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論 文 の 要 旨

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題 目　A Study on Maximum Power Extraction of Photovoltaic Systems Installed
　　　　on Ship Using Artificial Neural Network
　　　（ニューラルネットワークによる船舶に設置した太陽光発電システム
　　　の最大電力抽出に関する研究）

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Retrofitting photovoltaic systems to ships can help reduce their CO_2 emissions and cost of operation, by reducing the utilization of diesel generators. Although photovoltaic (PV) panels are widely used, research into methods for increasing the efficiency of such systems is still ongoing, as the expensive price and low efficiency of PV cells forces the development of efficient topologies, control and management systems, or a combination of the above, to decrease the cost/energy ratio of PV-based energy sources. Moreover, in ship application, space for PV panels is limited to the roof of the structure. Consequently, an efficient design and operation of the systems is required.

This study presents methods to increase the efficiency of the PV systems applied on ship in the stage of pre-design, optimal design and optimal control. The estimation of the monthly and hourly solar radiations is the method proposed in the pre-design stage. The optimal design is manifested in the determination of best inclination and orientation angles of the panels considering ship routes and schedules. On the other hand, the optimal control is proposed in the fast and accurate ANN-based electric maximum power point tracker (MPPT).

In order to obtain the optimal design of solar energy system, the data of solar radiation should be provided. In this study, estimation models of monthly and hourly solar radiations in Japan is developed using artificial neural network (ANN). The purpose of this study is to provide accurate models to estimate the solar radiations, especially for the location where measured data is not available. The structure of ANN is constructed using geographical and 6 years-meteorological data between 2011-2016. The model has been validated by comparing the estimation results with measured solar radiation data on five different stations in 2017. Considering relatively small mean absolute percentage error (MAPE) and root mean square error (RMSE), it is believed that the proposed model could accurately predict the monthly solar radiation, which further could be used to obtain optimal design of solar energy system in Japan area.

One of the most determining aspects in PV systems efficiency is the combination of the inclination and orientation angles of the panels, because it will affect the global solar radiation received by the panels. Part of this study aims to determine the monthly optimal combination of those angles. The ship location and direction during the cruise, time, and local weather conditions were the factors considered for the analysis. Six shipping lines in the territory of Japan were considered as case studies and ANN analysis were employed to calculate the general solar radiation received by the panels based on the input factors. Comparisons between the outputs of the panels arranged to the optimal angles and those at flat position are presented in one-year calculation. The results show that for the long route ships, low or constantly zero inclination angles are favorable, while monthly adjusted angles can draw higher solar energy for short route ships.

Since the space available for installation may not be on top of the structure, the possibility of a PV array operating in partially shaded conditions is higher with retrofitted ships than it is with new specifically designed solar-powered boats. Hence, to optimize the efficiency of PV systems, a new MPPT for partially

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shaded conditions (PSC) is introduced in this study. The proposed method employs an ANN to predict the area of the global maximum power point (GMPP), and the classic perturb and observe (P&O) algorithm to locate the exact position of the GMPP. The effectiveness of the technique has been validated using computer simulations performed with the MATLAB/Simulink Simscape program, the results of which verified that it can track the GMPP faster than other methods.

The details of the proposed methods are discussed in this study.