USER MANUAL

Maxwell Technologies, Inc.
Ultracapacitor Energy Storage Modules

Models:	Associated Datasheet
▪ BMOD0001 P005 B02	▪ 3001960
▪ BMOD0002 P005 B02	▪ 3001961

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1 Introduction

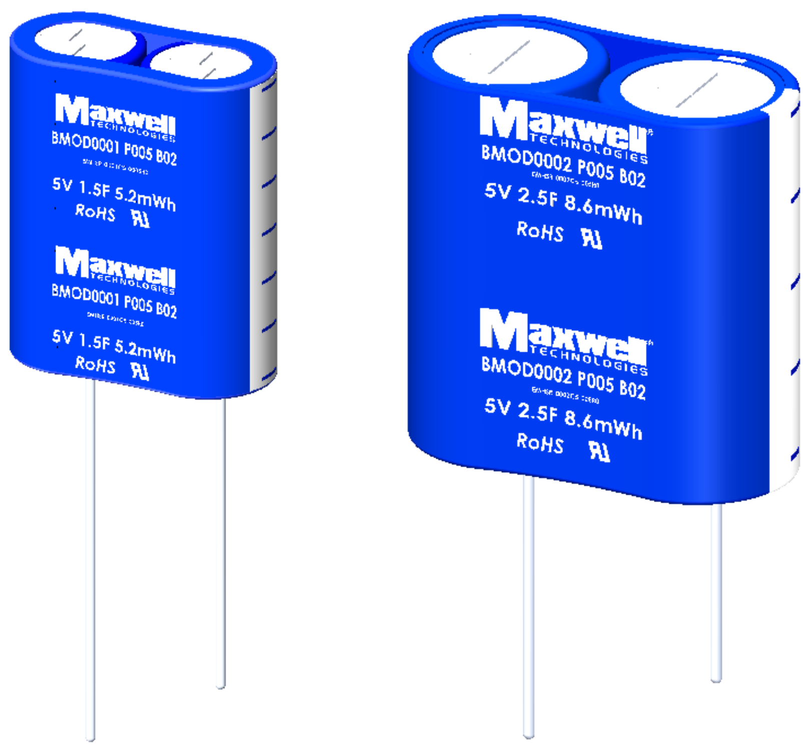
The BMOD0001 P005 B02, BMOD0002 P005 B02 energy storage modules are self-contained energy storage devices comprised of two ultracapacitor cells connected in series.

Multiple modules may be connected in series to obtain higher operating voltages, in parallel to provide additional energy storage, or a combination of series/parallel arrangements for higher voltages and energy.

- ✓ Passive balancing resistor are not used in these modules
- ✓ Lead-free soldering
- ✓ Covered by shrink tube

1.1 Module drawing

For reference only. The module exterior is shown below.



2 Unpacking and handling

2.1 Unpacking

Inspect the shipping packaging for signs of damage prior to unpacking each module. Damage to the packaging or module should be reported to the carrier immediately. Remove each module from the packaging and retain the shipping materials until the module has been inspected and is determined to be operational.

Note: The original shipping materials are approved for both air and ground shipment. When removing the module from the packaging, lift it by the steel handle.

If the unit is found to be defective or any parts are missing, contact your supplier. A Return Material Authorization (RMA) number must be requested and issued by Maxwell prior to returning the unit for repair or replacement.

2.2 Handling

Maxwell ultracapacitor modules are designed to provide years of trouble-free operation. Proper handling is required to avoid damage to the module. In particular, the following handling precautions should be observed:

- Do not drop modules. Internal damage may occur that will not be visible from the module exterior.
- Protect the module from impact

3 Installation

3.1 Electrical performance and installation

WARNING

To avoid arcing, the energy storage module should be in a discharged state and the system power disconnected during installation. The module is shipped discharged with a shorting wire connecting the positive (+) and negative (–) terminals. You must remove the shorting wire before making the electrical connections.

To provide the lowest possible equivalent series resistance, the energy storage modules are not fused. Care must be taken, within the application, to prevent excessive current flow. Excessive current and/or duty cycle will result in overheating the module, which will cause irreparable damage. **Please refer to the product datasheet for maximum allowable RMS current values.**

3.1.1 Capacitance Measurement

Capacitance is measured by the formula shown in Figure 2. Where the time to discharge a capacitor or a capacitor module from 80% of the rated voltage to 40% of the rated voltage using constant current output.

$$\textbf{Capacitance (F)} = I_{dch} \times (T_2 - T_1) / 0.4V_R$$

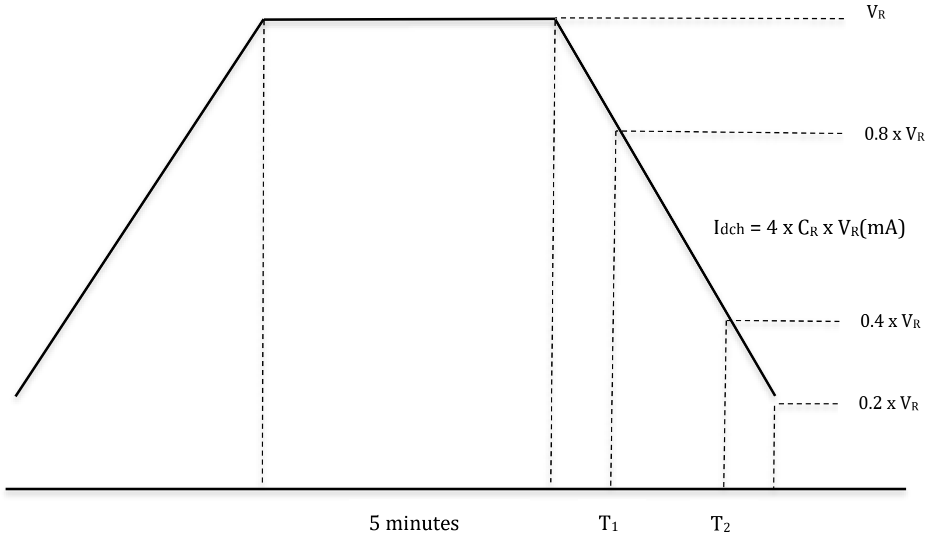


Figure 2. Capacitance Measurement

3.1.2 Internal Resistance (ESR) Measurement

Internal resistance of 5V/1.5F and 5V/2.5F module are measured using an impedance analyzer. The parameters used are as follows:

Voltage at measurement: Open Circuit Voltage
Amplitude: 5mV
Frequency: 1kHz

Initial ESR measurements are made before the initial charging of the module, i.e. when all the cells are at their shorted open circuit voltage. Typically, this is around 400mV per cell. It should be noted that the voltage of an ultracapacitor module, once it has been charged and discharged, will “recover” or increase over time. Therefore, any measurement made during this period when the voltage is changing is unreliable. Maxwell recommends at least 8 hours of shorting before any ESR measurements are made.

3.1.3 Self-Discharge Trend

The 5V/1.5F, 5V/2.5F modules are passively balanced. Self-discharge characteristics of the Maxwell 5V/1.5F, 5V/2.5F ultracapacitor module are shown in Figure 3 and Figure 4. If the ultracapacitor module is kept at open-circuit voltage, just after 0.1A constant current charge to 5V at room temperature, the module voltage will decrease gradually over time due to the leakage current of each cell. The charged 5V1.5F and 5V 2.5F module self-discharge will be about 20% of initial voltage over a period of 100 minutes.

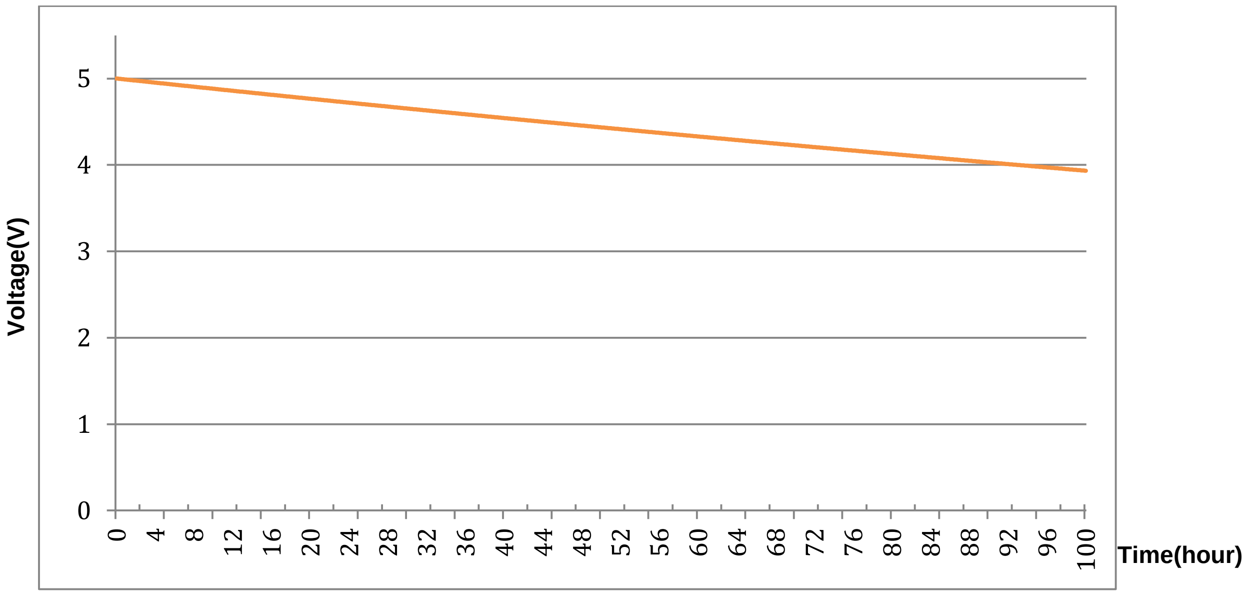


Figure 3. Self-Discharge profile of 5V/1.5F module

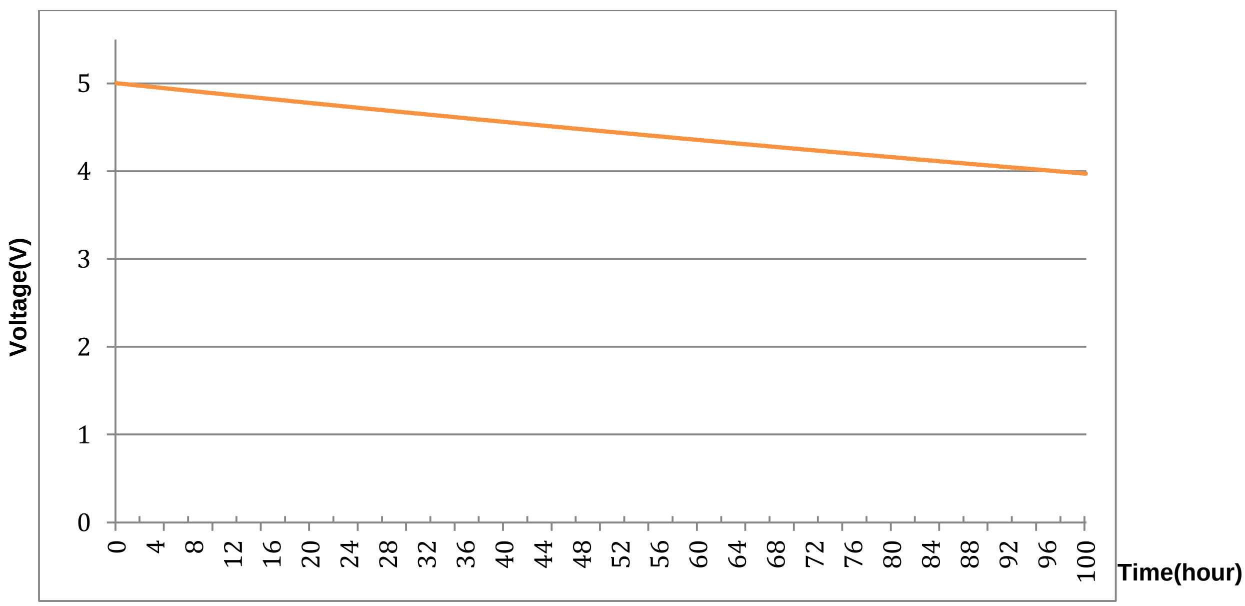


Figure 4. Self-Discharge profile of 5V/2.5F module

3.1.4 Simulated Electrical Performance

Simulated constant current discharge voltage profiles of 5V/1.5F and 5V/2.5F configuration are shown in Figure 5 and Figure 6.

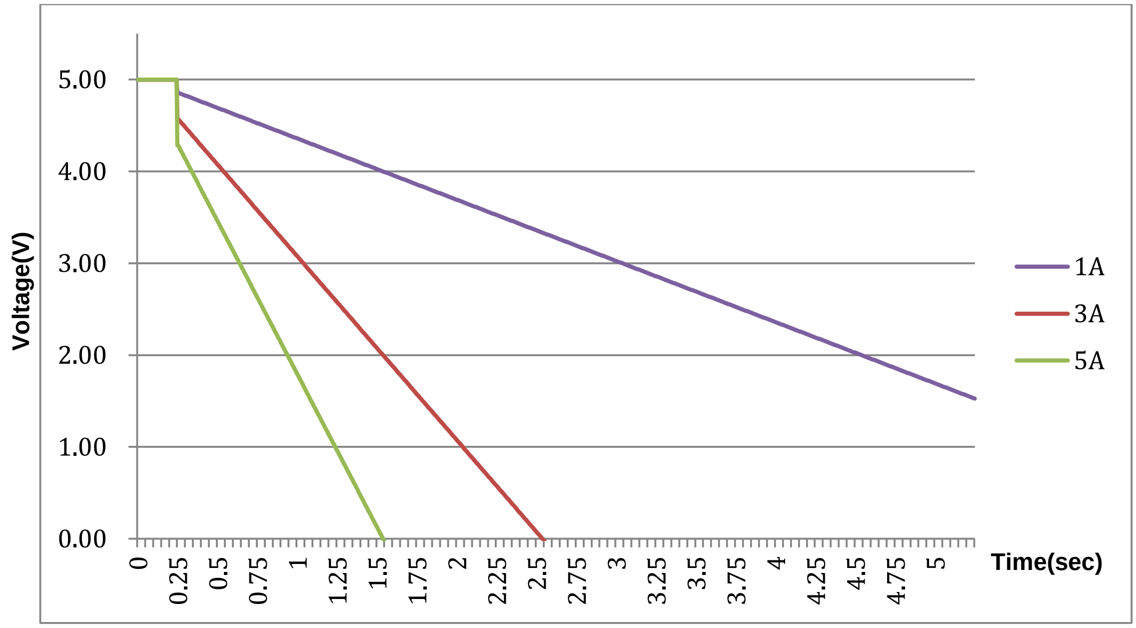


Figure 5. Constant Current Discharge Profile of 5V/1.5F

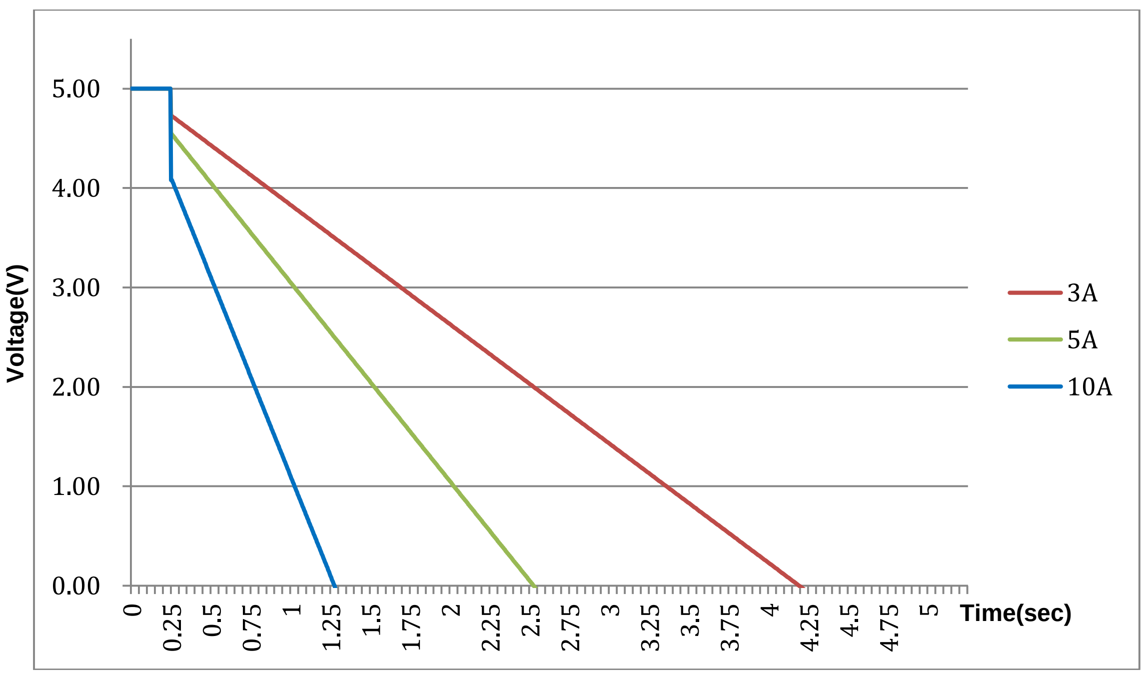


Figure 6. Constant Current Discharge Profile of 5V/2.5

Simulated constant power discharge voltage profiles of 5V/1.5F and 5V/2.5F configuration are shown in Figure 7 and Figure 8.

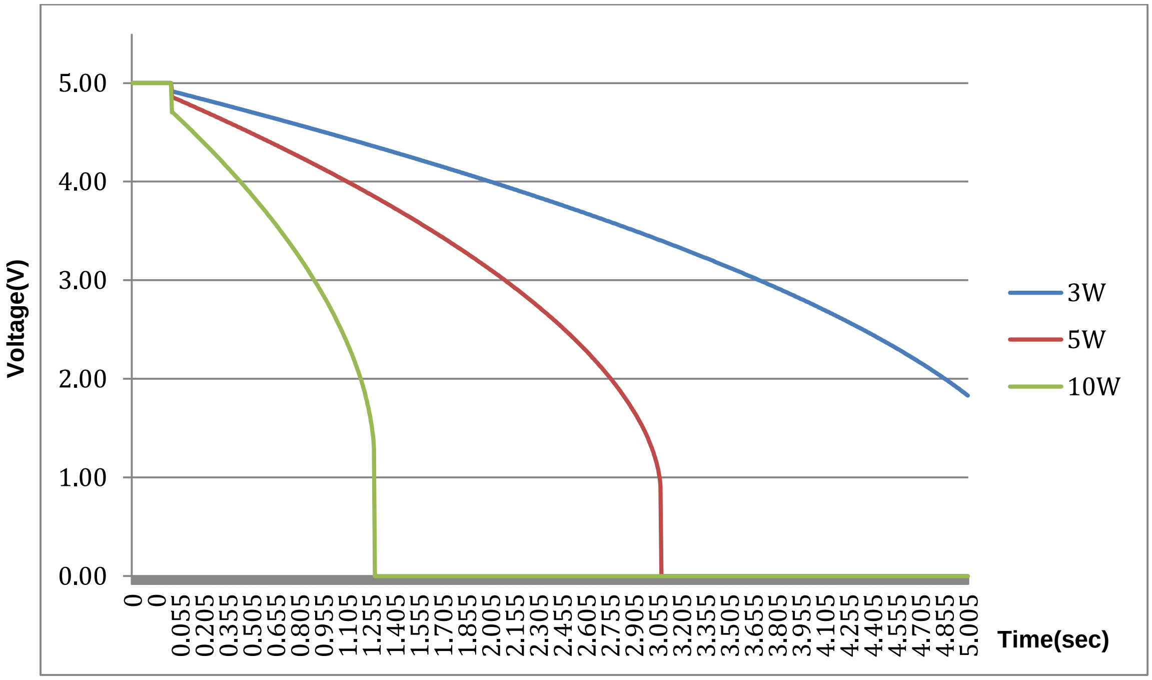


Figure 7. Simulated constant power discharge of 5V/1.5F

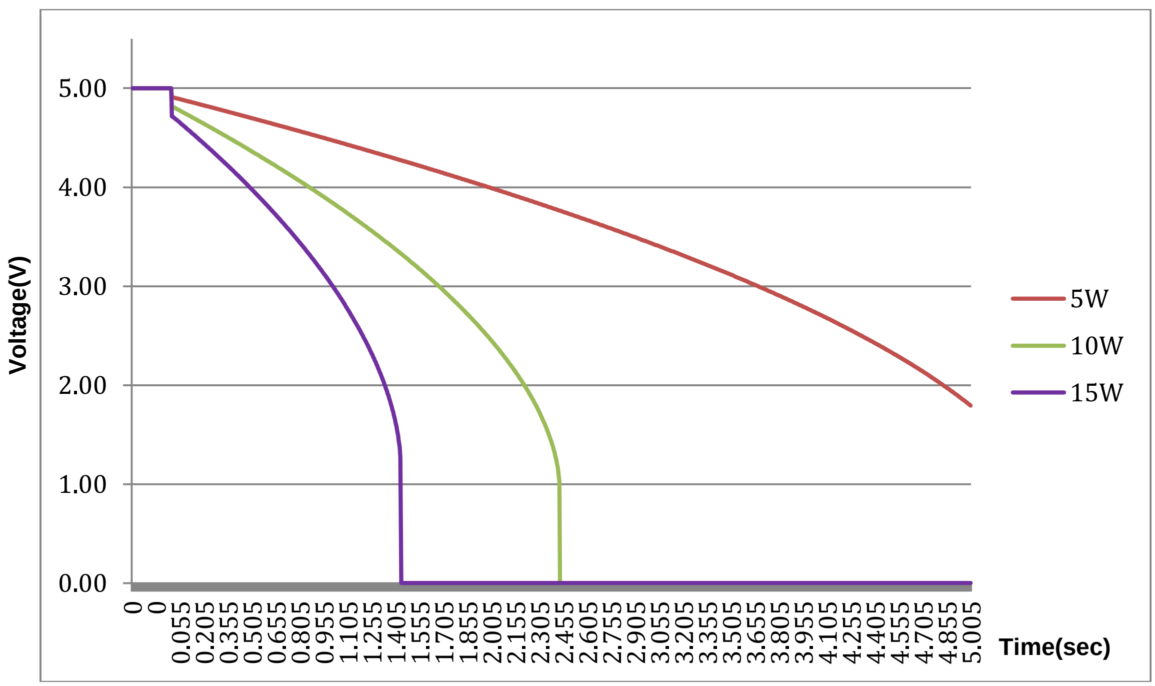


Figure 8. Simulated constant power discharge of 5V/2.5F

3.2 Thermal performance

The modules generate small amounts of heat during use. As with most electronic components, reduced operating temperature will extend the service life. In most applications, natural air convection is adequate for cooling; when operated at the rated module current. Majority of module heat rejection occurs from the flat top and bottom cover plates. Increasing airflow over these two module surfaces will further improve module heat rejection performance and reduce operating temperature.

The thermal resistance, R_{TH}, of the units has been experimentally determined assuming free convection at ambient temperature (~ 25 °C). The R_{TH} value provided on the datasheet is useful for determining the operating limits for the units.

Using the R_{TH} value, a module temperature rise can be determined based upon any current and duty cycle. The temperature rise can be expressed by the following equation.

$$\Delta T = I^2 R_{ESR} R_{TH} d_f$$

where:

I	= RMS current (amps)
R_{ESR}	= equivalent series resistance, R_{DC} (ohms)
R_{TH}	= thermal resistance (°C/W)
d_f	= duty cycle fraction

The ΔT value calculated above and ambient temperature must remain below the specified maximum operating temperature for the module (for maximum operating temperature, refer to the module datasheet). If supplemental cooling methods are employed, it may be possible to operate at higher currents or duty cycles than if cooling by natural air convection only.

Thermal capacitance is a parameter that is useful in calculating or estimating how fast the module will reach its stable temperature state under given I_{RMS}. This value can be estimated by the following equation.

$$t = 5 C_{TH} R_{TH}$$

where:

t	= time (sec.)
C_{TH}	= thermal capacitance, (J/°C)
R_{TH}	= thermal resistance (°C/W)

4 Operation

The module should only be operated within the specified voltage and temperature ratings specified on the datasheet. Designers should determine whether current limiting is necessary based on the current ratings of attached components. Observe polarity indicated on module. Do not reverse polarity.

The modules covered by this user manual ARE NOT interchangeable and cannot be mixed.

5 Safety

DANGER

HIGH VOLTAGE HAZARD

Never touch the positive (+) or negative (–) terminals as the module can be charged and cause **severe bodily harm**. Always verify that the module is fully discharged before handling the module. Wear adequate safety protection (safety glasses, gloves, etc.).

- Do not operate unit above the specified voltage
- Do not operate unit above the specified temperature rating
- -Do not touch terminals with conductors while the module is charged. Serious burns, shock, or material fusing may occur
- Protect surrounding electrical components from incidental contact

6 Storage

The discharged module can be stored in the original package in a dry place with <50% RH. Discharge a used module prior to stock or shipment.

7 Disposal

Do not dispose module in the trash. Dispose of according to local environmental regulations.

8 Specification

Refer to datasheets at our website, www.maxwell.com, for specifications of each product.

Please contact Maxwell Technologies directly for any technical specifications critical to application. Products and related processes may be covered by one or more U.S. or international patents and pending applications. Please see www.maxwell.com/patents for more information.