MATHEMATICAL MODEL FOR PREDICTING THE PERFORMANCE OF PHOTOVOLTAIC SYSTEM WITH DELAYED SOLAR IRRADIANCE

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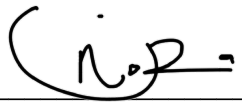

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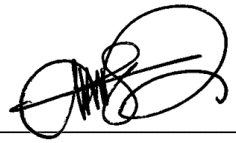

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ABSTRAK

Di Malaysia, tenaga suria merupakan sumber tenaga boleh diperbaharui yang utama disebabkan kedudukannya yang berdekatan dengan khatulistiwa. Berbanding dengan penggunaan bahan api fosil, teknologi tenaga suria adalah yang paling cepat berkembang, menjimatkan serta kurang menjejaskan kelestarian alam semula jadi. Sistem fotovolta menukarkan kesinaran suria kepada tenaga elektrik. Disebabkan oleh beberapa faktor, jumlah kesinaran suria yang sampai ke pengumpul fotovoltaik suria pada lokasi tertentu akan berbeza-beza. Tujuan kajian ini adalah untuk membangunkan model matematik bagi meramal prestasi sistem fotovolta, yang bergantung kepada jumlah kesinaran suria. Satu model baharu bagi kesinaran suria dalam bentuk persamaan pembezaan lewat diperkenalkan dengan mengambil kira faktor tundaan kesinaran suria, sudut masa dan pergerakan matahari. Kajian simulasi dijalankan untuk tiga senario keadaan cuaca iaitu: cuaca cerah, cuaca sedikit berawan, dan cuaca sangat mendung. Penyelesaian berangka diperoleh dengan menggunakan kaedah Runge Kutta yang dikaitkan dengan teknik penyesuaian parameter, algoritma Nelder Mead, yang dilaksanakan dengan menggunakan perisian MATLAB. Data dari loji solar di Pahang, Malaysia, digunakan untuk pengesahan model dan didapati profil ramalan bagi kesinaran suria sejajar dengan fasa pertengahan dan kemerosotan, tetapi sedikit berbeza semasa fasa pertumbuhan. Arus dan kuasa keluaran bagi panel fotovoltaik solar telah dianggap sebagai fungsi yang bergantung kepada masa. Apabila kesinaran suria meningkat, arus dan kuasa output bagi panel suria akan meningkat. Keputusan menunjukkan bahawa arus dan kuasa keluaran maksimum bagi Modul Solar Kristal STP250S-20/Wd menurun sebanyak 42% dan 76% masing-masing semasa cuaca sedikit berawan dan sangat mendung berbanding dengan cuaca cerah. Dengan kata lain, prestasi modul fotovoltaik adalah lebih baik pada hari yang cerah berbanding dengan hari yang berawan dan sangat mendung. Penemuan ini menekankan hubungan antara kesinaran suria lewat dan prestasi sistem fotovoltaik solar.

ABSTRACT

In Malaysia, solar energy is the primary renewable energy source due to its proximity to the equator. In comparison to fossil fuels, solar technology is the fastest-growing, most cost-effective, and least harmful to the environment. Photovoltaic systems convert solar irradiance into electricity. Due to some factors, the amount of solar irradiance arriving at the solar photovoltaic collector at a specific location varies. The goal of this study was to develop a mathematical model for predicting the performance of a photovoltaic system, which depends on the amount of solar irradiance. A novel model for solar irradiance in the form of a delay differential equation is introduced by including the factor of delayed solar irradiance, hour angle and the sun's motion. The simulation study is carried out for the three scenarios of weather conditions: a clear day, a slightly cloudy day, and a heavily overcast day. The numerical solution is obtained by adopting the Runge Kutta method coupled with a parameter fitting technique, the Nelder Mead algorithm, which is implemented by using MATLAB software. The data from a solar plant in Pahang, Malaysia, was used for model validation and it is found that the prediction profile for solar irradiance aligns well with the intermediate and decay phases, but deviates slightly during the growth phase. The output current and power for the solar photovoltaic panel were treated as time-dependent functions. As the solar irradiance increases, the output current and power of the solar panel will increase. The result showed that the maximum output current and output power of STP250S-20/Wd Crystalline Solar Module decreased by 42% and 76% , respectively, during slightly cloudy and heavily overcast conditions when compared to clear days. In other words, the performance of a photovoltaic module is better on clear days compared to cloudy days and heavily overcast. These findings highlight the relationship between delayed solar irradiance and the performance of the solar photovoltaic system.

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