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APPLICATION OF STRUCTURAL MATRICES FOR THE SIMULATION OF MEMS DEVICES

Розглянуто підхід до моделювання МЕМС пристроїв із використанням методу структурних матриць. Розроблено структуру підсистеми для визначення основних характеристик широкого класу пристроїв.

Ключові слова: МЕМС пристрій, математична модель, диференціальне рівняння, структурні матриці.

In the article the approach to modeling of MEMS devices using the method of structural matrices is presented. The structure of the subsystem to determine the basic characteristics of a broad class of devices.

Key words: MEMS device, mathematical model, differential equation, structural matrices.

Introduction

Nowadays MEMS continues to develop rapidly, introducing modern advanced technology in their production and use. With the development of science and technology, the advent of new technologies increased requirements for MEMS devices. Microsystem Technology is one of the sectors that most dynamically developing on the basis of interdisciplinary scientific and technological areas. An important aspect in modeling and designing microsystems is to build mathematical models that allow to take into account the relationship of all these factors influence the system.

Modern MEMS devices are complex systems. They are composed of heterogeneous elements (mechanical, electromechanical, electronic, optical). The complexity of their large dimension, the diversity of objects, the complexity of the objects themselves require above all a well-defined representation of the structure of these objects and systems [1, 2].

It is very important that the structural representation were clearly reflected the principles of system construction, allowing regarded in the same vein complex systems at different hierarchical levels, and further facilitate the transition to a system of mathematical models for their analysis and further research on the computer. It uses different methods, one of which is the structural matrix method, built on a combination of conventional matrices, graphs and block diagrams [3].

Presentation of complex structure by matrices

A complex system is characterized by its structure:

- The structure applies a set of all elements that shape this system.
- The structure should include all connections between the elements in which the interaction between them. Links can be constant or variable and may form a chain of actions or closed contours.
- The structure of the system and signs are bonds that have a major impact on the system.

Structural analysis systems to load information about the extent of its elements to ensure the stability, invariance systems and increase their reliability. Thus, the importance of structural studies, especially for complex systems is undeniable. The next step after structural analysis should be based parametric studies built mathematical models. For ease of analysis and synthesis is desirable that between the structures of the system and its model line was. This line, which provides the easiest transition from structured way of presenting to the metric system, the method gives structural matrix.

The process of constructing models begins with the construction of so-called conceptual model that reflects the concept and principle of representation systems in the developer.

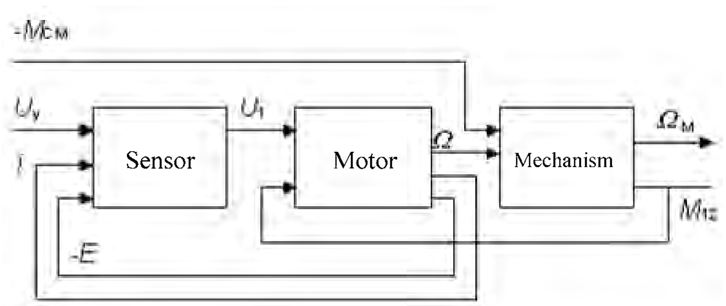
The conceptual model is presented on multiple levels of hierarchy. Lower level representation of the conceptual model is the one level in which the principle of the system is evident from complete, sufficient for constructing models of another type. The upper level is determined by the main purpose of a system that is designed or researched.

At the lower level conceptual model used functional level structural model, which defines all the characteristics and parameters of the object needed to build computational models.

The conversion process different types of models to build so that the computing unify procedures. It is important to ensure the required speed transformations, particularly in the operation of software systems in networked mode.

The most expedient is to use a matrix representation of all types of internal models. Matrix-structured presentation of the conceptual model is an ordered set of symbolic and numerical information that uniquely identifies the elemental composition and topology given level conceptual model. This approach is the only universal means of identification in computer memory circuits conceptual models at all levels.

Fig. 1 shows a conceptual model of the electromechanical facility, built on the basis of the structural matrix.



a

System coordinate name				Output voltage of sensor	Rota-tion speed	Motor EMF	Current circuit anchorage	Platform speed	Moment elastic relationship	Control voltage	Mechanism static moment
Subsystems and elements			№	U_1	Ω	E	i	Ω_2	M_{12}	U_y	$M_{см}$
Sensor	Mechanism	Loading	3	X		↰	↰			↵	
	Motor	Speed	4	↳	X				↰		
		EMF	5			X					
		Current	6				X				
	Reduction and platform	Speed	8		↳			X			
									X		↵

b

Fig. 1. Conceptual model of electromechanical object after the coordinates and determine the type of elements: a – the circuit model; b – matrix-structured presentation

The development of the structure of the method of iterative structural matrices performed in several stages, with each stage further refined the structure in relation to the results achieved in the previous step. Consider the stages of this process:

1. ***Definition of the external system.*** External system - a system of top-level hierarchy in which the system is included as an element**.**

2. ***Development of a large block matrix***. Identify additional or intermediate targets to be performed on the system, a list of goals. Square depicted in the form of a matrix nucleus of the future system and the right of the rectangle as the rights of the matrix (area input system), which is divided into two parts for image problems and obstacles. Details the connections between subsystems**.**

3. ***Detail Large matrix elements of large-block.*** Diagonal matrix is divided into components, as Subprocesses overall process. Forming links between elements of the subsystem. Details the connections between subsystems. The overall relationship between the blocks is divided into the required number of individual connections between specific elements of these diagonal blocks. Specifies the effect of each component of external factors on items subsystems. If necessary, made some permutation of columns and rows of the matrix to form a compact set of additional elements or closed circuits.

4. ***Creation of mathematical models.*** Represented all columns of the matrix corresponding coordinates. Multiplied matrix elements of each row and column coordinates derived works are summarized by line, which results in a mathematical model of the system in the form of contours.

$$a_{jj}x_j = \sum_{\substack{j=1 \\ j\neq 1}}^{l} a_{ji}x_i \, (i=1,2,...,n)\,. \qquad (1)$$

The resulting system of equations (1) Recorded in general for linear equations. To explore it, it is necessary to reveal the expression of matrix elements a_{ji} coefficients may be finite-difference or differential equations.

Education System Architecture

Fig. 2 shows the architecture of the educational system to study the structural matrix method.

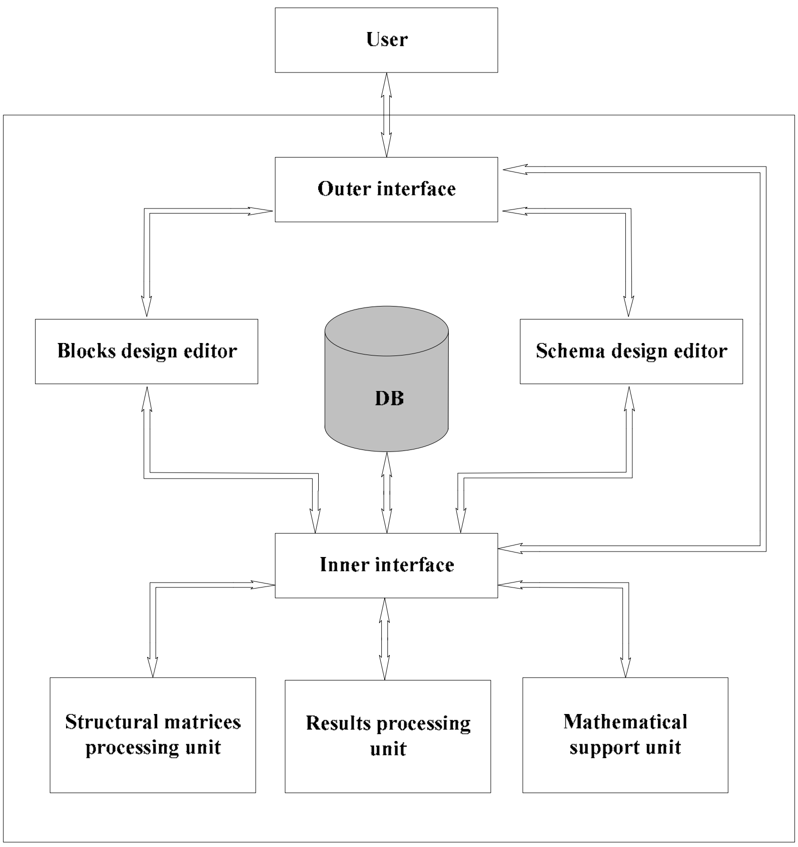


Fig. 2. Architecture of the educational

User interface with an external system has the ability to consistently perform stages modeling MEMS devices using the method of structural matrices:

- Formation and detailed elements of large-matrix system using *dlocks design editor* create models of elements that are placed in the database.
- The specific design of MEMS devices with the *schema design editor* a user creates a graphical block diagram of that program is converted into a mathematical model.
- *Structural matrix processing unit* conducts its formation and optimization.
- *Mathematical support unit* solves the mathematical equations.

Results processing unit carries out processing results and output of simulation results.

Figure 3 shows the window for building models of electromechanical systems.

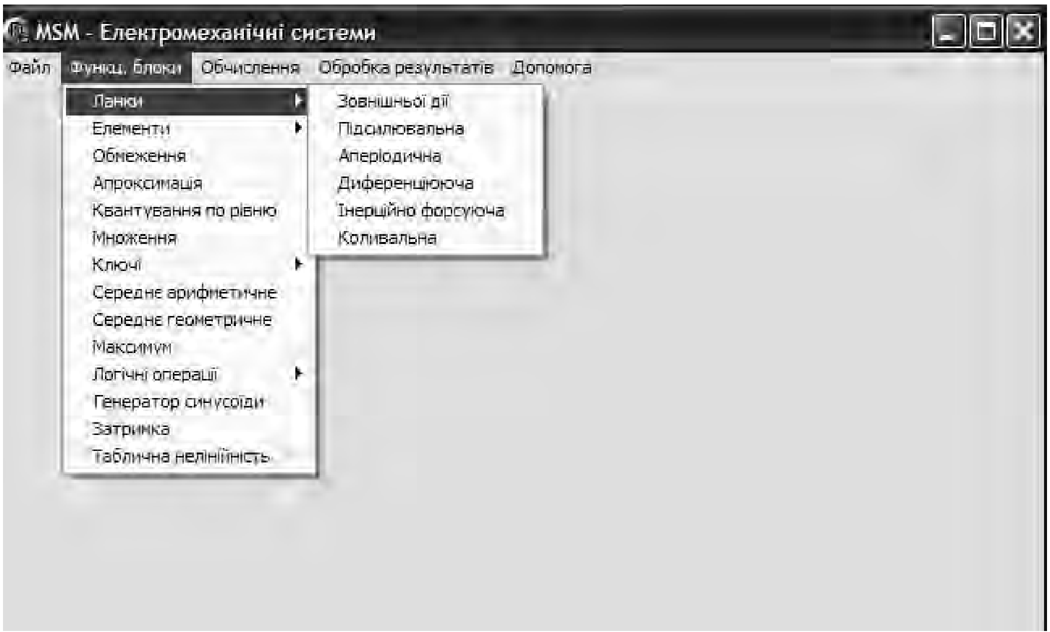


Fig. 3. Window constructing electromechanical system

Developed options for different functional blocks, which can be divided MEMS devices. Analysis of simulation results showed the feasibility and effectiveness of the structural matrix method for modeling complex systems.

Conclusion

Using matrices for structural modeling and design of complex systems to consider unified complex systems at different levels of the hierarchy. With this method, you can relatively easily make the transition to the mathematical models that describe the behavior of the system.

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