Study Committee B5

PROTECTION AND AUTOMATION

Paper 371_2022

Intelligent automatic control of isolated operating power system

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Motivation

- Development of emergency and regime control intelligent system for isolated power grids in order to increase the reliability of power supply to consumers
- Development and implementation of a two-level automatic emergency control system "System operator - power plant" in isolated power grids
- Development and implementation of a two-level automatic system of secondary and tertiary frequency control in isolated power grids

Method/Approach

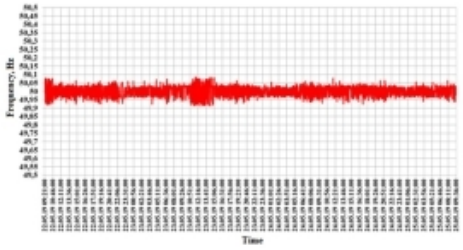
Russian experts consider the development of emergency control of regional power systems in the direction of creating modern digital centralized and decentralized (or local) complexes of emergency control. This allows real-time coordination and optimization of the control actions volumes using digital “twins-models”, high-performance data processing methods and high-data rate links.

Objects of investigation

The object of investigation is a regional relatively small capacity power system, which is forced to isolated mode from the Unified Power System for a long period of time. This requires changes in the generating capacity structure and the power system control system using modern digital technologies.

Experimental setup & test results

From 2019 to 2021 in the Kaliningrad power system carried out a number of full-scale tests during which this power system worked in isolated mode from the Unified Power System up to three days. The purpose of these tests was to verify the correctness of the implemented technical solutions for the frequency, power flow and emergency control systems organization.



Frequency changes in Kaliningrad power system for the test period

Discussion

The performed experiments confirmed the effectiveness of the proposed technical solutions.

- *Regime control*: the developed and implemented methods of primary and secondary frequency control ensured the necessary quality of electricity in an Kaliningrad power system isolated mode
- *Emergency control*: the developed and implemented emergency control complex has shown the possibility of reducing the load shedding control actions volumes after the generating equipment tripping. The effectiveness of this complex is up to 15% compared to traditional methods (UFLS).

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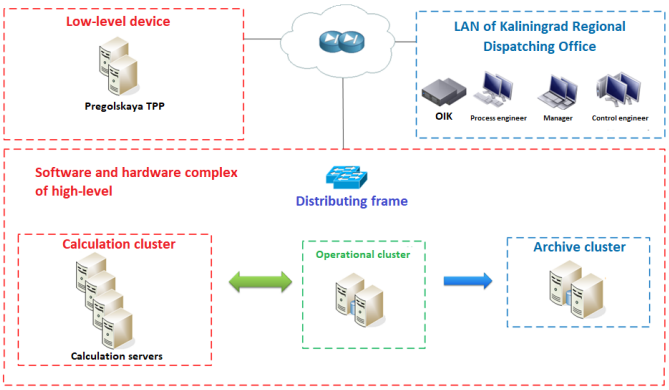
Emergency control in isolated power systems

In contrast to the large power systems, isolated power systems of relatively small capacity are most sensitive to changes in active power balances caused by the emergency generator outages. The consequences of such imbalances can be the short or long-termed unacceptable changes in frequency leading to the additional shutdown of power plant generators and to the occurrence of a frequency avalanche. This circumstance can be caused both by the comparability of the capacities of emergency shutdown power units or power plants with the total power consumption of the isolated power system, and by the relatively small values of the equivalent inertia constant such power systems.

The software and hardware emergency control complex was developed, which allows optimizing the emergency control actions by online-calculations of the processes and do not allow frequency deviation beyond the specified limits in isolated power systems. This complex was set in "SO UPS“ (Kaliningrad).



Structural diagram of the software and hardware emergency control complex

Conclusion

Universal solutions have been developed, implemented and tested for emergency and regime control of small power systems operating both in isolation and in parallel with the unified power system. These solutions combine centralized (two-level) and decentralized control principles and ensure reliable operation of the power system in a fully automatic mode.

As part of the work on the further development of the technology of intelligent energy systems and “digital twins” of energy facilities, it is planned to improve the existing systems of centralized emergency control in the following areas:

- use of promising technologies for managing the demand for electricity as control actions;
- use of RES resources for emergency and regime control;
- formation of a new group of actuating (lower) devices that provide control over the capacity of the protected sections based on the current calculated values of the limiting flows through them;
- cyclic in-depth topological analysis of the electrical network in order to automatically generate calculated disturbances that are subject to unconditional parrying;
- development of a multi-agent network of low-level devices with high survivability in terms of information support and reliability in the implementation of basic functions.