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3D FRAME MODELS SWITCHING ELEMENTS BY BEREZOVSKY FOR SOFTWARE-CONFIGURABLE SWITCHING STRUCTURES

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Abstract. The frame 2D and 3D models of patented by Berezovsky switching elements are proposed in relation to the construction of topologies of switching structures admissible for reconfiguration. It has been revealed that the use of frame models by Berezovsky switching elements allows to visualize the information about the state of the structure of switching elements, to vary the number of independent inputs and outputs, and provides additional possibilities in the simulation of topologies of modern structures with separated by planes data and control. The method of formation of states of the switching structure topology elements has been proposed.

Keywords: switching elements by Berezovsky, model of switching elements by Berezovsky, 3D switching structures on the elements by Berezovsky.

INTRODUCTION

The Fourth Industrial Revolution (4IR) is a new era in the development of mankind, characterized by the "blurring" the boundaries between the real world and digital technologies.

The fundamental part of the 4IR architecture is the digital economy and the integration of smart plants into industrial infrastructures.

One of the main tasks of the 4IR is the definition of common platforms of "service-oriented design" with a single information language space in which machines of different corporations will freely communicate.

A completely new type of industrial production, based on the so-called Big Data and their analysis, complete automation of production, augmented reality technologies, the Internet of things is emerging.

This means a wave of discoveries caused by the development of the possibilities of self-adjusting telecommunication architectures capable of adapting to new realities (needs) in a completely autonomous mode without human participation.

Cloud technologies, the development of collecting and analyzing methods for Big Data, secure and protected "smart network" technologies, intelligent switching systems and structures in the field of data transmission have become the key technologies of the new industrial revolution [1].

NEW SOFTWARE-DEFINED SWITCHING ARCHITECTURE

Traditionally, the main infrastructures nodes of Software Defined Switching Structures, Systems and Networks (*SDSSSN*) appear for customers in the form of some "black boxes": proprietary equipment, proprietary network operating system, hardwired by manufacturer set of functions and a specific utility for managing this entire pack.

The company Cisco is leading among the developers in this field, offering a platform that uses a unified switching matrix. However, the installation of newer and newer hardware devices, which configuration varies for each customer, leads to a multiple increase of the load i.e. the amount of service information sufficient to slightly get confused in new and specific data related to the basic computer control devices of the *SDSSSN*, not always clearly structured.

The construction components of the *SDSSSN* offered by the suppliers to the suppliers are still 2D component file structures, which dominate in the technology nowadays as well.

Topology was based on the use of the simplest integration mechanisms of individual components and was limited to the level of technology development, the implementation of elementary 2D models based on the interface of minimal user interaction with ECM [2]. This determined in many ways the capabilities of the *SDSSSN* designers.

In the new initiative *SDSSSN* construction two stages have been distinguished, in the first stage the existing monolithic approach is divided into hardware and software parts, the second one assumes a completely modular approach where all components can be isolated and replaced with suitable ones.

The new architecture framework

The new building element of the *SDSSSN* is a switching element (SE) without an operating system, a kind of SE without embedded software, but with a software boot environment providing the installation of compatible operating systems based on an open operating system (OS). This allows consumers to replace the operating system and avoid binding to the equipment supplier, and also fits into the tendency of building the *SDSSSN*.

As a basic generating framework, it is proposed to use Berezovsky's fully available 2D switching element (*KEB*-1), the graph of which is shown in Fig.1

KEB implements a set of states described by the characteristic equations [3].

The basic concept of such *KEB*-1 is its turn in fact into a common framework under the control of an open OS, whereas all switching functions are implemented by a special processor ("demon"), controlling the switching matrix, a field with its own driver, as one more service. In some developments, it is proposed to place the control processor on a separate daughter board, which will, in the future, even select the architecture of the processor.

The new switching element of *SDSSSN* must meet the most stringent requirements for continuity, flexibility and scalability, and in addition become "smarter" and faster, as a kind of "conductor" for all types of data passing through it.

2D frame models presentation of *KEB*-1. The need of developers and consumers in the possession of operational information on the structure, composition, state of *KEB*-1 predetermined the borrowing from psychology and philosophy the known concept of an abstract image, a model for representing a certain perception stereotype.

A real need to use the physical development of SEs from different manufacturers and in the case where the physical properties of SE are not important, it is preferable to use intelligent methods of knowledge representation to describe the functions of the model as a single solution that is the frame model.

Framed models of knowledge representation are one of the most important lines of research in the field of artificial intelligence, a component of the 4IR.

The integrated complex model should provide a study of the behavior of the simulated SE in general and the influence of the constituent parts on each other, herewith it should be easily modified and expanded.

It has been suggested to use a second-order geometric figure — an ellipse as a formalized model for displaying the abstract image, in our case, the *KEB* frame model [3].

Frame model of *KEB*-1 with the number of terminals points -input-output $n = 4$ is shown in Fig. 2.

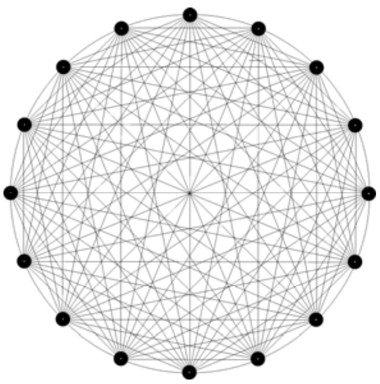

Fig. 1. Graph of commutation element by Berezovsky

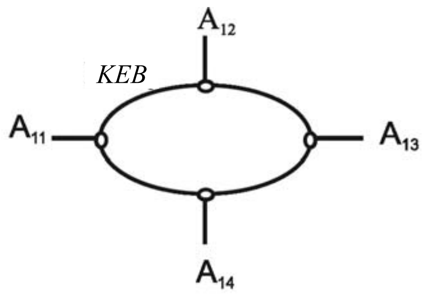

Fig. 2. Frame model by Berezovsky

Orientation of the *KEB* frame model is determined by the designer proceeding from their practical convenience of representing the structure (Fig. 3).

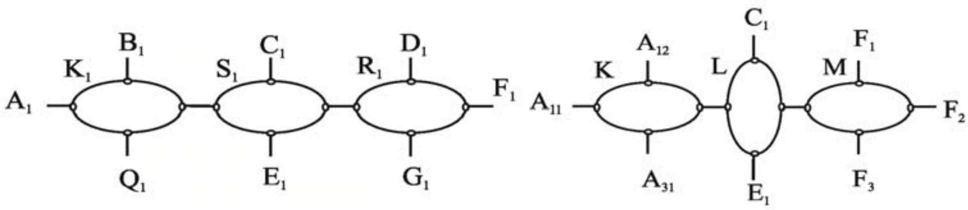

Fig. 3. Orientation options, *KEB* codes and I / O points

In general case, the frame data structure can contain a wide range of information, determined by the level of education, professional experience and personal maturity of both designers and consumers.

Authorial encodings of both the *KEB* themselves and the I / O points are possible.

3D frame models for the presentation of *KEB*-2. The emergence of new patent technologies of 3-DMS type, three-dimensional integration by means of through-silicon holes (Through Silicon Vias, TSV) will solve some problems of

3D modern electronics, which in turn will unable solving 3D *SDSSSN* design issues for new communication technology, automated control systems, computer systems, robotics, unmanned aerial vehicles [4].

The N-dimensional switching element by Berezovsky *KEB*-2 has been synthesized [5].

The main advantage of the frame model of *KEB*-2 representation is that it reflects the conceptual basis by Berezovsky-2 switching element, as well as its flexibility and visibility.

The singularity of this approach is the ability to synthesize 3D models of *KEB*-2 for *SDSSSN* in a Cartesian coordinate system. The left and right variants of the rectangular 3D frame model of the *KEB*-2 from two generating *KEB*-1 in the 3-dimensional space have been proposed (Fig. 4, 5):

- 3D rectangular single frame model of *KEB*-2 presentation;
- 3D rectangular colored frame model of *KEB*-2 presentation;
- 3D rectangular frame model with *KEB*-2 switching state display;
- 3D rectangular colored frame model with *KEB*-2 switching state display.

The frame model of *KEB*-2 representation is offered in two varieties:

- rectangular 3D *KEB*-2 frame model, as a particular kind of model (Fig. 4–6);

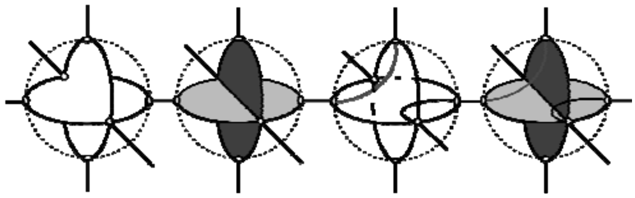

Fig. 4. Rectangular left 3D *KEB*-2 frame model

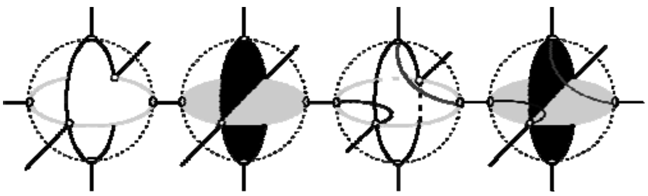

Fig. 5. Rectangular right 3D *KEB*-2 frame model

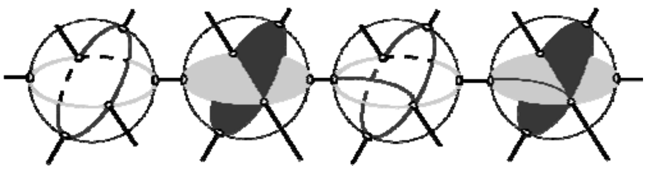

Fig. 6. Isometric frame model of the *KEB*-2 representation from $N = 2$ generating *KEB*-1 (green, yellow) in 3 -dimensional space

The frame model of *KEB* can be characterized by its relatively high complexity, which is manifested in a decrease in the speed of the output mechanism and increasing the complexity of making changes to the generic hierarchy. Therefore, when developing the *KEB* frame model, the special attention is paid to visual ways of displaying and effective means of editing of *KEB* frame models and frame structures on its base.

The frame model of 3D *KEB*-2 is formed on the ground of basic 2D *KEB*-1 in the affine space of N-planes (Fig. 7) [5].

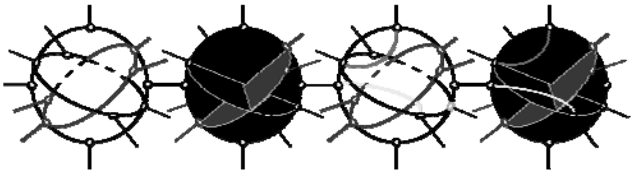

Fig. 7. Isometric frame model of the *KEB*-2 representation from $N = 3$ generating *KEB*-1 (red, blue, green) in 3 -dimensional space

Framed 3D models allow designing 3D switching matrices that can facilitate the development of options for parallel systems of collecting, processing and storing information. The *KEB* frame model provides an economical allocation of the knowledge base in memory, and the value of any attribute, i.e. a slot, can be calculated by appropriate procedures or found by heuristic methods.

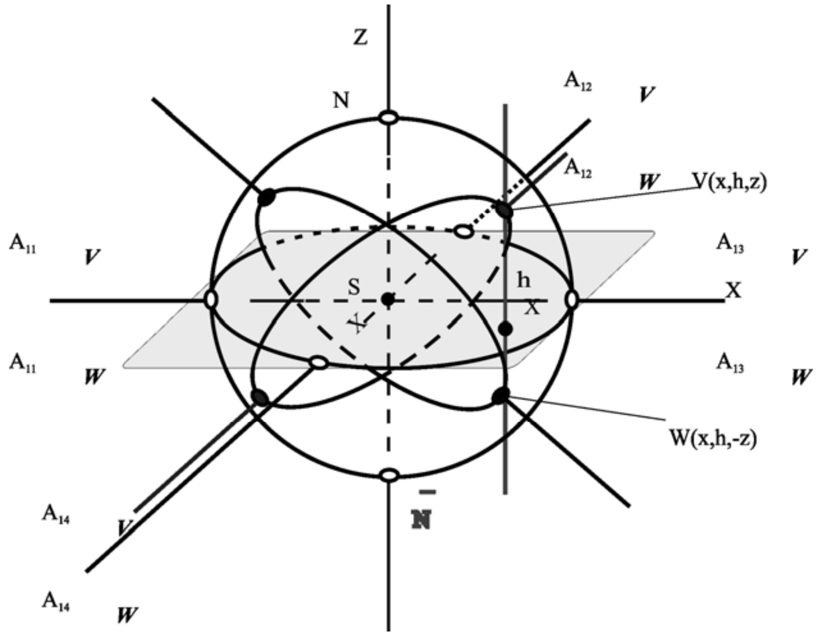

Fig. 8. The frame model

SWITCHING STRUCTURES ON ELEMENTS BY BEREZOVSKY

The 2D “flat technology” is still dominating in the world (humanity is used to and works with 2D, that is, in the plane (of a desktop) of information visualization: a diagram as a flat drawing; a picture as a flat image; chip as a plate; motherboard as a set of up to 51 layers.

Formation of the switching structure in 2D is performed according to the file principle that is by cascading entering of switching element into a line and further typing them into the page-field.

A field of 4 × 4 switching elements with 4 points (terminals) of inputs and outputs is shown in Fig. 9.

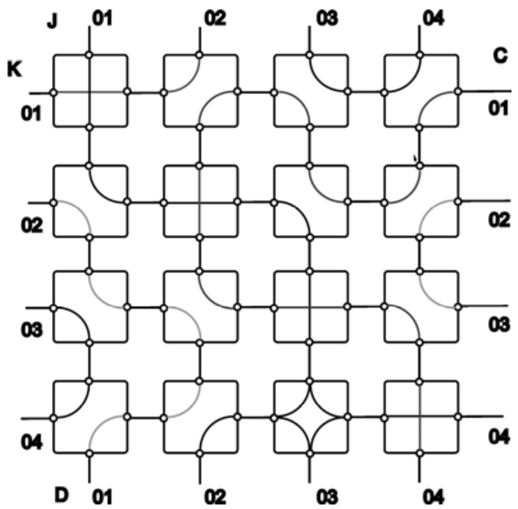

Fig. 9. Traditional file-switching structure model

The implementation of frame *KEB* models opens new opportunities for developers in the topology and architecture of *SDSSSN*.

In *SDSSSN* on the basis of *KEB*-1, *KEB*-2, branched, unbranched, rectilinear, curvilinear connections i.e. communication channels, transmitting information in any given direction, are synthesized.

Branching communication channels allow information to be transmitted from one terminal point, the *SDSSSN* input to several outputs.

In such *SDSSSN*s, it is possible to form intersecting communication channels between inputs and outputs located in different parts thereof.

In some cases in flat homogeneous *SDSSSN*, limiting the transfer of information from one part of the structure to another or even isolating one part from the other, communication channels may be formed.

The implementation of *KEB*-1, *KEB*-2 in the synthesis of new *SDSSSN* allows the more efficient and full use of the structure (Fig. 10, 11).

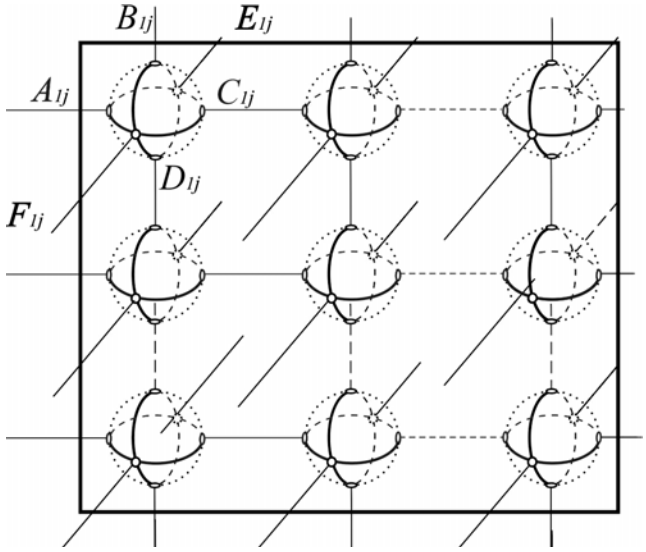

Fig. 10. 3D rectangular colored frame model *KEB* switching structure from $N=2$ generating of *KEB*-1 (green, red)

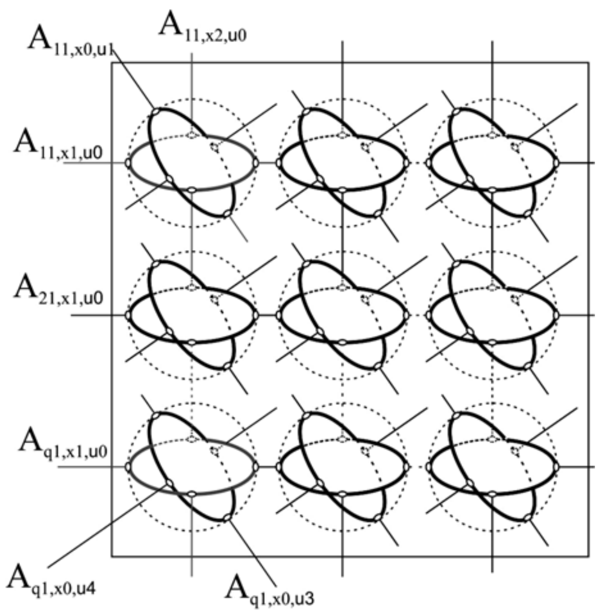

Fig. 11. 3D Isometric colored frame model *KEB* switching structure from $N = 2$ generating *KEB*-1 (blue-black, red)

3D rectangular colored frame model switching structure on the *KEB* from $N = 2$ generating *KEB*-1 (green, red) and 6 input-outputs $A_{1j}, B_{1j}, C_{1j}, D_{1j}, F_{1j}, E_{1j}$.

The interaction of different types of models (*KEB* -1, *KEB*-2) as augmented reality tools (contributs individual artificial elements to the perception of the real world) or knowledge base rules, their reuse in the modeling infrastructure is provided on the basis of the problem-oriented integration method.

The implementation of the method allows solving the problems of compatibility and interaction of models in the object-oriented modeling infrastructure intended for the work of *SDSSSN* designers.

3D rectangular colored frame model switching structure on the *KEB* from $N = 2$ generating *KEB*-1 (green, red) and 8 input-outputs A_{ij}, x_k, u_f, where $i = \overline{1,q}$, $j = \overline{1,p}$, $k = \overline{1,4}$, $f = \overline{1,4}$.

The model description is extended by the semantic constructions of the domain are and the knowledge bases determining the work logic of the models [6].

Regardless of whether the model functions are implemented in a specialized programming language or described in the form of rules, the user will operate them in the same way.

When performing the modeling, each model implements the algorithms embedded in it and interacts with other models through subscriptions to outputs from other models. Subscriptions are implemented on the basis of the constructed information-graphic description.

FORMATION OF STATES OF COMMUTATION STRUCTURES ON SWITCHING ELEMENTS BY BEREZOVSKY

These days, one of the topical tasks of designing in many technical branches is the development of efficient switching provision for *SDSSSN* in various modes of their operation [7]. This task, first of all, refers to the switching of complex computer systems and networks, to the management of monitoring systems and security networks, to switching of channel television, broadcasting, telephony and Internet networks, to maintaining the required state of optoelectronic communication networks, etc. [8]. Existing designing methods of appropriate patching facilities for the listed *SDSSSN* have a number of known shortcomings [9] that reduce the efficiency of multi-channel networks functioning, and therefore the proposed approach, the main concept of discussed below, is of some interest.

So, suppose that for a given *SDSSSN* containing M channels y_k $(k = \overline{1, M})$, it is necessary to ensure their switching to N states S_i $(i = \overline{1, N})$ on the basis of commuting module (*KEB*). In its turn, the *KEB* is characterized by n commuting variables x_r $(r = \overline{1, n})$ and m commutated poles (variables) z_l $(l = \overline{1, m})$. Furthermore, for the *KEB* there is also a certain number Q of switching states (SS) V_j $(j = \overline{1, Q})$ with respect to the set of variables z.

Then the task solution on switching the considered *SDSSSN* can be reduced to the determination of a certain number of *KEBs* that, on the basis of a number of states V under the control of n commuting variables x, by means of the variables z, ensure the commutation of the channels y for given states S.

Concurrently, the solution of the problem can be obtained on the basis of different *KEB*.

One of the simple way of presenting information about a given i-th *SS* (S_1) is shown in Table 1.

Table 1. Switching state table

y	y_1	y_2	…	y_M
y_1	0	1	…	0
y_2	0	0	…	1
⋮	⋮	⋮	⋮	⋮
y_M	0	0	…	0

Table 2. Modified table

y	y_1	y_2	…	y_M
y_1	1	1	…	0
y_2	0	1	…	1
⋮	⋮	⋮	⋮	⋮
y_M	1	0	…	1

Because of the presence of symmetry, Table 1 can be simplified (Table 2).

On the basis of Table 1 and Table 2, it is convenient to introduce the following notation, which in the presence of a connection between the p-th and q-th channels can be represented in the form

$$y_p y_q = 1 \; , \tag{1}$$

and in its absence it is written as follows

$$y_p y_q = 0 \; . \tag{2}$$

Then, taking into consideration the notations (1) and (2), the i-th SS (S1) can be represented in the form

$$S_i = g_1(i) + g_2(i) + \ldots + g_{ai}(i) = a_{i,} , \tag{3}$$

where $g_1(i)$ is the k-th connection of channels $y_p y_q$ (1) to the i-th SS *SDSSSN*.

Based on the introduced representations (Table 1, 2, expressions (1)–(3)) as a whole, the task for commutating of *SDSSSN* can be represented in the form of a table (Table 3).

Table 3. Channel Link Combination Table

S	g			
	g_1	g_2	…	g_A
S_1	1	0	…	0
S_2	1	0	…	1
⋮	⋮	⋮	⋮	⋮
S_N	0	1	…	0

In the Table 3, in line g, all used in *SS* combinations of *SDSSSN* channels of the type

$$g_1 = y_1 y_2,\ g_2 = y_1 y_3,\ ...,\ g_A = y_{M-1} y_M,$$

are represented, except $y_k y_k\ (k = \overline{1, M})$.

The same information (Table 3) can easily be represented in the form of expressions (3)

$$S_i = \sum_{k=1}^{a_i} g_k(i) = a_i,\ \ i = \overline{1, N}. \tag{4}$$

In particular, the simple inclusion of the *SDSSSN*, by virtue of relations (4), is described as follows

$$S_i = \sum_{k=1}^{a_i} g_k(i) = a_i,\ \ i = 1,2,$$

where $a_1 = 0,\ S_1 = 0$.

In its turn, for the *KEB* it is also possible to create tables similar to those considered above (Tables 1–3). Such tables for *KEB* are given below (Table 4, 5).

Table 4. Variable table

z	z_1	z_2	…z	z_m
z_1	0	1	…	0
z_2	0	0	…	1
⋮	⋮	⋮	⋮	⋮
z_m	0	0	…	0

Table 5. Variable table

V	w			
	w_1	w_2	…	
V_1	1	0	…	1
V_2	1	1	…	0
⋮	⋮	⋮	⋮	⋮
V_Q	0	1	…	1

Description of the *SS KEB* by analogy with the expression (4) has the form

$$V_j = \sum_{z=1}^{b_j} w_r(j) = b_j,\quad j = \overline{1, Q}, \tag{5}$$

where $w_r(j)$ is the r-th connection of the variables $z_1 z_n$ (1) in the j-th *SS*.

For *KEB* it is necessary additionally to describe the state of control variables $x_r\ (r = \overline{1, n})$ (control state (CS) X_j) for each *SS* V_j of commutated variables $z_l\ (l = \overline{1, m})$ (Table 5). For this purpose it is convenient to use the following table (Table 6).

Table 6. Control signal table

x_1	0	0	…	1	1
x_2	1	1	…	0	0
⋮	⋮	⋮	⋮	⋮	⋮
x_n	0	1	…	0	1
V	V_1	V_2	…	$V_{Q\text{-}1}$	V_Q

In Table 6 the agreed notation is as: 1 — has a control signal and 0 — this signal is not present that can be represented for the k- th manipulated variable in the following form

$$x_k = 1 \quad \text{или} \quad \overline{x}_k = 0, \quad k = \overline{1,n}\,. \tag{6}$$

Then the description of the j-th CS (X_j) for the j-th SS (V_j) has the form

$$X_j = \overline{x}_1 x_2 \overline{x}_3 ... \overline{x}_n\,. \tag{7}$$

Taking into consideration the relations (6) and (7), and also the well-known Boolean algebraic identities for the representation (5), we obtain

$$V_j = b_j X_j = b_j(\overline{x}_1 x_2 \overline{x}_3 ... \overline{x}_n), \; j = \overline{1,Q}\,.$$

Indeed, by virtue of Table 6 and the expressions (6), (7), for Vj we have

$$X_j = \overline{x}_1 x_2 \overline{x}_3 ... \overline{x}_n = 1\,.$$

It should be noted that, both for *SS SDSSSN* (S_i), and SS *KEB* (V_j) the simple and / or complex switching occurs. The first type of commutation is characterized by the absence of repetition of indices in the description of $g_k(i)$ (4) and $w_r(j)$ (5), i.e. each *SDSSSN* channel and each *KEB* pole has only one connection. Complex switching allows the repetition of mentioned indices, which indicates the presence of several connections for individual channels of the *SDSSSN* and *KEB* poles. The noted features impose additional requirements on the formation process of the complex *SDSSSN* set by SS, which determines the development of individual methods for solving the set task.

So, the first procedure for the formation of complex *SDSSSN* assigned by *SS* is called the method of direct substitution (MDS) and its essence is as follows.

Suppose that for *SDSSSN* with M channels y_k $(k = \overline{1,M})$ it is required to form N *SS* S_i $(i = \overline{1,N})$ based on *KEB* with n commuting variables x_r $(r = \overline{1,n})$, m commutated poles z_l $(l = \overline{1,m})$ and Q *SS* V_j $(j = \overline{1,Q})$. In the above descriptions (4) and (5) the representation of this problem has the form $(Q \ge N,\, m \ge M)$:

$$\sum_{k=1}^{a_i} g_k(i) = a_i,\; i = \overline{1,N};\; \sum_{z=1}^{b_j} w_r(j) = b_j,\; j = \overline{1,Q}\,, \tag{8}$$

where

$$g_1(i) = y_1 y_2, \quad g_2(i) = y_1 y_3\;, ..., \; g_{m-1}(i) = y_1 y_m;$$

$$g_m(i) = y_2 y_3, \quad g_{m+1}(i) = y_2 y_n \ ,..., \ g_{2m-3}(i) = y_2 y_m;$$

$$g_c(i) = y_{m-1} y_m. \tag{9}$$

For $w_r(j)$ the relations analogous to the equalities for $g_k(i)$ (8) are valid. Obviously, for $m > 0$, the individual values of $g_k(i)$ (9) are equal to zero by definition ($g_M(i) = y_1 y_{M+1} = 0$ etc.).

MDS provides for the identification of all possible solutions to the formulated above task. For this purpose, at each step of identifying connections between the channels $y_k \ (k = \overline{1, M})$ of *SDSSSN* and $z_l \ (l = \overline{1, m})$ *KEB* bands, these connections are set in the following form based on some search algorithm or randomly

$$y_1 = z_\alpha, \quad y_2 = z_\beta,...., \quad y_m = z_\omega. \tag{10}$$

Subsequently the *SS SDSSSN* $S_i \ (i = \overline{1, N})$ (8), (9) are rewritten taking into account the selected combinations (10) in the form:

$$\sum_{k=1}^{ai} w_k(i) = a_i, \quad i = \overline{1, N}, \tag{11}$$

and the following equalities are considered separately for each $S_i \ (i = \overline{1, N})$:

$$\begin{aligned} &V_j - S_1 = b_j - a_1, \ \ j = \overline{1, Q}; \\ &V_j - S_2 = b_j - a_2, \ \ j = \overline{1, Q}; \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ &V_j - S_N = b_j - a_N, \ \ j = \overline{1, Q}. \end{aligned} \tag{12}$$

The presence of non-coincident values of j for each *SS* $S_i \ (i = \overline{1, N})$ indicates the correctness of the selected compounds (10). Violation of this requirement determines the inaccuracy of the relations (10). Herewith, description of the control variables $x_r \ (r = \overline{1, n})$ (7) X_i corresponds to each value of j (V_j) entering into the obtained solution.

In particular cases, to solve the set task, the tables of SS indices (S1, Table 7 and V_j, Table 8) can be used.

Table 7. Index table

S	g			
	g_1	g_2	…	g_A
S_1	α_1	ε_2	…	ε_A
S_2	β_1	β_2	…	β_A
⋮	⋮	⋮	⋮	⋮
S_N	γ_1	γ_2	…	γ_A

Table 8. Index table

V	w			
	w_1	w_2	…	w_B
V_1	ε_1	ε_2	…	ε_B
V_2	δ_1	δ_2	…	ε_B
⋮	⋮	⋮	⋮	⋮
V_Q	ν_1	ν_2	…	ν_B

A simple search of lines in the Table 8, overlapping the lines in the Table 7, in the absence of their overlapping for different $S_i \ (i = \overline{1, N})$, also proves the correctness of the selected connections (10).

EXAMPLE OF APPLYING THE PROPOSED METHOD

To illustrate the proposed MDS, let's consider the following simple example. For a certain MCS having 4 channels y_k $(k = \overline{1,4})$, based on the given tables of the type of Table 1–3, a SS (4) S_i $(i = \overline{1,2})$ are created:

$$S_1 = y_1 y_3 + y_2 y_4 = 2; \quad S_2 = y_1 y_2 + y_3 y_4 = 2. \tag{13}$$

In addition, there is a *KEB* with 6 poles z_l $(l = \overline{1,6})$ and 10 control variables x_r $(r = \overline{1,10})$. To provide the SS (11) in the CM, the following SS (V_j) (5) can be used:

$$\begin{aligned} V_1 &= z_1 z_4 + z_2 z_3 + z_2 z_5 = 3; \\ V_2 &= z_1 z_5 + z_2 z_4 + z_3 z_6 = 3; \\ V_3 &= z_1 z_3 + z_2 z_4 + z_5 z_6 = 3. \end{aligned} \tag{14}$$

Taking into consideration the representation (9) of the *SS* description (14) will take the form:

$$\begin{aligned} V_1 &= w_3(1) + w_6(1) + w_8(1) = 3; \\ V_2 &= w_4(2) + w_7(2) + w_{12}(2) = 3; \\ V_3 &= w_2(3) + w_7(3) + w_{15}(3) = 3. \end{aligned} \tag{15}$$

The description of control variables (7) corresponds to each SS (14), (15)

$$X_1 = x_1 \overline{x_2} \ldots x_{10}, \quad X_2 = \overline{x_1} x_2 \ldots \overline{x_{10}}, \quad X_3 = \overline{x_1 x_2} \ldots \overline{x_{10}}. \tag{16}$$

Next, the connections (10) are assigned

$$y_1 = z_1, \; y_2 = z_2, \; y_3 = z_3, \; y_4 = z_4, \tag{17}$$

and expressions (11), (13) are written down,

$$S_1 = w_2(1) + w_7(1) = 2; \quad S_2 = w_1(2) + w_{10}(2) = 2. \tag{18}$$

The verification of conditions (12) on the basis of expressions (18) and (15) gives the following relations:

$$\begin{aligned} &V_1 - S_1 = 3; \quad V_2 - S_1 = 2; \quad V_3 - S_1 = 1; \\ &V_1 - S_2 = 3; \quad V_2 - S_2 = 3; \quad V_3 - S_2 = 3. \end{aligned} \tag{19}$$

In the set $V_j - S_1$ $(j = \overline{1,3})$ there is a solution $(V_3 - S_1 = 1)$, however there is no such solution in the second set $V_j - S_2$ $(j = \overline{1,3})$ which indicates the unsuccessful selection of connections (17).

The same conclusion can be made as well for example with respect to the following combinations:

$$y_1 = z_1, \; y_2 = z_3, \; y_3 = z_4, \; y_4 = z_5; \; y_1 = z_3, \; y_2 = z_4,$$

$$y_3 = z_5, \; y_4 = z_6; \; y_1 = z_6, \; y_2 = z_5, \; y_3 = z_4, \; y_4 = z_3$$

and etc.

The following relation is considered as successful:

$$y_1 = z_1,\quad y_2 = z_4,\quad y_3 = z_5,\quad y_4 = z_2\,, \tag{20}$$

which determines a SS of the form (18):

$$S_1 = w_4(1) + w_7(1) = 2;\qquad S_2 = w_3(2) + w_8(2) = 2\,.$$

In this case, the verification of the requirements (12), (19) has the form:

$$V_1 - S_1 = 3;\quad V_2 - S_1 = 1;\quad V_3 - S_1 = 2;$$

$$V_1 - S_2 = 1;\quad V_2 - S_2 = 3;\quad V_3 - S_2 = 3.$$

The second relation ($V_2 - S_1 = 1$) from the first set $V_j - S_1$ ($j = \overline{1,3}$) and the first equality ($V_1 - S_2 = 1$) from the second set satisfies the requirements (12) and, consequently, the connections (20) are the solution of the problem under consideration. Fig. 12, a) shows the realization of S_1 (13), and in Fig. 12, b) there is the realization of S_2 (13) by means of *SS KEB*, respectively, V_2 and V_1. The control variables X_2 and X_1 are then fed to the control circuit (CC) *KEB* respectively (16). In the first case (Fig. 12, *a*), there is a simple connection, and in the second case (Fig. 12, *b*) there is a double connection for Z_2.

The use of index tables (Table 7 and Table 8) gives a fairly clear idea of the presence and absence of a solution.

Thus for the variant of combinations (17) we have the following tables of indices (Table 9, 10).

Table 9. Index table for a variant of combinations (17)

S	g	
	g_1	g_2
S_1	$\boxed{2}$	$\boxed{7}$
S_2	1	10

Table 10. Index table for a variant of combinations (17)

V	w		
	w_1	w_2	w_3
V_1	3	6	8
V_2	4	7	.120
V_3	$\boxed{2}$	$\boxed{7}$	15

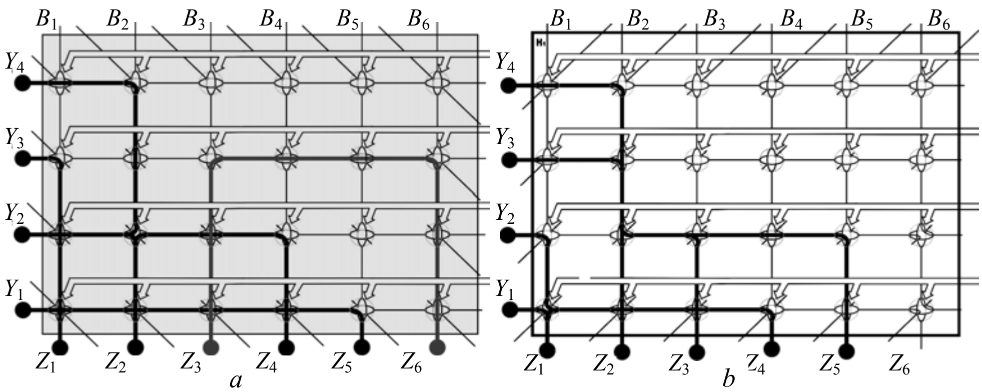

Fig. 12. Implementation of *SDSSSN* S_1 (*a*) and S_2 (*b*)

These tables (Table 9, 10) obviously demonstrate the abovementioned conclusions (19) on the absence of a solution.

For correct connections (20), there are the tables 11 and 12 take place, which convincingly illustrate the existence of a solution to the problem.

Table 11. Index table for correct connections (20)

S	g	
	g_1	g_2
S_1	4	7
S_2	$\boxed{3}$	$\boxed{8}$

Table 12. Index table for correct connections (20)

V	w		
	w_1	w_2	w_3
V_1	$\boxed{3}$	6	$\boxed{8}$
V_2	4	7	.120
V_3	2	7	15

In conclusion, we note that the proposed method has its advantages and disadvantages. Thus *SDSSSN* (8)–(12) allows to get all possible solutions, it is simply algorithmized and easily allows to take into account additional requirements when selecting connections. These requirements include restrictions on currents, voltages, power, speed, *SDSSSN* channels and their coordination with the *KEB* capabilities.

Frame 2D, 3D models of switching elements by Berezovsky give the researcher the opportunity to create their own multi-character material as an innovative database of interactive graphic data (DB) for the formation of special knowledge bases (KB).

Having a language system with which you can present the result and experience of developing a database, and also store and store knowledge bases directly in the system in close connection with a specific sensory channel of cognitive graphics [10].

Such a technology gives a researcher a highly efficient technical tool for direct, purposeful influence on the processes of figurative thinking of a person / developer / operator, and in natural (rather than model or test) conditions for finding a solution to a real scientific problem.

CONCLUSIONS

2D, 3D frame models by Berezovsky patented switching elements are proposed for constructing topologies of software-configured switching structures, systems and networks.

The proposed *KEB*-1 and *KEB* -2 can be in one of the specified states of Ni; a priori set each state of the switching elements by Berezovsky, which form the topology, is encoded by the logical statement Aj and can be represented as a graphical 2D, 3D model of the image of the *SDSSSN* element.

Models allow to visualize 2D, 3D topology of the *SDSSSN*.

They reflect the vision in the design of the role and place of cognitive graphics in the development of new *SDSSSNs*.

Reduction of various types of models (*KEB* -1, *KEB*-2) to single components of the modeling environment allows the designer-designer to build universal models of the *SDSSSN*, applying various options for the implementation of submodels.

A distinctive feature of the use of the *KEB* is the simplification of the procedure for the mathematic‘al design of 2D, 3D models of the SDSSSN topology.

The use of models *KEB* -1 *KEB* -2 allows visualizing the task of designing a given topology of the RCSS parallel systems for collecting and processing, storage of information.

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