Performance Optimizer for PV Panel Installations

Cost-effective means for rapidly monitoring performance of PV solar panels during operation.

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Background

Silicon-based photovoltaic (PV) systems undergo a drop in real-time performance in the field when compared to the predicted “laboratory” performance. The effects of dynamic operational environments where these PV panels are deployed give rise to various fault conditions which reduce PV panel efficiency and impacts the economic viability of PV investments. This could be due to a variety of external factors such as dust and adverse weather conditions. Monitoring and characterizing real-time performance or State-of-Health (SOH) of these installations are, therefore, essential. Online diagnostic information of PV panels add significant value to system operators and are critical to manage the system optimally. The data allows operators to react faster to resolve inefficiencies and obtain richer data on the operational panel.

Various technologies exist to measure critical parameters to determine the condition of PV panels but limitations exist when considering online monitoring. The more accurate systems (such as Electrochemical Impedance Spectroscopy or EIS) are not suitable for online application because their diagnostic ability is too slow and therefore they cannot account for “transients”, i.e. rapid changes in fault conditions. Other faster, online systems (typically measuring only voltage and current) are not very accurate and provide limited information.

Researchers at the University of Cape Town (UCT) devised a way to rapidily characterize, model and monitor online performance of PV panels / string of panels. The diagnostic information can be used to improve the efficiency, reduced fault conditions, increase life expectancy and ultimately improve the economic viability of the investment into PV systems.

Technology Overview

The technology is a low-cost platform for capturing the impedance spectrum of a PV module or string within a very short period of time (compared to conventional impedance analyzers). The impedance spectrum is correlated with PV performance and a variety of online fault conditions can be characterized.

The technology consists of measuring the electrical impedance response of an optimized and unique superimposed multisine broadband signal injected into the PV panel or string. The signal is capable of spanning a very large frequency range of between 100 Hz – 500 kHz with a very low crest factor, for characterizing various PV cells/modules.

The superimposition of waveforms allows rich information of the cell condition to become more rapidly available when compared to conventional EIS. This is due to the fact that signals of different frequencies are injected simultaneously, making the impedance spectrum available much sooner. With the reduction in time required to obtain this information, the technology has the potential to serve as a useful online state-of-health tool for PV panels/strings.

To date, broadband signals have not been applied to online PV modules/strings to determine their impedance and, as a result, the state of health of the PV panel/string. Impedance information provides more varied information based on the condition of the PV panel/string as opposed to voltage and current information.

Benefits

The technology has the following benefits:

- Fast response and quick characterization for rapid assessment of the state of health of PV panels. Response time is typically in the region of 1 second, making it suitable for online implementation as it limits the risk of transients having an impact on the results.
- Characterization of impedance response allows richer diagnostic information of a PV panel vs. conventional voltage and current measurements. The impedance values are also captured over a much wider frequency spectrum to allow for a wider breadth of fault conditions to be monitored and detected.
- The detailed parameter information allows for better management of PV panels by having more detailed data on the changing state of the PV panels whilst in operation. Better information allows system owners to optimize performance and reduce unnecessary maintenance expenditure.
- Diagnostic parameters can be trended over time to establish a baseline and monitor the baseline behaviour and compare them to each other. This also allows for prediction models for specific site level installations.

Applications

- Monitor the state of health, or obtain diagnostic information of PV panels in an online system environment.
- Primary function: To provide rapid online state of health monitoring and early warning system for PV systems to optimise system electrical energy output and reduce system losses and maintenance.
- A secondary function could be for the technology to surface rich system data to improve system prediction and management models.
- The technology can be integrated into power converter systems such as inverters or smart power modules or intelligent control systems to enable these systems to have more diagnostic functionality and extract better information from assets (PV panels). This technology will have low hardware cost and will complement the current value chain.

Opportunity

UCT is looking for a partner to further develop and commercialize the technology. UCT has specialized expertise to assist with further potential R&D, training and knowledge transfer. Data can be shared on the work conducted to date. UCT is seeking a partner wanting to take the technology forward into a commercial application.

Ideal partners include companies specializing in smart inverter or intelligent optimizer devices and systems.

Patents

- PCT/IB2019/051831 entering national phase in September 2021

IP Status

- Patent application submitted
- Provisional patent

Seeking

- Development partner
- Commercial partner
- Licensing