



Product Service

**Test Report No.704062319119-00A1**

**Dated 2023-12-31**

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

Doc No.: ITC-TTW0902.02E - Rev. 13

## 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-MAH54Mw
Voc (Vdc) $\pm 3\%$	40.59
Vmp (Vdc)	33.60
Isc (Adc) $\pm 3\%$	14.31
Imp (Adc)	13.55
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

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## 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

2023-12-04 ~ 2023-12-14

### 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-1478-001X	AIKO-A455-MAH54Mw	Z012311E446010045	61853-1
HA2023TL-1478-002X	AIKO-A455-MAH54Mw	Z012311E446006097	61853-1
HA2023TL-1478-003X	AIKO-A455-MAH54Mw	Z012311E446011131	61853-1
HA2023TL-1419-004X	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/m<sup>2</sup> to 1100 W/m<sup>2</sup> 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/m<sup>2</sup> 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-1478-001X							
T <sub>TARGET</sub> [°C]	IRR <sub>TARGET</sub> [W/m <sup>2</sup> ]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.243	33.031	1.403	1.324	43.731	83.67
15	200	38.674	33.994	2.870	2.711	92.161	83.04
15	400	39.701	34.170	5.723	5.497	187.821	82.67
15	600	40.201	34.432	8.511	8.182	281.724	82.34
15	800	40.561	34.648	11.318	10.853	376.028	81.91
15	1000	40.996	34.854	14.045	13.455	468.965	81.45
25	100	37.204	32.904	1.372	1.294	42.590	83.43
25	200	38.447	33.251	2.820	2.696	89.649	82.69
25	400	38.952	33.608	5.707	5.440	182.825	82.24
25	600	39.400	33.915	8.511	8.093	274.484	81.85
25	800	39.777	34.210	11.304	10.701	366.085	81.42
25	1000	40.040	34.339	14.113	13.310	457.049	80.88
25	1100	40.235	34.427	15.494	14.559	501.213	80.40
50	400	36.643	31.099	5.771	5.500	171.051	80.89
50	600	37.064	31.271	8.611	8.200	256.425	80.34
50	800	37.363	31.604	11.456	10.832	342.324	79.98
50	1000	37.598	31.820	14.323	13.424	427.155	79.32
50	1100	37.781	31.909	15.767	14.681	468.451	78.64
75	600	34.958	29.255	8.648	8.158	238.653	78.94
75	800	35.226	29.342	11.495	10.845	318.216	78.59
75	1000	35.462	29.521	14.374	13.459	397.317	77.95
75	1100	35.636	29.618	15.799	14.715	435.815	77.41



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T <sub>TARGET</sub> [°C]	IRR <sub>TARGET</sub> [W/m <sup>2</sup> ]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.259	33.041	1.404	1.325	43.783	83.71
15	200	38.709	34.001	2.836	2.713	92.239	84.02
15	400	39.728	34.184	5.589	5.501	188.058	84.69
15	600	40.225	34.444	8.505	8.183	281.849	82.38
15	800	40.589	34.651	11.310	10.855	376.153	81.94
15	1000	41.012	34.866	14.035	13.453	469.043	81.49
25	100	37.231	32.948	1.372	1.295	42.652	83.52
25	200	38.510	33.279	2.820	2.700	89.839	82.74
25	400	38.989	33.628	5.706	5.445	183.088	82.30
25	600	39.488	34.934	8.498	7.866	274.775	81.88
25	800	39.838	34.253	11.293	10.700	366.491	81.46
25	1000	40.101	34.383	14.094	13.305	457.458	80.94
25	1100	40.309	34.479	15.466	14.548	501.604	80.46
50	400	36.673	31.118	5.759	5.493	170.940	80.94
50	600	37.105	31.285	8.602	8.201	256.578	80.39
50	800	37.395	32.705	11.446	10.470	342.427	80.00
50	1000	37.619	31.844	14.347	13.418	427.284	79.17
50	1100	37.810	31.938	15.750	14.672	468.610	78.69
75	600	34.995	29.268	8.637	8.157	238.751	78.99
75	800	35.261	29.367	11.475	10.841	318.355	78.68
75	1000	35.501	29.538	14.356	13.458	397.515	78.00
75	1100	35.694	29.641	15.750	14.707	435.919	77.54

HA2023TL-1478-003X

T <sub>TARGET</sub> [°C]	IRR <sub>TARGET</sub> [W/m <sup>2</sup> ]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	37.259	33.057	1.403	1.324	43.761	83.69
15	200	38.694	34.013	2.872	2.715	92.346	83.09
15	400	39.716	34.198	5.724	5.498	188.019	82.71
15	600	40.207	34.461	8.508	8.180	281.901	82.41
15	800	40.563	34.658	11.311	10.852	376.120	81.98
15	1000	41.034	34.877	14.029	13.451	469.114	81.49
25	100	37.258	33.971	1.374	1.258	42.720	83.48
25	200	38.481	33.295	2.817	2.695	89.745	82.78
25	400	38.997	33.715	5.705	5.430	183.072	82.29
25	600	39.467	34.035	8.485	8.063	274.425	81.95
25	800	39.814	34.349	11.294	10.666	366.375	81.48

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25	1000	40.130	34.425	14.067	13.279	457.144	80.98
25	1100	40.341	34.519	15.440	14.522	501.294	80.48
50	400	36.678	31.108	5.772	5.500	171.081	80.81
50	600	37.084	31.283	8.615	8.201	256.548	80.30
50	800	37.350	31.615	11.470	10.831	342.423	79.93
50	1000	37.614	31.828	14.367	13.427	427.349	79.08
50	1100	37.808	31.931	15.770	14.674	468.566	78.59
75	600	34.948	29.264	8.661	8.162	238.841	78.91
75	800	35.219	29.337	11.508	10.859	318.558	78.60
75	1000	35.458	29.517	14.025	13.468	397.545	79.94
75	1100	35.651	29.613	15.778	14.719	435.884	77.49

Table 3:

Temperature Coefficients Measurement Data at the 1000 W.m<sup>-2</sup> Irradiance

HA2023TL-1478-001X				
T <sub>TARGET</sub> [°C]	IRR <sub>TARGET</sub> [W/m <sup>2</sup> ]	Voc [V]	Isc [A]	Pmp [W]
15	1000	40.996	14.045	468.965
20	1000	40.515	14.086	463.01
25	1000	40.04	14.113	457.049
30	1000	39.632	14.166	451.433
35	1000	39.148	14.202	445.442
40	1000	38.6	14.253	439.807
45	1000	38.087	14.267	433.032
50	1000	37.598	14.323	427.155

## 3.3.1 Test Data Analysis

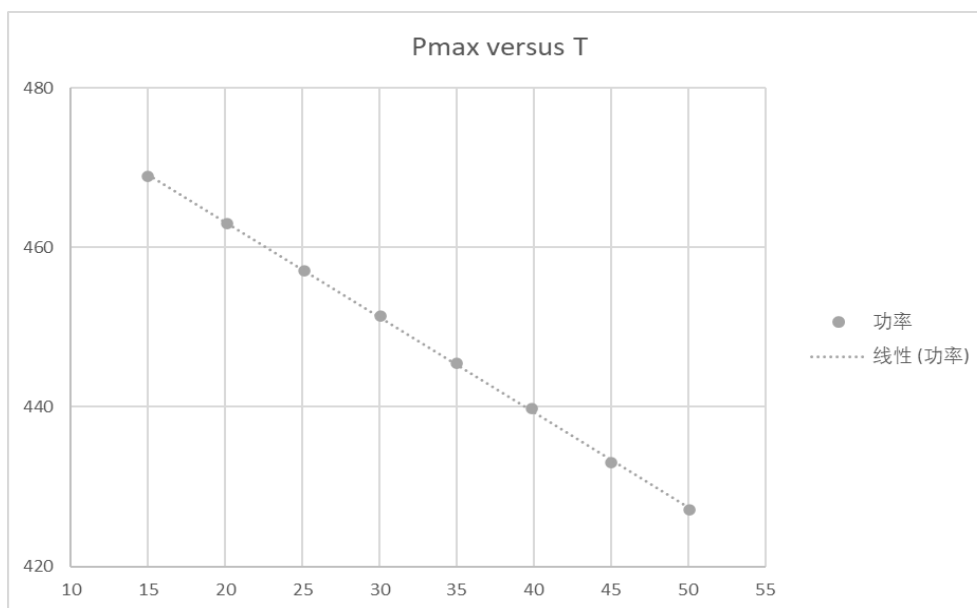
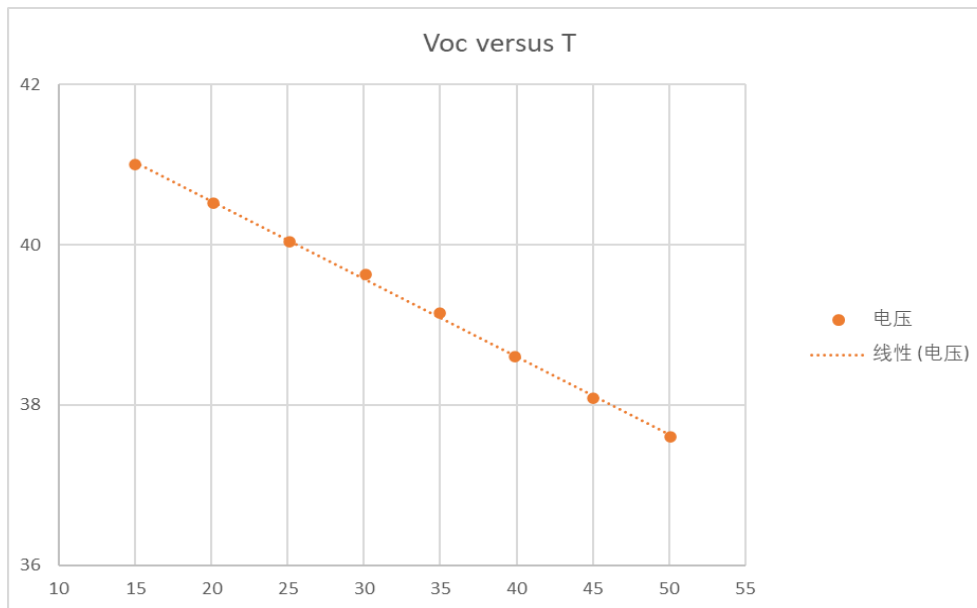
## 3.3.1.1 Temperature Coefficients

Figure 1:

Plot of measured P<sub>MAX</sub>, Voc vs. temperature of flash-tests taken at 1000 W/m<sup>2</sup> for each sample

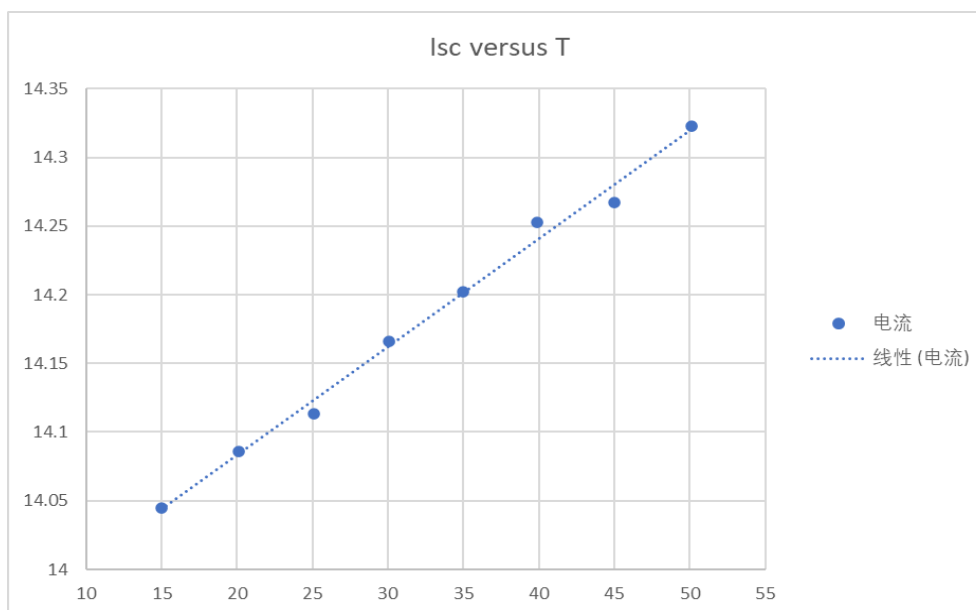


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**Figure 2:**  
**Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m<sup>2</sup> for each sample**

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**Table 4:**

**Average Temperature Coefficients Determined by Laboratory Results**

Sample No	Alpha ( $\alpha$ ) ISC [%]	Beta ( $\beta$ ) VOC [%]	Gamma ( $\gamma$ ) P <sub>MAX</sub> [%]
HA2023TL-1478-001X	0.056	-0.241	-0.260
—	—	—	—
—	—	—	—
<b>Average</b>	—	—	—

**3.3.1.2 P<sub>MAX</sub> vs. Irradiance & Temperature**

**Table 5:**

**Average P<sub>MAX</sub> Determined by Laboratory Results according to the IEC 61853-1 based on Table 2**

Irradiance [W/m <sup>2</sup> ]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	43.828	42.654	-	-
200	92.315	89.844	-	-
400	188.329	183.162	170.324	-
600	282.378	274.895	255.427	235.748
800	376.821	366.541	340.925	314.410
1000	469.974	457.674	425.344	392.459
1100	-	501.944	466.542	430.539



**Table 6:**  
**P<sub>MAX</sub> Determined by Laboratory Results Scaled to Nameplate Power at STC**

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m <sup>2</sup> ]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	43.572	42.405	-	-
200	91.776	89.319	-	-
400	187.229	182.092	169.329	-
600	280.728	273.289	253.935	234.371
800	374.620	364.400	338.933	312.573
1000	467.228	455.000	422.859	390.166
1100	-	499.011	463.817	428.024

**Table 7:**  
**Relative Efficiency by Laboratory Results Scaled to Nameplate vs. Irradiance at 25°C**

Sample No	Irradiance [W/m <sup>2</sup> ]						
	100	200	400	600	800	1000	1100
<b>Average</b>	93.20%	98.15%	100.05%	100.11%	100.11%	100.00%	99.70%

## 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<sub>MAX</sub> 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-MAH54Mw

Manufacturer	Aiko Solar	<b>Commercial data</b>	
Model	AIKO-A455-MAH54Mw	Availability :	Prod. Since 2023
		Data source :	TÜV SÜD
Pnom STC power (manufacturer)	455 W <sub>p</sub>	Technology	Si-mono
Module size (W x L)	1.134 x 1.757 m <sup>2</sup>	Rough module area (A <sub>module</sub> )	1.99 m <sup>2</sup>
Number of cells	2 x 54	Sensitive area (cells) (A <sub>cells</sub> )	1.85 m <sup>2</sup>

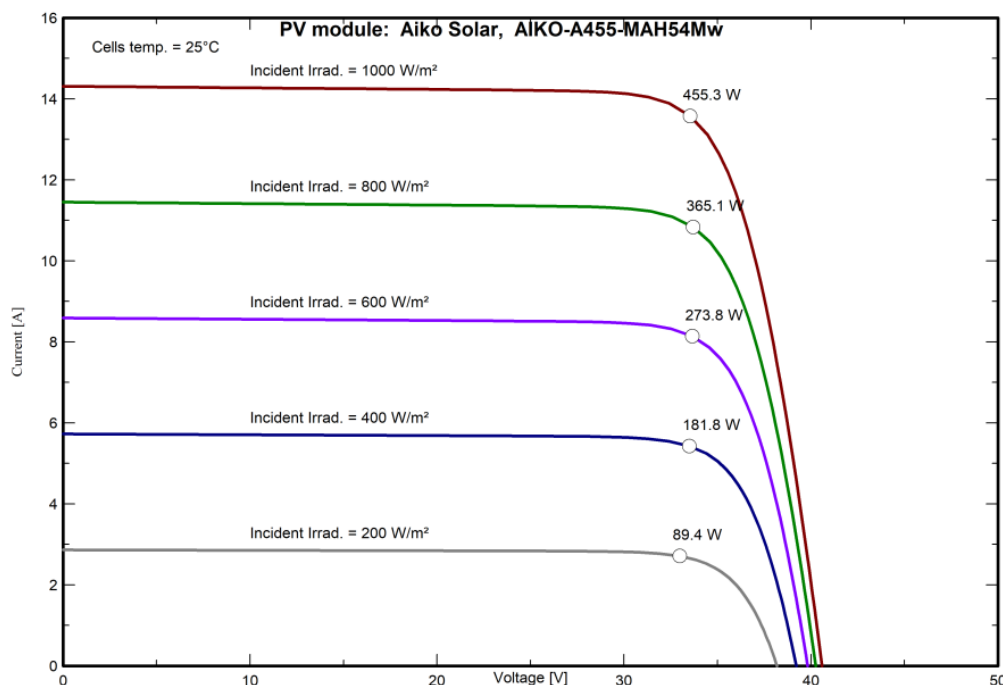
  

<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (T <sub>Ref</sub> )	25 °C	Reference irradiance (G <sub>Ref</sub> )	1000 W/m <sup>2</sup>
Open circuit voltage (V <sub>oc</sub> )	40.6 V	Short-circuit current (I <sub>sc</sub> )	14.31 A
Max. power point voltage (V <sub>mpp</sub> )	33.6 V	Max. power point current (I <sub>mp</sub> )	13.55 A
=> maximum power (P <sub>mp</sub> )	455.3 W	Isc temperature coefficient (muIsc)	8.0 mA/°C

<b>One-diode model parameters</b>			
Shunt resistance (R <sub>shunt</sub> )	260 Ω	Diode saturation current (I <sub>oRef</sub> )	0.023 nA
Series resistance (R <sub>serie</sub> )	0.17 Ω	Voc temp. coefficient (MuVoc)	-90 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.26 %/°C	Diode quality factor (Gamma)	1.08
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V

<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (V <sub>mpp</sub> )	33.5 V	Max. power point current (I <sub>mp</sub> )	13.64 A
Maximum power (P <sub>mp</sub> )	455.3 W <sub>p</sub>	Power temper. coefficient (muPmp)	-0.26 %/°C
Efficiency(/ Module area) (Eff <sub>mod</sub> )	22.8 %	Fill factor (FF)	0.784
Efficiency(/ Cells area) (Eff <sub>cells</sub> )	24.7 %		



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### 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**

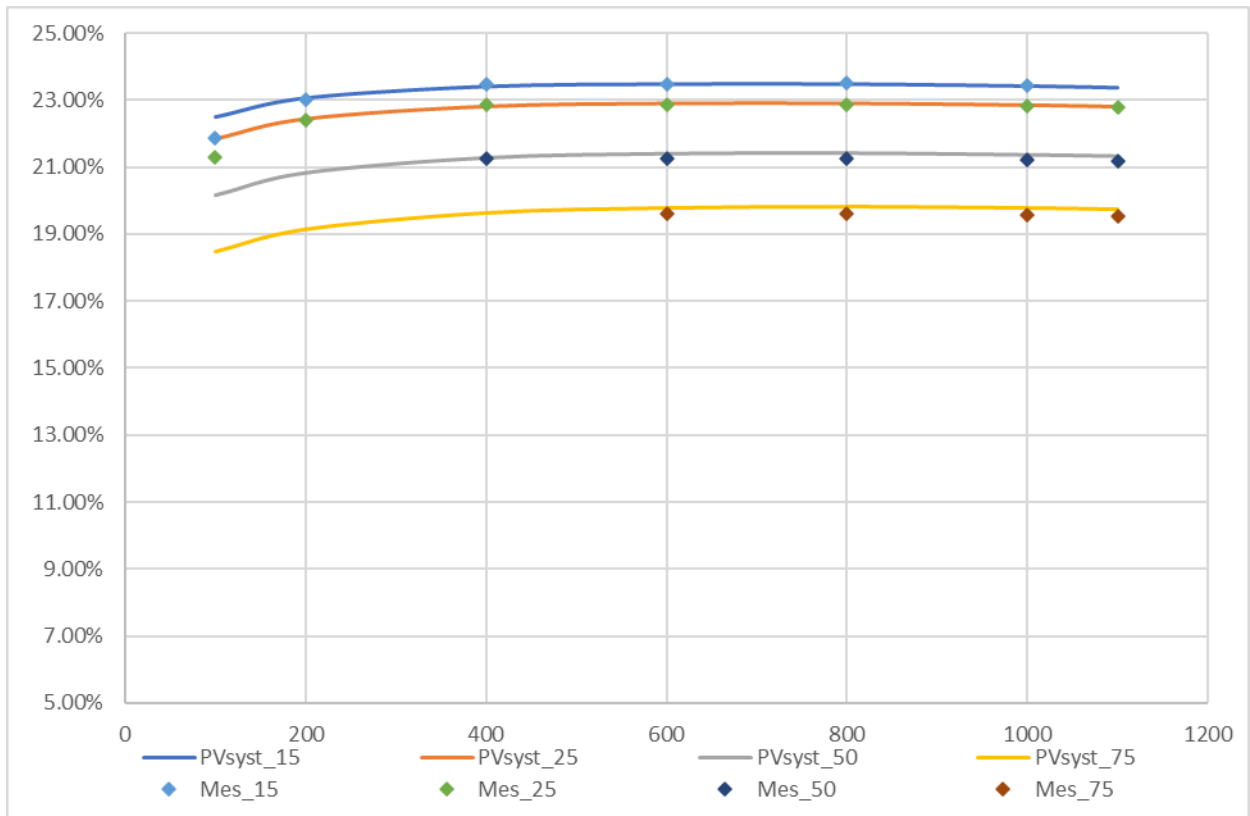
Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m <sup>2</sup> ]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	21.87%	21.28%	-	-
200	23.03%	22.41%	-	-
400	23.49%	22.85%	21.25%	-
600	23.48%	22.86%	21.24%	19.61%
800	23.50%	22.86%	21.26%	19.61%
1000	23.45%	22.84%	21.22%	19.58%
1100	-	22.77%	21.16%	19.53%

**Table 9:**

**Efficiency Generated Using PVSyst and the Newly Created PAN file.**

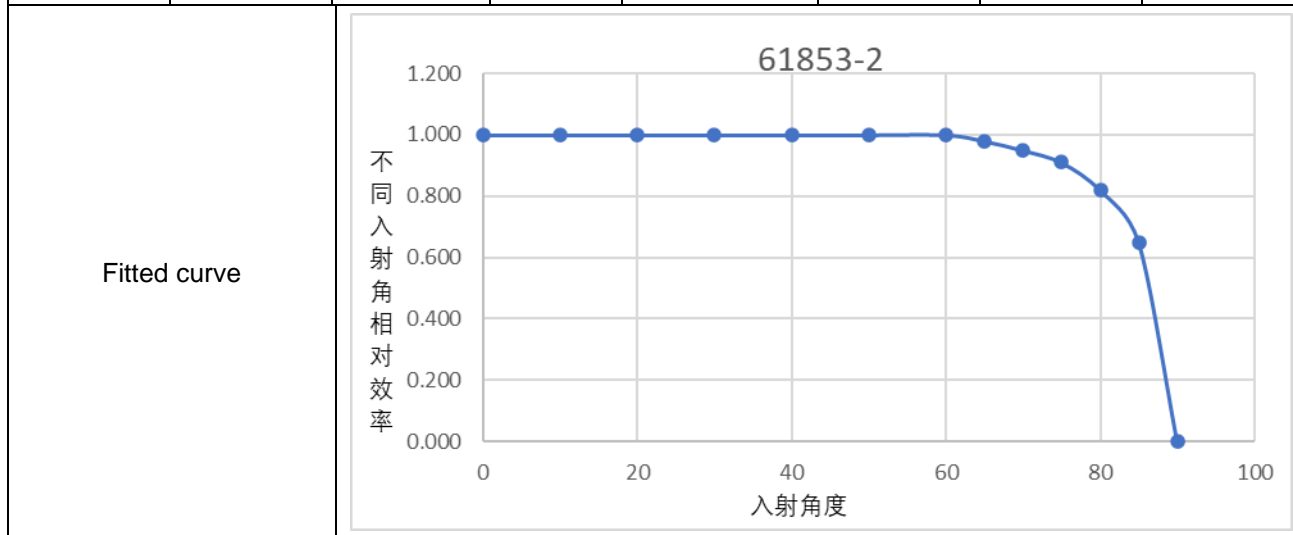
Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m <sup>2</sup> ]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	22.49%	21.83%	20.18%	18.47%
200	23.06%	22.43%	20.83%	19.15%
400	23.41%	22.81%	21.27%	19.65%
600	23.49%	22.90%	21.39%	19.80%
800	23.49%	22.91%	21.41%	19.84%
1000	23.43%	22.85%	21.36%	19.80%
1100	23.38%	22.80%	21.32%	19.76%

**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-1419-004X			—
Module Angle	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	IAM value according to IEC61853-2
0	—	—	7.362	—	—	—	1.00
10	—	—	7.309	—	—	—	1.00
20	—	—	6.975	—	—	—	1.00
30	—	—	6.412	—	—	—	1.00
40	—	—	5.659	—	—	—	1.00
50	—	—	4.717	—	—	—	1.00
60	—	—	3.683	—	—	—	1.00
65	—	—	3.036	—	—	—	0.98
70	—	—	2.389	—	—	—	0.95
75	—	—	1.743	—	—	—	0.91
80	—	—	1.054	—	—	—	0.82
85	—	—	0.415	—	—	—	0.65





## 5 Documentation

### List of measurement equipment

Description	Type/ Equipment ID	Calibration due date	Remark
Pulsed Solar Simulator	HYJC-YS-021	2024.01.04	-

### Statement of the estimated uncertainty of the test results

Pmax measurement uncertainty: 2.16% (K=2) Voc measurement uncertainty: 1.00% (K=2) Isc measurement uncertainty: 2.40% (K=2)
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## 6 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-A610-MAH72Dw to AIKO-A620-MAH72Dw were extended based on the measured parameter model of AIKO-A615-MAH72Dw.

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

Engineer:

*Xu Yang*  


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**Yang Xu**  
Project Handler

Technical Report checked:

*Tao Wang*  


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**Tao Wang**  
Designated Reviewer