

# CEA | PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | Trina

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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.

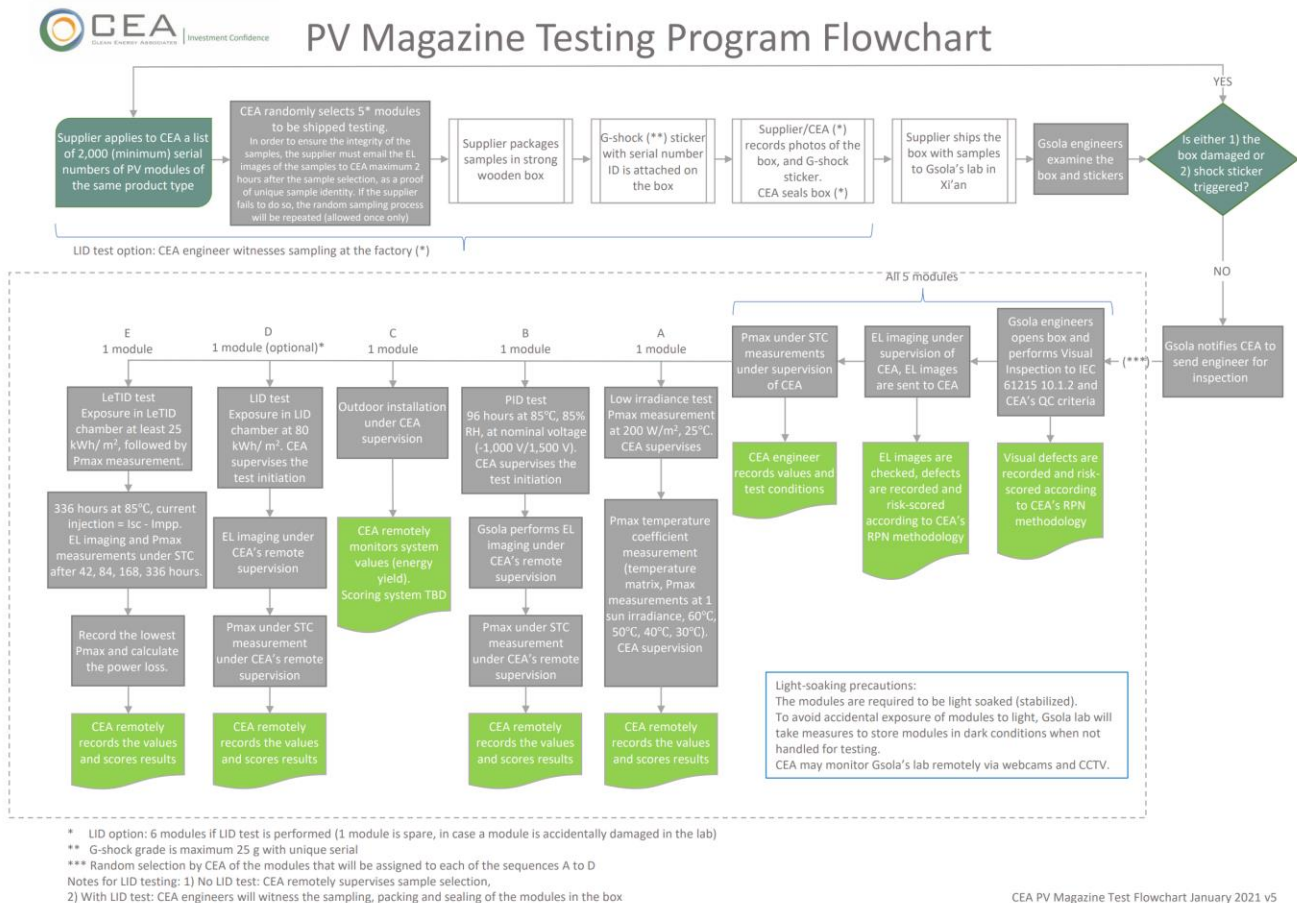


Figure 1 Test flowchart

## 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	A12231100100358
2	A12231100100354
3	A12231100100356
4	A12231100100359
5	A12231100100355

Table 4 Product information

Model	TSM-NEG9RC.27
Cell technology	N Type
Cell number	144
Cell format	210x182 mm
Number of busbars	14
Junction box	IP68, 3 bypass diodes
Laminate construction	Glass
Bifaciality ratio	80%

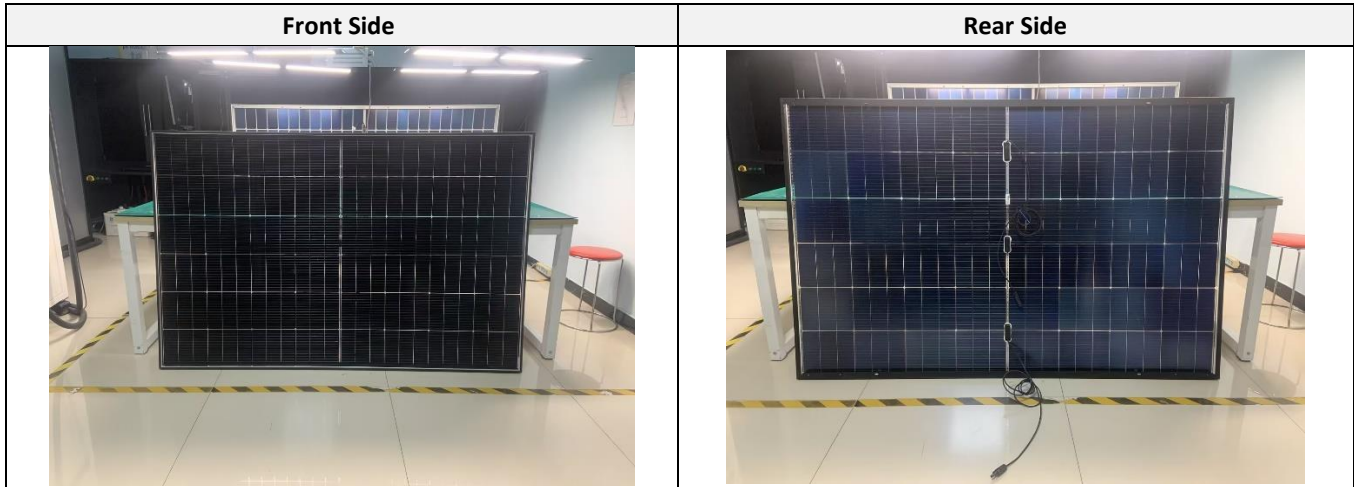


Figure 2 Product nameplate

### 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  $RPN\ score = Severity \times Detectability$ .

*Table 5 Product picture*



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

*Table 6 Visual inspection results*

TSM-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
Visual inspection	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-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

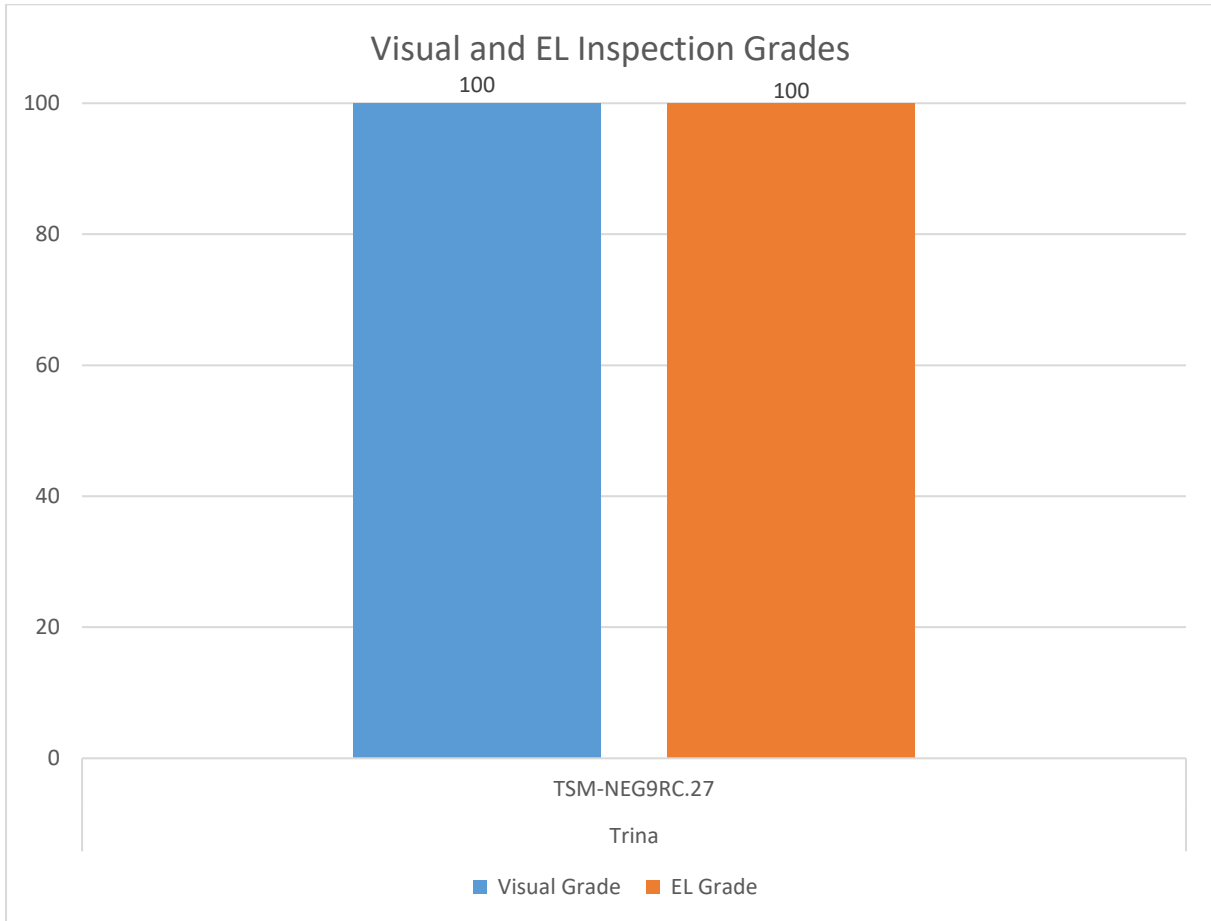


Figure 3 Visual and EL inspection results

### 3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

$$\text{Efficiency loss} = 1 - \left[ \left( \frac{\text{Pmax at low irradiance conditions}}{\text{Pmax at STC}} \right) * \left( \frac{1,000}{200} \right) \right]$$

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

Table 8 Low irradiance test results

TSM-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	3.44%					70

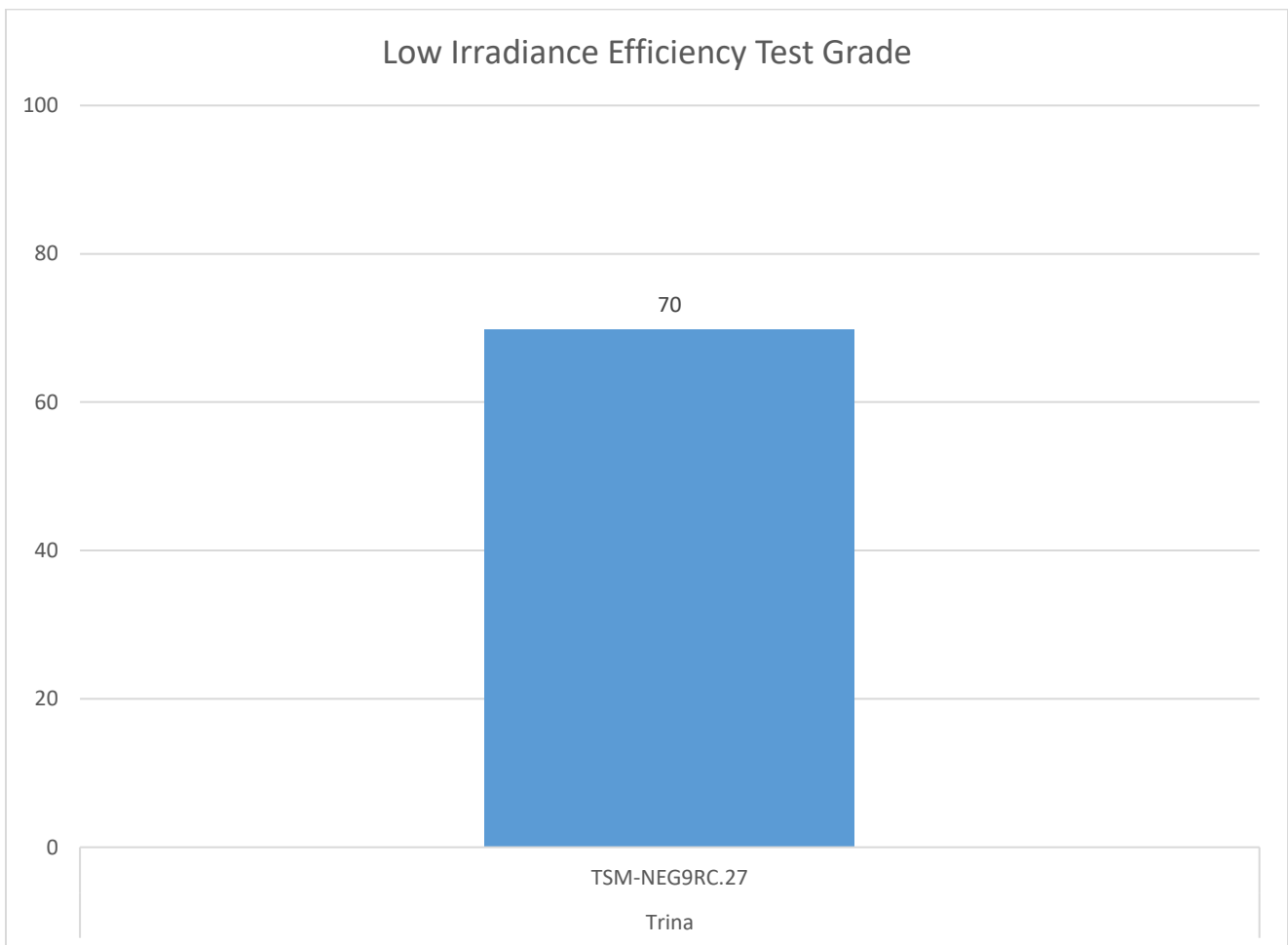


Figure 4 Low irradiance test result

### 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-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.31%					98

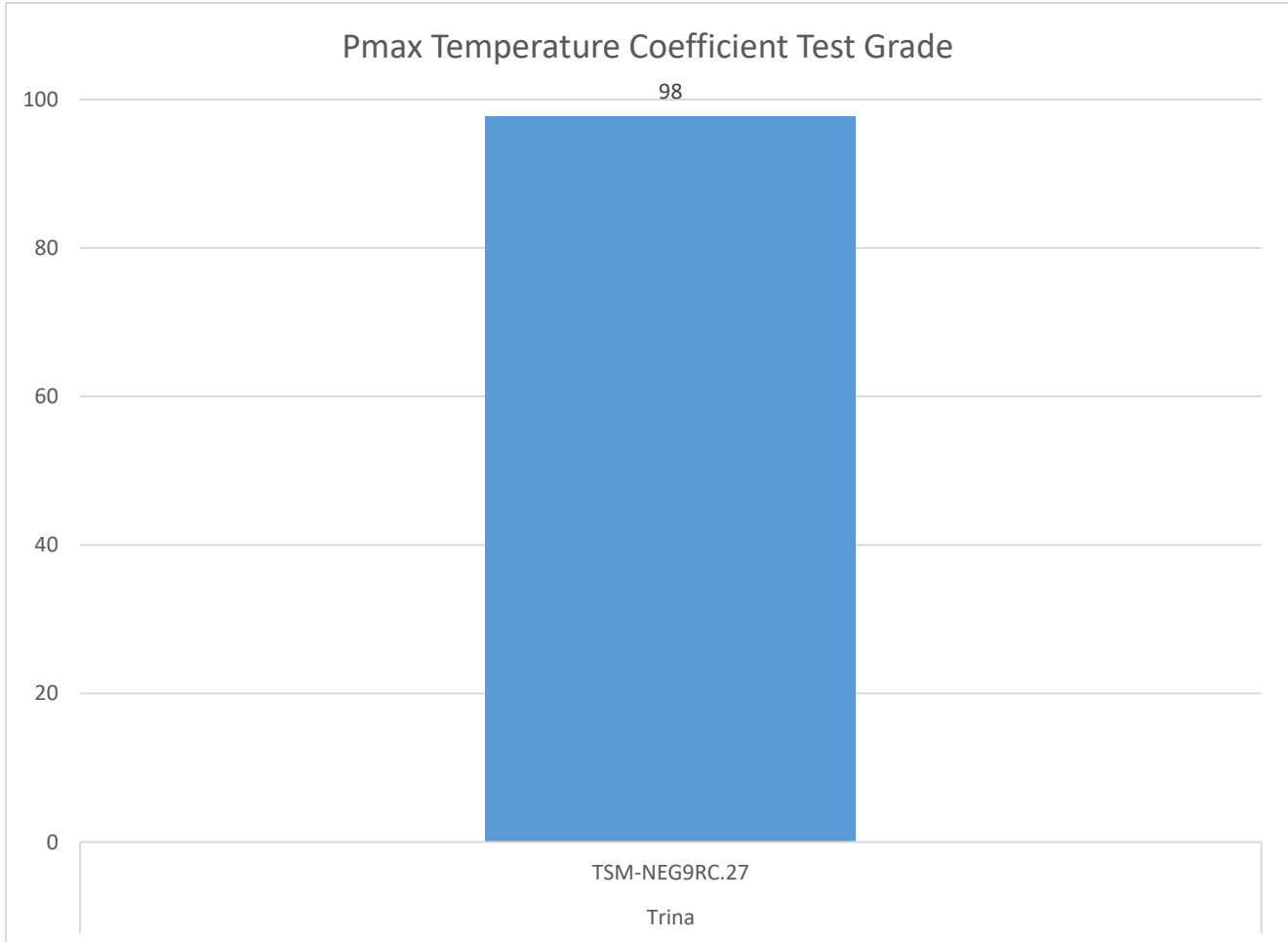


Figure 5 Pmax temperature coefficient test result

### 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-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		-0.16%				100

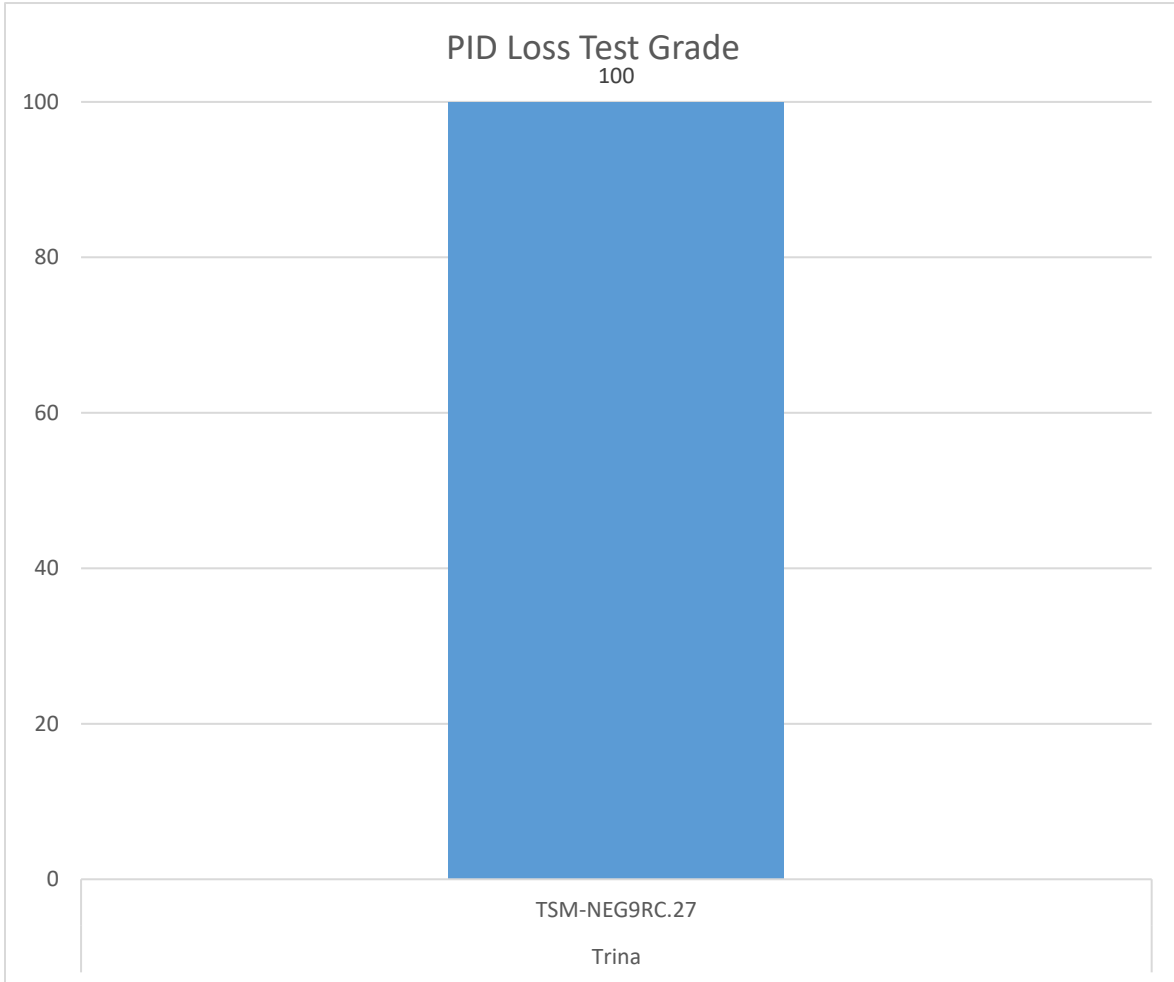


Figure 6 PID loss test result

### 3.6. LeTID loss test

Table 101 and Figure 6 depicts the LeTID loss test results:

*Table 11 LeTID loss test result*

TSM-NEG9RC.27	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LeTID loss (%)						



*Figure 7 LeTID loss test result*

### 3.7. 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 12 Bifaciality ratio test results*

<b>TSM-NEG9RC.27</b>	<b>Sample 1</b>	<b>Sample 2</b>	<b>Sample 3</b>	<b>Sample 4</b>	<b>Sample 5</b>	<b>Average</b>
Bifaciality ratio (%)	79.10%	79.01%	79.42%	79.07%	79.08%	79.14%

The bifaciality ratio is calculated from the following formula:

$$\text{Bifaciality ratio} = (\text{Pmax rear surface} / \text{Pmax front surface}) * 100\%$$

### 3.8. Score overview

Figure 8 shows the overview of the test scores. Figure 9 shows the average score.

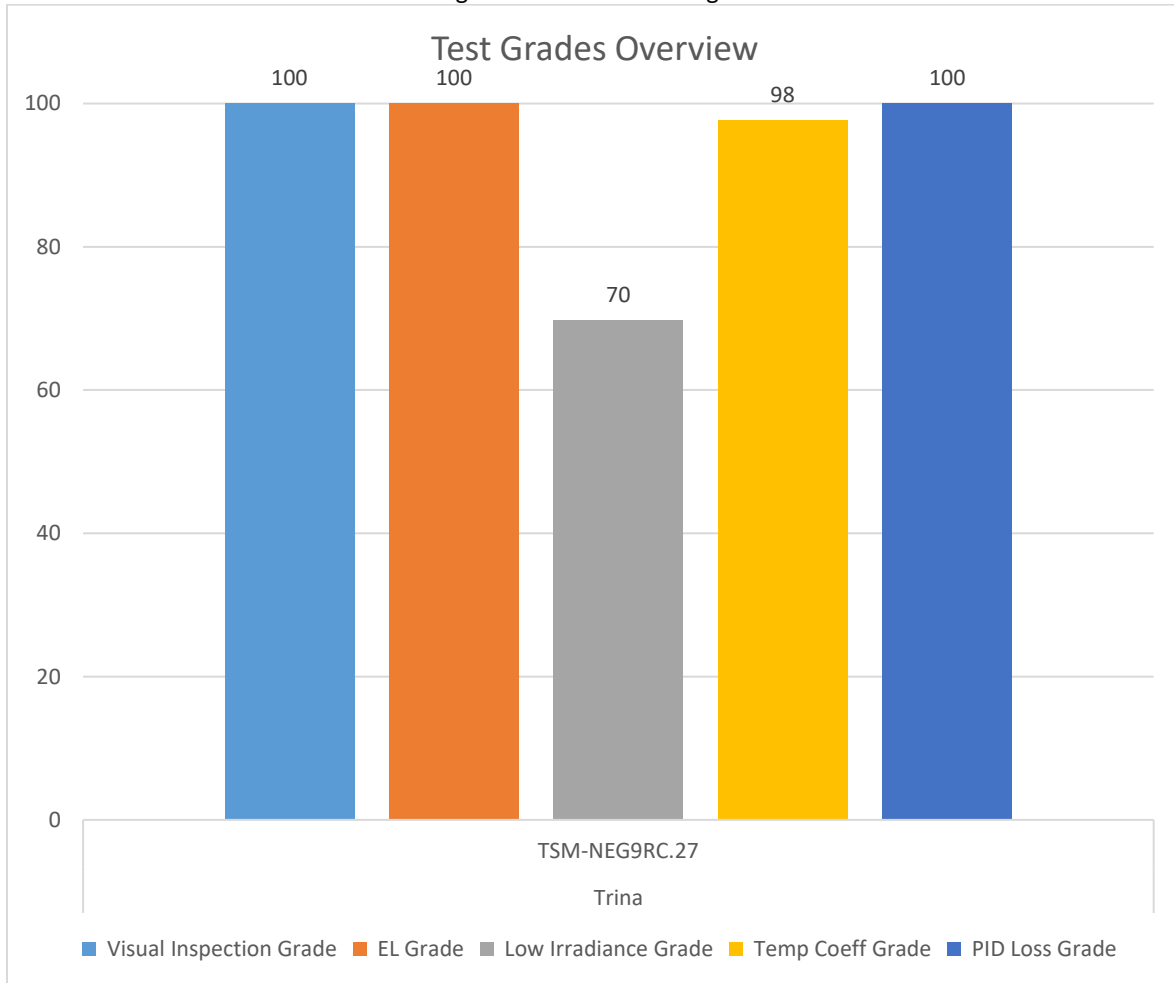
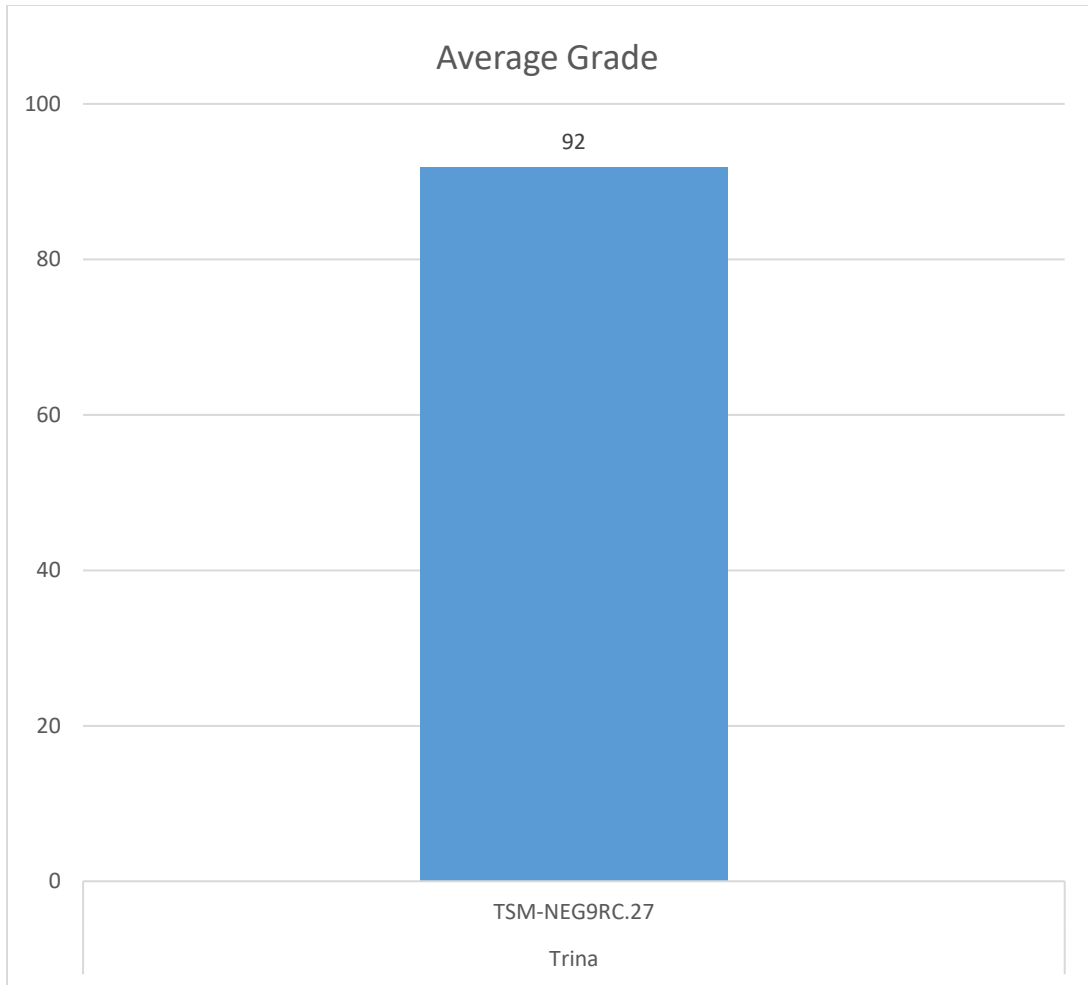


Figure 8 Test results overview

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



*Figure 9 Average test grade*

Appendix 1 – TSM-NEG9RC.27 Datasheet

Mono Multi Solutions

**Vertex S+**

**BIFACIAL DUAL GLASS MONOCRYSTALLINE MODULE**

PRODUCT: TSM-NEG9RC.27

POWER RANGE: 415-440W

**440W**

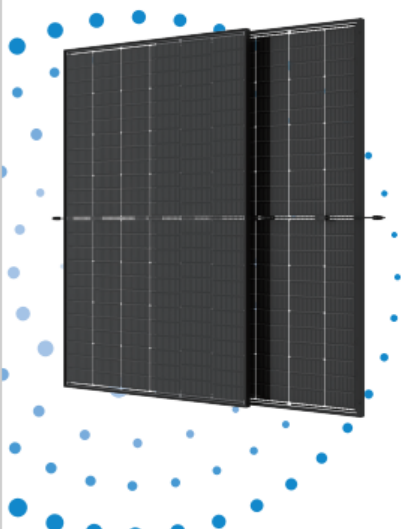
MAXIMUM POWER OUTPUT

**0~+5W**

POSITIVE POWER TOLERANCE

**22.0%**

MAXIMUM EFFICIENCY



**Small in size, bigger on power**

- Up to 440W, 22.0% module efficiency with high density interconnect technology
- Reduce installation cost with higher power bin and efficiency
- Boost performance in warm weather with low temperature coefficient and operating temperature



**Transparent Dual-glass Design**

- Transparent design with aesthetics appearance, 3.2% transparency
- Upgraded dual glass of Vertex S, less prone to micro-cracks and scratches on the back during installation
- Excellent fire rating, weather resistance, salt spray, sand dust, ammonia performance which is fully applicable in coastal, high temperature, humidity area and harsh environment



**Ultra-low Degradation, longer warranty, higher output**

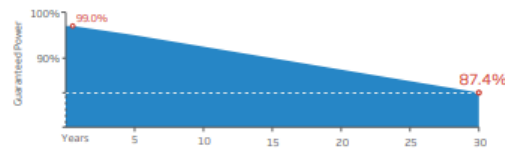
- First-year degradation 1% and annual degradation at 0.4%
- Up to 25 years product warranty and 30 years power warranty



**Universal solution for residential and C&I rooftops**

- Easy for integration, designed for compatibility with existing mainstream inverters and diverse mounting systems
- Perfect size and low weight for handling and installation
- Most valuable solution on low load capacity rooftops (weight similar to backsheet version)
- Mechanical performance up to 5400 Pa positive load and 4000 Pa negative load

**Trina Solar's Vertex Bifacial Dual Glass Performance Warranty**



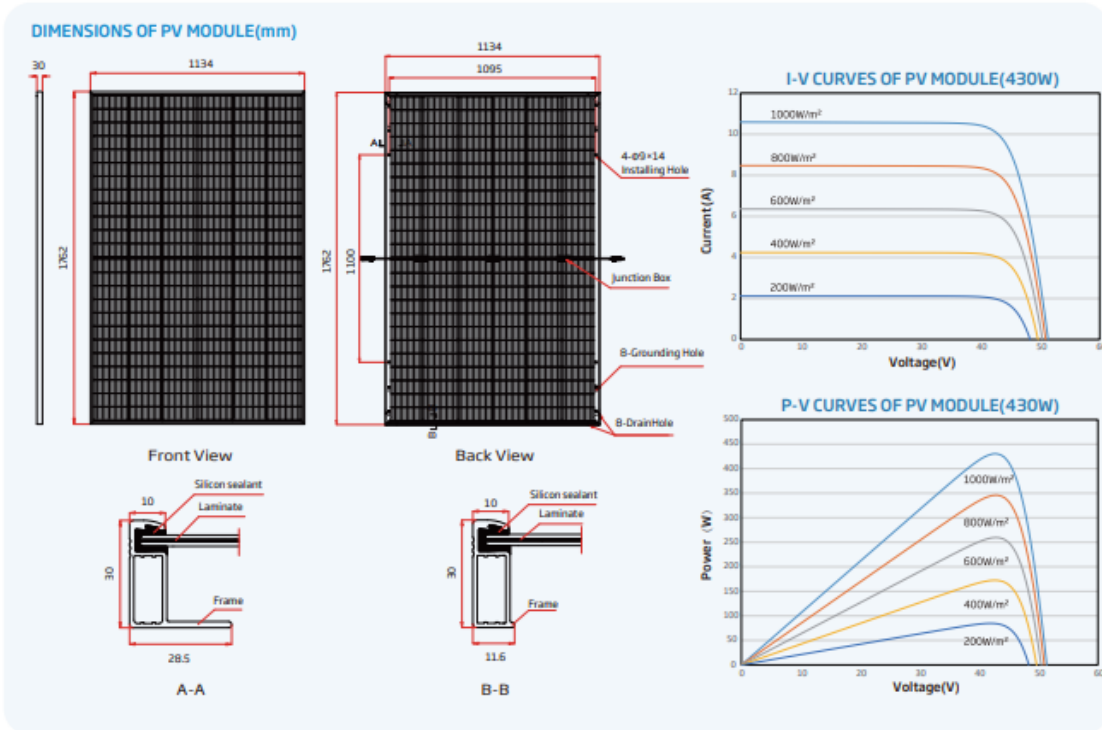
**Comprehensive Products and System Certificates**



IEC61215/IEC61730/IEC61701/IEC62716/UL61730  
 ISO 9001: Quality Management System  
 ISO 14001: Environmental Management System  
 ISO 14064: Greenhouse Gases Emissions Verification  
 ISO 45001: Occupational Health and Safety Management System

**TrinaSolar**

# Vertex S<sup>+</sup> BIFACIAL DUAL GLASS MONOCRYSTALLINE MODULE



**ELECTRICAL DATA (STC)**

Peak Power Watts - P <sub>MAX</sub> (Wp)*	415	420	425	430	435	440
Power Tolerance - P <sub>MAX</sub> (W)	0 ~ +5					
Maximum Power Voltage - V <sub>MPP</sub> (V)	42.1	42.5	42.9	43.2	43.6	44.0
Maximum Power Current - I <sub>MPP</sub> (A)	9.86	9.89	9.92	9.96	9.99	10.01
Open Circuit Voltage - V <sub>OC</sub> (V)	50.1	50.5	50.9	51.4	51.8	52.2
Short Circuit Current - I <sub>SC</sub> (A)	10.50	10.53	10.56	10.59	10.64	10.67
Module Efficiency <sub>STC</sub> (%)	20.8	21.0	21.3	21.5	21.8	22.0

STC: Irradiance 1000W/m<sup>2</sup>, Cell Temperature 25°C, Air Mass AM1.5. \*Measuring tolerance: ±2%.

**Electrical characteristics with different power bin (reference to 10% Irradiance ratio)**

Total Equivalent power - P <sub>MAX</sub> (Wp)	448	454	459	464	470	475
Maximum Power Voltage - V <sub>MPP</sub> (V)	42.1	42.5	42.9	43.2	43.6	44.0
Maximum Power Current - I <sub>MPP</sub> (A)	10.65	10.68	10.71	10.76	10.79	10.81
Open Circuit Voltage - V <sub>OC</sub> (V)	50.1	50.5	50.9	51.4	51.8	52.2
Short Circuit Current - I <sub>SC</sub> (A)	11.34	11.37	11.40	11.44	11.49	11.52

Power Bifaciality: 80 ± 5%

**ELECTRICAL DATA (NOCT)**

Maximum Power - P <sub>MAX</sub> (Wp)	316	320	324	328	332	335
Maximum Power Voltage - V <sub>MPP</sub> (V)	39.3	39.7	40.0	40.4	40.7	41.0
Maximum Power Current - I <sub>MPP</sub> (A)	8.09	8.07	8.09	8.11	8.15	8.17
Open Circuit Voltage - V <sub>OC</sub> (V)	47.5	47.8	48.2	48.7	49.1	49.4
Short Circuit Current - I <sub>SC</sub> (A)	8.46	8.49	8.51	8.53	8.57	8.60

NOCT: Irradiance at 800W/m<sup>2</sup>, Ambient Temperature 25°C, Wind Speed 1m/s.

**MECHANICAL DATA**

Solar Cells	Monocrystalline
No. of cells	144cells
Module Dimensions	1762×1134×30 mm (69.06×43.15×1.18 inches)
Weight	21.0kg (46.30 lb)
Front Glass	1.6 mm (0.06 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant material	POE/EVA
Back Glass	1.6 mm (0.06 inches), High Transmission, Heat Strengthened Glass
Frame	30mm (1.18 inches) Anodized Aluminium Alloy, Black
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm <sup>2</sup> (0.006 inches <sup>2</sup> ) 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.

TEMPERATURE RATINGS	MAXIMUM RATINGS
NOCT(Nominal Operating Cell Temperature)	43°C (±2°C)
Operational Temperature	-40 ~ +85°C
Temperature Coefficient of P <sub>MAX</sub>	-0.30%/°C
Maximum System Voltage	1500V DC (IEC)
Temperature Coefficient of V <sub>OC</sub>	-0.24%/°C
Max Series Fuse Rating	25A
Temperature Coefficient of I <sub>SC</sub>	0.04%/°C

WARRANTY	PACKAGING CONFIGURATION
15 year Product Workmanship Warranty	Modules per box: 36 pieces
30 year Power Warranty	Modules per 40' container: 936 pieces
1% first year degradation	
0.4% Annual Power Attenuation	

(Please refer to product warranty for details)



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

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