Optimal Design of Microstrip Feeding Network for Implementation of Dolph-Chebyshev Current Distribution on Antenna Arrays

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***Abstract*—A microstrip feeding network that implements a Dolph-Chebyshev current distribution on antenna arrays is presented. The feeding network is optimized by using an improved particle swarm optimization algorithm, which induces mutation to the velocities of the particles, which are unable to improve their fitness in the previous iteration. The feeding network is designed for an eight-element linear antenna array operating in 1900MHz LTE B2 band and is composed of 17 discrete microstrip line segments, which have proper lengths and widths to ensure that the array elements are equidistant and aligned to each other. The feeding network is symmetric, halving thus the number of parameters to be optimized. The optimization is considered to be successful when the feeding network achieves a standing wave ratio below 1.2, power efficiency over 80 percent, and output currents following a Dolph-Chebyshev amplitude distribution with a phase difference of three degrees at most.**

***Index Terms*—Antenna array, Dolph-Chebyshev distribution, microstrip lines, particle swarm optimization.**

I. Introduction

Microstrip feeding networks are popular because they can easily be fabricated and achieve the desired amplitudes and phases of antenna array feeding. A practical way to achieve a broadside radiation pattern with a specified side lobe level (SLL) is to feed the antenna array with currents that follow a Dolph-Chebyshev distribution.

In this study, a feeding network composed of 17 microstrip line segments is optimized for an eight-element linear antenna array, which operates in 1900MHz LTE B2 band. The output currents of the network must follow a Dolph-Chebyshev distribution that corresponds to SLL = –20dB. For the sake of simplicity in the structure and fast convergence of the optimization process, a symmetrical feeding network is considered. Thus, the dimensions of only nine microstrip line segments need to be adjusted. The substrate used here is Rogers RT5880, which has a relative dielectric constant of 2.2 and a loss tangent of 0.0009. The dielectric and copper thicknesses are 1.575 mm and 18 μm, respectively. The structure is optimized using the PSOvm algorithm [1]. The requirements to be satisfied are (a) standing wave ratio (SWR) below 1.2, (b) power efficiency above 80%, and (c) output currents following a Dolph-Chebyshev amplitude distribution with a phase difference of three degrees at most.

II. Formulation

The geometry of the feeding network is illustrated in Fig. 1. Each microstrip line segment has a different width w_m (m=1,…,9). The first four segments are of same length L to make the array elements align with each other. The next three have the same length d to ensure that the array elements are equidistant to each other, while the length of the 8th segment is d/2 due to the symmetry of the network. The 9th segment is used to match the network to 50 Ω characteristic impedance.

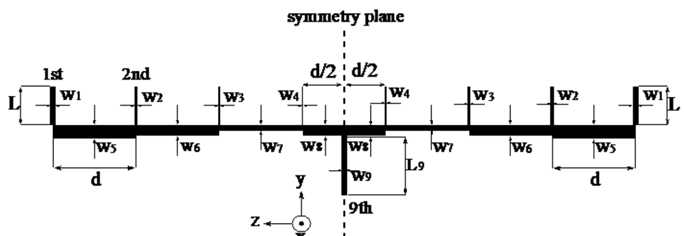

Fig. 1. Geometry of the proposed Dolph-Chebyshev feeding network.

For each iteration of the optimization process, closed-form equations [2] are used to calculate the characteristic impedance and complex propagation constant of each segment. For simplicity, we assume that the input impedance of each array element is 73 Ω. Then, the input impedance and the respective SWR at the input of the network are calculated. By considering a source of 1 Volt, we find the input current and then, by using ABCD parameters for lossy lines, we estimate the currents and voltages at the inputs of the array elements, and the perspective power efficiency of the network.

III. Simulation Results

Table I displays the optimized results by using PSOvm. It seems that all the optimization goals are met.

TABLE I
Optimized Results Using PSOvm

Element	Relative Current Amplitude	Current Phase Difference [°]
1 & 8	0.5799	2.7
2 & 7	0.6603	2.5
3 & 6	0.8751	1.3
4 & 5	1	0
SWR = 1.1	Power Efficiency = 83.2%	SLL = –20.3 dB

References

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