CEA I PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | Trina

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Date: 23 May 2024
Form Version: V1.0

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1. INTRODUCTION

As part of CEA's engagement in developing and supervising PV Magazine's test program at Gsola, CEA has developed a testing protocol and flowchart, a scoring system, a methodology and a reporting structure that it will be used to run this program. This report presents the test results and scoring grades for this product.

2. SCORING SYSTEM

2.1. Test flowchart and protocol

The following is a high-level flowchart of the testing procedure, describing the steps, and tests to be followed. Detailed checklists have been delivered to Gsola, that will also serve as records of the process.

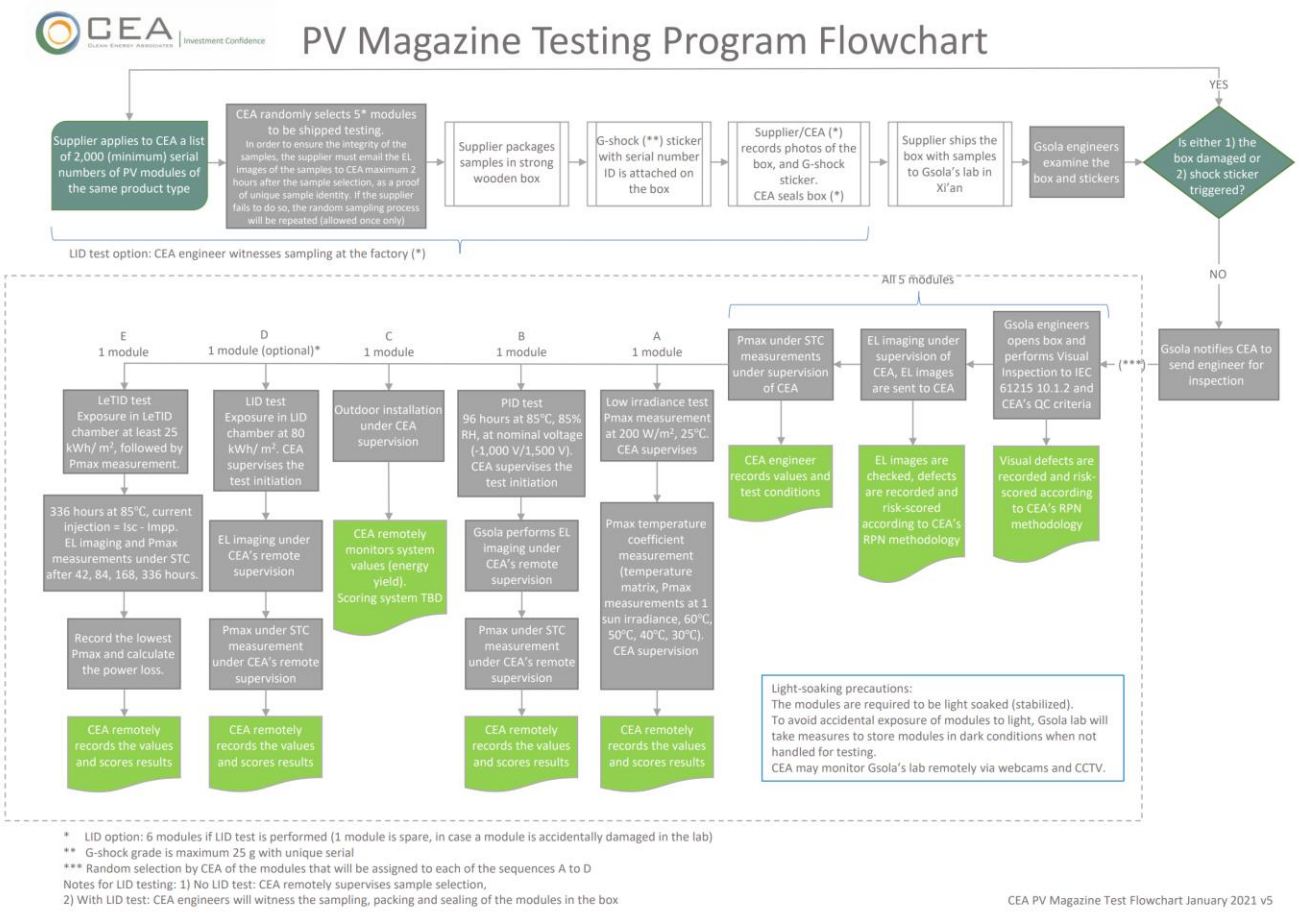


Figure 1 Test flowchart

2.2. Scoring methodology

For every product, 5 samples have been shipped to Gsola's lab to conduct the tests and inspections according to the above flowchart.

The following table describes the inspections and tests that have been applied on all products:

Table 1 Test/inspection grading system overview

	Test/inspection	# of samples	Method	Values	Average grade weight	Grades
1	Visual inspection	5	Inspection	RPN Scores	10%	1-100
2	EL image inspection	5	Inspection	RPN Scores	10%	1-100
3	Low irradiance efficiency loss	1	Test	%	25%	1-100
4	Pmax Temperature coefficient	1	Test	%/°C	25%	1-100
5	PID loss	1	Test	%	30%	1-100
6	LID loss (optional)	1	Test	%	NA	1-100
7	LeTID	1	Test	%	NA	1-100
8	Outdoor installation and yield measurement	1	Energy Yield Monitoring	Periodic kWh/kWp	NA	NA

Notes:

1. The RPN scoring method has been developed by CEA and is used to evaluate and create risk scores of Visual and EL defects.
2. The weights are used to calculate the average grade for tests 1-5.

A number within the 1-100 range will be used to grade the results, so that the overall ranking of the products will reflect general industry practices and requirements:

Table 2 Detailed scoring system

	Grade range:	100	90	80	70	60	50	40	30	20	10	0
1	Visual inspection (RPN scores)	0	0.74	2.20	4.39	7.30	10.94	15.30	20.39	26.20	32.74	≥ 40
2	EL image (RPN scores)	0.00	2.03	4.62	7.75	11.43	15.65	20.43	25.75	31.62	38.03	≥ 45.00
3	Low irradiance loss	≤ -2.00%	-0.02%	1.78%	3.41%	4.87%	6.16%	7.27%	8.21%	8.98%	9.58%	≥ 10.00%
4	Pmax Temp. coefficient	≥ -0.300%	-0.343%	-0.382%	-0.417%	-0.448%	-0.475%	-0.498%	-0.517%	-0.532%	-0.543%	≤ -0.550%
5	PID loss	≤ 0.0%	0.7%	1.6%	2.7%	4.0%	5.5%	7.2%	9.1%	11.2%	13.5%	≥ 16.0%
6	LID loss (optional)	≤ -0.50%	0.35%	1.20%	2.05%	2.90%	3.75%	4.60%	5.45%	6.30%	7.15%	≥ 8.00%
7	LeTID	≤ 0%	0.30%	0.60%	0.90%	1.20%	1.50%	1.80%	2.10%	2.40%	2.70%	≥ 3.00%

Notes:

1. The Visual and EL Inspection RPN scores will be divided by the number of samples, to normalize the score, as the total number of samples may vary.
2. The correspondence of the scores/test results to the grades follows a binomial or linear relationship, anchored to certain key values that are generally accepted and employed in the PV industry. For example, a PID loss of 5%,

which is the pass/fail threshold of the related IEC standard, will give a grade close to 50. In this sense, grades below 50 indicate a product performance that is below a generally acceptable threshold.

The scoring system shown in Table 2 is preliminary, and will be adjusted as the testing program develops, in order to better reflect the products standing per industry standards.

3. TEST DETAILS

A sample lot consists of 5 modules, one of which has been used as a spare for the chamber and outdoor testing, in case a module is accidentally damaged during handling at the lab. Refer to Table 3 and Table 4 for test sample and product information.

Table 3 Test sample information

Sample #	Serial number
1	A12240400100005
2	A12240400100002
3	A12240400100006
4	A12240400100001
5	A12240400100003
6	A12240400100007

Table 4 Product information

Model	TSM-685NEG21C.20
Cell technology	TOPCon
Cell number	132
Cell format	210x210 mm
Number of busbars	14
Junction box	IP68, 3 bypass diodes
Laminate construction	Glass
Bifaciality ratio	80%

Figure 2 Product nameplate

3.1. Visual inspection

All 5 modules of each product sample lot have undergone visual inspection, according to CEA's quality criteria for visual inspection. The defects found has been evaluated according to CEA's scoring system. The scoring system is a modified version of CEA's proprietary RPN (risk priority number) system, based on the formula RPN score = Severity x Detectability.

Table 5 Product picture

Front Side	Rear Side
	

The following table shows the visual inspection results, normalized for the number of tested modules:

Table 6 Visual inspection results

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Score	Grade
Visual inspection	None	None	None	None	None	None	0	100

3.2. EL image Inspection

The same sample lot was inspected for EL defects.
Table 7 shows the EL inspection results normalized for the number of tested modules. Visual and EL inspection scores are shown below in Figure 3.

Table 7 EL image inspection results

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Score	Grade
EL image inspection	None	None	None	None	None	None	0	100

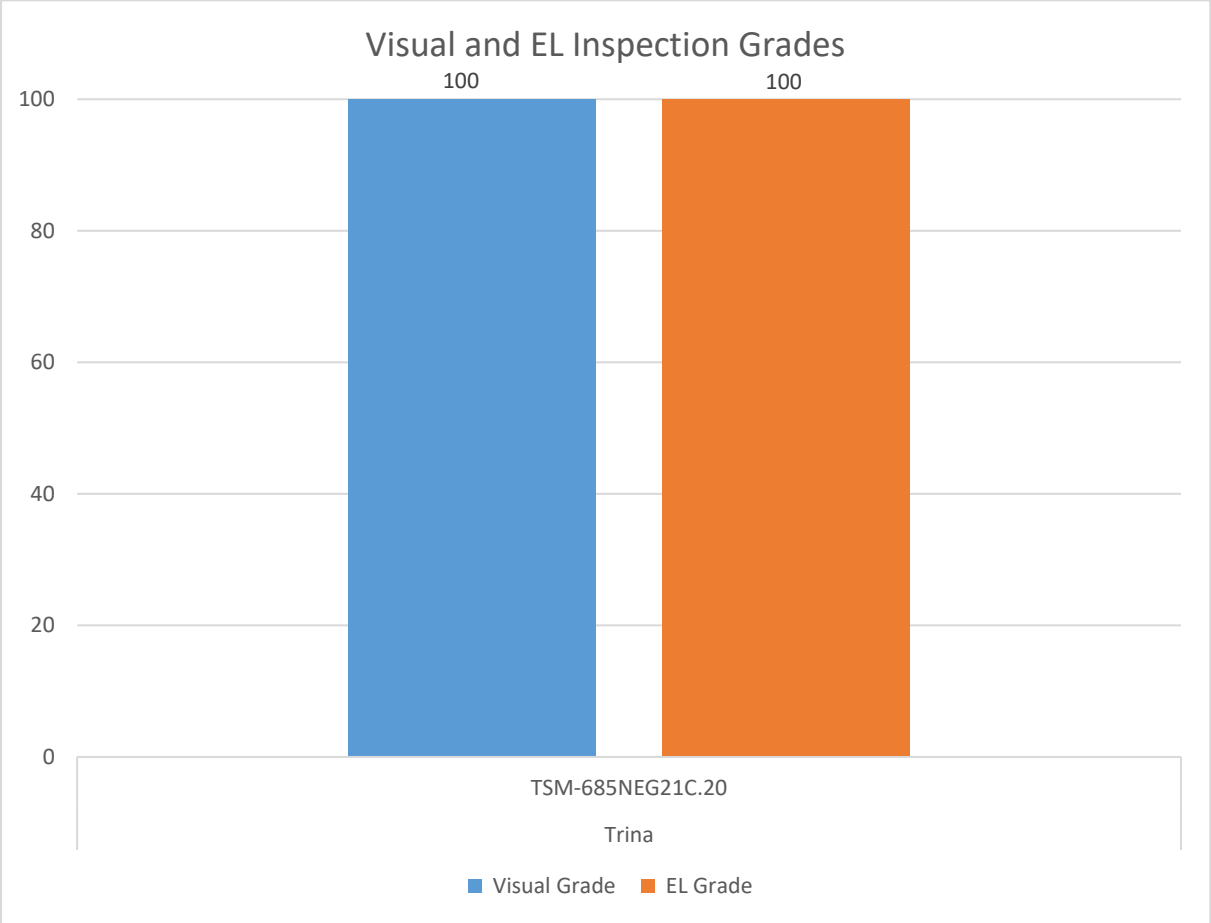


Figure 3 Visual and EL inspection results

3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

Efficiency loss = 1- [(Pmax at low irradiance conditions / Pmax at STC) * (1,000/200)]

Table 8 and Figure 4 show the low irradiance efficiency test results for the front side.

Table 8 Low irradiance test results

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Grade
Front side low irradiance efficiency loss (%)	1.90%						79

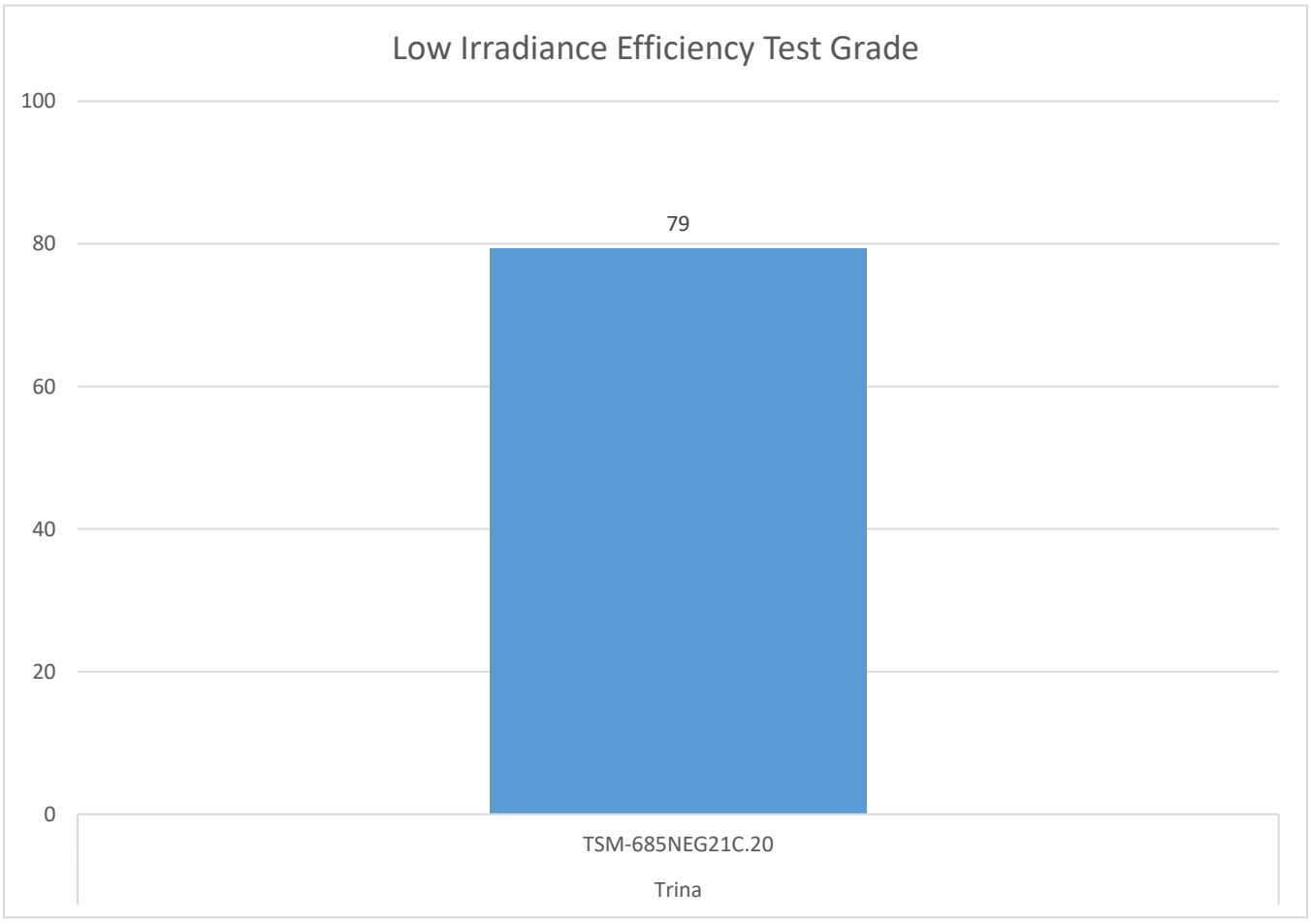


Figure 4 Low irradiance test result

3.4. Pmax temperature coefficient test

Table 9 and Figure 5 depict the Pmax temperature coefficient test results.

Table 9 Pmax temperature coefficient test result

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Grade
Pmax Temperature coefficient (%/°C)		-0.29%					102

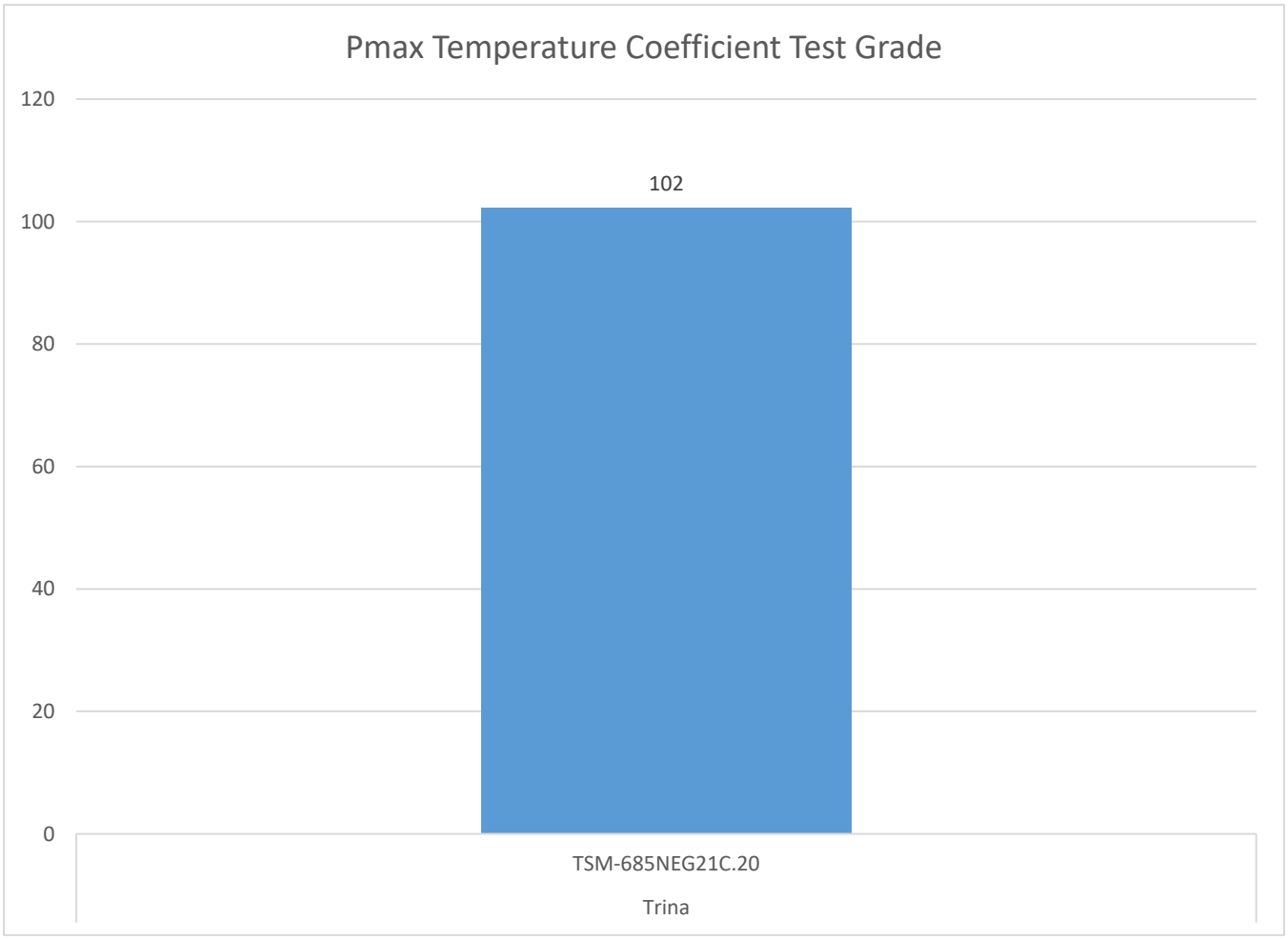


Figure 5 Pmax temperature coefficient test result

3.5. PID loss test

Table 10 and Figure 6 depicts the PID loss test results for the front side at **1500 V**:

Table 10 PID loss test result

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Grade
Front side PID loss (%)				-0.21%			100

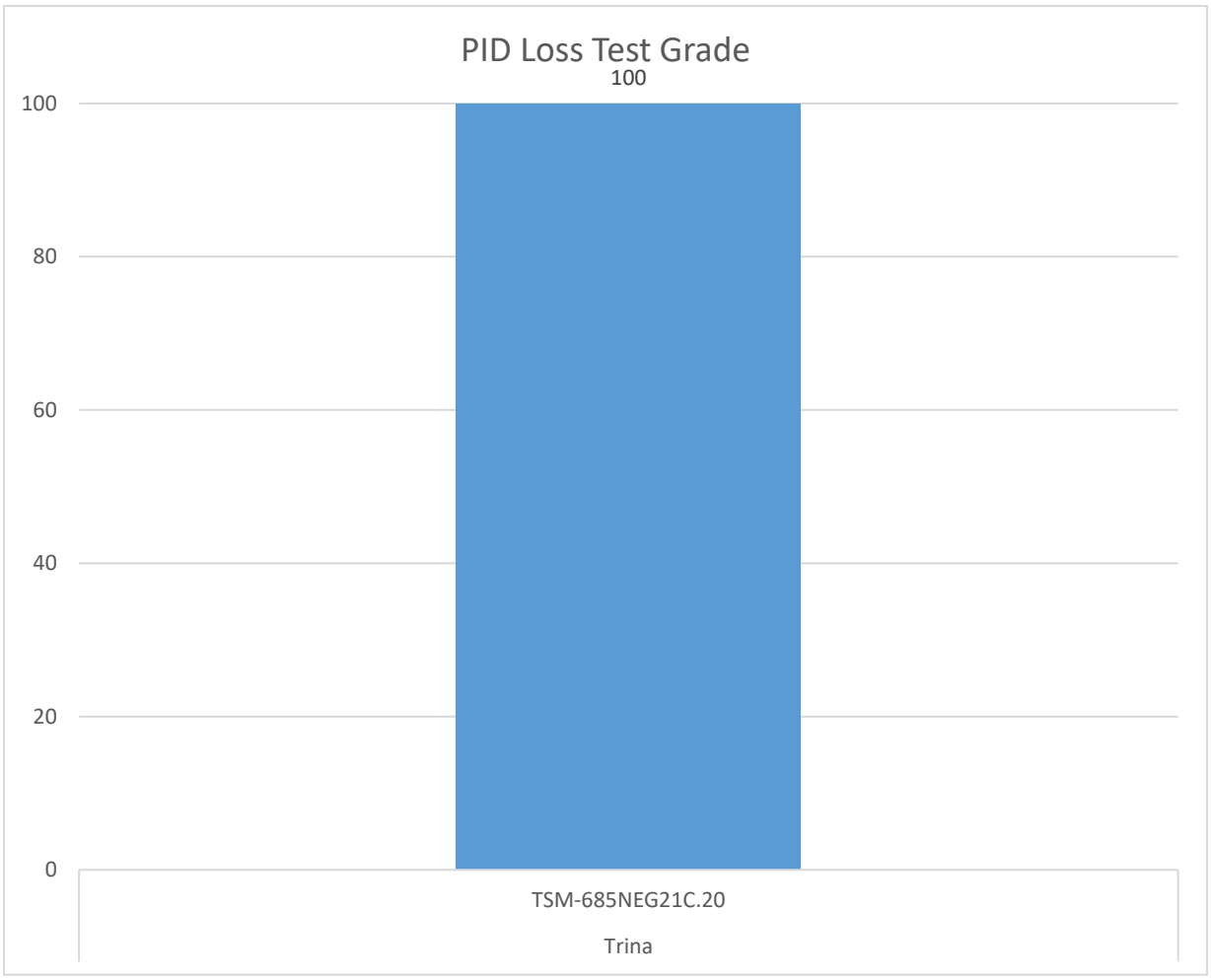


Figure 6 PID loss test result

3.6. Bifaciality ratio

The bifaciality ratio test result is not graded. We list the results here for informational purposes. The table below shows the bifaciality ratio results:

Table 11 Bifaciality ratio test results

TSM-685NEG21C.20	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
Bifaciality ratio (%)	76.85%	76.52%	77.04%	76.73%	76.43%	76.51	76.68%

The bifaciality ratio is calculated from the following formula:

Bifaciality ratio = (Pmax rear surface / Pmax front surface) * 100%

3.7. Score overview

Figure 7 shows the overview of the test scores. Figure 8 shows the average score.

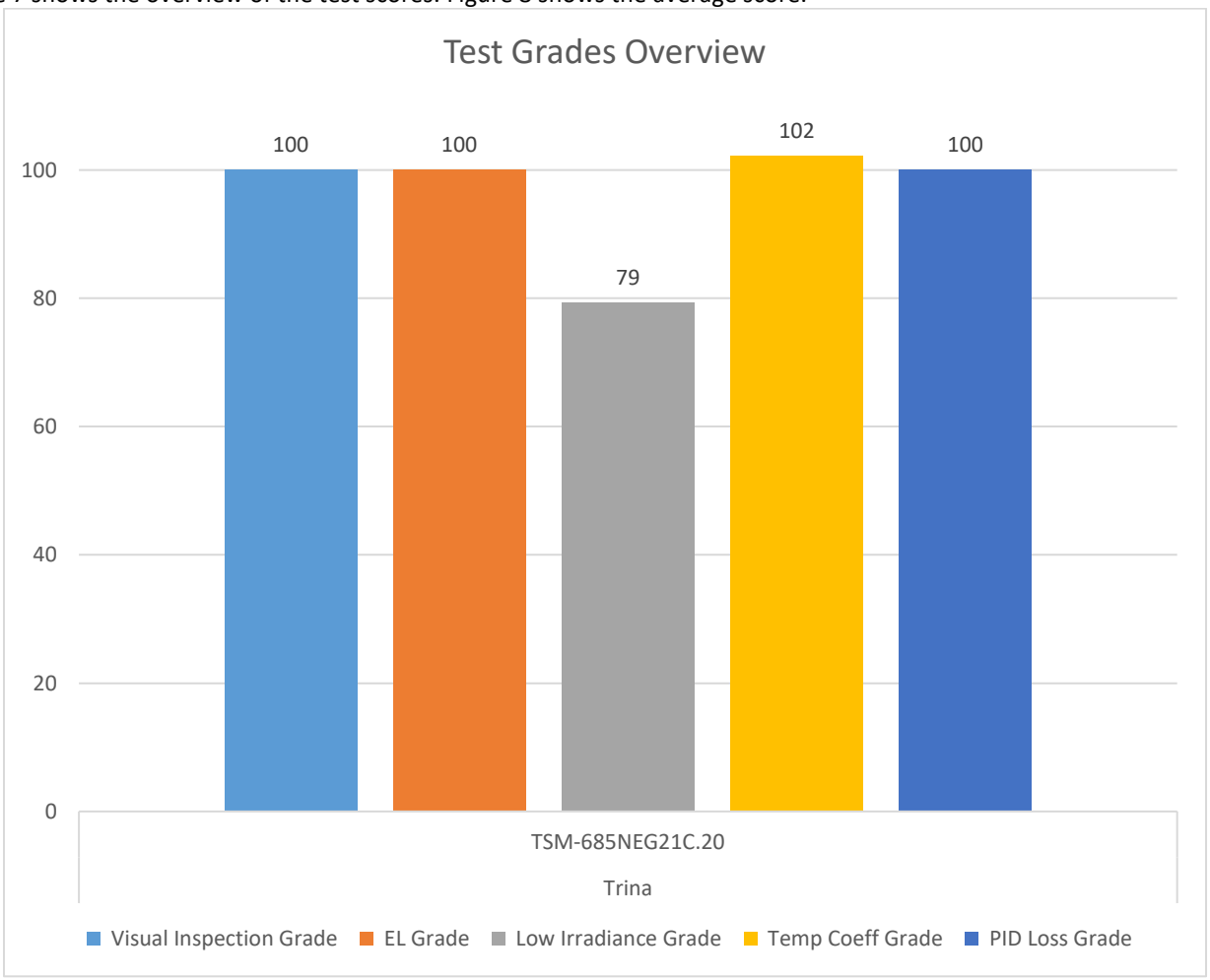


Figure 7 Test results overview

NOTE: The Average grade does **NOT** include the LID test, as it is optional and not performed for all products.

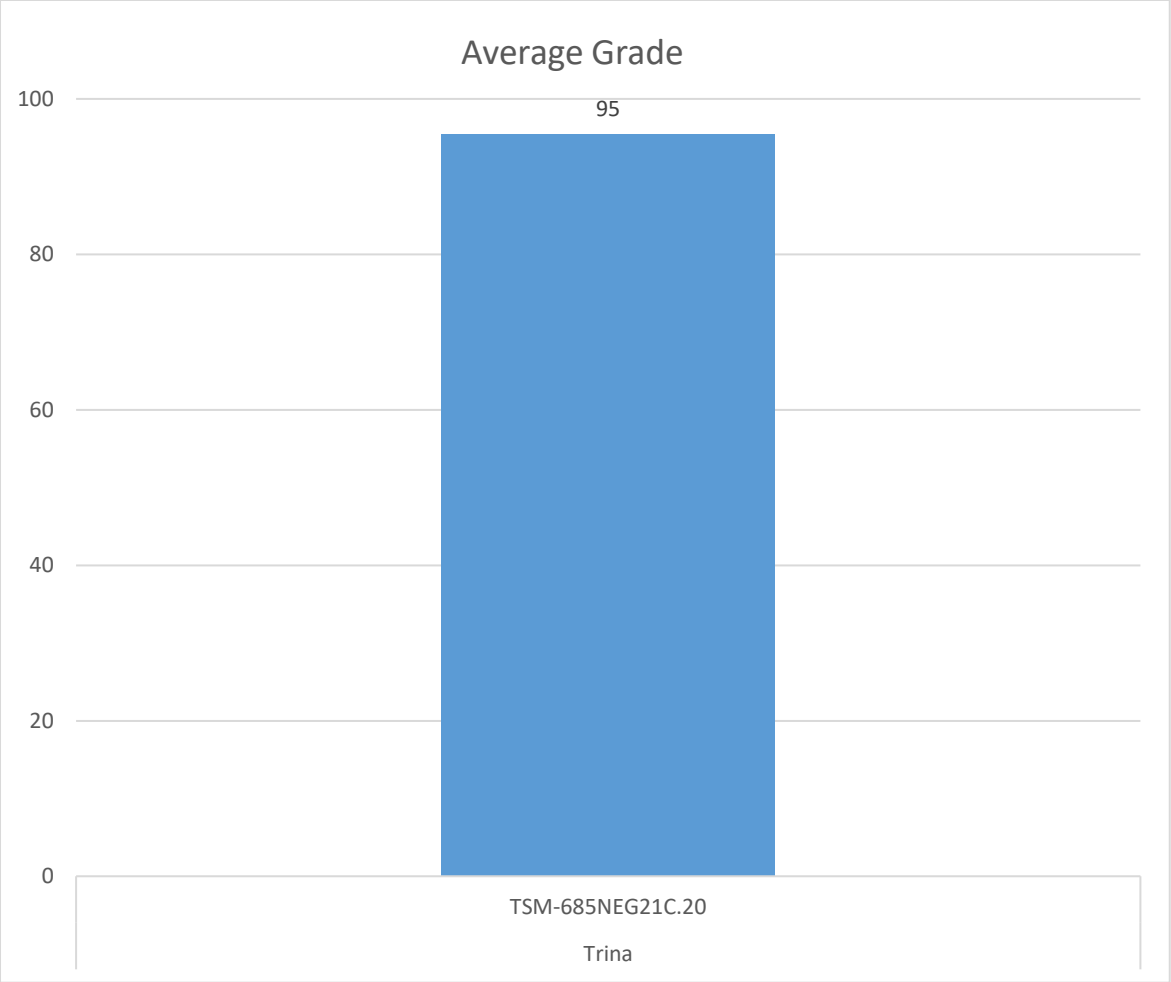


Figure 8 Average test grade

Appendix 1 – TSM-685NEG21C.20 Datasheet

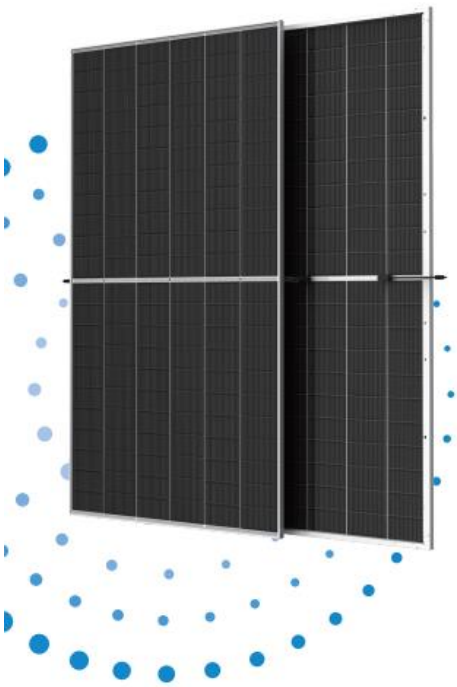
Mono Multi Solutions

Vertex N

N-type i-TOPCon bifacial dual glass
Monocrystalline module

PRODUCT: TSM-NEG21C.20
PRODUCT RANGE: 675-700W

700W	0~+5W	22.5%
MAXIMUM POWER OUTPUT	POSITIVE POWER TOLERANCE	MAXIMUM EFFICIENCY



High customer value

- The star of LCOE (Levelized Cost Of Energy) .Higher string power feature effectively reduces BOS (Balance of System)and LCOE
- More energy harvest with cutting-edge N-type i-TOPCon technology
- Designed for compatibility with existing mainstream system components

High power up to 700W

- Up to 22.5% module efficiency with high density interconnect technology
- SMBB (Super multi-busbar) technology for better light trapping effect, lower series resistance and improved current collection

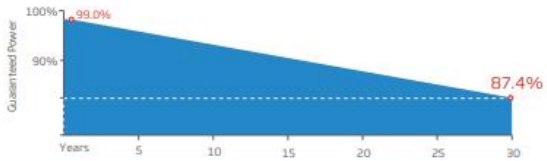
High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield

- Excellent product bifaciality and low irradiation performance, validated by 3rd party
- Lower degradation: 1% first year, 0.4% annually thereafter
- Lower temperature coefficient (-0.30%)
- Up to 30% additional power gain from back side depending on albedo

Trina Solar's Vertex Bifacial Dual Glass Performance Warranty



Comprehensive Products and System Certificates

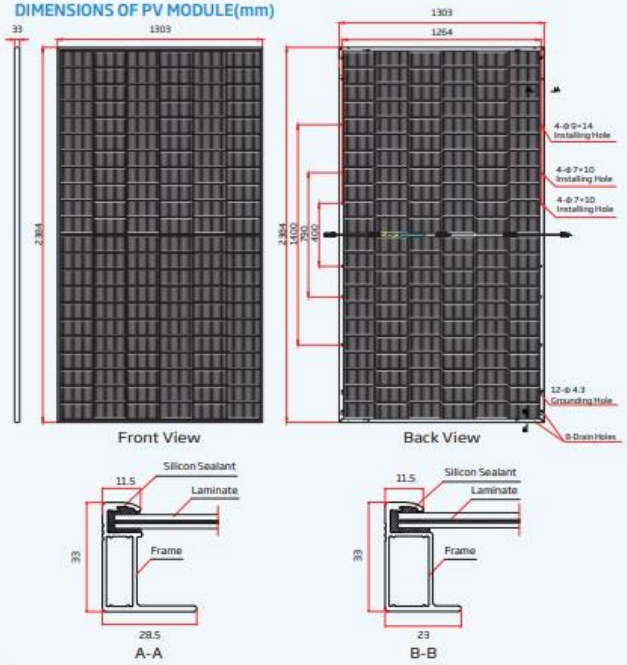
IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

Trinasolar

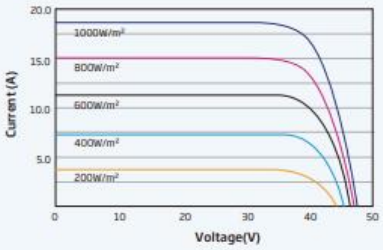
Vertex N

N-type i-TOPCon bifacial dual glass Monocrystalline module

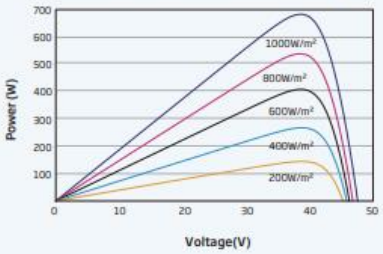
DIMENSIONS OF PV MODULE(mm)



I-V CURVES OF PV MODULE(690W)



P-V CURVES OF PV MODULE(690 W)



MECHANICAL DATA

Solar Cells	N-type Monocrystalline
No. of cells	132 cells
Module Dimensions	2384×1303×33 mm (93.86×51.30×1.30 inches)
Weight	38.3 kg (84.4 lb)
Front Glass	2.0 mm (0.08 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant material	POE/EVA
Back Glass	2.0 mm (0.08 inches), Heat Strengthened Glass (White Grid Glass)

Frame	33mm(1.30 inches) Anodized Aluminium Alloy
J-Box	IP68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²) Portrait: 350/280 mm(13.78/11.02 inches) Length can be customized
Connector	MC4 EVO2 / TS4 PLUS / TS4*

*Please refer to regional datasheet for specified connector.

ELECTRICAL DATA (STC & NOCT)

Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Peak Power Watts-PMAX (Wp)*	675	514	680	517	685	521	690	526	695	530	700	534
Power Tolerance-PMAX (W)	0~+5											
Maximum Power Voltage-VMPP (V)	39.4	37.0	39.6	37.2	39.8	37.3	40.1	37.7	40.3	37.8	40.5	38.0
Maximum Power Current-IMPP (A)	17.12	13.89	17.16	13.91	17.19	13.94	17.23	13.96	17.25	14.02	17.29	14.05
Open Circuit Voltage-VOC (V)	47.2	44.7	47.4	44.9	47.7	45.2	47.9	45.4	48.3	45.8	48.6	46.0
Short Circuit Current-ISC (A)	18.14	14.62	18.18	14.65	18.21	14.67	18.25	14.71	18.28	14.73	18.32	14.76
Module Efficiency ηm (%)	21.7		21.9		22.1		22.2		22.4		22.5	

STC: Irradiance 1000W/m2, Cell Temperature 25°C, Air Mass AM1.5. NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s. *Measuring tolerance: ±3%.

Electrical characteristics with different power bin (reference to 5% & 10% backside power gain)

Backside Power Gain	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%
Total Equivalent power -PMAX (Wp)	709	743	714	748	719	754	725	759	730	765	735	770
Maximum Power Voltage-VMPP (V)	39.4	39.4	39.6	39.6	39.8	39.8	40.1	40.1	40.3	40.3	40.5	40.5
Maximum Power Current-IMPP (A)	17.98	18.83	18.02	18.88	18.05	18.91	18.09	18.95	18.11	18.98	18.15	19.02
Open Circuit Voltage-VOC (V)	47.2	47.2	47.4	47.4	47.7	47.7	47.9	47.9	48.3	48.3	48.6	48.6
Short Circuit Current-ISC (A)	19.05	19.95	19.09	20.00	19.12	20.03	19.16	20.08	19.19	20.11	19.24	20.15

Power Bifaciality:80±5%.

TEMPERATURE RATINGS

NOCT (Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of PMAX	-0.30%/°C
Temperature Coefficient of VOC	-0.24%/°C
Temperature Coefficient of ISC	0.04%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85° C
Maximum System Voltage	1500V DC (IEC) 1500V DC (UL)
Max Series Fuse Rating	35A

WARRANTY

12 year Product Workmanship Warranty

30 year Power Warranty

1% first year degradation

0.40% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 33 pieces

Modules per 40' container: 594 pieces

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2023_C

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