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PMU placement in an alternating current network 110-220 kV for identification of the mathematical model of the Kaliningrad Region power system mode

M.G. GADZHIEV, E. A. GULEVICH, J.V. SHAROV

The Federal Budgetary Institution of Higher Education "National Research University" MEI"
Russia

V.N. Ryabchenko

Joint Stock Company "Research and Development Center at Federal Grid Company of Unified Energy System"
Russia

e-mail: ryabchenko.vn@gmail.com

Modern control systems of technological processes are based on mathematical models, which are derived through observation of dynamic processes. Identification of mathematical models is an indispensable element and the most complex stage of the process in finding solutions to current application management tasks. In the process of identification, adequate models are created that are necessary for the practical use of mathematical methods and complex science-intensive technologies.

Mathematical models of realistically functioning objects usually contain unknown structures and/or parameters, determination of which constitutes the task of structural and parametric identification. Accurate or approximate estimates of unknown parameters are determined by processing the observed input and output signals of an identifiable dynamic system. In the broadest formulation of the identification task, it is assumed that there are random factors and that in their presence accurate measurements are impossible.

Current space-distributed and time-synchronized WAMS systems, for vector measurement of electrical magnitude, bring the energy system identification problem to a level at which the success of its solution depends on the applied methods and algorithms.

The report examines the solution to the task of the PMU vector measurement devices placement in the power system of the Kaliningrad region, which is utilized to resolve the problem of parametric identification for the mathematical model of the power system mode.

The electrical power of the Kaliningrad region is currently provided by Kaliningradskaya CHPP-1 and CHPP-2, Gusevskaya CHPP, and Svetlovskaya GRES. At the moment, most

(>90%) of the electricity in Kaliningrad region is produced and consumed by the Kaliningradskaya CHPP-2.

Although Kaliningrad CHPP-2 is considered a modern power station, the power system of the region is not directly connected to the energy system of Russia, but connected to the Lithuanian energy system. Therefore, there are operational transit risks for reserve capacities from the Lithuanian energy system, as well as the presence of the technological branching of the Baltic energy system.

This circumstance reduces the reliability of the region's energy supply. In this regard, the government of the Russian Federation will intentionally, in the near future, strengthen the energy system of the Kaliningrad region by modernizing the networks and building four power stations (one coal power station and three power stations operating on natural gas) with a total electric power capacity of approximately 1 GW.

It is assumed that the introduction of WAMS into the energy system of the Kaliningrad region will provide an effective solution to the problem of identifying the power system mode and will allow, in real time, to form adequate linear and nonlinear mathematical models suitable for analysis of respective static (in the first linear approximation) and dynamic (in the full nonlinear model) stabilities. It will also allow to determine their reserves, as well as to synthesize the vector control for synchronous machines, system stabilizers, networked energy storage devices and static reactive power compensators.

The applied identification algorithms are based on the invariance property of the Kalman observability matrix, and the identification criterion is the average minimum of a specially constructed objective function. This makes it possible to identify the complete and equivalent (simplified) mathematical model of EPS, and also to synthesize control actions that provide vibration dampening and a given static stability of the power system.

In this regard, the minimum order of the Kalman observability matrix, which provides the solution of the parametric identification problem, is chosen as the criterion for the arrangement of the PMU in the power system of the Kaliningrad region. The mathematical methods and algorithms used for the solution of the PMU problem, include heuristic, algebraic methods and biotic algorithms. The final decision was made by consensus.

Mathematical modeling of the existing and updated power system of the Kaliningrad region confirmed the correctness of the solution obtained.