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OPTIMIZATION OF PLANNAR ANTENNA FOR ISM BAND USING PSO

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Abstract: An Inset feed E-Shape Microstrip Patch Antenna has been developed and simulated for operation of Industrial, Scientific and Medical **(ISM)** band (2.40-2.52 GHz). The patch antenna is simulated using **IE3D™** EM simulator (version 14.0) and optimized with an evolutionary stochastic optimizer i.e. Particle Swarm Optimization (PSO) technique. Optimized results show that the antenna is working in ISM frequency band. These bands include the designated frequency bands of wireless standards IEEE 802.11, 802.11b, 802.15.2 and Bluetooth. The antenna exhibits good radiation characteristics and moderate gain in the entire operating band.

Index terms: Patch antenna, PSO, IE3D™, Inset feed & ISM Band.

I. INTRODUCTION

Microstrip antennas are popular for their attractive features like: light weight, low profile, ease of fabrication and compatibility with Monolithic Microwave Integrated Circuits (MMICs). The patch antennas are used in satellite communication, wireless and microwave applications, due to their compact and planar structure [1]-[4]. Recent advancements in wireless technology and significant growth in consumer demands have significantly increased the popularity of wireless networks. In order to regulate the interaction of different devices in such wireless networks, Bluetooth have been developed and currently being adopted in different countries [5]-[6].

In recent years, many Electromagnetic simulation softwares are available for designing of Microstrip antennas. Among them, the one of the powerful electromagnetic simulation software is IE3D [7]. Besides the optimization schemes viz. Random optimizer, Powell optimizer, Adaptive optimizer & Genetic optimizer available in IE3D™, there are several other optimization techniques available such as (i) Particle swarm optimization (PSO) (ii) Genetic Algorithm (iii) Simulated annealing etc [8]-[10]. The PSO algorithm is very suitable and relatively simple method for optimization of electromagnetic problems [11].

In this paper an E-shape Microstrip patch antenna is optimized using PSO and simulated by IE3D simulator. This method is developed by combining the PSO with IE3D simulator software. This Antenna covers ISM band ranging from 2.40-2.52 GHz with VSWR 2:1 and -10 dB bandwidth of 121.9 MHz.

2. DESIGN OF MICROSTRIP PATCH ANTENNA

2.1 Geometry

The geometry of E-shape Microstrip patch antenna is shown in Figure 1. The rectangular patch has dimensions of W x L. It is constructed on a substrate with relative permittivity (ε_r) of 2.55 and thickness (h) of 2 mm. The resonant frequency of the Microstrip antenna is around 2.45 GHz. The patch is fed by INSET feeding method (>L/2).The inset depth (Y_0), inset width (W_f), Span (S) are the important parameters for controlling the frequency and Return loss. Two parallel slots of length (Ls) width (W_s) and distance between the slots P_s are incorporated into the patch.

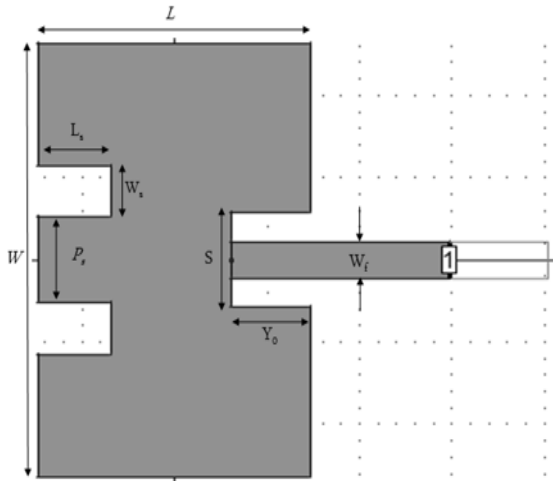

Fig 1/ Geometry of proposed Antenna

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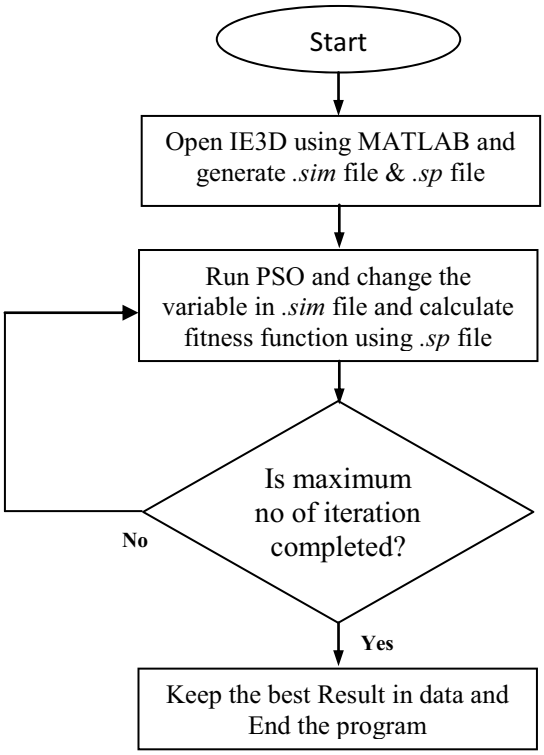

Fig 2: flow chart of IE3D/PSO

Table 1 Design parameter of patch antenna

Bound	**L**	**W**	**Y_0**	**S**	**Ls**	**Ws**	**Ps**
Low Bound	35	40	5	5	5	5	5
High Bound	45	70	20	15	15	10	20

(ε_r=2.55, h=2) All dimensions are in mm

2.2 Design Method

IE3D Electromagnetic simulation software is based on method of moment (MOM) for solving the structure of general shape. Different Optimization techniques are available in IE3D viz. Random optimizer, Powell optimizer, Adaptive optimizer & Genetic optimizer. The variables for optimization are defined by IE3D and controlled by its direction and bounds. However, the variables can only be connected with another by fixed rate. More complicated relation between variables cannot be set in IE3D. The width and the span of patch are placed on vertical position on patch and may cause overlap problems in IE3D optimization.

In this paper, the parameters of the rectangular Microstrip patch antenna are obtained by combining particle swarm optimization with IE3D.

2.3 Particle Swarm Optimization

Particle swarm optimization is a robust stochastic evolutionary computation technique based on the movement and intelligence of swarm. In PSO, the potential solution, called particle, fly through the problem space by following the current optimum particles. Each particle keeps track of its co-ordinates in the problem space which are associated with best solution. This value is called personal best *(P_{id-1})*. Another best value tracked by particle swarm optimizer is in the whole search space called global best *(P_{gd})*. The algorithm is formulated using the equation given below [8-10].

$$V_{id} = W * V_{id-1} + C_1 * \eta_1 * (P_{id-1} - X_{id-1}) + C_2 * \eta_2 * (P_{gd} - X_{id-1}) \quad \text{..... (1)}$$

$$X_{id} = X_{id-1} + V_{id} \quad \text{..... (2)}$$

Where X_{id} is the position of i^{th} *particle,* V_{id} is the velocity of i^{th} particle. P_{id-1} is the best position of i^{th} particle and P_{gd} is the global best particle position in the N-dimension space. η_1 and η_2 are two random function in the range *(0, 1).* W is the inertia weight. C_1 and C_2 are two positive constants.

PSO algorithm uses fitness evaluation to represent how well a solution satisfies the design parameter. Therefore the fitness is calculated by:

$$F = \sum_{i=o}^{N} W_i f_i \quad \text{..... (3)}$$

Where N is the number of fitness factor, f_i is the value of i^{th} fitness factor and W_i is the weighting coefficient.

The flow chart of interfacing between IE3D/PSO is shown in fig. 2. The variables for optimization defined by IE3D are saved in a *.sim* file, and the simulated results of return loss are saved in a *.sp* file. By changing the variables saved in the *.sim* file using the PSO program, optimization for complicated structure can be performed. Fitness function value is obtained by calculating the simulated results saved in the *.sp* file.

Table 2 optimized parameter of Microstrip patch antenna

L	W	Y_0	S	Ls	Ws	Ps
37.42	66.52	11.27	14.54	10.23	7.67	14.5

(ε_r=2.55, h=2) All dimensions are in mm

2.4 Design Parameters

In this paper, the rectangular Microstrip patch antenna for ISM band with resonant frequency at 2.45 GHz is designed. The design parameters for the antenna are listed in Table1 and optimized parameters of the antenna are listed in Table 2. The number of particle set to be 10 and number of generation set to be 1000. The fitness function is given by.

$$Fitness = \min\left(S_{11n}^2\right)_{(2.45GHz)}$$

Where n is the sample point in the return loss versus frequency.
The simulation took 4 hours (approx) on a HP mobile workstation with 2 GB RAM.

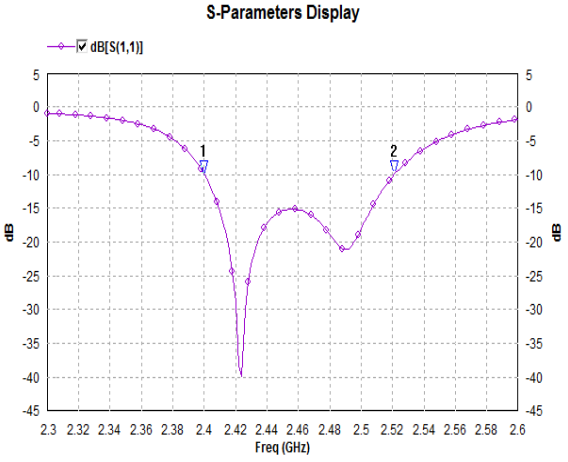

Fig 3 Return loss versus frequency

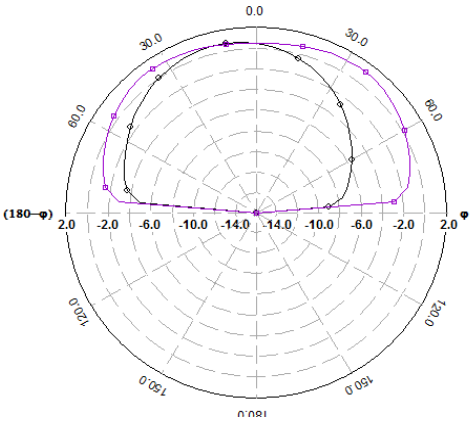

Fig 4 Radiation pattern at 2.4 GHz

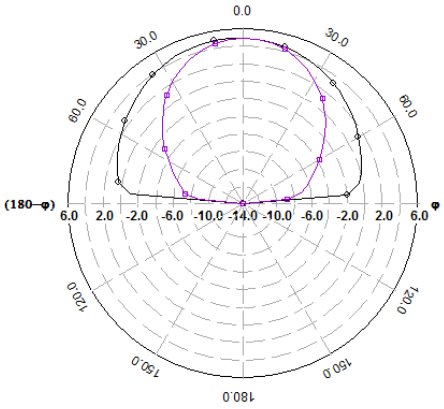

Fig 5 Radiation pattern at 2.52 GHz

II. RESULTS AND DISCUSSION

The parameters of rectangular Microstrip patch antenna in ISM band are obtained by IE3D/PSO method. The optimized parameters are listed in Table 2. The optimized antenna is simulated using IE3D^{TM} (version 14.0) simulation software. The return loss of -40dB at frequency 2.42 GHz is obtained and is shown in Fig. 3.The bandwidth of 121.9 MHz (<-10 dB) obtained ranging from 2.4-2.52 GHz which is suitable for ISM band. Fig. 4 & 5 show the radiation pattern at 2.4 GHz and 2.52 GHz in the broad side direction at V=0 and V= 90. The maximum gain of 6.2 dBi is obtained for the antenna.

III. CONCLUSION

The design & optimization of Inset fed E-shape Microstrip patch antenna is presented for ISM band. The antenna is developed by combining the efficient evolutionary optimization method (PSO) with a standard electromagnetic simulator (IE3D). The simulation results show that the proposed antenna can offer good performance for ISM band ranging from 2.40-2.52 GHz. The antenna achieved -10dB impedance bandwidth of 121.9 MHz. This method can also be effectively used in the design of various complex microwave and millimetre-wave circuits. Fabrication of the patch will be carried out in future

IV. REFERENCES

[1] C.A. Balanis, Antenna Theory (Analysis and Design), 2nd edition. *New York: John Wiley and Sons, Inc., 1997.*

[2] D.M. Pozar "Microstrip antennas", *IEEE Transaction on Antenna and Propagation*, Vol. 80, pp. 79-91, Jan.1992.

[3] R. Waterhouse, "Small Microstrip patch antenna," *Electron. Lett.* , Vol.31, pp. 604-605, 1995.

[4]. Shams, K. M. Z., M. Ali, and H. S. Hwang, "A planar inductively coupled bow-tie slot antenna for WLAN application," *Journal of Electromagnetic Waves and Applications*, Vol. 20, 861–871, 2006.

[5] Fan Yang, Xue-Xie Zhang And Yahya Rahamat-Samii, "Wide band E-shaped patch antennas for wireless communications," *IEEE Trans. Antennas Propag.*, Vol. 49, 1094–1100, 2001.

[6] Zeland Software Inc. "IE3D Electromagnetic Simulation and Optimization Package", *Version 14.0*, Fremont, CA, 2003.

[7] Johnson, J. M., & V. Rahmat-Samii. "Genetic algorithms in engineering electromagnetic", *IEEE Antennas Propagat.* Vol. 39, Page no. 7–21, 1997.

[8] X.F Liu et al, "Design of a Low –Profile Modified U Slot Microstrip Antenna Using PSO Based on IE3D", *Proc. of Microwave and Optical Technology Letters,* Vol.49, No.5, pp.1111-1114, May, 2007.

[9] R.C. Eberhart and Y. Shi, "Particle Swarm Optimization: Developments, Applications, and resources, *Proc 2001 Conf Evolutionary Computing* (2001), 81–86.

[10] D.W. Boeringer and D.H. Werner, "Particle swarms optimization versus genetic algorithms for phased array synthesis", *IEEE Trans Antennas Propag*, Vol. 52 (2004), 771–779.