Test Report No.64.290.23.30199.01

Dated 2023-03-13

Client:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. No. 01, Building 9, Lane 3, East of Dengdong Road, Longjiang Community, Longjiang Town, Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Manufacturer:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. No. 01, Building 9, Lane 3, East of Dengdong Road, Longjiang Community, Longjiang Town, Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Manufacturing place:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. No. 01, Building 9, Lane 3, East of Dengdong Road, Longjiang Community, Longjiang Town, Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF 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

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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	550D(HPM)72(182)
Voc (Vdc)	49.82±3%
Vmp (Vdc)	42.00
Isc (Adc)	13.97±4%
Imp (Adc)	13.10
Pmp (W)	550
Bifaciality factor, if bifacial module	N/A
Power tolerance	±3%
Maximum system voltage (V)	1500
Maximum over-current protection rating (A)	25
Application Class	Class II

2 Order

2.1 Date of Purchase Order, Customer's Reference

2023-01-16, 5767449

2.2 Receipt of Test Sample, Location

2023-02-17

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

2023-02-22 / 2023-03-13

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

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3 Test Results

3.1 Sample Information

Sample #	Model	Sample S/N	Remark
1	550D(HPM)72(182)	BH1C51LAC221102011634	IEC 61853-1
2	550D(HPM)72(182)	BH1C51LAC221102011635	IEC 61853-1
3	550D(HPM)72(182)	BH1C51LAC221102011637	IEC 61853-1
			IEC 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^2 to 1100 W/m^2 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^2 and ranging in temperature from 15 °C to 45 °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

#1							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.038	40.473	1.363	1.335	54.015	84.27
15	200	48.779	41.841	2.773	2.686	112.389	83.08
15	400	49.589	42.730	5.583	5.360	229.052	82.74
15	600	50.334	43.193	8.298	7.986	344.925	82.58
15	800	50.863	43.430	11.077	10.606	460.606	81.75
15	1000	51.256	43.377	13.778	13.215	573.213	81.17
25	100	46.123	38.860	1.359	1.341	52.107	83.15
25	200	47.454	40.405	2.778	2.688	108.606	82.38
25	400	48.302	41.201	5.597	5.374	221.416	81.90
25	600	49.053	41.760	8.362	7.988	333.570	81.32

25	800	49.581	41.901	11.105	10.616	444.815	80.79
25	1000	49.928	41.819	13.834	13.238	553.601	80.15
25	1100	50.119	41.924	15.226	14.503	608.034	79.68
50	400	44.891	37.390	5.630	5.382	201.242	79.63
50	600	45.765	37.804	8.397	8.003	302.524	78.72
50	800	46.392	37.918	11.110	10.648	403.755	78.34
50	1000	46.387	37.914	14.043	13.265	502.948	77.21
50	1100	46.488	38.055	15.452	14.501	551.817	76.82
75	600	41.971	33.914	8.509	8.027	272.227	76.23
75	800	42.630	34.004	11.305	10.680	363.147	75.35
75	1000	42.875	34.071	14.288	13.287	452.706	73.90
75	1100	43.062	34.254	15.670	14.510	497.037	73.66

#2							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	46.944	40.552	1.358	1.333	54.040	84.79
15	200	48.589	42.078	2.764	2.669	112.298	83.63
15	400	49.593	42.740	5.563	5.358	229.019	83.01
15	600	50.343	43.198	8.316	7.978	344.613	82.31
15	800	50.799	43.304	11.082	10.639	460.722	81.84
15	1000	51.228	43.251	13.800	13.246	572.918	81.04
25	100	45.865	38.634	1.363	1.353	52.262	83.60
25	200	47.331	40.508	2.788	2.689	108.926	82.54
25	400	48.340	41.312	5.589	5.367	221.740	82.07
25	600	49.082	41.540	8.373	8.054	334.544	81.40
25	800	49.546	41.826	11.177	10.668	446.207	80.57
25	1000	49.900	41.740	13.909	13.291	554.769	79.93
25	1100	50.095	41.658	15.278	14.593	607.903	79.43
50	400	44.917	37.624	5.630	5.366	201.897	79.84
50	600	45.781	38.098	8.409	7.980	304.026	78.97
50	800	46.400	38.423	11.153	10.547	405.271	78.31
50	1000	46.486	38.032	14.057	13.256	504.142	77.15
50	1100	46.611	38.169	15.450	14.504	553.587	76.87
75	600	42.214	34.204	8.499	8.001	273.647	76.27
75	800	42.876	34.317	11.286	10.636	365.002	75.43
75	1000	43.122	34.339	14.226	13.223	454.085	74.02
75	1100	43.234	34.411	15.597	14.474	498.063	73.86

#3							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.136	40.621	1.358	1.330	54.026	84.41
15	200	48.614	42.142	2.756	2.658	112.000	83.59
15	400	49.596	42.723	5.548	5.348	228.468	83.03
15	600	50.340	43.194	8.293	7.978	344.598	82.54
15	800	50.845	43.175	11.046	10.642	459.477	81.81
15	1000	51.210	43.248	13.800	13.229	572.130	80.96
25	100	45.759	39.126	1.373	1.344	52.595	83.74
25	200	47.418	40.547	2.788	2.688	108.978	82.43
25	400	48.366	41.325	5.609	5.377	222.224	81.91
25	600	49.113	41.665	8.379	8.030	334.567	81.30
25	800	49.634	41.817	11.157	10.677	446.463	80.62
25	1000	49.985	41.768	13.961	13.329	556.703	79.78
25	1100	50.150	41.704	15.353	14.634	610.309	79.27
50	400	44.941	37.756	5.653	5.355	202.167	79.58
50	600	45.788	38.218	8.422	7.975	304.797	79.04
50	800	46.395	38.422	11.156	10.568	406.055	78.45
50	1000	46.541	38.153	14.032	13.242	505.222	77.36
50	1100	46.832	38.089	15.373	14.554	554.371	77.00
75	600	42.356	34.155	8.539	8.075	275.806	76.26
75	800	43.024	34.467	11.255	10.621	366.070	75.60
75	1000	43.270	34.588	14.115	13.159	455.143	74.52
75	1100	43.399	34.680	15.505	14.389	499.021	74.16

Table 3:

Temperature Coefficients Measurement Data at the 1000 W.m^{-2} Irradiance

#1				
T [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Isc [A]	Pmp [W]
14.9	1000	51.256	13.778	573.213
20.1	1000	50.392	13.817	560.054
25.0	1000	49.928	13.834	553.601
30.2	1000	49.074	13.868	542.418
35.1	1000	48.411	13.907	532.259
39.9	1000	47.883	13.950	524.155
45.2	1000	47.132	13.984	514.740

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3.3.1 Test Data Analysis

3.3.1.1 Temperature Coefficients

Figure 1:

Plot of measured Voc vs. temperature of flash-tests taken at 1000 W/m^2 for sample #1

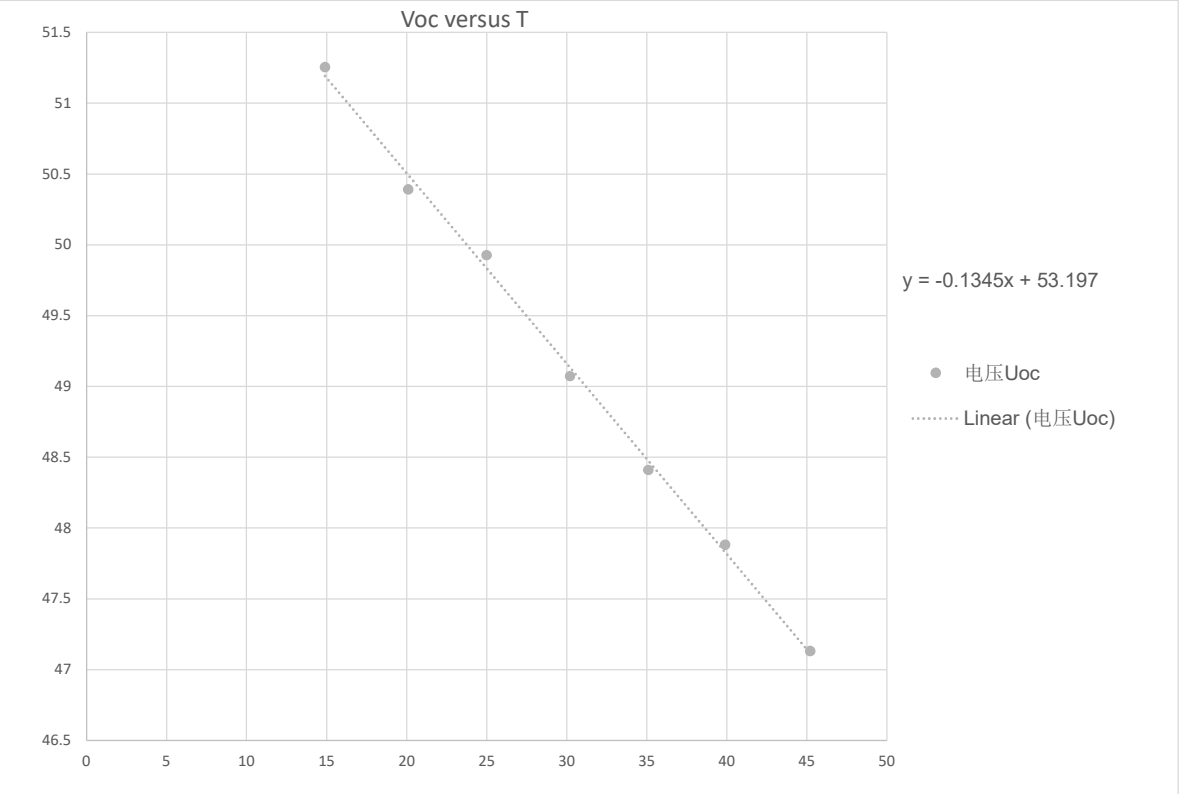

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Figure 2:

Plot of measured P_{MAX} vs. temperature of flash-tests taken at 1000 W/m² for sample #1

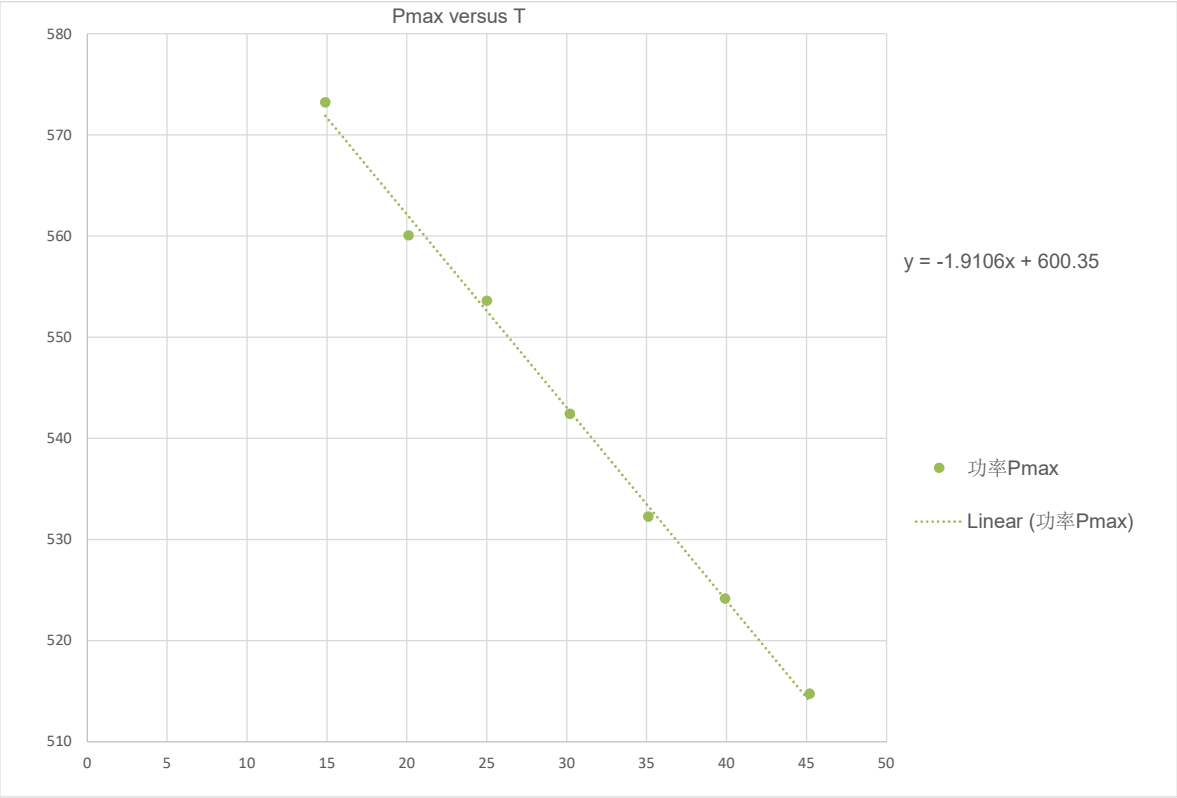

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Figure 3:

Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m² for sample #1

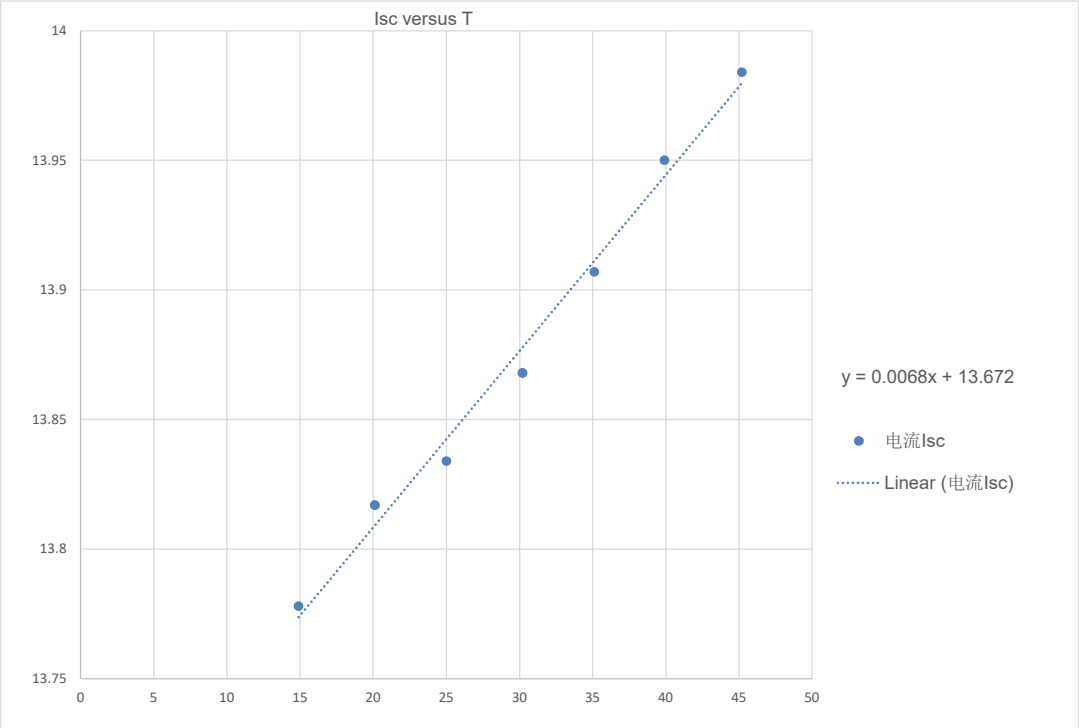

Table 4:

Average Temperature Coefficients Determined by Laboratory Results

Sample No	Alpha (α) ISC [%]	Beta (β) VOC [%]	Gamma (γ) PMAX [%]
#1	0.0494	-0.262	-0.333

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

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	54.027	52.321	-	-
200	112.229	108.837	-	-
400	228.846	221.793	201.769	-
600	344.712	334.227	303.782	273.893
800	460.268	445.828	405.027	364.740
1000	572.754	555.024	504.104	453.978

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1100	-	608.749	553.258	498.040

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/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	53.538	51.848	-	-
200	111.213	107.851	-	-
400	226.775	219.786	199.942	-
600	341.592	331.202	301.033	271.414
800	456.102	441.793	401.361	361.438
1000	567.569	550.000	499.541	449.869
1100	-	603.238	548.250	493.532

Table 7:

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

Sample No	**Irradiance [W/m²]**						
	100	200	400	600	800	1000	1100
Average	94.27%	98.05%	99.90%	100.36%	100.41%	100.00%	99.71%

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

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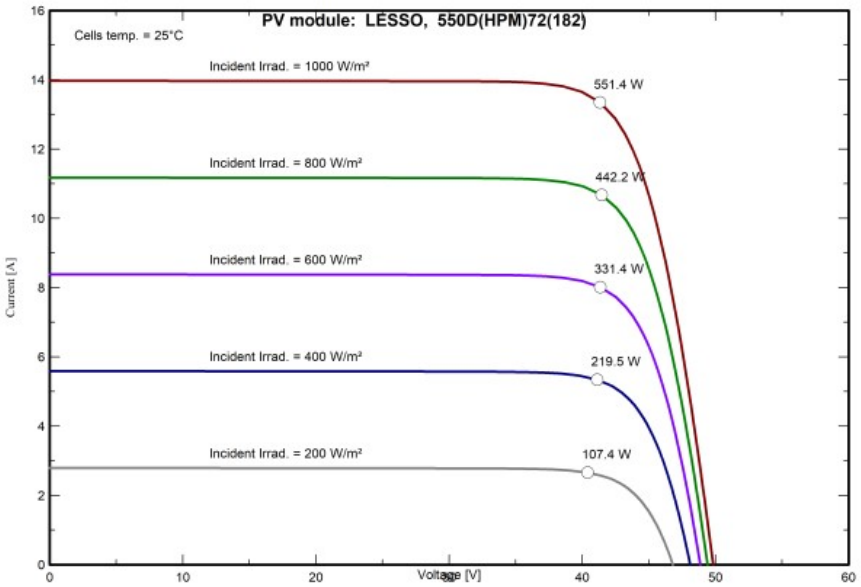
PV module - 550D(HPM)72(182)

Manufacturer	LESSO	**Commercial data**	
Model	550D(HPM)72(182)	Data source :	TUV SUD
Pnom STC power (manufacturer)	550 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.278 m²	Rough module area (Amodule)	2.58 m²
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m²
Specifications for the model (manufacturer or measurement data)			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m²
Open circuit voltage (Voc)	49.8 V	Short-circuit current (Isc)	13.97 A
Max. power point voltage (Vmpp)	42.0 V	Max. power point current (Impp)	13.10 A
=> maximum power (Pmpp)	550.2 W	Isc temperature coefficient (muIsc)	7.7 mA/°C
One-diode model parameters			
Shunt resistance (Rshunt)	2482 Ω	Diode saturation current (IoRef)	0.038 nA
Serie resistance (Rserie)	0.20 Ω	Voc temp. coefficient (MuVoc)	-146 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.35 %/°C	Diode quality factor (Gamma)	1.01
		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/V²	(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)	41.3 V	Max. power point current (Impp)	13.39 A
Maximum power (Pmpp)	551.4 Wp	Power temper. coefficient (muPmpp)	-0.35 %/°C
Efficiency(/ Module area) (Eff_mod)	21.3 %	Fill factor (FF)	0.792
Efficiency(/ Cells area) (Eff_cells)	23.1 %		



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.

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/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	20.73%	20.07%	-	-
200	21.53%	20.88%	-	-
400	21.95%	21.27%	19.35%	-
600	22.04%	21.37%	19.42%	17.51%
800	22.07%	21.38%	19.42%	17.49%
1000	21.97%	21.29%	19.34%	17.41%
1100	-	21.23%	19.29%	17.37%

Table 9:

Efficiency Generated Using PVsyst and the Newly Created PAN file.

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	20.90%	20.17%	18.19%	16.10%
200	21.54%	20.79%	18.83%	16.82%
400	21.98%	21.24%	19.34%	17.34%
600	22.11%	21.38%	19.50%	17.52%
800	22.12%	21.40%	19.53%	17.57%
1000	22.07%	21.35%	19.49%	17.55%
1100	22.02%	21.31%	19.45%	17.52%

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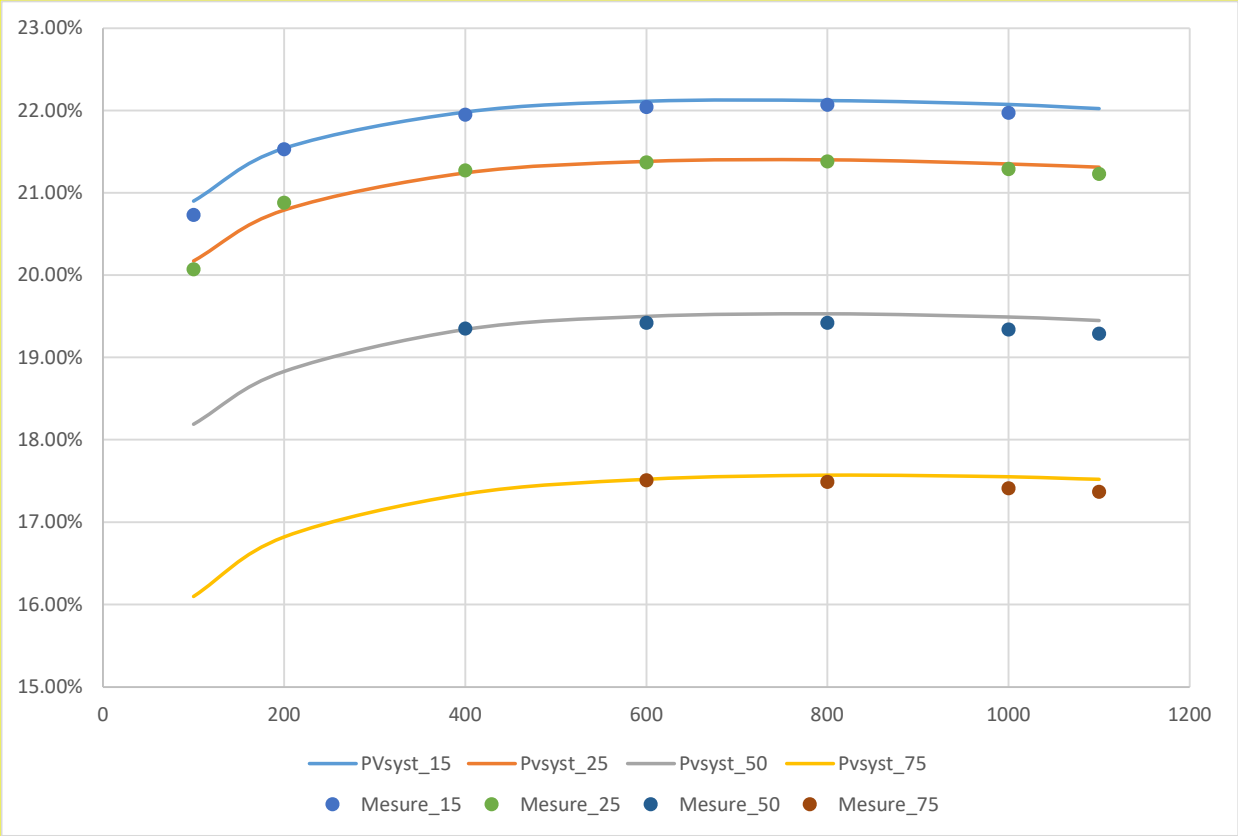
Figure 4:
Comparison of PVsyst Model, Using the Optimized PAN file, to the Laboratory Testing Results



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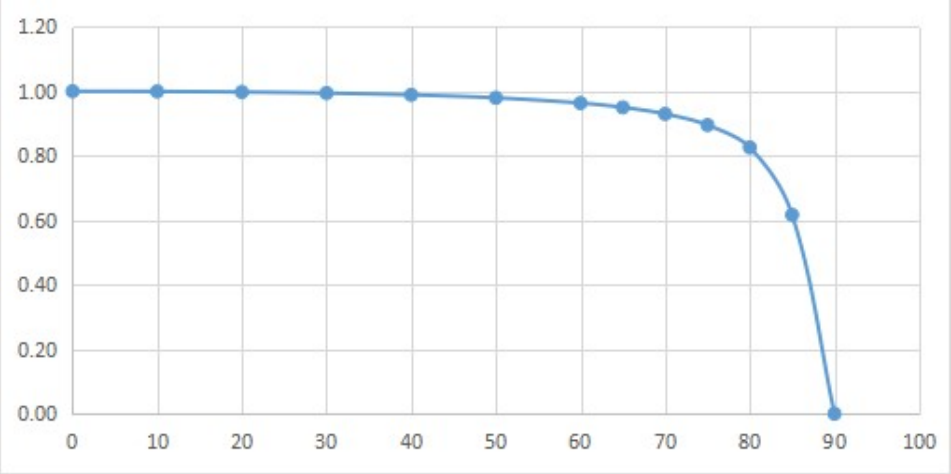
4.4 Measurement of incidence angle effects

Sample No	#3	—
Isc_80°/A:	1.864	—
Isc_-80°/A:	1.831	—
Isc_0°/A:	13.339	—
m=(Isc_80°/Isc_0°)/ cos 80°	0.805	—
n=(Isc_-80°/Isc_0°)/ cos 80°	0.790	—
DeviationΔ=|(m-n)/(m+n)|×100% ≤2%	0.9%	P

Module Angle	Im [A]	Vm [V]	Isc [A] (Average)	Voc [V]	P [W]	IAM value according to IEC61853-2	IAM value according to PVsyst
0	-	-	13.339	-	-	1.00	1.00
10	-	-	13.210	-	-	1.01	1.00
20	-	-	12.661	-	-	1.01	1.00
30	-	-	11.673	-	-	1.01	0.99
40	-	-	10.315	-	-	1.01	0.99
50	-	-	8.635	-	-	1.01	0.98
60	-	-	6.629	-	-	0.99	0.96
65	-	-	5.510	-	-	0.98	0.95
70	-	-	4.284	-	-	0.94	0.93
75	-	-	3.053	-	-	0.88	0.90
80	-	-	1.864	-	-	0.80	0.83
85	-	-	0.719	-	-	0.62	0.62

Fitted curve	 τ(θ) =1−bo×(1/cos(θ)−1) (formula according to PVsyst), b_0=0.0366

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5 Documentation

Annex 1: PRODUCT DESCRIPTION SHEET (MANUFACTURERS AND TYPE REFERENCES)

A1.1	**MODULE TYPE/S**	
	550D(HPM)72(182)	
A1.2	**MODULE DESIGN –DIMENSIONS**	
	Module dimensions (L x W x H) [mm] .....:	2278 x 1134 x 35
A1.3	**SOLAR CELL**	
	Cell type reference .....:	P type mono-Si, Cell type: M182ABPERCBP, 10BB Cell dimensions L x W: 182.0 × 91.0 ± 0.5(mm), Cell thickness: 175 ± 17.5 (μm), Tongwei Solar Energy Co., Ltd.
A1.4	**IDENTIFICATION OF MATERIALS**	
	Front cover .....:	Material:Anti-reflective coating low iron patterend solar glass, Thickness: 3.2(mm), XINYI PV PRODUCTS (ANHUI) HOLDINGS Ltd.
	Rear cover .....:	Type: FFC-JW3010(Plus), Color: White, Total Thickness: 310 ± 5% mm, Jolywood (Suzhou) Sunwatt Co., Ltd.
	Encapsulation material .....:	Type: F406PS (contact with front cover) Hangzhou First PV Material Co., Ltd
		Type: F806PS (contact with rear cover) Hangzhou First PV Material Co., Ltd
	Frame .....:	material：6005 T6，size：2384*1303*35, Heshan Linghe Electric Technology Co., Ltd.
	Adhesive for frame .....:	Type: SMG533, Material:Silicon, white, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Cell connector.....:	Type: Tin-coated copper ribbon, Cross section: Φ=0.32 (mm), Xi'an Telison New Materials Co.,Ltd
	String connector .....:	Type: Tin-coated copper ribbon, Cross section: 0.45 x 4 (mm) & 0.35 x 6 (mm), Xi'an Telison New Materials Co.,Ltd

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	Junction box .....:	Type: PV-JB12x, Suzhou UKT New Energy Technology Co., Ltd.
	Potting material.....:	Type: SKF323, Material:Silicon, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Adhesive for junction box .....:	Type: SMG533, Material:Silicon, white, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Cable .....:	Type H1Z2Z2-K 1×4mm^2, WUXI XINHONGYE WIRE & CABLE CO., LTD.
	Connector .....:	Type: PV-KST4-EVO2/xy_UR (female) & PV-KBT4-EVO2/xy_UR (male), Stäbli Electrical Connectors AG
	Bypass diode .....:	Type: TM3045-30, Suzhou UKT New Energy Technology Co., Ltd.

Annex 2: List of measurement equipment

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

Annex 3: 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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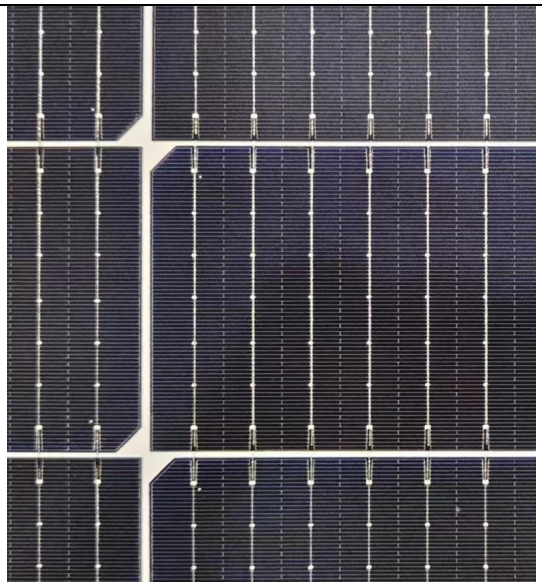
Annex 4: Picture of the module

	
Front face	Rear face
	
nameplate	Solar cell

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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.

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Tested by:

Catherine Shu, Project Handler

Approved by:

Tom Cai, Designated Reviewer

--- End of Report ---

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