Abstract

of attestation master's degree work

on subject:

"Research of features of the parallel method of Y-Δ transformation for constructing macromodels of non-electrical components of MEMS"

by

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Actuality of the work

Due to the wide spread of microelectromechanical systems (MEMS) in various fields of science and technology, demand on modern CAD systems with respect to the possibility of joint calculation of mechanical and electrical components is growing. To this end, all the subsystems of the object should be represented in the form of equivalent models of the same nature. Most often, the method of electromechanical analogies is used for the model constructing of objects with complex physical nature, but it's use requires a circuit realization of models of non-electric units. Most CAD systems that are used for the design of mechanical systems, use the finite element method for the construction of the mathematical model. However, the main problem in this case is the huge size of mathematical models, reaching hundreds of thousands of equations. The only possible solution to this situation is reducing the dimension of mathematical models of MEMS and getting its schematic analogue as a macromodel. Therefore, the development and study of the effectiveness of methods for constructing circuit equivalents of non-electrical components macromodels of MEMS is an urgent problem nowdays.

The purpose of the work

The purpose of the work is developing and researching of the features of the parallel method of Y-Δ transformation for the constructing of macromodels of non-electrical components of MEMS and extracted circuits from topologies (with a large density of

electronic components) on the crystal, which have large dimensions of mathematical models.

Tasks solved in work

1. Researching of existing algorithms of reducing of the size of mathematical models of complicated objects and the choice of basic algorithm for parallel implementation.
2. Development of an efficient modification of algorithm by A. Sangiovanni-Vincentelli, which allows splitting the original task onto subtasks of equal size and with a minimum number of nodes for interconnecting.
3. Development of the parallel algorithm of reducing RLC-circuits of the substitution of MEMS macromodels extracted from the crystal for getting the circuit analog as macromodel.
4. Researching of efficiency of the parallel algorithm of RLC-reducing circuits by time and accuracy based on solution of the test examples.

The achieved results

By solving the tasks put in work, the author protects:

- developed the modification of the algorithm by A. Sangiovanni-Vincentelli that allows to make paralleling of parallel method of Y-Δ transformation, as well as minimizes the effect of Haydn by reducing computation time due to an uniform loading of the balance of multiprocessor computing systems.
- results of the efficiency of the parallel method of Y-Δ transformation for the constructing of macromodels of circuit equivalents of non-electrical components of MEMS and extracted circuits from topologies on the crystal;
- results of the researching of efficiency of the parallel algorithm of Y-Δ transformation in multiprocessor computing systems (on supercomputer of NTUU "KPI") which are compared with the basic algorithm on the set of test examples.

Scientific novelty

The scientific novelty of the work consists of the following:

- analyzed the problems of the using of existing algorithms of reducing of the size of mathematical models of complicated objects of designing for large dimensions of their mathematical models, which is typical for the equivalent circuits of non-electric MEMS components with many degrees of freedom and complicated geometry;
- developed the modification of the algorithm by A. Sangiovanni-Vincentelli which can be used for easy paralleling many numerical algorithms and unlike the basic version provides effective partitioning into blocks of equal size with the minimum possible frame depending on the structural graph of circuit and the number of partitioning into blocks;
- developed the parallel method of Y-Δ transformation based on the developed modification of the algorithm by A. Sangiovanni-Vincentelli which alowed significantly to reduce the computation time. Herewith the accuracy of reduction with applying of the parallel algorithm is not inferior to the basic one and prevails it, especially onto the formed macromodels of substitution of the equivalent circuits of large dimension, where time and accuracy of the basic algorithm wish the best;
- recommendations to manage by accuracy and speed of getting of a final macromodel depending on the parameters of the developed parallel method;

Practical value

Practical value of work consists of the following:

- experimentally demonstrated the efficiency of program implementation of the parallel algorithm of reduction of the RLC-circuits based on Y-Δ transformations

that allows to significantly reduce the computation time (up to 180 times for the circuits with 4014 nodes and ≈ 94 thousands elements) on a test set of examples. Moreover, in practice proved that the developed parallel implementation of reduction of the RLC-circuits based on Y-Δ transformations allows to form macromodels of substitution of the equivalent circuits of extreme large dimensions (e.g. 180 803 nodes and ≈ 6.8 millions elements) , which are not possible got in that case of using the basic algorithm;

- experimentally demonstrated the efficiency of the modification by algorithm A. Sangiovanni-Vincentelli on the results of applying software implementation of the parallel method Y-Δ transformation on a test set of examples;
- in practice proved that the coefficient of acceleration of the parallel method of Y-Δ transformation is not restricted by law Amdala because it significantly reduced the number of computations in the parallel implementation.

Conclusions

1. Analyzed the principal methods and algorithms for the reduction of mathematical models of MEMS in terms of efficiency, possibility of adaptation to existing CAD packages including circuit technique designing, opportunities to use objects of extreme large dimensions, and as the basic method was chosen method of the reduction of RLC-circuits based on Y-Δ transformation.

2. Developed modification of the algorithm A. Sangiovanni-Vincentelli, which allows to make effectively paralleling of the parallel method of Y-Δ transformation, and furthermore can be used for easy paralleling of many numerical algorithms, and also it minimizes the effect of Haydn by reducing computation time due to a uniform loading of the balance of multiprocessor computing systems.

3. Developed a software implementation of the method of parallel Y-Δ transformation based on the developed modification of the algorithm by A. Sangiovanni-Vincentelli that allows significantly to reduce the computation time on a test set of examples. The got results show that the accuracy of reduction with using of the parallel

algorithm is not inferior to the basic one, and that it allows to form macromodels of equivalent circuits of extreme large dimensions, showing result there, where for the basic sequential algorithm it is simply absent.

The work contains 118 c., 77 images, 36 sources.

Keywords:: MICROELECTROMECHANICAL SYSTEMS, MEMS, PARALLEL METHOD, Y-Δ TRANSFORMATION, RLC, SANGIOVANNI, VINCENTELLI, ALLTED, MACROMODEL, ANSYS.