Chapter 7
Electromagnetic Optimization Using Genetic Algorithms

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ABSTRACT

This chapter focuses on the application of Genetic Algorithms (GAs) techniques in overcoming the limitations of microstrip antennas in terms of several key parameters such as bandwidth, power-handling capacity etc. In this chapter the effectiveness of GAs is discussed in relation to Electromagnetic optimization. A matching network has been designed for single band and dual band matching of microstrip antenna using GA.

INTRODUCTION

Microstrip geometries were originally contemplated in the 1950s (Grieg &Englemann, 1952). The microstrip antenna integrated with microstrip transmission line developed by Deschamps [1953] was the earliest known realization of this kind of structure. Figure 1 shows the structure of a simple microstrip patch antenna. The antenna is fabricated on one side of a substrate and on the other side the copper metallization is retained. A microstrip antenna can be modeled as a resonator with considerable radiation loss. The top and bottom metallization forms two electric walls and the four side slots form the magnetic walls. Radiation from the structure can be explained in terms of the leakage of field lines through the side slots. The length of the patch is chosen to be approximately half wavelength, so that out of the four side slots, only two radiates efficiently. Due to its resonant structure a microstrip antenna has a very narrow impedance bandwidth that limits the applicability of the antenna. The motivation behind the present work is to overcome this limitation with some simple structures of the antenna, so that it can be used as a wideband antenna that has a large range of application in the field of satellite or mobile communication. Artificial Neural Networks (ANNs), Genetic Algorithms (GAs), Swarm Intelligence (SI), etc. are well known in the field of Soft Computing for their

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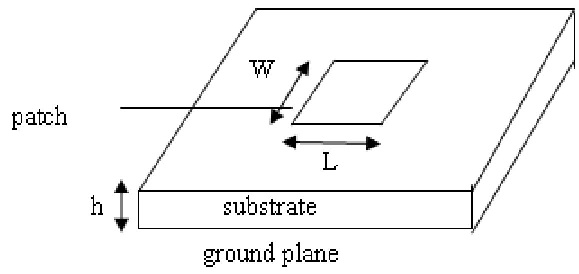
Figure 1. Geometry of a microstrip Antenna (h=substrate thickness, W=patch width, L= patch length)



ability to solve real world problems in areas such as design, optimization and so on. GAs provide a mechanism by which the solution space for a particular problem is searched for "good solutions". GAs are inspired by Darwin's theory about evolution and models his principles of 'Natural Selection' and 'Survival of the Fittest'. Goldberg (1989) presented the first GA optimizer. GAs have been successfully applied in designing printed antennas (Michael Johnson. & Rahmat Samii, 1997; Rahmat Samii & Michielson, 1999; Sun, Hines, Mias, Green, & Udrea, 2005; Namkung, Hines, Green, &Leeson, 2007). Popovic (1982) has shown that a monopole which is inclined at a particular angle can be perfectly matched and can also exhibit a directive pattern in the horizontal plane. A good match and a given pattern can be achieved simultaneously by properly choosing the angles of inclination of the different segments. In a particular example the length of each of the five segments have been chosen to be $l = \lambda_0/6$ (f = 0.964 GHz) and θ (angle of inclination) can vary from 0^o up to 180^o. The optimized values of the angles of the different segments can be obtained with the aid of GAs. Dual-frequency operation can be obtained with two slots printed on the patch. The number of slots, the positions of the slots, and the slot lengths on the patch are important parameters in the design. The effects of all the parameters of the antenna can be described successfully by the theory. Both the resonant frequency and input impedance of the slotted antenna depend on the loading slot length and position. The main difficulty of these kinds of designs is how to choose the loading slot that will satisfy the desired frequency and the input resistance at resonance simultaneously. In this case, the objective function can be chosen to be the summation of reflection coefficients at the two frequencies. The GA has been successfully applied by a number of researchers to improve the impedance bandwidth with an optimized patch shape (Delabie, Villegas, & Picon, 1997). In a particular method the patch has been considered to be made of a number of metallic cells and GAs have been used to remove some of the cells to obtain the desired impedance bandwidth. Artificial Neural Networks (ANN) also has been successfully applied for impedance matching of microstrip antenna (Pattnaik , Panda & Devi**,** 2002); for the optimization of the input impedance of rectangular microstrip patch antenna (Sharma & Gupta, 2007);in the analysis and synthesis of these antennas, to predict both patch dimensions and resonant frequency (Sagiroglu, Güney & Erler, 1999).

In many applications, it is desired to operate the same antenna in two or more discrete frequency bands with an arbitrary separation of bands. There are many techniques that ensure wideband and multiband operation of microstrip antennas. For example the frequencies of operation for an annular ring can be adjusted by choosing the inner and outer radii. However, the ratio of the two frequencies is somewhat limited (Wang & Lo, 1994). By modifying the geometry of the basic antenna it is possible to obtain a shift in the operating frequency