

Testing Report

Comparison Test of Optimizer

of

United International University (UIU)

Location: United City, Madani Avenue, Badda, Dhaka,

Dhaka 1212, Bangladesh.

Tested By:

Huawei Technologies Co., Ltd.

Testing Date:

31-October-2024

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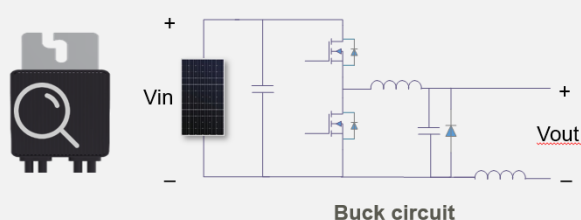
1 Introduction

- **Purpose of the Test:** The primary objective of this test is to evaluate the performance of a photovoltaic (PV) system equipped with Smart PV Optimizers (MERC-1100W-P) against a standard configuration without optimizers.
- **Importance of PV Optimizers:** PV optimizers enhance energy harvest by mitigating the effects of shading, module mismatch, and other factors that can lead to reduced output. They allow each panel to operate at its maximum power point (MPPT), improving overall system efficiency.

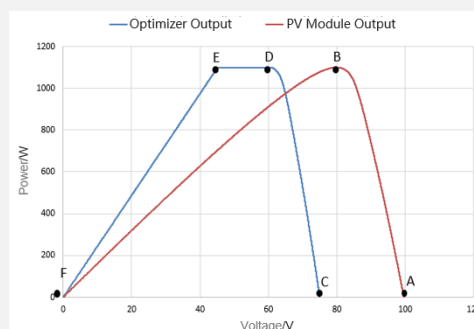
2 Background on PV Optimizers

- **Functionality:** PV optimizers are devices that attach to solar panels to manage their individual performance. Each optimizer connects to a specific number of panels (in this case, 2 panels per optimizer) and ensures that each panel operates at its optimal point.
- **Technical Mechanism:** Optimizers perform real-time monitoring and control of power output, adjusting for shading or mismatch conditions. This means that if one panel experiences shading, it won't significantly affect the output of the other panels connected to the same inverter.

The optimizer is a DC-DC circuit conversion device and has two working modes:
Buck or Bypass

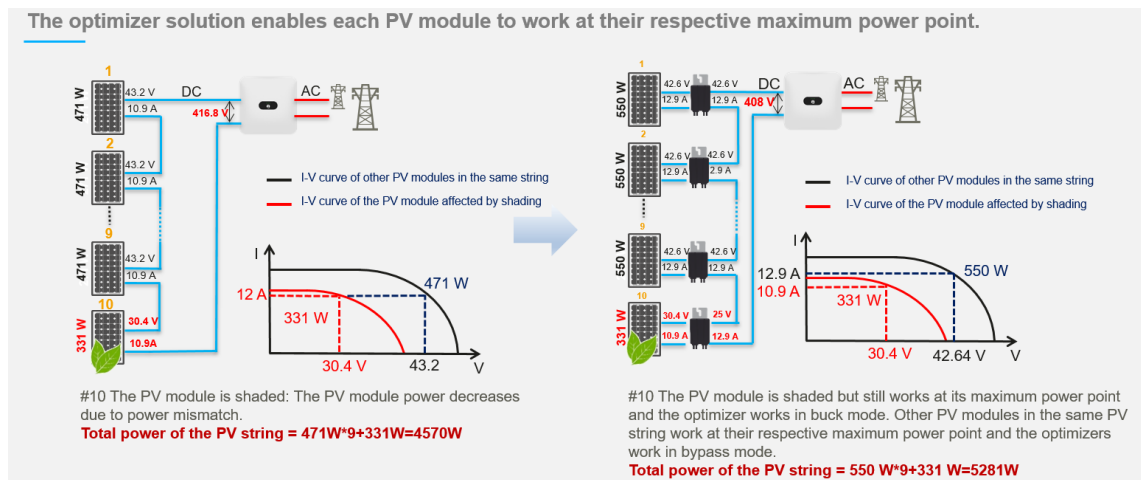


The buck circuit in an optimizer steps down the PV module voltage (increases the current) and outputs the voltage to the inverter. The optimizer interacts with the two-stage inverter to find the highest power point of the PV module.



The buck mode expands the MPPT operating range and enables long string design.

Optimizer Power generation



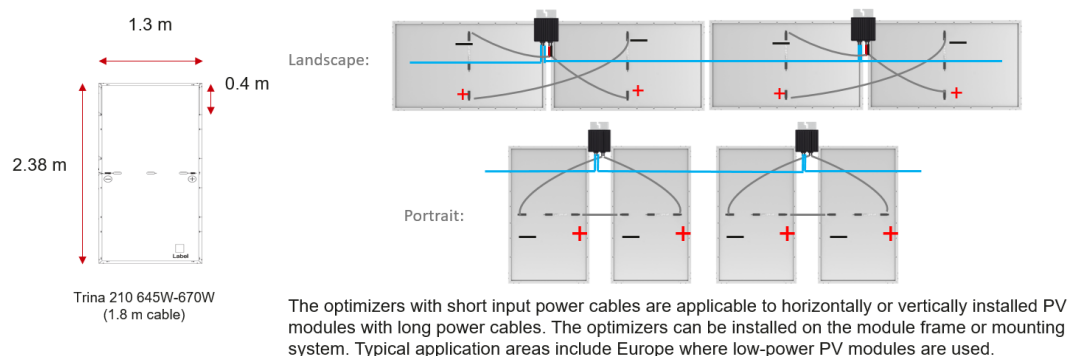
- Benefits:**

- Increased energy yield, especially in partially shaded conditions.
- Enhanced monitoring capabilities, allowing for better maintenance and fault detection.
- Flexibility in system design, enabling optimization in various installation scenarios.

3 Methodology

- Connection diagram**

Portrait or Landscape installation of PV modules with long power cables



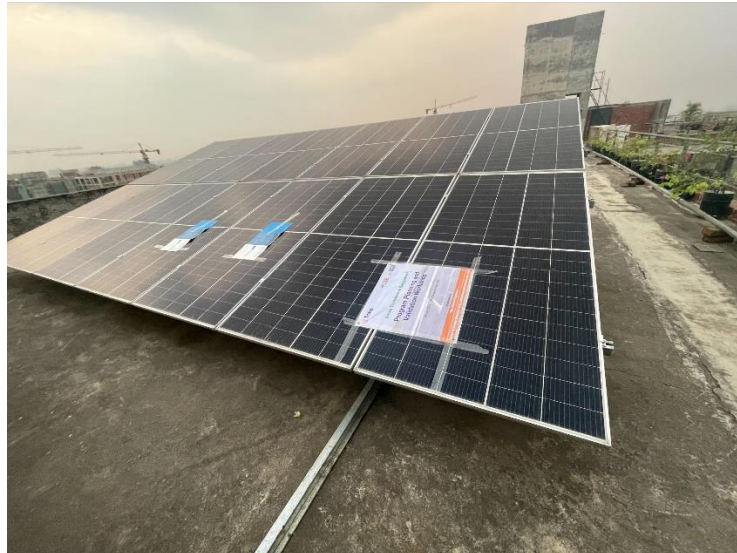
- Site Configuration:** Two identical Huawei Sun2000-50KTL-M3 inverters were installed, each connected to the same number and type of panels (2 strings connected to one inverter; 1 string containing 18 panels). The configurations included:
 - Inverter-01: Panels connected with Smart PV Optimizers.
 - Inverter-02: Panels connected without optimizers.

- **Testing Conditions:** Artificial shadows were placed on both inverters to simulate shading effects, ensuring both inverters experienced almost identical conditions.

Without optimizer connected panel shadow:



With optimizer connected panel shadow:



- **Data Collection:** Half hourly generation data was collected for a full day from both inverters, capturing their performance under the same shadowing conditions.

4. Data Analysis

- **Generation Data Overview:** Provide a detailed table and/or graph showing 30minutes interval generation data for both inverters. This could include:

30 minutes interval active power (kW) for both Inverter 01 and Inverter 02

Start Time	With Optimizer Inverter Active power(kW)	Without Optimizer Inverter Active power(kW)
00:00:00	0.000	0.000
06:30:00	0.424	0.387
07:00:00	1.299	1.170
07:30:00	1.692	1.632
08:00:00	3.126	2.845
08:30:00	6.856	5.588
09:00:00	7.983	6.759
09:30:00	9.102	8.442
10:00:00	9.599	9.113
10:30:00	10.847	10.597
11:00:00	11.215	10.899
11:30:00	11.715	11.404
12:00:00	11.229	10.959
12:30:00	9.370	9.062
13:00:00	5.715	5.501
13:30:00	5.569	5.302
14:00:00	4.323	4.089
14:30:00	6.906	6.648
15:00:00	5.438	5.206
15:30:00	3.808	3.632
16:00:00	2.285	2.208
16:30:00	1.060	1.030
17:00:00	0.181	0.190
17:30:00	0.000	0.000

30 minutes interval daily energy (kWh) for both Inverter 01 and Inverter 02.

Start Time	With Optimizer Inverter Daily energy(kWh)	With Optimizer Inverter Daily energy(kWh)
00:00:00	0.00	0.00
06:30:00	0.06	0.06
07:00:00	0.48	0.44
07:30:00	1.40	1.26
08:00:00	2.35	2.17
08:30:00	4.88	4.23
09:00:00	8.56	7.26
09:30:00	12.67	10.98
10:00:00	17.38	15.40
10:30:00	21.86	19.67
11:00:00	26.58	24.24
11:30:00	31.41	28.91
12:00:00	36.86	34.20
12:30:00	41.72	38.90
13:00:00	46.00	43.05
13:30:00	49.90	46.80
14:00:00	52.43	49.20
14:30:00	55.61	52.24
15:00:00	58.60	55.11
15:30:00	60.78	57.19
16:00:00	62.42	58.75
16:30:00	63.25	59.55
17:00:00	63.54	59.83
17:30:00	63.56	59.86

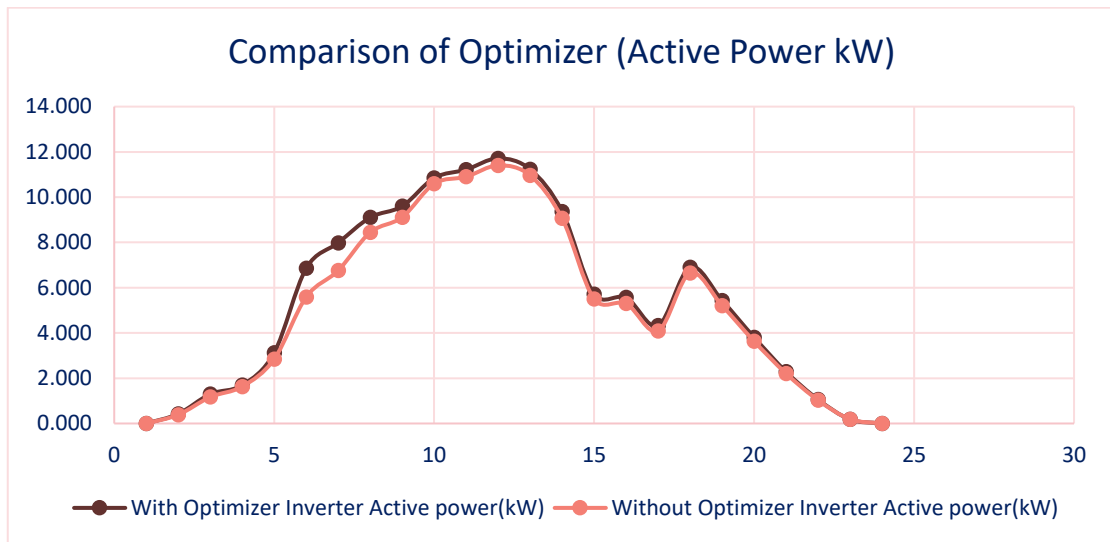
- **Performance Metrics:**

- **5.8% increase** in generation for the optimizer-connected inverter.
- Impact of shading on generation efficiency for both setups.

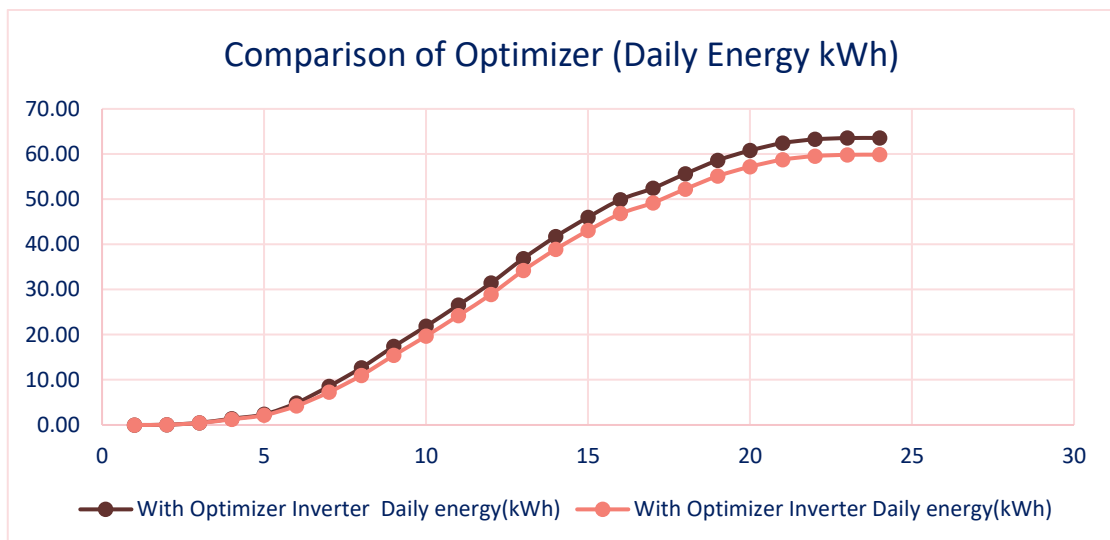
5. Results

- Performance Comparison:**

Comparison of Active Power (kW)



Comparison of total Active Power (kWh)



6. Conclusion

The comparative test of the Huawei Sun2000-50KTL-M3 inverters, conducted under controlled shading conditions, demonstrates a notable improvement in energy generation when utilizing Smart PV Optimizers (MERC-1100W-P). The optimizer-connected inverter generated approximately 5.8% more energy than the non-optimizer setup. This increase is attributed to the optimizer's ability to perform per-panel maximum power point tracking (MPPT), allowing each panel to operate at its peak potential even under partial shading.

This performance enhancement confirms the effectiveness of PV optimizers in mitigating the detrimental impact of shading and panel mismatch, leading to higher energy yield and improved overall system efficiency. For installations prone to shading or varied conditions, integrating PV optimizers offers a valuable solution, maximizing output and potentially improving return on investment. Given the positive results of this test, PV optimizers are recommended as a beneficial addition to solar systems where environmental or structural factors might limit uniform sunlight exposure across all panels. Further testing under diverse weather and seasonal conditions may provide additional insights into the long-term benefits and reliability of PV optimizers in varied environments.

This conclusion underscores the role of PV optimizers as a strategic enhancement for solar installations, particularly those susceptible to shading or layout constraints, promising a tangible boost in energy production and system resilience.

7. Appendices

- Appendix A: Technical specifications of the Huawei Inverter SUN2000-50KTL-M3

SUN2000-50KTL-M3 Technical Specification

Technical Specification	SUN2000-50KTL-M3
Efficiency	
Max. Efficiency	98.5%
European Efficiency	98.0%
Input	
Max. Input Voltage ¹	1,100 V
Max. Current per MPPT	30 A
Max. Current per Input	20 A
Max. Short Circuit Current per MPPT	40 A
Start Voltage	200 V
MPPT Operating Voltage Range ²	200 V ~ 1,000 V
Rated Input Voltage	600 V
Number of Inputs	8
Number of MPP Trackers	4
Output	
Rated AC Active Power	50,000 W
Max. AC Apparent Power	55,000 VA
Max. AC Active Power (cosφ=1)	55,000 W
Rated Output Voltage	400 Vac / 480 Vac, 3W+(N) + PE
Rated AC Grid Frequency	50 Hz / 60 Hz
Rated Output Current	72.2 A @ 400Vac, 60.1 A @ 480Vac
Max. Output Current	79.8 A @ 400Vac, 66.5 A @ 480Vac
Adjustable Power Factor Range	0.8 LG ... 0.8 LD
Max. Total Harmonic Distortion	<3%
Protection	
Input-side Disconnection Device	Yes
Anti-islanding Protection	Yes
AC Overcurrent Protection	Yes
DC Reverse-polarity Protection	Yes
PV-array String Fault Monitoring	Yes
DC Surge Arrester	Type II
AC Surge Arrester	Type II
DC Insulation Resistance Detection	Yes
Residual Current Monitoring Unit	Yes
Arc Fault Protection	Yes
Ripple Receiver Control	Yes
Integrated PID Recovery ³	Yes
Communication	
Display	LED Indicators, Bluetooth + APP
RS485	Yes
Smart Dongle	WLAN/Ethernet via Smart Dongle-WLAN-FE (Optional) 4G / 3G / 2G via Smart Dongle-4G (Optional)
Monitoring BUS (MBUS)	Yes (Isolation Transformer required)
Optimizer Compatibility	
DC MBUS Compatible Optimizer	MERC-1100/1300W-P
General Data	
Dimensions (W x H x D)	640 x 530 x 270 mm (25.2 x 20.9 x 10.6 inch)
Weight (with mounting plate)	49 kg (108.1 lb)
Operating Temperature Range	-25°C ~ 60°C (-13°F ~ 140°F)
Cooling Method	Smart Air Cooling
Max. Operating Altitude	4,000 m (13,123 ft.)
Relative Humidity	0% RH ~ 100% RH
DC Connector	Amphenol HH4
AC Connector	Waterproof Connector + OT/DT Terminal
Protection Degree	IP 66
Topology	Transformerless
Nighttime Power Consumption	≤ 5.5W
Standard Compliance (more available upon request)	
Safety	EN 62109-1/-2, IEC 62109-1/-2, EN 50530, IEC 62116, IEC 60068, IEC 61683
Grid Connection Standards	IEC 61727, VDE-AR-N4105, VDE 0126-1-1, BDEW, G59/3, UTE C 15-712-1, CEI 0-16, CEI 0-21, RD 1699, P.O. 12.3, RD 413, EN-50438-Turkey, EN-50438-Ireland, C10/11, MEA, Resolution No.7, NRS 097-2-1, DEWA

1. The maximum input voltage is the upper limit of the DC voltage. Any higher input DC voltage would probably damage inverter.
2. Any DC input voltage beyond the operating voltage range may result in inverter improper operating.
3. SUN2000-50-50KTL-M3 raises potential between PV- and ground to above zero through integrated PID recovery function to recover module degradation from PID. Supported module types include: P-type (mono, poly), N-type (nPERT, HIT)
4. 50KTL Platform only supports C&I Optimizer(MERC-1100/1300W-P). The current version does not support this function and it can be upgraded to optimizer version via new inverter software version(Dec 30th, 2022)
Refer to [HTTP://solair.huawei.com/](http://solair.huawei.com/)

- **Appendix B:** Technical specifications of the Smart PV Optimizer MERC-1100W-P.



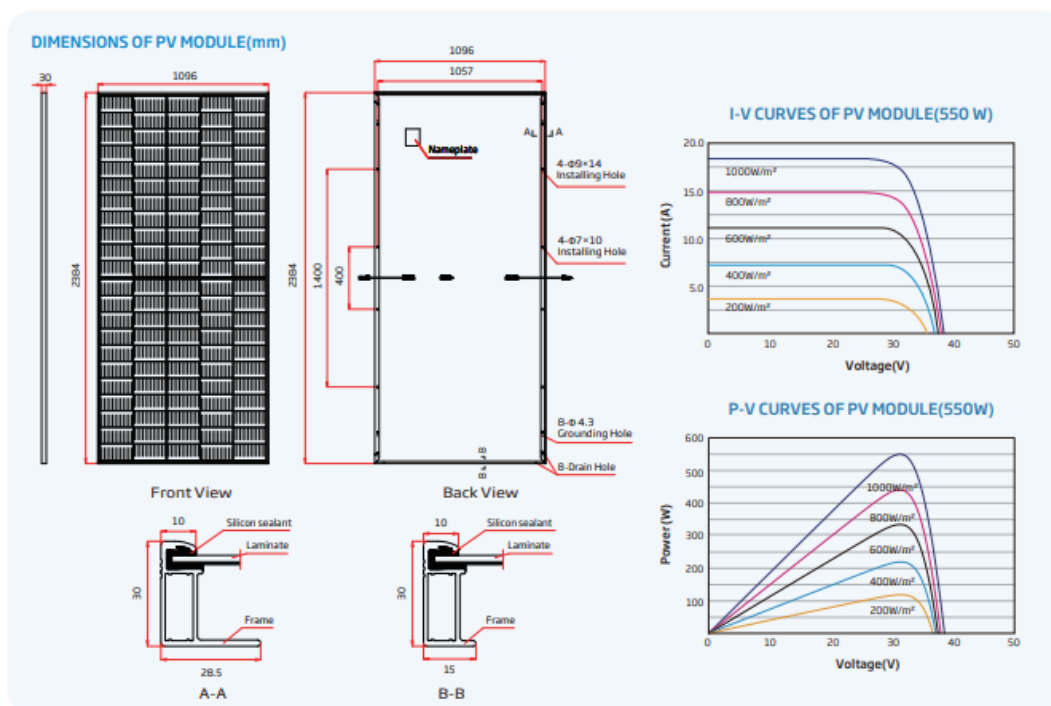
MERC-1100/1300W-P Technical Specification

Technical Specification	MERC-1100W-P	MERC-1300W-P
	Input	
Rated input DC power ¹	1100 W	1300 W
Absolute max. input voltage	125 V	
MPPT operating voltage range	12.5 ~ 105 V	
Max. short-circuit current (Isc)	20 A	
Max. efficiency	99.5%	
Weighted efficiency	99.0%	
Overvoltage category	II	
	Output	
Max. output voltage	80 V	
Max. output current	22 A	
Output bypass ²	Yes	
Safety output voltage ³	1 V	
	Standards Compliance	
Safety	IEC62109-1 (class II safety)	
RoHS	Yes	
	General Specification	
Dimension (W X H X D)	149 mm x 104 mm x 48.8 mm (5.9 in. x 4.1 in. x 1.9 in.)	
Weight (including wires)	1.0 kg (2.2 lb.)	
Installation part (optional)	PV Module Frame Plate/T-shaped Bolt ⁴	
Input connector	Staubli MC4	
Input wire length	0.1 m (+/-) (short-input-cable version) ⁵	
Output connector	Staubli MC4	
Output wire length	0.1 m (+), 5.1 m (-) (short-input-cable version) ⁵	
Operating temperature	-40°C to +85°C ⁶	
Relative humidity	0% ~ 100%	
IP rating	IP68	
Compatible inverters	SUN2000-8/10/12/15/17/20KTL-M2, SUN2000-30/36/40KTL-M3, SUN2000-12/15/17/20/25KTL-M5, SUN2000-50KTL-M3	

PV System Design ^{7/8/9}	SUN2000-12~25K-MB0	SUN2000-12~25KTL-M5	SUN2000-30~40KTL-M3	SUN2000-50KTL-M3
Minimum String Length (Power Optimizers)	8	8	8	8
Maximum String Length (Power Optimizers)	25	25	25	20
Maximum DC Power per String	20,000 W	20,000 W	20,000 W	20,000 W



- **Appendix C:** Technical specifications of the PV panel Trina solar TSM-550DE19



ELECTRICAL DATA (STC)

Peak Power Watts- P_{MAX} (Wp)*	540	545	550	555	560
Power Tolerance- P_{MAX} (W)			0 ~ +5		
Maximum Power Voltage- V_{MP} (V)	31.2	31.4	31.6	31.8	32.0
Maximum Power Current- I_{MP} (A)	17.33	17.37	17.40	17.45	17.49
Open Circuit Voltage- V_{OC} (V)	37.5	37.7	37.9	38.1	38.3
Short Circuit Current- I_{SC} (A)	18.41	18.47	18.52	18.56	18.60
Module Efficiency η_m (%)	20.7	20.9	21.0	21.2	21.4

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5. *Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power- P_{MAX} (Wp)	409	413	417	420	424
Maximum Power Voltage- V_{MPP} (V)	29.0	29.2	29.3	29.5	29.7
Maximum Power Current- I_{MPP} (A)	14.10	14.15	14.19	14.23	14.26
Open Circuit Voltage- V_{OC} (V)	35.3	35.5	35.7	35.9	36.1
Short Circuit Current- I_{SC} (A)	14.84	14.88	14.92	14.96	14.99

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline
No. of cells	110 cells
Module Dimensions	2384×1096×30 mm (93.86×43.15×1.18 inches)
Weight	28.3 kg (62.39 lb)
Glass	3.2 mm (0.13 inches), High Transmission, Tempered Glass
Encapsulant material	EVA/POE
Backsheet	White
Frame	30 mm(1.18 inches) Anodized Aluminium Alloy
J-Box	IP68 rated
Cables	Photovoltaic Technology Cable 4.0 mm ² (0.006 inches ²) Portrait: 350/280 mm(13.78/11.02 inches) Length can be customized
Connector	MC4 EV02 / TS4 Plus / TS4*

*Please refer to regional datasheet for specified connector.

TEMPERATURE RATINGS

NOCT (Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of P _{MAX}	-0.34%/°C
Temperature Coefficient of V _{OC}	-0.25%/°C
Temperature Coefficient of I _{SC}	0.04%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC) 1500V DC (UL)
Max Series Fuse Rating	30A

WARRANTY

- 12 year Product Workmanship Warranty
- 25 year Power Warranty
- 2% first year degradation
- 0.55% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 36pieces
Modules per 40' container: 720 pieces



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

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