СЕКЦІЯ XVII. ЕНЕРГЕТИКА ТА ЕНЕРГЕТИЧНЕ МАШИНОБУДУВАННЯ

ANALYSIS OF TRANSIENT PROCESSES OF THREE-PHASE ELECTRIC CIRCUITS WITH DISTRIBUTED PARAMETERS AND ELECTROMAGNETIC CONNECTIONS

SCIENTIFIC RESEARCH GROUP:

Viktoriia Oliinyk
graduate of the faculty of Electric Power Engineering and Automatics
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

Lobodzynskyi Vadym
ORCID ID: 0000-0003-1167-824X
PhD, Associate Professor, Department of theoretical electrical engineering
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

Svyatnenko Vadym
ORCID ID: 0000-0002-0518-1045
Senior teacher, Department of theoretical electrical engineering
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

Chunyak Yuliya
ORCID ID: 0000-0002-4506-912X
Assistant Professor, Department of theoretical electrical engineering
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

The scientific problems of calculating the transient processes that occur in three-phase electric circuits with distributed parameters during normal and emergency changes in throughput are among the most complex in modern electrical engineering. They are further complicated by the presence of interphase electromagnetic and capacitive couplings, which, in particular, occur in modern powerful three-phase power transmission lines [1–3]

Significant scientific results from studies of transient electromagnetic processes in branched multiphase electric circuits with distributed parameters and interphase connections (such as three-phase cable power transmission lines) were obtained by such famous scientists as Uidi B., Shidlovsky A.K., Shcherba A.A. , Podoltsev O.D., Rezinkina M.M., Kucheryava I.M., Yandulskyi O.S., Kyryk V.V., Bazhenov V.A., Denisenko G.I., Lezhnyuk P.D., Pivnyak G .H., Levinstein M.L., Wedepohl L.M. , Welcox D.J., Anderson R.J., Nagoaka N., Heaton A.G. and other.

The analysis of numerical studies showed that the most expedient for solving research problems of this type is the development of the theory of multipoles and numerical methods of mathematical modeling implemented in well-known application programs. This

significantly simplifies both conducting numerical calculation studies and obtaining generalizing results. However, for a long time, the use of such an approach in the study of transient electromagnetic processes in multiphase electric circuits with distributed parameters and interphase connections has not received enough attention until recently [4–7].

Usually, cable power lines, which are three-phase circuits with distributed parameters and interphase connections, were represented by electric circuits with concentrated parameters, and when transient electromagnetic processes were studied, the concepts of functions of time and spatial coordinates were introduced. In mathematical models, differential, integral and difference equations were used, the solution of which was significantly complicated in the presence of heterogeneous elements (concentrated and distributed), and if it was necessary to take into account interphase mutual inductances and capacities and violation of the symmetry of the modes, it became practically impossible.

The topic of the work is aimed at the development of the theory of multipoles in the direction of taking into account interphase connections in electric circuits with distributed parameters for improving the methods of calculating steady and transient processes in three-phase electric circuits with distributed parameters and interphase connections represented by multipole elements, is relevant.

The purpose of the work is the development of methods for analyzing transient processes in three-phase circuits with distributed parameters and interphase connections based on the representation of such circuits by multipoles, finding their corresponding concentrated parameters, and determining the boundary and initial conditions for the occurrence of transient processes.

When solving the tasks set in the work, the following were used: scientific provisions of the theory of analysis and synthesis of three-phase linear electric circuits, methods of the theory of multipoles and their use for modeling electromagnetic transient processes in circuits with distributed parameters and interphase connections, drawing up electrical substitution circuits with concentrated parameters for calculation electromagnetic processes in three-phase cable lines. Numerical modeling of electromagnetic transients is implemented using the Matlab application program package [7–10].

The practical significance of the obtained results lies in the development of engineering methods for the calculation and analysis of transient electromagnetic processes in three-phase circuits with mutual electromagnetic connections, in particular in cable power transmission lines.

The following results were obtained:

Based on the development of the theory of multipoles, the methodology for calculating transient electromagnetic processes in three-phase cable power lines has been improved, taking into account the given EMF of mutual induction between its sections with different constituent elements.

Recommendations have been developed for the calculation of transient electromagnetic processes in three-phase cable lines as in branched electric circuits with concentrated parameters, by taking into account the features of mutual electromagnetic connections between their sections with different parameters, which allows determining the necessary transpositions of cable screens to realize permissible short-circuit voltages and currents in cable lines.

A new methodology for calculating admissible and emergency electromagnetic processes in three-phase electric circuits with distributed parameters and interphase connections has been developed, in particular in three-phase cable lines using transposition of cable shields.

References:

1. Lobodzinskiy V., Buryk N., Spinul L., Chibelis V., Illina O. Reducing Overvoltages under Connection on a High-Voltage Cable Line Due to Optimal Controlled Switching. Problems of the regional energetics, №3 (59), 2023. p. 25-32. doi.org/10.52254/1857-0070.2023.3-59.03
2. Ostroverkhov M., Silvestrov A., Chibelis V., Lobodzynskyi V., Spinul L. Application of the Consistency Principle of Identification and Control Subsystems in Adaptive Systems. *Electronics and Control Systems*, 2023, *1*(75), p. 53-60. doi.org/10.18372/1990-5548.75.17556
3. Лободзинський В. Ю., Бурик М. П., Петрученко О. В., Ілліна О. О. Вплив системи Smart Grid на національну енергетичну мережу. *Енергетика: економіка, технології, екологія: науковий журнал, 2022,№ 1*, с. 57-64. doi.org/10.20535/1813-5420.1.2022.259182
4. Lobodzinskiy V. Transient Analysis in Three-Phase Cable Lines with the Transposition Phase Cables Conductive Screens during Short Circuit Fault. In *2021 IEEE 3rd Ukraine Conference on Electrical and Computer Engineering, UKRCON 2021-Proceedings. 2021,* pp.413-416. doi.org/0.1109/UKRCON53503.2021.9575468
5. Лободзинський В. Ю., Чибеліс В. І. Аналіз перехідних процесів у трифазних електричних колах з розподіленими параметрами і міжфазними зв'язками на прикладі високовольтної кабельної лінії. *Енергетика: економіка, технології, екологія: науковий журнал, 2021, № 3*, с. 64-69. doi.org/10.20535/1813-5420.3.2021.251207
6. Lobodzinskiy V., Chybelis V., Petruchenko O., Illina O., Chunyak Y., Babenko V. Features of transient research in three-phase high-voltage power transmission cable lines. *Грааль науки*, (6), 2021, 135-148. doi.org/10.36074/grail-of-science.25.06.2021.025
7. Грудська В. П., Чибеліс В. І., Лободзинський В. Ю. Дослідження автоматичного регулятора-стабілізатора вихідної напруги автономного інвертора. *Енергетика: економіка, технології, екологія: науковий журнал, 2020, № 4 (62)*. doi.org/10.20535/1813-5420.4.2020.233600
8. Lobodzinskiy V.Yu., Buryk M.P., Spinul L.Yu., Chybelis V.I., Illina O.A. Features of smart grid technologies introduction in the energy industry. *Вчені записки Таврійського національного університету імені В.І. Вернадського. Серія: Технічні науки.* Том 33 (72), №4, 2022, С. 160-166. doi.org/10.32838/2663-5941/2022.4/24
9. Бурик М.П., Лободзинський В.Ю., Бурик І.П., Гричановська Т.М., Бібик В.В. Моделювання електричного поля двожильного кабелю за допомогою системи чотирьох заряджених осей. *Вчені записки Таврійського національного університету імені В.І. Вернадського. Серія: Технічні науки.* Том 34 (73), №2 частина 1, 2023. с. 18-25. doi.org/10.32782/2663-5941/2023.2.1/04
10. Лободзинський В.Ю., Бурик М.П., Спінул Л.Ю., Чибеліс В.І., Ілліна О.О. Ідентифікація несправностей системи заземлення екранів високовольтних кабелів на основі аналізу струмів короткого замикання. *Вчені записки Таврійського національного університету імені В.І. Вернадського. Серія: Технічні науки.* Том 33 (72), №2, 2022. с. 29-33. doi.org/10.32838/2663-5941/2022.2/04