Tampere University

Aurinkosähkövoimalan kunnonvalvonta sähköisten mittausten avulla

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Aurinkosähkö on tällä hetkellä nopeimmin kasvava uusiutuva sähkön tuotantomuoto.

Electrical Specifications @ STC (AM1.5, 1,000 W/m², 25° C):

Module Type		BMU/214	BMU/224	BMU/227	BMU/233	BMU/239	BMU/245
Maximum Power	P_{MPP} [W]	214	224	227	233	239	245
Short Circuit Current	I_{SC} [A]	8.15	8.30	8.35	8.45	8.56	8.65
Open Circuit Voltage	V_{OC} [V]	36.4	37.0	37.1	37.5	37.8	38.1
MPP Current	I_{MPP} [A]	7.50	7.70	7.80	7.90	8.00	8.15
MPP Voltage	V_{MPP} [V]	28.5	29.0	29.2	29.5	29.8	30.2
Solar Cell Efficiency	η_C [%]	14.7	15.3	15.5	16.0	16.4	16.8
Module Efficiency	η_M [%]	13.1	13.7	13.9	14.3	14.6	15.0

Additional power classes available on request.
Efficiency of modules at low irradiation (200 W/m²) decreases to 95.7 % of efficiency at STC.

Electrical Specifications @ AM1.5, 800 W/m², Cell Temperature 44° C:

Module Type		BMU/214	BMU/224	BMU/227	BMU/233	BMU/239	BMU/245
Maximum Power	P_{MPP} [W]	158	165	168	172		
Short Circuit Current	I_{SC} [A]	6.62	6.74	6.78	6.86		
Open Circuit Voltage	V_{OC} [V]	33.8	34.3	34.4	34.8		
MPP Current	I_{MPP} [A]	6.06	6.23	6.31	6.39	6.47	6.59
MPP Voltage	V_{MPP} [V]	26.0	26.4	26.6	26.9	27.2	27.5
Solar Cell Efficiency	η_C [%]	13.5	14.2	14.3	14.7	15.1	15.5
Module Efficiency	η_M [%]	12.1	12.6	12.8	13.2	13.5	13.8

Electrical Specifications:

Solar Cell Type		Multicrystalline Silicon
Solar Cell Dimensions		156 mm x 156 mm (6+")
Number of Cells		60 in series
Power Output Tolerance		0/+ 6 W
Current Temperature Coefficient	α	+ 5.5 mA/° C
Voltage Temperature Coefficient	β	- 120 mV/° C
Power Temperature Coefficient	γ	- 0.40 %/° C
Maximum System Voltage		1,000 V (IEC 61730)
NOCT		44° C
Limiting Reverse Current		No external voltage higher than V_{oc} should be applied

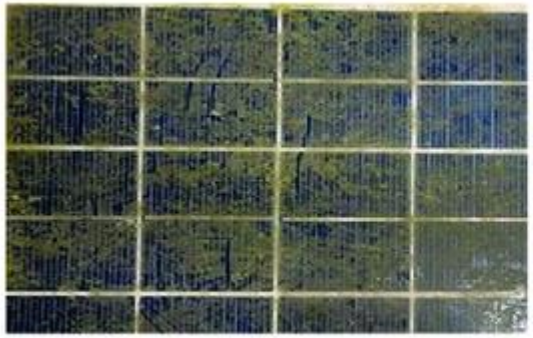
Warranties:

10-year product warranty

12-year warranty of 90 % power output

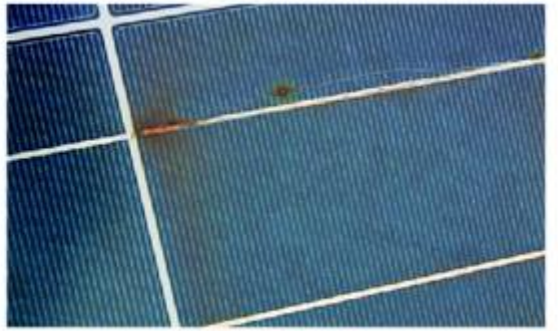
25-year warranty of 80 % power output

Kennot ikääntyvät



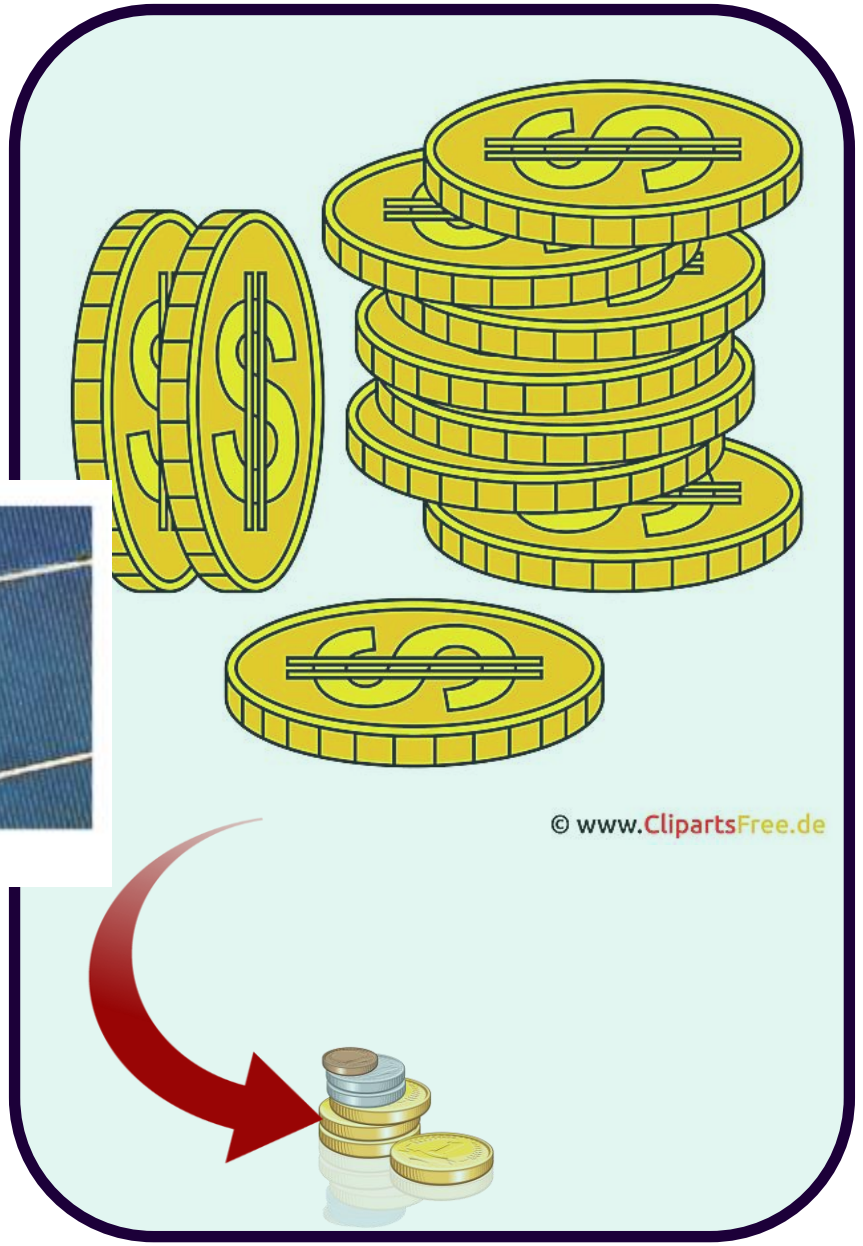
(a) Dust

(b) Delamination



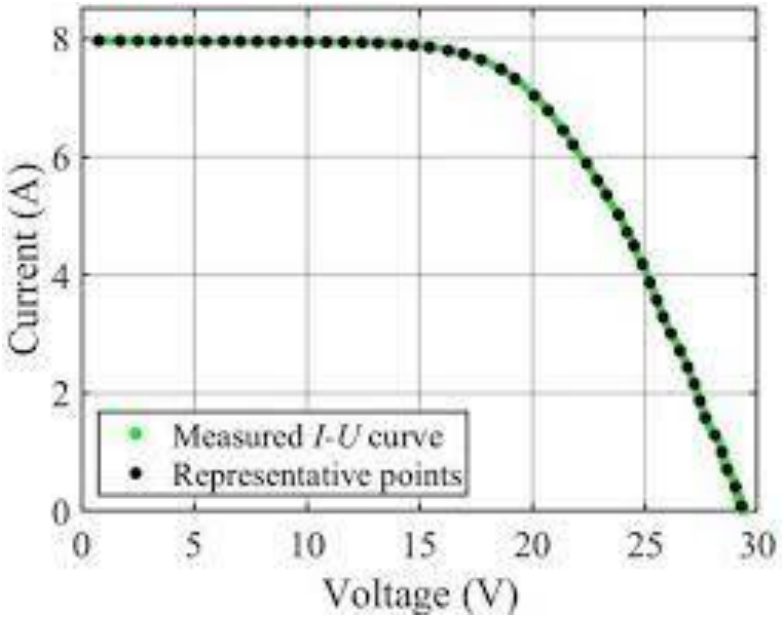
(c) Hotspot

Kuva:T. Rahman et al., Energies (2023), https://doi.org/10.3390/en16093706.



Aurinkopaneelit

Kuva: Lakkapaa.com



Virta-jännitekäyrä

Invertteri

Kuva: SMA

$$I = I_{ph} - I_o\left(e^{\frac{U+IR_S}{AU_t}} - 1\right) + \frac{U+IR_S}{R_h}$$

Matemaattinen malli

Mallin parametrien tunnistamisen haasteita

HAASTE 1

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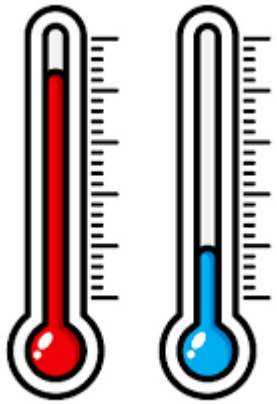
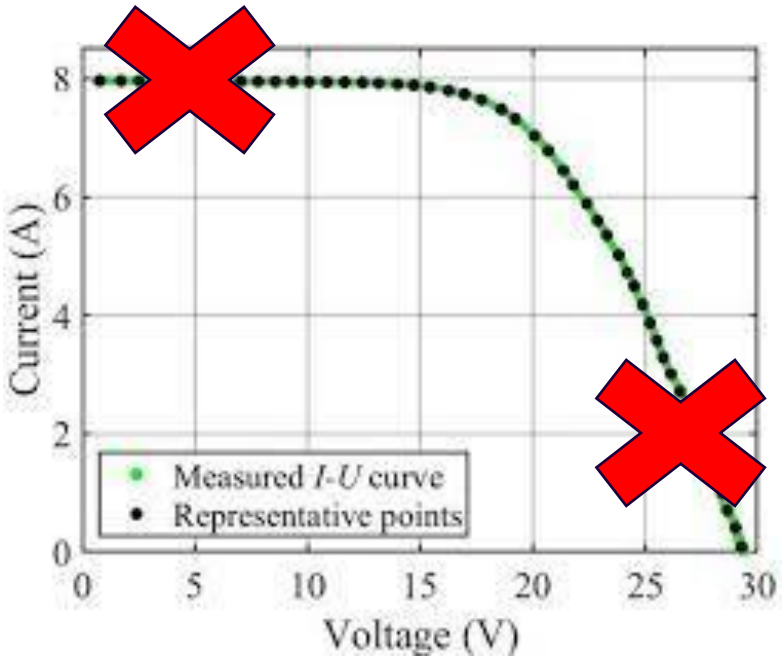
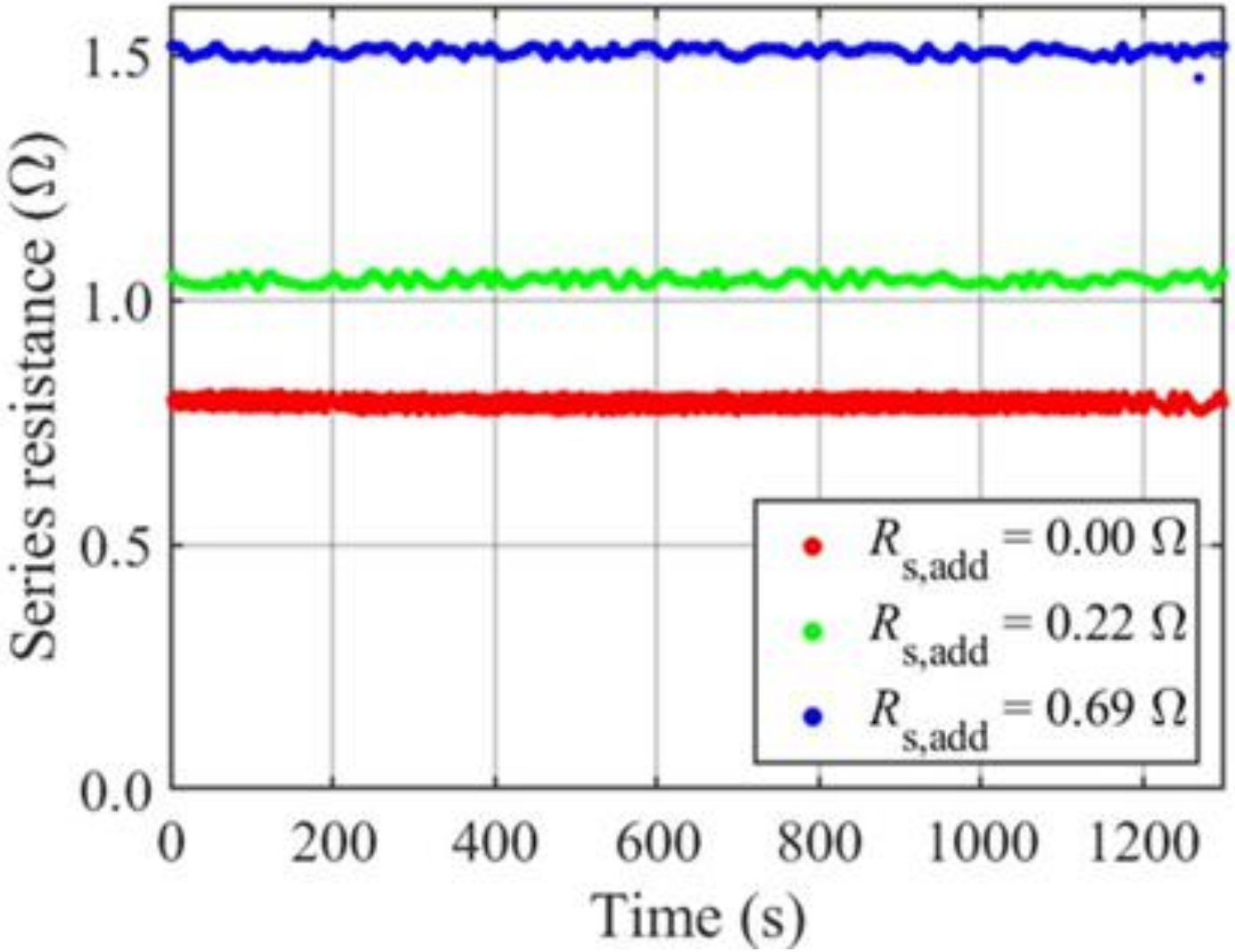


HAASTE 2



Ikääntymisen tunnistaminen



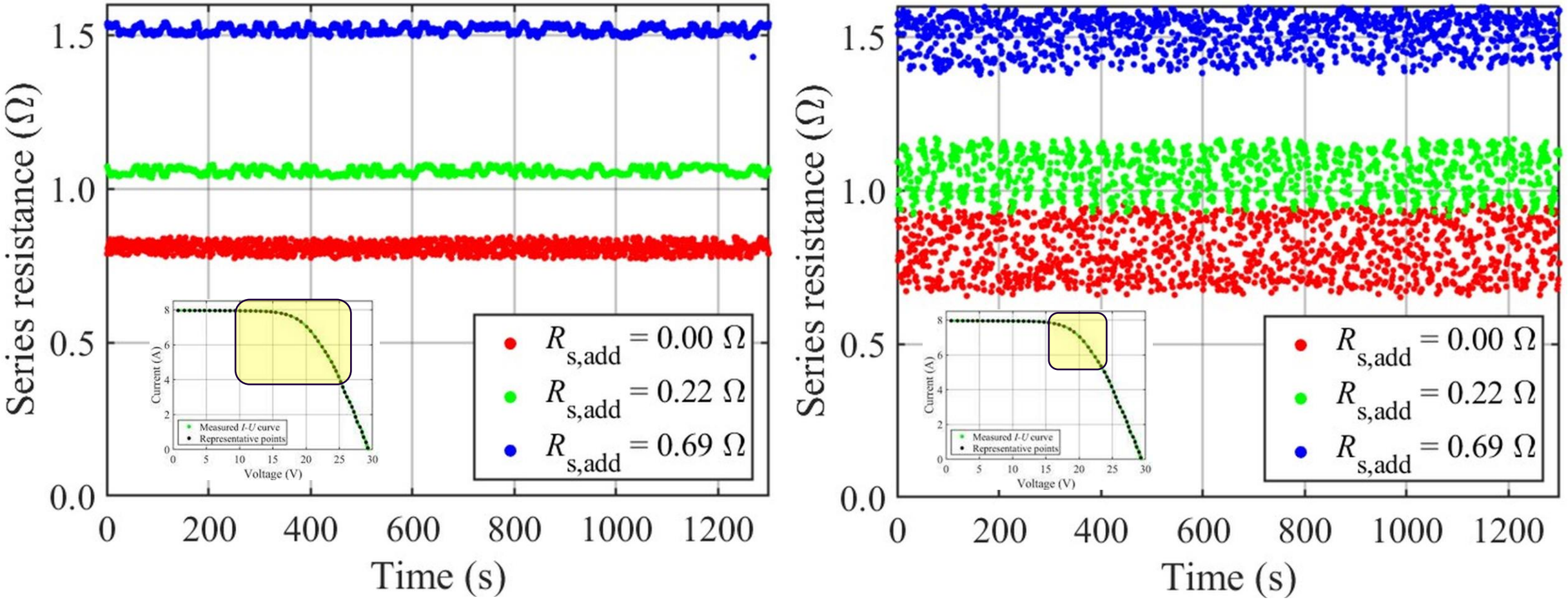
ERITTÄIN IKÄÄNTYNYT

HIEMAN IKÄÄNTYNYT

NORMAALIKUNTOINEN

Kokonaan mitatuilta virta-jännitekäyriltä tunnistetut sarjaresistanssiarvot.

Ikääntymisen tunnistaminen



Osittain mitatuilta virta-jännitekäyriltä tunnistetut sarjaresistanssiarvot, kun käyrästä on mitattu huipputehon ympäriltä 50 % (vasemmalla) ja 20 % (oikealla).

Julkaisuja

Kalliojärvi-Viljakainen, H., Lappalainen, K. and Valkealahti, S.: Preprocessing of PV panel measured current-voltage characteristics before curve fitting. 2020 47th IEEE Photovoltaic Specialists Conference (PVSC), Calgary, AB, Canada (2020) pp. 0117-0123. https://doi.org/10.1109/PVSC45281.2020.9300445.

Kalliojärvi-Viljakainen H., Lappalainen K. and Valkealahti. S.: A novel procedure for identifying the parameters of the single-diode model and the operating conditions of a photovoltaic module from measured current-voltage curves. Energy Reports 8 (2022) pp. 4633-4640. https://doi.org/10.1016/j.egyr.2022.03.141.

Kalliojärvi, H., Lappalainen, K. and Valkealahti, S.: Feasibility of photovoltaic module single-diode model fitting to the current-voltage curves measured in the vicinity of the maximum power point for online condition monitoring purposes. Energies 15(23) (2022), 9079. https://doi.org/10.3390/en15239079.

Kalliojärvi, H.: Detection of single-diode model characteristic values from measured current-voltage curves for online condition monitoring purposes of photovoltaic power systems. Dissertation, Tampere University (2024). ISBN:978-952-03-3156-6.

Kiitos!

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