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# Genetic Algorithms for the Synthesis of Circular Microstrip Ring Antenna

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## Abstract

Microstrip antennas synthesis is a demanding task; many of the equations involved in the process use various approximations due to the nonlinear properties and relations that govern the antenna synthesis. In This paper we tried to use genetic algorithm to design a circular microstrip ring that operates in a predefined frequency band (402 – 405 MHz) Medical Implant Communication Service Frequency Band. The methodology and procedures are presented, a presentation of the method is provided and an HFSS simulation of the antenna is made. Results are presented with guidelines for further future work

## 1. INTRODUCTION

Microstrip antennas gained large attention due to their characteristics; they are electrically thin, lightweight, low cost, conformable , easy to manufacture and can be produced as arrays. However, they generally suffer from some drawbacks, like the narrow bandwidth, and low power handling capacity [1]. Even with the mentioned drawbacks the advantages of microstrip antennas overcome the drawbacks and make them preferable antennas for wireless applications like satellite, high-performance spacecraft, aircrafts, missiles and mobile phones. They are in the category of resonant type antennas which makes an accurate determination of the operating frequency of the antenna an essential part of the antenna design due to their small bandwidth [1].
These methods for computing the resonance frequency of MS antennas can be broadly categorized into three main categories: analytical, numerical and optimization methods. Analytical methods based on physical phenomena and physical assumptions that describe the radiation mechanism of the antenna through the solution of Maxwell's equation are the most useful ones. However, due to various assumptions the accuracy of these methods is limited within the restriction conditions of the antenna like the relationship between substrate thickness and wavelength.
The numerical methods provide veritable results however, the computational effort and the error outcomes of rounding are a considerable trade off factors for accuracy. Changing the geometry and the details of the antenna would require solutions to be redone [2]. A more recent trend or the third category is the use of optimization techniques and artificial neural networks (ANN) for antenna design and analysis [3].
In our research project we tried to apply genetic algorithm using MATLAB to synthesis a circular ring antenna to work in the 402 – 405 MHz frequency range. Trial was based on the work done by [6], however we did not go through to the end due to various obstacles. Some of the optimization techniques used for antenna design are presented in the literature and previous work; in [6]

genetic algorithms combined with cavity methods are used for determining the radius of annular ring microstrip antennas, while in [7] genetic algorithms are used to design a small size antenna for body implanted devices, the synthesis of triangular antenna using ANN was done in [8], in [9] a hybrid method combining neural network and fuzzy inference was design for the computing resonant frequency of various microstrip antennas. The novelty in this paper comes from the fact that synthesis is based on experimental results and we are calculating the feed point of the coaxial line.

This report is organized as follows, after the brief introduction, the circular ring antenna and the formulas based on cavity models are presented, then a general overview of genetic algorithm with an example in section 3, our problems and a way to overcome them are reported in section 4 and finally our conclusion in section number 5.

## 2. MICROSTRIP CIRCULAR ANTENNA

With applications as a resonator in measurements of a substrate dielectric constant and as a radiator in medical applications the microstrip ring antenna comes as an improvement of the circular patch antenna, the improvement in the sense of size reduction. Figure 1 shows the antenna.

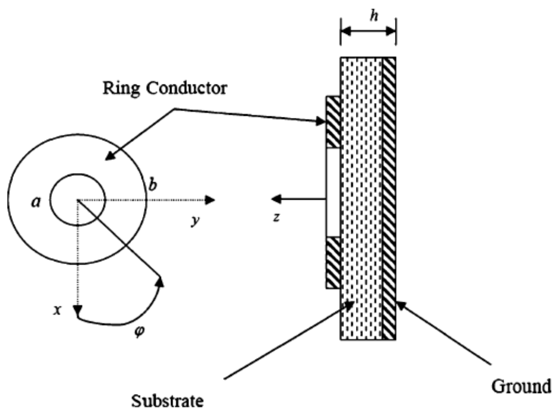


Figure 1 microstrip circular ring antenna

Where: a the inner diameter of the ring
b the outer diameter of the ring

The circular ring antenna has a couple of useful features:

1. The separation of resonant modes can be controlled by the ratio of outer to inner radii.
2. The impedance bandwidth in TM12 mode is several times larger than on other patches, but at the cost of a larger size.
3. it is possible to combine a circular ring with another concentric ring to form a compact dual band

Cavity model essentially used to analyze the antenna, and due to circular shape, Bessel functions are found in the relations that governs the approximation in the cavity model. The relations based on cavity model are summarized as follows:

Radii of the antenna are governed by the Bessel derivatives:

$$J_n'(kb)Y_n'(ka) - J_n'(ka)Y_n'(kb) = 0 \ldots (1)$$

The constants which are substituted in the Bessel derivative:

$$k = \frac{X_{nm}}{a} \ldots \ (2)$$

The operating frequency with fixed dielectric constant:

$$f_{nm} = \frac{X_{nm}c}{2\pi a\sqrt{\varepsilon_r}}$$

The operating frequency with effective dielectric constant:

$$f_{nm} = \frac{X_{nm}c}{2\pi a\sqrt{\varepsilon_{re}}}$$

The input impedance of the antenna:

$$Z_{in} = j\omega\mu_0 h \times \left\{ \sum_{n=0}^{\infty}\sum_{m=1}^{\infty} \frac{\pi k_{nm}^2 \left(\frac{\sin 2\pi\omega f}{2n\omega f}\right)[J_n(k_{nm}\rho_0)Y_n'(k_{nm}a_e) - Y_n(k_{nm}\rho_0)J_n'(k_{nm}a_e)]}{2\epsilon o_n n\left(k_{eff}^2 - k_{nm}^2\right)\left[\frac{J_n'^2(k_{nm}a_e)}{J_n'^2(k_{nm}b_e)}\right]\left(1 - \frac{n^2}{k_{nm}^2 b_e^2}\right) - \left(1 - \frac{n^2}{k_{nm}^2 a^2}\right)} \right\} \times cos^2 n\varphi_0 \ldots (5)$$

The effective radii (a & b)

$$a_e = a - 3h/4$$
$$b_e = b + 3h/4$$

Where:

$$k_{eff} = k_0\sqrt{\varepsilon_{re}\left(1 - j\delta_{eff}\right)}$$

## 3. GENETIC ALGORITHMS

Genetic Algorithms is a fast growing optimization technique that imitates the natural selection process and survival of the fittest for finding optimum values of nonlinear multidimensional functions. A predefined objective function is optimized to find its global and/or local maxima and minima.

The basic and general steps for genetic algorithm are:

1. Generalization of a random population (variables to be optimized)
2. Calculating the fitness of that population (substituting the variables in the objective function)
3. Selection of population members to proceed and cancelation of population members who did not pass the selection process
4. Cross-Over Producing offspringof the passed members
5. Mutation (changing the offspring’s properties)

6. Back to point no. 2 and repeat 2-5 until the best fit of variables is found.

Flow charts for a general genetic algorithm and for application for antenna design is shown in figure 2 and 3 respectively

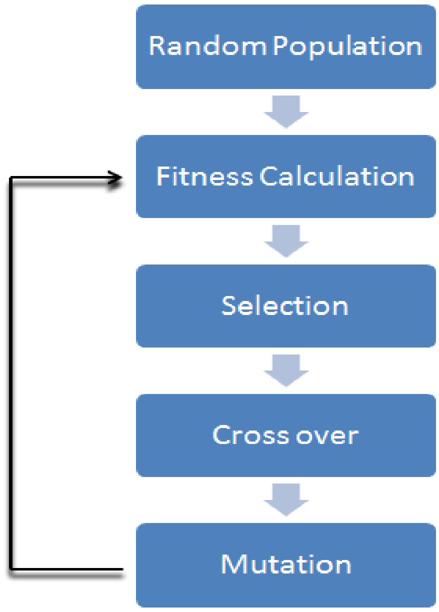


Figure 2 General flow chart for genetic algorithm

Based on flow chart figure 3 and formulas for rectangular microstrip antenna using transmission line model, a demonstrative genetic algorithm code was written and used to synthesis rectangular microstrip antennas. The code is shown in the appendix of this report.
The program asks the used to enter the desired frequency, substrate height and substrate dielectric constant, and then it calculates L and W for the user.

## 4. PROBLEMS WE ARE FACING, RESULTS AND FURTHER WORK

Some unexpected problems were face during our work, and the most crucial ones are the interpretation of physical concepts derived by cavity model. Like Keff, feed angular width 2ωf. The whole procedure of antenna synthesis using cavity model is not clear and no practical examples available in literature.Using equations 3 and 4 an approximate value of inner radius was received and that value was used in HFSS to see if the antenna works well. The antenna and its return loss are shown in appendix b.
However due to not so good results of the return loss not very deep investigation was made. Further work is summarized as follows: deeper and longer literature review and survey to adequately list the steps for analytically and using genetic algorithm, implement the design found in previous work and test it using an adequate software (HFSS) and finally build the antenna in case of simulation success.
One drawback though of the antenna is the fact that the operation frequency is relatively low, this is reflected on the size of the microstrip antenna. Generally, low operating frequencies result in larger size of regular and semi-regular antennas;so another idea for further work plans is to think of different shape or even different type of antenna.

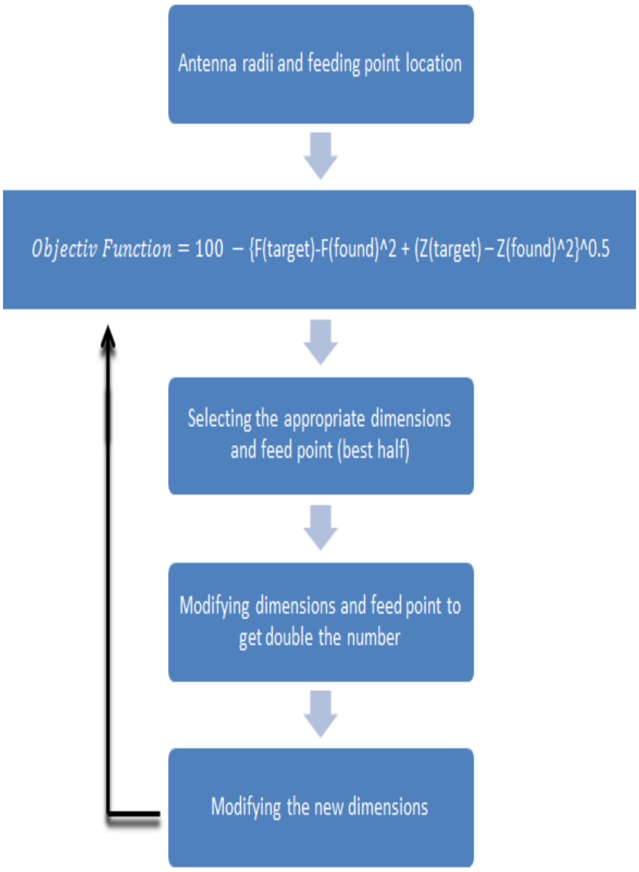


Figure 3 flow chart of genetic algorithm to be used for ring microstrip antenna

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