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# Optimal array factor radiation pattern synthesis for linear antenna array using cat swarm optimization: validation by an electromagnetic simulator

**Key words:** Patch antenna; Linear antenna array; Cat swarm optimization (CSO); Side lobe level (SLL)

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# Motivation/Main ideas

- **Motivation**

  The contemporary research is going on for the development of antenna with accuracy and efficiency. For the prolonged distance communication the design of antenna should be highly directive with high gain and directivity with less interference.

- **Main ideas**
  - linear antenna arrays having microstrip patch antenna elements has been carried out using cat swarm optimization.
  - Cat swarm optimization (CSO) has been applied for the optimization of the control parameters of radiation pattern of an antenna array.
  - The arrays are designed by using MATLAB computation and are validated through Computer Simulation Technology-Microwave Studio (CST-MWS).

# Method(I)

The array factor (AF) for the broadside direction is given by

$$\mathrm{AF}(\theta) = 2\sum_{n=1}^{M} I_n \cos\left[\left(\frac{2n-1}{2}\right) kd \cos\theta\right]. \tag{1}$$

The cost function (CF) for reducing SLL is given as

$$\mathrm{CF} = \frac{\left|\mathrm{AF}(\theta_{\mathrm{msl}}, I_n)\right|}{\left|\mathrm{AF}(\theta_0, I_n)\right|}, \tag{2}$$

# Method(II)

where $\theta_0$ is the angle of the elevation plane of the maximum of radiation pattern in range $[0, \pi]$, $\theta_{\mathrm{msl}}$ the angle of elevation plane of the maximum side lobe, $\mathrm{AF}(\theta_{\mathrm{msl}}, I_n)$ is obtained on either side of the main beam. CSO technique is inked for optimizing nonuniform amplitude excitation and uniform inter-element spacing.

# Method(III)

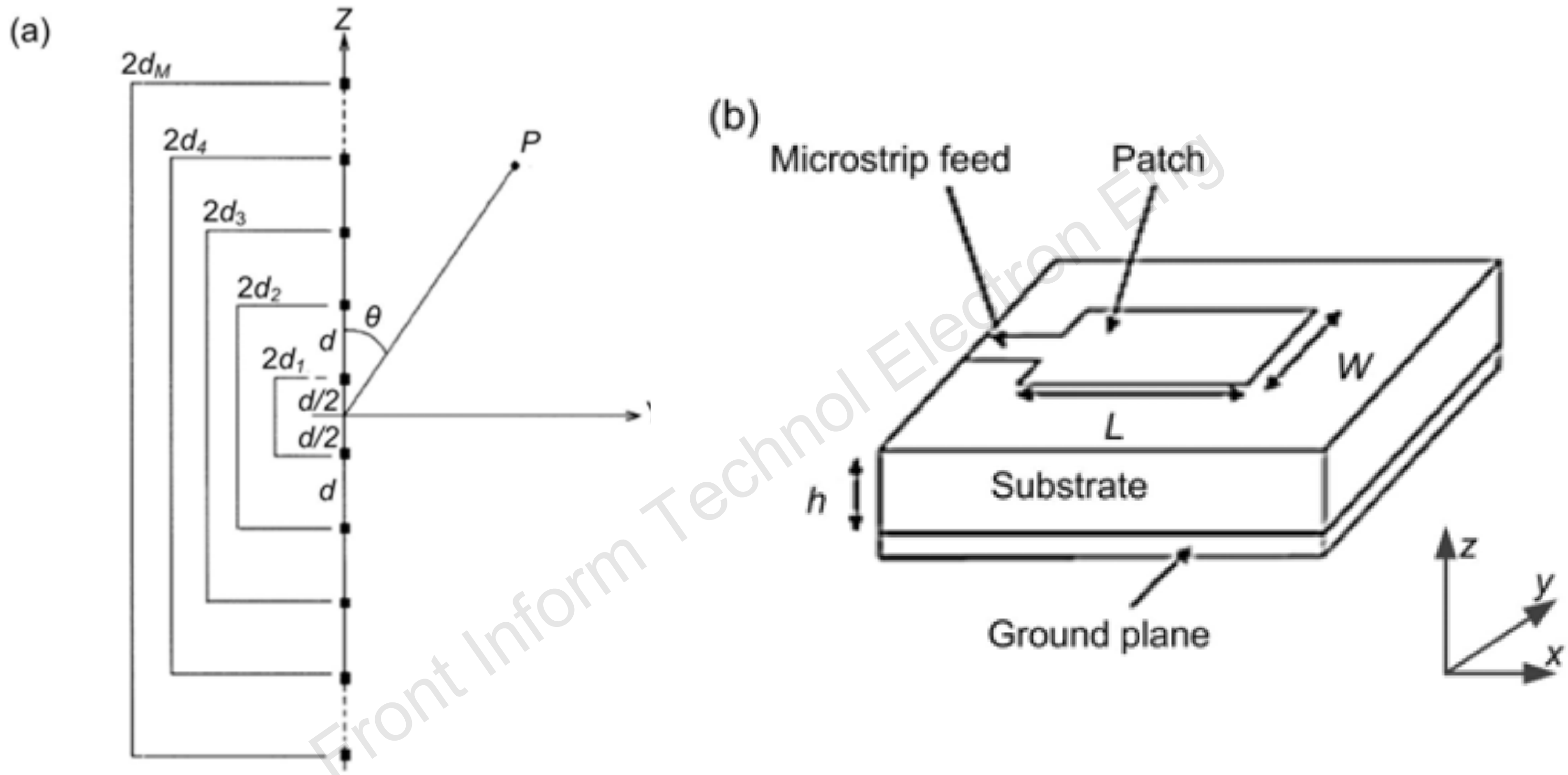




**Fig. 1 Geometry of a 2*M*-element linear antenna array of microstrip patch antennas placed along *Z*-axis (a) and structure of single microstrip patch antenna (b)**

# Major results(I)

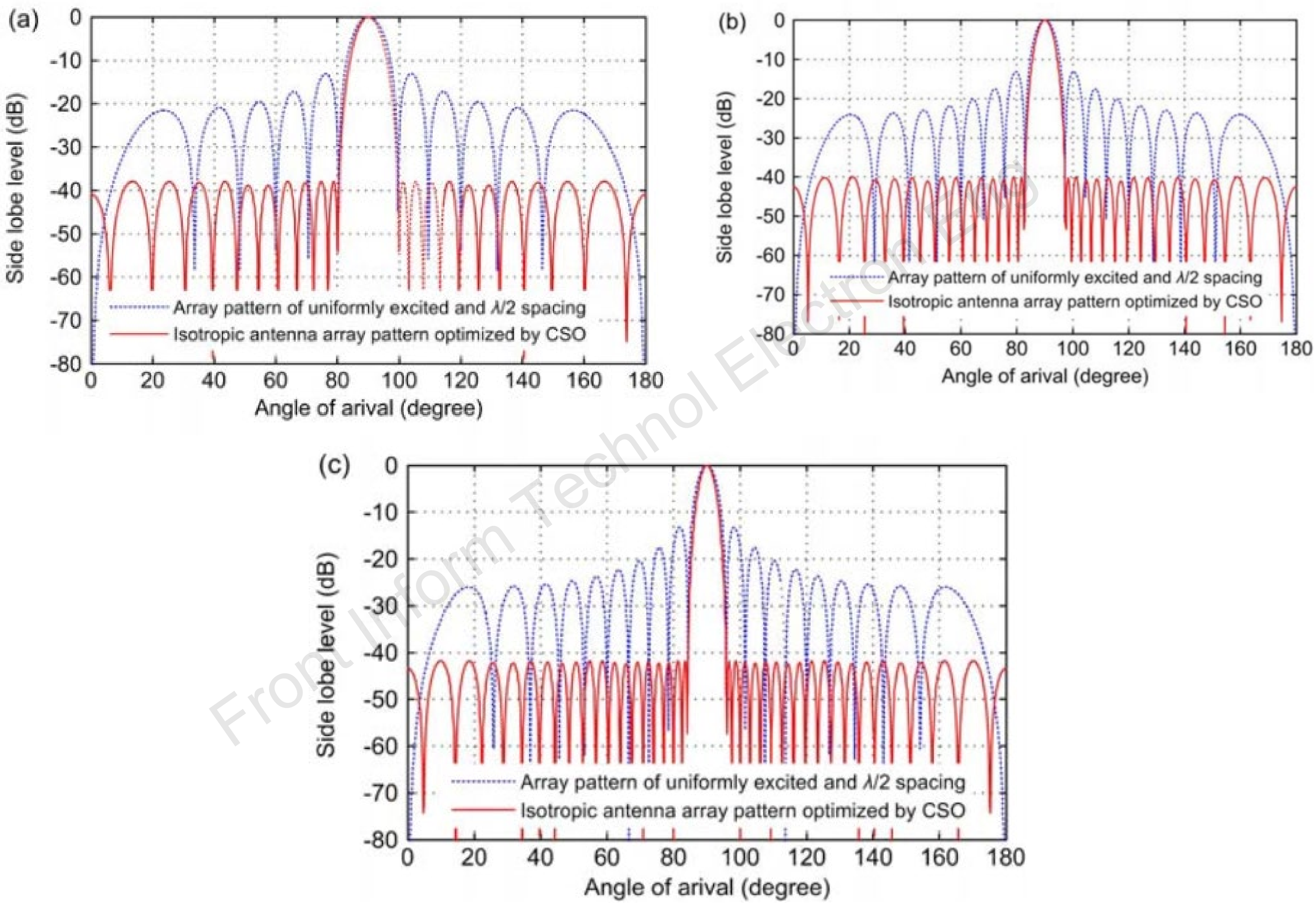


**Fig. 2 Optimal radiation pattern obtained by using CSO for linear array of microstrip patch antennas with 12 (a),16 (b), and 20 (c) elements**

# Major results (II)

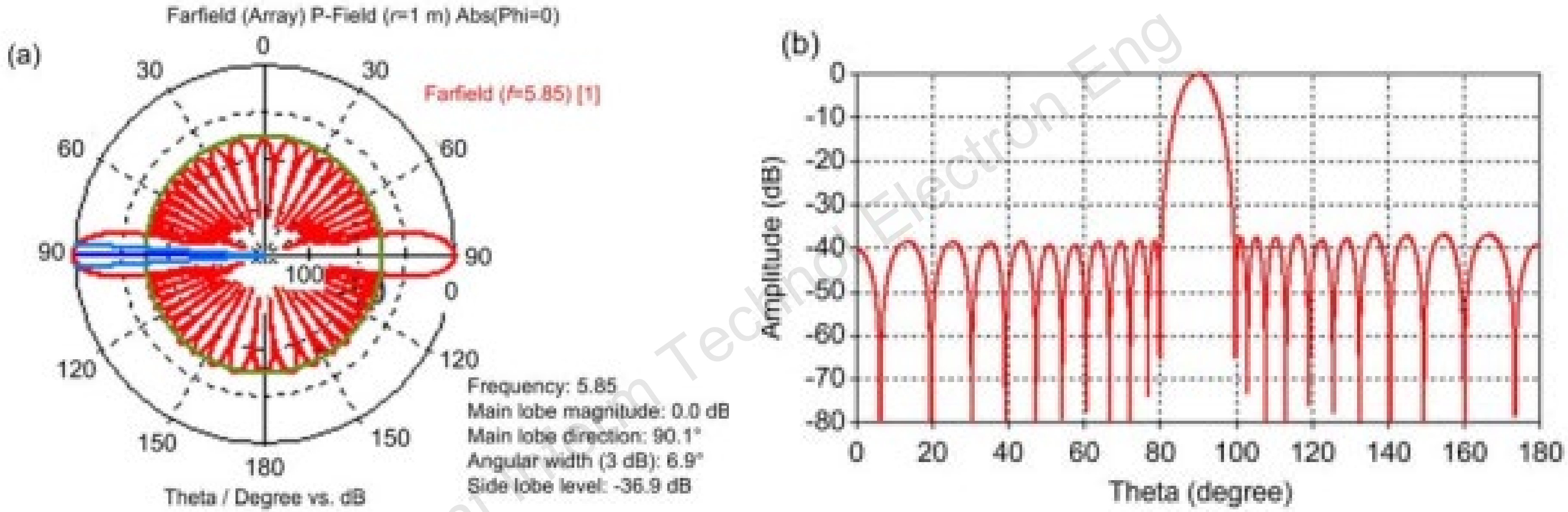




**Fig.3 Polar plot for the elevation angle of the designed 12-element linear array of microstrip patch elements (a) and array pattern of the linear array of microstrip patch antenna (b) obtained in CST-MWS**

# Conclusions

- The optimal designs of linear arrays of microstrip patch antenna elements with uniform and nonuniform inter-element spacing and current excitations have been carried out using an evolutionary optimization technique called cat swarm optimization (CSO).
- From the simulation results, it is clear that, for the arrays with 12, 16, and 20 elements, the SLLs have been reduced much more as compared with the corresponding uniform linear arrays of microstrip patch antenna elements, with a very little change in first null beamwidth (FNBW).
- The FNBWs of the elementary and concluding radiation patterns are almost the same.