In-situ Electroluminescence (EL) Inspection of Solar Modules being part of PV Installations

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ABSTRACT

We present in-situ electroluminescence measurements of single solar modules being part of PV installations. Electroluminescence inspection is performed without the need of dark boxes or covers, instead measurements are undertaken under free sky conditions. The mobile electroluminescence system consists mainly of a cooled back-illuminated CCD Camera equipped with infrared filters and a mobile power supply. The solar module under investigation is disconnect from the PV grid and connected to the mobile power supply for the time of the measurement. In this report, we investigated the influence of the disturbing sky light on electroluminescence measurements. We found that electroluminescence inspection under free sky is already possible at twilight time. The mobile system under study allows to monitor large PV installations on-site without the need to demount solar modules from their superstructure. In consequence, defect modules can be identified and replaced helping to maintain the performance of PV installation over time.

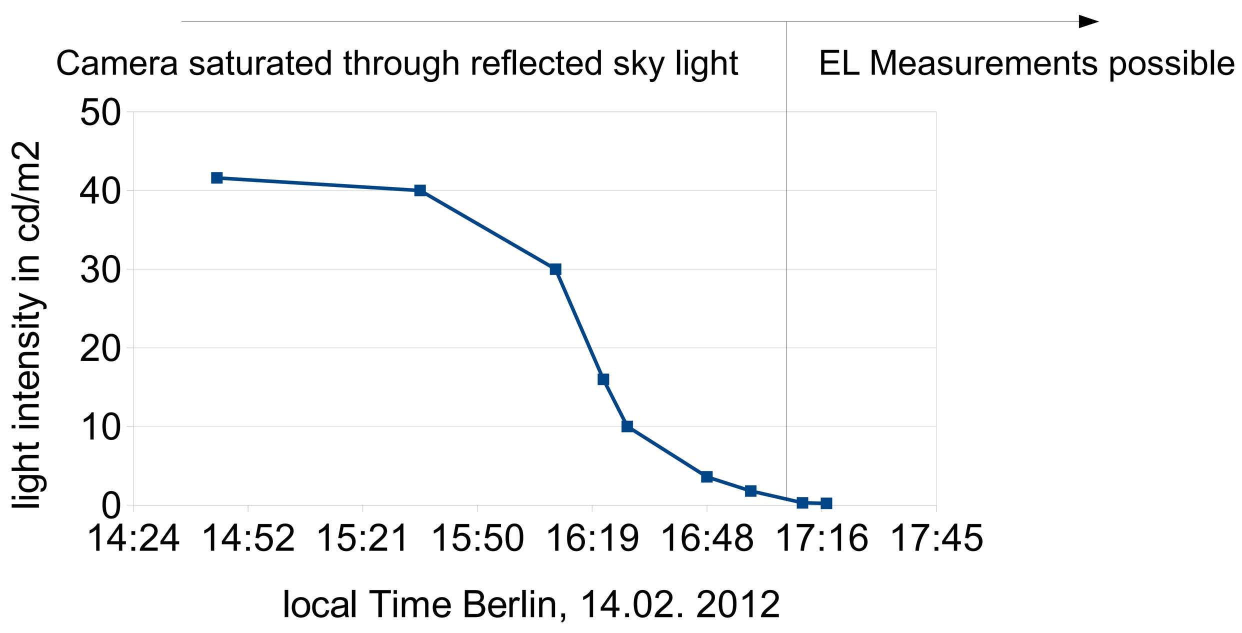
MOTIVATION

EL Inspection of Solar Modules is typically performed in dark labs or mobile boxes to prevent the influence of disturbing light sources which superimpose the faint electro-luminescence emission. In consequence modules from PV installations must be demounted from their superstructure in order to be inspected. That requires cost and time as well as the risk for additional damage. For this reason a direct EL measurement of the modules at the place of installation is feasible. The purpose of this study is the development of an in-situ electroluminescence inspection system that is able to tolerate disturbing light sources like the night sky.

APPROACH

We used the following measurement set-up for the study: 1. Electroluminescence Imaging Camera: greateyes GE 1024 1024 BI (1MPixel, 13µm Pixel size, Quantum Efficiency: 12% @1000nm, 16bit Dynamic Range, Peltier-Cooling), 2. Objective with NIR transmission filter , 3. Programmable Power Supply: 150V/10A, 4. Battery-based power supply for single solar modules or line-powered 10kW supply for strings

In the first step we determined the tolerance of the system to disturbing sky light. On a normal cloudy day we measured the intensity of the sky light reflected by the solar module at the viewing point of the camera. Concurrently we tried to obtain EL images of a poly-Si Solar Module.



At reflected sky light intensities lower than 1 cd/m^2 (twilight conditions) EL measurements are possible because saturation of the camera does not occur.

IN-SITU MEASUREMENTS

Measurement Parameters:

Applied current: I_{ISC}~7..8A

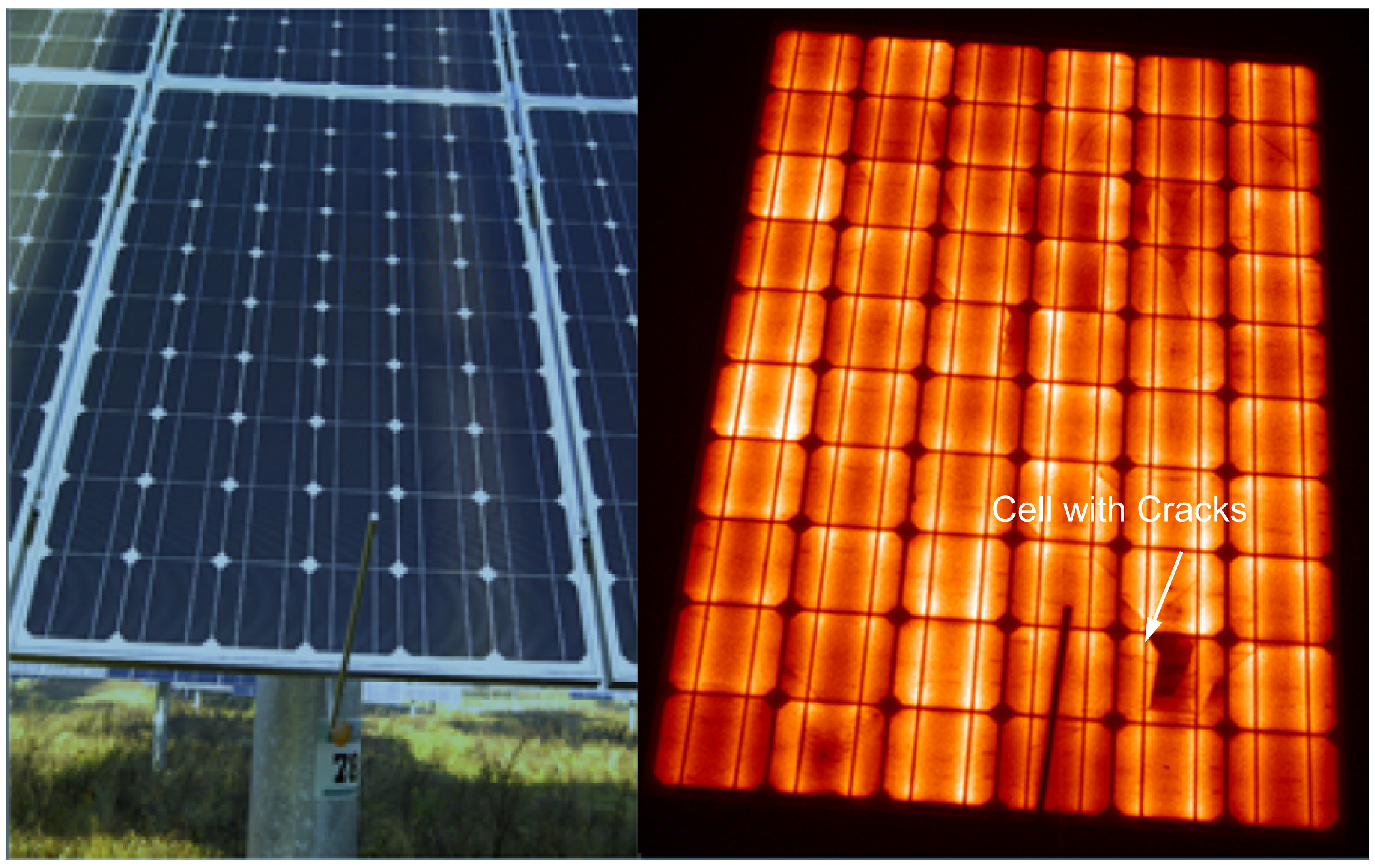
Measurement Time: 2sec

Automatic Background subtraction

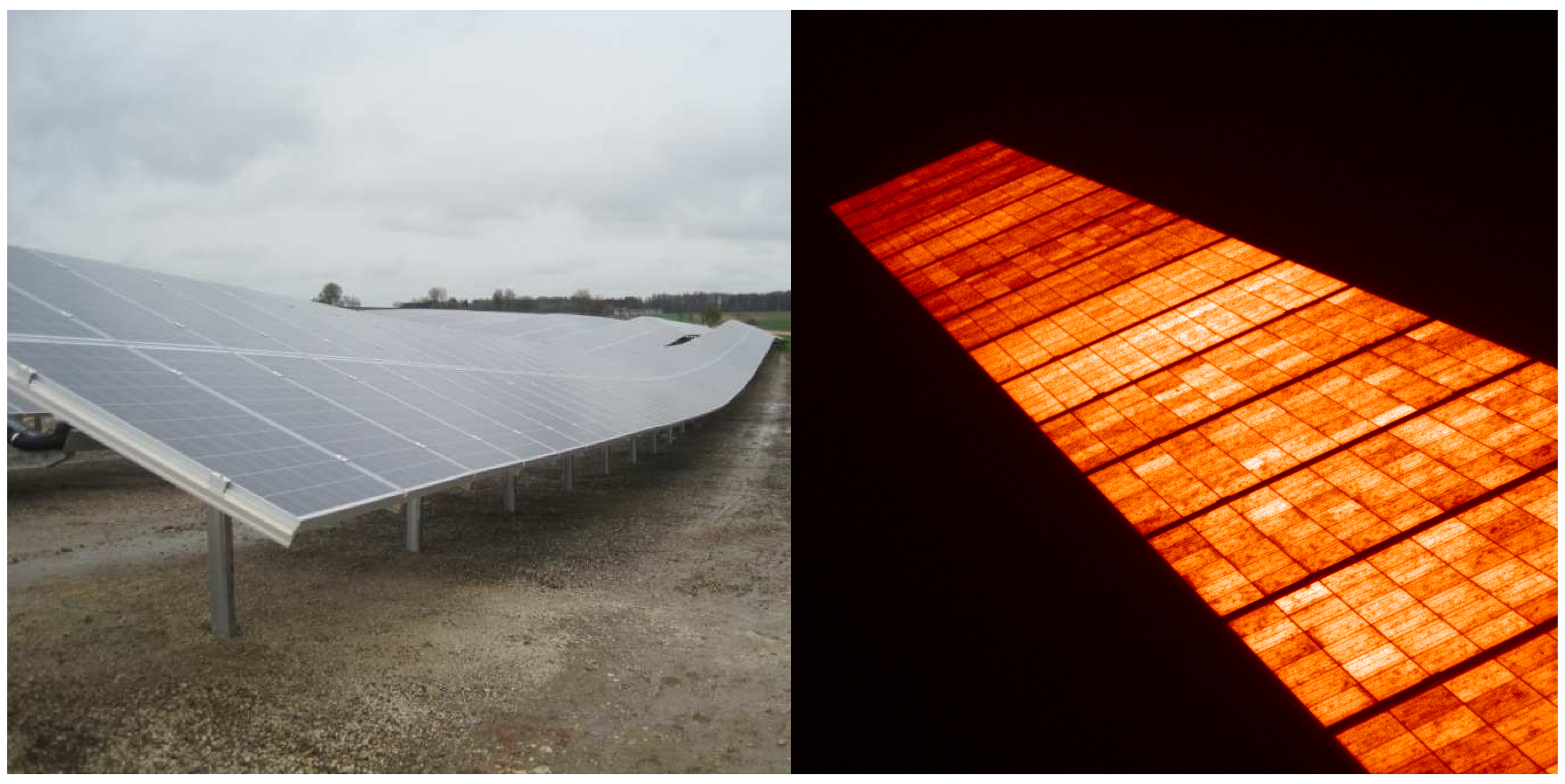
Distance to the module: 3-4m

Solar Modules are disconnected from the grid, attached to the mobile power supply for the time of the measurement. EL Images were taken under night sky conditions.

RESULTS



Left: Visible Image, right: EL Image measured under night sky using a battery based mobile power supply



Left: Visible Image of Solar module string, right: EL Image measured under night sky using a line-powered 10KW supply

SUMMARY

A mobile Electroluminescence Inspection System has been developed for direct inspection of PV installations. A combination of adequate signal filtering and image subtraction allows measuring EL images under twilight or night sky conditions. A battery based power supply is used to power single solar modules whereas a line powered supply can be employed to excite a whole string of solar modules. EL Inspection of modules directly at the place of their installation is a cost-saving, fast method with unique advantages compared to mobile dark boxes or trailer based EL labs. Applications include final inspection of solar modules before Installation, acceptance tests, documentation purposes, failure diagnoses, detection of handling and transport damages as well as general purpose quality control.