Modern PV Module Quality Testing

Markus B. Schubert
University of Stuttgart, Institute for Photovoltaics

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Michael Reuter,
Liviu Stoicescu,
Jürgen Werner.
Institute for Photovoltaics - ipv

- director Jürgen H. Werner
- 4+1 work groups
- new group Energy Storage (Peter Birke)
- 25 coworkers, including 10 PhD candidates

Technology
Industrial solar cells
Laser processes
Sensor technology

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Markus Schubert
Outline

- Quality Assurance in PV - why?
- Common methods
- Imaging techniques
- Daylight Luminescence System (DaySy)
- DaySy - a very good option!
Motivation: keep 38 GW alive!

Development of electricity generation and installed capacity of photovoltaic plants in Germany

38 GW PV installed in Germany
all cells/modules series-connected!!
Only few methods for troubleshooting

- compare strings (big PV plants)
- analyse string or module $I/V$
- outdoor thermography
- electroluminescence
- dismantle and check indoor
Indoor flasher measurement: effect of broken cell after 5 years of outdoor operation [courtesy of Peter Bentz, Solarfabrik Freiburg]
Thermography of complete PV park

Infrared imaging of PV Parks
[courtesy of C. Buerhop, ZAE Bayern]

failure of one inverter
Typical thermography image

hot spot, probably due to broken cell
Thermography

poor cable connection, wrong connector type?
Module Failure Modes

- Delamination
- Microcracks, broken cells, finger interruptions
- Browning
- Hot spots
- Potential induced degradation (PID)
**Optical Characterization Methods**

- **UV - Fluorescence**: Irradiate module with UV light and visually inspect the response.

- **Thermography**: Detect heat where it is now…

- **Luminescence**: Use solar cells as light emitting diode and see where the current is going.
Electroluminescence of transport damage

transport damage

Solar cells before thermal cycling

\[ P_{MPP} [Wp] = 7.9 \]

Solar cells after thermal cycling

\[ P_{MPP} [Wp] = 6.3 \]

aging after 200 cycles in climatic chamber:

power loss!
The DaySy Method

Electro (EL)- and photoluminescence (PL) characterization

- In full daylight → Independent of surrounding light
- On mounted modules and full strings
- Using either the PV-plant or a DC source as power supply
  → From an overview to detail images!
Availability of outdoor imaging methods

Measure when YOU want: 100% Availability Day and Night

DaySy - PL
DaySy – Self Powered EL
DaySy – EL with Power Generator
Night -EL
Night -EL

Thermography

0 100 700 700 100 0

Daytime Irradiance in W/m²

DaySy EL of installed Module
8 MP Dark-Box EL
MPP Thermography
Hail on c-Si Modules
'Angry birds'

Damage detected in Japan near golf course at coastline.
DaySy – EL (self-powered)

DaySy EL

Dark Box EL @ 10 A

2 - 6 Generator-Strings

DaySy Box
Do NOT "Kärcher" your PV!

Severe damage due to high-pressure cleaning

https://www.kaercher.com/de/inside-kaercher/sponsoring.html
Do NOT drop PV modules from the truck

ONE broken module will kill the performance of your complete string (until bypass diodes will take effect).
Broken bypass diodes - very common!

- easily detected by DaySy, if in short-circuit
- not so easy in I/V
- almost no chance, if in open-circuit
Polarization of long strings (PID)

Polarization of Sunpower modules towards high-voltage end of string.
Whole string imaging
Scenario
- Field PV installation, 250W$_p$ modules, 20 modules/string
- Unpacking & Setup: 30 minutes; Wrap up: 15 minutes
- Location of PV strings is known (good documentation) 10 min / string / operator
- 1 minute for a EL image; 2 minutes for a EL+PL image
Conclusion

*DaySy detects*
- transport damage
- wrong handling during installation
- installation / maintenance faults
- module damage during operation (thermal stress, mechanical strain, aging ..)
- failures (bypass diodes, cell contacts, PID ..)

*DaySy*
- helps training installers / PV companies
- is THE good option for PV in Cyprus!
bonus track

for Questions & Discussion
Whole String Imaging (1)

- Potential induced degradation (PID)
- poor low light response
- damaged areas
- groups of broken fingers
- Very high throughput possible
LED Flasher

source: http://www.wavelabs.de
everything connected in series