



Midnight Sun Solar Car Team
University of Waterloo

MSXII
Solar Cell Tech Report
Electrical

Prepared by:
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March 29, 2018

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1 Manufacturer

MSXII uses SunPower Gen E (E60), bin Le1 cells. They are manufactured by SunPower Corporation. The team's primary point of contact for cell ordering was Scott McHugo. His email and phone number on record is scott.mchugo@sunpower.com and +1 (408) 240-5500.

Scott is the regional representative for SunPower in the Americas but helped the team organize purchasing and shipping of cells from SunPower's european operations to an array manufacturer in Germany.

2 Specifications

SunPower's quote for the Gen E bin Le1 cell area is 153.328 cm^2 . Their quote for cell performance is 23.7 % efficiency, yielding a typical power output of 3.63 W per cell. The cost per cell quoted to the team, excluding shipping and handling, is EUR 5.21. The equivalent cost in USD quoted by SunPower is USD 6.38.

3 Layout

MSXII has a total of 322 full-cells and 8 half-cells, yielding a total cell area below the equivalent of 326 full-cells. Based on SunPower's quoted cell area of 153.328 cm^2 , this gives a total absolute area under $49\,985\text{ cm}^2$, meeting ASC regulations. A CAD drawing of the cell layout and MPPT layout is shown in Figure 1.

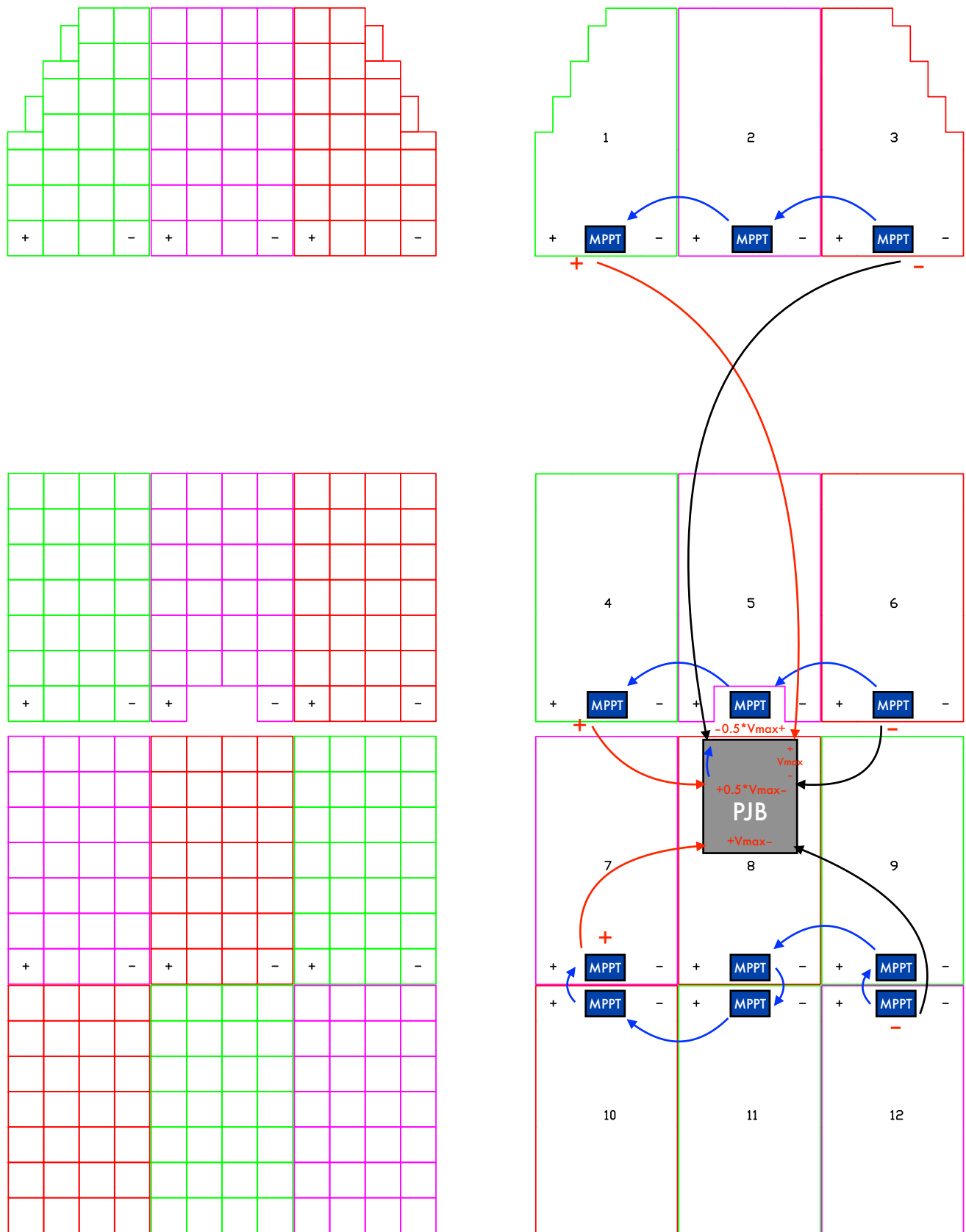


Figure 1: Cell and MPPT layout



SunPower Cell and Interconnection Tab Purchase Process for Solar Car Teams

SunPower's Specialty Product Group is launching an initiative to support Solar Car Teams and University Projects in the use SunPower cells. To aid the teams, the Specialty Product Group is reducing prime cell pricing equally for all University teams and expanding outreach efforts.

At the time of this writing, SunPower provides discounts on all cell bins, and access to the highest power bin, in exchange for logo placement, as detailed in Attachment C. Step by Step Process:

1. Complete the order template below. Once cell type and quantity is confirmed, SunPower will generate a Purchase Order Agreement, which includes, Attachment A (Schedule of Delivery and Payments), Attachment B (Solar Cells Purchase Terms and Conditions), and Attachment C (Logo Use and Marketing Terms and Conditions).
2. Solar Team signs and returns to SunPower. SunPower will provide a countersigned copy in parallel to next step.
3. Solar Team wires payment to SunPower.
4. Upon receipt of payment, SunPower ships cells. Cells may be shipped directly to panel integrators upon request.

This process typically takes two to three weeks; but, buffer is always recommended, as unexpected delays have occurred in the past.

Good luck in your races and please send pictures!

3-Jan-2017



Solar Team Order Template

Team name:

Primary point of contact:

Phone and email:

Purchasing entity:

Bill to address:

Billing contact person:

Billing phone and email:

VAT (if located in EU):

Delivery Address:

Delivery Phone:

Requested Cells:

Please insert quantity in green fields shown below in the table.

Cells come in packs of 150 and tabs in boxes of 1200.

Nominal cell area is 153.328 cm²

Pricing is indicative, non-binding, and does not include shipping.

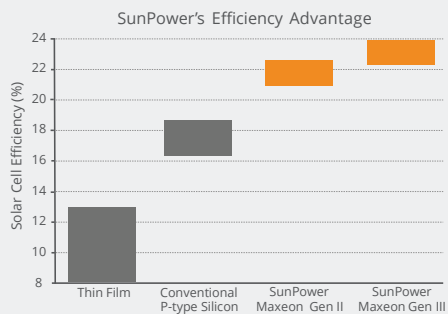
Please contact SunPower to confirm latest pricing.

Quantity	Cell Gen	Bin	Aesthetic Quality	Typical Power (W)	Typical Efficiency	Special Offer (\$/cell)	Regular Price (\$/cell)
	E	Me1	Highest	3.72	24.3%	\$11.23	Not avail
	E	Le1	Highest	3.63	23.7%	\$6.38	\$6.62
	E	Ke1	Highest	3.54	23.1%	\$5.13	\$5.81
	C	Kp	Highest	3.48	22.7%	\$3.21	\$3.57
	C	Jp	Highest	3.44	22.4%	\$3.15	\$3.48
	C	Hp	Highest	3.41	22.3%	\$2.52	\$3.31
	Tabs					\$0.07/tab	\$0.10/tab

MAXEON™ GEN III SOLAR CELLS

Power Advantage

SunPower designs, manufactures, and delivers high-performance solar electric technology worldwide. SunPower™ cells produce 25-35% more power compared to Conventional Cells¹ with outstanding aesthetics.



Energy Advantage

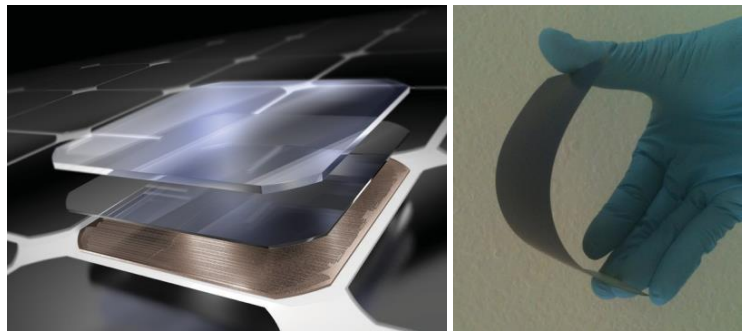
SunPower panels deliver the highest energy per rated watt compared to a Conventional Panel. (Photon International, Mar 2013, out of 151 panels tested).

- No Light-Induced Degradation = 2 - 3% more energy.
- Low Temperature Coefficient = 1 - 2% more energy at 35-40°C ambient temperature.
- Low Light and Broad Spectral Response = up to 1% more energy in overcast and low-light conditions.

¹ As used throughout, "Conventional Cells" are silicon cells that have many thin metal lines on the front and 2 or 3 interconnect ribbons soldered along the front and back. "Conventional Panel" means a panel with 240W, 15% efficiency and approximately 1.6 m² made with Conventional Cells.

Durability Advantage

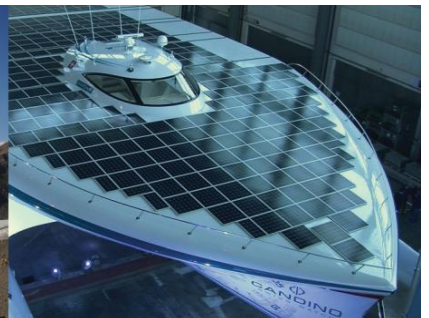
The Maxeon cell has strength and durability to survive extreme conditions year after year, enabling SunPower to provide superior, long-term performance in a broad range of applications.



- Corrosion Resistance: SunPower's tin-copper metal system is more corrosion resistant compared to the porous metal paste used in Conventional Cells, which can crack more easily and corrode.
- Crack Resistance: SunPower's cells are thinner and more flexible than Conventional Cells. When a SunPower cell does crack, the backside copper metal foundation keeps the cell intact and maintains a high power output. When Conventional Cells crack, the cell breaks apart with typically a significant loss of power.
- Eco-Friendly: SunPower cells solder to lead-free components and are RoHS compliant. Conventional Cells often require components with lead.



Photo courtesy of 3S Photovoltaics



MAXEON™ GEN III SOLAR CELLS

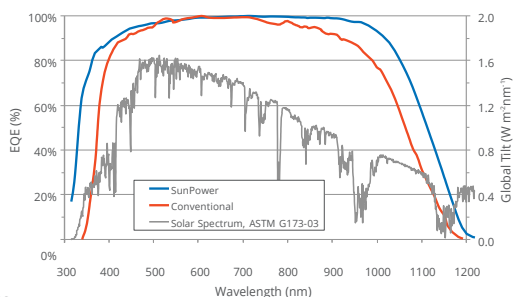
Electrical Characteristics of a typical Maxeon Gen III Cell At Standard Test Conditions (STC) STC: 1000W/m², AM 1.5g and cell temp 25°C

	P _{mp} (Wp)	Eff. (%)	V _{mp} (V)	I _{mp} (A)	V _{oc} (V)	I _{sc} (A)
Ultra Premium Performance	3.63	23.7	0.632	5.9	0.73	6.15
Ultra High Performance	3.54	23.1	0.621	5.8	0.72	6.12
Ultra Performance	3.46	22.6	0.612	5.8	0.71	6.08

Electrical parameters are nominal values.

Temp. Coefficients in SunPower Panels: Voltage: -1.74mV/°C, Power: -0.30%/°C

Spectral Response



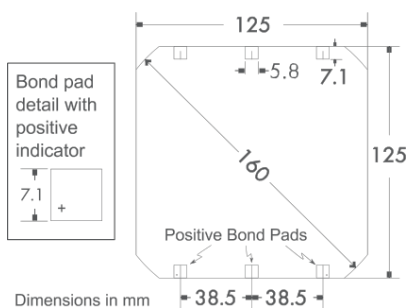
References

SunPower: NREL data, commissioned by SPWR

Conventional: Progress in Photovoltaics: Research and Applications, Solar cell efficiency tables version 36 18(5), (2010) 46-352

Cell Physical Characteristics

Wafer:	Monocrystalline silicon
Design:	All back contact
Front:	Uniform, black antireflection coating
Back:	Tin-coated, copper metal grid
Cell Thickness:	165µm +/- 40µm



Bond pad area dimensions are 5.8mm x 7.1mm.

Metal finger pitch between positive and negative fingers is 471µm.

Positive/Negative pole bond pad sides have "+/-" indicators on leftmost and rightmost bond pads

Positive Electrical Grounding

If the cell voltage is below frame ground the cell power output will be reduced. Therefore, modules and systems produced using these cells should be configured as "positive ground systems." If this creates a problem, please consult With SunPower.

Interconnect Tab and Process Recommendations



SunPower recommends customers use SunPower's patented tin-plated copper strain-relieved interconnect tabs, which can be purchased from SunPower. These interconnects are easily solderable and compatible with lead free processing.

Our patented interconnect tabs are packaged in boxes of 3600 or 36,000 each.

<http://us.sunpower.com/about/sunpower-technology/patents/>

SunPower suggests that the cells are built into modules using SunPower's proprietary encapsulant for optimal performance. Encapsulant is available in rolls of 0.8m or 1m wide by 140m long.

Production Quality

ISO 9001:2008 certified

Soft handling procedures to reduce breakage and crack formation

100% cell performance testing and visual inspection

Packaging

Cells are packed in boxes of 1500 each; grouped in 10 shrink-wrapped stacks of 150 with interleaving. Minimum order size is 1 box. 24 boxes are packed in a water-resistant "Master Carton" containing 36,000 cells suitable for air transport.

Purchase Terms

Customers shall not reverse engineer, disassemble or analyze the Solar Cells or any prototype, process, product, or other item that embodies Confidential Information of SunPower. Customers shall not cause or allow any inspection, analysis, or characterization of any properties (whether mechanical, structural, chemical, electrical, or otherwise) of the Solar Cells, whether by itself or by a third party.

Customer agrees that it will not transfer (whether by sale, loan, gift, or other conveyance) the Solar Cells from its possession.

SunPower solar cells are provided "AS IS" without warranty.

Full terms and conditions are in the Cell Purchase Agreement



SALES ORDER ACKNOWLEDGMENT

SunPower Systems Sarl (SPSW OU)

WTC II 29 Route de Pré Bois

Switzerland

Geneva 1215

Order Number: 13115927

Order Date: 22-MAR-2018

Bill To:

University of Waterloo

200 University Ave W

Waterloo, Ontario N2L 3G1

Canada

VAT Number:119260685

Attention: Minghao Ji

Telephone: 1-519-888-4567

Ship To:

University of Waterloo

AM Meierhof 36

Holm 25488

Germany

Attention: Minghao Ji

Telephone: 1-519-888-4567

Purchase Order: 0001580520

INCO Terms: DDP-Delivered Duty Paid

Destination Warehouse

Payment Terms: Prepayment

Shipping Method: DHL-Air-Standard

SalesPerson: McHugo, Scott A (Scott

McHugo)

Remarks:

Line	Item Number	Item Description	Schedule Arrival Date	Qty.	UOM	Unit Price	Total
1.1	513646	CELL, E60-135-B-Le1, Diamond Wire HEM	30-MAR-2018	450	EA	5.21	2,344.50
2.1	110760	FREIGHT	30-MAR-2018	1	EA	89.00	89.00

Note - VAT Rate in this transaction is final unless we receive any special documents for reduced VAT Rate within 48 hours.

Subtotal:	2,433.50
VAT%:0.00	Tax: 0.00
Total:	2,433.50
Currency:	EUR

SunPower Systems Sarl (SPSW OU)

www.sunpowercorp.com



Team Coordinator

asc teams@americansolarchallenge.org
www.americansolarchallenge.org

ASC/FSGP Solar Cell Info

Email completed form to asc teams@americansolarchallenge.org
 The manufacturer's specification sheet also needs to be submitted

Team Information	Date Submitted: October 14, 2017 Team Number: 24 Organization/School: Midnight Sun Solar Rayce Car Team/University of Waterloo
Team Array Contact	Name: Minghao Ji Phone: 519-500-1296 Email: minghao.ji@uwmidsun.com
Manufacturer's Specifications	Manufacturer: Sunpower Corporation Manufacturer Contact POC, Phone, & Email: Zach Campeau, N/A, Zach.Campeau@sunpower.com Type: Monocrystalline Silicon Cell Name: Maxeon Gen 3 E Cell Model Number: Bin Le1 Area of Single Cell (Square Centimeters): 153.33
Complete at Least Three of the Following Spaces Based on Manufacturer's Specifications	Vmp (Volts): 0.632 Imp (Amperes): 5.9 Pmp (Watt): 3.63 Efficiency (Percent): 23.7%
Vehicle Array Specs	Cell Area After Trimming For Placement on Car (cm²): 153.33 Number of Cells in Array: 326 Total Array Photovoltaic Area (Square Meters): 4.999 Additional Comments:
Supplier Information	Supplier: Sunpower Corporation Contact Person: Zach Campeau Phone: N/A Email: Zach.Campeau@sunpower.com Supplier Cell Name: Maxeon Gen 3 E Supplier Cell Model Number: Bin Le1 Pre-Encapsulated Price Per Cell (US Dollars): \$6.38 Pre-Encapsulated Cost Per Watt (US Dollars): \$1.76

Notes: