

Test Report No.704062319119-00A3

Dated 2024-03-13

Client: Zhejiang Aiko Solar Technology Co., Ltd.
No. 655,Haopai Road, Suxi Town, Yiwu City, Zhejiang Province,
P.R.CHINA

Manufacturer: Zhejiang Aiko Solar Technology Co., Ltd.
No. 655,Haopai Road, Suxi Town, Yiwu City, Zhejiang Province,
P.R.CHINA

Test subject: Product: Photovoltaic modules

Test specification: IEC 61853-1:2011
IEC 61853-2:2016
IEC 60891:2009

Purpose of examination: PAN File Parameters Determination

Test result: The test results for the present samples are show in clause3



1 Description of the test subject

1.1 Function

Manufacturer's specification for intended use:

The PV modules for electricity generation systems with max. voltage of 1500 V DC

1.2 Consideration of the foreseeable misuse

- Not applicable
- Covered through the applied standard
- Covered by the following comment
- Covered by attached risk analysis

1.3 Technical Data

Type or model number	AIKO-A455-MAH54Db
Voc (Vdc) $\pm 3\%$	40.93
Vmp (Vdc)	33.90
Isc (Adc) $\pm 3\%$	14.15
Imp (Adc)	13.43
Pmp (W)	455
Bifaciality factor, if bifacial module	N/A
Power tolerance	0~+3%
Maximum system voltage (V)	1500
Maximum over-current protection rating (A)	25
Application Class	II

This technical report may only be quoted in full. Any use for advertising purposes must be granted in writing. This report is the result of a single examination of the object in question and is not generally applicable evaluation of the quality of other products in regular production.



2 Order

2.1 Date of Purchase Order, Customer's Reference

2023-11-28

2.2 Receipt of Test Sample, Location

Changzhou HuaYang Inspection and Testing Technology Co., Ltd.

No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, P.R.China

2.3 Date of Testing

2023-12-25 ~ 2024-01-14

2.4 Location of Testing

Changzhou HuaYang Inspection and Testing Technology Co., Ltd.

No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, .R.China

2.5 Points of Non-compliance or Exceptions of the Test Procedure

N/A

3 Test Results

3.1 Sample Information

Sample #	Model	Sample S/N	Remark
HA2023TL-1528-001X	AIKO-A455-MAH54Db	Z012312E530000100	61853-1
HA2023TL-1528-002X	AIKO-A455-MAH54Db	Z012312E530000107	61853-1
HA2023TL-1528-003X	AIKO-A455-MAH54Db	Z012312E532000851	61853-1
HA2023TL-0775-005X	Special samples	-	61853-2

3.2 Flash Tests According to Table 2 of the IEC 61853-1



To determine the relationship between efficiency and irradiance & temperature, PV modules are tested across a matrix of operating conditions according to the standard IEC 61853-1:2011, ranging in irradiance from 100 W/m² to 1100 W/m² and ranging in temperature from 15 °C to 75 °C.

To determine the temperature coefficients, PV modules are tested according to IEC 60891:2009, under irradiance 1000W/m² and ranging in temperature from 15 °C to 50 °C.

Based on the laboratory measurement data, PAN file can be optimized, then match ability between the resulting efficiencies in PVsyst software and the lab data can be compared.

3.3 Raw Data

TABLE 2:
Flash test data for each sample at the real irradiance and temperature conditions in table 2 of the IEC 61853-1

HA2023TL-1528-001X							
T _{TARGET} [°C]	IRR _{TARGET} [W/m ²]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.319	33.285	1.403	1.318	43.870	83.79
15	200	38.792	34.314	2.864	2.694	92.425	83.18
15	400	39.833	34.508	5.707	5.453	188.185	82.78
15	600	40.341	34.744	8.482	8.120	282.116	82.45
15	800	40.718	34.985	11.263	10.755	376.248	82.04
15	1000	41.185	35.169	13.991	13.350	469.500	81.48
25	100	37.341	33.078	1.370	1.290	42.671	83.40
25	200	38.559	33.445	2.822	2.688	89.904	82.61
25	400	39.075	33.849	5.700	5.410	183.120	82.21
25	600	39.514	34.158	8.502	8.045	274.811	81.80
25	800	39.943	34.395	11.278	10.655	366.462	81.35
25	1000	40.199	34.517	14.072	13.250	457.368	80.85
25	1100	40.402	34.624	15.443	14.483	501.455	80.37
50	400	36.918	31.432	5.744	5.440	170.977	80.63
50	600	37.334	31.610	8.577	8.114	256.494	80.10
50	800	37.520	31.978	11.456	10.719	342.778	79.75
50	1000	37.734	32.162	14.270	13.278	427.067	79.31
50	1100	37.921	32.264	15.679	14.519	468.447	78.79
75	600	34.931	29.290	8.657	8.136	238.308	78.81
75	800	35.204	29.408	11.536	10.825	318.341	78.39
75	1000	35.425	29.615	14.399	13.395	396.696	77.77
75	1100	35.618	29.720	15.794	14.631	434.848	77.30



Product Service

HA2023TL-1528-002X

T _{TARGET} [°C]	IRR _{TARGET} [W/m ²]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.302	33.271	1.461	1.306	43.789	83.74
15	200	38.775	34.305	2.893	2.805	92.326	83.12
15	400	39.814	34.495	5.773	5.566	188.050	82.75
15	600	40.324	34.729	8.485	8.030	281.755	82.38
15	800	40.698	34.972	11.275	10.673	376.069	81.99
15	1000	41.175	35.148	14.059	13.251	469.185	81.53
25	100	37.328	33.085	1.434	1.368	42.569	83.34
25	200	38.531	33.453	2.905	2.758	89.875	82.58
25	400	39.064	33.856	5.812	5.578	182.950	82.17
25	600	39.478	34.175	8.496	8.022	274.655	80.77
25	800	39.910	34.404	11.297	10.684	366.238	81.31
25	1000	40.144	34.529	14.116	13.222	456.883	80.80
25	1100	40.339	34.631	15.500	14.628	501.323	80.32
50	400	36.896	31.420	5.856	5.646	170.893	80.73
50	600	37.318	31.602	8.756	8.080	256.351	80.19
50	800	37.511	31.973	11.410	10.687	342.583	79.84
50	1000	37.708	32.158	14.237	13.387	426.921	79.24
50	1100	37.914	32.249	15.626	14.679	467.992	79.56
75	600	34.905	29.278	8.836	8.100	237.758	78.86
75	800	35.197	29.395	11.540	10.801	317.659	78.45
75	1000	35.412	29.604	14.374	13.518	395.958	77.87
75	1100	35.609	29.708	15.799	14.854	434.331	77.39

HA2023TL-1528-003X

T _{TARGET} [°C]	IRR _{TARGET} [W/m ²]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.313	33.274	1.403	1.319	43.903	83.84
15	200	38.776	34.308	2.866	2.696	92.511	83.24
15	400	39.820	34.486	5.710	5.460	188.291	82.81
15	600	40.324	34.725	8.487	8.130	282.304	82.49
15	800	40.694	34.971	11.274	10.766	376.489	82.06
15	1000	41.172	35.158	13.993	13.358	469.643	81.52
25	100	37.323	33.031	1.369	1.292	42.684	83.51
25	200	38.520	33.418	2.819	2.689	89.848	82.74
25	400	39.031	33.810	5.702	5.417	183.135	82.29
25	600	39.482	34.089	8.495	8.059	274.708	81.90
25	800	39.977	34.340	11.250	10.675	366.581	81.51

Doc No.: ITC-TTW0902.02E - Rev. 14



Product Service

25	1000	40.159	34.453	14.070	13.280	457.517	80.97
25	1100	40.410	34.555	15.427	14.514	501.517	80.45
50	400	36.923	31.448	5.732	5.441	171.120	80.86
50	600	37.348	31.617	8.557	8.119	256.685	80.32
50	800	37.529	31.984	11.415	10.707	342.448	79.94
50	1000	37.745	32.169	14.281	13.284	427.334	79.28
50	1100	37.940	32.271	15.690	14.528	468.842	78.76
75	600	34.945	29.295	8.658	8.150	238.754	78.91
75	800	35.211	29.410	11.516	10.831	318.553	78.56
75	1000	35.428	29.624	14.383	13.403	397.051	77.92
75	1100	35.531	29.718	15.814	14.653	435.459	77.50

Table 3:
Temperature Coefficients Measurement Data at the 1000 W.m⁻² Irradiance

HA2023TL-1528-001X				
T[°C]	IRR _{TARGET} [W/m ²]	Voc [V]	Isc [A]	Pmp [W]
15.0	1000	41.185	13.991	469.500
20.1	1000	40.702	14.041	463.139
25.1	1000	40.199	14.072	457.368
30.1	1000	39.734	14.127	450.791
35.0	1000	39.258	14.158	444.821
39.9	1000	38.724	14.187	438.674
45.0	1000	38.260	14.220	432.675
50.1	1000	37.734	14.270	427.067

3.3.1 Test Data Analysis

3.3.1.1 Temperature Coefficients

Figure 1:

Plot of measured P_{MAX}, Voc vs. temperature of flash-tests taken at 1000 W/m² for each sample

Doc No.: ITC-TTW0902.02E - Rev. 14

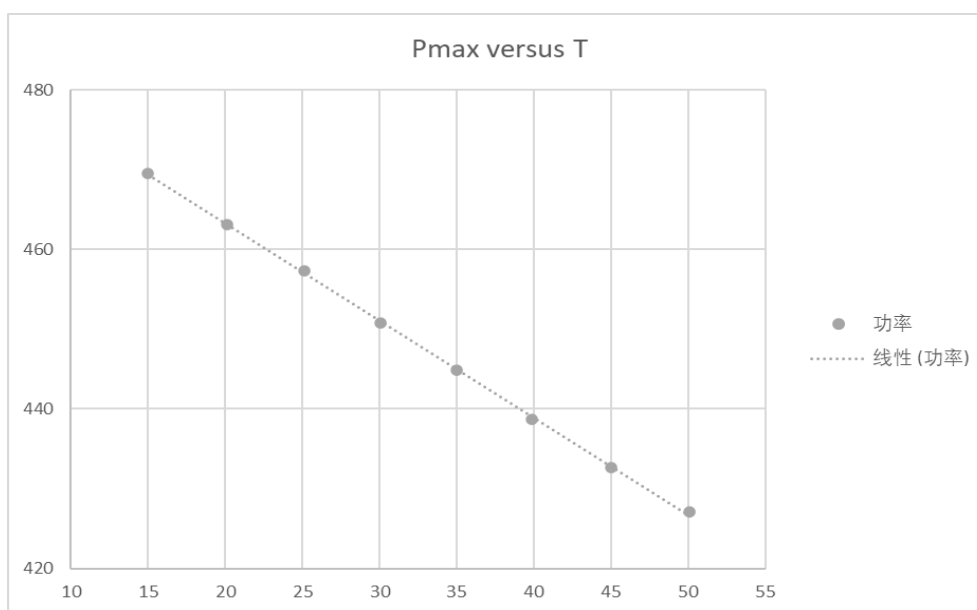
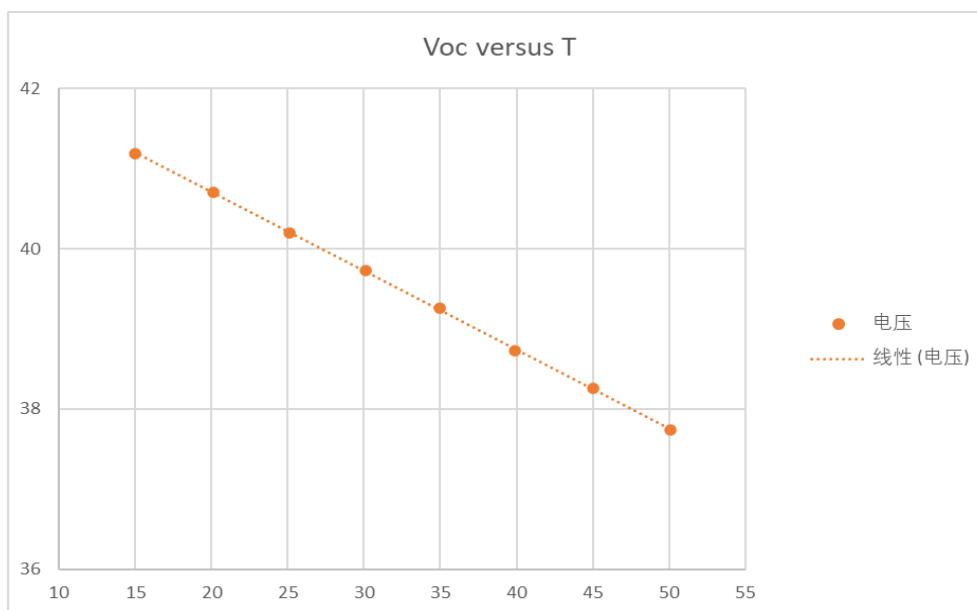


Figure 2:
Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m² for each sample

Doc No.: ITC-TTW0902.02E - Rev. 14

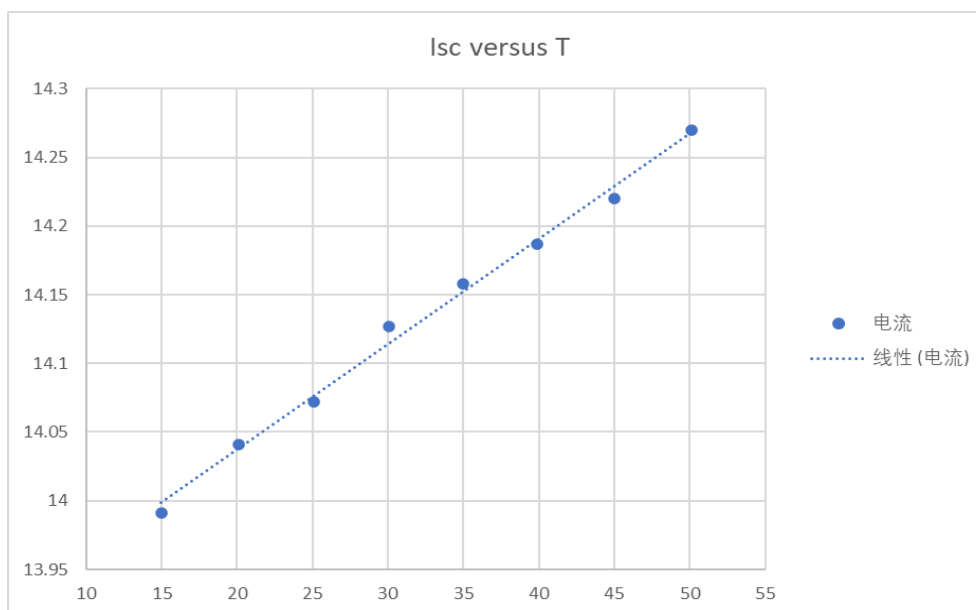


Table 4:

Average Temperature Coefficients Determined by Laboratory Results

Sample No	Alpha (α) ISC [%]	Beta (β) VOC [%]	Gamma (γ) P _{MAX} [%]
HA2023TL-1528-001X	0.054	-0.243	-0.265
Average	—	—	—

3.3.1.2 P_{MAX} vs. Irradiance & Temperature

Table 5:

Average P_{MAX} Determined by Laboratory Results according to the IEC 61853-1 based on Table 2

Irradiance [W/m ²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	43.854	42.641	-	-
200	92.421	89.876	-	-
400	188.175	183.068	170.997	-
600	282.058	274.725	256.510	238.273
800	376.269	366.427	342.603	318.184
1000	469.443	457.256	427.107	396.568
1100	-	501.432	468.427	434.879

Table 6:

P_{MAX} Determined by Laboratory Results Scaled to Nameplate Power at STC



Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m ²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	43.638	42.431	-	-
200	91.965	89.432	-	-
400	187.247	182.165	170.153	-
600	280.667	273.369	255.244	237.098
800	374.412	364.619	340.913	316.614
1000	467.127	455.000	425.000	394.612
1100	-	498.958	466.116	432.734

Table 7:

Relative Efficiency by Laboratory Results Scaled to Nameplate vs. Irradiance at 25°C

Sample No	Irradiance [W/m ²]						
	100	200	400	600	800	1000	1100
Average	93.25%	98.28%	100.09%	100.14%	100.17%	100.00%	99.69%

4 PAN File Creation

4.1 PAN File Creation Method

The PAN file contains a number of model parameters organized in different tabs within PVsyst. The parameters which affect the model results in forward bias (normal operation) are located in the tabs labeled “Basic Data” and “Model Parameters”. TUV-SUD’s approach to PAN file creation is as following:

1. Enter manufacturer specifications on the “Basic Data” tab;
2. Enter the relative efficiency test results in **Table 7** under different irradiance at 25°C into “Additional Data/Low-light data”, and optimized the Rserie; It is mentioned that the relative efficiency is calculated after scale the average measured P_{MAX} lab data from **Table 5** to the manufacturer’s nameplate power. The scaled data is shown in **Table 6** and **Table 7**.
3. Define the Rsh, Rsh0 and Rexp (on the “Model parameters” tab) for default values;
4. Enter the Pmax, Isc, Voc temperature coefficient in **Table 4** into “Model parameters” tab;

4.2 Optimized PAN File Results



PV module - AIKO-A455-MAH54Db

Manufacturer	Aiko Solar	Commercial data	
Model	AIKO-A455-MAH54Db	Availability :	Prod. Since 2024
		Data source :	TÜV SÜD
Phom STC power (manufacturer)	455 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 1.757 m ²	Rough module area (Amodule)	1.99 m ²
Number of cells	2 x 54	Sensitive area (cells) (Acells)	1.85 m ²

Specifications for the model (manufacturer or measurement data)

Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m ²
Open circuit voltage (Voc)	40.9 V	Short-circuit current (Isc)	14.15 A
Max. power point voltage (Vmpp)	33.9 V	Max. power point current (Impp)	13.43 A
=> maximum power (Pmpp)	455.3 W	Isc temperature coefficient (muIsc)	7.6 mA/°C

One-diode model parameters

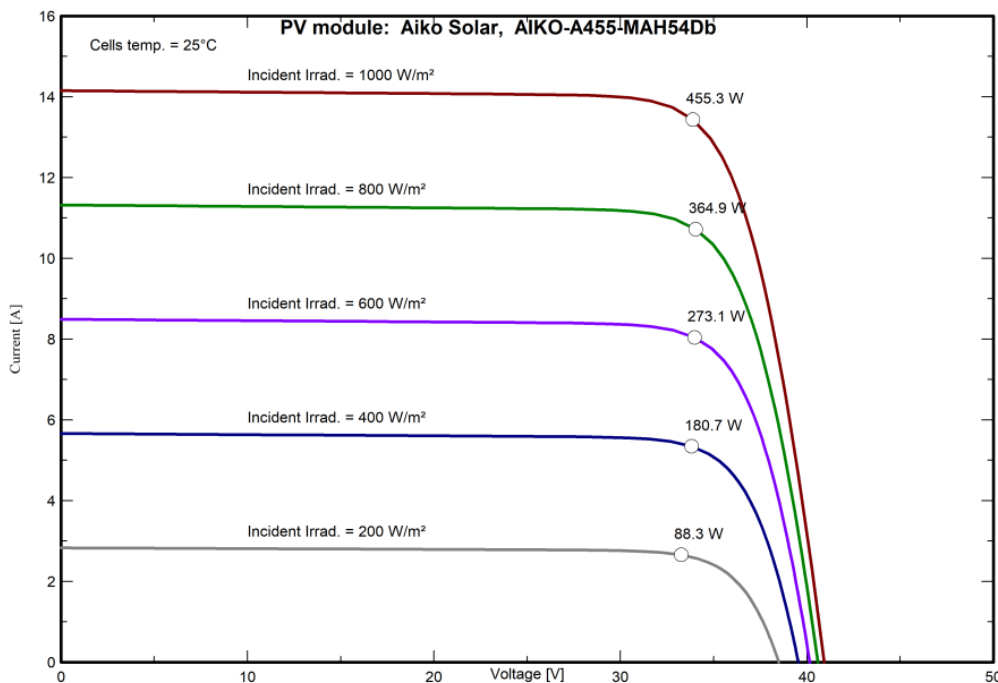
Shunt resistance (Rshunt)	280 Ω	Diode saturation current (IoRef)	0.021 nA
Series resistance (Rserie)	0.17 Ω	Voc temp. coefficient (MuVoc)	-92 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.27 %/°C	Diode quality factor (Gamma)	1.08
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch

Reverse characteristics (dark) (BRev)	3.20 mA/V ²	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V

Model results for standard conditions (STC: T=25 °C, G=1000 W/m², AM=1.5)

Max. power point voltage (Vmpp)	33.9 V	Max. power point current (Impp)	13.50 A
Maximum power (Pmpp)	455.3 Wp	Power temper. coefficient (muPmpp)	-0.26 %/°C
Efficiency(/ Module area) (Eff_mod)	22.9 %	Fill factor (FF)	0.786
Efficiency(/ Cells area) (Eff_cells)	24.7 %		



Doc No.: ITC-TTW0902.02E - Rev. 14



4.3 PAN File Result Verification

After creating the PAN file, a quality check is implemented in order to compare the PAN file model consistence with measurements from the laboratory. The laboratory test results scaled are plotted as efficiency vs. irradiance curves for each temperature of the IEC61853-1 test matrix, as shown in **Table 8**. Similarly, efficiency vs. irradiance curves are generated using PVsyst and the newly created PAN file, as shown in **Table 9**. Comparison between the model and the measurements is represented with the following graph and table, and the RMSE (Root Mean Square Error) of the optimized PAN file is reported, as shown in **Table 10 and Figure 4**.

Table 8:

Efficiency Determined by Laboratory Results Scaled to Nameplate Power at STC

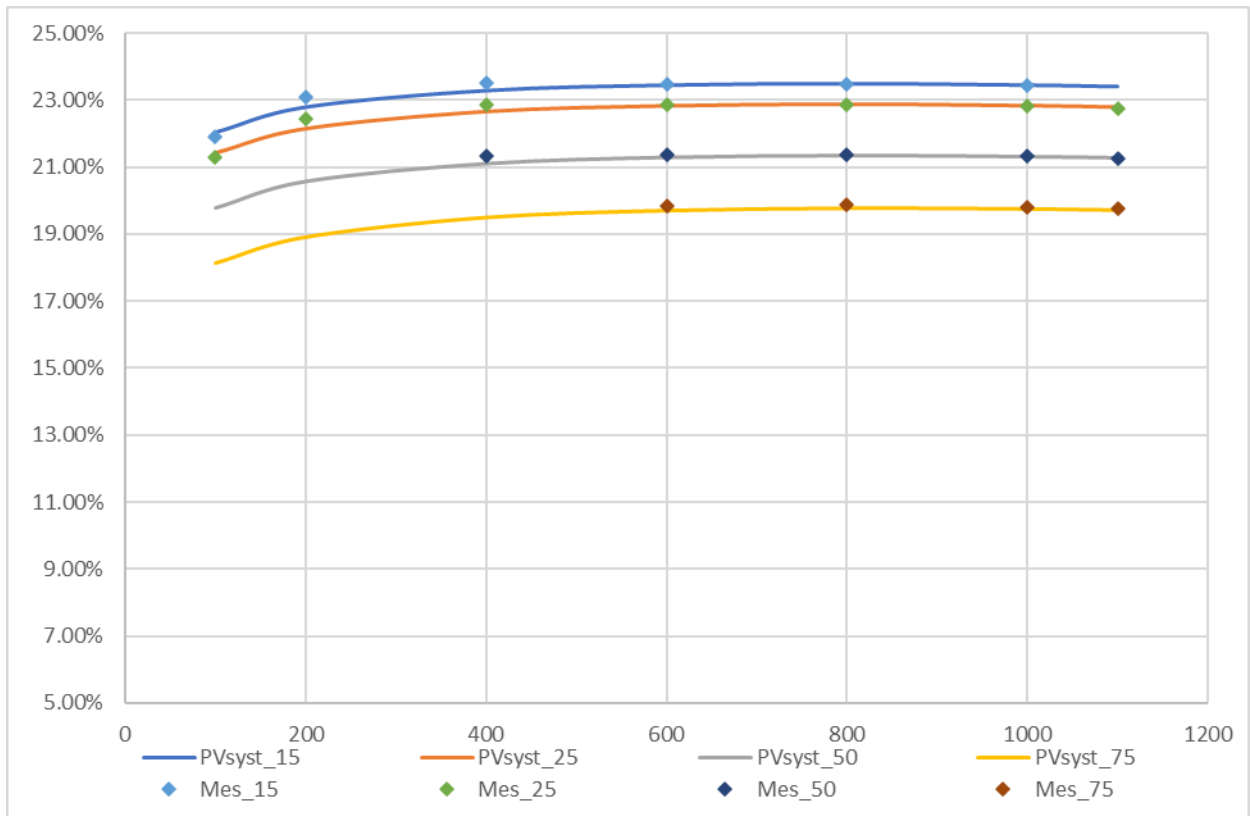
Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m ²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	21.90%	21.30%	-	-
200	23.08%	22.44%	-	-
400	23.49%	22.86%	21.35%	-
600	23.48%	22.87%	21.35%	19.83%
800	23.49%	22.88%	21.39%	19.86%
1000	23.44%	22.84%	21.33%	19.81%
1100	-	22.77%	21.27%	19.74%

Table 9:

Efficiency Generated Using PVsyst and the Newly Created PAN file.

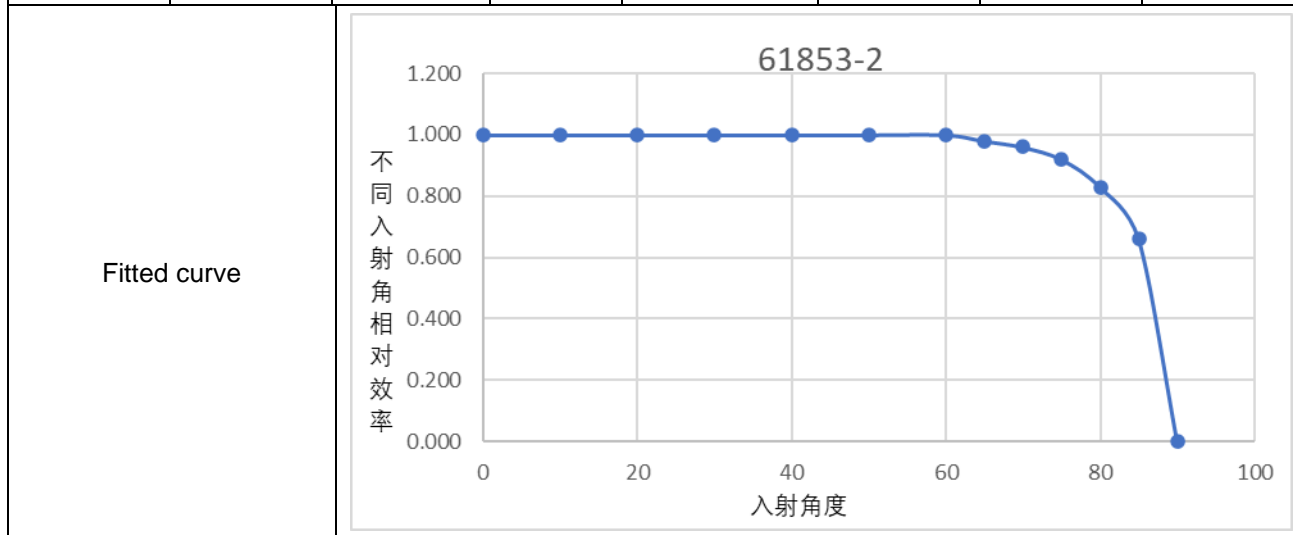
Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m ²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	22.03%	21.43%	19.77%	18.12%
200	22.79%	22.16%	20.58%	18.90%
400	23.28%	22.67%	21.12%	19.49%
600	23.44%	22.84%	21.31%	19.69%
800	23.48%	22.89%	21.36%	19.76%
1000	23.44%	22.85%	21.33%	19.74%
1100	23.40%	22.81%	21.29%	19.71%

Figure 4:
Comparison of PVsyst Model, Using the Optimized PAN file, to the Laboratory Testing Results



4.4 Measurement of incidence angle effects

Sample No				HA2023TL-0775-005X			—
Module Angle	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	IAM value according to IEC61853-2
0	—	—	6.653	—	—	—	1.00
10	—	—	6.619	—	—	—	1.00
20	—	—	6.281	—	—	—	1.00
30	—	—	5.787	—	—	—	1.00
40	—	—	5.153	—	—	—	1.00
50	—	—	4.308	—	—	—	1.00
60	—	—	3.314	—	—	—	1.00
65	—	—	2.767	—	—	—	0.98
70	—	—	2.177	—	—	—	0.96
75	—	—	1.576	—	—	—	0.92
80	—	—	0.955	—	—	—	0.83
85	—	—	0.382	—	—	—	0.66





Documentation

List of measurement equipment

Description	Type/ Equipment ID	Calibration due date	Remark
Pulsed Solar Simulator	HYJC-YS-021	2024.03.06	-

Statement of the estimated uncertainty of the test results

Pmax measurement uncertainty: 2.06% (K=2) Voc measurement uncertainty: 0.48% (K=2) Isc measurement uncertainty: 2.23% (K=2)

5 Summary

Below parameters are measured on three representative PV modules:

- The relative efficiency test results under different irradiance at 25°C
- Performance at the real irradiance and temperature conditions in table 2 of the IEC 61853-1

Based on the test results, PANFILE are optimized in Pvsyst. Efficiency vs. irradiance curves are generated using Pvsyst and the newly created PAN file, which is highly matched with the test results in lab.

According to the customer's requirements, the PAN Files from AIKO-A440-MAH54Db to AIKO-A460-MAH54DDb were extended based on the measured parameter model of AIKO-A455-MAH54Db.

**TÜV SÜD Certification and Testing (China) Co., Ltd, Shanghai branch,
TÜV SÜD Group**

Engineer:

Xu Yang

Yang Xu
Project Handler

Technical Report checked:

Tao Wang

Tao Wang
Designated Reviewer