DNV·GL

Light-soak Measurements

Engineering Report
Chint Solar Co., Ltd.

CHSM6610P/HV, CHSM6610M/HV, CHSM6612P/HV, and CHSM6612M/HV Modules

Report No.: R10072536K-1
Date: 1 May 2018

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Task and objective:
Perform light-soak measurements of CHSM6610P/HV, CHSM6610M/HV, CHSM6612P/HV, and CHSM6612M/HV modules for Chint Solar Co., Ltd.

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Revision	Date	Reason for Issue	Prepared by	Verified by	Approved by
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List of abbreviations

Abbreviation	**Meaning**
DNV GL	DNV GL PVEL, LLC
I_{MP}	Current at maximum power
I_{SC}	Short-circuit current
P_{MAX}	Maximum power
PV	Photovoltaic
STC	Standard test conditions
V_{MP}	Voltage at maximum power
V_{OC}	Open-circuit voltage

1 SUMMARY

Chint Solar Co., Ltd. submitted Astronergy CHSM6610P/HV, CHSM6610M/HV, CHSM6612P/HV, and CHSM6612M/HV photovoltaic (PV) modules for PAN file parameter measurements. Before the PAN file parameter measurements, each module was exposed to 40 kWh/m^2 of sunlight. Modules were flash-tested at standard test conditions (STC) before and after light-soaking.

The results of the light-soak measurements are presented in this report.

1.1 Manufacturer specifications

The CHSM6610P/HV-280 datasheet values were taken from the “STAVE™ II 275W~290W 5BB-Polycrystalline PV Module” datasheet (Astronergy 09-2017). The CHSM6610M/HV-295 datasheet values were taken from the “STAR™ II 290W~305W 5BB-Monocrystalline PV Module” datasheet (Astronergy 09-2017). The CHSM6612P/HV-335 datasheet values were taken from the “STAVE™ II 330W-350W 5BB-Polycrystalline PV Module” datasheet (Astronergy 11-2018). The CHSM6612M/HV-355 datasheet values were taken from the “STAR™ II 350W~370W 5BB-Monocrystalline PV Module” datasheet (Astronergy 11-2017). The datasheets were provided by the manufacturer. The datasheets can be found in Appendix C, D, E, and F, respectively.

Astronergy Datasheet Values					
Model	P_{MAX} [W]	V_{OC} [V]	V_{MP} [V]	I_{SC} [A]	I_{MP} [A]
CHSM6610P/HV-280	280	38.69	31.2	9.59	8.99
CHSM6610M/HV-295	295	39.81	32.38	9.56	9.12
CHSM6612P/HV-335	335	45.98	37.26	9.57	9.00
CHSM6612M/HV-355	355	47.31	38.82	9.60	9.15

2 LIGHT-SOAK MEASUREMENTS

2.1 Pre-light-soak measurement data

These measurements were taken before any modules received any outdoor sunlight exposure.

Pre-light-soak Measurements						
Model	Serial Number	P_{MAX} [W]	V_{OC} [V]	V_{MP} [V]	I_{SC} [A]	I_{MP} [A]
CHSM6610P/HV-280	6577235262000010	282.5	38.71	31.31	9.492	9.021
CHSM6610M/HV-295	6577335261300050	292.3	39.15	31.76	9.691	9.205
CHSM6610M/HV-295	6577335261300053	294.8	39.23	31.94	9.738	9.229
CHSM6612M/HV-355	7720535261500051	349.6	46.97	38.18	9.631	9.156
CHSM6612P/HV-335	7720635262200019	338.8	46.57	37.78	9.465	8.968

Pre-light-soak Measurements' Percent Difference from Nameplate Data						
Model	Serial Number	P_{MAX} [%]	V_{OC} [%]	V_{MP} [%]	I_{SC} [%]	I_{MP} [%]
CHSM6610P/HV-280	6577235262000010	0.89	0.05	0.36	-1.02	0.35
CHSM6610M/HV-295	6577335261300050	-0.91	-1.67	-1.92	1.37	0.93
CHSM6610M/HV-295	6577335261300053	-0.06	-1.46	-1.35	1.86	1.20
CHSM6612M/HV-355	7720535261500051	-1.53	-0.72	-1.65	0.33	0.07
CHSM6612P/HV-335	7720635262200019	1.14	1.28	1.41	-1.10	-0.36

2.2 Post-light-soak measurement data

These measurements were taken after each module received 40 kWh/m^2 of outdoor sunlight exposure.

Post-light-soak Measurements						
Model	**Serial Number**	**P_{MAX} [W]**	**V_{OC} [V]**	**V_{MP} [V]**	**I_{SC} [A]**	**I_{MP} [A]**
CHSM6610P/HV-280	6577235262000010	285.2	38.76	31.49	9.599	9.056
CHSM6610M/HV-295	6577335261300050	294.9	39.15	31.89	9.741	9.247
CHSM6610M/HV-295	6577335261300053	294.2	39.15	31.86	9.766	9.236
CHSM6612M/HV-355	7720535261500051	351.4	46.94	38.19	9.654	9.201
CHSM6612P/HV-335	7720635262200019	342.4	46.67	38.05	9.500	8.997

Post-light-soak Measurements' Percent Difference from Pre-light-soak Measurements						
Model	**Serial Number**	**P_{MAX} [%]**	**V_{OC} [%]**	**V_{MP} [%]**	**I_{SC} [%]**	**I_{MP} [%]**
CHSM6610P/HV-280	6577235262000010	0.97	0.14	0.58	1.13	0.39
CHSM6610M/HV-295	6577335261300050	0.87	0.02	0.41	0.52	0.46
CHSM6610M/HV-295	6577335261300053	-0.19	-0.21	-0.27	0.28	0.08
CHSM6612M/HV-355	7720535261500051	0.52	-0.06	0.03	0.23	0.49
CHSM6612P/HV-335	7720635262200019	1.05	0.22	0.71	0.38	0.33

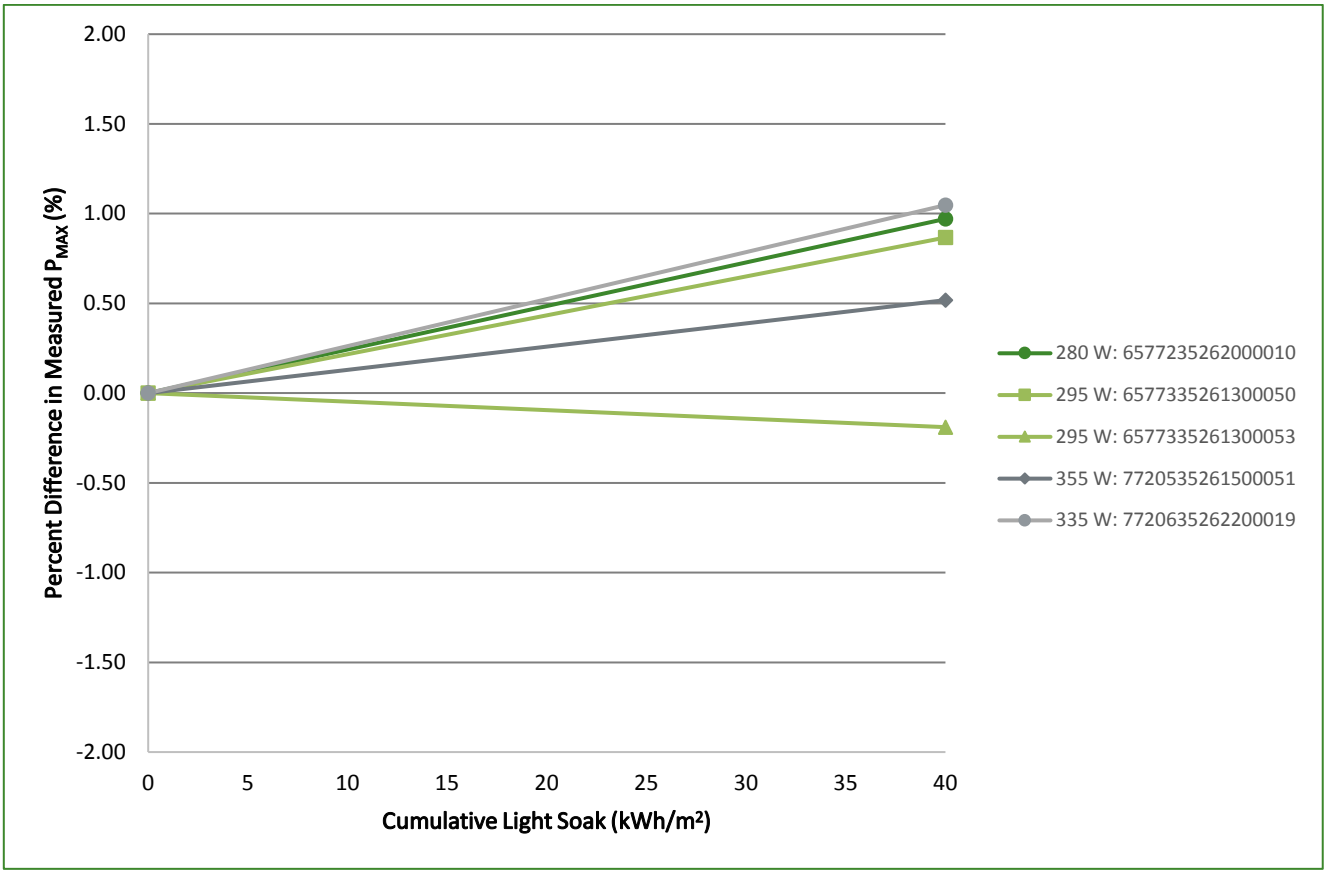
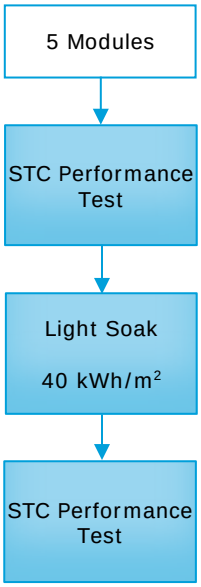


Figure 2-1 Measured Change in P_{MAX}

APPENDIX A – LIGHT-SOAK MEASUREMENTS



APPENDIX B – FLASH-TEST MEASUREMENT SUMMARY

Per IEC 60904-1 Second Edition 2006-9

Pasan SunSim 3b pulsed solar simulator (flash-tester)

- Class A+A+A+
  - Non-uniformity of irradiance ≤ 1%
  - Long-term pulse instability ≤ 1%
  - Spectral irradiance distribution ≤ ± 12.5%
- All performance values are extracted from the measured I-V data
- Expanded (k = 1.96) uncertainty values at STC (assuming a spectral mismatch factor of 1 and not including module metastability behavior):
  - V_{OC}: ± 0.79%
  - I_{SC}: ± 1.64%
  - P_{MAX}: ± 2.00%
- Maximum difference of achieved temperature/irradiance from target temperature/irradiance:
  - Temperature: ± 1°C
  - Irradiance: ± 0.5%

DNV GL's Pasan SunSim 3b pulsed solar simulator was calibrated using a JA Solar polycrystalline reference module (Serial Number 147P607222930001) and a JA Solar monocrystalline reference module (Serial Number 147M607222950007) that was calibrated by Fraunhofer Institut für Solare Energiesysteme (ISE). The next calibration due date is October 27, 2018. After calibrating the flash-tester to the JA Solar reference module, the modules were flash-tested according to IEC 60904-1.

APPENDIX C – CHSM6610P/HV-280 DATASHEET

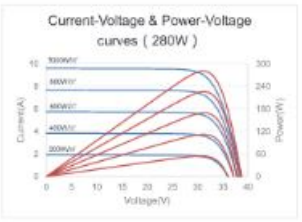
ELECTRICAL SPECIFICATIONS

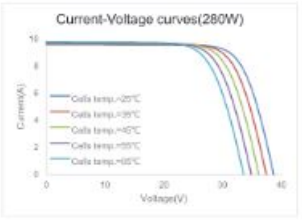
STC rated output (Pmpp)*	275 Wp	280 Wp	285 Wp	290 Wp
Rated voltage (Vmpp) at STC	31.12 V	31.20 V	31.38 V	31.55 V
Rated current (Impp) at STC	8.85 A	8.99 A	9.09 A	9.20 A
Open circuit voltage (Voc) at STC	38.45 V	38.69 V	38.94 V	39.18 V
Short circuit current (Isc) at STC	9.52 A	9.59 A	9.68 A	9.75 A
Module efficiency	16.9%	17.2%	17.5%	17.8%
Rated output (Pmpp) at NOCT	206.3 Wp	210.0 Wp	213.8 Wp	217.5 Wp
Rated voltage (Vmpp) at NOCT	28.15 V	28.22 V	28.41 V	28.56 V
Rated current (Impp) at NOCT	7.33 A	7.44 A	7.52 A	7.62 A
Open circuit voltage (Voc) at NOCT	35.13 V	35.35 V	35.57 V	35.79 V
Short circuit current (Isc) at NOCT	8.02 A	8.08 A	8.15 A	8.21 A
Temperature coefficient (Pmpp)	- 0.407%/°C			
Temperature coefficient (Isc)	+0.049%/°C			
Temperature coefficient (Voc)	- 0.310%/°C			
Normal operating cell temperature (NOCT)	43±2°C			
Maximum system voltage (IEC/UL)	1000V_{DC} or 1500V_{DC}			
Number of diodes	3			
Junction box IP rating	IP 67			
Maximum series fuse rating	15 A			

* Measurement tolerance +/- 3%

STC: Irradiance 1000W/m², Cell Temperature 25°C, AM=1.5
NOCT: Irradiance 800W/m², Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s

CURVE





MECHANICAL SPECIFICATIONS

Outer dimensions (L x W x H)	1648 x 990 x 35 mm 64.88 x 38.98 x 1.38 in
Frame technology	Aluminum, silver / black anodized
Module composition	Glass / EVA / Backsheet (white)
Front glass thickness	3.2 mm / 0.13 in
‡Cable length (IEC/UL)	1000 mm / 39.37 in
Cable diameter (IEC/UL)	4 mm² / 12 AWG
‡Maximum mechanical test load	6000 Pa
Fire performance (IEC/UL)	Class C (IEC) or Type 1 (UL)
Connector type (IEC/UL)	MC4 compatible

‡ Option: 900(+) /600(-) mm for defined projects in advance.

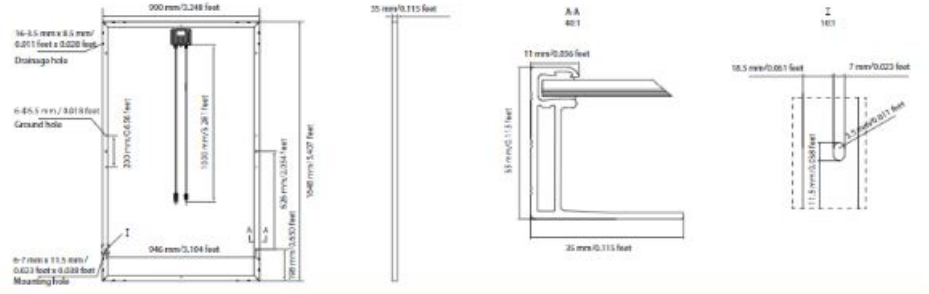
‡ Refer to Astronergy crystalline installation manual or contact technical department.
Maximum Mechanical Test Load=1.5×Maximum Mechanical Design Load.

PACKING SPECIFICATIONS

‡Weight (module only)	18.3 kg / 40.34 lbs
‡Packing unit	31 pcs / box
Weight of packing unit (for 40'HQ container)	616 kg / 1358 lbs
Number of modules per 40'HQ container	868 pcs

‡ Tolerance +/- 1.0kg
‡ Subject to sales contract

MODULE DIMENSION DETAILS



APPENDIX D – CHSM6610M/HV-295 DATASHEET

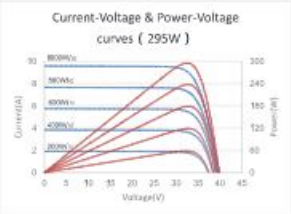
ELECTRICAL SPECIFICATIONS

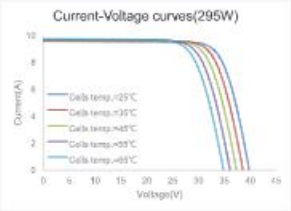
STC rated output (Pmpp)*	290 Wp	295 Wp	300 Wp	305 Wp
Rated voltage (Vmpp) at STC	32.15 V	32.38 V	32.59 V	32.80 V
Rated current (Impp) at STC	9.03 A	9.12 A	9.21 A	9.30 A
Open circuit voltage (Voc) at STC	39.45 V	39.81 V	39.90 V	40.05 V
Short circuit current (Isc) at STC	9.54 A	9.59 A	9.68 A	9.72 A
Module efficiency	17.8%	18.1%	18.4%	18.7%
Rated output (Pmpp) at NOCT	213.1 Wp	216.8 Wp	220.5 Wp	224.1 Wp
Rated voltage (Vmpp) at NOCT	29.58 V	29.79 V	30.00 V	30.21 V
Rated current (Impp) at NOCT	7.20 A	7.28 A	7.35 A	7.42 A
Open circuit voltage (Voc) at NOCT	36.60 V	36.93 V	37.01 V	37.15 V
Short circuit current (Isc) at NOCT	7.67 A	7.71 A	7.79 A	7.82 A
Temperature coefficient (Pmpp)	- 0.380%/°C			
Temperature coefficient (Isc)	+0.042%/°C			
Temperature coefficient (Voc)	- 0.284%/°C			
Normal operating cell temperature (NOCT)	46±2°C			
Maximum system voltage (IEC/UL)	1000V_{dc} or 1500V_{dc}			
Number of diodes	3			
Junction box IP rating	IP 67			
Maximum series fuse rating	15 A			

* Measurement tolerance +/- 3%

STC: Irradiance 1000W/m², Cell Temperature 25°C, AM=1.5
NOCT: Irradiance 800W/m², Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s

CURVE





MECHANICAL SPECIFICATIONS

Outer dimensions (L x W x H)	1648 x 990 x 35 mm 64.88 x 38.98 x 1.38 in
Frame technology	Aluminum, silver anodized
Module composition	Glass / EVA / Backsheet (white)
Front glass thickness	3.2 mm / 0.13 in
‡Cable length (IEC/UL)	1000 mm / 39.37 in
Cable diameter (IEC/UL)	4 mm² / 12 AWG
‡Maximum mechanical test load	6000 Pa
Fire performance (IEC/UL)	Class C (IEC) or Type 1 (UL)
Connector type (IEC/UL)	MC4 compatible

‡ Option: 900(+) /600(-) mm for defined projects in advance.

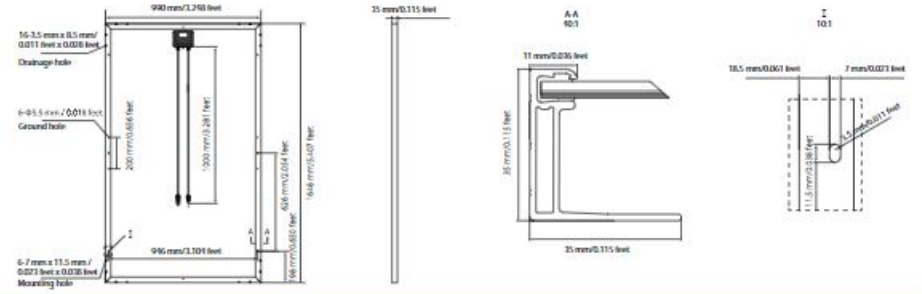
‡ Refer to Astronergy crystalline installation manual or contact technical department.
Maximum Mechanical Test Load=1.5XMaximum Mechanical Design Load.

PACKING SPECIFICATIONS

‡Weight (module only)	18.3 kg / 40.34 lbs
‡Packing unit	31 pcs / box
Weight of packing unit (for 40'HQ container)	616 kg / 1358 lbs
Number of modules per 40'HQ container	868 pcs

‡ Tolerance +/- 1.0kg
‡ Subject to sales contract

MODULE DIMENSION DETAILS



APPENDIX E – CHSM6612P/HV-335 DATASHEET

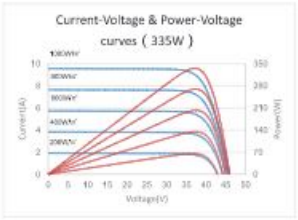
ELECTRICAL SPECIFICATIONS

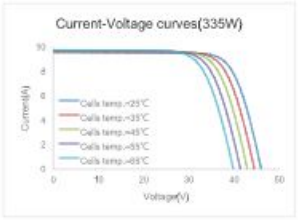
STC rated output (Pmpp)*	330 Wp	335 Wp	340 Wp	345 Wp	350 Wp
Rated voltage (Vmpp) at STC	37.15 V	37.26 V	37.33 V	37.38 V	37.48 V
Rated current (Impp) at STC	8.89 A	9.00 A	9.11 A	9.23 A	9.34 A
Open circuit voltage (Voc) at STC	45.86 V	45.98 V	46.16 V	46.37 V	46.57 V
Short circuit current (Isc) at STC	9.52 A	9.57 A	9.62 A	9.67 A	9.72 A
Module efficiency	17.1%	17.3%	17.6%	17.8%	18.1%
Rated output (Pmpp) at NOCT	230.4 Wp	233.9 Wp	237.4 Wp	240.9 Wp	244.4 Wp
Rated voltage (Vmpp) at NOCT	33.92 V	34.01 V	34.10 V	34.15 V	34.24 V
Rated current (Impp) at NOCT	6.79 A	6.88 A	6.96 A	7.05 A	7.14 A
Open circuit voltage (Voc) at NOCT	42.08 V	42.19 V	42.36 V	42.55 V	42.73 V
Short circuit current (Isc) at NOCT	7.37 A	7.40 A	7.44 A	7.48 A	7.52 A
Temperature coefficient (Pmpp)	- 0.408%/°C				
Temperature coefficient (Isc)	+0.050%/°C				
Temperature coefficient (Voc)	- 0.311%/°C				
Normal operating cell temperature (NOCT)	46±2°C				
Maximum system voltage (IEC/UL)	1000V_{DC} or 1500V_{DC}				
Number of diodes	3				
Junction box IP rating	IP 67				
Maximum series fuse rating	15 A				

* Measurement tolerance +/- 3%

STC: Irradiance 1000W/m², Cell Temperature 25°C, AM=1.5
NOCT: Irradiance 800W/m², Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s

CURVE





MECHANICAL SPECIFICATIONS

Outer dimensions (L x W x H)	1954 x 990 x 40 mm 76.93 x 38.98 x 1.57 in
Frame technology	Aluminum, silver anodized
Module composition	Glass / EVA / Backsheet (white)
Front glass thickness	3.2 mm / 0.13 in
≙Cable length (IEC/UL)	1150 mm / 45.28 in
Cable diameter (IEC/UL)	4 mm² / 12 AWG
≙Maximum mechanical test load	6000 Pa
Fire performance (IEC/UL)	Class C (IEC) or Type 1 (UL)
Connector type (IEC/UL)	MC4 compatible

PACKING SPECIFICATIONS

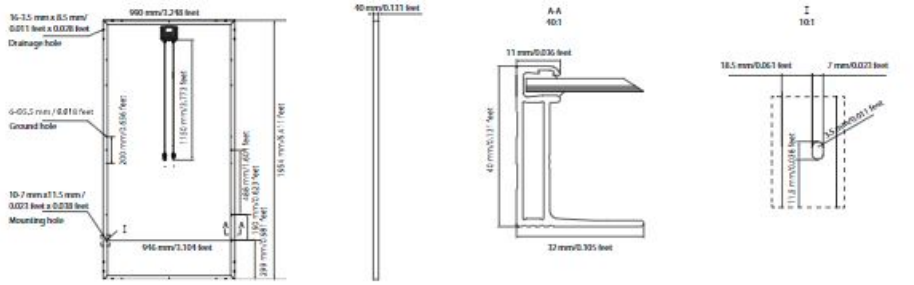
≙Weight (module only)	21.8 kg / 48.06 lbs
≙Packing unit	27 pcs / box
Weight of packing unit (for 40'HQ container)	648 kg / 1424 lbs
Number of modules per 40'HQ container	648 pcs

≙ Tolerance +/- 1.0kg
≙ Subject to sales contract

≙ Option: 900(+) /600(-) mm for defined projects in advance.

≙ Refer to Astronergy crystalline installation manual or contact technical department.
Maximum Mechanical Test Load=1.5XMaximum Mechanical Design Load.

MODULE DIMENSION DETAILS



APPENDIX F – CHSM6612M/HV-355 DATASHEET

ELECTRICAL SPECIFICATIONS

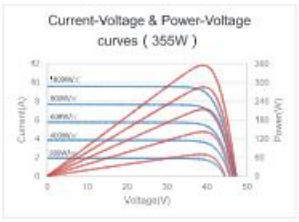
STC rated output (Pmpp)*	350 Wp	355 Wp	360 Wp	365 Wp	370 Wp
Rated voltage (Vmpp) at STC	38.58 V	38.82 V	39.14 V	39.38 V	39.66 V
Rated current (Impp) at STC	9.08 A	9.15 A	9.20 A	9.27 A	9.34 A
Open circuit voltage (Voc) at STC	47.01 V	47.31 V	47.62 V	47.82 V	48.13 V
Short circuit current (Isc) at STC	9.53 A	9.60 A	9.66 A	9.75 A	9.82 A
Module efficiency	18.1%	18.4%	18.6%	18.9%	19.1%
Rated output (Pmpp) at NOCT	257.8 Wp	261.5 Wp	265.1 Wp	268.8 Wp	272.5 Wp
Rated voltage (Vmpp) at NOCT	35.58 V	35.81 V	36.13 V	36.36 V	36.58 V
Rated current (Impp) at NOCT	7.24 A	7.30 A	7.34 A	7.39 A	7.45 A
Open circuit voltage (Voc) at NOCT	43.59 V	43.87 V	44.15 V	44.34 V	44.62 V
Short circuit current (Isc) at NOCT	7.66 A	7.71 A	7.76 A	7.83 A	7.89 A
Temperature coefficient (Pmpp)	- 0.376%/°C				
Temperature coefficient (Isc)	+0.043%/°C				
Temperature coefficient (Voc)	- 0.282%/°C				
Normal operating cell temperature (NOCT)	46±2°C				
Maximum system voltage (IEC/UL)	1000V$_{DC}$ or 1500V$_{DC}$				
Number of diodes	3				
Junction box IP rating	IP 67				
Maximum series fuse rating	15 A				

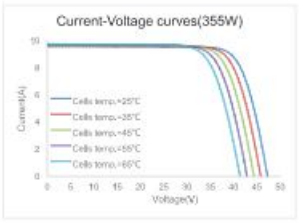
* Measurement tolerance +/- 3%

STC: Irradiance 1000W/m², Cell Temperature 25°C, AM=1.5

NOCT: Irradiance 800W/m², Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s

CURVE





MECHANICAL SPECIFICATIONS

Outer dimensions (L x W x H)	1954 x 990 x 40 mm 76.93 x 38.98 x 1.57 in
Frame technology	Aluminum, silver anodized
Module composition	Glass / EVA / Backsheet (white)
Front glass thickness	3.2 mm / 0.13 in
‡Cable length (IEC/UL)	1150 mm / 45.28 in
Cable diameter (IEC/UL)	4 mm² / 12 AWG
‡Maximum mechanical test load	6000 Pa
Fire performance (IEC/UL)	Class C (IEC) or Type 1 (UL)
Connector type (IEC/UL)	MC4 compatible

‡ Option: 800(+) /600(-) mm for defined projects in advance.

‡ Refer to Astronergy crystalline installation manual or contact technical department.
Maximum Mechanical Test Load=1.5XMaximum Mechanical Design Load.

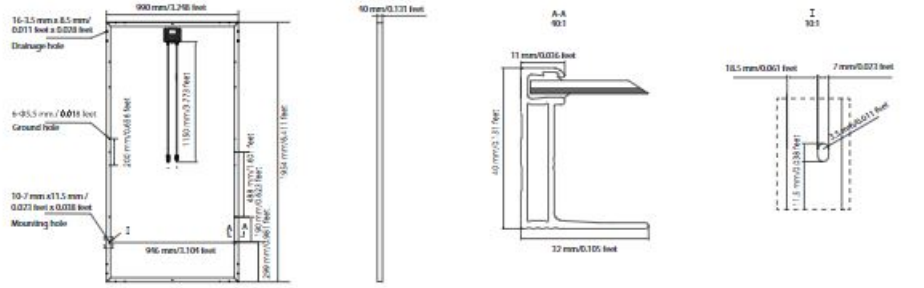
PACKING SPECIFICATIONS

‡Weight (module only)	21.8 kg / 48.06 lbs
‡Packing unit	27 pcs / box
Weight of packing unit (for 40'HQ container)	646 kg / 1424 lbs
Number of modules per 40'HQ container	648 pcs

‡ Tolerance +/- 1.0kg

‡ Subject to sales contract

MODULE DIMENSION DETAILS



About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, we empower our customers' decisions and actions with trust and confidence. We continuously invest in research and collaborative innovation to provide customers and society with operational and technological foresight. Operating in more than 100 countries, our professionals are dedicated to helping customers make the world safer, smarter and greener.