



## PS1 – S3-12



### Accident Precaution in Electric Power Systems at the Expense of Forecasting of Damages of Electric Installations

Konstantin I. NIKITIN, Maxim M. SARYCHEV  
Omsk State Technical University  
Russia  
[nki@ngs.ru](mailto:nki@ngs.ru); [nki@omgtu.ru](mailto:nki@omgtu.ru)

#### KEYWORDS

Predicting protection, isolation service life, dead time, interruption time, automatic load transfer.

#### 1 INTRODUCTION

Now it is difficult to save up the electric power for powerful electroinstallations for the period of a dead time. Therefore for realization of an uninterrupted supply by the electric power at a unilateral supply devices of automatic inclusion of a reserve are widely used. Start-up devices of automatic inclusion of a reserve is carried out or auxiliary contacts of the switch of a working supply, or special fault detector. Thus devices of automatic inclusion of a reserve should work only after switching-off of a working source to prevent inclusion on not eliminated short circuit. Therefore there is dead time in a supply of load. The dead time in a combination with reduced voltage brings to heavy self-start of load. In certain cases on conditions of technological process of the consumer it is necessary to use high-speed devices of automatic inclusion of a reserve, more expensive and demanding uses of high-speed switches. Especially in cases of synchronous loading. Often after devices of automatic inclusion of a reserve it is necessary to carry out start-up of engines anew.

Use of predicting protection allows to exclude fall of voltage and dead time a pause, having included at first a reserve, and then having disconnected the working power supply.

#### 2 THE BASIC PART

##### 2.1 Purpose

Use of predicting protection for the purpose of an exception dead time, increase of stability of an electrical supply at refusal from self-starts and elimination of dynamic influences short circuit is offered.

##### 2.2 Theoretical preconditions

In electric power industry energy is transferred on power line. Its basic elements are the conductor and isolation. The period of deterioration of conductors is considered considerably big, than isolation service life. Therefore isolation defines service life power line. If in aerial line insulators can be replaced with use of former conductors, but cable power line it is necessary to change all or on the worn most out sites.

Very many works [2, 3, 4] are devoted process of aging of isolation. In [5] the list of the most important factors of influence and isolation operating modes is resulted:

- The thermal factor of influence (T)
- The electric factor of influence (E)
- The factor of influence of environment (A)
- The mechanical factor of influence (M)

- The expected operational characteristic (P)
- Equipment work mode (Д)

One of the basic influencing factors is thermal influence. Its influence on isolation is described by the law of Arrhenius:

$$K_t = K \cdot e^{-W_a/(kT)}, \quad (1)$$

where  $K_t$  – average probability of disintegration of one molecule in unit of time, defining speed of chemical reactions,  $K$  – a constant depending on structure of substances, entering reaction;  $W_a$  – energy of activation;  $k$  – constant Boltzmann.

In [2] dependence which allows to calculate service life  $\tau_{с.л}$  concrete изоляционного products depending on several influencing factors of temperature  $T$ , intensity of electric field  $E$ , mechanical pressure  $\sigma$  is offered:

$$\tau_{с.л} = \tau_0 \exp \left( \frac{D_1 - Ae^{-bT} \sqrt{E^2 + \frac{\sigma^2}{\varepsilon G_M}} \ln \frac{2D_1 e}{Ae^{-bT} \sqrt{E^2 + \frac{\sigma^2}{\varepsilon G_M}}}}{2kT} \right), \quad (2)$$

where

$$Ae^{-bT} = \frac{aeM\sqrt{\varepsilon G_M}}{3,2N\rho \left(1 - \frac{2m}{m_u}\right)}$$

and  $D_1$  – energy диссоциации communications;  $G_M$  – the elasticity module;  $b$  – parameter, зависящий by nature polymer and test specifications;  $N$  – number of Avogadro;  $m$  – molecular weight of the end of the chain capable to проскальзыванию without perceiving of mechanical loading;  $m_u$  – molecular weight of a chain of polymer;  $a$  – the characteristic of curvature of dependence of potential energy of influence of the next atoms of a chain of polymer from interatomic distance.

Except the account of the analysis of physical processes of destructions of isolation, authors had been carried out the statistical analysis [6] more than 2500 refusals (fig. 1) cable power line on the basis of the data "Omskelektro" for three years.

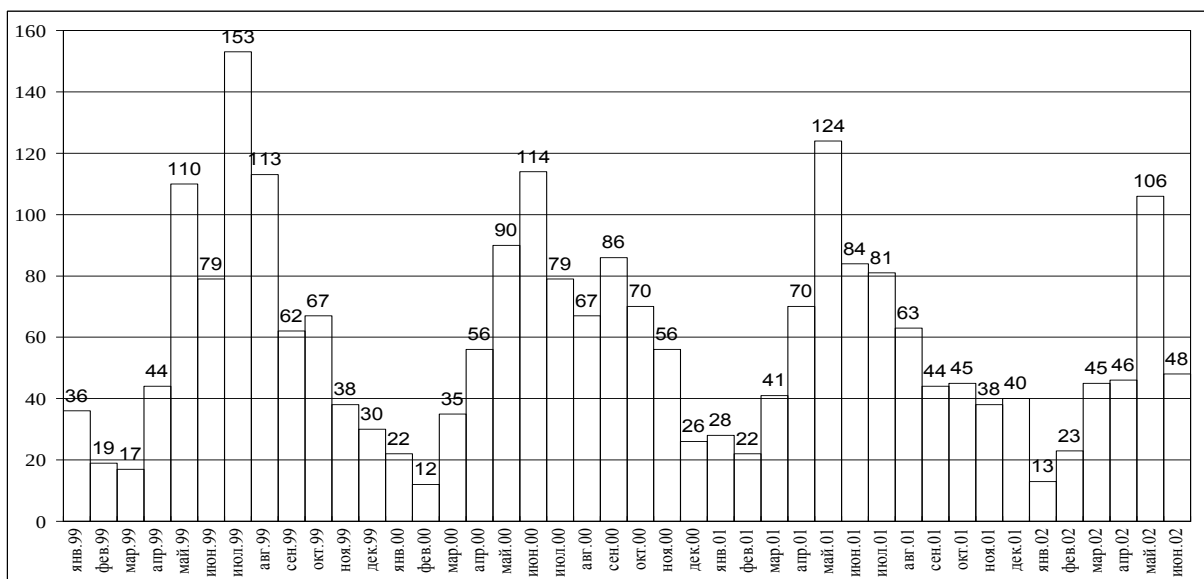


Fig. 1: The time number representing tabulated by the month value of number of fault of cable power line for the period January, 1999 – June, 2002

As the full information on the reasons of damages, length and type of a cable, trouble-free operation time usually is absent, the analysis should be spent without this data. It was considered seasonal a component and monthly level of deposits. The analysis was carried out by means of the spectrogram of Fourier, with preliminary definition of a trend.

After calculation of size seasonal components and calculation of errors, the forecasting model has been constructed:

$$F = T + S \pm E, \quad (3)$$

where  $F$  - predicted value number of damages;  $S$  - seasonal a component,  $S = -5,801 \cdot M^2 + 81,214 \cdot M - 232,04$ ;  $T$  - a trend,  $T = 58,143$ ;  $E$  - a model error,  $E = \pm 11,5$ . Real value of number of fault – 106. In spite of the fact that the volume of the statistical data isn't enough because of a small time interval of supervision, and the calculation error makes more than 6 %

### 2.3 Predicting protection

Taking into account the above-stated facts has been offered predicting protection [7] which block diagram represented on **fig. 2**.

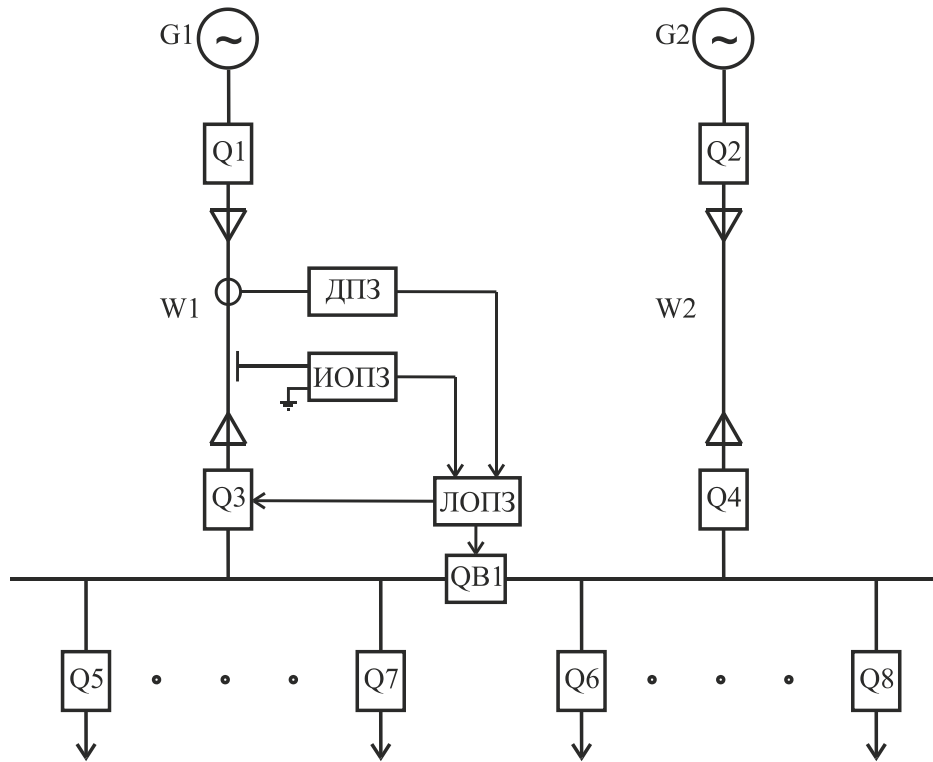


**Fig. 2:** The device block diagram of predicting protection

On the block diagram: ИОПЗ – measuring device of predicting protection, ЛОПЗ – logic device of predicting protection, ДПЗ – additional sensors of predicting protection.

ИОПЗ measures resistance of isolation of cable power line and at achievement of critical parameters ЛОПЗ gives a command on inclusion of a reserve power supply – section switch QB1, then switching-off of the switch of working power supply Q3 is made. Thus switching is made without interruption a power supply that is important for some kinds of consumers, for example synchronous motors. For the objective information in protection it is desirable to use additional sensors – a current of loading, temperature, light radiation (in case of direct influence of a sunlight on isolation), radiation and so forth. Besides, for correct work in ЛОПЗ it is necessary to write down service life cable power line, date (a season of year) and time. In an operating time in memory ЛОПЗ write overloads, increases of external temperature and other above-stated parameters for calculation of deterioration of isolation of a cable are considered.

### **3 CONCLUSION**

1. Predicting protection measures and models aging of isolation that allows to disconnect cable power line before damage.
2. Thus predicting protection works before fault, excludes a power supply break and that is especially important for synchronous loading.

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