A photovoltaic performance dataset for benchmarking of failure detection and diagnosis algorithms

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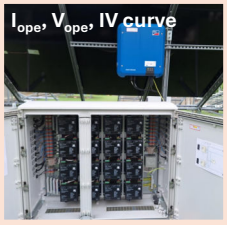
J.D. Santos [a] (jose.santos@tecnalia.com), S. Riaño [a], A. Lucea [a], M. Jankovec [b], A. Del Pozo [a], R. Alonso [a], A. Sanz [a]
[a] TECNALIA, Parque Científico y Tecnológico de Bizkaia, Astondo Bidea, Edificio 700. E-48160 Derio (Bizkaia), Spain
[b] UNIVERSITY OF LJUBLJANA, Faculty of Electrical Engineering, Tržaška cesta 25, 1000 Ljubljana, Slovenia

INTRODUCTION

- The development of algorithms for remote identification of failures from SCADA data requires PV datasets with known degradation modes. However, publicly available PV datasets often present a lack of information on existing failures. Synthetic datasets with software simulated degradation, while useful, do not reflect the complexity of real PV systems.
- To address this gap, this work present a new dataset based on the continuous monitoring of a set of PV modules with well-characterized failure modes. Designed for O&M applications, this PV performance dataset is shared open-access with the PV community within the SERENDIPV and CACTUS projects.

EXPERIMENTAL SETUP



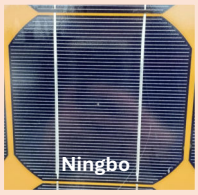
PV Monitoring System

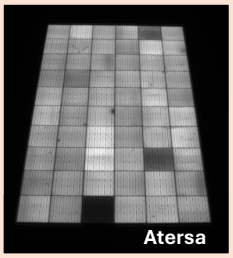
- LPVO-MS1X16 system continuously monitored the performance of each PV module.
- Operating voltage and current (V_{OPE} & I_{OPE}) measured by MPPTs with 1-min frequency.
- Entire IV curve of each module characterized by an IV tracer with 5-min frequency.
- Plane-of-array irradiance (G_{POA}) measured synchronously with a combination of pyranometer and calibrated solar cell.
- PV module temperature (T_{MOD}) measured at the center and corner of each device.
- Environmental conditions such as global horizontal irradiance (GHI), air temperature, relative humidity, and wind speed (WS) recorded simultaneously.

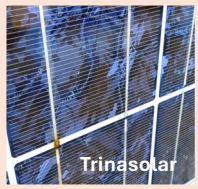
PV modules and Failure modes

- The PV modules set included four different manufacturers and three solar cell technologies.
- JASolar modules were new and showed no defects. JASolar1 was used as the reference for benchmarking.
- JASolar2 and JASolar3 were used to simulate, through fabricated resistance boxes, the impact that some failure modes have on increasing series resistance (R_{SERIE}) and decreasing shunt resistance (R_{SHUNT}).
- Ningbo, Trinasolar and Photowatt exhibited combinations of failure modes caused by long-term exposure to harsh operation conditions in Spanish PV plants. Atersa showed defects associated with improper handling.
- Failure modes were identified by combining indoor IV curve, visual inspection and electroluminescence.

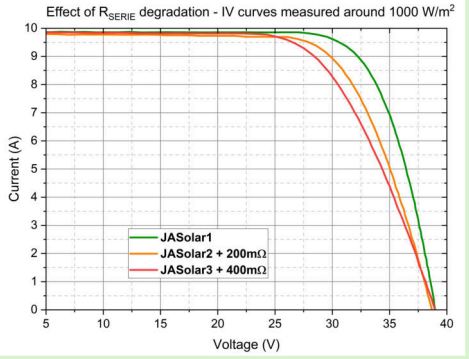
Manufacturer	Cell technology	Label Pmax	State	Main failure modes
JA Solar	Mono / PERC / 5 busbars	315 W	As new	None - Reference
JA Solar	Mono / PERC / 5 busbars	315 W	As new	Artificially higher Rserie or lower Rshunt
JA Solar	Mono / PERC / 5 busbars	315 W	As new	Artificially higher Rserie or lower Rshunt
Ningbo Solar	Mono / Al-BSF / 2 busbars	210 W	Degraded	Yellowing / Interconnect ribbon break
Trina Solar	Mono / Al-BSF / 2 busbars	185 W	Degraded	Internal circuitry corrosion
Atersa	Mono / PERC / 5 busbars	330 W	Degraded	MicroCracks / Shorted solar cells
PhotoWatt	Poly / Al-BSF / 2 busbars	160 W	Degraded	Solar cell cracks / Interconnect ribbon break





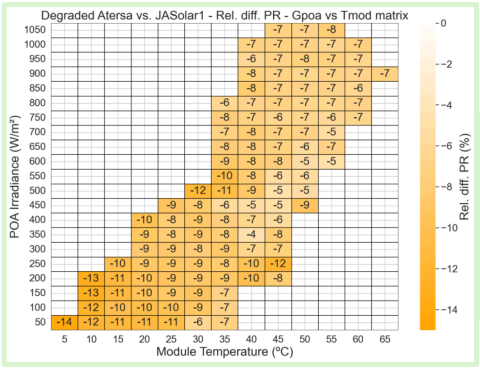


RESULTS



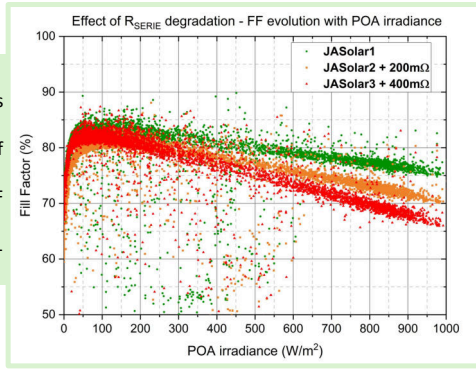
R_{SERIE} impact on IV curve

- Failure modes like internal circuitry corrosion cause an increase in the R_{SERIE} of the PV module.
- Impact of R_{SERIE} degradation on PV performance was investigated by connecting resistance boxes of 200 mΩ and 400 mΩ in series with JASolar2 and JASolar3.
- IV curves measured in outdoor conditions at G_{POA}≈1000 W/m² were filtered to show how R_{SERIE} degradation altered the shape of the IV curve, affecting MPP voltage or fill factor (FF) among other parameters



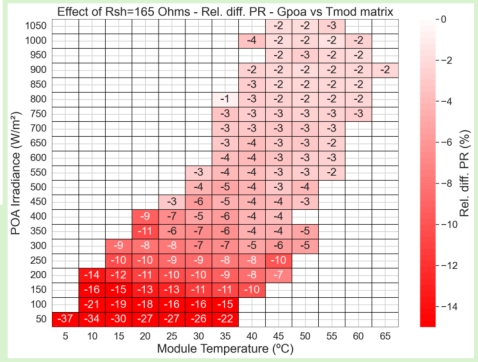
R_{SERIE} impact on irradiance dependence of FF

- Continuous monitoring enabled the study of how different failures affect the dependence of PV performance on operation conditions .
- Impact of R_{SERIE} increase on the FF was investigated as function of G_{POA}.
- R_{SERIE} degradation caused significant differences with reference FF (JASolar1) for G_{POA} >300 W/m².
- At 1000 W/m², FF values ≈75% and ≈65% were measured for JASolar1 and JASolar3 respectively.



G_{POA} & T_{MOD} dependence of PR – Atersa vs. JASolar1

- Relative difference in performance ratio (PR) between Atersa and JASolar1 was plotted as G_{POA} vs. T_{MOD} matrix analogous to IEC 61853-1.
- Atersa showed a PR a 6-7% lower than JASolar1 for G_{POA}>800 W/m².
- Rel. diff. PR between Atersa and JASolar1 was sensitive to changes in operating conditions, reaching -14% at G_{POA}=50 W/m² and T_{MOD}=5ºC.
- For G_{POA}<600 W/m², rel. diff PR seemed to become more negative as T_{MOD} decreased.



G_{POA} & T_{MOD} dependence of PR - Lower R_{SHUNT} + JASolar3 vs. JASolar1

- Failure modes such as potential induced degradation cause a reduction in R_{SHUNT} of the PV module.
- Impact of R_{SHUNT} degradation was investigated by connecting a 165 Ω resistance box in parallel to JASolar3.
- JASolar3 showed a 2-3% lower PR than JASolar1 for G_{POA}>800 W/m² . JASolar3 presented a 20-30% lower PR than JASolar 1 for G_{POA}<100 W/m².
- For a given POA irradiance interval, the R_{SHUNT} degradation also led to lower PR values as T_{MOD} decreased.

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SERENDIPV
CACTUS