FH MÜNSTER
University of Applied Sciences

EU PVSEC 2016
32nd European Photovoltaic Solar Energy Conference and Exhibition

FH Bielefeld
University of Applied Sciences

LowCost-Outdoor-Electroluminescence: Significant Improvements of the Method

K. Mertens, A. Arnds, G. Behrens*), A. Domnik*)

Fachhochschule Münster, Fachbereich Elektrotechnik und Informatik, Photovoltaik-Prüflabor,48565 Steinfurt, E-Mail: mertens@fh-muenster.de

*) **Fachhochschule Bielefeld**, Minden

Introduction

Electroluminescence pictures (EL pictures) of solar modules are a **powerful tool** for **quality analysis**. Recently, it was shown that with modified inexpensive DSLR cameras and suitable blocking filters even onsite-outdoor measurements can be realized. This LowCost-Outdoor-Electroluminescence method facilitates a **detailed error analysis of whole strings** with respect to micro cracks, potential induced degradation (PID), defective bypass diodes etc. [1-5]. A **disadvantage** of the hitherto existing method lies in the relatively **long exposure time** which enforces the **use of a tripod**. At least for a quick first inventory of the PV plant it would be desirable to find the string set under current on the roof with the **video mode** of the camera and to already roughly **examine it for peculiarities**.

Deployment of Consumer Cameras

The **frame rate** of typical consumer cameras (e.g. Canon EOS-700D) is in the order of **25 or 50 fps** (frames per second). However with the **alternative camera operation system *Magic Lantern*** also **smaller frame rates** can be adjusted (Fig. 1 and 2). This leads to a **sufficient EL-brightness** even **in video mode** (Fig. 3). In practice to make a first quick inventory of the plant a frame rate of **7 fps** hast been **well-tried**.

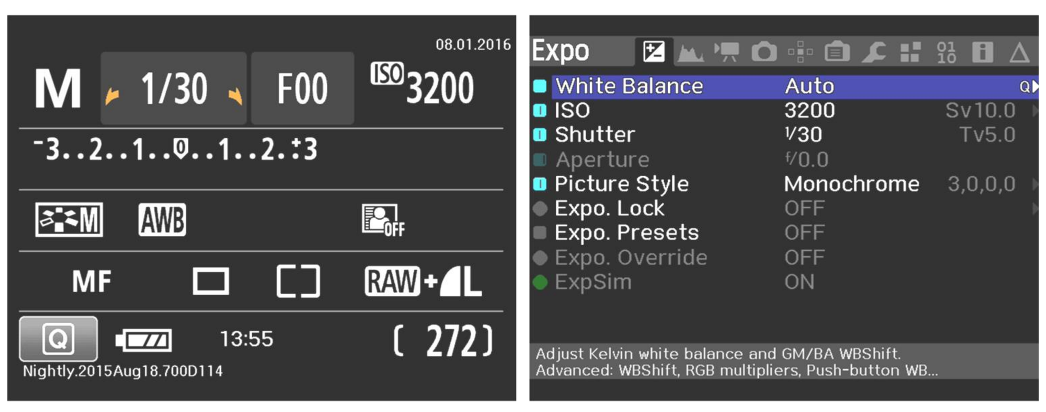

Fig. 1: Screenshot of the original user interface (left) and the alternative firmware *Magic Lantern* (right)

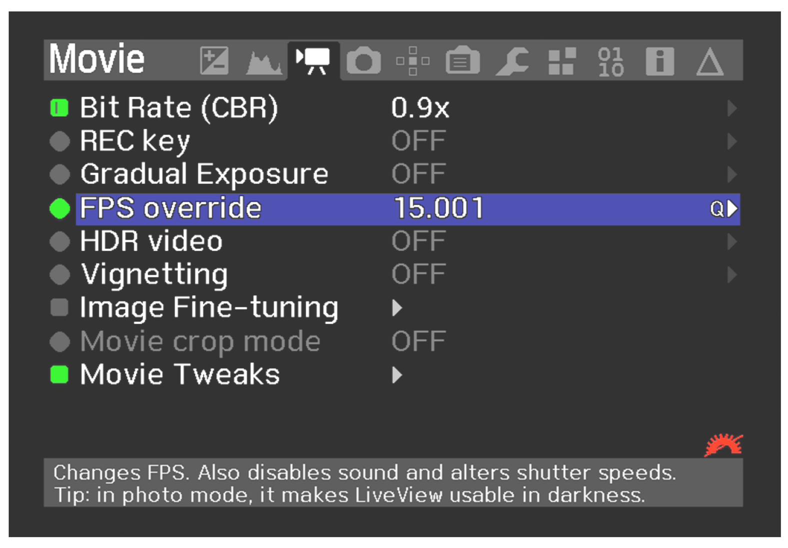

Fig. 2: Possibility to adjust the frame rate (in frames per second) in *Magic Lantern*

a) 15 fps

b) 5 fps

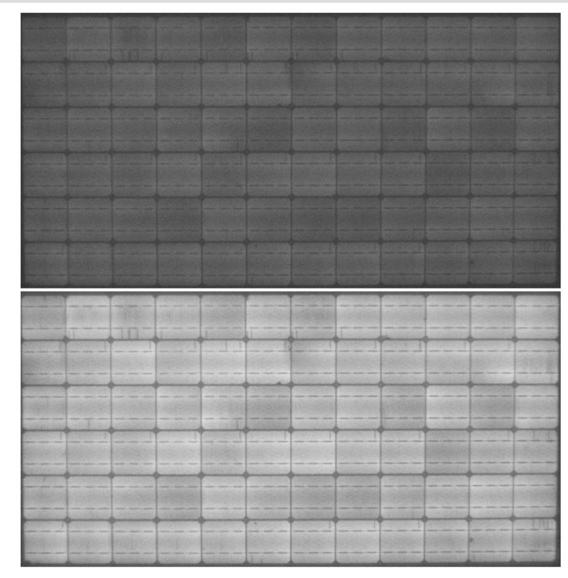

Fig. 3: Depiction of two single video frames at different frame rates: Only picture b) shows a sufficient brightness

Deployment of semi-professional Cameras

Only shortly **compact system cameras** (< 2000 €) are on the market which show **excellent detector sensitivities** (with **ISO values up to 400,000**). This is combined with a relatively high sensivity also **in the IR spectrum** relevant for EL measurements. Therefore this **camera is suitable** (after modification) **to take EL videos** at high frame rates with meaningful results of PV plants. As an example**, Fig. 4** shows a single frame of a video which was taken with 25 fps. Obviously the **brightness is sufficient** to see details and to detect errors.

With this type of camera the **whole inspection of the PV plant can be done in video mode** without taking single pictures. This extremely **speeds up the inspection** of a plant. The EL video technique even facilitates the **deployment of copters** with attached EL camera (Fig. 5). As a copter has only restricted battery time it is desirable to subsequently energize the separate strings of a plant. Figure 6 shows the **developed string-switching-box**. This box can **subsequently switch the current** of a high voltage power supply **to 8 different strings**. Control can be done by a **wireless remote control** device.

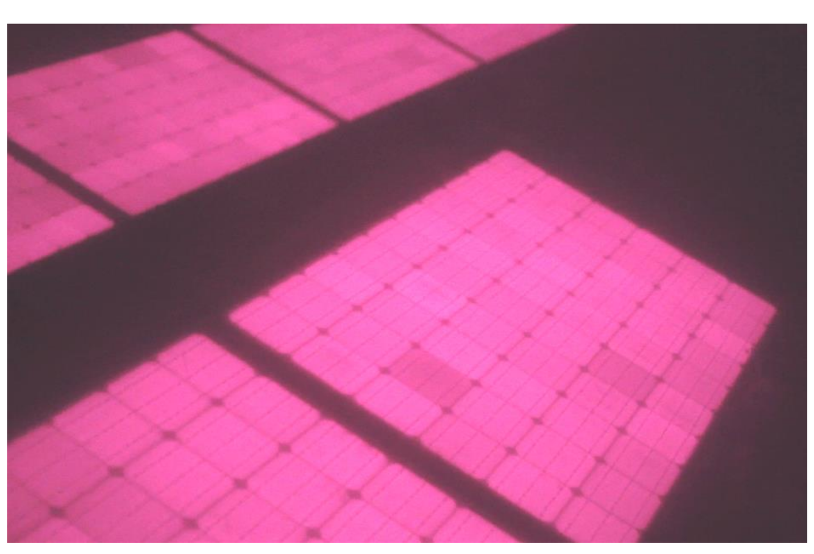

Fig. 4: Single frame of a video that was made with 25 fps: The picture shows all relevant details (Sony Apha 7)

a) Defective bypass diode b) PID

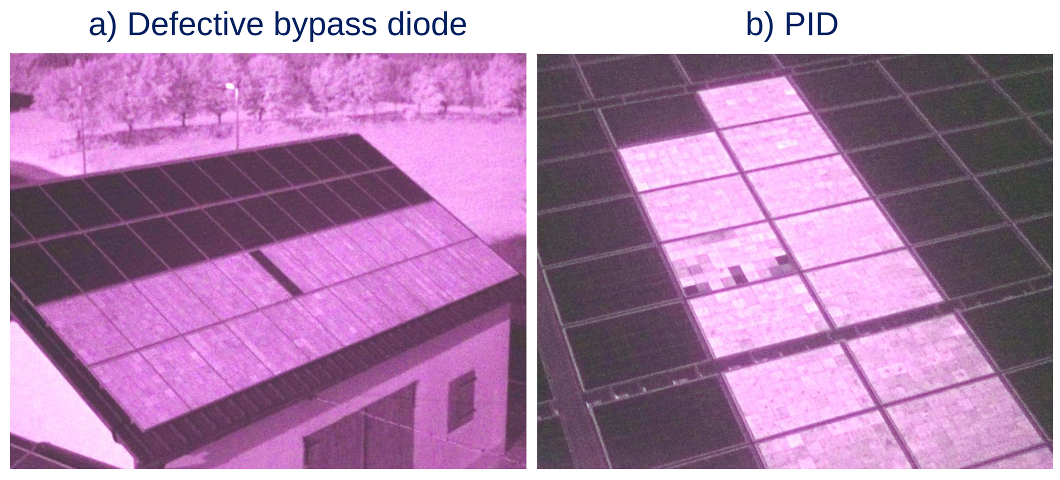

Fig. 5: Example of EL exposures taken with a copter (Source: Fladung Solartechnik, Aachen, Germany)

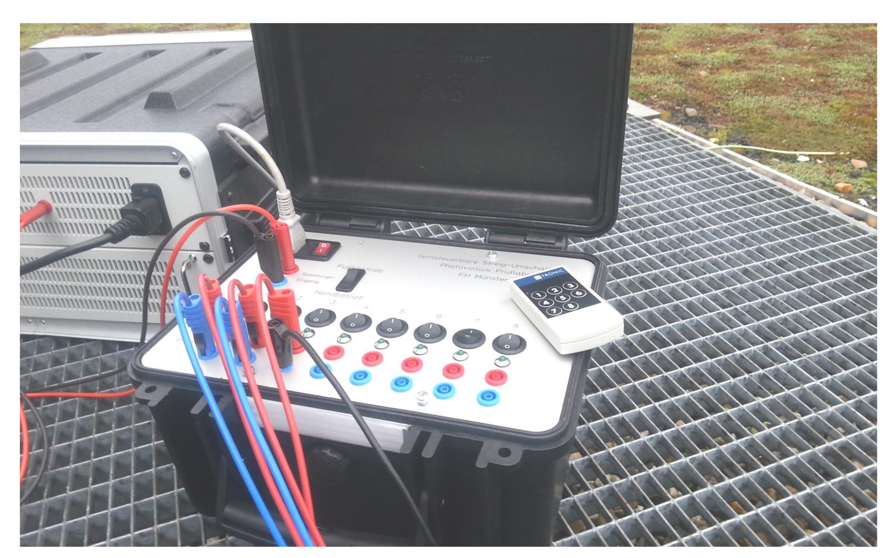

Fig. 6: String-switching-box with remote control to quickly switch between different module strings

Suppression of extraneous light

With the blocking filters mentioned above already a large amount of the extraneous light can be suppressed. However in the IR emission range **around 1100 nm sunlight still has large spectral contributions** [3]. Therefore EL measurements are **typically** done **in the night**. In order to make high-contrast **EL exposures also at dawn** first a picture with EL current and then one without EL current is taken. By forming the **difference of both pictures** already **large contrast improvements** can be attained.

In case of **EL videos** the reverse feeding **current must be modulated**. In the simplest case it is simply switched on and off. Afterwards the **frames of the "dark cycle"** can be **subtracted from the "bright cycle"**. An example of such an extraneous light suppression is shown in Figures 7-9. In Fig. 7 (with current) the EL characteristics are only poorly to be seen. Fig. 8 shows the exposure without feeding current (only diffuse light from the Sun). After subtraction of Fig. 8 from Fig. 7 a **much better EL contrast** is achieved (Fig. 9).

Fig. 7: EL exposure with extraneous light at dawn with reverse current feeding of the rear modules

Fig. 8: EL exposure with extraneous light at dawn without current feeding

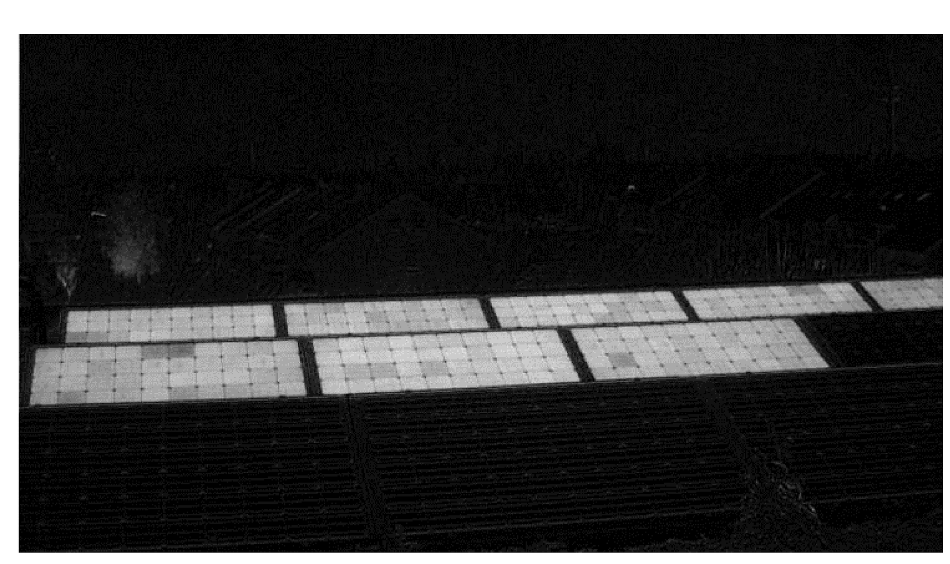

Fig. 9: Subtraction of Fig. 7 and 8: The influence of the extraneous light ist drastically reduced, the EL contrast is enhanced

Conclusion

With suitable measures the **Low-Cost-Outdoor-EL method** can be **extended to** the possibility to take **EL videos of whole PV plants**. With this extension the **capabilities** of the method are **significantly improved and expanded**. Besides facilitating a **quick overview** of the PV plant to whole **detailed plant inspec-tions** the video mode offers a lot of **possibilities** that were **not possible up to now**. As a result the **Low-Cost-Outdoor-EL method** will continue its way to **become a standard inspection method besides thermography** to analyze PV plants onsite.

Literature

[1] Mertens, K.; Stegemann, T.; Stöppel, T.: LowCost EL - Erstellung von Elektrolumineszenzbildern mit einer modifizierten Standard-Spiegelreflexkamera, 27. Symp. Photovoltaische Solarenergie, 2012

[2] Mertens, K., Pascual Gonzales, D., Diehl, M.: „LowCost-Outdoor-EL: Kostengünstige umfassende Vorort-Qualitätsanalyse von Solarmodulen", 30. Symp. Photovoltaische Solarenergie, 2015

[3] Mertens, K., Kösters, H., Diehl, M: „Low-Cost-Outdoor-EL: Cost-Efficient Extensive on-Site Quality Analysis of Solar Modules", Proceedings of 31st EU PVSEC, Hamburg, 2015

[4] Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis; 3.,neu bearbeitete und aktualisierte Auflage, Carl Hanser Verlag, München, 2015

[5] Mertens, K.: Photovoltaics - Fundamentals, Technology and Practice, John Wiley & Sons Ltd, London, 2014