UDC 621.313

DETERMINATION OF FUNCTIONING QUALITY OF AREA WITH MIONECTIC RESISTANCE ISOLATION OF OPERATIVE DIRECT-CURRENT NETWORK BY NEURO-FUZZY MODELING

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Summary: *investigational possibility of the use of neuro-fuzzy modeling is at determination of functioning quality of area with mionectic resistance of isolation. Investigational parameters which characterize quality functioning of area of operative direct-current network: an amount of proceedings in an isolation is after passing of signals; current isolation resistance of area; resistance of area isolation is after renewal. Determination of area with mionectic isolation resistance of operative direct-current network it is suggested to carry out by a calculation the coefficient of quality of its functioning. A coefficient of functioning quality of operative direct-current network area is a complex parameter, which takes into account not only possibility of area to execute the functions but also possibility effectively to proceed in an isolation after passing of test or other influencing on its state signals. The method of determination of area is improved with mionectic isolation resistance of operative direct-current network, which allows to warn development of emergency situations and enables to conduct the done early replacement, repair, adjusting of areas of operative direct-current network. The method of determining the coefficient functioning as the operative parts of current permanent ones so using methods based on fuzzy modeling and driven to software implementation in a complex MATLAB. The advantage of this method is to attract an evaluation experience for field personnel, taking into account in calculating the quantity, quality, regulatory parameters, etc., and enable the optimization mathematical model on real data.*

Keywords: *operative direct-current network, mionectic resistance of isolation, coefficient of functioning quality, neural-fuzzy modelling.*

Introduction

Operative direct-current networks (ODCN) of electric substation are designed to power the devices of relay protection and automation, alarm systems, responsible mechanisms of own needs, emergency lighting, coils of turn on and off high-voltage switches, etc. [1-2]. The research set out in the article can be used in the creation and management of network power DC supply for consumers and businesses (power plants and substations) that use two-wire networks of operating DC [2].

There are many ways and means of controlling isolation ODCN [1-2], but the specificity of the control object requires an increase in the accuracy of determining the correct appearance of dangerous reduction of insulation resistance at an early stage and providing selective identification of damaged cable lines.

One of the promising directions for improving the reliability of the ODCN is the prediction of their condition, namely forecasting of non-renewable reduction in insulation resistance. To solve this class of prediction problems are proven methods of neuro-fuzzy modeling [3-5]. Methods based on neuro-fuzzy modeling are improving from year to year, as evidenced by the large number of publications and is already used in airport security systems to identify defects in power transformers to predict future consumption and generation of electricity etc [6-12]. Therefore, the aim of this article is to improve the method of determining the area with low resistance network isolation operating DC voltage by calculating the quality factor of the functioning of the ODCN area with the use of means of neuro-fuzzy modeling.

Material and research results

Definition of the area with mionectic resistance isolation of ODCN is proposed by calculating the quality factor of its functioning. The quality factor of the functioning of the ODCN area is a complex parameter that takes into account not only the ability of the ODCN area to perform its functions but also enables the possibility to restore the insulation after passing a test or other affecting its status signals. Consider the task of finding the quality factor of the functioning of the ODCN area depending on the number of reductions in the value of insulation resistance, value the insulation resistance of the section and the recovery time of a coating ODCN area after a disturbance (signal):

$$\mathrm{k_{q.f.}} = a_{\sum} \cdot \mathrm{k_n} \cdot \mathrm{k_z} \cdot \mathrm{k_{rec.}}, \tag{1}$$

where $\mathrm{k_n}$ – the ratio of the amount of recovery of insulation after passing the signal is given by:

$$k_n = \frac{n_{rec.}}{n_{tot.}},\qquad (2)$$

$n_{tot.}$ – the total number of signals that have passed through the study ODCN area;

$n_{rec.}$ – the total number of signals, after passing which the ODCN area recovered in a short time;

where k_Z – he ratio of insulation resistance of ODCN area is determined by the expression:

$$k_Z = \left|\frac{Z_{reg.lim.} - Z_{con.}}{Z_{reg.lim.} - Z_{init.}}\right|,\qquad (3)$$

$Z_{reg.lim.}$ – regulatory limit resistance value of the ODCN area;

$Z_{con.}$ – the resistance value of the ODCN area at the time of control;

$Z_{init.}$ – initial resistance value of the ODCN area (at the time of the introduction of new equipment or after repair);

where k_{rec} – recovery factor of insulation resistance of ODCN area is defined by the expression:

$$k_{rec} = \frac{Z_{rec}}{Z_{init}},\qquad (4)$$

Where Z_{rec} – resistance value of the ODCN area after the recovery;

$$a_\Sigma = a_1 \cdot a_2 \cdot a_3,\qquad (5)$$

where a_1, a_2, a_3 – weight coefficients which are set by the experts of their own experience, describing the impact of a factor depending on the features of the ODCN area and take into account peculiarities of operation conditions, namely a_1 – factor which considers the effect of the number of updates after the passage of the signals; a_2 – factor, which takes into account the impact of insulation resistance of ODCN area; a_3 – factor, which takes into account the effect of restoring the insulation resistance of the ODCN area.

To predict the possibility of further development of identified defects and the possibility of exploitation of the ODCN area it is necessary to assess the dynamics and the rate of change of insulation resistance. With the aim of increasing adequacy for such an assessment, there is a need for accounting expertise in the subject area. An example of such expert judgments, which can become a basis of formation of the knowledge base are the following: “IF the insulation resistance of the ODCN area decreases, THEN decreases its reliability and raises the possibility of false action” or “IF the rate of decrease of the insulation resistance of the ODCN area does not exceed 10% for single pass of the test signal, a dangerous defect is not growing, but requires attention”.

Specialized diagnostic and audit are carried out by staff from specialized maintenance departments or organizations. This stage is of great importance to assess the reliability of the results of previous studies, their improvement and completion of database and knowledge base. At the same time, the effectiveness of these measures depends on the previously obtained results. The results of the diagnosis the decision about the feasibility of further exploitation of the ODCN area.

Systems of the monitoring of the insulation resistance of ODCN areas, that currently exist, used in their calculations the well-known mathematical models, but these models have a significant drawback – they can not determine and take into account the functional relationship between many of their controlled diagnostic parameters at the same time, in one mathematical model (which, moreover, often multidirectional). The task is complicated by incomplete source data, when the parameters are unknown at the time of the calculations, for example, for reasons of the need for additional research. Note that quantitative methods are unable to provide the possibility to operate with this information. If move in the plane of the purely qualitative approaches, losed the ability to optimize the parameters of the model on real statistical data. An effective tool to establish these functional relationships, consideration of the different nature of information and expert domain knowledge, is the technology of neuro-fuzzy modeling.

Note that expert knowledge can shape the analysis of the monitored diagnostic parameters specialists who directly diagnose the state of insulation of the ODCN areas, be set according to the literature sources or according to the service insulation, etc., which gives the possibility of establishing the reasons for the decommissioning of ODCN area. Under the controlled diagnostic parameter to understand the parameter deviation from the norm which has led to the development of the ODCN area repair. After analyzing the literature [1-3], developed the diagram (see Fig. 1), which determines the dependent or independent influence of scan parameters on the quality factor of the functioning of the ODCN area.

Fig. 1. Structural scheme of the calculation model, the quality factor of the functioning of the ODCN area

Summing up the above, concluded that:

1. Information support of the diagnosis of isolation of the ODCN area reduces the time spent on the study of the technical condition, inspection, and repair of the ODCN area as a whole, as well as revealing and localization of possible faults and defects that develop in ODCN area.

2. Information systems for decision support reduce the amount of work on the diagnosis of isolation ODCN related to turning off the ODCN, to improve the reliability and efficiency of electricity supply. With the use of such systems fails along with the simplification of the assessment of the impact of defects to streamline the solution of problems that arise in the life cycle of ODCN that have not yet moved into the category of disabled.

3. To improve the efficiency of information support it is necessary to apply new methods of representation and processing of heterogeneous information required (quantitative indicators, expert evaluations, normative values, and the like).

4. The use of mathematical apparatus of neural-fuzzy modeling allows to represent and identical processing various types of quantitative and qualitative, incomplete, uncertain, contradictory, and other information, allowing the configuration of parameters of mathematical models on real data.

The advantages of neuro-fuzzy modeling are handling fuzzy input data, the connection between them is unknown in advance, not always known for their accuracy and truthfulness. Fundamentals of the theory of fuzzy sets were founded by Professor of University of California Lotfi Zadeh half a century ago in the seminal article “Fuzzy Sets” [4]. The concept of fuzzy sets was formed by Zadeh as a response to “dissatisfaction with the mathematical methods of the classical theory of systems, which prompted to pursue artificial precision that is uncharacteristic of many real-world systems” [5]. Fuzzy logic has provided a convenient tool to represent expert knowledge regarding the development of systems and processes in a mathematical form. The involvement of the neural network technology to fuzzy models provides the ability to automatically adjust their settings based on quantitative and qualitative factors and provides a number of other undeniable advantages for the simulation. Indeed, the inclusion in the model along with the quantitative, and even expert evaluations of a number of informative qualitative factors and the organization of the mechanism of logical inference allows counting on a significant increase in forecast accuracy [6]. To create a mathematical model for calculation of the coefficient operation section of the ODCN the following parameters were used: 1 – number of recoveries insulation after passing the signal; 2 – current insulation resistance phase of ODCN; 3 – insulation resistance of the ODCN area after recovery, each of which can be inferred about the state of the ODCN area. But none of these parameters fully characterizes the state of the ODCN area – it's just pointing some changes of its technical state. If one of these technical parameters is beyond the specified limits, this does not mean that the ODCN has lost its efficiency.

Therefore, the challenge lies in finding not always known, fuzzy interactions of various technical parameters on the current overall technical condition of the ODCN area, and given the forecast of dynamics of development of damage and its impact on the overall technical condition of the ODCN.

Application of methods of the theory of fuzzy logic to solve this problem gives us the opportunity to consider the meaning of the various controlled parameters in the diagnosis of the condition of the ODCN area to create the base of rules of their interaction, not knowing the mathematical relationships between them.

To find a solution to the problem of determining the quality factor of the operation it was decided to apply the software package MATLAB because it allows to solve the optimization problem with initial data, which is represented as fuzzy sets, and consider expert information.

The system of computer mathematics MATLAB provided an opportunity on the basis of formed sample of the training data to obtain the analytical dependence of the quality factor of the functioning of the ODCN area from the diagnostic parameters in the polynomial. This output of the model is fuzzy logic can be implemented using the method of constructing fuzzy knowledge bases Takagi-Sugeno fuzzy model [7], and the conditional part of the rule in the model is implemented using fuzzy sets. This dependence can be used in the software of modern microprocessor devices of diagnosing the condition of the ODCN area.

The formation of the original training data was implemented as follows. For the three input model parameters that were varied randomly from 0 to 1, a coefficient of the quality of functioning of the ODCN area was defined. For ease of application and simplification of current payments in the system of computer mathematics MATLAB.

The full table contains an enumeration of the considered variants of combinations of diagnostic parameters and corresponding values of the quality factor of the functioning of the ODCN area as shown in table 1. T

he data presented in Tables 1 and 2 were obtained with the help of experimental data, which were measured at the Novodnestrovskaya hydroelectric power station.

Three input parameters of the model are the coefficients, corresponding to three controllable diagnostic parameters. To increase the accuracy of determining the coefficient of the quality performance it is possible to increase the number of diagnostic parameters.

A mathematical model of the quality factor of the functioning of the ODCN area is a system of logical equations in a general form (6):

$$\begin{cases} \text{IF}\, k_n \in \text{"normal" AND } k_Z \in \text{"normal" AND } k_{rec} \in \text{"normal"} \\ \text{THAT }\; k_{q.f.} = a_{11}\cdot k_n + a_{12}\cdot k_Z + a_{13}\cdot k_{rec} \\ \text{IF}\, k_n \in \text{"minor deviation" AND } k_Z \in \text{"minor deviation" AND } k_{rec} \in \text{"minor deviation"} \\ \text{THAT }\; k_{q.f.} = a_{21}\cdot k_n + a_{22}\cdot k_Z + a_{23}\cdot k_{rec} \\ \text{IF}\, k_n \in \text{"pre-fault" and } k_Z \in \text{"pre-fault" and } k_{rec} \in \text{"pre-fault"} \\ \text{THAT }\; k_{q.f.} = a_{31}\cdot k_n + a_{32}\cdot k_Z + a_{33}\cdot k_{rec} \\ \text{IF}\, k_n \in \text{"fault" AND } k_Z \in \text{"fault" AND } k_{rec} \in \text{"fault"} \\ \text{THAT }\; k_{q.f.} = a_{41}\cdot k_n + a_{42}\cdot k_Z + a_{43}\cdot k_{rec} \end{cases} \quad (6)$$

A mathematical model of the quality factor for the functioning of a specific ODCN area is a system of logical equations (7):

$$\begin{cases} \text{IF}\, k_n \in \text{"normal" AND } k_Z \in \text{"normal" AND } k_{rec.} \in \text{"normal"} \\ \text{THAT }\; k_{q.f.} = 0,3234k_n + 0,233k_Z + 0,03k_{rec.} + 0,098 \\ \text{IF}\, k_n \in \text{"minor deviation" AND } k_Z \in \text{"minor deviation" AND } k_{rec.} \in \text{"minor deviation"} \\ \text{THAT }\; k_{q.f.} = 0,456k_n + 0,345k_Z + 0,133k_{rec.} + 0,094 \\ \text{IF}\, k_n \in \text{"pre-fault" AND } k_Z \in \text{"pre-fault" AND } k_{rec.} \in \text{"pre-fault"} \\ \text{THAT }\; k_{q.f.} = 0,3245k_n + 0,238k_Z + 0,235k_{rec.} + 0,097 \\ \text{IF}\, k_n \in \text{"fault" AND } k_Z \in \text{"fault" AND } k_{rec.} \in \text{"fault"} \\ \text{THAT }\; k_{q.f.} = 0,234k_n + 0,153k_Z + 0,343k_{rec.} + 0,093 \end{cases} \quad (7)$$

Further, the rows of this table have been adjusted by value of the quality factor of the functioning of the ODCN area by interviewing independent experts: qualified customer service representatives and ODCN service (data is shown in table 2). Adjustment factors quality of functioning for the accounting of operation features a specific ODCN area.

The corrected data were used as training data while modeling in the system of computer mathematics MATLAB. For this purpose, used the package Fuzzy Logic Toolbox. With the help of the ANFIS editor with using of hybrid training algorithm and the algorithm of the fuzzy inference Sugeno [7] neuro-fuzzy model of the quality factor of the functioning of ODCN area was obtained (using the subclusters method). The structure of the obtained neuro-fuzzy network is shown in Fig.2.

For each input variable of the neuro-fuzzy model four linguistic terms with Gaussian membership functions, which are represented by the expression (8) were used [3]:

$$k_{pec.i1} = f\ (x_{i1}; y_{i1}; c_{i1}) = e^{\frac{-(x_{i1}-c_{i1})^2}{2\cdot y_{i1}^2}}, \quad (8)$$

where: y_{i1} та c_{i1} – numeric parameters, y_{i1}^2 – in probability theory called the variance of the distribution, and the second parameter c_{i1} – expectation, i_1 – input factor of the neuro-fuzzy model that meets the diagnostic option, x_{i1} – value of i_1–th input factor of the model: $x_1=k_n$, $x_2=k_Z$, $x_3=k_{rec}$.

To describe the state of the ODCN, such terms as “normal” parameter values, “minor deviation” value options, “pre-fault” parameter values, “fault” parameter values were used.

Table 1

The results of calculations of the quality factor of the functioning of the ODCN area

Diagnostic parameters			***The quality factor of the functioning of the ODCN area***
k_n, conventional units	***k_Z, conventional units***	***k_{rec}, conventional units***	
0	0	0	0
1	1	1	1
0	1	1	0
1	0	1	0
…	…	…	…
0,93	0,93	0,93	0,930063
1	1	0,97	0,653953
1	1	0,96	0,644808
1	1	0,87	0,264758
1	1	0,78	0,248279
…	…	…	…
1	1	0,67	0,924798
1	1	0,65	0,927788
1	1	0,56	0,93044
…	…	…	…
0,94	0,94	0,94	0,940054
0,6	0,5	0,8	0,614157
0,2	0,5	0,3	0,446311
0,5	0,3	0,4	0,492952

Table 2

A fragment of the adjusted values of the coefficient of quality of functioning

Diagnostic parameters			***The quality factor of the functioning***
k_n, conventional units	***k_Z, conventional units***	***k_{rec}, conventional units***	
0	0	0	0
1	1	1	1
0	1	1	0
1	0	1	0
…	…	…	…
0,93	0,93	0,93	0,960
1	1	0,97	0,750
1	1	0,96	0,650
1	1	0,87	0,660
1	1	0,78	0,560
…	…	…	…
1	1	0,67	0,909
1	1	0,65	0,850
1	1	0,56	0,820
…	…	…	…
	0,94	0,94	0,940
0,6	0,5	0,8	0,500
0,2	0,5	0,3	0,440
0,5	0,3	0,4	0,445

To facilitate the configuration and adaptation of the structure of the developed model in real settings, site-specific ODCN model is implemented in the form of adaptive neuro network multilayer feed forward

ANFIS. ANFIS is a simple feed forward network that contains adaptive nodes (Fig. 2). The purpose of the layers of the network.

Layer 1 defines fuzzy terms of diagnostic parameters. Each node of this layer is adaptive function of belonging μAi(xi) де xi – input node i. Ai – fuzzy linguistic variable that is associated with this node. So: μ“normal” (kn) – the value of the belonging function for the “normal” term number of parameter value updates after isolation of signals; μ“normal”Z (kZ) – the value of belonging function for “normal” term parameter value of insulation resistance of the ODCN area,

μ“normal”rec (krec) – the value of the membership function for term “normal” value of the parameter recovery of the insulation resistance of the ODCN area, μ“minor deviation” n (kn) – the value of the belonging function for term “minor deviation” parameter value of the number of recoveries isolation after the passage of the signals; μ“minor deviation”Z (kZ) – the value of the belonging function for term “minor deviation” parameter value insulation resistance of the ODCN area, μ“minor deviation” rec. (krec) – the value of the belonging function for term “minor deviation” the value of the parameter recovery of the insulation resistance of the ODCN area, μ“pre-fault” n (kn) – the value of the belonging function for term “pre-fault” parameter value of the number of recoveries isolation after the passage of the signals; μ“pre-fault”Z (kZ) – the value of the belonging function for term “pre-fault” parameter value insulation resistance of the ODCN area μ“pre-fault” rec. (krec) – the value of the belonging function for term «pre-fault» the value of the parameter recovery of the insulation resistance of the ODCN area, μ“fault” n (kn) – the value of the belonging function for term “fault” parameter value of the number of recoveries isolation after the passage of signals; μ “fault”Z (kZ) – the value of the belonging function for term “emergency” parameter value insulation resistance of the ODCN area μ“fault” rec (krec) – the value of the belonging function for term “fault” value of the parameter recovery of the insulation resistance of the ODCN area.

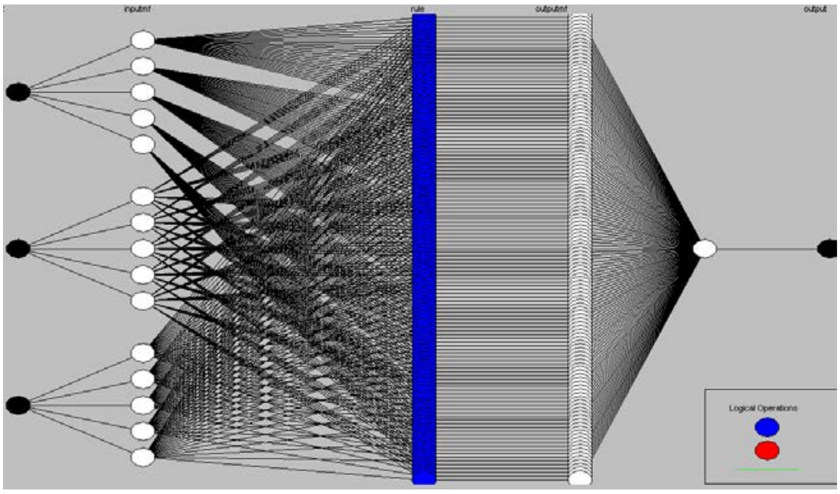

Fig. 2. Structure ANFIS network of the quality factor of the functioning

To find the value of the quality factor of the functioning of the ODCN area used the autoregressive nonlinear model of the quality factor of the functioning of the ODCN area.

To determine the value of the quality factor of the functioning of the ODCN area used Takagi-Sugeno inference model. In this model, fuzzy rules are defined based on a specified number of values “in-out” of modeled object in the view:

$$\text{if } x_1 \in A_1 \text{ and } x_2 \in B_2 \text{ and} \ldots x_m \in V_i \text{ that } y_i = f(x_1, x_2, \ldots, x_m), \tag{9}$$

where: A1, B2, Vm – fuzzy sets links, a yi=f($x_1, x_2, \ldots, x_m$) – a clear function of the output, f ($x_1, x_2, \ldots, x_m$) – is defined as a polynomial of input variables $x_1, x_2, \ldots, x_m$.

A mathematical model of the quality factor of the functioning of the ODCN area is a system of logical equations (6).

The output of the model kq.f. is found as a balanced amount of conclusions (9) base rules, written as a system of logical equations (6) [8].

$$k_{q.f.} = \sum_{j_2=1}^{m_3} w_{j2}\left(a_{j21}\cdot k_n + a_{j22}\cdot k_Z + a_{j23}\cdot k_{rec.}\right), \tag{10}$$

where: $0 \le w_{j2} \le 1$ – level of performance (weight) j2-th rule, which is determined by the actual changes in the diagnostic parameters of the ODCN area, j2 – number of the rule, m3 – the number of rules reflected in j2-th rule (11):

$$w_n = \frac{\Omega_n}{\xi}, \tag{11}$$

where:

$$\xi = \sum_{j_1=1}^{m_3}[\text{м}_j(k_n)\cdot \text{м}_j(k_Z)\cdot \text{м}_j(k_{rec})]$$

$$\text{Щ}_n = \text{м}_{"j"}(k_n)\cdot \text{м}_{"j"}(k_z)\cdot \text{м}_{"j"}(k_{rec}) \quad ,$$

$\text{м}_j(k_n)$, $_j(k_Z)$, $_j(k_{rec})$ – belonging functions of the coefficients of remaining resource controlled diagnostic parameters corresponding to the fuzzy set values of parameters relevant rules, $\text{м}_1(k_n) = \text{м}_{"normal"}(k_n)$, $\text{м}_1(k_Z) = \text{м}_{"normal"}(k_Z)$, $\text{м}_1(k_{rec}) = \text{м}_{"normal"}(k_{rec.})$. Setting the model is to determine the parameters of the Gauss functions of belonging (standard deviation $y_{k_n}, y_{k_Z}, y_{k_{rec}}$ and expectation c_{kn}, c_{k_Z}, c_{rec}), and parameters of conclusion equations. Using the rules of learning the parameters of the nodes of the ANFIS adaptive neuro-fuzzy multilayer network feed forward are adjusted to minimize the error between the calculated output of the model kq.f.mod. and the real ratio of total remaining resource kq.f. (12):

$$\text{д} = \sqrt{\frac{1}{N_1}\sum_{k_3=0}^{N_1-1}\left(k_{q.f.mod.k_3} - k_{q.f.k_3}\right)^2} \to \min, \tag{12}$$

where: N1 – the number of rows in the study sample, k3 – the line number in the training set starting from the row with sequence number «0».

Used hybrid learning algorithm every era of which consists of direct and reverse optimization calculations. In direct calculation of initial information on the value of the vector input y kn, kZ, krec and output kq.f. is used to determine the output method of least squares. Then calculated error ANFIS-network..

Using variational method based on the criterion of minimizing the mean square error learning neuro-fuzzy network for the terms selected Gauss belonging functions. Based on the constructed neuro-fuzzy network conducted a pilot study of the adequacy of modeling the coefficient of quality of functioning for 8 different sites of ODCN networks. Using neuro-fuzzy network the rules were formed, which gave the possibility to determine the quality factor of operation for each ODCN area. The results are shown in table 3. From the above table. 3 data concluded that phases 1 and 3 require replacement or additional diagnosis. ODCN areas 2-5, 7 and 8 have average values of the coefficient of the quality of performance that indicates the occurrence of minor defects which with proper maintenance can be eliminated in the early stages of development and will not develop into more severe injuries that usually lead to accidents, incorrect shutdown of the equipment etc.ODCN area at number 6 has the highest quality of functioning, so it can be used longer and does not require additional costs to a diagnosis.

Table 3

The simulation results of the coefficient of quality of functioning for 8 different areas of ODCN networks

Sequence number of the ODCN area	kZ	kn	krec	$k_{q.f.}$
1	0,13	0,25	0,23	0,23
2	0,95	0,34	0,28	0,65
3	0,56	0,32	0,68	0,35
4	0,47	0,36	0,78	0,67
5	0,45	0,38	0,88	0,75
6	0,91	0,76	0,91	0,81
7	0,87	0,75	0,75	0,79
8	0,67	0,65	0,74	0,67

Conclusions

In this article, proposed a method of determining a phase with low resistance network isolation operating DC voltage, which can prevent the development of emergency situations and allow you to do the advance replacement, repair, and adjustment of the parts of the ODCN areas.

The developed method of determining the quality factor of the functioning of the ODCN area is based on the use of methods of neuro-fuzzy modeling and brought to implementation in the package MATLAB. The advantage of this method is the possibility to involve for the evaluation of the experience of operating personnel, taking into consideration quantitative, qualitative, normative indicators, etc., and possibility for optimization of the mathematical model on real data.

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ВИЗНАЧЕННЯ ЯКОСТІ ФУНКЦІОНУВАННЯ ДІЛЯНКИ ІЗ ЗНИЖЕНИМ ОПОРОМ ІЗОЛЯЦІЇ МЕРЕЖІ ОПЕРАТИВНОГО ПОСТІЙНОГО СТРУМУ ЗА ДОПОМОГОЮ НЕЙРО-НЕЧІТКОГО МОДЕЛЮВАННЯ

Анотація: *досліджено можливість використання нейронечіткого моделювання при визначенні якості функціонування ділянки із зниженим опором ізоляції. Досліджено параметри, які характеризують якість функціонування ділянки мережі оперативного постійного струму: кількість відновлень ізоляції після проходження сигналів; поточний опір ізоляції ділянки; опір ізоляції ділянки після відновлення. Визначення ділянки із зниженим опором ізоляції мережі оперативного постійного струму пропонується здійснювати шляхом розрахунку коефіцієнту якості її функціонування. Коефіцієнт якості функціонування ділянки мережі оперативного постійного струму є комплексним параметром, який враховує не лише можливість ділянки виконувати свої функції, а й можливість ефективно відновлювати ізоляцію після проходження тестових чи інших впливаючих на її стан сигналів. Вдосконалено метод визначення ділянки із зниженим опором ізоляції мережі оперативного постійного струму, який дозволяє попередити розвиток аварійних ситуацій і дає змогу провести завчасну заміну, ремонт, наладку ділянок мережі оперативного постійного струму.*

Ключові слова: *коефіцієнт якості функціонування, ділянка із зниженим опором ізоляції мережі оперативного постійного струму, нейронечітке моделювання.*

ОПРЕДЕЛЕНИЕ КАЧЕСТВА ФУНКЦИОНИРОВАНИЯ УЧАСТКИ С ПОНИЖЕННОЙ СОПРОТИВЛЕНИЯ ИЗОЛЯЦИИ СЕТЕЙ ОПЕРАТИВНОГО ПОСТОЯННОГО ТОКА С ПОМОЩЬЮ НЕЙРО-НЕЧЕТКОГО МОДЕЛИРОВАНИЯ

Аннотация: *исследована возможность использования нейронечеткого моделирования при определении качества функционирования участка с пониженным сопротивлением изоляции. Исследованы параметры, характеризующие качество функционирования участка сети оперативного постоянного тока: количество обновлений изоляции после прохождения сигналов; текущий сопротивление изоляции участка; сопротивление изоляции участка после восстановления. Определение участка с пониженным сопротивлением изоляции сети оперативного постоянного тока предлагается осуществлять путем расчета коэффициента качества ее функционирования. Коэффициент качества функционирования участка сети оперативного постоянного тока является комплексным параметром, который учитывает не только возможность участки выполнять свои функции, но и эффективно восстанавливать изоляцию после прохождения тестовых или иных влияющих на ее состояние сигналов. Усовершенствован метод определения участка с пониженным сопротивлением изоляции сети оперативного постоянного тока, который позволяет предупредить развитие аварийных ситуаций и позволяет провести предварительную замену, ремонт, наладку участков сети оперативного постоянного тока.*

Ключевые слова: *коэффициент качества функционирования, участок с пониженным сопротивлением изоляции сети оперативного постоянного тока, нейронечетких моделирования.*