SECTION 3

MANAGEMENT BY TECHNICAL, TECHNOLOGICAL, BIOTECHNOLOGICAL OBJECTS

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SYNTHES OF ROBUST QUASIINVARIANT SYSTEM OF ACTIVE SHIELDING OF OVERHEAD TRANSMISSION LINES MAGNETIC FIELD

Annotation. Synthesis of robust quasiinvariant systems of active screening of a magnetic field generated by overhead transmission lines has been developed. The synthesis is based on the solution of a multi-criteria stochastic game, in which the gain vector is calculated on the basis of the Maxwell equations solutions in the quasi-stationary approximation. The equilibrium state of the game is based on the stochastic particles multiagent multiswarm optimization algorithms. An example of synthesis is given and the possibility of reducing the induction of the initial magnetic field to the sanitary standards level and reducing the sensitivity of the system to variations of the plant parameters is shown.

Key words: overhead transmission lines, power frequency magnetic field, robust active screening system, multicriteria stochastic game.

Introduction. Methods of active contour screening of magnetic field (MF) created by overhead transmission lines [1] are the most acceptable and economically feasible for ensuring the sanitary norms of Ukraine of power frequency magnetic field. The method of synthesis of active shielding systems (ASS) for MF, created by overhead transmission lines, was developed in [2]. However, this method does not take into account the uncertainty of the system parameters due to the inaccurately known model of the control object, as well as changes in the parameters of the system during its operation [3].

Purpose of the work is synthesizing of robust quasiinvariant active shielding systems of magnetic field created by overhead transmission lines, which allows to reduce the sensitivity of the system to variations of the plant parameters.

Problem Statement. In the synthesis of the active shielding systems, the mathematical model of the original MF is known inaccurately [3]. In particular, bus currents have daily, weekly, seasonal variations are approximately known. The geometric dimensions of the compensating coil, the parameters of the regulators, are not accurately realized. Therefore, we introduce a vector of deviations of the plant parameters from their nominal values used in the synthesis of the system. The problem of synthesizing a robust ASS is reduced to the determination of such a vector of spatial arrangement and geometric sizes of compensated windings, as well as parameters of the regulator and the vector of variable parameters, at which the maximum value of the magnetic field induction at selected points of the considered space assumes a minimum value in the regulator parameter vector, but the maximum value for the vector of variable parameters. This technique corresponds to the standard

approach to the synthesis of robust systems for the worst-case case [3], when the variations of the parameters lead to the greatest deterioration in the compensation of the initial magnetic field created by overhead power transmission lines. This problem can be formulated in the form of the multi-criteria game with vector gain, in which the components are the module of the induction vector at the points of the space under consideration.

In the multi-criteria game, the first player is the parameter vector of the regulator and its strategy is the minimization of the vector gain, and the second player is a vector of variable parameters characterizing the uncertainty of the parameters of the control object model and the strategy of this game is maximization of the same vector gain.

Note that the components of the vector gain are non-linear functions of the vectors of the required parameters and are calculated on the basis of the solutions of the Maxwell equations in the quasi-stationary approximation [2].

Game Equilibrium Finding Algorithm. To find the equilibrium state of the multi-criterion game from Pareto-optimal solutions taking into account the preference relations [2], we construct an algorithm of stochastic multi-agent optimization based on the set of particle swarms, the number of which is equal to the number of components of the vector gain. Note that in connection with the fact that the vector of the solutions of the game is represented in the form of strategies of two players – the vector of the parameters of the regulators and the vector of the variable parameters, where it is necessary to minimize the vector gain along the parameter vector of regulators and maximize the same vector gain with respect to the vector of variable parameters. Therefore, each of the particles of this swarm has two components of position, and velocity, to find the two desired components of the vector of the parameters of the regulators and the vector of the variable parameters. We note that the original multi-criteria game taking into account the algorithm for its solution is a multi-criteria stochastic dynamic game, since it clearly has time and random search.

Computer simulation results. As an example, the synthesis of a robust quasiinvariant ASS of MF created by group of overhead transmission lines is considered. This situation is typical for the outskirts of cities, where group of overhead transmission lines are suitable, as well as near power line substations.

For the synthesis of ASS, in addition to the geometric dimensions of the transmission lines and the shielding zone, the values of the currents in the current conductors of the transmission lines are necessary. Moreover, the main uncertainty in the synthesis of this system is the variation of the currents of different power lines, which leads not only to a change in the level of magnetic field induction, but also to a change in the position of the spatially temporal characteristics of the magnetic field in the shielding zone. To this, first, experimental studies of the level of the magnetic field both in the shielding zone and near the transmission lines were carried out. Based on the obtained experimental data, the problem of current identification in current conductors of the power line is solved, under which the sum of the squares of the errors of the measured and model-them magnetic field induction values at given points is minimized. Based on the MF model obtained by several power lines, the problem of synthesis of a robust quasiinvariant ASS was solved. The ASS contains one compensation coil.

Synthesized robust quasiinvariant ASS makes it possible to reduce the sensitivity of the system to changes in the parameters of the control object in comparison with the initial ASS. The calculated screening efficiency of the synthesized robust ASS (more than 4 units) was confirmed experimentally on its full-scale model.

Conclusions. Synthesis of robust quasiinvariant active shielding systems of magnetic field created by overhead transmission lines has been developed, which makes it possible to reduce the sensitivity of the system to the uncertainty of the parameters of the control object model. The synthesis of a robust quasiinvariant system reduces to a multi-criteria stochastic game, the equilibrium state of which is based on multi-rounder stochastic multi-agent optimization. An example of the synthesis of a robust active shielding systems MP, created by several transmission lines, is given. The system contains one compensation coil, allows to reduce the level of induction of the initial MP throughout the considered residential area up to the level of sanitary norms of Ukraine and has less sensitivity to variations of the plant parameters in comparison with the known active shielding systems.

References

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