Test Report No.64.290.23.30406.01

Dated 2023-04-13

Client:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. The 1st and 2nd floors of the workshop in Zone 2 No. 58, Longzhou West Road Longjiang Town Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Manufacturer:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. The 1st and 2nd floors of the workshop in Zone 2 No. 58, Longzhou West Road 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. Plot A-2, South side of Longjiang Dachong, beside Chanxi Avenue, Longjiang Town, Shunde District, 528000 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(HBD)72(182)
Voc (Vdc)	49.78±3%
Vmp (Vdc)	41.93
Isc (Adc)	14.01±4%
Imp (Adc)	13.11
Pmp (W)	550
Bifaciality factor, if bifacial module	0.70
Power tolerance	±3%
Maximum system voltage (V)	1500
Maximum over-current protection rating (A)	30
Application Class	Class II

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2 Order

2.1 Date of Purchase Order, Customer's Reference

2023-02-10, 5779149

2.2 Receipt of Test Sample, Location

2023-03-14

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

2023-03-07 / 2023-03-31

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(HBD)72(182)	BH1F61AC230227010638	IEC 61853-1
2	550D(HBD)72(182)	BH1F61AC230227010620	IEC 61853-1
3	550D(HBD)72(182)	BH1F61AC230227010593	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	47.089	41.651	1.359	1.316	54.810	85.62
15	200	48.356	42.029	2.755	2.683	112.748	84.63
15	400	49.574	42.793	5.630	5.419	231.878	83.08
15	600	50.319	43.133	8.449	8.089	348.907	82.07
15	800	50.829	43.324	11.228	10.743	465.419	81.55
15	1000	51.313	43.490	13.877	13.354	580.754	81.56
25	100	46.599	40.485	1.358	1.301	52.683	83.27
25	200	47.077	40.617	2.794	2.674	108.603	82.57
25	400	48.560	41.253	5.618	5.419	223.531	81.94
25	600	49.078	41.695	8.413	8.056	335.908	81.36

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25	800	49.606	41.918	11.165	10.687	447.964	80.88
25	1000	50.069	41.897	13.911	13.353	559.428	80.32
25	1100	50.198	41.834	15.270	14.629	611.996	79.84
50	400	45.258	37.708	5.635	5.436	204.977	80.38
50	600	46.196	38.353	8.411	8.057	309.028	79.53
50	800	46.776	38.569	11.166	10.687	412.186	78.92
50	1000	47.006	38.377	14.014	13.380	513.475	77.95
50	1100	47.184	38.437	15.358	14.624	562.115	77.57
75	600	43.153	34.801	8.420	8.067	280.725	77.26
75	800	43.355	34.982	11.247	10.711	374.679	76.84
75	1000	43.877	35.004	14.107	13.343	467.072	75.46
75	1100	44.056	34.959	15.460	14.649	512.133	75.19

#2							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	46.946	41.217	1.362	1.320	54.399	85.10
15	200	48.360	41.594	2.760	2.702	112.397	84.21
15	400	49.564	42.803	5.591	5.385	230.478	83.17
15	600	50.308	43.130	8.400	8.048	347.119	82.14
15	800	50.824	43.198	11.175	10.716	462.912	81.50
15	1000	51.207	43.061	13.889	13.413	577.565	81.21
25	100	46.325	40.931	1.365	1.295	53.008	83.85
25	200	46.988	40.897	2.773	2.647	108.261	83.08
25	400	48.308	41.264	5.582	5.389	222.362	82.46
25	600	49.056	41.711	8.391	8.031	334.973	81.38
25	800	49.564	41.809	11.131	10.686	446.759	80.98
25	1000	50.015	41.906	13.846	13.289	556.909	80.42
25	1100	50.159	41.861	15.174	14.576	610.171	80.17
50	400	45.333	38.137	5.661	5.403	206.048	80.30
50	600	46.200	38.779	8.420	7.996	310.067	79.71
50	800	46.773	38.670	11.224	10.704	413.915	78.84
50	1000	47.259	38.888	14.006	13.268	515.970	77.95
50	1100	47.104	38.692	15.467	14.613	565.394	77.60
75	600	42.872	35.031	8.493	8.045	281.810	77.40
75	800	43.355	35.066	11.317	10.710	375.548	76.54
75	1000	44.014	35.347	14.145	13.270	469.056	75.34
75	1100	43.998	35.251	15.586	14.580	513.976	74.95

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#3							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	46.942	41.904	1.353	1.295	54.266	85.45
15	200	48.339	42.129	2.753	2.660	112.045	84.19
15	400	49.555	42.802	5.585	5.372	229.946	83.08
15	600	50.314	43.123	8.340	8.022	345.923	82.44
15	800	50.826	43.196	11.111	10.682	461.439	81.71
15	1000	51.202	43.183	13.858	13.342	576.132	81.20
25	100	46.226	40.835	1.359	1.290	52.689	83.88
25	200	47.087	40.623	2.777	2.674	108.611	83.06
25	400	48.413	41.265	5.594	5.417	223.527	82.53
25	600	49.159	41.830	8.411	8.021	335.517	81.15
25	800	49.668	42.058	11.171	10.645	447.715	80.69
25	1000	50.163	41.959	13.859	13.316	558.732	80.37
25	1100	50.259	42.046	15.272	14.562	612.276	79.77
50	400	45.373	38.181	5.609	5.372	205.108	80.59
50	600	46.196	38.651	8.395	8.002	309.292	79.75
50	800	46.777	38.798	11.196	10.640	412.789	78.82
50	1000	47.057	38.626	14.002	13.304	513.867	77.99
50	1100	47.148	37.987	15.429	14.813	562.715	77.35
75	600	42.989	35.165	8.513	8.034	282.521	77.20
75	800	43.493	35.197	11.346	10.705	376.772	76.35
75	1000	43.935	35.386	14.155	13.294	470.429	75.64
75	1100	44.019	35.254	15.576	14.629	515.740	75.22

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]
15.2	1000	51.313	13.877	580.754
20.2	1000	50.636	13.900	570.532
25.1	1000	50.069	13.911	559.428
30.1	1000	49.531	13.925	549.503
35.3	1000	48.956	13.953	542.280
40.2	1000	48.338	13.962	532.900
45.2	1000	47.745	13.994	523.023

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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

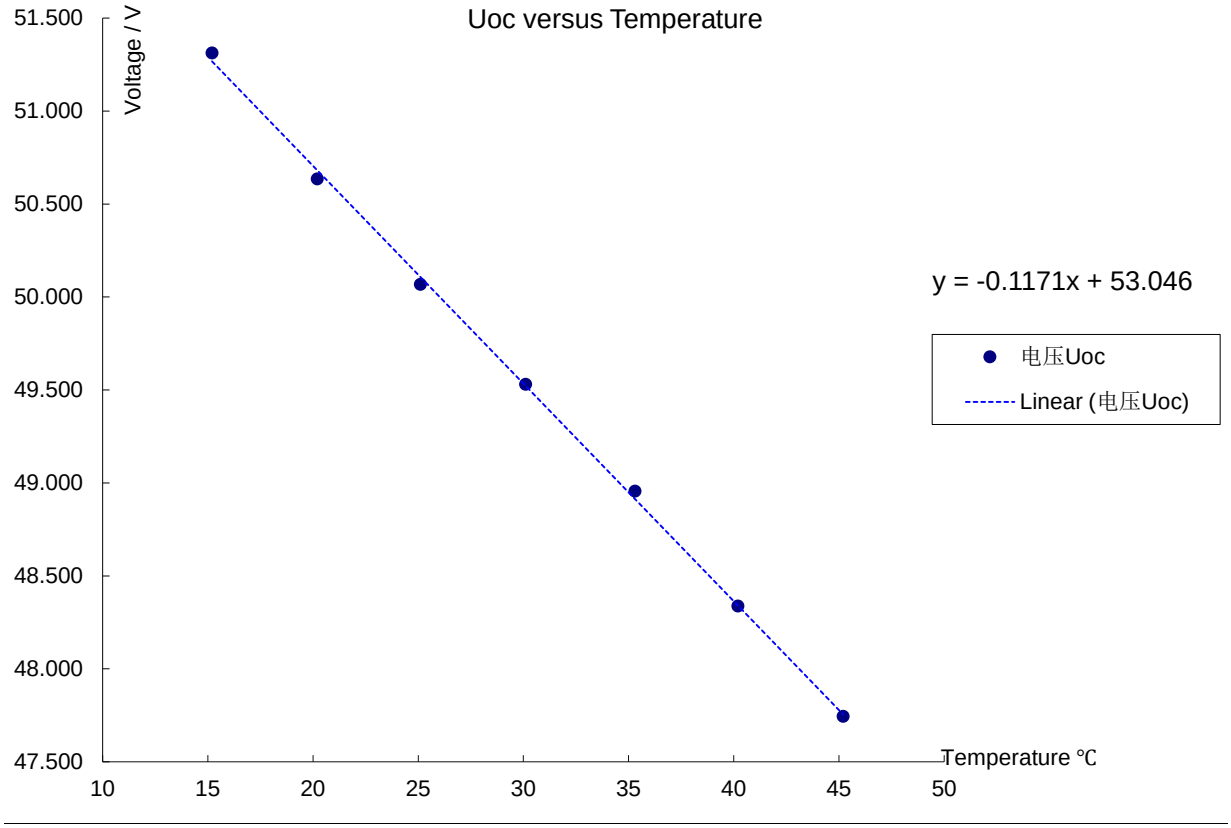

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Figure 2:

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

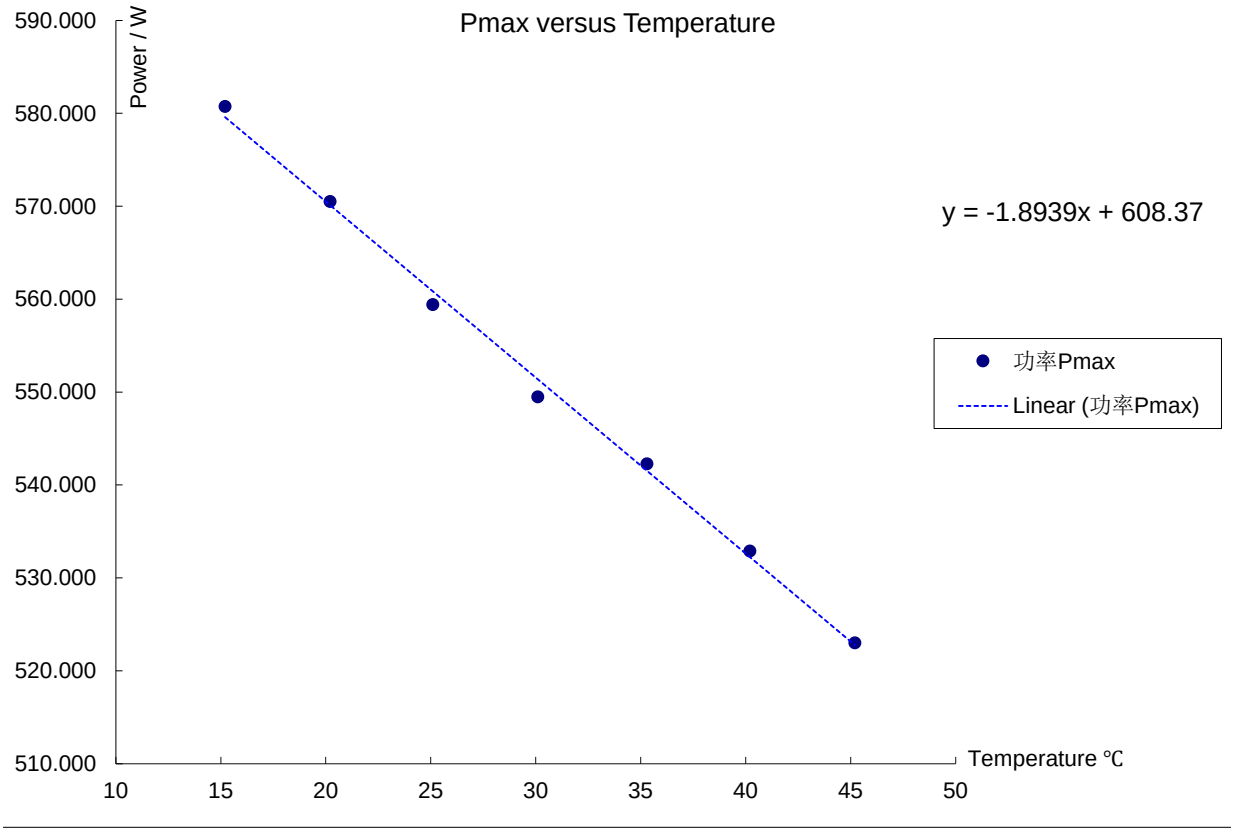

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Figure 3:

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

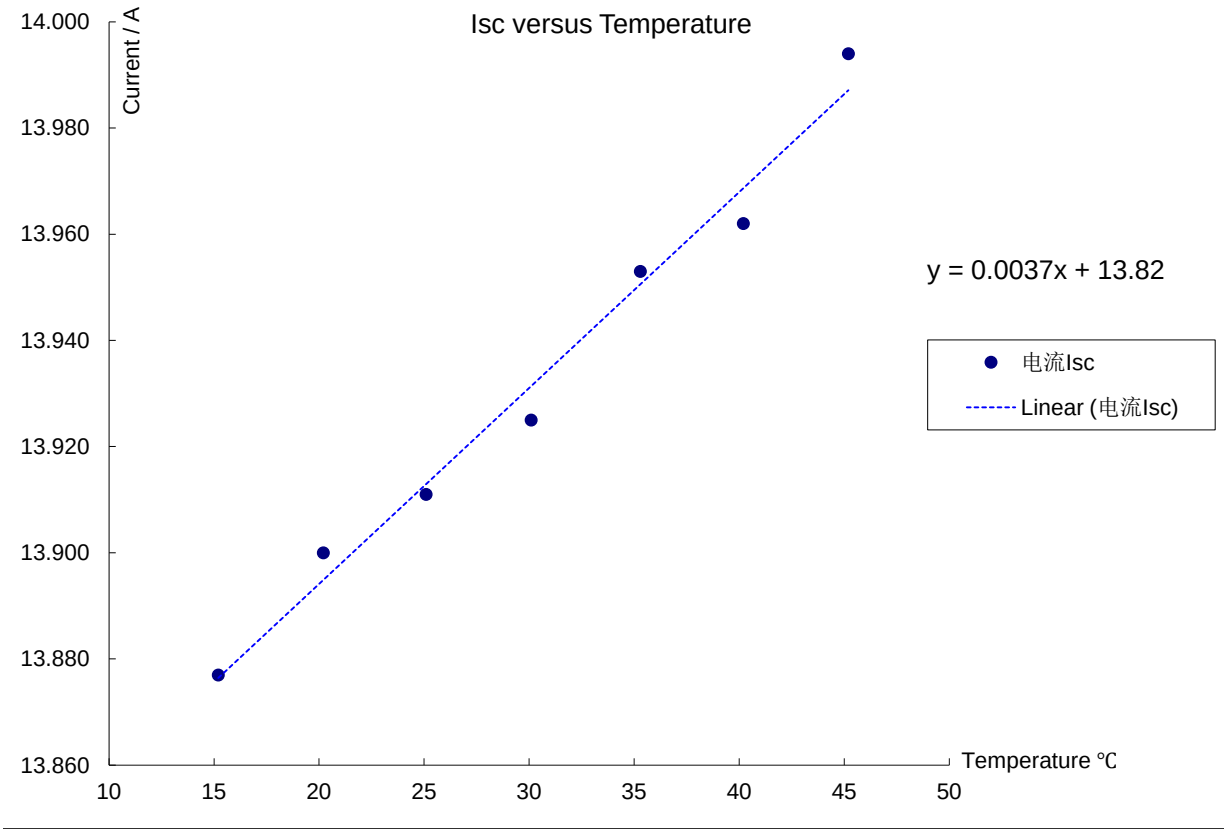

Table 4:

Average Temperature Coefficients Determined by Laboratory Results

Sample No	Alpha (α) ISC [%]	Beta (β) VOC [%]	Gamma (γ) PMAX [%]
#1	0.0266	-0.2281	-0.3261

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	54.492	52.793	-	-
200	112.397	108.492	-	-
400	230.767	223.140	205.378	-

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600	347.316	335.466	309.462	281.685
800	463.257	447.479	412.963	375.666
1000	578.150	558.356	514.437	468.852
1100	-	611.481	563.408	513.950

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	53.676	52.003	-	-
200	110.715	106.868	-	-
400	227.314	219.801	202.304	-
600	342.119	330.446	304.831	277.470
800	456.324	440.783	406.783	370.044
1000	569.498	550.000	506.739	461.836
1100	-	602.330	554.976	506.258

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	94.55%	97.15%	99.91%	100.14%	100.18%	100.00%	99.56%

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 - 550D(HBD)72(182)

Manufacturer	LESSO	**Commercial data**	
Model	550D(HBD)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)	14.01 A
Max. power point voltage (Vmpp)	41.9 V	Max. power point current (Impp)	13.12 A
=> maximum power (Pmpp)	550.1 W	Isc temperature coefficient (muIsc)	3.8 mA/°C

One-diode model parameters

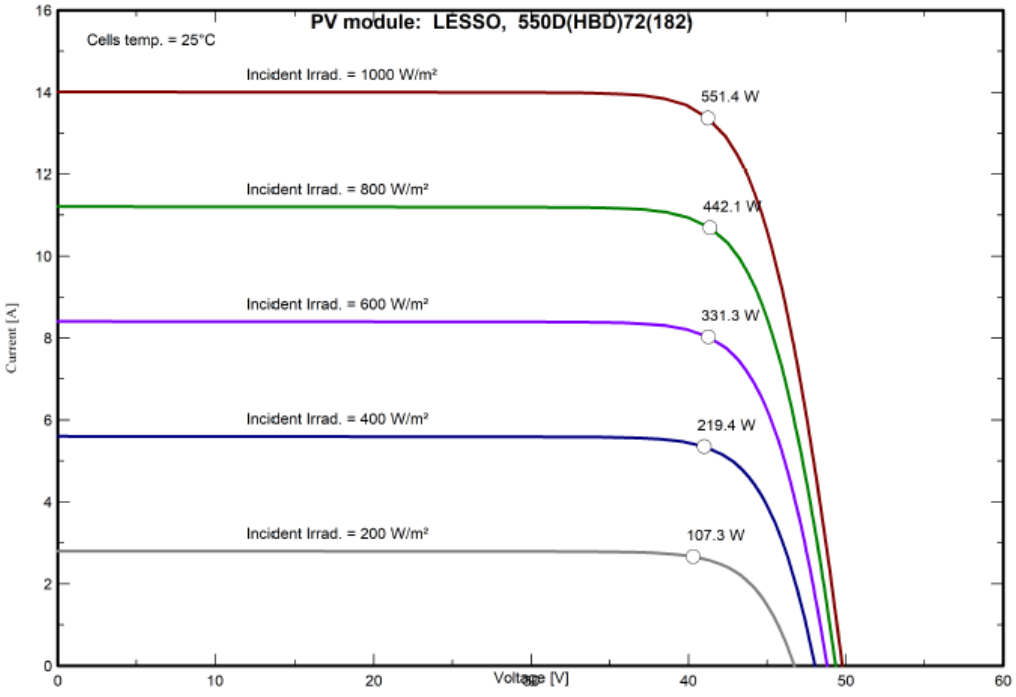
Shunt resistance (Rshunt)	2482 Ω	Diode saturation current (IoRef)	0.053 nA
Serie resistance (Rserie)	0.20 Ω	Voc temp. coefficient (MuVoc)	-131 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	1.02
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

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)	41.2 V	Max. power point current (Impp)	13.35 A
Maximum power (Pmpp)	551.4 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.3 %	Fill factor (FF)	0.791
Efficiency(/ Cells area) (Eff_cells)	23.1 %		



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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.

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	20.78%	20.13%	-	-
200	21.43%	20.68%	-	-
400	22.00%	21.27%	19.58%	-
600	22.07%	21.32%	19.67%	17.90%
800	22.08%	21.33%	19.68%	17.91%
1000	22.05%	21.29%	19.62%	17.88%
1100	-	21.20%	19.53%	17.82%

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	20.56%	19.82%	17.92%	15.99%
200	21.12%	20.40%	18.54%	16.65%
400	21.50%	20.80%	18.99%	17.12%
600	21.63%	20.94%	19.16%	17.30%
800	21.66%	20.97%	19.20%	17.36%
1000	21.62%	20.93%	19.17%	17.34%
1100	21.58%	20.90%	19.14%	17.31%

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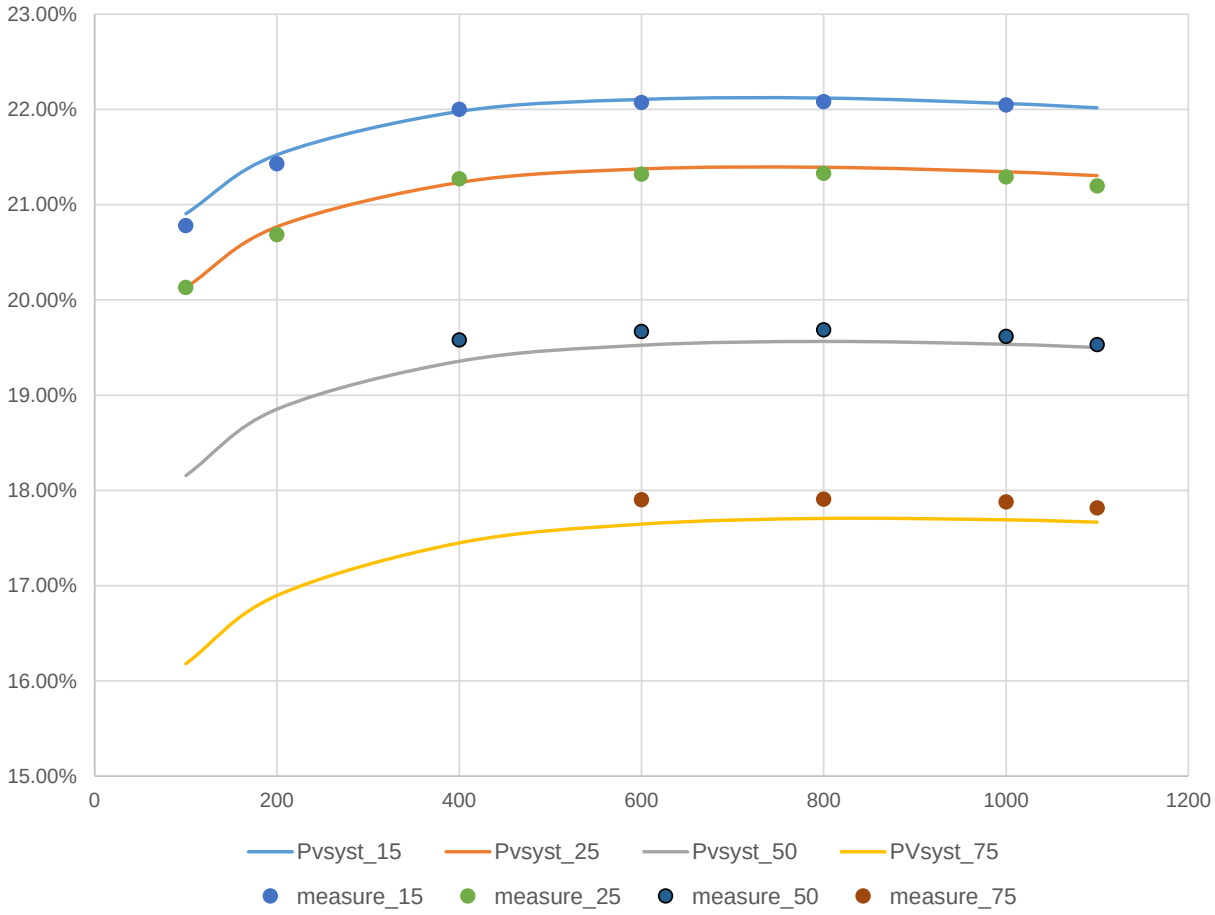
Figure 4:
Comparison of PVsyst Model, Using the Optimized PAN file, to the Laboratory Testing Results



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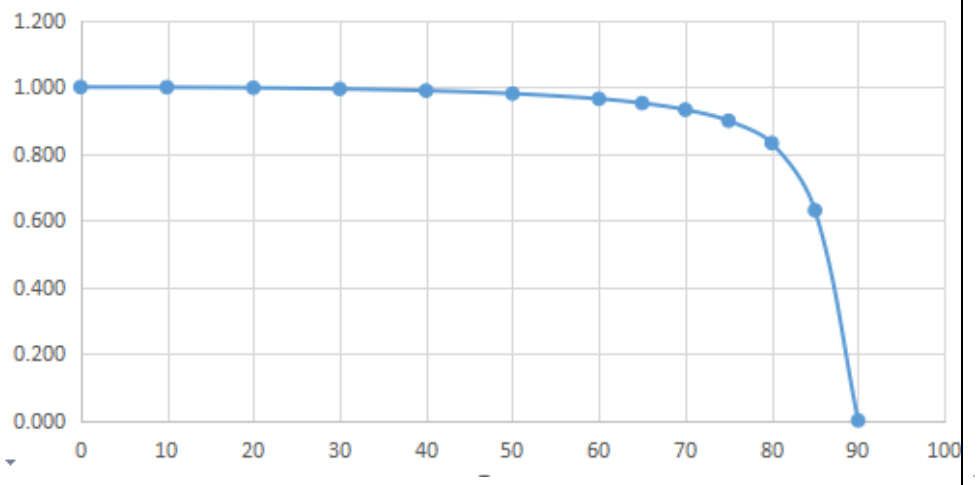
4.4 Measurement of incidence angle effects

Sample No	#3	—
Isc_80°/A:	1.892	—
Isc_-80°/A:	1.855	—
Isc_0°/A:	13.624	—
m=(Isc_80°/Isc_0°)/ cos 80°	0.800	—
n=(Isc_-80°/Isc_0°)/ cos 80°	0.784	—
DeviationΔ=|(m-n)/(m+n)|×100% ≤2%	1.0%	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	-	-	13.624	-	-	1.00	1.00
10	-	-	13.453	-	-	1.00	1.00
20	-	-	12.889	-	-	1.01	1.00
30	-	-	11.888	-	-	1.01	0.99
40	-	-	10.484	-	-	1.00	0.99
50	-	-	8.789	-	-	1.00	0.98
60	-	-	6.765	-	-	0.99	0.96
65	-	-	5.646	-	-	0.98	0.95
70	-	-	4.418	-	-	0.95	0.93
75	-	-	3.127	-	-	0.89	0.90
80	-	-	1.892	-	-	0.80	0.83
85	-	-	0.756	-	-	0.64	0.63

Fitted curve	 τ(θ) =1−bo×(1/cos(θ)−1) (formula according to PVsystem), b_0=0.0353

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5 Documentation

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

A1.1	**MODULE TYPE/S**	
	550D(HBD)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 .....:	Bifacial PERC Cell(T-V1), Cell type: 7M9E1018A-L1, 10BB Cell dimensions L x W: 182.0 × 91.0 ± 0.5(mm), Cell thickness: 185 ± 18.5 (μm), Zhejiang Aiko Solar Energy Technology Co., Ltd
A1.4	**IDENTIFICATION OF MATERIALS**	
	Front cover .....:	Material:Anti-reflective coating low iron patterend solar glass, Thickness: 2.0(mm), XINYI PV PRODUCTS (ANHUI) HOLDINGS Ltd.
	Rear cover .....:	Material: Semi tempered glass with grid, Thickness: 2.0(mm), XINYI PV PRODUCTS (ANHUI) HOLDINGS Ltd.
	Encapsulation material .....:	Type: F406PS (contact with front cover), Thickness: 0.55(mm), Hangzhou First PV Material Co., Ltd
		Material: POE, Tpye: EP304 (contact with backsheet), Thickness: 0.55(mm), Hangzhou First PV Material Co., Ltd
	Frame .....:	Material：6005 T6, Guangdong Lesso Banhao New Energy Technology Group 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

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	String connector .....:	Type: Tin-coated copper ribbon, Cross section: 0.35 x 4 (mm) & 0.35 x 6 (mm), Xi'an Telison New Materials Co.,Ltd
	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: CO02, Suzhou UKT New Energy Technology Co., Ltd.
	Bypass diode .....:	Type: TM3045-25, 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	-

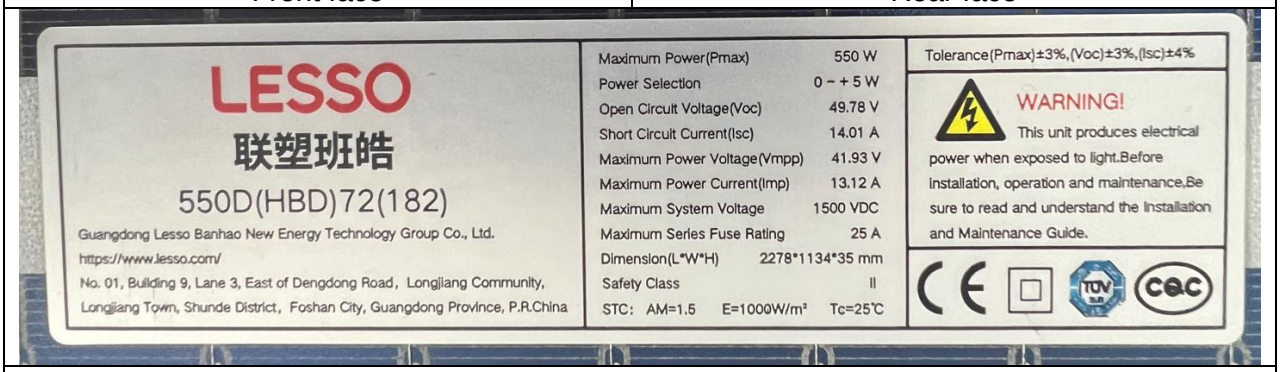
Annex 3: Statement of the estimated uncertainty of the test results

Pmax measurement uncertainty: 2.16% (K=2) Voc measurement uncertainty: 1.00% (K=2) Isc measurement uncertainty: 2.40% (K=2)

Annex 4: Picture of the module

Front face

Rear face



Nameplate

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	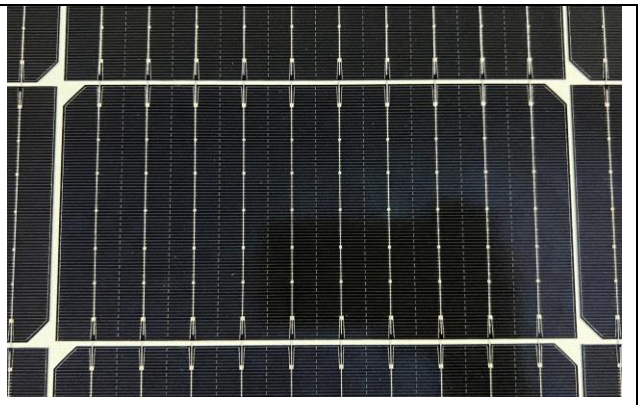
Frame	Solar cell

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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