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AUTOMATED COMPUTATION OF DOZED CONTROL ACTIONS IN ADAPTIVE AUTOMATION OF ELECTRIC POWER SYSTEM STABILITY ASSURANCE

The ultimate goal of the project is creation of adaptive emergency control automation for ensuring stability of the United Energy System of Ukraine at a given UES intersection. Adaptability is provided by correction (at a certain time interval) of settings of microprocessor emergency control automatics in accordance with UES current electric mode conditions. The current mode parameters are determined by computational estimation of UES state (electric mode) on the basis of remote measurements. The amounts of control actions for ensuring stability standards are determined for the given set of external disturbances and for the given mode weighting trajectories.

Key words: *electric power system, intersection, steady-state stability, emergency control automation, adapted control actions.*

Introduction

A component part of the project, dealing with creation of emergency control automation for preventing steady-state instability (APSI) of UES of Ukraine at a given intersection [1], is development of software tools for automated calculation of the dozed control actions. Adaptability of automation is provided by correction (at a certain time interval) of the settings of microprocessor emergency control automatics (ECA) in accordance with UES current mode conditions. Current mode parameters are determined by computational estimation of UES state on the basis of remote measurements using KOCMOC software package.

The centralized complex of APSI technical means includes pre-emergency information measuring facilities, starting members (SM) and operating members (OM), devices for automatic dozing of control influences (ADI), devices for automatic storage of dozing of the control influences (control actions – CA) (ADS) and devices for receiving-transmitting pre-emergency and emergency information, control command signals. Pre-emergency information measuring facilities provide information required for computations of control influences in ADI means in accordance with the embedded algorithms:

– about the state of switching devices of the lines, transformers, generators or generator-transformer units, etc.;

– about the mode (power, current, voltage of the lines and intersection nodes) of the controlled network and the adjacent network;

– other parameters that determine control influences.

Information about the initial state of the circuit and network mode (pre-emergency information) is transmitted to ADI via communication channels with the application of telemechanics equipment and via other specialized information channels.

On the basis of measured and calculated parameters of the energy system pre-emergency mode control influences (CI) are determined in ADI for all emergency disturbances (ED). CI choice is performed on the basis of periodic stability calculations for current modes before emergency disturbance occurs. The intensity of control influences is determined by the previous mode, ED type and the required power reduction at the intersection for ensuring stability in the post-emergency mode.

Research results

The amounts of control actions in order to provide stability standards [2] are determined for the given set of external disturbances as well as for the given mode weighting trajectories and transmitted to the central automation complex via information network «ЕНЕРГІЯ».

Weighting trajectory is a sequence of the weighted steady-state modes, which makes it possible to achieve the limits of the static stability region for the current circuit and operating mode of the energy system. APSI is intended for performing load cutoff in the energy system nodes, realized by special load cutoff automatics (SLCA) so that standard stability margin at the controlled intersection will be provided [3]. Starting members (SM) of the automatics are such emergency disturbances that bring the system to the post-emergency mode with the reduced stability level, which is determined by the active power stability margin coefficient K_p and voltage stability margin coefficient K_u.

Thus, general algorithm of adaptive emergency automatics operation (Fig. 1) provides external cycle for starting members of the automatics and the cycle of stepwise weighting of the post-emergency mode with calculation and verification of $K_{p\ standard}$ and $K_{u\ standard}$ coefficients. If standard values of $K_{p\ standard}$ and $K_{u\ standard}$ are achieved, the following conclusion is made: control actions of the automatics for ensuring steady-state stability of the post-emergency mode are not required for given SM. In the opposite case the cycle of control actions is performed. The algorithm aims at formation of the code of control actions (CA) as a sequence of 0s and 1s (1 is off-signal for the load and 0 – absence of signal) in accordance with the sequence of SLCA queues.

The formed tables of CA are stored in ASD device, which is built on the basis of RTU-560 equipment produced by ABB company, which enables exchanging data according to IES 60870-5-104 protocol as well as receiving the discrete signals from starting members and their transmission to operating members. For receiving commands from SM and transmitting them to OM the existing commands of «ECA SOUTH » are used (emergency control automatics, the central complex of which is located at Novokakhovka PS 330 KW and which ensures UES stability in one of the most critical regions). The commands are multiplied (in the case of SM) or duplicated (in the case of OM).

This problem is characterized by the necessity to calculate self-established steady-state post-emergency voltage modes created after emergency disturbances under the influence of automatic excitation regulators (AER) of synchronous generators and compensators.

The algorithms of adaptive emergency control automation were realized in a special module included into the Software package for analyzing the modes of electric power systems. Operation of the module for determining the amount of control actions, which is included into the centralized complex of the adaptive emergency control automatics for ensuring stability of the United Energy System of Ukraine at the given UES intersection, is provided by creation of the corresponding information exchange protocol.

Testing of the software module for determining the amount of control actions was performed using the Software package ABP-74 of electric power system stability analysis [4].

Parameters of the mode, obtained with the application of Software package KOCMOC, form the informational basis for performing calculations. For entering the information about control actions (Fig. 2), using the data on SLCA devices installed in the UES nodes, defined for the given intersection, the load cutoff sequence is set in accordance with the existing (preliminary determined) sequence. For this the nodes, where SLCA is provided, are chosen from the list of nodes and load volumes to be cut off are set.

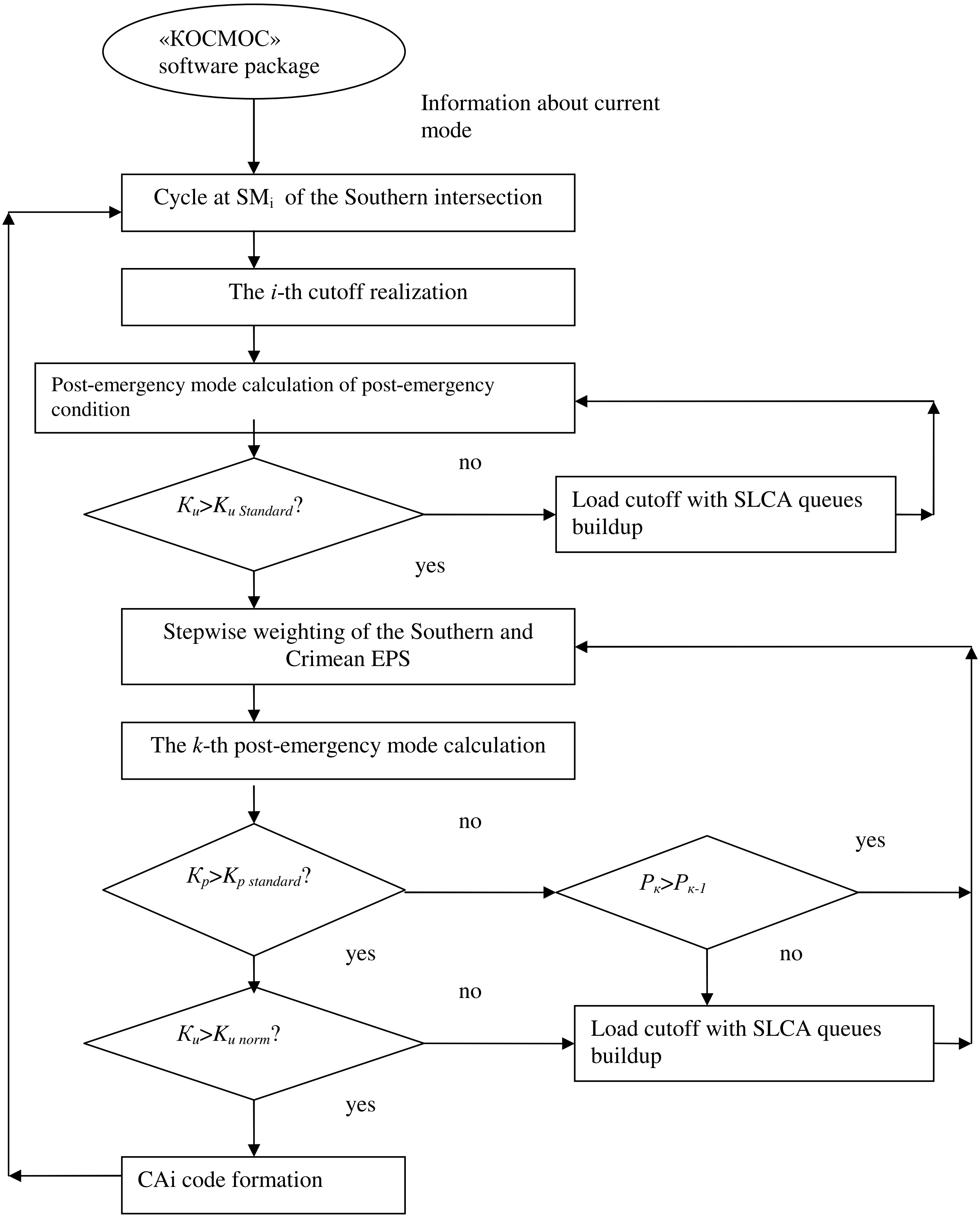

Fig. 1. General algorithm of the adaptive emergency control automatics operation

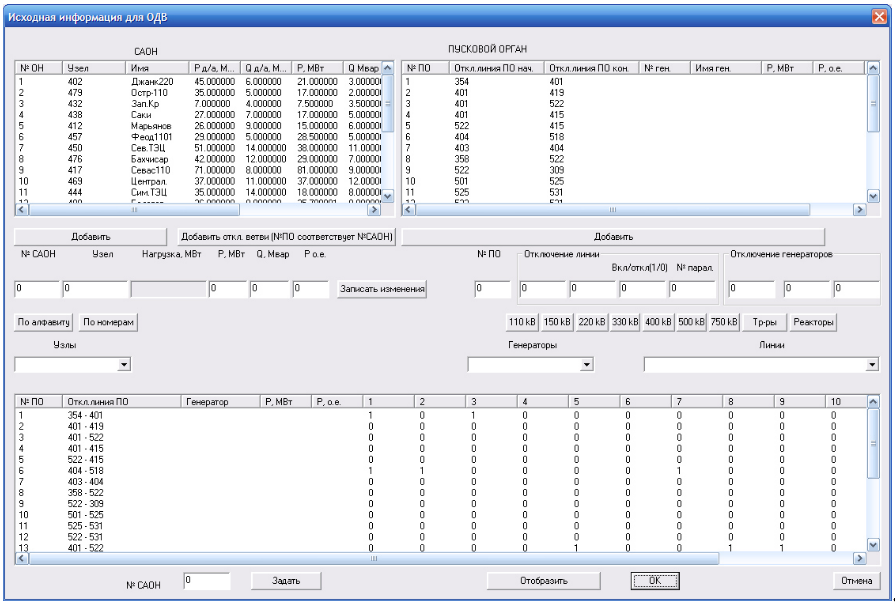

Рис.2. Меню підготовки інформації

In order to provide stability standards, the amount of control actions is determined for certain external disturbances, which are set from the proposed list. Service, offered by the Software package, enables prompt finding and setting the corresponding actions. After formation of the tables of control actions and disturbances that cause them, the table of their mutual correspondence is filled in. For this, after direct presentation of the possible combinations in accordance with the existing documents, the numbers of the queues of control actions are set for each separate disturbance or for a group of disturbances. In this way the file of initial information is formed (Fig. 1).

Testing was conducted in the mode of UES of Ukraine. The amount of control actions and the list of disturbances corresponded to the state on 02.03.12. First, for each separate disturbance (or weighting trajectory) a steady state pre-emergency mode is calculated and it is determined whether it will lead to the reduction of voltage and power stability margin coefficients below the standard levels. If so, post-emergency steady-state modes are calculated, taking into account the queues of control actions for bringing stability margin coefficients back to the permissible limits or to the levels set by SLCA. Thus, due to gradual discrete increase of the load to be cut off with simultaneous calculation of the post-emergency mode and verification of the stability margin coefficients, the amounts of control actions for ensuring stability reserve is determined. Initial mode, calculated by KOCMOC software package, is stored in the library and is read for each calculation, connected with other disturbances. Then it becomes a basic one. SLCA cutoff sequence creates a scenario for performing calculations. The results are given in the form of a table, which is written in the required format for transmitting to corresponding EA means.

In order to test the program module, the amount of control actions for NEC “UKRENERGO” network, including 714 nodes and 1137 lines, was calculated. According to pre-emergency mode results, total load of UES of Ukraine is 27766 MW and total generation – 30624 MW.

Load cutoff automatics within the Crimean energy system and the list of disturbances, activating this automatics, are also set in accordance with the existing instructions. The Software package makes it possible to provide calculation of all disturbances indicated in the normative document (SLCA and 15 various disturbances are provided). The Software package enables obtaining not only the chart of control actions, but also studying the calculation process protocol (Fig. 3).

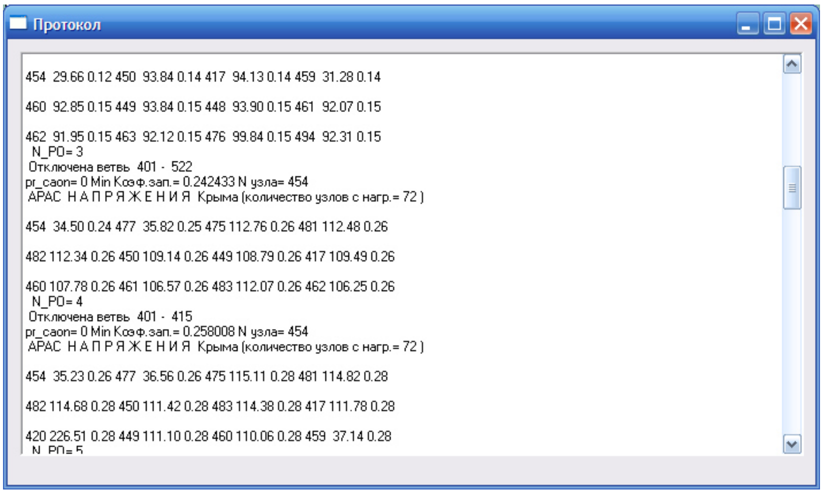

Fig. 3. Fragment of the protocol of CA amount calculation

Study of the calculation results makes it possible to draw the following conclusion: if disturbances occur in the existing mode, cutoff of the lines Melitopol – Dzhankoy 330 KW, Kakhovka MSDS (main step-down substation) – Titan 220 KW and cutting off the generator at Simferopol HPS with the power of 25 MWT will not cause stability reserve reduction beyond the permissible limits. However, if the lines Melitopol – Dzhankoy 330 KW, Kakhovka MSDS – Ostrovska and the line Kakhovka MSDS – Titan 220 KW are cut off simultaneously, the value of stability reserve coefficient will be below the standard level and the indicated amount of control actions will not ensure bringing it back to the permissible limits.

Conclusions

It is shown, that in order to solve the problem of ensuring steady-state stability at the given intersection of UES of Ukraine, the created software tools for automated calculation of the dozed control actions are expedient to be used. Main characteristics of the software tools are presented as well as the results of their testing in the given mode of UES of Ukraine.

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