July 28, 2010

SM3320-1A1
SolarMagic Power Optimizer

30122629

Safety and Quality

- UL1741 certified, Bauart mark, CE mark IEC/EN61558, EN50178
- Radiated emissions (EMI) complies with FCC part 15 Class B and IEC/EN61000-6-3,-4 Class B
- Radiated Immunity/ESD complies with IEC/ EN6100-6-1,-2 Class A (Residential and light industrial)
- 25 year limited warranty
- State of the art design, no electrolytic capacitors
- Built in fault protections including over-temperature and output short circuit

Electrical Specifications

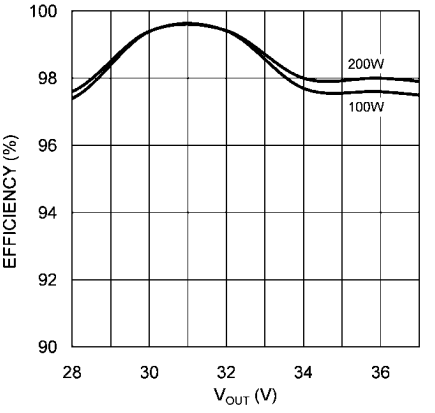
- Up to 50V module V_{OC}
- Up to 11A module I_{SC}
- Operation from -40°C to 90°C

Key Features

- Reclaims up to 71% of the energy lost due to environmental and system mismatch (e.g. trees, clouds, module aging, etc.)
- Up to 99.5% efficiency
- Patent pending Panel-Mode
- Junction Box integrated power optimizer solution
- Wide range of PV module compatibility
- Compact form factor with ultra-thin profile for integration into modules with 25mm frames
- Built in EMI shielding and heat-sinking
- Flexible connection options for Input/Output terminals

Typical Performance

Typical Efficiency, Vmp 33V



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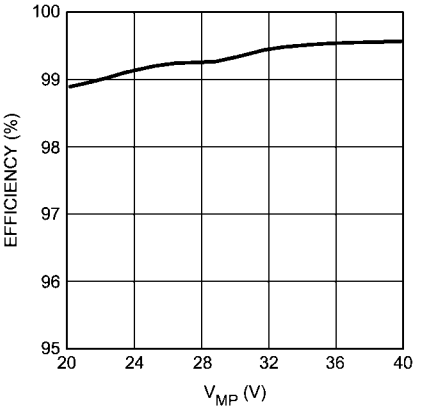
Peak Efficiency vs Vmp



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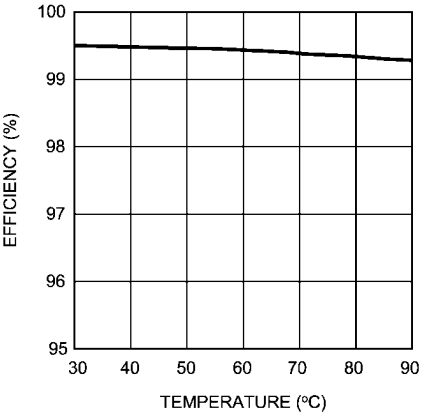
Peak Efficiency vs Temperature



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Important WARNINGS

Before installing the SolarMagic™ SM3320 power optimizer, and SM2100 blocking diode, read all instructions and cautionary markings in the user manual, on the unit, on the system inverter and on the photovoltaic array. There are lethal levels of current present within the SolarMagic™ SM2100 blocking diode that are extremely hazardous if precautions are not followed. Installation should only be conducted by a trained professional installer. All service guidelines must be followed.

The SolarMagic SM3320 is not intended for use as a battery charge controller. Do not attach directly to a battery.

Avant l'installation de l'optimisateur de puissance SolarMagic SM3320 et de la diode de blocage SM2100, lire toutes les instructions et mises en gardes presentes dans le manuel d'utilisateur ainsi que sur l'unité, sur l'invertisseur et sur les panneaux solaires. Les niveaux de courant electrique presents au sein des diodes SolarMagic SM2100 sont extremement dangereux si les précautions ne sont pas suivies. L'installation ne doit etre menée que par des intallateurs professionnels et formés. Toutes les consignes d'emplois doivent etres suivies.

SolarMagic SM3320 n'est pas destiné à être utilisé come chargeur de batterie. Ne pas connecter directement a une batterie.

Vor dem Installieren der SolarMagic™ SM3320 Power Optimizer und der SM1200 Blocking Diode bitte alle Anleitungen und Gefahrenhinweise in der Gebrauchsanweisung, auf dem Geraet, auf dem Systemwechselrichter und dem PV System durchlesen. Es sind Stroeme innerhalb der SolarMagic™ SM2100 Blocking Diode vorhanden welche zur toedlichen Gefahr werden koennen wenn nicht richtig gehandhabt. Die Installation sollte nur von geschultem, qualifiziertem Installateur gemacht werden. Alle Installationsrichtlinien sind unbedingt zu befolgen.

Der SolarMagic SM3320 nicht als Batterieladegeraet verwenden. Nicht direkt an eine Batterie anschliessen.

Conformance Certifications

The SolarMagic SM3320-1A1 power optimizer complies with the following standards.

CERTIFICATIONS			
	USA / Canada / Japan	**EU/EEA**	**Markings**
EMC	FCC, CFR 47 part 15, Class B ICES-003, Class B Complies with VCCI Regulation V-3 Class B	EN 61000-6-3 EN 61000-6-4 EN 61000-6-1 EN 61000-6-2 Class A, B	
Safety	UL1741 CSA C22.2 No. 107.1-01 CB Test IEC61558-1	EN 5017 IEC/EN 61558-1	
RoHS / WEEE	Markings per JEDEC Standard JESD97	RoHS Directive 2002/95/EC WEEE Directive 2002/96/EC http://www.national.com/analog/quality/green	
RF Immunity			
ESD	Follow ESD safe handling procedures. JESD625-A, EIA 625, MIL-STD-129 and MILHDBK-263.	IEC/EN61000-6-1,-2 4kV CD 8kV AD	
RF EMF	80% 1kHz AM	EN/IEC61000-6-4,-3 Class A 80MHz - 1000MHz 10V/m 1.4GHz - 2.7GHz 10V/m	

Introduction

National Semiconductor's SolarMagic™ SM3320 power optimizer is the perfect solution to address real-world problems facing photovoltaic (PV) arrays.

Today's photovoltaic arrays are defined as strings of series-connected PV modules, which are then paralleled together and converted to AC power through an inverter. The key challenge of these arrays is how a small amount of real-world mismatch with just a few of the PV modules can dramatically affect the power output of the entire array. The causes of mismatch can come in the form of shading (e.g. trees, chimneys, overhead power lines, bird droppings, handrails, etc.) module-to-module mismatch (current, voltage, aging), different module orientations and tilts, or different string lengths. Mismatch affects all arrays, ranging from residential to commercial to utility scale. The mismatch inhibits the arrays from achieving their maximum performance.

To maximize the energy output of each solar PV module in the array, National Semiconductor has developed the SolarMagic SM3320, which enables each solar module to produce the maximum available energy regardless of whether other modules in the array are under-performing due to mismatch. The SM3320 is assembled as a component inside the PV module junction box for the ultimate smart module solution. The SM3320 establishes a new level of performance while maintaining ease of system design and installation.

The SM3320 monitors and maximizes the energy harvest of each individual PV module through advanced algorithms combined with leading-edge mixed-signal technology, thereby recouping up to 71% of the lost energy due to mismatches.

SM3320 Electrical Operating Parameters

Symbol	Parameter	Min	Typ	Max
V_{SYS}	UL System String Voltage			600Vdc
	CE System String Voltage			1000Vdc
V_{OC}	PV Module Open-Circuit Voltage			50Vdc
I_{SC}	PV Module Short-Circuit Current			11A
P_{MPP}	MPP Power	10W		320W
V_{MPP}	MPP Voltage	15Vdc	28Vdc	40Vdc
V_{OUT}	Output Voltage	0Vdc		43Vdc
I_{OUT}	Output Current			12.5A
	Over Voltage Protection Threshold		45Vdc	
	Over Temperature Protection Threshold		125°C	
η_{MPP}	MPP Efficiency		98.50%	
η_{PM}	Panel Mode Efficiency		99.50%	
T_A	Ambient Operating Temperature	-40°C		90°C
T_s	Storage Temperature	-40°C		125°C
	Ambient Humidity			85%

Physical Specifications

Model	Body Dimensions	Weight
SM3320-1A1	127 x 87.63 x 14.72 mm	181g

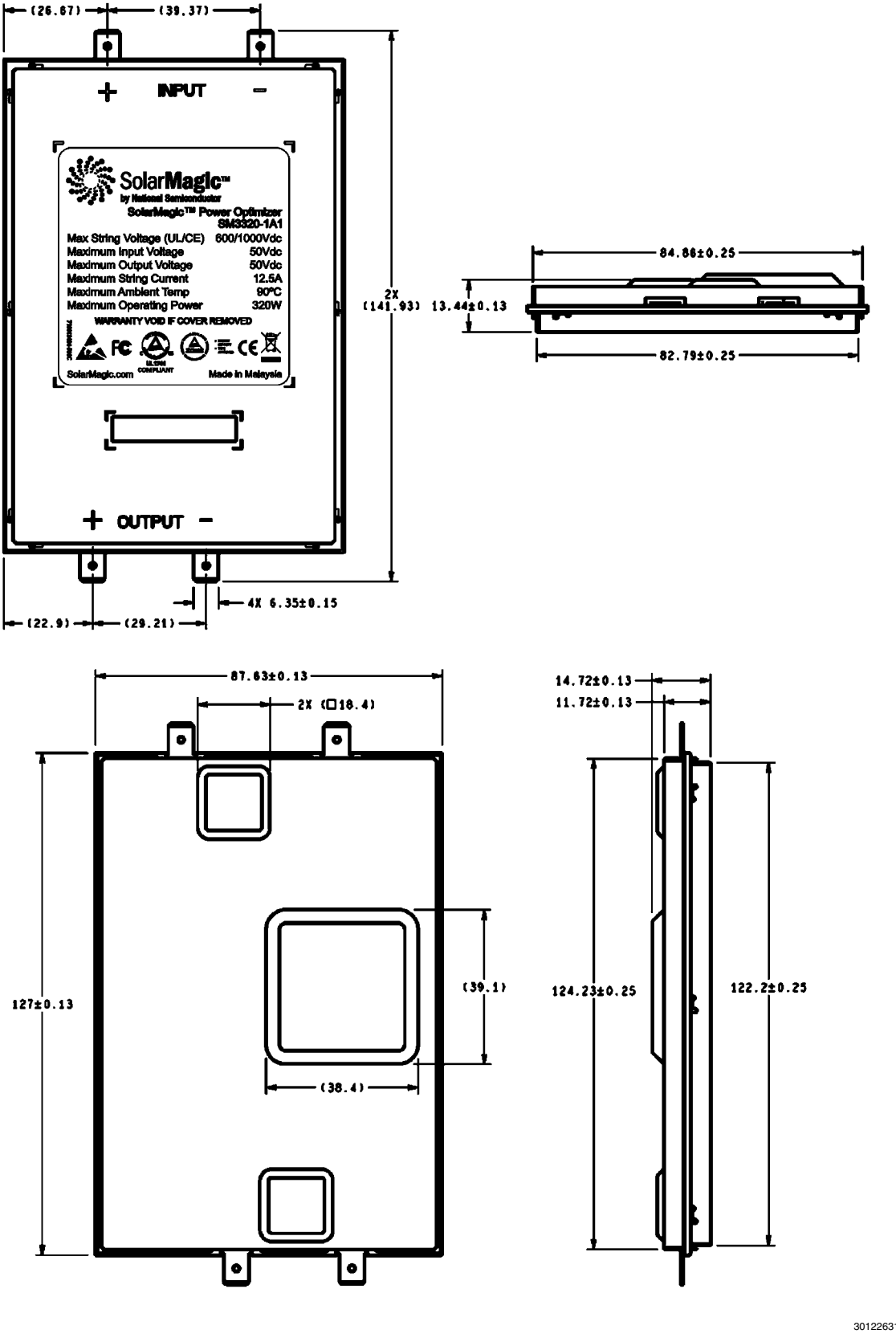


FIGURE 1. SM3320 Physical Dimensions

Operation and Safety Features

The SM3320 uses custom designed state of the art analog / digital ICs and components. Several operational and safety modes controlled by the SolarMagic™ proprietary algorithm insure the upmost in performance and reliability.

Modes of Operation

To maintain maximum power point tracking (MPPT) the SM3320 operates in three primary modes: Buck, Boost, and Panel-Mode (PM). Buck and Boost describe the switching circuitry's mode of operation with respect to the input and output. PM is an active bypass of the internal switching circuitry and is triggered whenever the SM3320 output is in close proximity to the input. This is an extremely high efficiency mode allowing up to 99.5% efficiency. The SM3320 also uses PM by default during startup and shutdown virtually eliminating unwanted inverter interaction.

Safety Features

- **Over Current Protection (OCP):** If the output load current exceeds the internal threshold (approx. 12.5A), the SM3320 will default into Panel-Mode. A PV module's current capability is inherently limited by its Isc specification. Defaulting into PM will force the removal of the overload condition.
- **Over Temperature Protection (OTP):** Several active temperature sensors are built into the SM3320 to monitor the power components. An over temperature condition (approx. 125°C or higher) will also trigger Panel-Mode. The SM3320 will self recover as the temperature falls back within the normal range. All power FETs used in the SM3320 are rated for full operation up to 175°C. While rare, the FETs can safely operate beyond 125°C.
- **Over Voltage Protection (OVP):** The maximum boost output voltage is internally limited. If an external condition forces the voltage to go beyond the OVP threshold (approx. 45V), the SM3320 will trigger an internal reset to recover from the condition.
- **Internal By-Pass Diode:** In the highly unlikely event that a catastrophic failure happens to the SM3320, a built in bypass diode will bypass all of the internal circuitry including Panel-Mode. This ensures that the PV module will always remain online and active, even in the most extreme scenarios of failure.

General Junction Box Guidelines

Junction box design and material selection must meet local certification requirements for Photovoltaic installation and use in the intended application.

- The SM3320 is a RoHS compliant component. All materials used in the junction box manufacturing or assembly process should take this into account if the wish is to maintain RoHS compliancy.
- The SM3320 must be fully enclosed inside the junction box. A plastic non-conductive type material is recommended to avoid metal surface grounding requirements.
- The junction box must meet environmental protection NEMA 4/4X or IP65 minimum.
- A minimum air space of 3mm is recommended between the SM3320 and the back of the PV module to avoid hot spotting.
- Bypass diodes are required as per standard junction boxes. Bypass diodes are not integrated into the SM3320 to avoid thermal loading and need to be provided inside the junction box.
- The junction box should house the SM3320 such that the non-label side is facing away from the PV module.
- The junction box should be designed such that the SM3320 is properly and securely held in place.

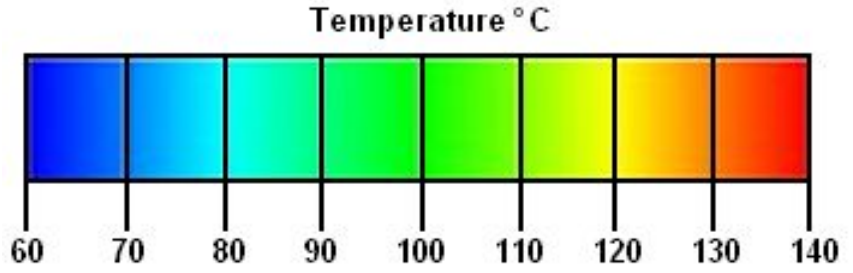
Thermal Management

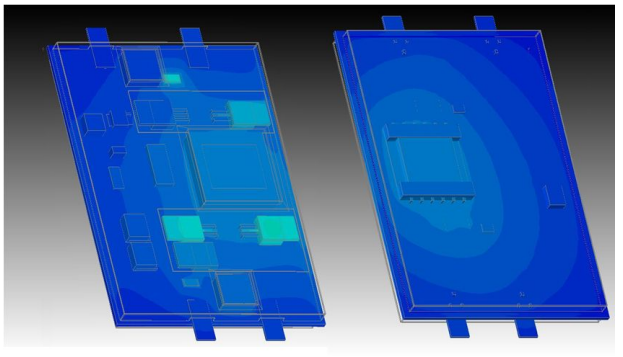
The SM3320 components are fully encased by metal EMI shields. The shields provide heat sinking by drawing heat from the power components. All power components directly contact the shield. Maintaining a 3mm minimum air gap between the SM3320 and PV module is necessary to avoid module heating. Mechanical integrity of the shields is critical to proper operation. Forces applied during the junction box assembly must not permanently flex the shield. Do not install an SM3320 that has a damaged shield. Do not tamper with the shields in any way. Tampering with the shields will void the warranty.

A series of thermal simulation images are presented in the next few figures. Note that these images reflect worst case operating conditions that are unlikely to occur. The SM3320 will operate at lower temperatures during typical conditions. Power FETs used in the SM3320 are designed for continuous operation at 175°C. Simulations assume -0.45%/°C power temperature coefficient for the PV module.

PV Module Applications Up To 280W

For PV modules rated up to 280 watts at STC, the factory installed metal EMI shields are sufficient for cooling the SM3320 during operation. No additional heat sinking is necessary. *Figure 2* and *Figure 3* illustrate the SM3320 temperature profile for 280W module operation at 25°C and 90°C ambient temperatures.





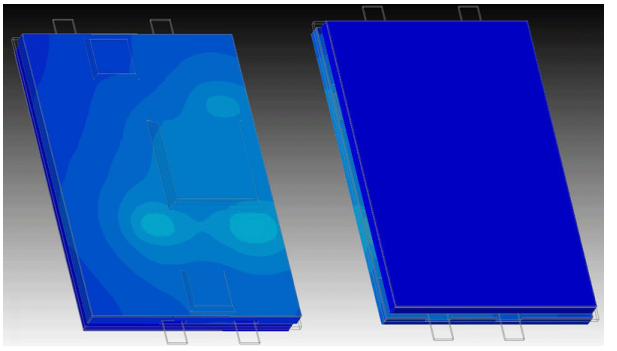
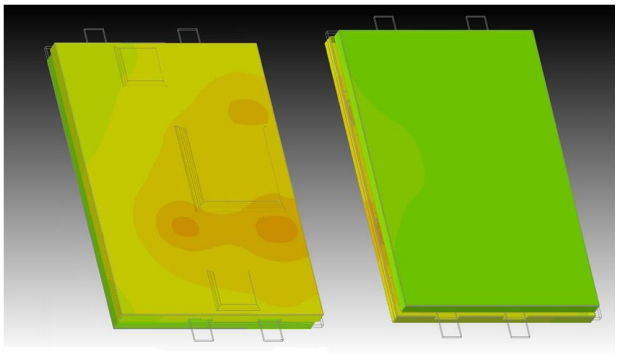


FIGURE 2. Shield & Component Thermal Images, 280W Module at 25°C



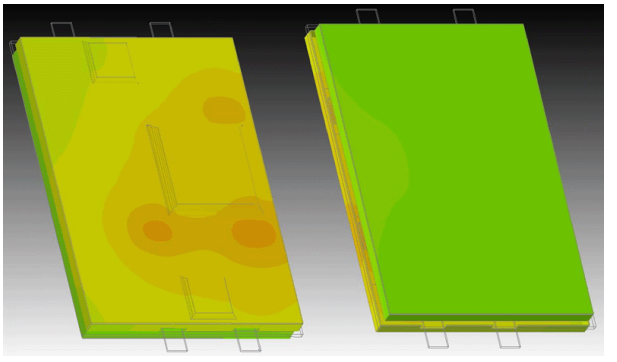


FIGURE 3. Shield & Component Thermal Images, 280W Module at 90°C

PV Module Applications Up To 320W

For PV modules up to 320 watts at STC, an additional heatsink is necessary. The recommended design is outlined in *Figure 4*. The heatsink should be made out of aluminum with a minimum surface area of 4900mm^2 and minimum thickness of 3mm. All dimensions are listed in millimeters (mm).

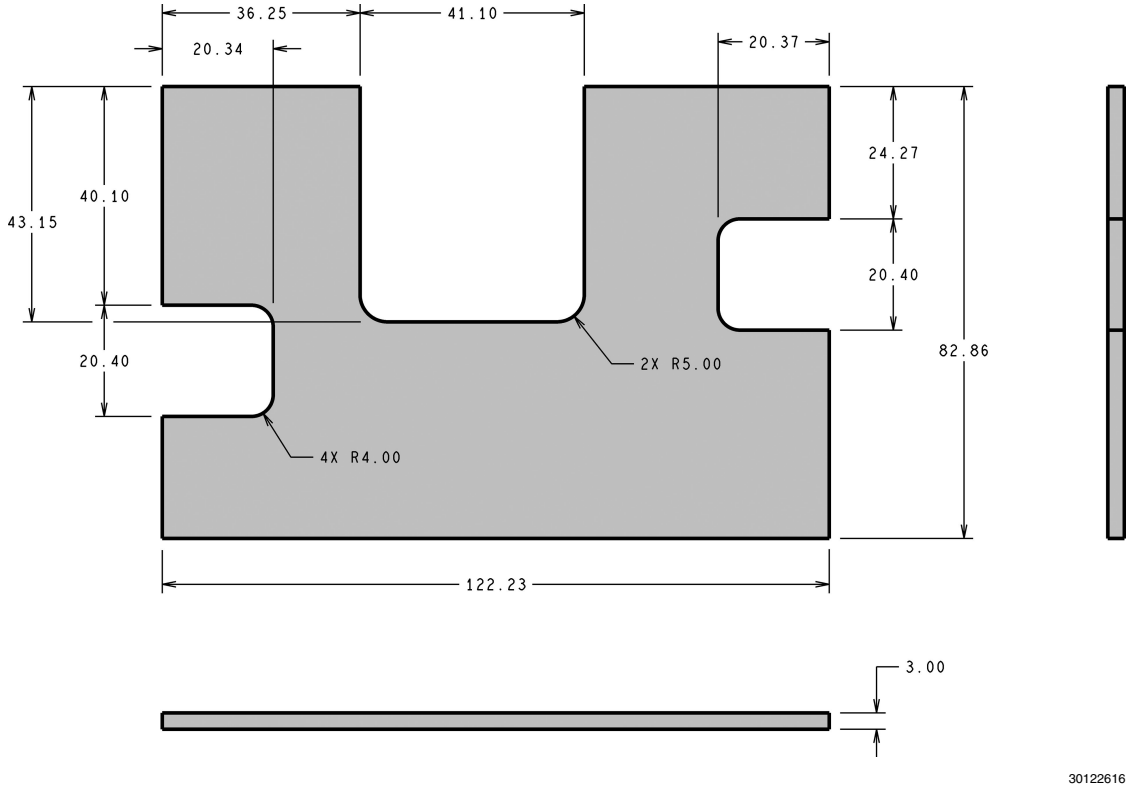


FIGURE 4. Recommended Heatsink Design

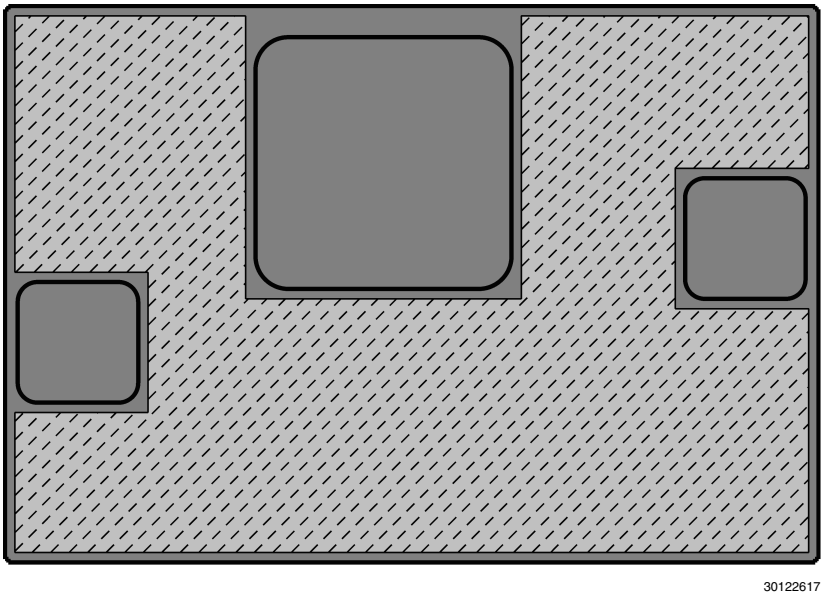
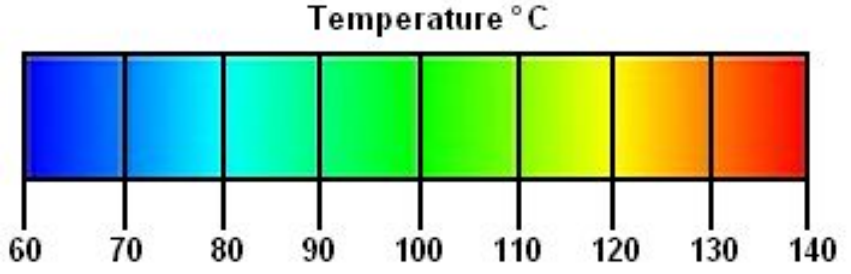


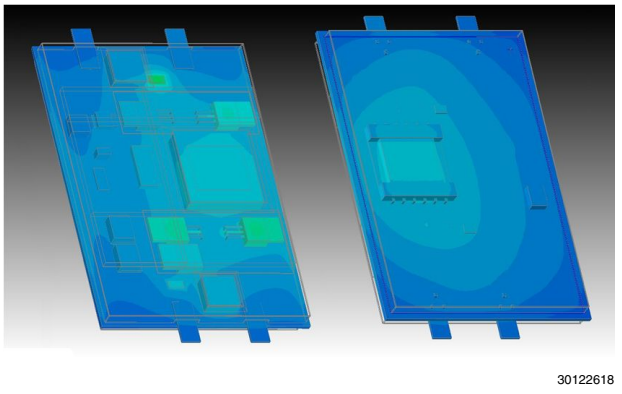
FIGURE 5. SM3320 Non-label Side
Heatsink Should Contact Shaded Area.

The heatsink must make good contact with the shield surface via a thermal gap pad or thermal grease and needs to be mounted on the non-label side of the SM3320. Ensure that the contact surfaces are clean before applying the thermal interface material.

Apply the thermal compound on the SM3320 surface as outlined in the shaded area in *Figure 5*, then place the heat sink on top.

Figure 6 and *Figure 7* illustrate the SM3320 temperature profile for 320W module operation at 25°C and 90°C ambient temperatures.





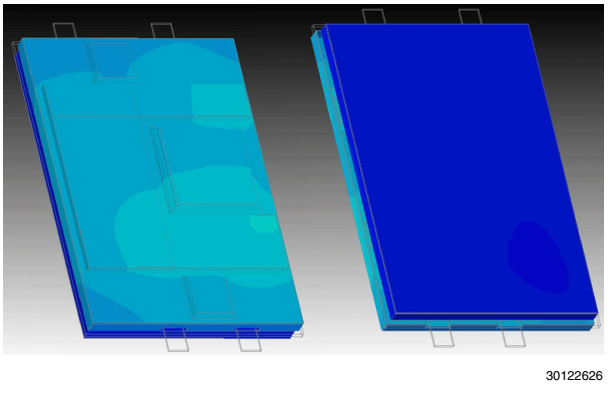
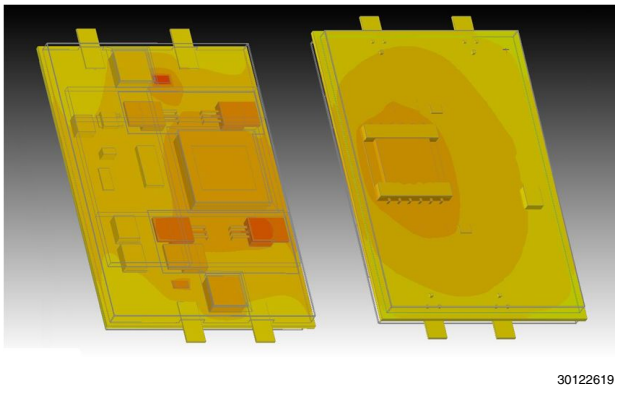


FIGURE 6. Shield & Component Thermal Images, 320W Module at 25°C



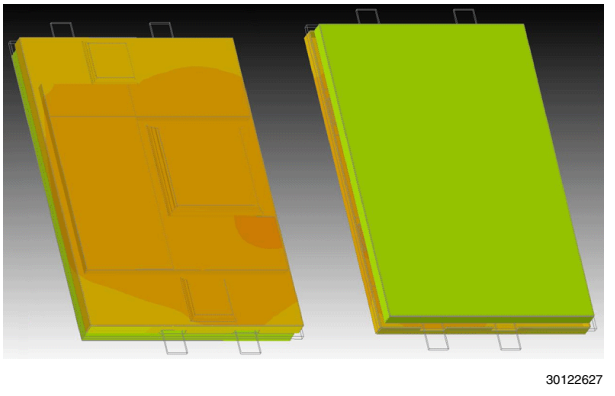


FIGURE 7. Shield & Component Thermal Images, 320W Module at 90°C

Bypass Diodes

Bypass diodes are required and are not integrated into the SM3320. The diodes must be installed inside the junction box as typically done in standard junction boxes. In the event that the bypass diodes become active during operation, they can emit large amounts of heat. The bypass diodes should be thermally isolated from the SM3320. The preferred method is to have the bypass diodes and the SM3320 installed in separate chambers of the junction box isolated by a thermal barrier (wall). If that is not possible then a minimum air gap of 20mm should separate the bypass diodes from the SM3320. Use the same 20mm minimum requirement if the junction box is to be potted. *Figure 8* is the electrical diagram for a standard 3-diode PV module.

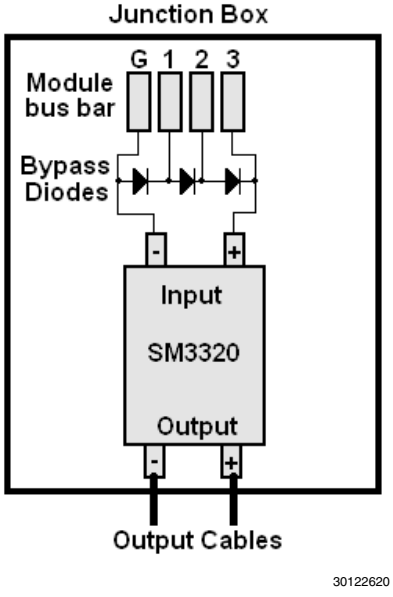


FIGURE 8. Junction Box Wiring

Electrical Connection

All electrical conductors inside the junction box need to be a minimum of 12 AWG (4mm2). The SM3320 has four exposed electrical terminals. Two are labeled as input and two are labeled as output. Refer to *Figure 8* . The SM3320 connector terminals allow for three methods of connection: direct soldering, resistance welding, and crimp connectors. The cable or electrical lead may be soldered directly onto the terminal. The soldering temperature should be in the range of 300°C – 350°C and must only be applied for the duration necessary to allow sufficient solder flow. Resistance welding can be used to make the electrical connection. Follow proper guidelines and procedures associated with the welding equipment and support materials. Use of crimp connectors is also acceptable. Connectors used should comply with certification requirements. Follow the connector manufacturer's procedures for proper assembly and use.

UL And NEC Cable Requirements For Connecting To The SM3320

UL Type PV (Photovoltaic) UL 4703, or USE-2, 600V or 1000V, -40°C to 90°C	
Single conductor, insulated and non-integrally jacketed, sunlight resistant, photovoltaic wire rated for 90°C wet or dry, 600V for interconnection wiring of grounded and ungrounded photovoltaic power systems as described in Section 690.31 (And other applicable parts of the National Electrical Code (NEC), NFPA 70).	
Electrical Characteristics:	Maximum Operating Voltage: 600 or 1000 VRMS (UL PV)
Physical Characteristics:	Temperature Rating: -40°C to 90°C Conductor AWG: 12 AWG (4mm^2) Conductor Material: Copper Jacket Material: Sunlight-Resistant PVC
Applicable Specifications:	UL Type PV (overall) UL 4703 USE-2 Rated
Flame Resistance:	VW-1

Blocking Diode Installation

NOTE: A single SM2100 blocking diode must be installed in each assisted string to protect the SolarMagic SM3320 power optimizers from electrical damage.

WARNING: Before installing the SolarMagic blocking diode, read all instructions and cautionary markings in the installation manual, on the blocking diode, on the inverter, and on the photovoltaic array. There are lethal levels of current present within the blocking diode that are extremely hazardous if precautions are not followed. Installation should only be conducted by a trained professional installer. All service guidelines must be followed.

WARNING: Risk of electric shock. Normally grounded conductors may be ungrounded and energized when a ground fault is indicated. Proper safety equipment should always be worn by personnel handling photovoltaic arrays.

NOTE: The blocking diode should be mounted in the shadow of the PV module or other permanent structure. The blocking diode must be mounted at least one 1 inch (25mm) from the back of the PV module to prevent overheating.

NOTE: Refer to the PV module installation instructions for proper sizing of current-carrying conductors and fuses.

The SolarMagic™ SM2100 blocking diode is designed to block reverse current flow by allowing current to flow in only one direction and disconnecting the circuit if current attempts to flow in the opposite direction. Due to this interaction, strings containing PV modules equipped with SolarMagic SM3320 power optimizers will have varying voltage levels during energy production hours.

Four mounting holes are available on the blocking diode for convenience. However, only two holes are needed for attachment as shown in *Figure 9*. Hold the blocking diode against the structure where it is to be mounted; be sure that the blocking diode rests on a flat surface. Using the provided #10 self-drilling screws, securely mount the blocking diode onto the rail. Tighten the screws to 5ft-lb (6.8N-m). Over-tightening may result in damage to the housing.

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FIGURE 9. SolarMagic Blocking Diode Mounted to Extruded Railing

The SM2100 is certified for use on systems of up to 1000V. There are a several connector models currently available. Please refer to the table below contact your authorized SolarMagic dealer or distributor for assistance in choosing the proper SolarMagic blocking diode.

Blocking Diode Models

Model	SM2100-1B1	SM2100-2B1	SM2100-3B1	SM2100-4B1
Connector	Tyco	Huber+Suhner (Twist Lock)	MC3	MC4

Notes

National Semiconductor Americas Technical Support Center
Email: support@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Technical Support Center
Email: europe.support@nsc.com

National Semiconductor Asia Pacific Technical Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Technical Support Center
Email: jpn.feedback@nsc.com