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Prototype of a Low-Cost AC-Side Anomaly Detection and Alert System for Residential Photovoltaic Installations

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Abstract

The increasing deployment of residential photovoltaic (PV) systems calls for affordable and reliable monitoring solutions to enhance safety and operational awareness. This paper presents a prototype Indicator Light Photovoltaic (ILPV) system for low-cost AC-side anomaly detection and alerting in small-scale PV installations. The system integrates a voltage sensor (ZMPT101B) and a current sensor (ACS712) with an ESP32 microcontroller to provide real-time measurements, visual status indicators, audible alarms, and optional Wi-Fi-enabled remote notifications. Experimental validation was performed under two supply scenarios, grid and standalone inverter, using both no-load and 10 W load tests. Results showed voltage measurement accuracy within 1% of a calibrated multimeter, detection of load-induced voltage drops, and current variations averaging 0.035 A under load. The system also detected transient overvoltage events, registering a simulated surge of approximately 6 V in milliseconds. While testing was limited to low-power indoor conditions and AC-side monitoring, the ILPV demonstrated the ability to classify basic supply states and promptly alert operators. Designed as a scalable, cost-effective add-on, the ILPV can serve as a secondary protection and awareness layer in residential PV systems, with future work extending capabilities to PV-side fault detection, environmental sensing, and outdoor real-world deployment. © 2025 IEEE.

Author keywords

AC-side anomaly detection; ESP32-based monitoring; inverter output monitoring; Photovoltaic monitoring; residential PV safety

Indexed keywords

Engineering controlled terms

Cost effectiveness; Electric inverters; Housing; Load testing; Photovoltaics; Real time systems; Safety engineering

Engineering uncontrolled terms

AC-side; AC-side anomaly detection; Anomaly detection; ESP32-based monitoring; Inverter output monitoring; Photovoltaic monitoring; Photovoltaic systems; Photovoltaics; Residential photovoltaic; Residential photovoltaic safety

Engineering main heading

Ability testing

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