DESIGN OF JAUMANN ABSORBERS USING ADAPTIVE GENETIC ALGORITHM

Ali Reza Foroozesh, Ahmad Cheldavi, Farokh Hodjat
Department of Electrical Engineering
Iran University of Science and Technology
Narmak, 16844 Tehran, Iran
foroozesh@sun.iust.ac.ir
cheldavi@sun.iust.ac.ir

Abstract

In this paper, an adaptive genetic algorithm which its operators are sensitive to the state of the problem, has been introduced and applied for designing Jaumann absorbers. The Jaumann absorbers has appropriate characteristics, considering our specified conditions. Optimization algorithm were done to reduce reflection coefficient and thickness of the dielectrics. An error analysis, also, has been performed on this design, which shows its reliability for fabrication.

*Index terms*__ Jaumann absorber, genetic algorithm.

I. *Introduction*

Jaumann absorbers are widely used for military and industrial purposes. In the literature, for example [1]-[4], several kinds of analysis, synthesis and optimization of Jaumann absorbers are performed. In all of these refrences, Jaumann absorbers has been modeled by transmission line and shunt impedance (Fig. 1). On the basis of transmission line model and using adaptive genetic algorithm, in this paper design of the Jauamnn absorbers has been performed, which satisfy following conditions:

1. Reflection coefficient must be less than -35dB in the X band.
2. Only one dielectric (nonmagnetic) material must be used as dielectric spacers.
3. All of the sheets must have resistance (not reactance) characteristics.
4. Total thickness of the absorbers must be decreased at least by %45 in comparison with classic Jaumann absorbers [1].

In fact, the above conditions specify our problem. We try to find its solutions, by using transmission line model and adaptive GA.

Our design is very simple for fabricating, considering that we only use one dielectric material. As we know the magnetic materials characteristics varies as frequency changes, and they are frequency dependent specially at high frequencies. Also, we use only resistance for our design because, capacitance or inductance model over wide range of frequencies and with good approximation, has not been exhibited for circuit analog sheets, yet. All of the frequency selective surfaces act as a filter and we can not use them for modeling capacitance or inductance, exactly. Our design has better thickness in comparison with the designs in [1]. In the Section II, we state the formulation of the problem. In Section III, we introduce a new adaptive GA for fast convergence. The cost function is introduced in Section IV. We have an error analysis and results in Section V. In Section VI, we have conclusion.

II. *Formulation using transmission line model*

It is assumed that Jaumann absorber has dielectric material spacers and resistive sheets which all of them are infinite and homogeneous in transverse dimension and isotropic in axial dimension. Thus we can apply transmission line model as Jaumann absorbers [1].

Considering Fig. 1 we have:

$$Y_i = \begin{cases} G_i + Y_c \dfrac{Y_{i-1} + jY_c \tan(\beta d_i)}{Y_c + jY_{i-1} \tan(\beta d_i)} & i = 2,3,\ldots,N \\ G_i - jY_c \cot g(\beta d_1) & i = 1 \end{cases} \qquad (1)$$

where $Y_c = (Z_c)^{-1}$ is intrinsic admittance of the dielectric, and dielectric material are the same for all of the spacers and has $\varepsilon_r = 1.03$ (Styrofoam) and $\mu_r = 1$. Reflection coefficient is:

$$|\rho| = \left| \frac{Y_{in} - Y_a}{Y_{in} + Y_a} \right| \qquad (2)$$

where Y_a is free space admittance and is equal to $(120\pi)^{-1}$, Y_{in} is input admittance of the network and is equal to Y_N and $(Z_{in})^{-1}$.

III. *Genetic algorithm using adaptive mutation*

In traditional GAs [5]-[6], mutation is applied in order to prevent function, getting stuck in local minima. Mutation randomly affect on a few bits in chromosomes and usually status of the problem is not been considered. But, in nature, mutation occurs for more adaptation between animates and their environment. It is obvious, environment has significant role on this operation. Even we can state that mutation affects on special genes for more adaptation to lengthen animate life. So, in the optimization methods, one is able to determine a kind of adaptive mutation, considering the status and structure of the problem. These kind of GAs could increase convergence speed of the algorithm. Specially in the case that entire solution space is not very large and also, the solution is not global minima.

To clarify this idea notice the following example:

Suppose, the first elements of the chromosomes table, approach to the desired solution, in each iteration. Suddenly, mutation affects on two most significant bits of two important genes in each chromosomes. In this situation the status of the problem changes , some appropriate elements (chromosomes) are lost and we are not able to approach desired solution rapidly. Thus if we have some chromosomes in the table that they are very close to the desired chromosomes (desired solution), it is better to prevent them of mutation effect, or at least define some constraints for mutation. For example only least significant bits (LSBs) are allowed to be affected by mutation.

In the opposite case, suppose that the function locates in valley of spurious local minimum. This local minimum is very close to our solution but does not satisfy all of the desired conditions. In this case adaptive mutation needs some counter for preventing getting stuck in the local minimum, i.e., after specified number of iteration and mutation, we can use traditional mutation. In some cases, even increasing number of bits which affected by mutation and specifying some special (important) genes and applying mutation on those genes, could help us to prevent getting stuck in spurious local minima. Even, one can use some constraints for mutation. For example only the first four bits (MSBs) in each gene are allowed to be affected by mutation.

Of course combination of above implementation and ellistism, could increase the speed of convergence.

IV. *Solving the problem using adaptive genetic algorithm*

The corresponding cost function is:

$$f = \alpha_1 \rho_{BW} + \alpha_2 d_t \qquad (3)$$

where ρ_{BW} is a reflection coefficients in X band which must be less than -35dB and d_t is total thickness of Jaumann absorber. α_1 and α_2 are weighting coefficients for each terms. Spacers thickness and sheets resistance are variables. The genes that determines thickness of the spacer are important genes. Because, in addition to their significant role in reflection they corporate in cost function, directly.

V. *Results and error analysis*

Two 5-layer Jaumann absorbers were designed which satisfied the conditions of the problem, specified in Section I. We call those two designs, design (a) and design (b). Figs. 2(a) and 2(b) shows their reflection characteristics. Surface resistance of the sheets and thickness of the dielectric are shown in Table1 and 2, respectively.

Because of the fabricating error, we round the values of design (a) and call it design (c). One can see that the reflection coefficient of design (c) is less than -30dB in X band (Fig. 2(c)) and it is a appropriate design for fabrication.

VI. Conclusion

In this paper a new kind of adaptive GA was presented which uses adaptive mutation. This algorithm was successfully used for design of Jaumann absorbers.

Table.1
Resistance of the sheets in (Kilo Ohm per square)

	R_1	R_2	R_3	R_4	R_5
design (a)	0.39	0.58	1.00	2.30	10.00
design (b)	0.146	0.36	2.20	3.30	7.60
design (c)	0.39	0.60	1.00	2.30	10.00

Table.2
Thickness of the dielectric layer in (cm) and decreasing percent in comparison with classic Jaumann absorber

	d_1	d_2	d_3	d_4	d_5	total thickness	decreasing percent of total thickness
design (a)	0.4999	0.1800	0.4699	0.3599	0.4799	1.9896	%46.15
design (b)	0.2220	0.5864	0.4777	0.3343	0.0573	1.6777	%54.60
design (c)	0.5	0.2	0.5	0.4	0.5	2.1	%43.17
classic Jaumann absorber	7.39	7.39	7.39	7.39	7.39	3.6950	–

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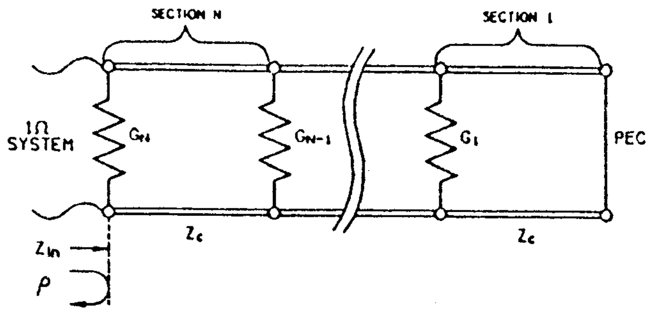

Fig. 1. The Jaumann network model (from [1]).

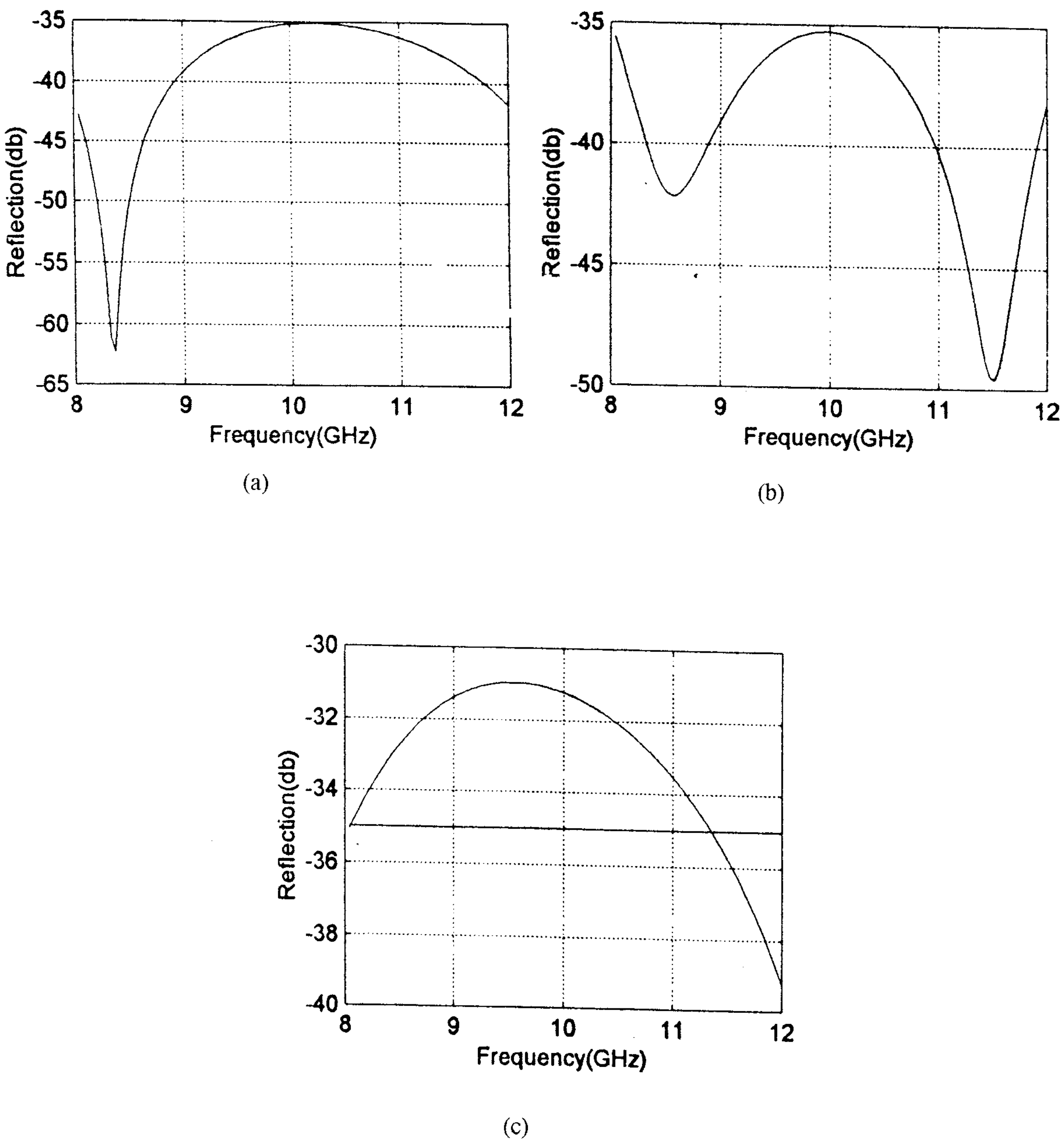

Fig. 2. Three different Jaumann absorbers characteristics. Design (a) and (b) obtained by using GA. Design (c) obtained by rounded values of design (a). All of related values are shown in Table 1 and 2.