Development of hardware and a system for analyzing energy parameters based on simulation in SimInTech

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Abstract. The work is devoted to the issue of improving the efficiency of information systems in the field of energy, in particular, specialized systems in the field of data analysis and processing, designed for operational processing of information with its subsequent visualization, analysis and decision-making on the management of energy parameters of technological equipment, based on the developed ranking block information on monitored electrical power parameters using SimInTech software.

1. Introduction

Increasing the efficiency of information systems in the field of energy, in particular, specialized systems in the field of analysis and information processing, is an urgent task and contributes to the development of the energy sector in Russia as a whole. In this scientific direction, a number of developments of Russian scientists are known [1–8], in which various options for solving this problem are proposed, in particular, the development of information systems, methods, and models that allow for the prompt processing of an array of electric power parameters, but the solution to the issue to improve the efficiency of analysis and processing of data on parameters that ensure the stable operation of technological equipment using the SimInTech package in published scientific papers is currently unknown [14]. This work is devoted to research in the field of creating new information systems using the SimInTech software package based on parameter ranking.

2. Materials and methods

The starting point of the author's research was an information system containing a monitoring center, including communication tools, system, and application software, databases, display and documentation tools, an archive server database of local monitoring systems, and many local monitoring systems [15-17].

In the course of the research carried out in this work, the following tasks were solved:

– the efficiency of analysis and processing of information by the system has been increased, due to ranking according to the degree of influence on the stable operation of electric power parameters [18-20];
– the functionality of the information analysis and processing system has been expanded for making management decisions based on the domestic software SimInTech [21-23].
3. Results and Discussion

The solution of these scientific problems became possible due to the implementation of a new concept for the implementation of the system's operation, the proposed principle of organizing the joint work of the system blocks and, in particular, the unit for ranking electric power parameters, as well as the use of SimInTech models and software.

Taking into account the many years of research experience proposed earlier by A. A. Sokolov and other information systems in the field of analysis and processing [9–10]. The developed system is presented in Figure 1 in the form of a block diagram.

The principle of operation of the proposed system for the analysis and processing of information is illustrated in Figure 1. The information ranking block contains a number of subsystems, which receives control information on electrical energy parameters from monitoring centers. To simulate processes and create an adequate mathematical model, it is proposed to start work on creating a ranking system with modeling in the SimInTech environment. This will allow you to assess the sensitivity of the model to input data, even very weakly changing [24, 25].

![Block diagram of the new organization of the system of analysis and processing of ranked information.](image-url)
Figure 2 shows an example of the implementation of the block of ranking information of electric power parameters based on the model of the SimInTech package (the model from [10] is used).

![Figure 2. Block for ranking information on electric power parameters based on models of the SimInTech package.](image)

Figure 3 shows a graphical model of the implementation of the electric drive circuit shown in Figure 2: the dependence $I = f(t)$ is shown in red.

![Figure 3. Dependence $I = f(t)$ [10].](image)
The removal of a real characteristic due to errors in the technology for measuring energy parameters (especially in real production conditions) can lead to an insufficiently correct interpretation of the experimental results. In particular, it is possible to take readings at uncharacteristic points of the characteristic. For example, taking measurements at points \( t = 0, 5, 10, 15, 20, 25, 30, 35 \) s will lead to the fact that extreme values of the current \( I = f (2.5) = 123 \) A will not fall into the analysis area, \( I = f (17) = 117 \) A. In this case, the curve will slightly differ from the predicted one (shown in blue in Figure 3).

To reduce this collision, it will be necessary to carry out experimental measurements several times, repeating the conditions of the experiment, in order to accumulate statistical data. Further, you will need to rank the data by means of the information system we offer, since at the same and/or nearby time point there will be several measurement results, refining and complementing each other to the required accuracy.

4. Conclusion
This system will improve the efficiency of the analysis and processing of information with the subsequent decision-making on the management of the energy parameters of technological equipment. Since it is known that the task of extracting the largest amount of data on the studied processes in power systems with reduced costs, both time and economic, is currently very relevant. In this regard, in order to find out the number of different states of an object or conditions for the development of energy systems, it is necessary to carry out a number of tests and implement appropriate monitoring of the created model in the SimInTech software package. In this situation, it is obvious that the studies listed below, which may contain all possible laboratory tests, are rejected since there is a risk of obtaining a large amount of unclaimed data. Therefore, a natural question arises of how to determine how much and what research needs to be included in the experiment in order to quickly solve the problem of monitoring electrical energy parameters. For this, the authors of the article focused on the need for the initial planning of the experiment, and it is this process that is not only the direction of processing experimental data but is also one of the tools that are extremely necessary for the calendar organization of the research process. This timing implies the following:

1) movement towards compulsory minimization of the total number of laboratory experiments on modeling electric power parameters;
2) simulation in real-time of all variable parameters simultaneously, which determine the process according to special algorithms;
3) it is necessary to use specially created mathematical models and a specific mathematical apparatus that will determine the reliability of modeling and exclude an increase in the error in measuring the control parameters of modeling;
4) it is necessary, before the implementation of the modeling process in the SimInTech software, to determine the strategy that allows taking objective decisions on the basis of the results of statistical analysis after each series of laboratory experiments;
5) it is necessary to plan the development of an appropriate mathematical model and the simultaneous planning of simulation experiments, as well as the parallel implementation of virtual simulation, in real-time;
6) before completing the experiments, it is necessary to analyze and evaluate simulation experiments with a mathematical model and develop algorithms for making appropriate decisions. This article is based on the virtual method proposed by the authors, which is a developed methodology and a specially structured complex of probabilistic models (for the solution, the Monte Carlo method was used) and statistical methods. The implementation of this method is especially relevant at the stage of predicting the development of complex electrical power systems and equipment with constantly changing electrical energy parameters, when it comes to analyzing and assessing the magnitude of the influence of several key variables on the behavior of the modeled system under conditions of unstable operating modes, including emergency operating modes.
The most urgent for further research is the task of developing and implementing new modeling technologies and specially created technical means for them, for example, devices for protection against single-phase faults, including single-phase ground faults, and also technical means that monitor online such parameters as current, power, and tension.

The main difference between the proposed in the work direction of modeling of electric power parameters from the previously created ones is as follows:

– in virtual modeling, theoretical hypotheses and mathematical models, coupled with a specially created methodology, allow the transition from deterministic models to be reduced to simpler stochastic models for the perception of electric power facilities by workers;
– most of the applied statistical methods and the corresponding algorithms were in advance when creating the software, adapted to the production models and equipment on which the laboratory research took place;
– in the software, a dialog mode was implemented in which the user could perform such functions as the conjugation of various stages of simulation research and management decision-making.

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The use of the proposed system for analyzing and processing ranked information will increase the efficiency of analysis and processing of information due to the new functionality of the ranking unit and SimInTech software, and in the future will allow developing control solutions and choosing optimal ones based on the analysis of data obtained using the model and determined empirically. The models presented in the article, in this case, are intended not only to predict trends in energy consumption, possible abnormal operating modes of electrical equipment, including emergency modes of operation, but also to explain the interrelationships of the factors under study and energy indicators within the framework of monitoring the stable operation of electrical equipment.

The performed studies allow, among other positive effects, to highlight the essential features of the technology of direct study in real-time of typical real energy systems, due to the following features of the modeling methodology: firstly, mathematical models were introduced into the methodology, taking into account the probability of the need to stabilize interfering factors (variable parameters); secondly, the use of virtual modeling methods presupposes a clear logical block diagram for all computational operations and calculations; thirdly, it seems for the first time for researchers the opportunity to analyze and evaluate the effect of research methods both in statistical and deterministic models. Moreover, the most realistic way to obtain a guaranteed reliable calculation result with minimal errors is determined by good organization, as well as by the fact that the user is able to actively control during the experiment and introduce corrections into the technological process of equipment operation.

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