

- No. 14 – 12 defective cells in 1 column
- No. 15 – 24 defective cells in 2 columns
- No. 16 – 36 defective cells in 3 columns

Table IV shows sample of measurements 17 – 21 (microshades). The intensity of solar radiation I varies between 731 and 749 $W.m^{-2}$ and temperature T between 17,4 and 21,1°C, so that this sample can be also used for the VA characteristics comparison as displayed on Fig. 10.

Table IV. – Sample of Measurements 17 – 21 (microshades)

Measurement	P_m [W]	U_{oc} [V]	U_m [V]	I_m [A]	I_{sc} [A]	I [$W.m^{-2}$]	T [°C]	Fill Factor [%]
17	142,98	38,96	29,44	4,86	5,34	731,00	17,40	69,00
18	125,31	39,10	33,23	3,77	5,41	739,00	17,90	59,00
19	94,99	39,09	19,30	4,92	5,41	740,00	18,50	45,00
20	94,86	39,01	19,15	4,95	5,42	745,00	19,40	45,00
21	95,15	38,87	19,22	4,95	5,46	749,00	21,10	45,00

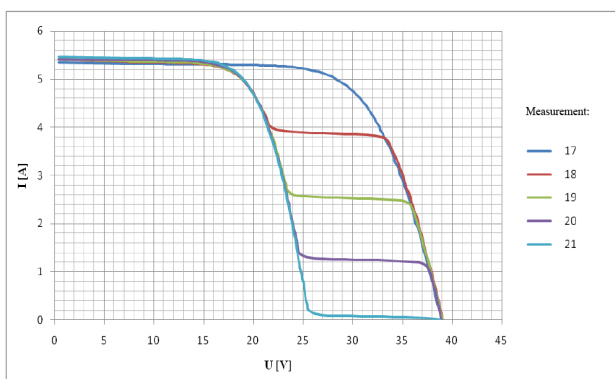


Fig. 10. VA characteristic – measurements 7 – 16 (microshades).

Configuration of microshades:

- No. 17 - no microshades
- No. 18 – 1/4 of 1 cell (0,35%)
- No. 19 – 1/2 of 1 cell (0,69%)
- No. 20 – 3/4 of 1 cell (1,04%)
- No. 21 – 4/4 of 1 cell (1,39%)

Sample of measurements 24 – 26 (shading) is summarized in Table V. Values of solar radiation intensity I oscillate between 731 and 786 $W.m^{-2}$ and temperature T between 17,4 and 19,4°C, so this sample can be also used for the VA characteristics comparison. The results are presented on Fig. 11.

Table V. – Sample of Measurements 24 – 26 (shading)

Measurement	P_m [W]	U_{oc} [V]	U_m [V]	I_m [A]	I_{sc} [A]	I [$W.m^{-2}$]	T [°C]	Fill Factor [%]
24	142,98	38,96	29,44	4,86	5,34	731,00	17,40	69,00
25	132,97	39,10	32,44	4,10	5,61	786,00	19,00	61,00
26	94,86	39,01	19,15	4,95	5,42	745,00	19,40	45,00

Configuration of shaded cells:

- No. 24 - no shading
- No. 25 – 3x 1/4 of 1 cell (1,04%)
- No. 26 – 3/4 of 1 single cell (1,04%)

Amount of 16 different shadings was analysed during this measurements. Shade intensity varied from 0% to 75%. Model shades covered from 0% to 11,11% of the panel with different geometry (vertical or horizontal orientation).

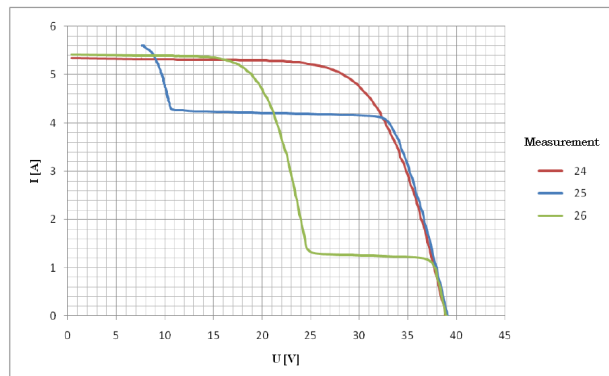


Fig. 11. VA characteristic – measurements 24 – 26 (shading).

6. Results and Conclusions

Sample measurements presented in chapter 5 have proven early hypothetical expectations. Different types of operating malfunctions have characteristic influence on shape of the VA characteristic. Typical deformations for particular malfunctions in the sample set are visualized on Fig. 9 – Fig. 11.

Developed automated acquisition system is based on LabVIEW application and is capable for realtime measurements of PV system. This DAQ system can be used for detection and identification of operating malfunctions.

Detection consists from 2 stage measurement based on balancing of measured operating values (output voltage, output current, panel temperature and incident solar radiation). If some unexpected PV system behaviour is detected, controlled contactor switches VA characteristic measurement. Measured VA characteristic is compared to stored history and proves or disproves the initial detection. If some malfunction is detected, shape of the curve identifies the origin.

Future research should focus on more complex numerical analysis of measured VA characteristics to develop more general application for larger systems consisting from larger number of either uniform or non-uniform panels.

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