Parameter Optimization Based on GA and HFSS *

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Abstract *A new project based on genetic algorithm (GA) and high frequency simulation software (HFSS) is proposed to optimize microwave passive devices effectively. This project is realized with a general program named as optimization program. The program is compiled by Matlab and the macro language of HFSS which is a fast and effective way to accomplish tasks. In the paper, two examples are used to show the project's feasibility.*

Key words *GA; HFSS; Matlab; macro language*

There are a lot of optimization and self-adaptive problems in the field of computational electromagnetics. It is difficult to solve these problems in large and complex systems except for some simple applications.

Genetic algorithm (GA) is essentially a search algorithm based on the mechanics of nature (e.g. natural selection, survival of the fittest) and natural genetics. It combines solution evaluation with randomized and structural exchanges of information among solutions to obtain optimization. GA is considered to be a robust method because no restrictions on the solution space are made during the process. The power of this algorithm comes from its ability to exploit historical information structures from previous solution guesses in an attempt to increase performance of future solution structures[1].

High frequency simulation software (HFSS) is an interactive software package for calculating electromagnetic behavior of a structure. The software also includes post-processing commands for analyzing the electromagnetic behavior of a structure in more detail. Using HFSS, we can compute basic electromagnetic field quantities, radiated near and far fields for open boundary problems, port characteristic impedances and propagation constants, general *S*-parameters and *S*-parameters renormalized to specific port impedances, and the eigenmodes or resonances of a structure.

By combining the merits of GA and HFSS, the optimization can be realized for high frequency's structures, especially for large and complex systems.

1 Related Work

We propose a new project which is suitable for the optimization of microwave passive devices by combining the merits of GA with HFSS. The project includes two processes: one is that HFSS simulates each structure whose parameters are produced and optimized by GA and returns the results of simulation to GA, and another is that GA optimizes the structure's parameters continually according to the data returned from HFSS. The two processes are being run alternately until a satisfying optimization is obtained.

A program named as optimization program has been compiled to realize the project. We complete the work with two softwares, Matlab and HFSS. Our optimization program shown in Fig.1 includes two parts: genetic algorithm module and fitness module.

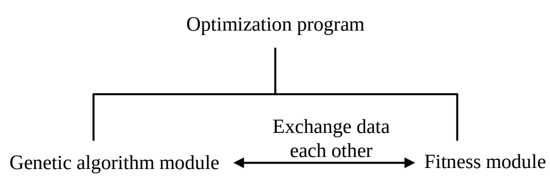

Fig.1 The framework of the optimization program

The genetic algorithm module shown in Fig.2 is compiled with Matlab. It is not only the main program but also a general optimization program. The genetic algorithm module is based on simple genetic algorithm (SGA) and some new genetic techniques proposed in recent years[2,3]. It has three functions. First, it sends each structure's parameters produced by itself to the fitness module. Second, it receives each structure's fitness from the fitness module. Third, it optimizes structure's parameters continually according to the fitnesses returned from the fitness module until a satisfying optimization is obtained.

Received 2004-03-08

* Supported by the Specialized Research Fund for the Doctored Program of Higher Education (No.20010614003) and the Key Project of Chinese Ministry of Education (No.104166)

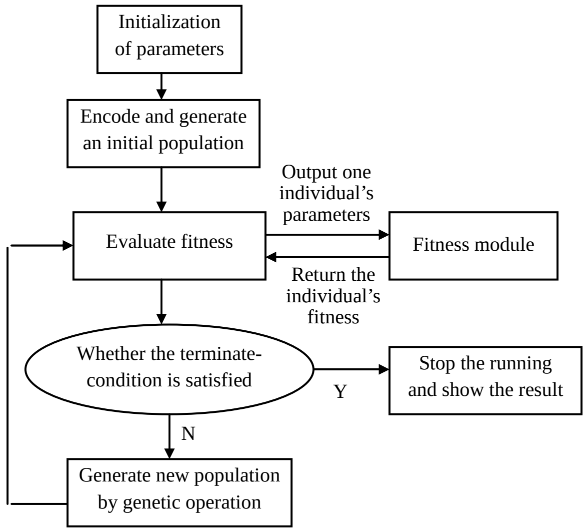

Fig.2 The framework of the genetic algorithm module

The fitness module shown in Fig.3 is made up of several subprograms compiled by Matlab and the macro language of HFSS[4]. It has two functions as follows.

1) It receives each structure's parameters from the genetic algorithm module and then sends them to HFSS.

2) It calls HFSS to simulate the structure after sending a structure's parameters to HFSS and returns the results of simulation to the genetic algorithm module as the structure's fitness after simulation.

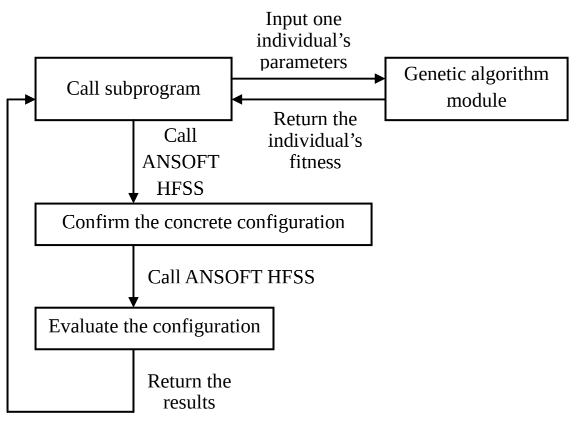

Fig.3 The framework of the fitness module

The optimization program requires users to do parameter preassignment by using the macro language of HFSS to compile program sentences. In order to make the optimization program be used conveniently, the preassignment is done through the interface of HFSS according to the datum-saving character of HFSS.

2 Examples

2.1 Impedance Converter of Rectangular Waveguides

The size of a section of impedance convertor of the rectangular waveguides shown in Fig.4 has been optimized to reduce S_{11} at 10 GHz. The parameters of optimization include the length *c*, the width *a*, and the height *b* of the middle section of the rectangular waveguides. Tab.1 shows the ranges for parameter optimization. Without the middle section, S_{11} is equal to 0.24076 at 10 GHz. After inserting the middle section and optimizing its parameters, S_{11} is equal to 0.004 93 at 10 GHz and the optimized results are also shown in Tab.1. The *S* parameter curves are shown in Fig.5 respectively.

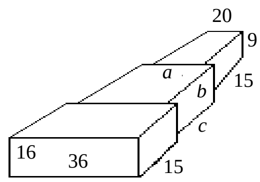

Fig.4 The rectangular waveguides

Tab.1 The ranges for parameter optimization and the optimized results

Parameters	*a*/mm	*b*/mm	*c*/mm
Minimum	21	10	1
Maximum	35	15	30
Optimized results	34.835 294	12.333 333	22.266 667

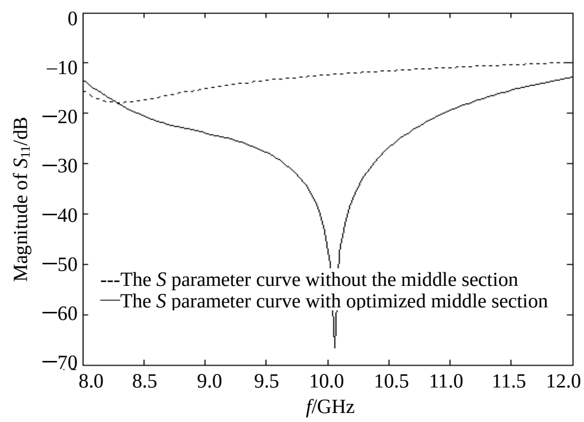

Fig.5 The *S* parameter curve

In the genetic algorithm module, each optimized parameter is expressed by 8 binary bits, and the population size and the number of generations are equal to 10 and 80, respectively. The curve of each generation's best value of fitness is shown in Fig.6.

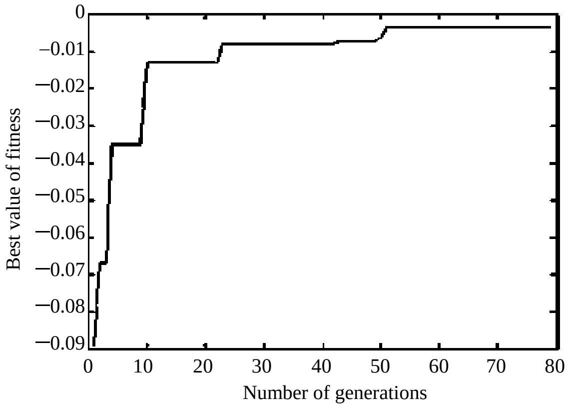

Fig.6 The curve of each generation's best value of fitness

2.2 Microstrip Antenna

The size of a microstrip antenna shown in Fig.7 has been optimized to reduce S_{11} at 2.45 GHz. The parameters to be optimized include the thickness h of the substrate and the length a of the foursquare patch. Tab.2 shows the ranges for parameter optimization and the optimized results. The optimized S parameter curve is shown in Fig.8.

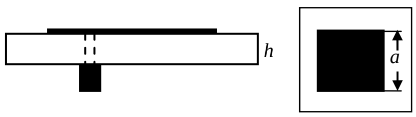

Fig.7 A microstrip antenna

Tab.2 The ranges for parameter optimization and the optimized results

Parameters	a/mm	h/mm
Minimum	25	2
Maximum	40	8
Optimized results	29.823 529	7.811 765

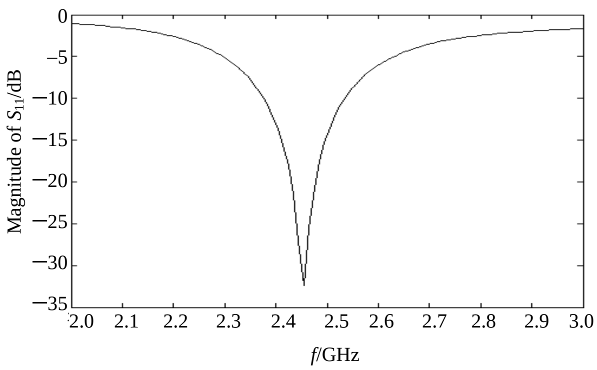

Fig.8 The optimized S parameter curve

In the genetic algorithm module, each optimized parameter is expressed by 8 binary bits, and the population size and the number of generations are equal to 10 and 80, respectively. The curve of each generation's best value of fitness is shown in Fig.9.

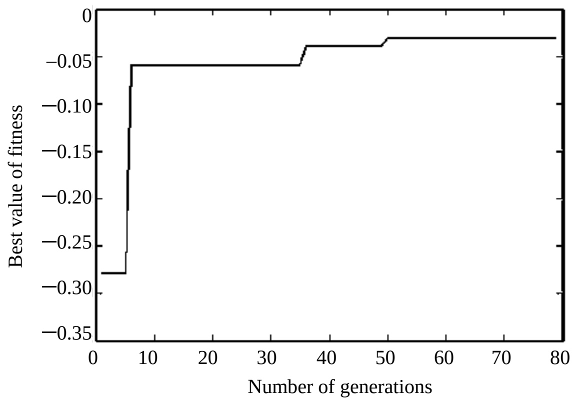

Fig.9 The curve of each generation's best value of fitness

3 Conclusions

Two examples have been optimized, and the results of optimization show the project is effective and can offer beneficial reference for the device design. In the later work, we will make the program be used more conveniently. At the same time, new genetic techniques will be introduced into the program continuously to improve the convergence velocity and search ability of its optimization algorithm.

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