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THE EXPERIENCE OF "MATLAB 6.0"[®] USE IN THE SIMULATION OF THE PULSE-PHASE CONTROL SYSTEM OF THE THYRISTOR VOLTAGE REGULATOR WITH THE ACTIVE-INDUCTIVE LOAD

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Abstract: The paper is dedicated to the realization of the structural model of the pulse-phase control system (PPC) of the thyristor voltage regulator (TVR) with an active-inductive (RL) load in the medium of "MATLAB 6.0"[®]. Describing the possibilities of "MATLAB 6.0"[®] in the dynamic systems simulation, some problems connected with the use of special instrument means, included in structure of Toolbox Simulink Library, are examined.

Keywords: computer simulation, using of "MATLAB 6.0"[®], methods of models, Simulink library.

1 INTRODUCTION

System control design of one object or another will entail the solution of a number of complex technical problems. In this case the compulsory stage is the development and research of mathematical model of separate components as well as the entire system together with the object of control. In spite of importance of this problem at present time there is a very small quantity of computer mathematic systems (CMS), which are minutely developed and actively used in conducting of effective, clear and valuable mathematical simulation of systems of different nature with obtaining the results of the required precision and maximum approximation to physical essence of the processes being investigated. Among such packets one should mark following [1]:

1 OrCAD 9.0 – the automated design system (SAD), built on the base of PSpice packet and oriented especially for the development of digital electronic equipment [1,2];

2 TCAD – the packet of the simulation of electrical systems, which have not received wide acceptance outside the Poland borders, where it had been worked out [1];

3 "MathCAD 8.0"[®] (Math Soft, Inc.). The main advantage of this CMS is a simplicity and convenience of the user interface. But it loses somewhat because of a comparatively low efficiency of the visual

simulation application MathConnex supplied with "MathCAD 8.0"[®] [3];

4 "MATLAB 6.0"[®] (Math Work, Inc) This CMS was worked out more than 20 years ago and primarily was oriented to the use in the strategic fields (MIC, aerospace branch, automobile construction, etc.). At present time, judging by the intensity of publications [4–7, 2], it is the most promising and flexible medium for the solution of a broad class of problems.

The essential problem in the use of any CMS is the presence of number undocumented special features. The task of this work is, after indicating the possible methods of models designing in "MATLAB 6.0"[®], to describe the special features of this system based on the example of the development of the mathematical model of the energy pulse converter.

2 THE METHODS OF MODELS CONSTRUCTING IN "MATLAB 6.0"[®]

Distinctive feature of the CMS "MATLAB 6.0"[®], that makes work in this medium at most effective, is its openness and the expansibility: the majority of system commands and functions are realized in the form of text m-files and files in the language C, accessible for modification; and the presence of more than ten groups of the specialized functional

modules in Toolbox Simulink raises the system adaptation to the solution of specific problems of different spheres.

It is possible to name four fundamental methods of mathematical model developing in "MATLAB 6.0" Simulink [4, 2]:

1. The use of standard and user s-functions – modules, written in the languages C, C++, Ada or FORTRAN and compiled into the files of dynamic libraries (*.dll). Separate module can have unlimited complex organization and incomes into the composition of mathematical model as subsystem. The disadvantage of standard s-function, primarily existing in the system, is their description. It is so brief that in number of cases it is impossible to modify s-functions with due regard of the specific problems to be solved.
2. The use of units, income in the structure of specialized libraries Simulink (Power System Blockset, Fuzzy Logic Toolbox, Neural Network Blockset) (Fig. 1). The main disadvantage of this method consists in the fact that, as it will be shown below, some of the named modules do not completely or accurately realize required function.
3. The use of primitive, indivisible units of the standard library of Simulink (Fig. 1). We have to return to this method of the model constructing in those cases when it is impossible to correct or add (by supplementing of additional chains) the units' composition of those specialized libraries (p. 2).
4. The combined method of the model constructing includes several methods, named above.

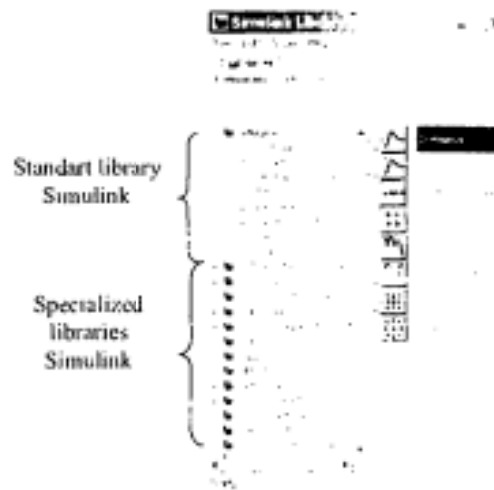


Fig. 1 - Composition of the Simulink libraries

3 MODEL PPCS-TVR-RL IN "MATLAB 6.0" SIMULINK

Let us consider the construction of the pulse-phase control system of the thyristor voltage regulator, which works with active-inductive load (Fig. 2).

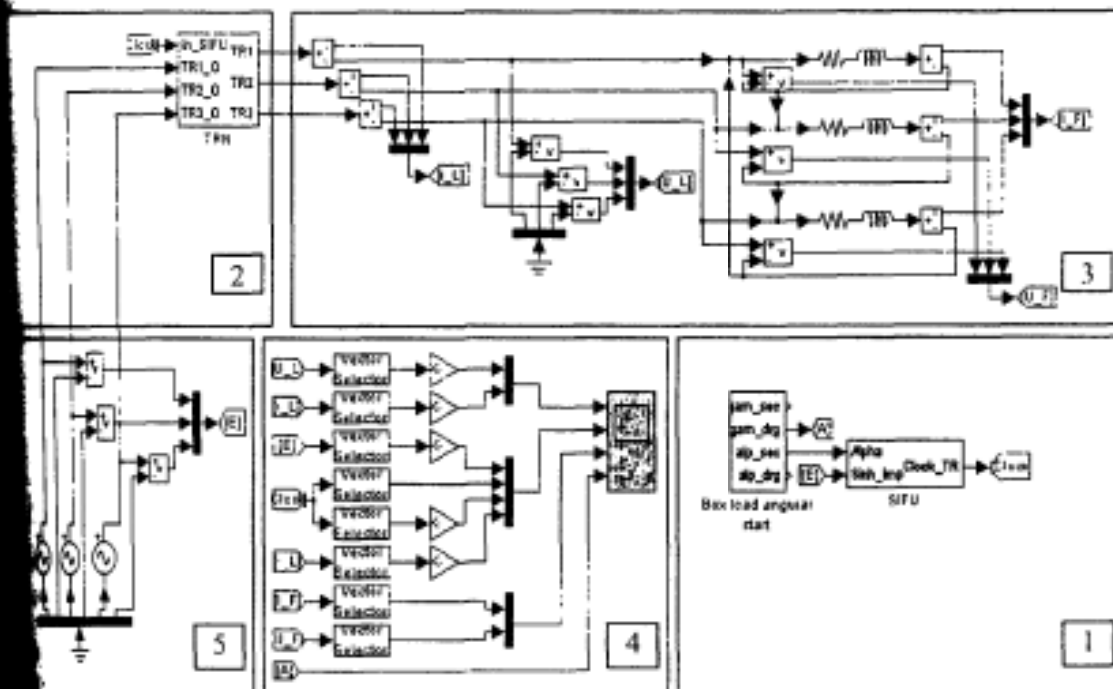


Fig. 2 - S-model PPCS-TVR-RL

This model includes in its structure the following basic blocks:

1. PPCS is a six-channel generator of the TVR control pulses with two channels on each thyristor module and control algorithm realization unit. The input of PPCS is supplied with the control angle (α deg.), assigning the shift of drive signals relative to the source of the sinusoidal voltage with star connection according to the control algorithm (unit 5).
2. TVR – three pairs of the thyristors, which are reverse parallel connected in each phase and formed the 3-phase voltage, supplied to the load.
3. Symmetrical RL – load with delta connected and the necessary meters of current and voltage.
4. Unit of visualization.

4 THE SPECIAL FEATURES OF THE SIMULINK LIBRARY POWER SYSTEM BLOCKSET UNITS USED IN THE MODEL

For realization of PPCS in the library structure of the Power System Blockset / Extra Library / Control Blocks there is a synchronized 6-pulse generator (Synchronized 6-Pulse Generator) [7]. The generator has five inputs (control, three-phase feed and activation) and one output – the 6-element control pulse vector (Fig. 3). Fig. 4 shows the generator work visualization from the source of three-phase

power. The angle of control ($\alpha \in [0;180]$) is changed according to the linear function (Fig. 4). The analysis of the diagram, represented in Fig. 4, shows the fact that the generator works as a correctly, with exception of the first period. In the moment of time $t = 0$ control pulses appear on the outputs of generator, besides, positive control signal is absent at the moment of time $t = T/2$ (Fig. 4.a) negative control signal is absent at the moment time $t = T/3$ (Fig. 4.b) and positive control signal is absent at the moment of time $t = T/6$ (Fig. 4.c) should also be noted that in the simulation of TVR the control pulses, has been supplied to thyristors, are taken at a drop of voltage therefore, in order to use a standard motor generator it is necessary, first, to reduce the disadvantage in its work during the first period secondly, to form control pulses of m duration.

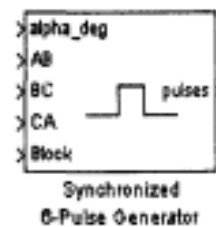


Fig. 3 - A unit image of the synchronized 6-pulse generator in Power System Blockset / Extra Library Control Blocks

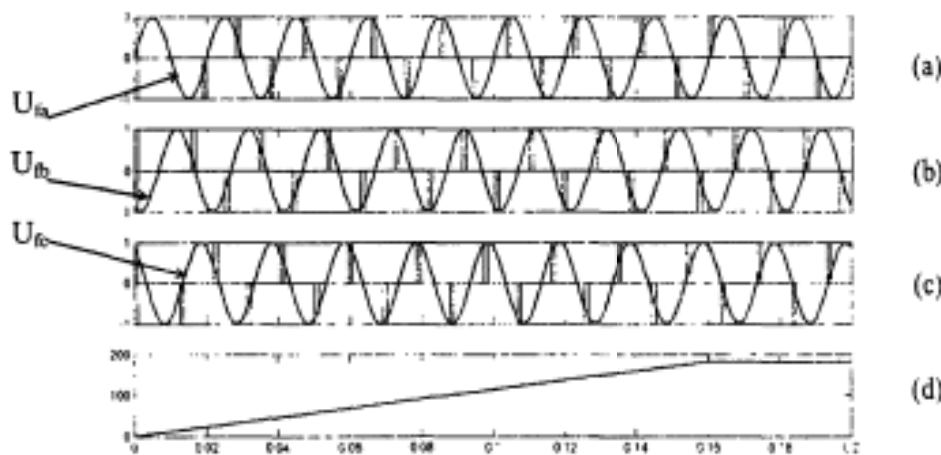


Figure 4. The diagram of 6-pulse generator work from the library of Power System Blockset / Extra Library / Control Blocks (U_{fa}, U_{fb}, U_{fc} – the phase voltages of source in rel)

Resolving the indicated problems we consider that it is more conveniently to give up at all the use of a standard generator, realizing it on the base of the elementary modules included in the standard

library of Simulink. The work visualizer generator obtained by such method is given in Fig. 5.

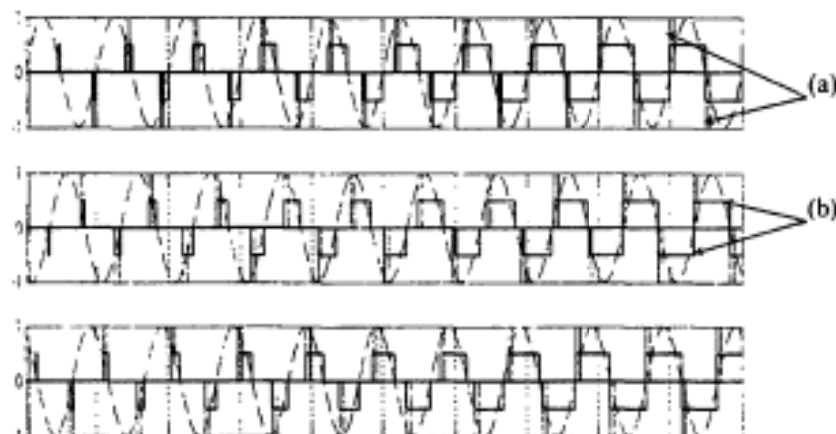


Fig. 5 - The diagram of the standard synchronized 6-pulse generator work from the library of Power System Blockset / Extra Library / Control Blocks (a) and the generator work, assembled from the elementary units of Simulink (b).

It would be good to say a few words about one more special feature, and it is the realization of TVR in "MATLAB 6.0". In the library Power System Blockset / Power Electronics there are two models of the thyristor keys: thyristor and detailed thyristor. The latter is characterized by the presence of two additional parameters: the latching current (I_L , A) and turn-off time (T_q , s) [7]. The parameters of shunting RC-chains has the main value among the other parameters of the thyristor models. Practice shows that simulation of ideal TVR (without the shunting chains) in "MATLAB 6.0" is impossible, because the ideal key is interpreted as the current source of infinite power and system returns the error message (Fig. 6).

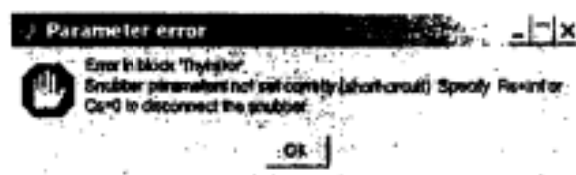


Fig. 6 - Error message in an attempt of the ideal thyristor keys simulation.

Development of TVR model must be forestalled by the calculation of the damping circuit, which decreases the pulsations of the TVR output current. It is because of the shown features above.

In figure 7 are shown the results of simulation of the PPCS-TVR with RL-load.

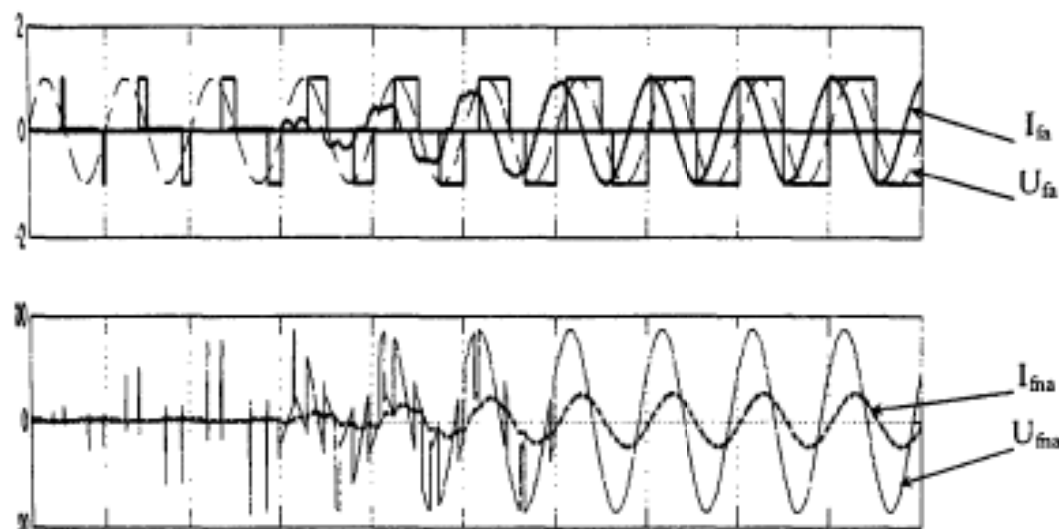


Fig. 7 - The results of simulation PPCS-TVR with RL-load (I_a - current in the phase "a" at the output of TVR; U_a - phase voltage of the generator (in rel.un.); U_{fa} - phase voltage at one of the load branches; I_{fa} - current in one of the load branch).

Implementing of the damping circuits and special feature of formation of control angle leads to the situation, in which at $\alpha \leq 60^\circ$ the closed "thyristor-load" circuit is absent, and current in the load flows through the damping chains only. This remark is reflected on the diagram (Fig. 7) being represented above. The observed picture emphasizes a good approximation of model to physical essence of investigated processes.

5 CONCLUSION

The solution of mathematical simulation problems is connected with the known difficulties of describing the modules connection structure which compose the researched object, as well as the solution of the equations, which describe their behavior. The main tendency that has been formed at present time is a refusal from highly tailored software writing for special task solution under the above circumstances. They are characterized by high efficiency, convenience in use and constant expansion of functional possibilities.

The best indices (according to the number of criteria) contemporary CMS has the medium Simulink "MATLAB 6.0"™ (Math Work, Inc.), while solving the problems of the dynamic system block simulation. Using of approaches, existing in Simulink "MATLAB 6.0"™, to the development of the pulse energy converter mathematical model has revealed the flexibility and universality of this packet. But it is necessary to register a number of special features while doing practical tasks. In particular, it is impossible sometimes to carry out the asymptotic (estimated) simulation in spite of the presence of idealized elements in Simulink libraries. And using of specialized libraries modules frequently requires their modification for the elimination of the existing functional disadvantages.

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