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Sidelobe Level Optimization of Rectangular Microstrip Patch Antenna Array using Binary Coded Genetic Algorithm

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***Abstract:** In modern world, communication systems requires development of low cost, minimal weight, and low profile antennas which are capable of maintaining high performance over wide range of frequencies. Patch antenna is one such antenna which fulfills the demands of current communication systems. The widely used microstrip patch antennas are rectangular patch antennas. This paper presenting the application of binary coded Genetic Algorithm (BGA) which is applied to the rectangular patch microstrip antenna with uniform linear arrays. The fitness function of GA is maximum reduction in peak side lobe level of the radiation pattern of the antenna with maximum reduction in the side lobe level and also achieved the minimum possible null to null beam width, the resultant radiation patterns for both before GA and after GA of microstrip array are compared. The radiation patterns are presented for 20,50,100 number of elements. All the simulated results are obtained by using MATLAB software.*

***Keywords:** Rectangular patch antenna, Genetic algorithms, Linear array antenna, MATLAB soft ware.*

I. INTRODUCTION TO RECTANGULAR MICROSTRIP ANTENNA

Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side of the antenna are shown in Fig 1.

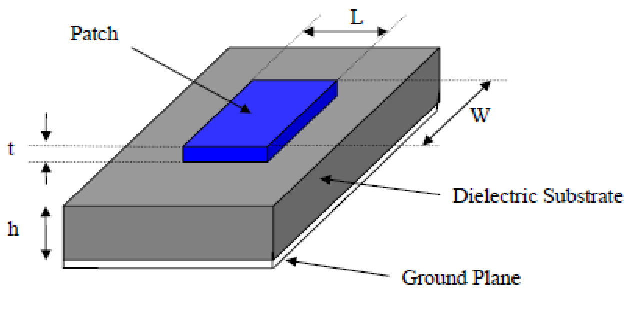

Fig. 1 Microstrip patch antenna

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The patch is made of conducting material such as copper or gold and can be found in various shapes. The radiating patch and the feed lines are usually fabricated using a process of photo etching which uses a photo resist and etchants to corrosively machine away selected areas on the dielectric substrate.

In order to simplify the analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shapes shown in Fig. 2.

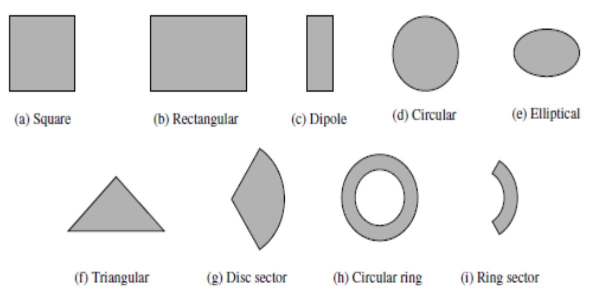

Fig. 2 Common shapes of microstrip patch elements

II. PROBLEM FORMULATION FOR RECTANGULAR UNIFORM LINEAR ARRAY

For the microstrip antenna, the *x-y* plane ($\theta = 90^\circ$, $0^\circ \leq \varphi \leq 90^\circ$ and $270^\circ \leq \varphi \leq 360^\circ$) is the principal *E*-plane. For this plane, the expressions for the radiated fields

$$E_\Phi{}^t = \frac{+jk_0 W V_0 e^{-jk_0 r}}{\Pi r} \left\{ \frac{\sin(\frac{k_0 h}{2}.\cos\phi)}{\frac{k_0 h}{2}\cos\phi} \right\} \cos(\frac{k_0 Le}{2}\sin\phi)$$

E- plane(θ=90°,0°≤ϕ≤90° and 270°≤ϕ≤360°)

$$E_\theta{}^t = +j\frac{k_0 W V_0 e^{-jk_0 r}}{\Pi r} \left\{ \sin\theta \frac{\sin(\frac{k_0 h}{2}\sin\theta)}{\frac{k_0 h}{2}\sin\theta} \frac{\sin(\frac{k_0 W}{2}\cos\theta)}{\frac{k_0 W}{2}\cos\theta} \right\}$$

H-plane(ϕ=0°, 0°≤θ≤180°)

For the E-plane for the x-y plane the expression for the radiated fields is

$$E_a(\phi) = E(\phi) \times AF$$

$$= \frac{\sin\left(\frac{k_0 h}{2}\cos\phi\right)}{\frac{k_0 h}{2}\cos\phi} \sin\left(\frac{k_0 L}{2}\cos\phi\right) \times \frac{\sin\left(\frac{N\psi}{2}\right)}{\sin\left(\frac{\psi}{2}\right)}$$

Power pattern is normalized, P(θ) can be written as

$$P(\theta) = 20\log\left(\frac{|E_{total}(\theta)|}{|E_{total}(\theta)_{\max}|}\right)$$

fitness function is formulated as

$$Fitness = Max\left(\frac{AF(\theta)}{AF_{Max}}\right)$$

III. ANTENNA PERFORMANCE PARAMETERS

A. Reflection Coefficient |Γ|

$$\Gamma = \frac{V_0^+}{V_0^-} = \left(\frac{Z_L - Z_0}{Z_L + Z_0}\right)$$

Where |Γ| is the reflection coefficient
Z_L and Z_0 are the load and characteristic impedances.

B. Voltage Standing Wave Ratio(VSWR)

$$VSWR = \frac{V_{\max}}{V_{\min}} = \frac{(1+|\Gamma|)}{(1-|\Gamma|)}$$

C. Return Loss

Return Loss is determined in dB as follows:

$$RL = -20\log|\Gamma|(dB)$$

IV. RESULT AND DISCUSSIONS

This paper consider with rectangular patch microstrip antenna with uniform linear array is used. The elements of the array with d = 0.25λ along the x-axis. Radiation patterns linear array before and after Genetic Algorithm applied with 20,50,100 elements as shown in figures. Before GA First side lobe level of -13.34db is obtained. For the same linear array after GA side lobe level of -31db is achieved.

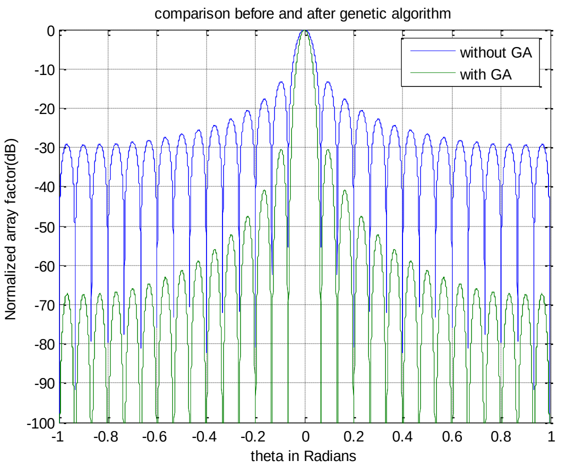

Fig. 3 Comparison of Radiation patterns of linear array and linear array with GA of 20 elements. without GA SLL= -13.36dB; With GA SLL= -31dB.

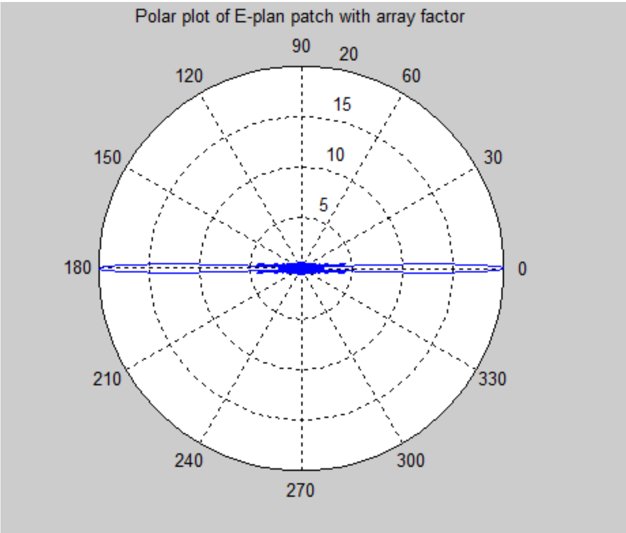

Fig. 4. Polar plot for 20 element rectangular microstrip patch antenna array.

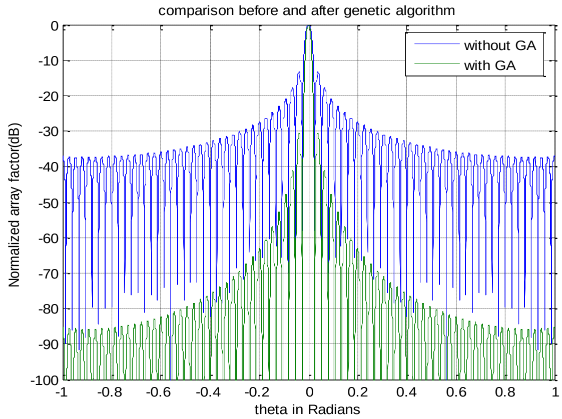

Fig. 5 Comparison of Radiation patterns of linear array and linear array with GA of 50 elements. without GA SLL= -13.36dB; With GA SLL= -31dB.

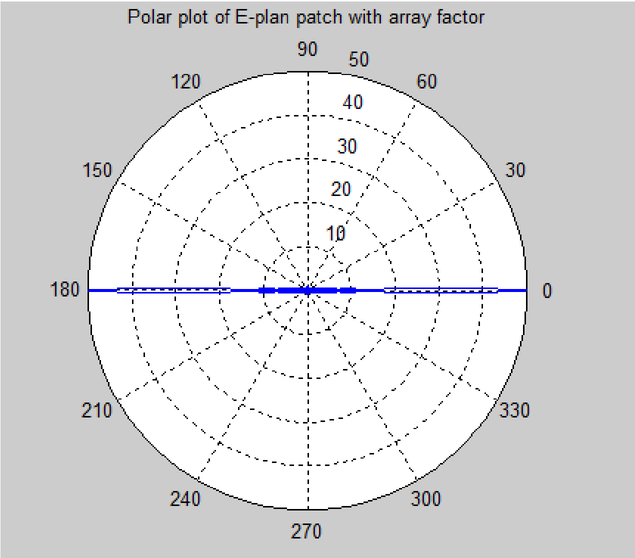

Fig. 6 Polar plot for 50 element rectangular microstrip patch antenna array.

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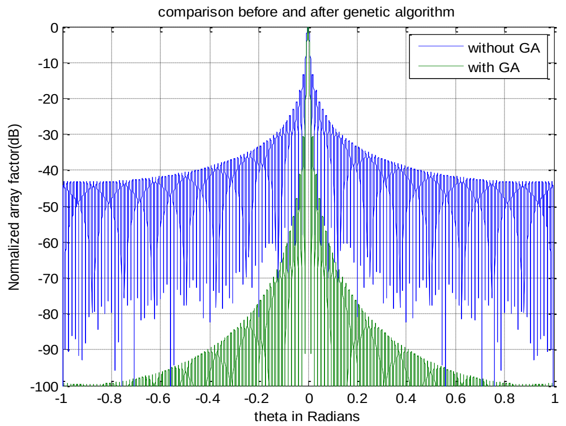

Fig. 7 Comparison of radiation patterns of linear array and linear array with GA of 100 elements. without GA SLL= -13.36dB; With GA SLL= -31dB.

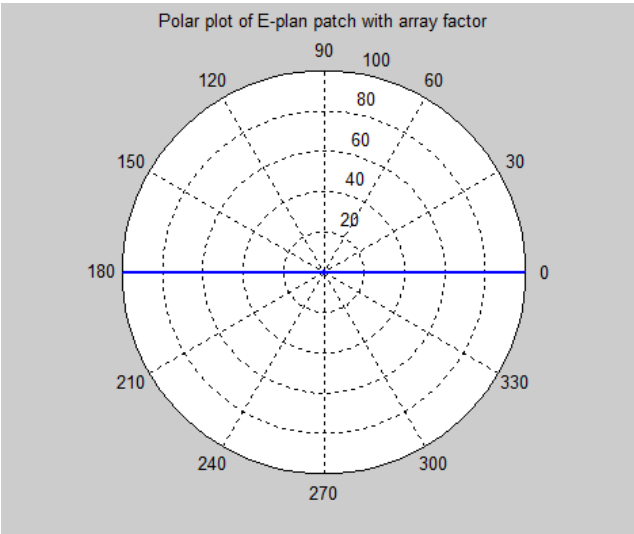

Fig. 8 Polar plot for 100 element rectangular microstrip patch antenna array.

Table 1.Comparison of FNBW, HPBW and SLL before and after GA with uniform linear rectangular microstrip antenna array

No .of Elements of Microstrip antenna with linear array	FPBW in Degrees		HPBW in Degrees		Side Lobe Level(SLL) in dBs	
	Before GA	*After GA*	*Before GA*	*After GA*	*Before GA*	*After GA*
10	46.4	46.4	20	13.4	-13.36	-31
20	23.5	22.75	10	6.76	-13.36	-31
50	11	10	4	2.2	-13.36	-31
100	4.58	4.5	2.16	1.36	-13.36	-31

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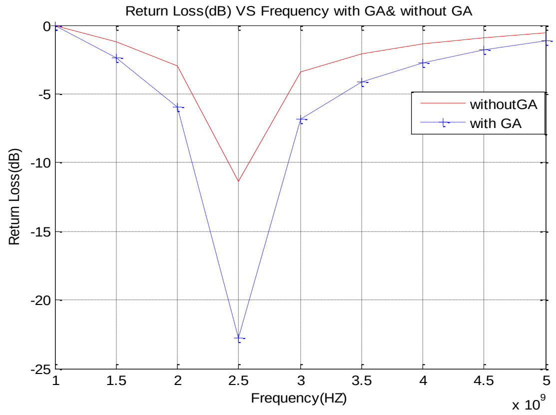

Fig. 9 Plot of Return loss verses Frequency with GA without GA at dielectric constant at 9.8.

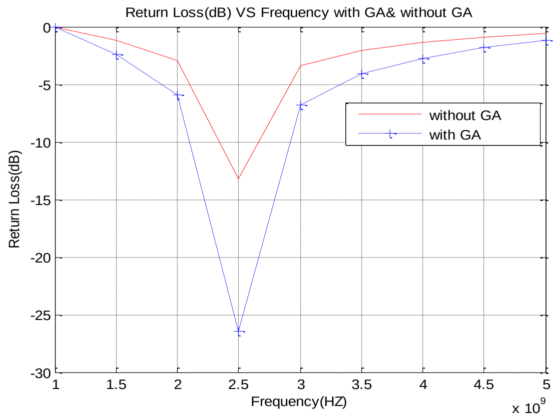

Fig. 10 Plot of Return loss verses Frequency with GA without GA at dielectric constant at 4.4.

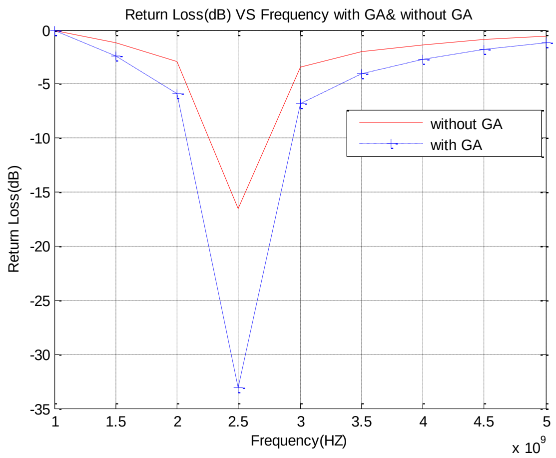

Fig. 11 Plot of Return loss verses Frequency with GA without GA at dielectric constant at 2.23.

V. CONCLUSION

From the results, we conclude that the GA produced the better results, the SLL obtained with GA for linear array is -31 dB and also reduces the beamwidth. The application of GA for reduction in the SLL and as well as beamwidth is found to be useful in many wireless communications.

Return loss of antenna at 2.23 low dielectric constant produces the without
GA=-16.5dB and with GA=-33.5, at 9.8 high dielectric constant produces the with out GA=-11.5dB and with GA=-22.5 .

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K. Karuna Kumari, did her M.E in ECE in Andhra University. She has been working in the faculty of ECE in GITAM University for the last 14 years. She is pursuing her Ph.D. in the field of Optimization of microstrip antenna arrays in the Department of ECE, AU. She has published 18 papers in International Journals.

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