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## VISUALIZATION OF EVENTS AND SYSTEMS IN MATLAB SYSTEM

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*The article is devoted to engineering methods for modeling processes and systems using the methods of graphical (visual) modeling in the MatLAB / Simulink system environment.*

**Key words:** *MatLAB, Simulink, method, model, process, system, visual, graphic, software, Eureka, Gauss.*

The MatLAB system allows you to build a real-time visual model of complex dynamic processes. Simulink and Power System extensions packages of the MatLAB system are used. The libraries of these packages have many virtual elements and measuring devices available to help you investigate any complicated system.

The MatLAB system programming language has advantages over traditional programming languages, and its capabilities are extensive and can be used in all fields of science and technology to process and process processes [3].

The development of computerized modeling tools and tools has always been the simplification of communication between the simplified system of computing and programming languages to bring it closer to the engineering problem.

In the MatLAB system, the software developer uses a visual approach to programming, in the modern programming complexes, the virtual model of the problem solves the display screen. The virtual elements are written in a high level programming language using automated programming tools and are an essential part of the related mathematical operations.

The process of creating a structured scheme on the display screen completely fits the problem solving software, which can consist of hundreds or even thousands of commands, depending on the complexity of the problem. The user is free to install, compile, and configure complex applications.

Graphic means that visual programming tools automatically translate the subject into computer language, which is natural for the user, with easy graphic format. Provides the results of the modeling in graphic form, such as time or phase diagrams and animated images. The complexity of creating models using these tools and the time spent in computing experiments are reduced by ten times as much as the customary way of handling each individual application for manual processing.

The relative affordability of the graphical environment of visual modeling and the ease of use make it possible for the widest possible use of computer modeling for every engineer, technician and managers.

At the same time, there are several dozens of graphic visualizations that can be distinguished from the following:

- Simulink application based on MatLAB software system complex of MathWorks Inc.

- LabVIEW complex of National Instruments. This environment is used to manage data collection and processing systems, as well as to manage technical objects and technological processes.

• Electronics Workbench (MultiSIM) software complex of Interactive Image Technologies Ltd. This environment is used to solve the problems of automation of modeling and design of electronic circuits.

• FemLAB (COMSOL MULTIPHYSICS) software complex. This medium is used for a distributed parametric modeling system, which is described by means of elementary elements, represented by the generated integro-differential equations. It can run in the MatLAB complex or autonomously.

Simulink software is an application for the MatLAB package. The MatLAB package focuses primarily on data processing (Matrices, Vectors, and so on). It can significantly increase the performance of the data type with the traditional programming languages (Pascal, C, etc.) and separate the MatLAB system from other systems such as Maple, MathCAD, Mathematica.

The Simulink application is an important tool for combining blocks that match specific elements of a dynamic system and learning its features in time. Creating visual models using the Simulink (S-model) technology is based on the drag-and-drop technology. In order to build the S-model, the Simulink library uses the same module as the [2].

Any S model has a hierarchical structure, that is, low-level models. Hierarchical levels are not limited. It is possible to track the processes in the system during modeling. Allows you to The complexity of creating models using these tools and the time spent in computing experiments are reduced by ten times as much as the customary way of handling each individual application for manual processing.

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Any S model has a hierarchical structure, that is, low-level models. Hierarchical levels are not limited. During modeling, it is possible to track the processes in the system. A special "observation mirror" that is part of the Simulink library is used for this purpose. It is possible to provide user-friendly features in digital and graphical formats.

Application of structured and modular programming principles allows to present different algorithms in the form of a set of unified program modules. This ultimately improves the appearance of the application, makes it easy to adjust, and reduces the overall software. In addition, the Simulink library can also extend the content of the user's own program blocks.

MatLAB contains a set of applications that are based on graphical (visual) programming tools and can work together with the Simulink application:

- Arosospace Blockset - special equipment for modeling space, jet and turbo-systems.

- DSP Blockset is designed for modeling and designing systems for digital signal processing (DSP) issues. These libraries include classic, multipolar, and

adaptive filtering, modification, matrix operations and linear algebra, statistical and spectral analysis.

- Advanced Control Design Blockset-Provides a graphical interface for customizing dynamic objects to the user.

- SimPowerSystems- is designed for modeling electrotechnical and electro-power equipment and systems.

- SimMechanics - modeling control systems using non-referenced signaling radios, allowing them to integrate with physical models and models in other libraries.

Analogue computational technique has several methods of modeling objects that are represented by algebraic equations [1]. One of the common methods among them is the system of linear equations, which is used to solve ordinary differential equations and the resulting solutions provide a solution to the algebraic equations system.

It is well known that non-inertial objects can be described as linear equations in the following way:

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n &= b_1 \\ a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n &= b_2 \\ a_{n1}x_1 + a_{n2}x_2 + \dots + a_{nn}x_n &= b_n \end{aligned}$$

In order to build this model, we will replace the system of algebraic equations with the equivalent system of differential equations.

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n &= b_1 \\ a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n &= b_2 \\ a_{n1}x_1 + a_{n2}x_2 + \dots + a_{nn}x_n &= b_n \end{aligned}$$

$$\begin{aligned} \frac{dx_1}{dt} + a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n - b_1 &= 0 \\ \frac{dx_2}{dt} + a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n - b_2 &= 0 \\ \frac{dx_n}{dt} + a_{n1}x_1 + a_{n2}x_2 + \dots + a_{nn}x_n - b_n &= 0 \end{aligned}$$

For all  $i (dx_i) / dt = 0$ , we get the following solutions  $(x_1, x_2, \dots x_n)$ .

The equivalence of the equation of both equations and the solution of the differential equations system must be satisfied. The criterion for suitability of the solution is the positive detection of the matrix formed by the coefficients of linear equations. This can be especially true if the following condition is fulfilled:  $a_{ij} \geq S_{ij} (j = 1) \wedge n_{ij}$ .

Below is the system of two unknown linear algebraic equations

$$4x_1 + 2x_2 = 8$$

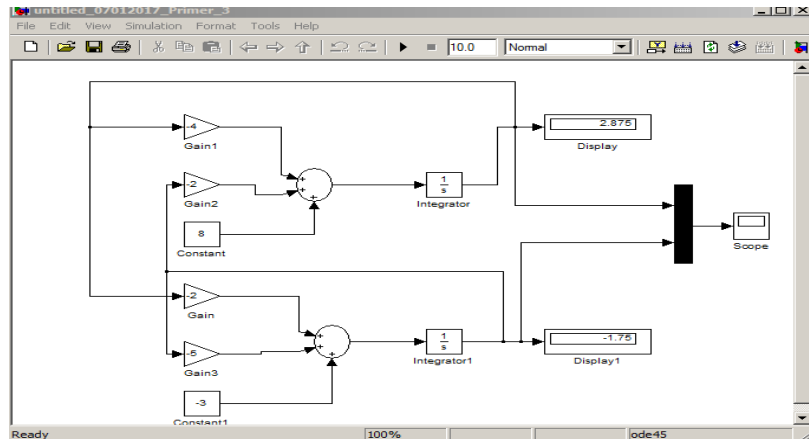
$$2x_1 + 5x_2 = -3$$

we convert it to the equivalent system of differential equations,

$$\frac{dx_1}{dt} = 8 - 4x_1 - 2x_2$$

$$\frac{dx_2}{dt} = -3 - 2x_1 - 5x_2.$$

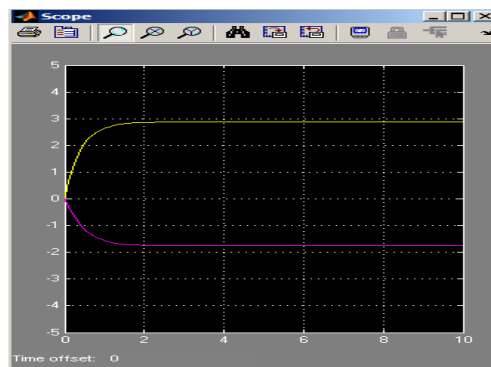
The structural scheme of the visual model of this system is as follows (Figure 1)



Picture 1. Structural scheme of the system of differential equations, which is equivalent to the system of linear algebraic equations of the second order.

As shown in Figure 2, when  $t = 2$ , the outputs of the virtual integrators were aligned with linear algebraic equations:

$$x_1 = 2.875, x_2 = -1.75$$



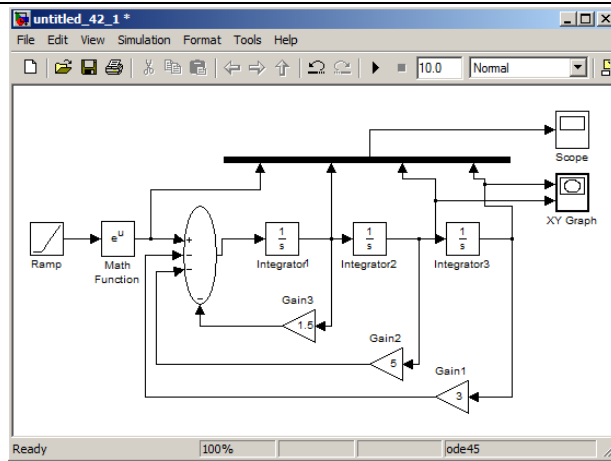
Picture 2. The process of passing the solutions by bringing the system of linear algebraic equations to the system of differential equations, which is equivalent to it.

It is well-known that the most common methods of expression of the dynamic system are the system of differential or integral differential equations. Below we create a visual model structure for a dynamic system model represented by a third order differential equation.

$$\frac{d^3 y(t)}{dt^3} + 1.5 \frac{d^2 y(t)}{dt^2} + 5 \frac{dy(t)}{dt} + 3y(t) = e^{-t},$$

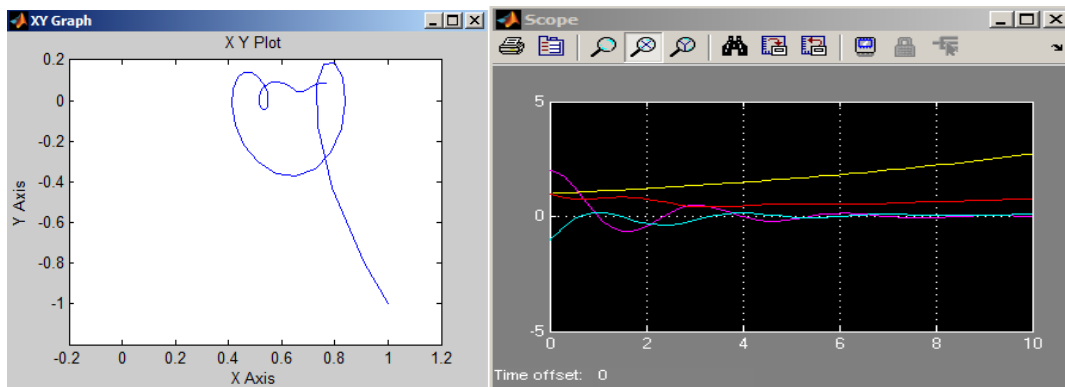
$$y(0) = 1, \quad y'(0) = -1, \quad y''(0) = 2.$$

The structural scheme of the dynamic system model is based on Simulink's corresponding blocks (Figure 3).



Picture 3. Structural scheme of the third-order dynamic system model

We equate equation coefficients in the parameters of the Gain1 Gain3. We set the initial conditions for functions and creations in the Integrator-Integrator3 windows



Picture 4. Moving the system Figure 5. The space portrait of the system

**Sources**

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