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DESIGN of RECTANGULAR MICROSTRIP PATCH ANTENNA USING PARTICLE SWARM OPTIMIZATION

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Abstract: Particle swarm optimization is a popular optimization algorithm used for the design of microstrip patch antenna. This paper presents design of probe fed rectangular microstrip patch antenna for WCDMA using soft computing technique, particle swarm optimization. A substrate with dielectric constant of 4.4 and height 1.588mm has been used for the design of microstrip patch antenna. PSO has been used to optimize the parameters like patch length, width and feed position at center frequency of 1.95 GHz using Sonnet13.52

Keywords: Dielectric constant, FR-4,Microstrip Patch antenna; Particle swarm optimization; Probe feed; Resonant frequency; Return loss; Smith chart; WCDMA.

I. INTRODUCTION

In recent years, microstrip patch antenna has gain attention due to its low profile, low weight, low cost and small size [1]. Microstrip patch antenna is preferred for wireless communication applications. Microstrip patch antenna consists of a conducting rectangular patch of width W and length L on one side of dielectric substrate of thickness h and dielectric constant ε_r. Most popular methods to feed the microstrip patch antenna are microstrip line feed, coaxial probe feed, aperture coupled feed and proximity coupled feed. Top view of rectangular microstrip patch antenna using coaxial probe feed is shown in figure1.

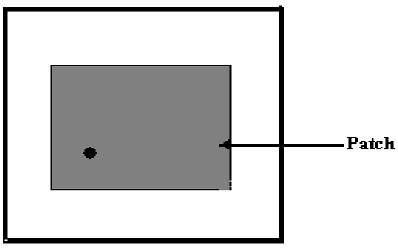

Fig1.Top view of probe fed rectangular microstrip patch antenna

Probe fed [2] microstrip patch antenna shown in Fig2.uses a coaxial connector soldered to the patch.

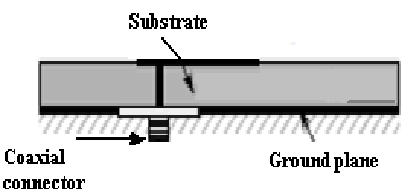

Fig.2.Side view of coaxial probe fed rectangular microstrip patch antenna [2]

II. PSO ALGORITHM

In 1995, particle-swarm optimization (PSO) was presented by James Kennedy and Russell Eberhart. PSO is based on movement and intelligence of swarm of bees or flock of birds [3] [4].A swarm of bees whenever fly in the field always try to find the location with abundance of flowers. Bee starts from a random location and a random velocity. Each bee has a change of velocity and position at each step. Change of Velocity v_n of the particle is given as

$$v_n = wv_n + c_1 \text{rand}\,()\left(p_n^{bp} - x_n\right) + c_2 \text{rand}\,()\left(g^{bp} - x_n\right)$$

Where x_n is the coordinate of the particle along the Nth dimension.

p_n^{bp}, g^{bp} are the personal best position and global best position respectively. The personal position and value are related to individual particles. The global best position and value are equal to all individuals.

c_1, c_2 are scaling factors and rand ( ) is uniformly distributed random number in the range 0 to 1.

w is inertial weight and is used for controlling the convergence.
Determine next position according to the equation given below

$$x_n = x_n + v_n * \Delta t$$

Δt is time step whose value is chosen to be 1 .

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III. RESULTS AND DISCUSSIONS

In this paper, length, width and probe offset of the patch have been optimized to resonate the microstrip patch antenna at 1.95GHz used for WCDMA. Taking the following equations

Resonant frequency (f_r) of the rectangular microstrip patch is given by [6]:

$$f_r = \frac{c}{2L\sqrt{(\varepsilon_{reff})}} \quad (1)$$

Here c is velocity of light.

Equation for ε_{reff} is given as below:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{W}\right)^{-0.5} \quad (2)$$

The resonant length of patch is not exactly equal to the physical length due to the fringing fields on the sides of patch. Effective length L_{eff} of patch is longer than its physical length and is given as:

$$L_{eff} = (L + 2\Delta L) \quad (3)$$

Increase in patch length (ΔL) is given as:

$$\Delta L = 0.412\frac{h(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (4)$$

Considering the fringing fields on sides of the patch, resonant frequency of patch is given as [6]:

$$f_r = \frac{c}{2L_{eff}\sqrt{\varepsilon_{reff}}} \quad (5)$$

Equation (6) gives the width of microstrip patch.

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (6)$$

TABLE-1

Optimum Patch length, Width, Feed position and Return loss for 1.95 GHz Resonant Frequency

Resonant frequency	1.95 GHZ
Optimized Patch length using PSO	36.43mm
Optimized Patch Width using PSO	25.79mm
Probe offset using PSO	14.79mm
Return loss	-27 dB

Design parameters chosen for microstrip patch antenna are

1. Center frequency is 1.95 GHz
2. The substrate material is FR-4
3. Dielectric constant of the material is 4.4
4. Substrate thickness is 1.588mm
5. Input impedance is 50 ohm

Different parameters plotted in Sonnet software are plotted below:

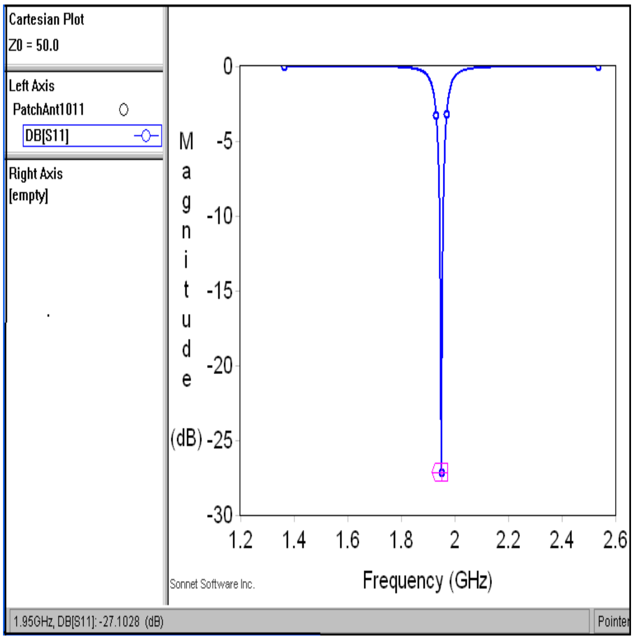

Fig.3 Return Loss Plot for 1.95 GHz resonant frequency

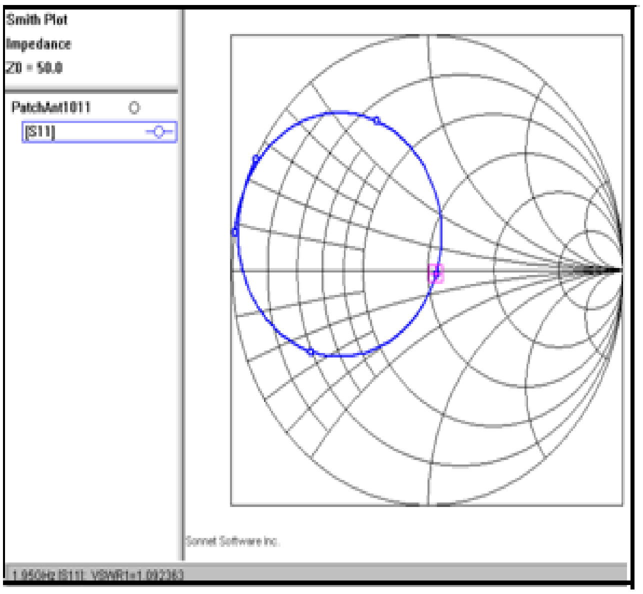

Fig.4 Smith chart of the 1.9GHz patch antenna

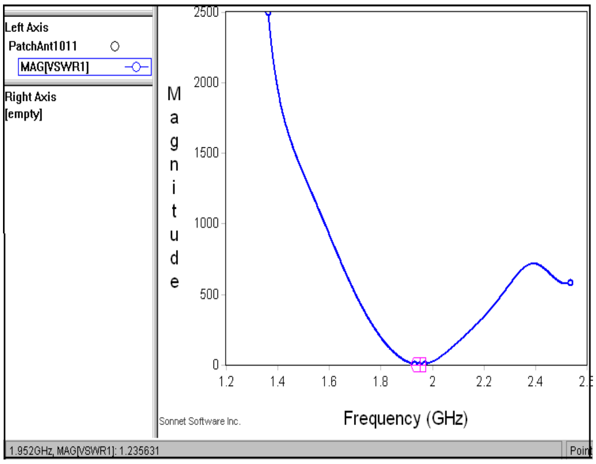

Fig.5 VSWR versus frequency plot of the patch antenna

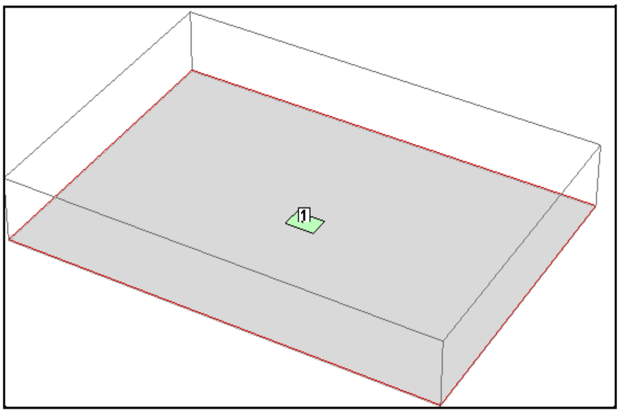

Fig.6 3-D view of rectangular microstrip patch antenna

CONCLUSION

Microstrip patch antenna resonated at exact 1.95GHz with the use of PSO. It can be concluded that the use of PSO saves time as compared to the design of patch antenna without optimization algorithm and also PSO restricts the variation from center frequency.

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