Optimal sun-tracking of a photovoltaic system considering the electric drive losses

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Abstract. Doctoral thesis deals with optimal sun-tracking of a photovoltaic system considering the electric drive losses. The Sun tracking PV system assures that the highest possible share of the available solar radiation reaches the surface of the PV modules. The electric drive which enables tracking is considered as the loss of the energy produced in the PV system. The maximum of the energy produced in the PV system is achieved by the continuous tracking of the PV system. Since the electric drives are determined by constant speed and time, and angle quantization the maximum of the energy produced can only approximate.

The doctoral thesis presents a new method for determining such trajectories of the PV modules that change the position of the PV modules in such a way that the production of the electric energy in the given time interval of the observation reaches its maximum. The goal is to determine the maximum efficiency of the PV tracking system considering the tracking system energy consumption. To achieve this, exact values of the available solar energy are needed for a given moment. To do this, a new method for predicting direct and diffuse solar radiation on the Earth's surface, in the form of the time dependent function, is developed. The method is confirmed by the comparison of the measured and the predicted solar radiation for clear days. The developed method for predicting the solar radiation in the form of the time dependent function and energy consumption of the tracking system, given as the functions of the azimuth and tilt angle change, are applied together to determine those trajectories of the PV module, where the PV system energy production, gives the maximum. To find a solution of the nonlinear and bounded optimization problem, a stochastic search algorithm called Differential Evolution is applied. The approach for determining the maximum of the energy produced in the PV system has not been researched yet. The explicitly defined objective function, which is minimized in the optimization procedure considering the optimization bounds, is used. Thus it is assured the maximum of the possible energy produced in the PV system, considering the applied model of the PV system, tracking system consumption, predicted solar radiation, and the properties of the applied optimization method. The use of the different and more advanced models of the PV system, the sun tracking system consumption or prediction of the solar radiation, can lead to the different optimal trajectories of the sun tracking system. However, this cannot reduce the importance of the proposed method. The proposed method gives the maximum of the possible energy produced in the discussed PV system, considering the applied models and data.

Optimal Arrangement of Overhead Power Line Conductors Considering Emissions of Electromagnetic Fields and Audible Noise

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Abstract. The legal procedures to obtain the right of way for the new overhead power lines in Slovenia are extremely difficult nowadays. Due to the large public opposition against the building of the new overhead lines is necessary to invest a lot of effort in both, the planning of overhead power lines and the minimization of their impacts on the environment.

In that sense, within the given overhead power line right of way, all of the impacts on the environment should be under prescribed limits. Therefore, most of our attentions should be devoted to minimize emissions of the electromagnetic fields and the audible noise.

The aforementioned emissions depend mostly on the values of overhead power line voltage, current and geometrical arrangement of conductors. Especially with the proper arrangement of the overhead power line conductors the emissions of the electromagnetic fields and the audible noise could be essentially reduced.

Moreover, with an appropriate software tool, the optimal arrangement of conductors, with respect to the given objective function, could be determined.

Such an optimal arrangement of the conductors can be determined with the Differential Evolution based optimization environment proposed in this dissertation. It contains the module for calculating the audible noise emissions as well as the module for calculation the emissions of the electromagnetic fields. In the calculations it is possible to consider the sagged conductors or their approximation with the straight conductors.

The aim of this dissertation is to find an optimal arrangement of the three-phase power line conductors. The acceptable emissions of the electromagnetic fields and audible noise are considered as the optimization bounds, while the optimization goal is the minimal height of the tower defined with the attachment of the overhead ground wire.

The developed software tool can be used for designing the new overhead power lines, where the restrictions as the width of the overhead power line right of way, the safety clearances, the allowable emission of electromagnetic fields and audible noise are considered.

Additionally, the proposed software tool can be applied to check where the overhead power line with the lower rated voltage level can be upgraded to the higher rated voltage level inside already existing right of way.