where \( \gamma = (RCL/\Delta t^2) + (L/2\Delta t) \). This finite-difference equation in combination with (2) and (6) can analyze this case. Figure 8 shows the admittance of a concatenation with a capacitor of \( C = 1 \text{ pF} \), an inductor of \( L = 10 \text{ nH} \), and a resistor of \( R = 10 \text{ k\Omega} \). The FDTD results can be found to have the same accuracy as those from the circuit method.

CONCLUSIONS

In this paper, distributed electromagnetic systems with lumped elements were analyzed, and alternative formulations for FDTD simulations of a capacitor, inductor, and diode were proposed, which make it possible that any concatenation of multiple lumped elements can be inserted into one Yee cell or the dynamic range can be extended in the FDTD calculations. Several circuit configurations were simulated by using the FDTD method, and their results were found to have the same accuracy as those from the circuit method.

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LOW-SIDELOBE PATTERN SYNTHESIS OF SPHERICAL ARRAYS USING A GENETIC ALGORITHM

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ABSTRACT: A genetic algorithm (GA) finds complex weights that yield low-sidelobe levels for spherical arrays. The first example is a spherical–planar array with an initial high sidelobe of \(-13 \text{ dB} \), and which has an optimized pattern with a maximum sidelobe level of \(-27 \text{ dB} \). The second example is a spherical–circular array with an initial high sidelobe of \(-16 \text{ dB} \), and which has an optimized pattern with a maximum sidelobe level of \(-34 \text{ dB} \). © 2002 Wiley Periodicals, Inc. Microwave Opt Technol Lett 32: 412–414, 2002.

Key words: genetic algorithm; low-sidelobe pattern; spherical arrays; conformal arrays

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1. INTRODUCTION

Low-sidelobe array pattern synthesis techniques developed for linear and planar arrays do not work well with spherical arrays. Since the array elements are conformal to the surface of a sphere, the phase at each element becomes critical for synthesizing low-sidelobe patterns. Pattern synthesis of conformal arrays has been attempted using several different approaches [1–4].

In this paper, we use a GA to synthesize low-sidelobe amplitude and phase distributions for spherical arrays. GAs have been successfully applied to the antenna array synthesis. Haupt introduced GAs for antenna array pattern synthesis in [5]. A GA was applied to optimize linear and planar arbitrary array patterns [6], and to reduce the sidelobe levels of a linear and circular array [7]. In addition, the superiority of the GA to the MMSE method (minimization of mean-square errors) was also shown in [7].

The analysis of a spherical array was introduced by Hoffman [8]. This paper uses these equations to form an objective function for reducing the sidelobe levels using a GA. The GA successfully reduces the sidelobe levels of two types of spherical arrays by finding the optimum complex weights for the 256-element arrays.

2. MODELING OF SPHERICAL ARRAYS

Spherical arrays conform to the surface of a sphere. Their main beams can be steered over a hemispherical coverage area. Figure 1 shows the coordinate system used for analyzing a spherical array. A spherical array factor with no beam steering is given by Hoffman [8] as

\[
E(\theta, \phi) = \sum_{n=1}^{N} A_n \cdot f_n(\theta, \phi) \cdot \exp[-jkR(\cos \xi_n - \cos \xi_0)]
\]
cost = −|peak sidelobe level (dB)| − |loss in gain (dB)|. (3)

The second item in the cost function compensates for main-beam degradation.

The GA controls the amplitude between 0 and 1 using eight out of eight bits, and the phase between 0 and π using seven least significant bits out of eight. The GA has an initial population of 48, a discard rate of 50%, a mutation rate of 10%, and random selection for the mating.

In Figure 4, the sidelobe level of a spherical–circular array, generated by a GA, is −34 dB expressed by a solid line, and the dashed lines indicate the spherical–circular array initial patterns with uniform amplitude weights and zero phase shifts.

In Figure 5, the dashed lines indicate the spherical–planar array patterns with uniform amplitude weights and zero phase shifts, and the solid lines indicate low-sidelobe patterns which are generated by a GA. The initial −13 dB sidelobe level is reduced to −27 dB by a GA.
4. CONCLUSIONS

This paper shows that a GA controls the amplitude weights and phase shifters of arrays, and generates low-sidelobe array patterns from the initially distorted high-sidelobe patterns due to the conformal surface of spherical–circular and spherical–planar arrays.

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