A NEW APPROACH TO THE OPTIMIZATION OF PASSIVE MICROWAVE STRUCTURES ON THE BASIS OF A FDTD–METHOD

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***Abstract*— A new approach to the optimization of passive microwave structures on the basic of a FDTD–field simulator is presented. The method is suitable for reducing the number of time consuming numerical FDTD–field simulations in the automatic optimization process. The results of a minimized number of field simulations are projected on IIR filters. The pole and zero positions are parameter vector dependent curves or fields in the z–domain.**

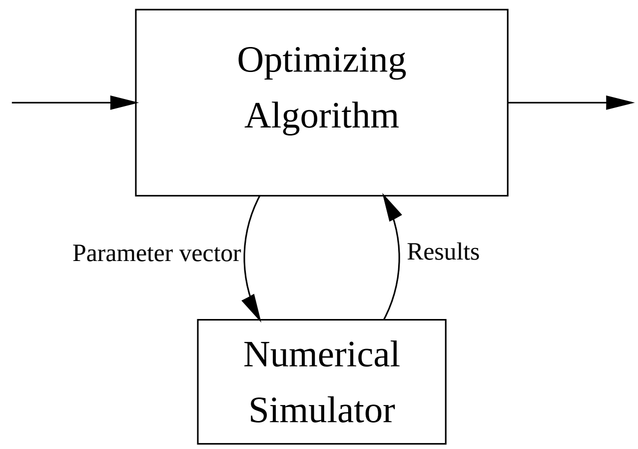

Fig. 1. Optimization scheme

Theoretical Background

In optimizing passive microwave structures, e.g. MMIC's, a large number of time consuming numerical field simulations is needed for transient analysis. A useful field simulation normally needs large computation time, mostly between one and several hours.

The structures that will be simulated in an optimization process are always very similar. Only a few parameters, in most cases dimensions, will be varied inside the parameter interval. After varying a parameter, a new field simulation is needed (Fig. 1). In this article a new method is presented. By this method it is possible to reduce the necessary computation time by reducing the number of needed field simulations (Fig. 2).

In the following description of the method a parameter vector with only one element will be used, because a larger parameter vector will exceed the limitation of this summary. Larger parameter vectors, however, may be used in the application of this method.

The field simulation method that is used in this work is the FDTD–method (finite differ-

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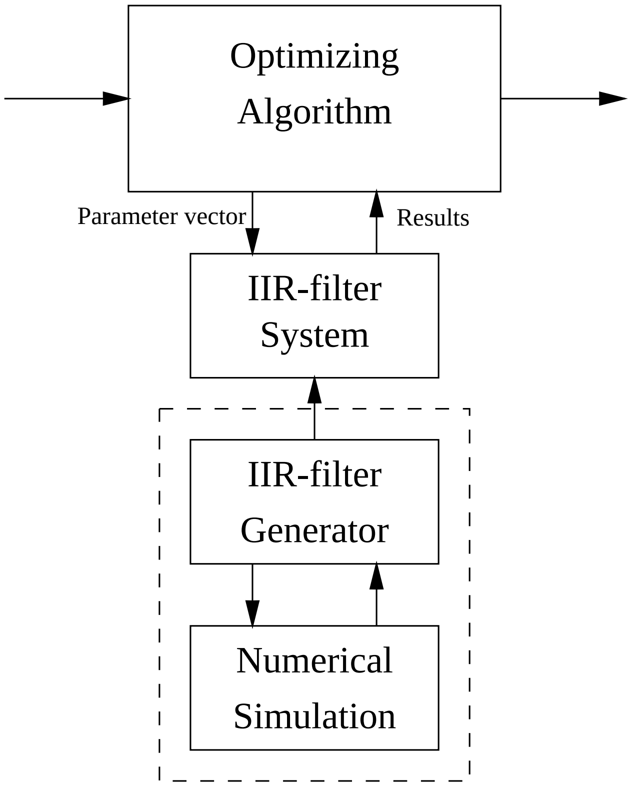

Fig. 2. New optimization scheme

ence time domain) [1], [2]. For the FDTD–method the Maxwell's equations are solved by the leap–frog–algorithm.

In a first step, the parameter vector dependent pole and zero positions of the transmission and reflection function in z–domain are determined. The parameter interval must be sampled by an adequate number of field simulations. The number of the necessary field simulations can be minimized by the choice of suitable sampling points. From the result of all field simulations, a corresponding IIR filter (Fig. 3) will be calculated. All IIR filters must have the same order. By a suitable choice of coefficients each IIR filter is a reproduction of the passive MMIC simulated in time domain.

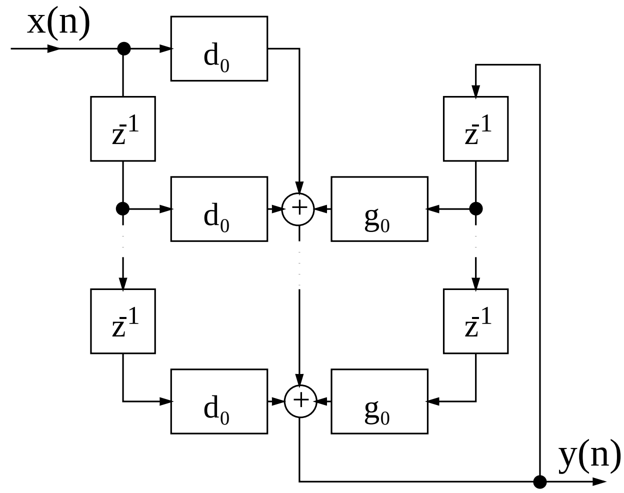

Fig. 3. IIR–filter structure

The evaluation of the coefficients is not explained here because only known methods like the LeRoux–Gueguen algorithm [3] are used in this article. The IIR filter function in time domain is,

$$y(n) = \sum_{i=0}^{k} d_i x(n-i) - \sum_{i=1}^{k} g_i y(n-i) \ , \quad (1)$$

where x is the filter input, y is the filter output, k is the order of the IIR filter and n is the time index. The following function is the transfer function in z–domain of the considered passive structure,

$$H(z) = \frac{\sum_{i=0}^{k} d_i z^{-i}}{1 + \sum_{i=1}^{k} g_i z^{-i}} \ . \quad (2)$$

Applying the Jenkens–Traub–algorithm the complex pole and zero positions of equ (2) are calculated. Thereby equ (2) can be trans-

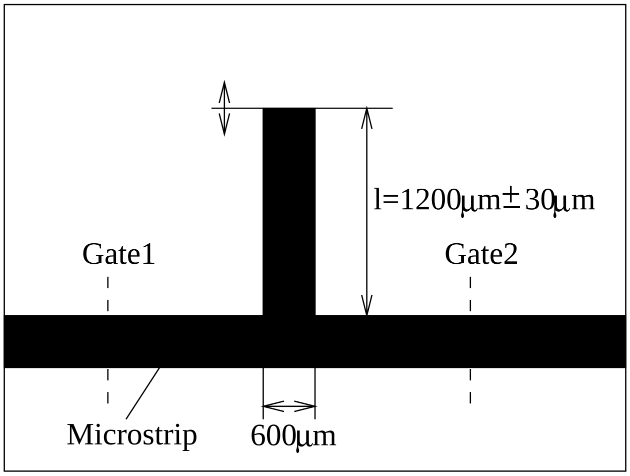

Fig. 4. Example filter structure

formed to:

$$H(z) = \frac{\prod_{i=0}^{k-1}(z - n_k)}{\prod_{i=0}^{k-1}(z - p_k)} . \qquad (3)$$

The pole and zero positions of the z–domain transfer function are interpolated using cubic spline functions.

For any value inside the defined parameter interval the coefficients of an IIR filter describing the passive structure can be determined. This filter has approximately the same behavior in time domain as the field simulation of the structure.

If all pole and zero positions in z–domain are known, no further time consuming field simulations inside the parameter interval are needed for the optimization procedure.

For the majority of the structures to be optimized, the optimum behavior can directly be determined from the z–domain chart. For these structures no further optimizing algorithms are needed.

Example

The new method will be demonstrated on a very simple example stucture shown in Fig. 4. In this example only one parameter will be varied.

The structure consists of a $600\mu m$ wide microstrip line on a $3.75mm$ substrate with $\epsilon_r = 9.978$. The stub is $600\mu m$ wide and the length varies between $t = 1170\mu m$ and $t = 1230\mu m$. In this example it is sufficient to simulate five samples inside the parameter interval

$$t = [1170, 1185, 1200, 1215, 1230]\mu m.$$

Each sample of the parameter t is simulated using the FDTD–method. As results the simulations yield the waves on gate 1 and

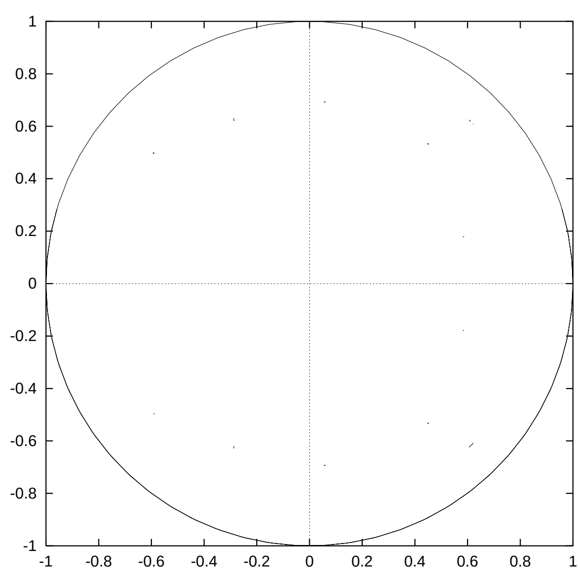

Fig. 5. Curves of all transmission pole positions

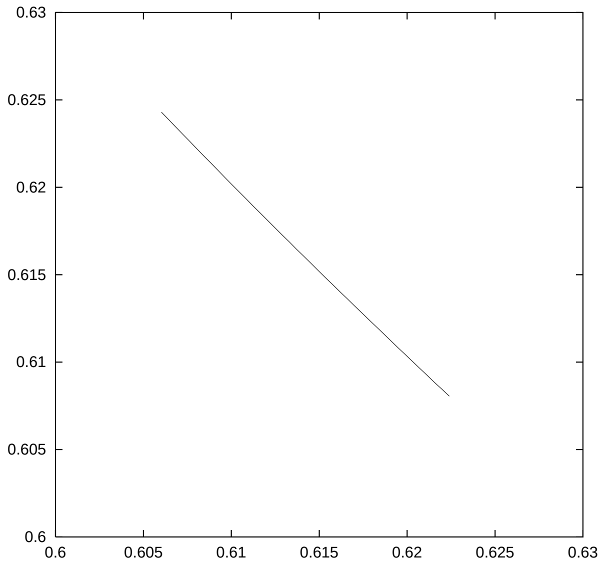

Fig. 6. Curve of one transmission pole position plotted with larger scale

gate 2 in both directions. With these values the transmission– and reflection–signal can be obtained. By applying the Jenkens–Traub–algorithm the complex pole and zero positions of equ (2) are calculated.

In Fig. 5 the curves of the complex pole positions of the transmission IIR-filter are shown. Fig. 6 contains one of the curves in Fig. 5 in larger scale.

The curve sections between the calculated points can be interpolated using cubic spline functions. The result of any numerical simulation in the parameter interval $t = [1170\mu m ... 1230\mu m]$ can be predicted. Thus, no further time consuming field simulations are needed for the optimization procedure (Fig. 2).

References

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