Technical Report No.: 64.290.23.31934.01

Date: 2024-01-23

Client:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. (no. 116394) The 1st and 2nd floors of the workshop in Zone 2, No. 58, Longzhou West Road, Longjiang Town, Shunde District, Foshan City, Guangdong Province, P.R.China
Manufacturer:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. (no. 116394) The 1st and 2nd floors of the workshop in Zone 2, No. 58, Longzhou West Road, Longjiang Town, Shunde District, Foshan City, Guangdong Province, P.R.China
Factory:	Lesso Banhao Photovoltaic New Energy Technology (Guangdong) Co., Ltd (no.120999) Bay Area No. 1 Key & Core Technology Intellectual Manufacturing Industrial Park No.1 Xinyu Road, Wusha Community Daliang Subdistrict Shunde District 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Test object:	Product: Photovoltaic modules Model: 575C(HBD)72(182)
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 clause 3

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Guangzhou Branch
5F&8F East, Communication Building, No.163 Pingyun Road, Huangpu Ave. West, Guangzhou, Guangdong 510656
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1. Description of the test object

1.1 Picture(s)

	
Front view	Rear View

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 Solar cell	 #4 small sample

1.2 Function

Manufacturer's specification for intended use:
The PV modules for electricity generation systems with max. voltage of 1500 V DC

1.3 Consideration of the foreseeable use

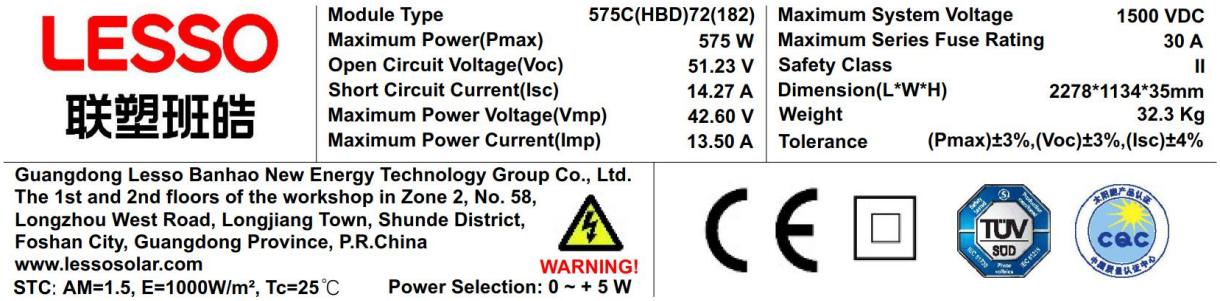
☒ Not applicable
☐ Covered through the applied standard
☐ Covered by the following comment*
☐ Covered by attached risk analysis

1.4 Technical Data

Type or model number	575C(HBD)72(182)
Voc (Vdc)	51.23±3%
Vmp (Vdc)	42.60
Isc (Adc)	14.27±4%

Imp (Adc)	13.50
Pmp (W)	575
Bifaciality factor, if bifacial module	N/A
Power tolerance	±3%
Maximum system voltage (V)	1500
Maximum over-current protection rating (A)	30
Application Class	Class II
Module dimensions L x W x H [mm]	2278 x 1134 x 35

1.5 Rating Label



2. Order

2.1 Date of Purchase Order, Customer's Reference

2023-10-26, 5896438

2.2 Test Sample(s)

- Reception date(s): 2023-10-24
- Location(s) of reception: Changzhou HuaYang Inspection and Testing Technology Co., Ltd.
  No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, P.R.China
- Condition of test sample(s): Receive 3 sample models 575C(HBD)72(182) and 1 small sample

2.3 Testing

- Testing date(s): 2023-11-10 to 2023-11-23
- Location(s) of testing: Changzhou HuaYang Inspection and Testing Technology Co., Ltd.
  No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, P.R.China

2.4 Points of Non-Compliance or Exceptions of the Test Procedure

- None

3. Test Results

3.1 Sample Information

Sample #	Model	Sample S/N	Remark
1	575C(HBD)72(182)	BH1F61LAC231016010018	IEC 61853-1
2	575C(HBD)72(182)	BH1F61LAC231015040766	IEC 61853-1
3	575C(HBD)72(182)	BH1F61LAC231015040759	IEC 61853-1
4	Small sample	-	IEC 61853-2
Supplementary information: Small sample design for IAM test.			

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	47.246	41.238	1.406	1.344	55.428	83.43
15	200	50.031	43.315	2.801	2.684	116.269	82.96
15	400	51.464	43.938	5.604	5.398	237.167	82.24
15	600	51.893	44.267	8.397	8.029	355.425	81.57
15	800	52.564	44.485	11.131	10.651	473.814	80.98
15	1000	52.756	44.449	13.961	13.312	591.705	80.34
25	100	46.226	39.695	1.408	1.357	53.871	82.78
25	200	48.769	41.512	2.817	2.721	112.964	82.24
25	400	49.975	42.685	5.641	5.394	230.238	81.67
25	600	50.464	42.796	8.456	8.082	345.897	81.06

25	800	50.985	42.986	11.245	10.727	461.124	80.43
25	1000	51.325	42.928	14.029	13.394	574.978	79.85
25	1100	51.492	42.549	15.382	14.758	627.948	79.28
50	400	46.968	38.756	5.714	5.49	212.786	79.58
50	600	47.038	38.986	8.553	8.212	320.156	79.06
50	800	47.734	39.157	11.372	10.878	425.964	78.47
50	1000	48.085	39.245	14.182	13.541	531.417	77.93
50	1100	48.237	39.149	15.583	14.85	581.351	77.34
75	600	43.986	35.102	8.664	8.379	294.131	77.18
75	800	44.395	35.325	11.517	11.093	391.863	76.64
75	1000	44.862	35.604	14.33	13.726	488.701	76.02
75	1100	44.782	35.368	15.807	15.109	534.358	75.49

#2							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.134	40.922	1.412	1.351	55.268	83.04
15	200	49.867	42.867	2.813	2.699	115.714	82.48
15	400	51.362	43.982	5.620	5.374	236.365	81.89
15	600	51.932	43.861	8.408	8.091	354.863	81.27
15	800	52.436	44.385	11.195	10.662	473.254	80.62
15	1000	52.698	44.288	13.985	13.321	589.955	80.05
25	100	45.764	39.191	1.440	1.379	54.035	82.02
25	200	48.635	41.438	2.845	2.723	112.836	81.54
25	400	49.814	42.158	5.712	5.461	230.232	80.92
25	600	50.612	42.502	8.510	8.146	346.233	80.39
25	800	51.085	42.636	11.321	10.833	461.862	79.86
25	1000	51.461	42.837	14.056	13.429	575.258	79.53
25	1100	51.254	42.436	15.541	14.776	627.035	78.72
50	400	46.439	38.596	5.806	5.499	212.236	79.83
50	600	46.568	38.711	8.568	8.228	318.531	78.24
50	800	47.910	38.968	11.417	10.906	424.968	77.69
50	1000	48.202	39.023	14.218	13.573	529.660	77.28
50	1100	48.065	38.657	15.660	14.966	578.524	76.86
75	600	44.238	35.173	8.679	8.321	292.662	76.23
75	800	44.662	35.225	11.546	11.079	390.258	75.68
75	1000	45.125	35.429	14.368	13.738	486.717	75.07
75	1100	45.016	35.134	15.828	15.135	531.739	74.63

#3							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.062	41.186	1.401	1.342	55.274	83.83
15	200	49.738	42.961	2.810	2.706	116.237	83.18
15	400	51.248	44.037	5.589	5.378	236.814	82.68
15	600	52.017	44.125	8.346	8.061	355.712	81.94
15	800	52.384	44.424	11.130	10.678	474.368	81.36
15	1000	52.670	44.430	13.902	13.307	591.224	80.75
25	100	45.836	39.396	1.413	1.366	53.822	83.12
25	200	48.538	41.722	2.813	2.704	112.831	82.63
25	400	49.984	42.297	5.618	5.448	230.424	82.05
25	600	50.526	42.585	8.425	8.134	346.369	81.37
25	800	51.012	42.734	11.210	10.798	461.428	80.69
25	1000	51.385	43.013	13.962	13.376	575.342	80.19
25	1100	51.434	42.647	15.391	14.759	629.438	79.51
50	400	46.765	38.863	5.724	5.477	212.851	79.96
50	600	46.832	39.164	8.548	8.174	320.108	79.38
50	800	47.863	39.285	11.338	10.870	427.036	78.69
50	1000	48.226	39.257	14.117	13.545	531.740	78.10
50	1100	47.468	38.925	15.628	14.932	581.214	78.35
75	600	44.085	35.286	8.601	8.319	293.561	77.42
75	800	44.576	35.428	11.444	11.053	391.582	76.76
75	1000	44.963	35.624	14.258	13.712	488.474	76.20
75	1100	44.835	35.286	15.707	15.132	533.951	75.82

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]
15.1	1000	52.756	13.961	591.705
20.7	1000	51.989	14.005	584.535
25.0	1000	51.325	14.029	574.978
30.7	1000	50.489	14.057	566.403
35.4	1000	50.191	14.089	557.147
40.2	1000	49.385	14.133	547.920
45.4	1000	48.836	14.152	540.432
50.0	1000	48.085	14.182	531.417

#2				
T [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Isc [A]	Pmp [W]
15.4	1000	52.698	13.985	589.955
20.4	1000	52.045	14.011	581.669
25.2	1000	51.461	14.056	575.258
30.4	1000	50.721	14.091	564.559
35.2	1000	50.236	14.118	556.745
40.1	1000	49.422	14.153	547.606
45.2	1000	48.763	14.172	538.725
50.1	1000	48.202	14.218	529.660

#3				
T [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Isc [A]	Pmp [W]
15.5	1000	52.670	13.902	591.224
20.2	1000	52.027	13.928	582.614
25.2	1000	51.385	13.962	575.342
30.7	1000	50.824	13.989	567.847
35.2	1000	50.125	14.028	558.783
39.5	1000	49.411	14.057	548.826
45.2	1000	48.763	14.079	538.838
50.0	1000	48.226	14.117	531.740

3.3.1 Temperature Coefficients

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

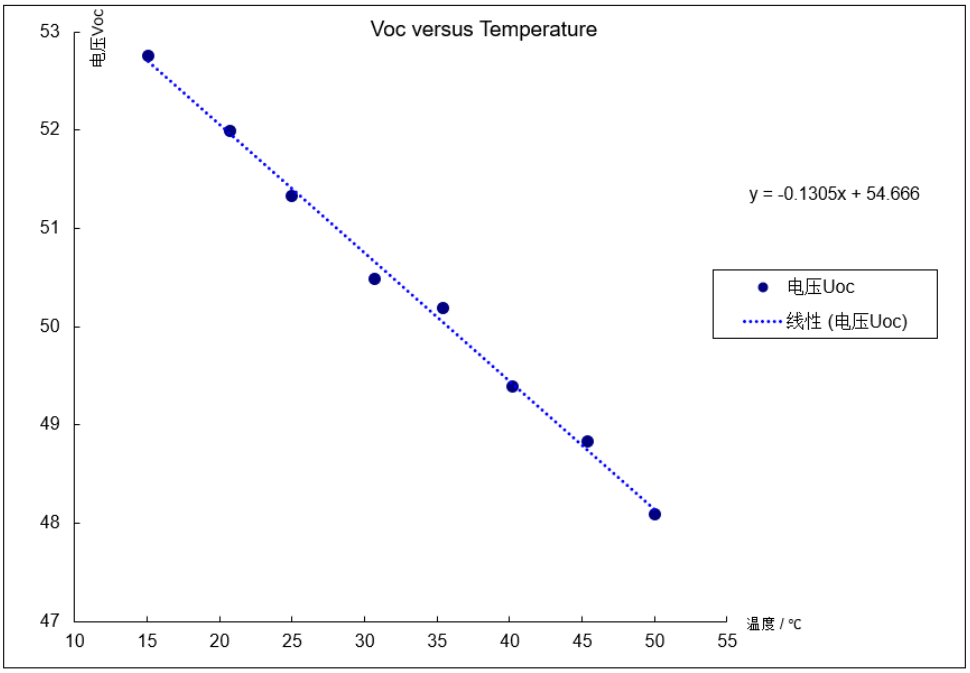


Figure 2:
Plot of measured P_{MAX} vs. temperature of flash-tests taken at 1000 W/m² for sample #1

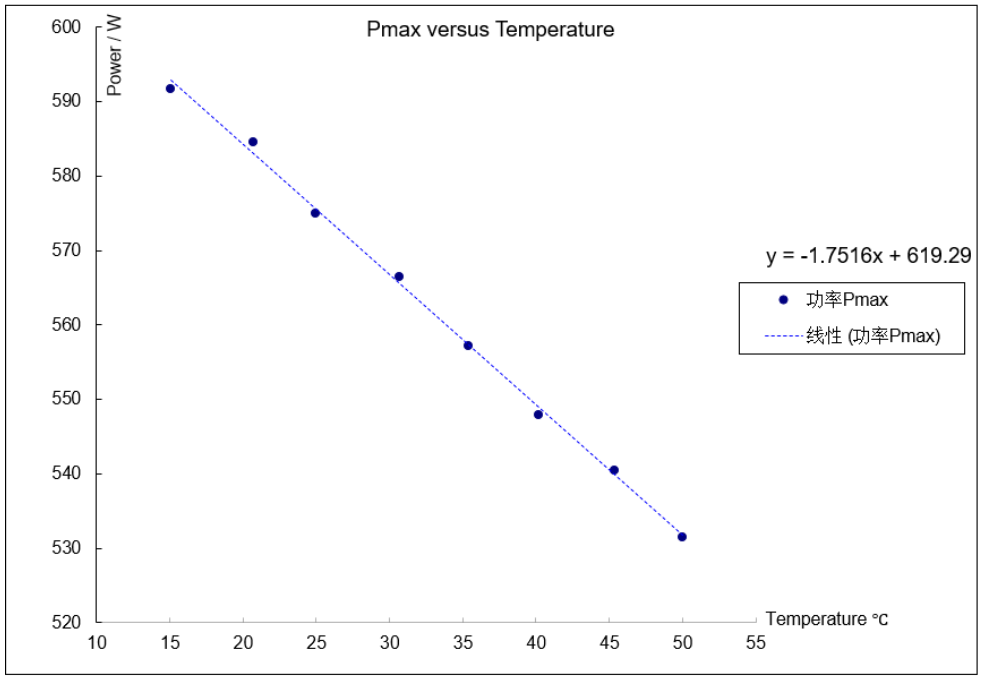


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Figure 3:
Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m^2 for sample #1

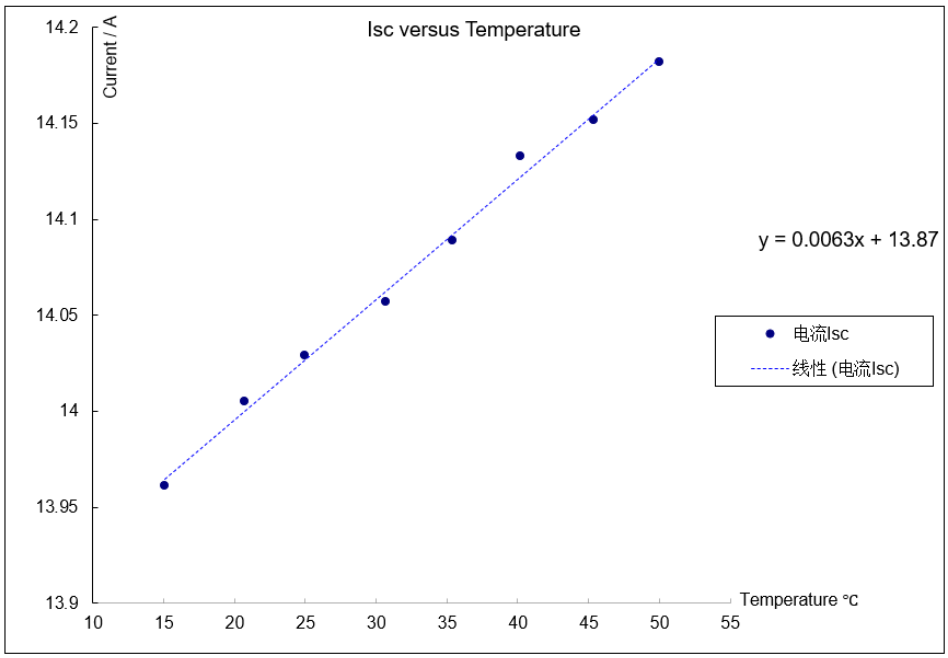

Figure 4:
Plot of measured Voc vs. temperature of flash-tests taken at 1000 W/m^2 for sample #2

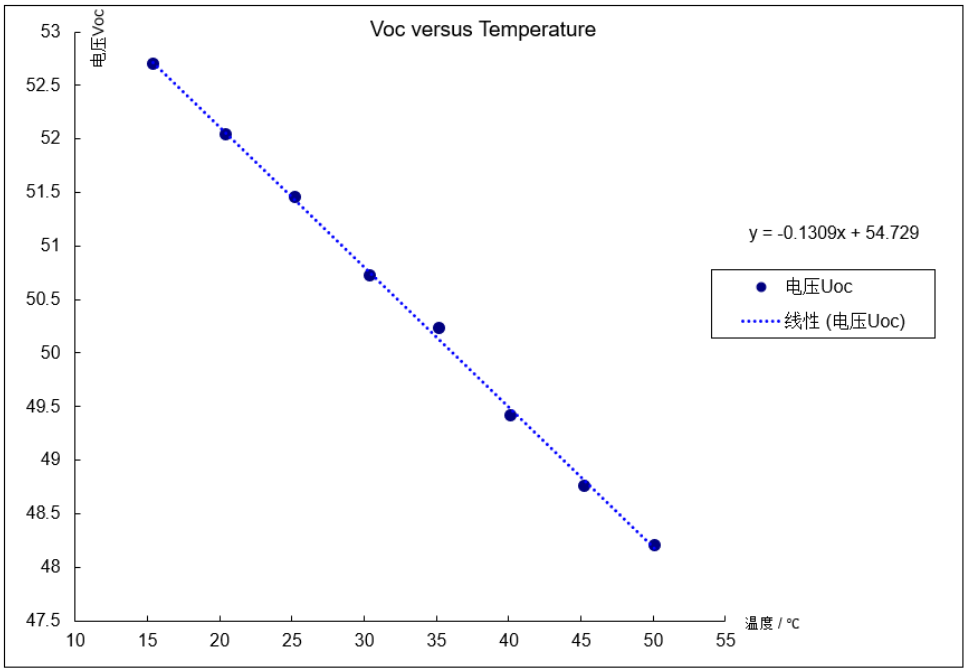

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Figure 5:
Plot of measured P_{MAX} vs. temperature of flash-tests taken at 1000 W/m^2 for sample #2

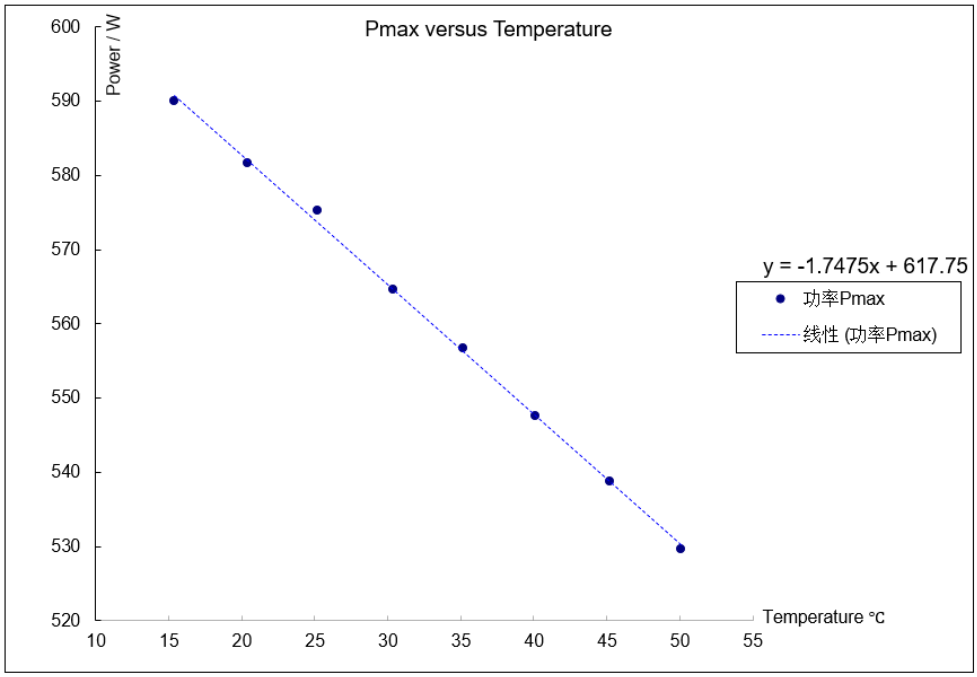


Figure 6:
Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m^2 for sample #2

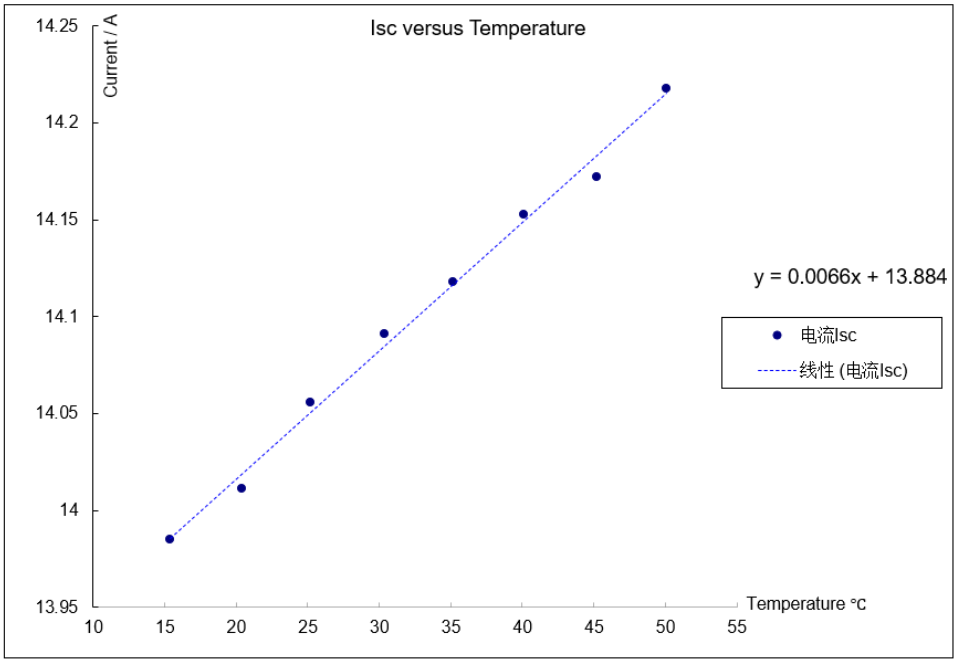


Figure 7:
Plot of measured Voc vs. temperature of flash-tests taken at 1000 W/m² for sample #3

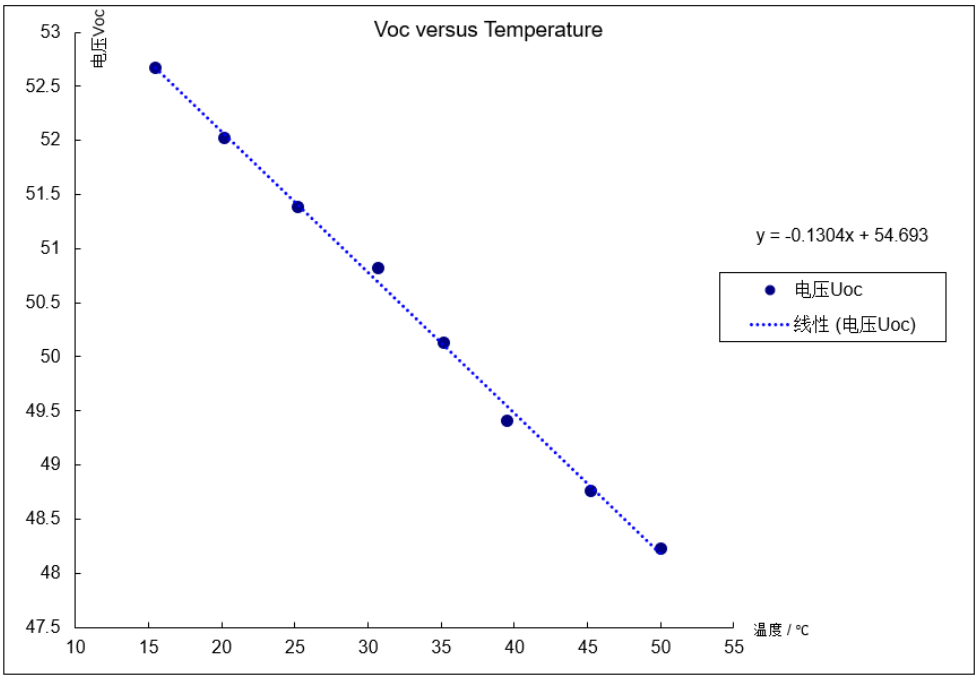


Figure 8:
Plot of measured P_{MAX} vs. temperature of flash-tests taken at 1000 W/m² for sample #3

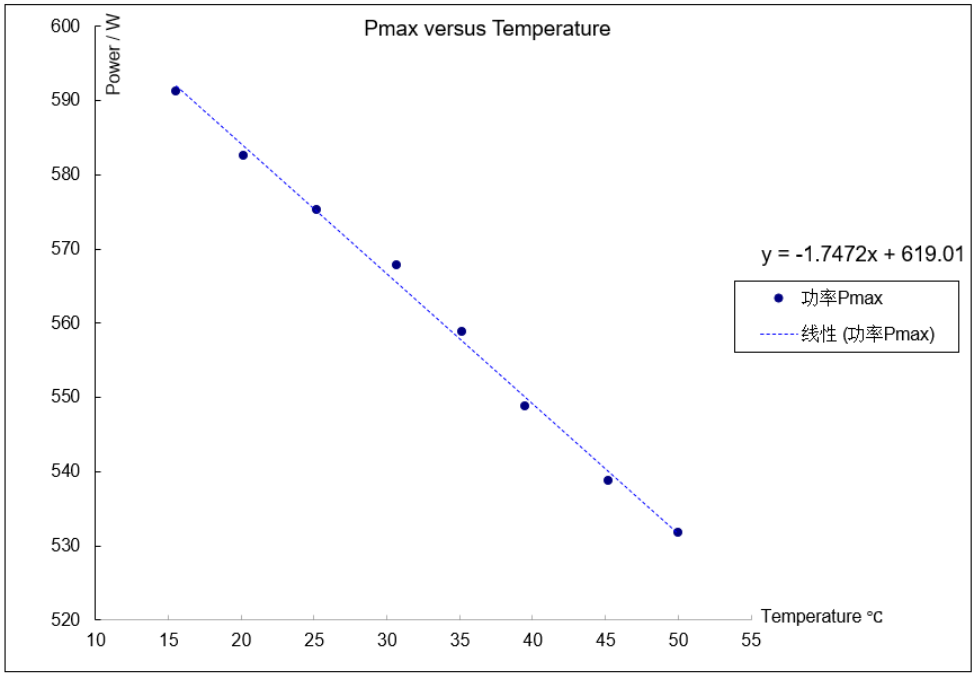


Figure 9:
Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m² for sample #3

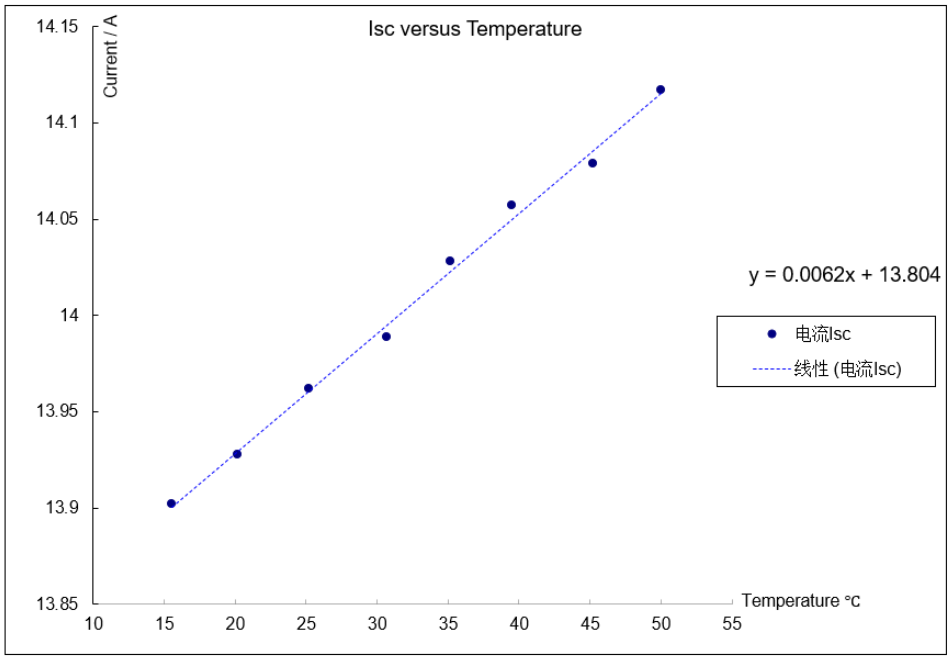


Table 4:
Average Temperature Coefficients Determined by Laboratory Results

Sample No	Alpha (α) ISC [%]	Beta (β) VOC [%]	Gamma (γ) PMAX [%]
#1	0.045	-0.252	-0.304
#2	0.046	-0.257	-0.311
#3	0.044	-0.256	-0.308

3.3.2 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	55.323	53.909	-	-
200	116.073	112.877	-	-
400	236.782	230.298	212.624	-
600	355.333	346.166	319.598	293.451
800	473.812	461.471	425.989	391.234
1000	590.961	575.193	530.939	487.964

1100	-	628.140	580.363	533.349

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	55.305	53.891	-	-
200	116.034	112.839	-	-
400	236.703	230.221	212.553	-
600	355.214	346.050	319.491	293.353
800	473.653	461.316	425.846	391.103
1000	590.763	575.000	530.761	487.800
1100	-	627.930	580.168	533.170

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	93.72%	98.12%	100.10%	100.30%	100.29%	100.00%	99.28%

3.4 PAN File Creation

3.4.1 PAN File Creation Method

The PAN file contains a number of model parameters organized in different tabs within PVsyst. The checksum of PAN file is ”7565EBFF4DE2ACEE58D3130A967D71EE” by MD5.
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 Da-ta/Low-light data” , and optimized the Rserie; It is mentioned that the relative efficiency is calculated after scale the average measured PMAX 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;

3.4.2 Optimized PAN File Results

PV module - 575C (HBD) 72 (182)

Manufacturer	LESSO	**Commercial data**	
Model	575C (HBD) 72 (182)	Data source :	TUV SUD
Pnom STC power (manufacturer)	575 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)	51.2 V	Short-circuit current (Isc)	14.27 A
Max. power point voltage (Vmpp)	42.6 V	Max. power point current (Impp)	13.50 A
=> maximum power (Pmpp)	575.1 W	Isc temperature coefficient (muIsc)	6.4 mA/°C

One-diode model parameters

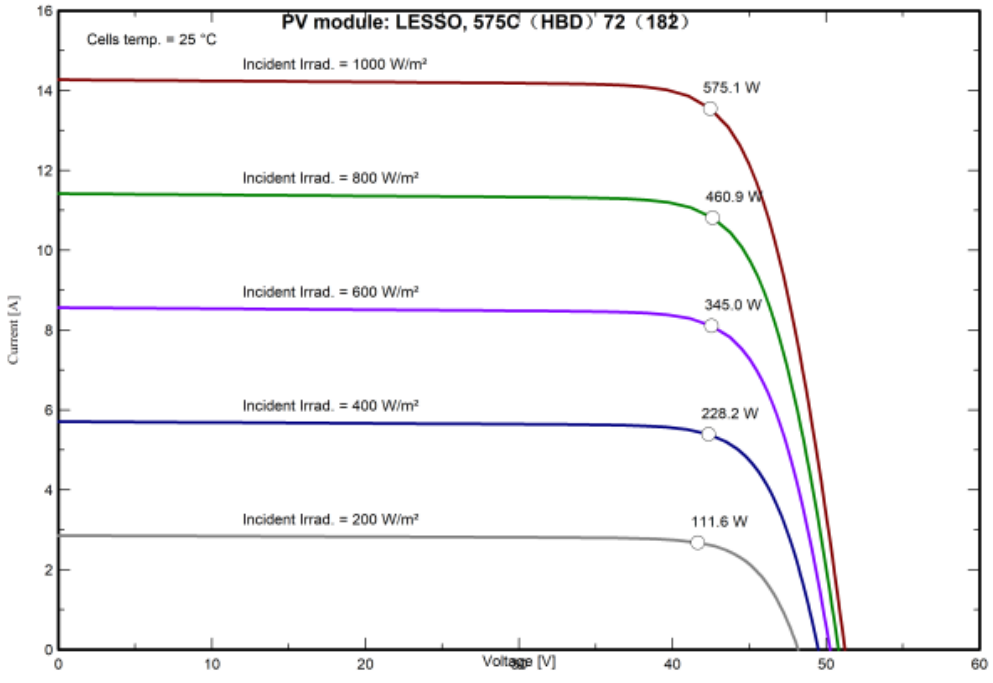
Shunt resistance (Rshunt)	350 Ω	Diode saturation current (IoRef)	0.020 nA
Serie resistance (Rserie)	0.21 Ω	Voc temp. coefficient (MuVoc)	-130 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.31 %/°C	Diode quality factor (Gamma)	1.01
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

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)	42.5 V	Max. power point current (Impp)	13.58 A
Maximum power (Pmpp)	575.1 Wp	Power temper. coefficient (muPmpp)	-0.31 %/°C
Efficiency(/ Module area) (Eff_mod)	22.3 %	Fill factor (FF)	0.787
Efficiency(/ Cells area) (Eff_cells)	24.1 %		



3.4.3 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.

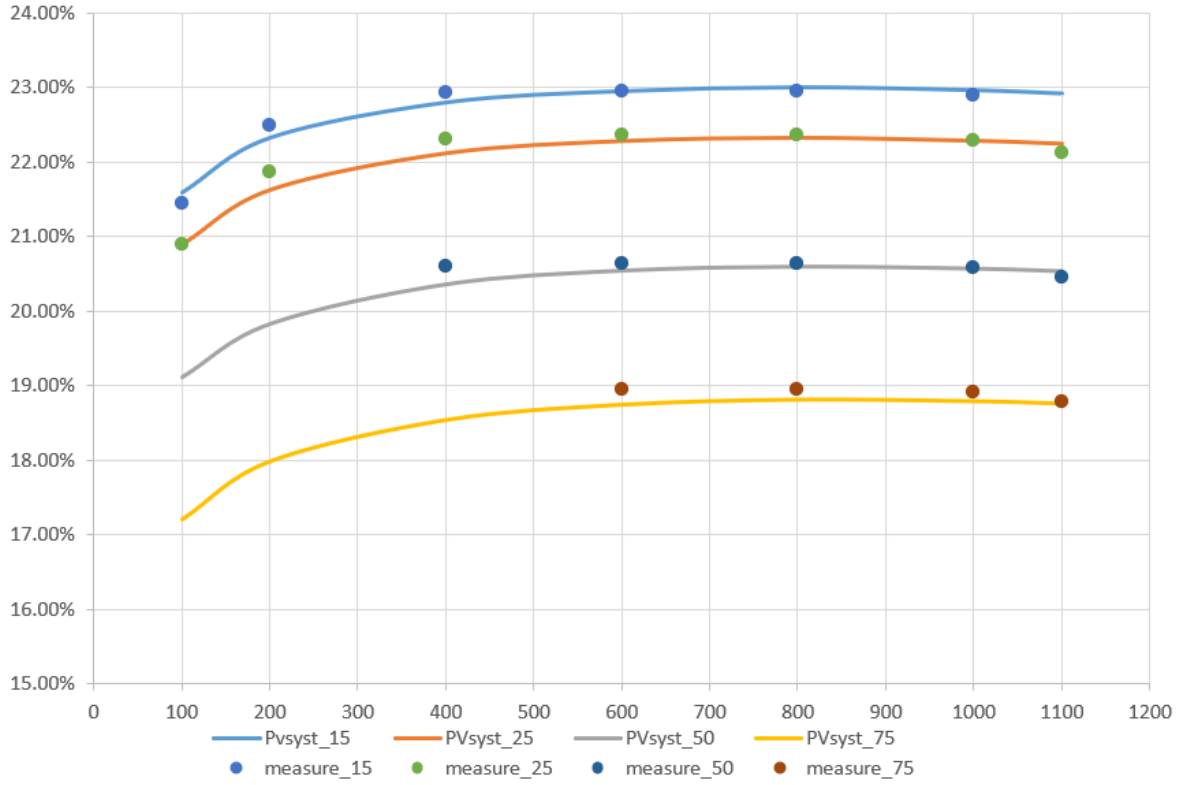
Table 8:
Efficiency Determined by Laboratory Results Scaled to Nameplate Power at STC

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m^2]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	21.44%	20.89%	-	-
200	22.49%	21.87%	-	-
400	22.94%	22.31%	20.60%	-
600	22.95%	22.35%	20.64%	18.95%
800	22.95%	22.35%	20.63%	18.95%
1000	22.90%	22.29%	20.57%	18.91%
1100	-	22.13%	20.44%	18.79%

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	21.59%	20.89%	19.11%	17.21%
200	22.33%	21.63%	19.83%	17.98%
400	22.80%	22.12%	20.36%	18.54%
600	22.95%	22.29%	20.54%	18.74%
800	23.00%	22.33%	20.60%	18.81%
1000	22.97%	22.29%	20.57%	18.79%
1100	22.92%	22.25%	20.54%	18.76%

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

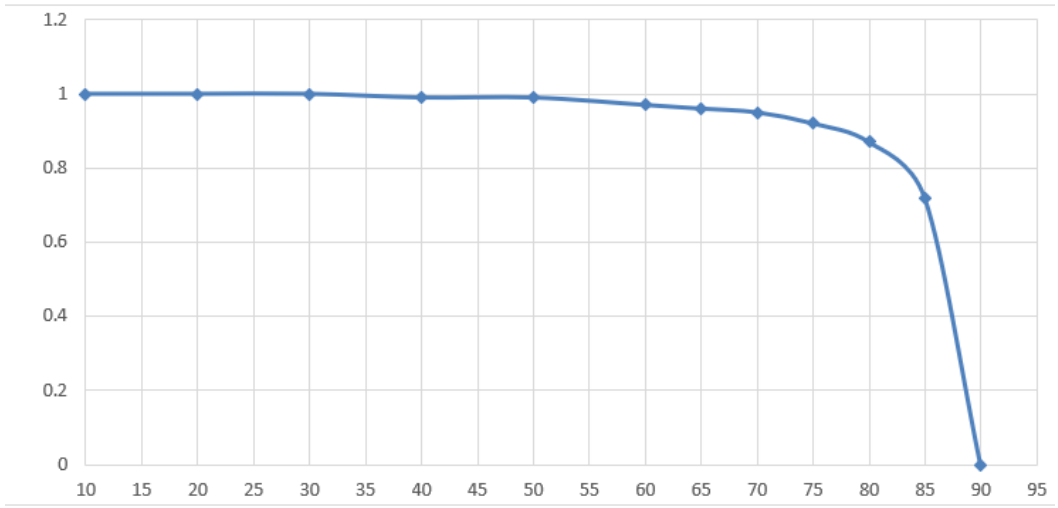


3.4.4 Measurement of incidence angle effects

Sample No				#4			-
Isc_80°/A:				1.005			-
Isc_-80°/A:				0.997			-
Isc_0°/A:				6.930			-
m=(Isc_80°/Isc_0°)/ cos 80°				0.835			-
n=(Isc_-80°/Isc_0°)/ cos 80°				0.828			-
DeviationΔ=|(m-n)/(m+n)|×100% ≤2%				0.4			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	-	-	6.930	-	-	1.00	1.00
10	-	-	6.838	-	-	1.00	1.00
20	-	-	6.529	-	-	1.00	1.00

30	-	-	6.003	-	-	1.00	1.00
40	-	-	5.313	-	-	1.00	0.99
50	-	-	4.456	-	-	1.00	0.99
60	-	-	3.449	-	-	1.00	0.97
65	-	-	2.878	-	-	0.98	0.96
70	-	-	2.250	-	-	0.95	0.95
75	-	-	1.633	-	-	0.91	0.92
80	-	-	1.005	-	-	0.83	0.87
85	-	-	0.445	-	-	0.74	0.72

Fitted curve



$\tau(\theta) = 1 - bo \times (1/\cos(\theta) - 1)$ (formula according to PVsystem), $b_0 = 0.0266$

4. Test History

N/A

5. Remarks

N/A

6. Documentation

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

A1.1	**MODULE TYPE/S**	
	575C(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 ..... :	N type Bifacial TOPCON Cell, Cell type: NM1016BF1B3, 16BB Cell dimensions L x W: 182.0 × 91.0 ± 0.5(mm) Cell thickness: 150 ± 15.0 (μm) Jiangsu Runergy New 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:Anti-reflective coating low iron patterend solar glass, Thickness: 2.0(mm) XINYI PV PRODUCTS (ANHUI) HOLDINGS Ltd.
	Encapsulation material ..... :	Material: POE, Tpye: EP304 ((contact with glass) Thickness: 0.50mm±0.10mm Material: POE, Tpye: EP304 (contact with backsheet) Thickness: 0.50mm±0.10mm 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, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.

	Cell connector..... :	Type: Tin-coated copper ribbon, Cross section: Φ=0.26 (mm), Xi'an Telison New Materials Co.,Ltd
	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, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Cable..... :	Type H1Z2Z2-K 1×4mm^2, WUXI XINHONGYE WIRE & CABLE CO., LTD.
	Connector ..... :	Type: PV-CO02,1500V DC,30A, -40 to 85°C, IP68(1m, 1h) Suzhou UKT New Energy Technology Co., Ltd.
	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	2024.03.06	-

Annex 3: 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)

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7. 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

TÜV SÜD Certification and Testing (China) Co., Ltd. Guangzhou Branch
TÜV SÜD Group

Tested by: Wendy Zhao
(Project Handler)
printed name, function & signature

Approved by: Tom Cai
(Designated Reviewer)
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