

Article Title in Sentence Case Investigation of Emergency Asymmetric Modes

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Abstract

When modeling asymmetric emergency modes, it is necessary to take into account all possible parameters of the simulated elements, such as power lines, transformers, electrical equipment, electrical load, etc. Each parameter affects the calculated model and the values obtained.

This study investigates the modeling of asymmetric emergency modes in electrical power systems, focusing on the influence of various parameters such as power lines, transformers, and electrical loads. Despite extensive research on electrical networks, a knowledge gap persists in the comprehensive assessment of mutual inductive resistances and capacitive line conductivities in emergency scenarios. Using a feeder model, calculations were performed for different emergency conditions, including short circuits, phase breakages, and double-phase faults. Findings indicate that excluding mutual inductive resistances and capacitive conductivities results in deviations of phase currents and voltages, ranging from 1.4% to 45%, depending on fault type and line length. Notably, voltage stabilization in autonomous power sources remains a challenge, requiring improvements in control devices to ensure symmetric voltage conditions. The implications of this research extend to the development of automated transport energy systems and emergency stabilization techniques for agricultural power sources.

Key words: capacitive line, damaged phases, control devices

Introduction

It is necessary to find out the influence, for example, of the Feeder model on the parameters of the emergency mode.

The Feeder model (Fig.1) includes: a head transformer (D), a load transformer (NT), a measuring transformer (NT), sections of a power line (I1, I2) load, reverse voltage filters (F0) and zero sequence (Fn), an asymmetry block (BN).

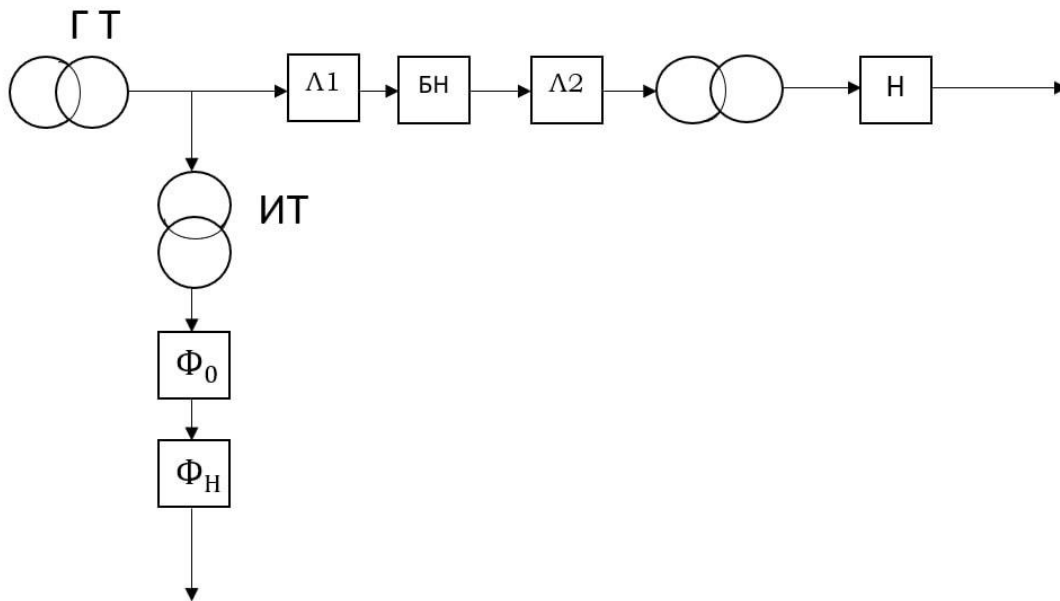


Fig.1-Schematic diagram of the model of the network under study.

When calculating the parameters of asymmetric emergency modes of Feeders, lines of various lengths from 2.5 to 20 km are used. The following modes were calculated: normal mode, phase A short circuit to earth (A-O), phase-to-phase short circuit of phases A-B, three-phase short circuit A-B-C, phase A breakage, phase A short circuit to earth after its breakage, double earth short circuit.

The stability and efficiency of electrical power systems are critical in modern infrastructure, particularly in ensuring uninterrupted energy supply in industrial, agricultural, and transport sectors. Power systems operate under various conditions, and emergency asymmetric modes represent one of the most significant challenges in network reliability. These modes occur due to disturbances such as short circuits, phase breakages, and asymmetries in electrical parameters, leading to system instability, voltage deviations, and potential equipment failures. Addressing these challenges requires an in-depth understanding of power system dynamics and the factors influencing asymmetric modes, such as mutual inductive resistances and capacitive line conductivities.

While several studies have analyzed asymmetric emergency conditions in power networks, a critical gap exists in assessing how mutual inductive resistances and capacitive conductivities impact feeder models under different emergency scenarios. Previous research primarily focused on voltage regulation, short-circuit analysis, and power flow optimization. However, limited attention has been given to the combined effects of these parameters on the behavior of asymmetric modes. Studies by Baranov (2011) and Pokov (2005) explored the influence of line parameters on asymmetric faults, but their models did not fully incorporate mutual inductive resistances and capacitive conductivities. This research aims to bridge this gap by

systematically evaluating the impact of these parameters in emergency scenarios to enhance power system stability.

To achieve this, a feeder model was developed, incorporating transformers, power lines, and filters to simulate different fault conditions. The study analyzed multiple emergency scenarios, including phase-to-earth faults, interphase short circuits, three-phase faults, and phase breakages. The research methodology involved comparative calculations where mutual inductive resistances and capacitive conductivities were alternately included and excluded. By quantifying the deviations in phase currents and voltages, the study provides empirical insights into how these parameters influence system performance under emergency conditions.

Findings from this research reveal that excluding mutual inductive resistances and capacitive conductivities leads to significant variations in current and voltage deviations, ranging from 1.4% to 45%, depending on fault type and line length. The study confirms that considering these parameters is crucial for accurate emergency mode analysis and voltage stability improvements. These results have significant implications for designing more resilient electrical networks, particularly in autonomous power sources used in agriculture and transport systems. The ability to predict and mitigate asymmetric emergency conditions enhances power system reliability, reducing the risk of failures and optimizing energy distribution.

this study advances the understanding of asymmetric emergency modes by addressing a key knowledge gap in power system modeling. By integrating mutual inductive resistances and capacitive conductivities into emergency mode calculations, the research provides a more comprehensive framework for managing power system disturbances. The findings contribute to the development of more effective stabilization devices and control mechanisms, ensuring improved performance in electrified mechanization and transport power systems. Future studies can build on this research to develop automated solutions for real-time power system monitoring and emergency response

Materials and Methods

The source of the asymmetry is located on the load at the end of the Feeder. Calculations were carried out for three cases :

All parameters of the power line are taken into account.

Mutual inductive line resistances are excluded.

Capacitive line conductivities are excluded.

$$I_d = (I_1 - I_2) / I_1 * 100\%$$

Where: I_1 - the values of phase currents when taking into account the mutual inductive resistances and capacitive line conductivities.

I_2 - phase values with the exclusion of mutual inductive resistances and capacitive line conductivities.

$$U_d = (U_1 - U_2) / U_1 * 100\%$$

U_1 - the values of phase voltages when taking into account the mutual inductive resistances and capacitive line conductivities.

U_2 - the values of phase voltages with the exclusion of mutual inductive resistances and capacitive line conductivities.

Research and methods.

The analysis of calculations showed that with the exclusion of mutual inductive resistances and capacitive line conductivities.

In normal mode, the currents in the phases on the F_n and F_o decreased and their from 1 to 8.9%, respectively, with a line length from 2.5 to 20 km. The voltages on the F_o and F_n in normal mode are small and amount to 3V.

When phase A is short-circuited at different line lengths, the deviations of phase currents and voltages on the F_n range from 1 to 8.9%. The F_o filter does not react to the single-phase earth fault mode and to the consideration of mutual inductive resistances and capacitive line conductivities.

With an interphase short circuit of phases A-B, the effective current values decreased in the damaged phases and their deviations amounted to 24-25%, and in the undamaged phase, current deviations amounted to 1.7-10.7%. At the same time, the stresses on the F_n decreased, and their deviations amounted to 24-37%.

With a three-phase short circuit, the currents in the phases decreased and their deviations amounted to 23-44%, while the voltage deviations on the F_n range from 1.6 to 3V.

If the phase wire A is broken, the current in the damaged phase is less than 0.4 A. In the intact phases, the currents decreased and their deviation was 1.4-8.6%. Voltage deviations on the F_n range within 4V. Deviations do not depend on the mutual inductive resistances and capacitive line conductivities.

When the phase wire A is broken before and after the earth fault, the current of the damaged

phase is less than 0.5 A, in the undamaged phases the current decreased and their deviations ranged from 1.4 to 8.6%. The voltages on the Fn fluctuate within 4V and do not depend on mutual inductive resistances and are equal to 63.5 V.

With a double circuit on for phases A and B, the current values in the damaged phases decreased, which corresponds to a deviation of 23-45%, and in the intact phase they range from 1.75 to 10.7%. The deviation on the reacting organ of the Fn was 7%, excluding mutual inductive line resistances. Thus, the analysis of the results showed that in the calculation model of non-symmetrical feeder modes, it is necessary to take into account both mutual inductive resistances and capacitive line conductivities.

Results and Discussion

Transient processes in such dynamic objects as modern electric power systems have recently acquired new properties that do not take place in systems of simple structure, and represent a complex set of oscillatory processes of a local and systemic nature. Stabilization of low-frequency oscillations and increasing their damping is a difficult task due to their system-wide nature and the participation of a large number of sufficiently powerful generators, which requires the involvement of a correspondingly larger number of automatic excitation regulators (ARVs) of these generators.

Improvements in the quality of autonomous power sources used in agriculture in emergency situations are considered by several methods. At the same time, we will keep in mind the following circumstance: the symmetry of the generator voltages, obviously, can take place only with the symmetry of the currents that load it and consist of the currents of the asymmetric load and the currents of the actuators of the balancing device. Thus, voltage symmetry, in essence, comes down to ensuring the symmetry of the load currents of the generator.

The analysis of asymmetric emergency modes in electrical networks revealed significant deviations in phase currents and voltages depending on the inclusion or exclusion of mutual inductive resistances and capacitive line conductivities. The results indicate that excluding these parameters leads to notable variations, particularly in cases of short circuits and phase breakages. Specifically, the deviations in phase currents ranged from 1.4% to 45%, while voltage deviations fluctuated between 1.6V and 63.5V. These findings highlight the necessity of incorporating mutual inductive resistances and capacitive conductivities in power system modeling to ensure more accurate simulations and stability assessments.

From a theoretical perspective, these results contribute to the broader understanding of power system asymmetries and transient processes. Modern power grids, especially those

integrating renewable and distributed energy sources, exhibit increasingly complex oscillatory behaviors that cannot be fully addressed using traditional symmetric models. The findings align with previous studies on voltage regulation and network stability but extend their scope by providing empirical evidence on the role of mutual inductive effects and capacitive conductivities. This study reinforces the need for enhanced computational models that can capture real-time variations in electrical parameters, thereby improving predictive maintenance strategies and fault detection mechanisms.

Practically, the implications of these findings are significant for the design and operation of power networks, particularly in autonomous power sources used in agriculture and transport. The deviations observed in current and voltage suggest that inadequate consideration of inductive and capacitive effects can lead to inefficient energy distribution, increased losses, and potential equipment damage. To address these challenges, power system operators must implement advanced control strategies, including adaptive filtering mechanisms and real-time monitoring systems, to mitigate the risks associated with asymmetric emergency conditions. Moreover, regulatory frameworks should incorporate refined stability criteria that account for these newly identified variables.

Despite these contributions, certain knowledge gaps remain, necessitating further research. The study primarily focused on feeder models under controlled conditions, yet real-world power systems exhibit additional complexities, including dynamic load variations, nonlinearities, and environmental influences. Future research should explore the integration of machine learning and artificial intelligence techniques to enhance the predictive capabilities of power system models. Additionally, experimental validation through real-time simulations and hardware-in-the-loop testing could provide deeper insights into the practical implications of the observed phenomena.

This study advances the field of power system engineering by identifying critical factors influencing asymmetric emergency modes. The results underscore the importance of incorporating mutual inductive resistances and capacitive conductivities into network models to improve reliability and stability. However, further theoretical and practical investigations are required to refine these models and develop adaptive solutions for real-world applications. Future research should focus on optimizing control algorithms, integrating smart grid technologies, and addressing emerging challenges associated with decentralized energy systems. Through these efforts, power system resilience can be significantly enhanced, ensuring sustainable and efficient energy distribution across various industrial and agricultural applications.

Conclusion

The practical application of the above experimental developments is consistent with the characteristics of the regulated object, its working conditions, as well as with the requirements for the accuracy of regulation and speed in emergency situations of generators used to power electrified mechanization and power tools in agriculture. Research in the field of development of voltage symmetry stabilization devices and control devices allows us to obtain a number of new results that can be used in the development of automated transport energy systems.

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