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Role of Informational Technologies in the analysis of the effects of geomagnetic storms energy systems

Shavazov A.A., Maxammadiev F. M., Seyfullaeva L.I., Dauletbaev Aziz Baxadirovich., Tuxtaev Bobur Baxodir ugli.

Senior researcher of the Institute of Energy Problems of the Academy of Sciences Republic of Uzbekistan,
Senior researcher of the Institute of Energy Problems of the Academy of Sciences, Republic of Uzbekistan
Senior researcher of the Institute of Energy Problems of the Academy of Sciences, Republic of Uzbekistan

ABSTRACT: Geomagnetic storms have an effect on the operation of the power transmission system and damage to the power transmission lines. Unlike other types of natural disasters, geomagnetic has little experience in operating power systems during storms, as well as eliminating their consequences. For a long time, this problem was solved only by specialists in the field of Geophysics. The use of the traditional method of assessing the stability of energy systems in relation to geomagnetic storms requires the lack of information necessary for the public domain to carry out studies. The article shows that analyzing the stability of energy systems to geomagnetic storms is a multi-criterion task.

I. INTRODUCTION

The developed calculation methods make it possible to determine the geo-induced currents in the elements of the EES, taking into account their geographical location on the terrain map. The computer implementation of the developed methods in the Simulink expansion package of the MATLAB system using blocks developed by the authors makes it possible to simulate the saturation processes of power transformers during geomagnetic storms and determine the instantaneous and effective values of the magnetization currents of power transformers; the effective values of geoinduced currents in neutral and grounded ST windings and phase wires of power lines, instantaneous values of total currents and voltages in all elements of the EPS, as well as perform their harmonic analysis to assess the influence of geoinduced currents on the modes of operation of the EPS, which will determine the permissible values of GIT for reducing their negative impact [1].

The functioning of modern electric power systems (EES) is associated with significant difficulties due to the complexity of the structure of generating capacities and the main electrical network, the variety of their operating modes, the need to take into account the requirements of reliability and continuity of power supply to consumers, strong external technological links, uncertainty of future conditions for the development of EES, the risk of possible extreme conditions in the development of the system and other important factors. All this leads to the fact that modern EPS become more vulnerable to external disturbances, including geomagnetic storms (GMB) [2-6].

The dynamics of processes during geomagnetic storms in the EES, which contains many interacting elements, has not been practically studied. Conducting field experiments on a scale is almost impossible. Therefore, the development of alternative methods and tools is required.

One of such alternative methods is modeling, which makes it possible to study the functioning of the EES under the influence of geoinduced currents with values characteristic of geomagnetic storms for regions of middle and high latitudes [1].

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II. LITERATURE SURVEY

The developed method makes it possible to calculate the values of geoinduced currents in high-voltage power lines depending on the configuration and parameters of the replacement circuit of the power supply system, as well as the orientation angles of the transmission lines relative to the direction of the geoelectric field power lines. Estimation of the values of GIT in power transmission lines of different voltage classes will allow us to study the stability of power supply systems during geomagnetic storms of varying intensity [7].

The degree of elaboration of national strategies to minimize the effects of GMB on technological systems depends on the geographical area. Countries that have faced negative effects over the previous decades are more prepared. The continued development of high and ultra-high voltage lines, on the one hand, and the aging of network equipment, on the other hand, leads to the expansion of the map of “high risk" zones. Consequently, even countries that do not have registered cases of the influence of space weather on the EPS benefit from the analysis of the stability of national EPS to GMB. The purpose of this study was to identify and analyze critical factors affecting the stability of EPS to EMF, and to develop an algorithm for assessing the robustness of EPS based on the data obtained [8].

The science of physical processes on the surface of the Sun, the magneto-ionosphere is young and dynamically developing. The development of this science is associated with the emergence of new technical means of observing the cosmos and processing the received data. Undoubtedly, an important role was played by the factor of shifting priorities to peaceful space exploration, which allowed expanding the range of research conducted. The simultaneous development of the theoretical base and the increase of public awareness expands the map of GMB zones. At the same time, the principles of development and operation modern nuclear power plants are also undergoing significant changes: the complexity of architecture, the use of new equipment, etc.The occurrence of an accident caused by GMB is caused by a combination of technical and natural factors. [8].

III. SYSTEM ANALYSIS

GIT is a classical random process, therefore, it can be analyzed using the standard mathematical apparatus of probability theory. At the same time, this process is well predictable at time intervals of the order of several seconds or more. Consequently, at such intervals, the deterministic component prevails in this process, and the process itself can be considered quasi-deterministic [9].
It should be noted that solar activity, including the intensity of solar flares, has a cyclical character, on average with an 11-year periodicity (Fig._2). As can be seen from this figure, the activity of cycles varies. Not all cycles are the same -- some are intense, with lots of sunspots and explosive solar flares. So, if the activity index of the 19th cycle (1954 – 1964_y.) averaged 180, and individual bursts exceeded 230 units, then the index of the cycle following it (1965 – 1976_y.) averaged only 105 units, and the indices of maximum outbreaks did not exceed 120 units.

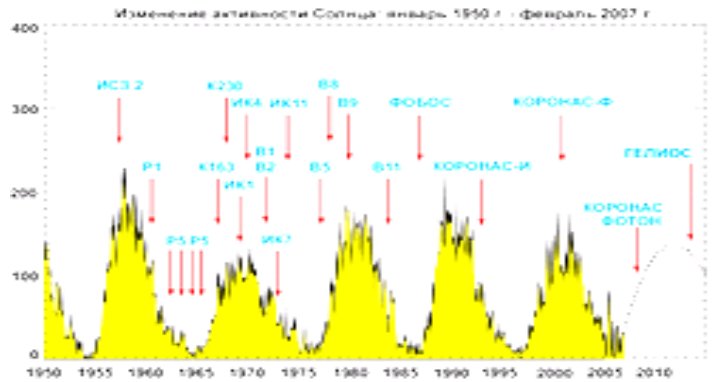

Fig. 2. Cyclical nature of solar flares since 1950

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The previous (2009-2020_y.) 24th cycle was also passive. Firstly, he was double-humped, secondly, his average index did not exceed 117 units, and the maximum bursts did not reach 145 units [9].

GMBS can lead to simultaneous failure of k network elements, where k is a natural number greater than one. The impossibility of obtaining a reliable long-term forecast about the area and time of the appearance of GMB on the Earth's surface necessitates a preventive analysis of the stability of the EPS to possible effects. The algorithm presented in this article allows not only to identify “high risk” zones, but also to identify nodes whose protection is necessary in the first place. Although it is still necessary to answer the following questions: 1) what is the cost of preventing future system accidents caused by GMB; 2) what are the indicators of the cost-effectiveness criterion for each of the measures; 3) what time interval is required for the implementation of measures. At the moment, we recommend that interested parties implement a preliminary analysis of the stability of EPS to EMBA in their practice, regardless of their geographical location [1].

IV. CONCLUSION

New data on the occurrence of emergency outages of high-voltage power transmission in the event of solar flares and manit storms of varying intensity confirmed the previously revealed pattern of dependence of high-voltage power transmission exposure.

There are still many unexplained issues in the emergence and development of powerful and medium-sized solar flares, but bearing in mind the importance and high price of emergency high-voltage power lines and the damage to power transformers, it is necessary to pay special attention to this issue in the future.

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