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Name of the Department: Department of Electrical Engineering
Name of the topic: Modelling and Analysis of Photovoltaic Generation System under Different Fault Conditions

Findings:

Key Words: Fault detection, Fault localization, I-V characteristics, Partial shading, Solar PV system.

This research explores the modeling, analysis, and fault diagnosis of photovoltaic (PV) generation systems under various fault conditions to improve their reliability, efficiency, and safety. The work begins by establishing a simplified mathematical model of a PV cell using the one-diode equivalent circuit. The model is further extended to simulate the behavior of a PV array under variable irradiance and temperature conditions. This provides a foundation for evaluating system performance in real-world environments and is used to extract key I-V (current-voltage) and P-V (power-voltage) characteristics.

Simulations are conducted to analyze the impact of different fault conditions on PV array performance, including line-to-line faults, line-to-ground faults, degradation faults, and partial shading. Each fault type is shown to cause unique distortions in the P-V curve and varying degrees of power loss. These insights enable a better understanding of how faults disrupt system efficiency and energy yield.

The thesis introduces a novel detection method based on the I-V curve to address shading-related faults. By analyzing the impedance at the first power peak (FPP), the technique identifies the presence of partial shading and distinguishes it from other operational disturbances. This method is validated using MATLAB/Simulink simulations and proves effective for early shading detection.

Building on this, the research presents a general fault detection and identification method for PV arrays. It uses voltage and current ratios, along with threshold values, to diagnose faults such as open circuits, LL/LG faults, and partial shading. The methodology is tested both in simulation and with experimental setups using a 4×4 PV array, demonstrating strong correlation and detection accuracy.

For fault diagnosis in power converters, the thesis focuses on *n*-phase interleaved buck converters. A logic-based framework is developed to detect and localize open-circuit faults in switches and diodes. The system is capable of identifying single and multiple fault scenarios and is supported by both simulation and experimental results, using PWM analysis and error generation blocks.

The research concludes by emphasizing the effectiveness of the proposed models and detection techniques in enhancing PV system fault tolerance. It recommends future work in integrating these approaches with IoT-based real-time systems and extending the techniques to hybrid PV systems such as PV-wind or PV-storage combinations.