Methods for increasing the Y-Δ transformation effectiveness to build MEMS circuit macromodels

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Abstract – **The features of making use of the Y-Δ transformation procedure to form circuit macromodels for MEMS non-electrical components have been analyzed. The modifications of the method for selection of nodes to be reduced have been suggested, which provide the considerable reduction both a calculation time and a number of newly created elements during Y-Δ transformation process.**
Keywords – **macromodel, Y-Δ transformation, RLC-circuit, MEMS, simulation.**

I. INTRODUCTION

One of the ways for joint simulation of the compound devices is to present non-electrical subsystems of a source object as equivalent electrical circuits. But the sizes of the equivalent circuits being obtained require in most cases making use of the methods to reduce dimensions of the object’s mathematical model.

II. MAIN PART

The considered in [1] RLC-circuit reduction method did not take into account the features specific for the equivalent circuits of MEMS non-electrical parts, namely, a big number of nodes with the same time constants τ. In this case, the order of nodes to be excluded influences considerably on the reduction accuracy and time. The number of newly created elements is *N = k(k-1)/2* where *k* is a number of nodes connected to the node to be excluded. It is obviously that the maximal number of the elements in a circuit during the reduction process (Fig. 1) define both time and accuracy of the macromodel being obtained [2].

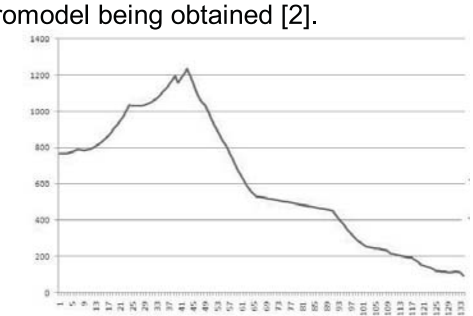

Fig.1 Dependence of a circuit elements number on the reduction step

The modifications 2 and 3 of the RLC reduction method concerning the selection order for the nodes to be excluded are suggested (***modification 1*** is presented in [2]).

Modification 2.

Step 1. To form a set of the nodes meeting the condition $\tau_i < \tau_{\min}$;

Step 2. To exclude firstly a node from this set that has a minimal number of connected elements;

Step 3. If there are some such nodes, then the priority is given to the node with the smallest time constant.

Modification 3.

Step 1. To define τ_{max} as a maximal τ value among all the nodes;

Step 2. To form a set of the nodes meeting the conditions $\tau_i < \tau_{\min}$ and $\tau_i \le \Delta \cdot \tau_{\max}$ where Δ is a some constant less than 1;

Step 3. To exclude firstly a node from this set that has a minimal number of connected elements;

Step 4. If there are some such nodes, then the priority is given to the node with the smallest time constant.

Simulation results for different method modifications are shown on Fig. 2.

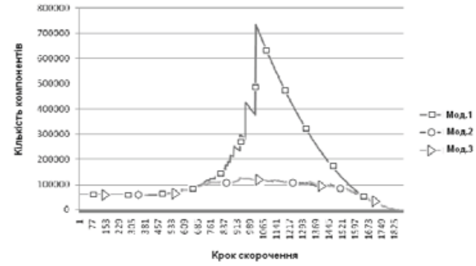

Fig. 2 Dependence of a circuit elements number on the reduction step for the membrane macromodel

III. CONCLUSION

Based on the analysis of possible sources of the Y-Δ transformation method errors, two modifications of the selection method for the nodes to be excluded have been proposed, which differ from the existing ones by the technique to define set of the nodes that may be excluded at each step of the Y-Δ transformation and node selection criteria that has to be excluded providing significant reduction of a number of newly created elements during Y-Δ transformation and not leading to the error increase.

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