



Test Report

PV module Irradiance and temperature performance measurement and Power Rating as per IEC 61853-1:2011

MCIND SPVL Report Number: MCIND/22-23/LB/065.V1

Issue Date: 23-08-2022

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Report number	MCIND/22-23/LB/065.V1	Order date	06-06-2022
Order number	MCIND/22-23/015	Sample Receive Date	13-06-2022
Test start Date:	20-06-2022	Test end date:	12-07-2022

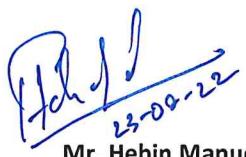
Customer Information (Shared by the Customer)

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Signatures

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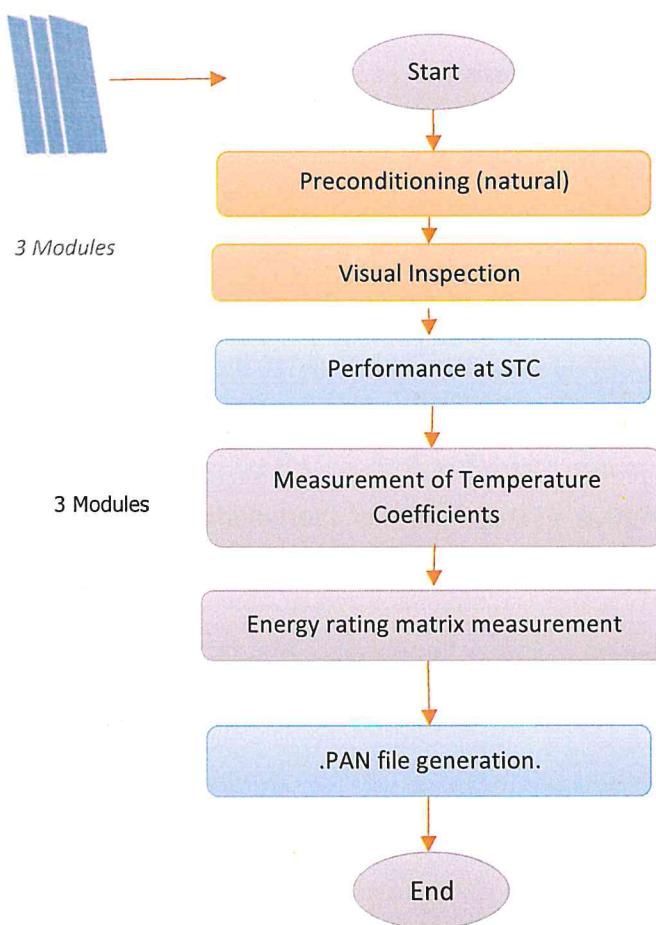
1 General Information about the Report

1.1 Order

The objective of the project is to evaluate different Irradiance and temperature performance measurements and power rating on PV module.

1.2 Approach

MCIND received 3 no. of PV modules of **Novasys Greenergy Pvt Ltd.**, model type **NOVA550MP144** for which the following test sequence was agreed. In order to create the PAN file for models **NOVA545MP144 & NOVA540MP144** in PVsyst, the parameters of temperature coefficients, low-light data were same as **NOVA550MP144**. The other necessary parameters were left as PVsyst defaults.



1.3 List of abbreviations and symbols used

MCIND	Mitsui Chemicals India Pvt Ltd
A	Ampere
Dev	Deviation
FF	Fill Factor = $P_{max} / (I_{sc} * V_{oc})$
I_{mpp}	Maximum power point current (in Ampere)
Irr	Irradiance (Watt per square meter)
I_{sc}	Short circuit current (in Ampere)
I-V curve	Current-voltage curve
Max	Maximum
Min	Minimum
ms	Millisecond
P	Electric power (in Watt)
P@STC	Performance @ standard test conditions
P_{mpp} or P_{max}	Maximum power point (in Watt)
Ref	Reference
%	Percentage
Sr	Serial number
IR	Infrared Thermography
VI	Visual Inspection
EL	Electroluminescence
P@LI	Performance @ Low Irradiance
MQT	Module Qualification Testing
Mfg.	Manufacturing
IV	Current Voltage (measurement)
STC	Standard test conditions
NOCT	Nominal operating cell temperature
LIC	Low Irradiance condition
HTC	High temperature condition
LTC	Low temperature condition

2 General Information about the Test and Test Objects

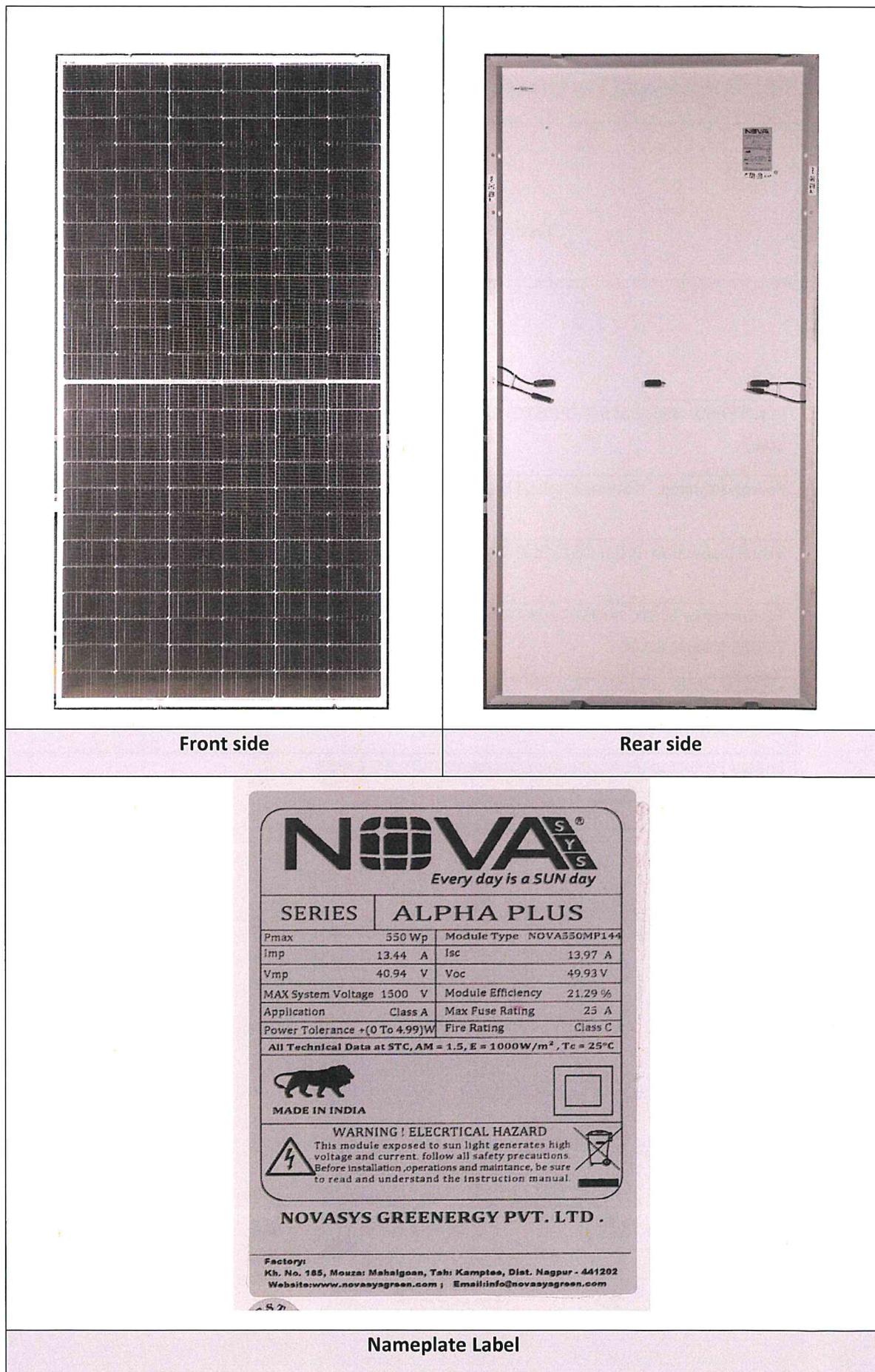
2.1 Delivery Condition

- **Delivery Condition:** No physical Damage observed.
- **Packaging comments:** Test samples are packed in good condition.
- **Location:** Gate no. 4 , Solar PV Laboratory, Mitsui chemicals India Pvt. Ltd., Ahmedabad, Gujarat 382220.

Note: The PV modules received are new PV modules

2.2 Sample Description

Make:	Novasys Greenergy Pvt. Ltd.	Model Type:	NOVA550MP144	Cell Material:	Mono PERC	No. of Cells: 144
Sr. No.	MCIND Serial No.		Product No.		Module Area in m²	Remarks
1	MCIND/2022/0179		NOVABTMPVD00006		2.58	Tested
2	MCIND/2022/0180		NOVABTMPVD00036		2.58	Tested
3	MCIND/2022/0181		NOVABTMPVD00042		2.58	Tested



3 Performed Tests

3.1 Overview of Performed Tests

Tests	MCIND Number		
	MCIND/2022/0179	MCIND/2022/0180	MCIND/2022/0181
Initial Performance at STC (P@STC) IEC 61215-2:2005 (Clause 10.6)	X	X	X
Preconditioning - Natural IEC 61215-2:2005 (Clause 5)	X	X	X
Visual Inspection (VI) IEC 61215-2:2005 (Clause 10.1)	X	X	X
Performance at STC (P@STC after Preconditioning) IEC 61215-2:2005 (Clause 10.6)	X	X	X
Measurement of Temperature Coefficient (Tcoeff) IEC 61215-2:2005 (Clause 10.4)	X	X	X
Energy Performance Matrix measurements (GT) IEC 61853 - 1:2011 (Clauses 7 , 8 , 9)	X	X	X

3.2 Detailed Test Results

3.2.1 Preconditioning (IEC 61215-2:2005 (Clause 5))

Standard

The test is performed in accordance with IEC 61215-2:2005 (Clause 5).

Purpose

The purpose is to stabilize the electrical properties of the PV module by irradiation with natural or artificial solar radiation.

Test Result:

Serial number	Start (DD-MM-YYYY)	End (DD-MM-YYYY)	Radiation source (Outdoor / Sun simulator)	Irradiation per cycle in kWh/m ²
MCIND/2022/0179	21-06-2022	23-06-2022	Indoor	5.5
MCIND/2022/0180				
MCIND/2022/0181				

3.2.2 Result Compilation of Performance at STC (Initial & After Preconditioning)

MCIND ID	Status	P _{MPP} [W]	V _{oc} [V]	I _{sc} [A]	V _{MPP} [V]	I _{MPP} [A]	Power deviation to label * / to After Preconditio ning [%]
	Nameplate Value	550	49.93	13.97	40.94	13.44	-
MCIND/2022/0 179(Tested)	Initial	552.26	49.96	13.46	42.49	13.00	0.41
	After Preconditioning	551.04	49.68	13.57	42.16	13.07	-0.22
MCIND/2022/0 180 (Tested)	Initial	550.81	50.05	13.45	42.59	12.93	0.15
	After Preconditioning	549.61	49.79	13.46	42.37	12.97	-0.22
MCIND/2022/0 181(Tested)	Initial	550.37	49.9	13.44	42.37	12.99	0.07
	After Preconditioning	548.91	49.66	13.48	42.29	12.98	-0.27

Pass Criteria:

1. The values of STC power measured after stabilisation falls within the power range specified by the manufacturer of this product considering the tolerance ($\pm 2\%$).

3.3 Visual Inspection (IEC 61215-2:2005, Clause 10.1)

Purpose:

The modules are examined by naked eye under the illumination of >1000 lux (thoroughly scrutinized) for the visually defects which impairs the performance.

Test procedure:

Each module is carefully inspected under an illumination of not less than 1000 lux for the following conditions:

- cracked, bent, misaligned or torn external surfaces;
- broken cells;
- cracked cells;
- faulty interconnections or joints;
- cells touching one another or the frame;
- failure of adhesive bonds;
- bubbles or delamination forming a continuous path between a cell and the edge of the module;
- tacky surfaces of plastic materials;
- faulty terminations, exposed live electrical parts;
- any other conditions which may affect performance.

Requirements for qualification:

Visual conditions other than the major visual defects listed below are acceptable for the purpose of type approval:

- broken, cracked or torn external surfaces, including superstrates, substrates, frames and junction boxes;
- bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired.
- a crack in a cell whose propagation could remove more than 10% of that cells' area from the electrical circuit of the module;
- bubbles or delamination forming a continuous path between any part of the electrical circuit and the edge of the module;
- loss or mechanical integrity, to the extent that the installation and/or operation of the module would be impaired

3.3.1 Result Compilation of Visual Inspection:

Manufacturer	Novasys Greenergy Pvt. Ltd.	Product No.	NOVABTMPVD00006
Model Type	NOVA550MP144	MCIND Serial No.	MCIND/2022/0179
Observation: No defects observed			
Manufacturer	Novasys Greenergy Pvt. Ltd.	Product No.	NOVABTMPVD00036
Model Type	NOVA550MP144	MCIND Serial No.	MCIND/2022/0180
Observation: No defects observed			
Manufacturer	Novasys Greenergy Pvt. Ltd.	Product No.	NOVABTMPVD00042
Model Type	NOVA550MP144	MCIND Serial No.	MCIND/2022/0181
Observation: No defects observed			

3.4 Measurement of Temperature Coefficient (IEC 61215-2:2005 (Clause 10.14))

Purpose:

To Determine Temperature coefficient of current ($\alpha\%/\text{°C}$), Voltage ($\beta\%/\text{°C}$), Power ($\delta\%/\text{°C}$) for given PV module.

Test Procedure:

To determine the temperature coefficients (TC) the module is prepared to ensure decelerated cooling. After dry heating to 65°C, the Power determination is accomplished in the Sun simulator in selected temperature ranges and an irradiance of 1000 W/m². Module thermal coefficients α , β the temperature coefficient of module power (W) at the maximum power point (γ) is determined.

3.4.1 Result Compilation of Temperature Coefficients:

Irradiance:	1000	W/m ²				
Maximum temperature:	65	°C				
Minimum temperature:	15	°C				
MCIND Serial No.	α, I_{sc}		β, V_{oc}		δ, P_{MPP}	
MCIND/2022/0179	0.019	%/°C	-0.244	%/°C	-0.334	%/°C
MCIND/2022/0180	0.020	%/°C	-0.248	%/°C	-0.339	%/°C
MCIND/2022/0181	0.021	%/°C	-0.254	%/°C	-0.347	%/°C
Average	0.020	%/°C	-0.249	%/°C	-0.340	%/°C

3.5 Energy Performance Matrix (IEC 61853-1-2011 (Clauses 7 , 8 , 9))

Purpose:

To determine the impact of irradiance and temperature on module performance.

Test Procedure:

Multi-irradiance and multi-temperature measurements are performed to obtain Power rating matrix of PV module in accordance with IEC 61853-1:2011 (Clauses 7 , 8 , 9). The test covers irradiance from 100 to 1100 W/m², and temperature from 15 °C to 75°C . The results at desired temperature and irradiance points are obtained by varying and adjusting the irradiance of the solar simulator. The light source is a xenon lamp (according to IEC 60904-9:2007-10).

3.5.1 Result Compilation -Average values of 3 test modules:

Irr. in W/m ²	Temp. [°C]	Test	MCIND serial No.	P _{MAX} [W]	V _{MAX} [V]	I _{MAX} [A]	Voc [V]	I _{sc} [A]
1100	75	1	MCIND/2022/0179	506.94	35.74	14.19	43.93	15.08
		2	MCIND/2022/0180	502.93	35.46	14.20	43.79	15.01
		3	MCIND/2022/0181	503.51	35.56	14.16	43.77	15.01
		Average		504.46	35.59	14.18	43.83	15.03
	50	1	MCIND/2022/0179	553.69	38.92	14.23	46.79	15.00
		2	MCIND/2022/0180	553.39	38.97	14.20	46.88	14.91
		3	MCIND/2022/0181	552.16	38.94	14.18	46.75	14.93
		Average		553.08	38.94	14.20	46.81	14.95
	25	1	MCIND/2022/0179	604.95	42.31	14.30	49.85	14.92
		2	MCIND/2022/0180	603.69	42.44	14.23	49.97	14.81
		3	MCIND/2022/0181	602.82	42.22	14.27	49.82	14.83
		Average		603.82	42.32	14.27	49.88	14.85
1000	75	1	MCIND/2022/0179	461.41	35.86	12.87	43.72	13.70
		2	MCIND/2022/0180	458.11	35.56	12.89	43.59	13.64
		3	MCIND/2022/0181	458.40	35.69	12.84	43.58	13.64
		Average		459.31	35.70	12.87	43.63	13.66
	50	1	MCIND/2022/0179	503.89	38.81	12.99	46.57	13.64
		2	MCIND/2022/0180	503.71	38.93	12.94	46.69	13.55
		3	MCIND/2022/0181	502.77	38.88	12.93	46.58	13.57
		Average		503.46	38.87	12.95	46.61	13.59
	25	1	MCIND/2022/0179	551.04	42.16	13.06	49.68	13.57
		2	MCIND/2022/0180	549.61	42.62	12.89	49.79	13.46
		3	MCIND/2022/0181	548.91	42.29	12.98	49.66	13.48
		Average		549.85	42.36	12.98	49.71	13.50
	15	1	MCIND/2022/0179	572.22	43.79	13.07	51.02	13.55
		2	MCIND/2022/0180	570.67	43.91	13.00	51.00	13.49
		3	MCIND/2022/0181	574.77	44.11	13.03	51.26	13.48
		Average		572.55	43.94	13.03	51.09	13.51
800	75	1	MCIND/2022/0179	369.28	35.76	10.33	43.22	10.97
		2	MCIND/2022/0180	367.07	35.71	10.28	43.12	10.91
		3	MCIND/2022/0181	366.93	35.64	10.30	43.11	10.91
		Average		367.76	35.70	10.30	43.15	10.93
	50	1	MCIND/2022/0179	403.54	38.85	10.39	46.12	10.91
		2	MCIND/2022/0180	403.29	39.08	10.32	46.24	10.84
		3	MCIND/2022/0181	402.58	38.71	10.40	46.14	10.85
		Average		403.14	38.88	10.37	46.17	10.87
	NOCT	1	MCIND/2022/0179	39.87	10.32	46.88	10.87	39.87
		2	MCIND/2022/0180	39.76	10.34	46.64	10.80	39.76
		3	MCIND/2022/0181	39.58	10.30	46.64	10.80	39.58
		Average		39.74	10.32	46.72	10.82	39.74
	25	1	MCIND/2022/0179	441.46	42.40	10.41	49.28	10.85
		2	MCIND/2022/0180	439.99	42.47	10.36	49.38	10.77
		3	MCIND/2022/0181	439.54	42.32	10.39	49.24	10.79
		Average		440.33	42.40	10.39	49.30	10.80
	15	1	MCIND/2022/0179	458.17	43.91	10.44	50.61	10.84
		2	MCIND/2022/0180	456.90	43.87	10.41	50.62	10.79
		3	MCIND/2022/0181	459.38	44.25	10.38	50.84	10.78
		Average		458.15	44.01	10.41	50.69	10.80
600	75	1	MCIND/2022/0179	275.91	35.67	7.33	42.62	8.23

	500	50	2	MCIND/2022/0180	274.30	35.50	7.73	42.51	8.18
			3	MCIND/2022/0181	273.99	35.54	7.71	42.47	8.19
			Average		274.73	35.57	7.59	42.53	8.20
			1	MCIND/2022/0179	301.94	38.57	7.83	45.56	8.19
		25	2	MCIND/2022/0180	301.40	38.96	7.74	45.64	8.13
			3	MCIND/2022/0181	300.82	38.88	7.74	45.56	8.14
			Average		301.39	38.80	7.77	45.59	8.15
		15	1	MCIND/2022/0179	330.39	42.40	7.79	48.76	8.14
			2	MCIND/2022/0180	329.06	42.48	7.75	48.82	8.08
			3	MCIND/2022/0181	328.73	42.39	7.76	48.74	8.09
			Average		329.39	42.42	7.77	48.77	8.10
		400	1	MCIND/2022/0179	342.68	43.67	7.85	50.08	8.13
			2	MCIND/2022/0180	341.73	43.80	7.80	50.09	8.09
			3	MCIND/2022/0181	343.37	43.96	7.81	50.34	8.08
			Average		342.59	43.81	7.82	50.17	8.10
		200	1	MCIND/2022/0179	284.64	43.62	6.53	49.75	6.78
			2	MCIND/2022/0180	283.70	43.60	6.51	49.76	6.75
			3	MCIND/2022/0181	285.19	43.98	6.49	50.01	6.73
			Average		284.51	43.73	6.51	49.84	6.75
		100	1	MCIND/2022/0179	199.14	38.51	5.17	45.20	5.46
			2	MCIND/2022/0180	198.55	38.30	5.18	44.80	5.42
			3	MCIND/2022/0181	198.21	38.16	5.19	44.73	5.43
			Average		198.63	38.32	5.18	44.91	5.44
		15	1	MCIND/2022/0179	218.37	42.03	5.20	47.98	5.43
			2	MCIND/2022/0180	217.04	41.71	5.20	48.01	5.39
			3	MCIND/2022/0181	216.57	42.20	5.14	47.96	5.40
			Average		217.33	41.98	5.18	47.98	5.41
		25	1	MCIND/2022/0179	226.53	43.69	5.18	49.36	5.42
			2	MCIND/2022/0180	225.72	43.55	5.18	49.33	5.40
			3	MCIND/2022/0181	226.57	43.72	5.18	49.58	5.39
			Average		226.27	43.65	5.18	49.42	5.40
		50	1	MCIND/2022/0179	106.12	41.01	2.59	46.65	2.72
			2	MCIND/2022/0180	105.46	40.87	2.58	46.67	2.69
			3	MCIND/2022/0181	104.55	41.01	2.55	46.62	2.70
			Average		105.38	40.96	2.57	46.65	2.70
		15	1	MCIND/2022/0179	110.17	42.35	2.60	48.03	2.71
			2	MCIND/2022/0180	109.79	42.22	2.60	48.03	2.70
			3	MCIND/2022/0181	110.08	42.29	2.60	48.27	2.69
			Average		110.01	42.29	2.60	48.11	2.70
		25	1	MCIND/2022/0179	50.72	40.09	1.27	45.28	1.36
			2	MCIND/2022/0180	50.51	39.76	1.27	45.17	1.34
			3	MCIND/2022/0181	49.32	40.25	1.23	45.20	1.32
			Average		50.18	40.03	1.26	45.22	1.34
		15	1	MCIND/2022/0179	52.89	41.40	1.28	46.61	1.35
			2	MCIND/2022/0180	52.61	41.66	1.27	46.68	1.34
			3	MCIND/2022/0181	52.86	41.61	1.27	46.87	1.34
			Average		52.79	41.56	1.27	46.72	1.34

3.5.2 GT matrix - Average values of test 3 modules with respect to Irradiance and Temperature

GT Matrix of P_{max}						
Irradiance	Spectrum	Module temperature °C				
		15 °C	25 °C	NOCT	50 °C	75 °C
1100 W/m ²	AM 1.5	-	603.82	-	553.08	504.46
1000 W/m ²	AM 1.5	572.55	549.85	-	503.46	459.31
800 W/m ²	AM 1.5	458.15	440.33	410.05	403.14	367.76
600 W/m ²	AM 1.5	342.59	329.39	-	301.39	274.73
500 W/m ²	AM 1.5	284.51	-	-	-	-
400 W/m ²	AM 1.5	226.27	217.33	-	198.63	-
200 W/m ²	AM 1.5	110.01	105.38	-	-	-
100 W/m ²	AM 1.5	52.79	50.18	-	-	-

GT Matrix of V_{oc}						
Irradiance	Spectrum	Module temperature °C				
		15 °C	25 °C	NOCT	50 °C	75 °C
1100 W/m ²	AM 1.5	-	49.88	-	46.81	43.83
1000 W/m ²	AM 1.5	51.09	49.71	-	46.61	43.63
800 W/m ²	AM 1.5	50.69	49.30	46.72	46.17	43.15
600 W/m ²	AM 1.5	50.17	48.77	-	45.59	42.53
500 W/m ²	AM 1.5	49.84	-	-	-	-
400 W/m ²	AM 1.5	49.42	47.98	-	44.91	-
200 W/m ²	AM 1.5	48.11	46.65	-	-	-
100 W/m ²	AM 1.5	46.72	45.22	-	-	-

GT Matrix of I_{sc}						
Irradiance	Spectrum	Module temperature °C				
		15 °C	25 °C	NOCT	50 °C	75 °C
1100 W/m ²	AM 1.5	-	14.85	-	14.95	15.03
1000 W/m ²	AM 1.5	13.51	13.50	-	13.59	13.66
800 W/m ²	AM 1.5	10.80	10.80	10.82	10.87	10.93
600 W/m ²	AM 1.5	8.10	8.10	-	8.15	8.20
500 W/m ²	AM 1.5	6.75	-	-	-	-
400 W/m ²	AM 1.5	5.40	5.41	-	5.44	-
200 W/m ²	AM 1.5	2.70	2.70	-	-	-
100 W/m ²	AM 1.5	1.34	1.34	-	-	-

GT Matrix of V_{max}						
Irradiance	Spectrum	Module temperature °C				
		15 °C	25 °C	NOCT	50 °C	75 °C
1100 W/m ²	AM 1.5	-	42.32		38.94	35.59
1000 W/m ²	AM 1.5	43.94	42.36	-	38.87	35.70
800 W/m ²	AM 1.5	44.01	42.40	39.74	38.88	35.70
600 W/m ²	AM 1.5	43.81	42.42	-	38.80	35.57
500 W/m ²	AM 1.5	43.73	-	-	-	-
400 W/m ²	AM 1.5	43.65	41.98	-	38.32	-
200 W/m ²	AM 1.5	42.29	40.96	-	-	-
100 W/m ²	AM 1.5	41.56	40.03	-	-	-

GT Matrix of I_{max}						
Irradiance	Spectrum	Module temperature °C				
		15 °C	25 °C	NOCT	50 °C	75 °C
1100 W/m ²	AM 1.5	-	14.27	-	14.20	14.18
1000 W/m ²	AM 1.5	13.03	12.98	-	12.95	12.87
800 W/m ²	AM 1.5	10.41	10.39	10.32	10.37	10.30
600 W/m ²	AM 1.5	7.82	7.77	-	7.77	7.59
500 W/m ²	AM 1.5	6.51	-	-	-	-
400 W/m ²	AM 1.5	5.18	5.18	-	5.18	-
200 W/m ²	AM 1.5	2.60	2.57	-	-	-
100 W/m ²	AM 1.5	1.27	1.26	-	-	-

3.5.2 Result Compilation of Energy Performance Matrix:

Condition	Pmax [W]	V _{mpp} [V]	I _{MPP} [A]	V _{oc} [V]	I _{sc} [A]
STC (1000 W/m ² , 25°C)	549.85	42.36	12.98	49.71	13.50
NOCT (800 W/m ² , 20°C Ambient)	410.05	39.74	10.32	46.72	10.82
LIC (200W/m ² , 25°C)	105.38	40.96	2.57	46.65	2.70
HTC (1000W/m ² , 75°C)	459.31	35.70	12.87	43.63	13.66
LTC (500W/m ² , 15°C)	284.51	43.73	6.51	49.84	6.75

-----End of Test Report-----

