

# Design Of Microstrip Patch Antenna Using Particle Swarm Optimization Technique In Matlab

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## ABSTRACT

Particle swarm optimization (PSO) has been introduced to the electromagnetic community recently it is used for design optimization of microstrip patch antenna. Particle Swarm Optimization is an evolutionary optimization technique. In this paper PSO has been used for Optimization of Resonant Frequency and the Area of the patch of rectangular microstrip antenna. The investigation is made at 3GHz frequency range. The technique develops in this paper seems to be a generalized soft computing tool to calculate parameters of microstrip antenna such as Area, Resonant frequency and Probe position respectively. Accuracy of the results encourages the use of PSO.

## KEYWORDS

Rectangular micro strip patch antenna, Particle Swarm Optimization (PSO), patch length, patch width

## 1. INTRODUCTION

Antenna acts as the interface between transmitter and space. An antenna only converts an electromagnetic signal to an electrical signal at a receiver or electrical signal to an electromagnetic signal at a transmitter. Antenna can be defined as a conductor. Here the system of conductors used for radiating electromagnetic energy into space or for collecting electromagnetic energy from space.

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate as shown in Figure 1. The radiating patch and the feed lines are usually photo etched on the dielectric substrate [7]. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The first practical antenna was developed by Howell [3] and Munson [6]. A microstrip antenna is patch of dimensions  $W \times L$  fabricated on a substrate of thickness  $h$  and dielectric constant  $\epsilon_r$ . This paper presents a method for optimization of patch length, width and feed position so we use optimization soft computing tool to calculate the patch area, resonant frequency and feed position. Particle Swarm Optimization is optimization

technique; it is used by many researchers [2-5], due to its more accurate, speed and deterministic nature.

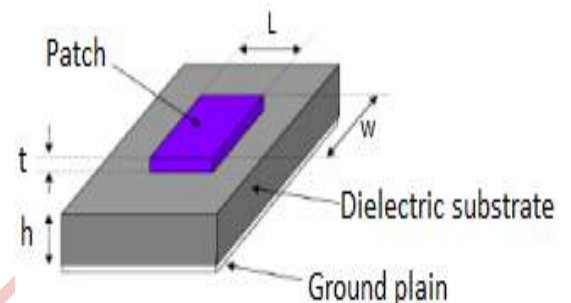


Figure 1: Structure of a Microstrip Patch Antenna

## 1.1 Particle Swarm Optimization Technique

The Particle Swarm Optimization (PSO) is one of the population-based stochastic optimization technique inspired by social behavior of bird flocking [4-9]. This is a local to global search method based on particle search. It follows the optimization process by means of local best (lbest), global best (gbest), particle displacement and particle velocity. In PSO, the individuals, called particles, are collected into a swarm and fly through the problem space by following the optima particles. [10] Each individual has a memory, remembering the best position of the search space it has visited. In particular, particle remembers the best position among those it has visited, referred to as pbest, and the best position by its neighbors. There are two versions for keeping the neighbors best position, namely lbest and gbest. The first (lbest) is related to the best position of the particle in the neighbors of the particle itself while gbest refers to the best position recorded by the entire swarm. Each individual of the population has an adaptable velocity (position change), according to which it moves in the search space. Thus, its movement is an aggregated acceleration towards its best previously visited position and towards the best individual of a topological neighborhood. The evolution of particles, guided only by the best solution, tends to be regulated by behavior of the neighbors. In the simplest form, the position  $S$  and velocity  $V$  of each particle are represented by the

following equations by considering lbest rather than gbest as the best position of the particle referred to the neighbors [4,9]. The velocity expression of the particle is represented as [9]

$$V(t) = W * V(t-1) + C1 * r1 (lbest - S(t-1)) + C2 * r2 (gbest - S(t-1)) \quad (1)$$

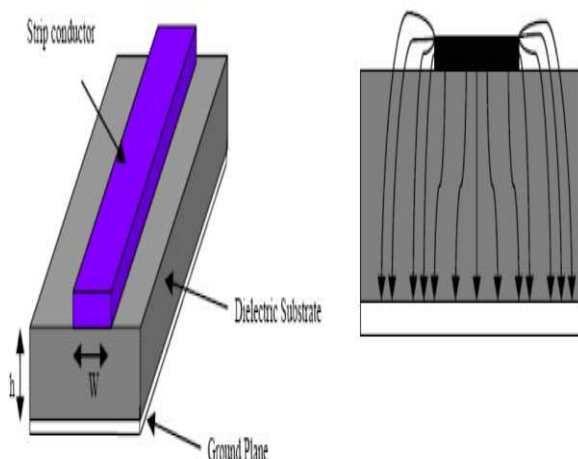
The position of the particle is represented as [9]

$$S(t) = S(t-1) + V(t) \quad (2)$$

Where V(t) is the velocity of the particle along the (t) th dimension and S(t) is the co-ordinate of the particle in that dimension. W is known as the 'internal weight' and its value, chosen to be between 0 and 1, determines to what extent the particle remains along its original course unaffected by the pull of IBEST and GBEST. C1 & C2 are the scaling factors that determines the relative 'pull' of IBEST and GBEST. C1 is a factor determining how much the particle is influenced by its IBEST and C2 is a factor determining how the particle is influenced by the rest of the swarm. The random function 'r1,r2' is introduced to incorporate the slight unpredictable component of natural swarm behavior.

## 2. RECTANGULAR PATCH ANTENNA

The parameters of this antenna can be calculated by the transmission line method as exemplified below. This model represents the microstrip antenna by two slots separated by a transmission line of length (L). Due to the finite dimensions of the patch along the length and width, the fields at the [8] edges of the patch undergo fringing. The fringing fields act to extend the effective length of the patch. Thus, the length of a half-wave patch is slightly less than a half wavelength in the dielectric material.



**Fig. 2 Microstrip line and its electric field lines**

Due to fringing, electric field lines travel in non-homogeneous material, typically substrate and air (shown in Fig 2), an effective dielectric constant

( $\epsilon_{\text{reff}}$ ) is introduced. The effective dielectric constant is expressed by the function of frequency. Generally, the relationship of effective dielectric constant ( $\epsilon_{\text{reff}}$ ), width (W), height (h) and relative dielectric constant ( $\epsilon_r$ ) of the substrate are related as follows [5]

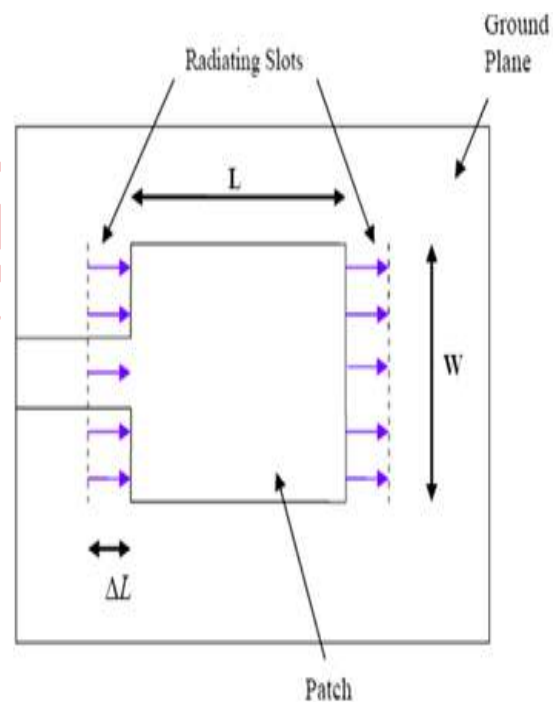
$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + \frac{12h}{W}\right)^{-0.5} \quad (3)$$

Extension of the length is obtained from below equation (4) [1]

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

Since the effective length of the patch has been extended by  $\Delta L$  on each side, (shown in Fig. 3) the effective length of the patch is expressed as

$$L_{\text{eff}} = (L + 2\Delta L) \quad (5)$$



**Fig. 3 Extension of the side of patch**

Length L and Width W of patch as follow

$$L_{\text{eff}} = \frac{c}{2 f_r \sqrt{\epsilon_{\text{reff}}}} \quad (6)$$

$$W = \frac{c}{2 f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (7)$$

### 3. RESULTS AND DESIGN

The antenna is designed and optimized at 3GHz using PSO algorithm, Initial values are taken as per given in the table 1.

**Table 1. Initial values for Optimization**

Parameters	Value
Center frequency of antenna	3GHz
Substrate thickness	1.578 mm
Permittivity of the substrate	2.42
Tangent loss of substrate	0.0012
Metal conductivity	Infinite
Thickness of the metal	0.7 mm
Input impedance	50 ohm

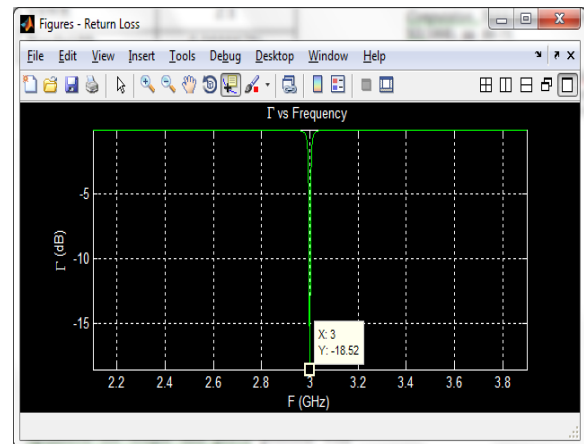
The optimized values are calculated as per given in the table 2.

**Table 2. Optimized Parameters of Patch Antenna**

Parameters	Value
Patch length	1.266 (in)
Patch Width	1.2432 (in)
Patch Area	1.5738(in)
Probe Offset	0.33979 (in)
Input Impedance	50.3858 ohm
Input Impedance Error	0.7716%
Resonance Frequency	3 GHz
Resonance Frequency Error	0%
VSWR	2:1
Bandwidth	0.066667%

For a radio (transmitter or receiver) to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna's impedance. The parameter **VSWR** is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR is determined from the voltage measured along a transmission line leading to an antenna. VSWR is the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave When an

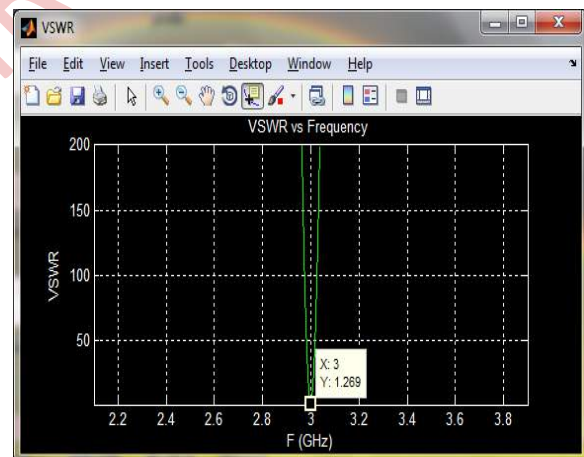
antenna is not matched to the receiver, power is reflected (so that the reflection coefficient,  $\Gamma$ , is not zero). This causes a "reflected voltage wave", which creates standing waves along the transmission line.



**Figure 4: Return loss**

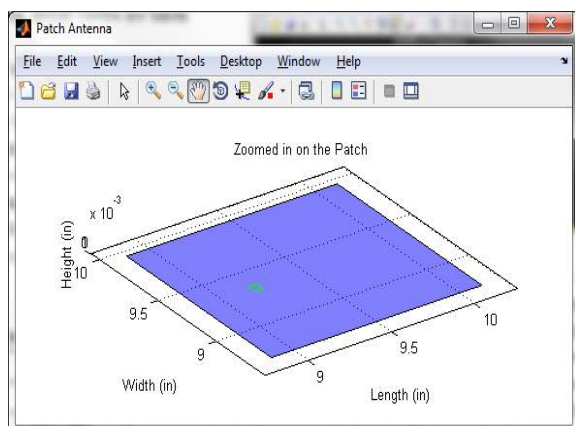
The results are the peaks and valleys as seen. If the VSWR = 1.0, there would be no reflected power and the voltage would have a constant magnitude along the transmission line.

Figure 4 shows that return loss of the rectangular microstrip patch antenna at the 3GHz Frequency is -18.52dB.



**Figure 5: VSWR**

Figure 5 show that VSWR (voltage Standing Wave Ratio) of the rectangular microstrip patch antenna is 1.269



**Figure 6: Designed patch**

Figure 6 shows that length, width and probe offset of the rectangular microstrip patch antenna at the 3GHz Frequency is 1.266(in), 1.2432(in) and 0.33979(in) respectively.

#### 4. CONCLUSION

Due to their small size patch antenna are gaining popularity. A rectangular micro strip patch antenna has been designed in MATLAB and is optimized for Area and probes position with targeted resonant frequency of 3GHZ. Results shows that antenna exactly resonate at 3GHZ frequency with reasonable return losses.

#### 5. ACKNOWLEDGMENT

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