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TECHNOLOGY TRANSFER OFFICE

Improved Solar Power Plant Efficiency: Low Cost Solar Irradiance Sensor

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Patent pending; available for exclusive or non-exclusive licensing.

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Background

Photovoltaic (PV) systems are of great interest to the efforts of sustainable energy. Solar irradiance is a measure of the sun's electromagnetic power radiating on a given area, and plays a major role in the efficiency of these systems. In additional to solar irradiance (which fluctuates as environmental conditions change), the power generated by PV cells depends on temperature and total resistance; this relationship creates a non-linear output efficiency. Identifying the maximum power point (MPP), and adapting voltage accordingly, is a key aspect of efficient PV operation.

While temperature sensing is simple, devices for solar irradiance measurement, such as pyranometers and pyrheliometers, are expensive and difficult to calibrate; as a result, they are seldom utilized in photovoltaic power plants. Instead, some MPP tracking algorithms use a pre-calculated solar irradiance estimate, which may be more or less accurate averaged over the full power plant but is does not reflect less-than-uniform conditions within the plant. Other methods avoid measuring or estimating irradiance, and instead use the other factors to define the power curve, then search iteratively along the curve to identify the MPP - while somewhat acruate, these guess-and-check algorithms are unstable and likely to fail when irradiance changes rapidly.

Technology

A University of Colorado research group led by Fernando Mancilla-David has developed a low cost irradiance sensor using a network modeled on a neural network. In this approach, a trained NN algorithm uses a small number of PV cells arranged into a small sensing PV panel, as well as a temperature sensor and a low-cost microcontroller, to directly sense solar irradiance; this data can then be fed back into the MPP tracking algorithm to dynamically improve PV efficiency as conditions change.

Such a sensor may be located next to a power–producing PV panel or even integrated with it, so that the sensing PV panel will "see" exactly the same solar irradiance and temperature as that "seen" by the power–producing PV panel, leading to improved performance. The use of a microcontroller allows for easy calibration, updates, and enhancement by simply adding code libraries. Furthermore, it can be interfaced via standard communication means with other control devices, integrated into control schemes, and remote-controlled through its embedded web server.

An initial estimate suggests the device may cost less than 10% with respect to its commercially available counterparts, making it ideal for use in photovoltaic power plants.

Key Documents

"Neural Network Solar Irradiance Sensor." Provisional patent application filed March 15, 2013.

A Neural Network-Based Low-Cost Solar Irradiance Sensor. IEEE Transactions on Instrumentation 2013; volume PP, issue 99. *PDF available upon request.*

An Estimator of Solar Irradiance in Photovoltaic Arrays with Guaranteed Stability Properties. IEEE Transactions on Industrial Electronics 2013; volume PP, issue 99. *PDF available upon request.*