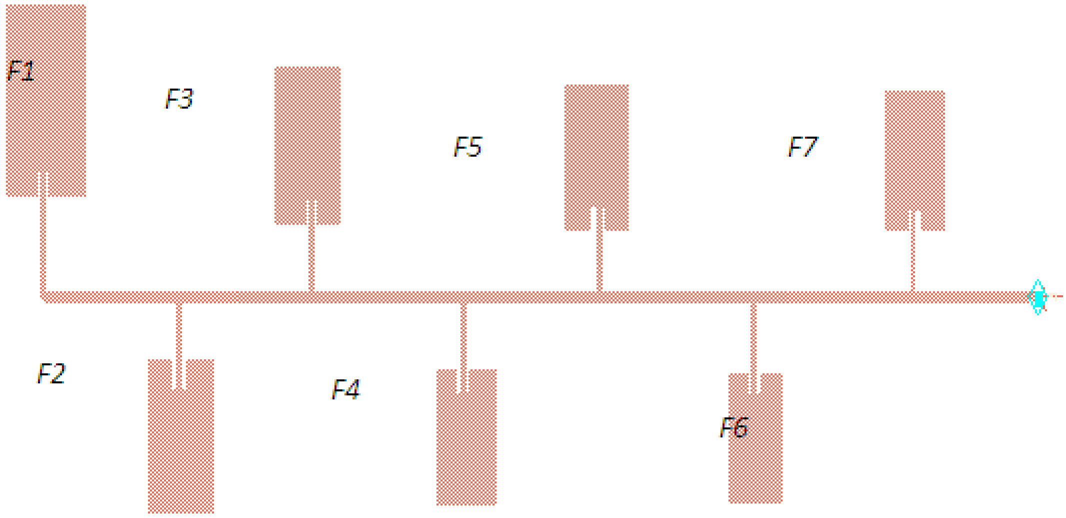


Figure 1: Circuit and Layout for seven element rectangular LPA

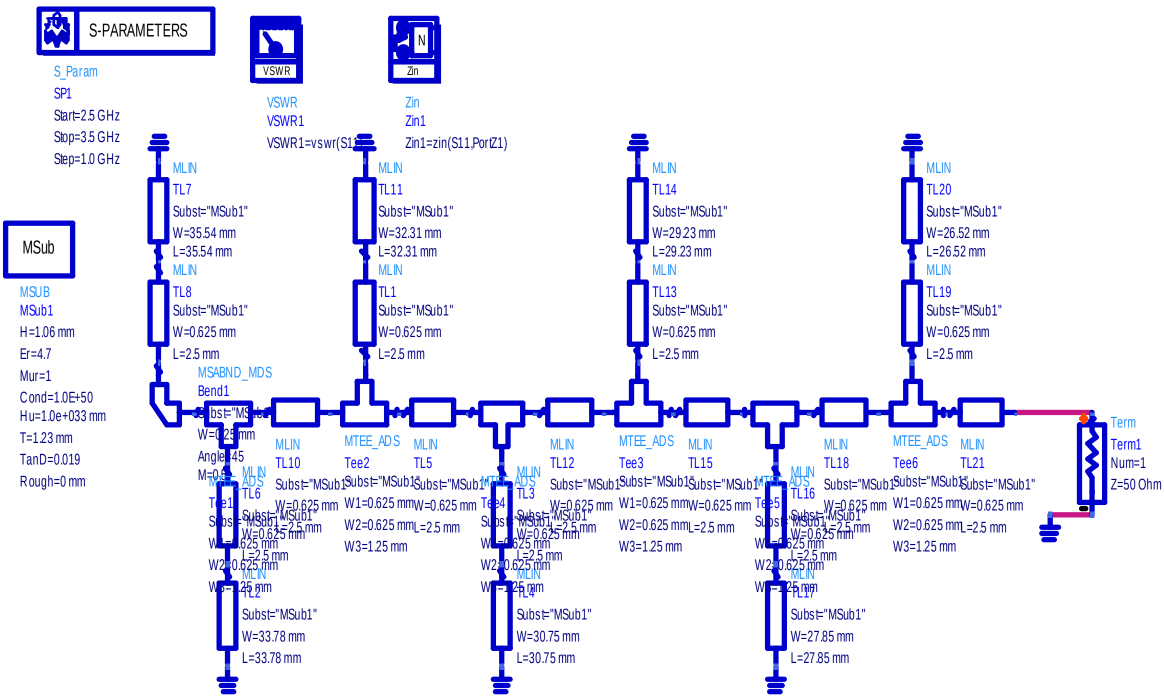


Figure 2: Circuit modeling diagram for seven element square log periodic antenna

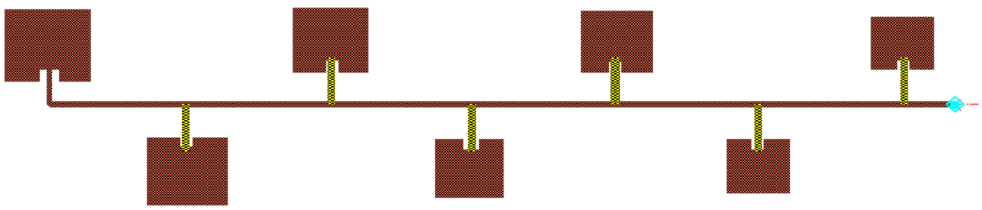


Figure 3: Circuit and Layout for seven element rectangular LPA

2.RESULT AND DISCUSSION

The simulated results of the input and output return loss for the seven elements passive log periodic antenna is shown in the figures (5-10) and the comparative values on Table 2: for the comparative of the rectangular and square array shows a real distinct difference in their parameters. Rectangular log periodic array Microstrip antenna: The broadband antenna of seven element array shown on Figure 2,the simulation using ADS2009 software package [ ],the antenna exhibit a 3.99GHz resonant frequency ,gain and directivity of 7.06 and 6.038dB respectively with efficiency of 1.089%. Square log periodic array Microstrip antenna: this exhibit a resonant frequency of 2.

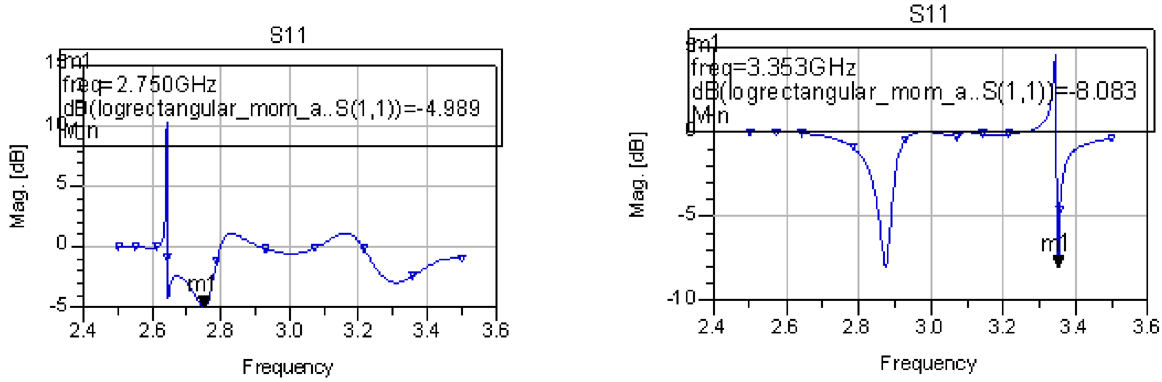


Figure 4: The Return Loss for Rectangular and Square Log Periodic Array Microstrip Antenna

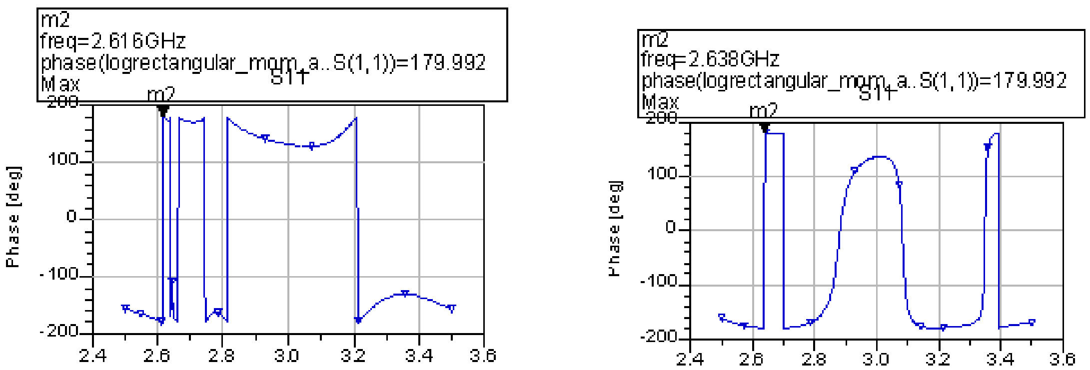


Figure 5: The output Return Loss of Rectangular and Square

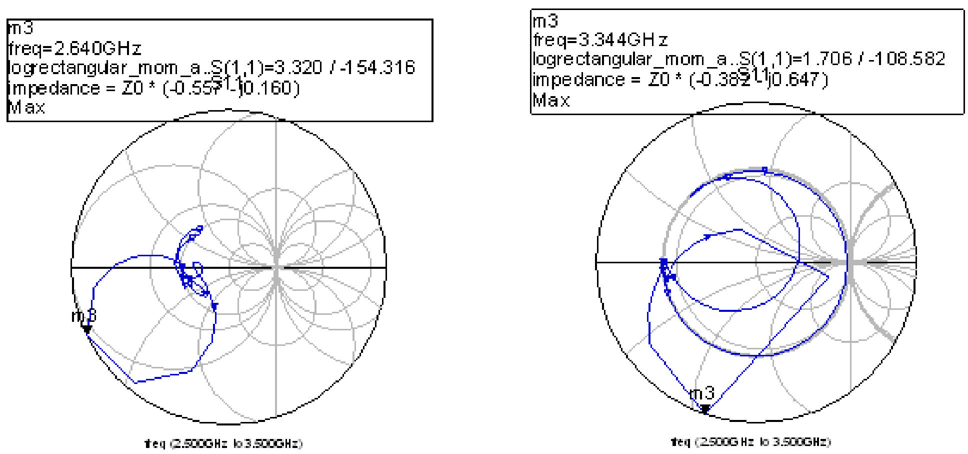


Figure 6: Smith Chart for the input impedance

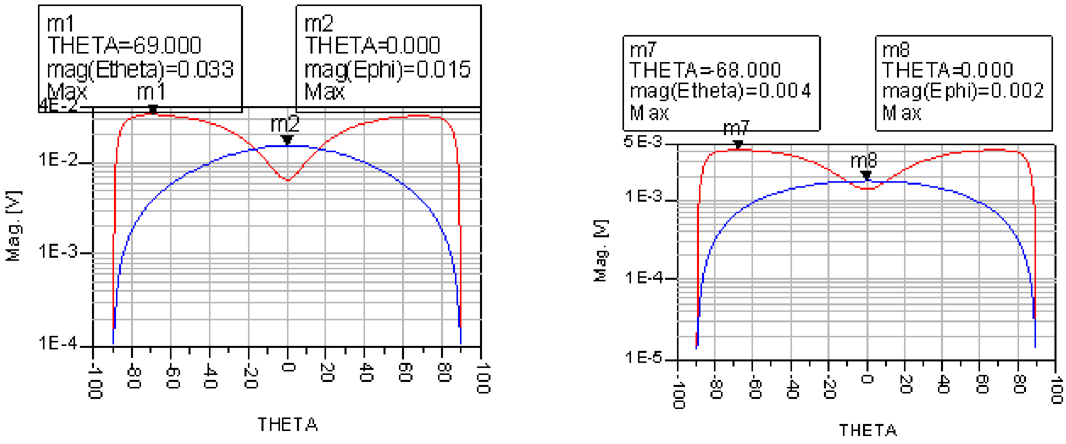


Figure 7: The radiation Pattern for Rectangular and Square LPA

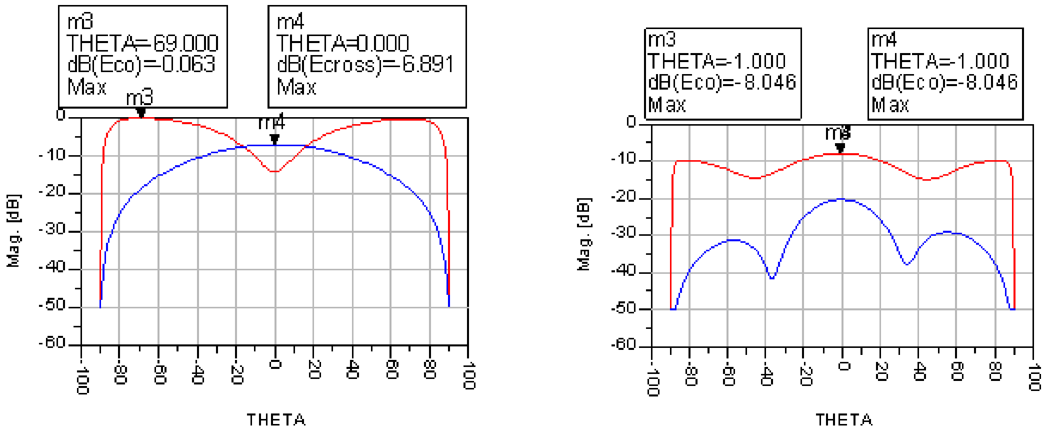


Figure 8: The E-co and E-cross of Rectangular and Square LPA

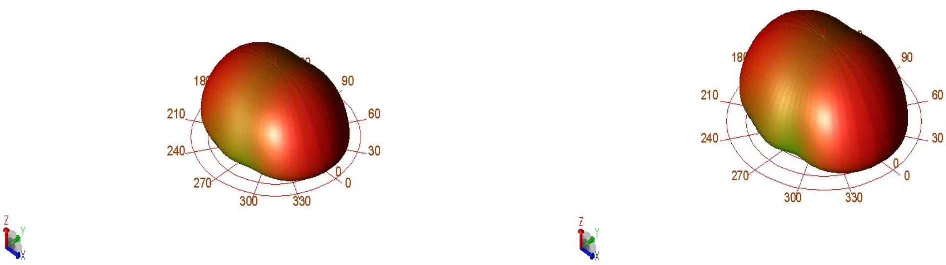


Figure 9: The 3D radiation pattern for rectangular and Square LPA

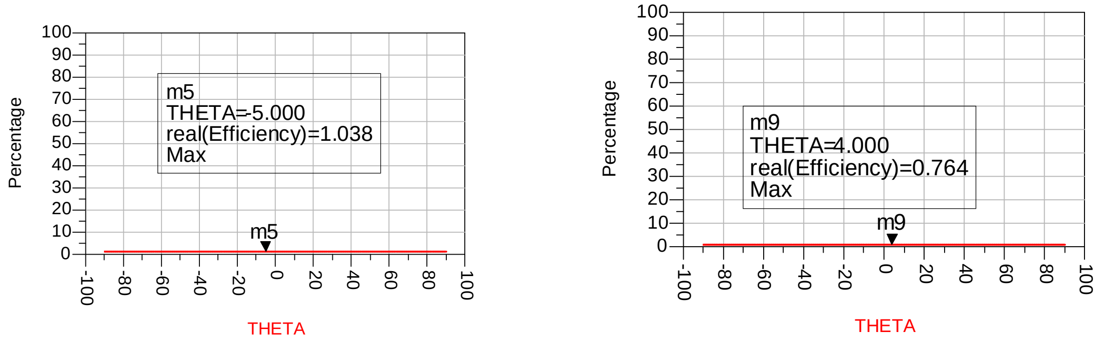


Figure 10: Efficiency for Rectangular and Square LPA

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*
Rectangular	-4.989	-168.93	5.33E-06	7.06	2.943	2.27	1.038
Square	-8.083	-162.48	5.209E-08	6.99	3.471	2.04	0.74

3.CONCLUSION

The seven elements log periodic rectangular and square array has been designed and analyzed using Agilent electromagnetic simulator. The results show a little difference from their performances in terms of resonating frequency 2.75GHz and 3.35GHz respectively ,gain of 2.80dB and 3.471dB which is high compare to that of rectangular and directivity as well as power radiated, but with 51% bandwidth and are both efficient in performance. It can be deduced that each shape is appropriate for different purposes of wireless communication application.

References

[1] Balanis, C.A.,'Antenna Theory Analysis and Design "2nd edition, john Willey & Sons Inc. New York, 1997.
[2] Chen H.M, Sze, J.Y, Lin, Y.F.,'A Broadband rectangular microstrip Antenna with a pair of U shaped slots "Microwave and Optical tech.letters, Vol.27, no.5, Dec.2000, pp369-370.
[3] Grag, P.Bhartia, P., I. Bahl and A. Itlipiboon.2001.Microstrip Antenna Design Handbook. Artech House Inc. Norwood, USA.
[4] Rahim, M.K.A and Gardner, P." The Design of Nine Elements Quasi Microstrip Log Periodic Antenna" RF and Microwave Conference, Oct.2004.
[5] Hall, P.S., 'Multioctave bandwidth Log periodic Microstrip Antenna Array'IEE proc.vol.133Pt H No.2.1986.pp127-136.