



USER MANUAL

Maxwell Technologies® Ultracapacitor Energy Storage Modules

Models:

16 V Series:

- BMOD0500 P016 B01
- BMOD0500 P016 B02
- BMOD0250 P016 B01
- BMOD0110 P016 B01

48 V Series:

- BMOD0165 P048 B01
- BMOD0110 P048 B01
- BMOD0083 P048 B01
- BMOD0165 P048 B06
- BMOD0165 P048 B09

Document 1008491

Please contact Maxwell Technologies directly for any technical specifications critical to application. All products featured on this user manual are covered by the following U.S. patents and their respective foreign counterparts: 6643119, 7102877, 7180726, 7203056, 7295423, 7342770, 7352558, 7384433, 7440258, 7492571, 7508651, 7580243, 7791860, 7791861, 7816891, 7859826, 7883553, 7935155, 7859826, 7883553, 7935155, 8072734, 8098481, 8279580 and patents pending.

MAXWELL TECHNOLOGIES, MAXWELL, MAXWELL CERTIFIED INTEGRATOR, ENABLING ENERGY'S FUTURE, BOOSTCAP, C CELL, D CELL, CONDIS, RAD-PAK and their respective designs and/or logos are either trademarks or registered trademarks of Maxwell Technologies, Inc. and may not be copied, imitated or used, in whole or in part, without the prior written permission Maxwell Technologies, Inc. All contents copyright © 2014 Maxwell Technologies, Inc. All rights reserved. No portion of these materials may be reproduced in any form, or by any means, without prior written permission from Maxwell Technologies, Inc.

1. Introduction

The 16 V and 48 V series energy storage modules are self-contained energy storage devices comprised of either six or eighteen individual ultracapacitor cells, respectively. The modules include bus bar connections and integrated cell balance voltage management circuitry. Units may be connected in series to obtain higher operating voltages, parallel to provide additional energy storage, or a combination of series/parallel arrangements for higher voltages and energy. Voltage management and alarm circuits function to protect each cell from operating in a damaging overvoltage condition.

The module packaging (except for BMOD0110 P016) is a heavy-duty aluminum extruded enclosure. The enclosure is a sealed, water-resistant device (per IEC 529 – IP65). The package for the BMOD0110 P016 consists of a plastic housing with a metallic cover for thermal transfer. The voltage management electronics have a single open collector logic output (except for models with "B02" suffix) which indicates if any cell within the module is experiencing an over voltage condition. Each module contains one temperature monitor output in the form of an NTC thermistor.

2. Unpacking and Handling

2.1 Unpacking

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

The following items are included with the module:

- 1 x Product Information Sheet
- 1 x Certificate of Conformance
- 1 x Hex head cap, M10x16, Zinc plated screw
- 1 x Hex head cap, M8x16, Zinc plated screw

NOTE: The original shipping materials are approved for both air and ground shipment. The module should be removed from the shipping carton by lifting it by the module body and not by the terminal posts.

If the unit is found to be defective or any parts are missing, contact your supplier. A Return Material Authorization (RMA) number must be issued 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 module. In particular, the following handling precautions should be observed:

- Do not stack modules once they have been removed from the shipping containers.

- Do not drop modules. Internal damage may occur that will not be visible from the exterior.
- Do not step on modules.
- Protect the PCBA cover from impact. If any damage occurs to the PCBA cover, contact Maxwell for replacement instructions.
- Do not use tools such as hammers to disengage mounting or terminal bolts. Serious damage may occur.

3. Installation

3.1 Mechanical

Modules may be mounted and operated in any orientation. Two mounting surfaces are available (except for BMOD0110 models); one at the top and the other at the bottom surface. These top and bottom plates are designed to support the module with no additional mechanical contact. See the data sheet for available mounting locations. The BMOD0110 models may only be mounted with the bottom side down to the mounting surface.

For best results the modules should not be mounted in locations where they are directly exposed to the environment. In particular, areas of direct splash should always be avoided. In systems that operate at voltages in excess of 60 V, appropriate protection and sealing should be used on both module terminals to avoid shock hazards and corrosion.


A proper installation should not exert any bending or twisting torque to the module enclosure. Ensure that the module's mounting points are co-planar within ± 1 mm. If the actual mounting location is out-of-plane, use spacers to bring all four mounting locations within plane to within ± 1 mm.

Modules (except for BMOD0110 P016) have been qualified to SAE J2380 for vibration performance. Ensure that this is adequate for the end-use environment.

Each module is provided with a threaded vent hole on the top plate. The module is shipped from the factory with a vent plug in this vent hole. The use of the vent is optional. If the application recommends/requires remote venting, a threaded hose barb can be provided upon request.

To use the hose barb, remove the vent plug which is in the hole when the module is received and replace it with the hose barb. Attach a 5/32 (4 mm) ID hose, preferably Teflon or polypropylene, to the hose barb and route the hose to a safe venting location. In the event of cell venting, the cell may release gas, which will build pressure in the module. That pressure can be relieved through the vent tube.

3.2 Electrical

WARNING

<p>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 and with a shorting wire. The shorting wire should be removed prior to electrical connections.</p>
<p>To provide the lowest possible ESR the energy storage modules are not fused. Care should be taken within the application to prevent excessive current flow as required. Excessive current and/or duty cycle will result in overheating the module which will cause irreparable damage. Please consult the specific data sheet for each module for current and duty cycle capabilities.</p>

Module-to-module cabling should be sized for the applications peak and/or RMS current. Undersized cables may cause excessive cable or interconnect temperature rise and system electrical resistance. High resistance wiring/cables or module power connections will increase terminal cell temperature and degrade module lifetime and long term performance. Reference applicable wire sizing guides. Wire temperature must not exceed module temperature.

Note: *The module chassis should be grounded to the system chassis through any of the module mounting holes. Refer to applicable ground wiring guides and standards for the application.*

The anodized coating of the module on the ground connection surface should be removed to ensure an optimal electrical contact. Apply a layer of high conductivity anti-oxidant joint compound between the mating surfaces (IDEAL Noalox[®] Anti-Oxidant Compound or equivalent).

3.2.1 Output Terminal Posts

The output terminals of the module consist of internally threaded aluminum posts. They are designed to connect directly to a ring lug or a bus bar. Maximum thread depth is 20 mm. If ring terminals and lock washers in excess of 10 mm are to be used, a longer bolt must be selected. In no instance should the total amount of thread engagement be less than 10 or greater than 20 mm.

The terminal contact surface should be cleaned with a light abrasive such as Scotch-Brite[™] to remove any oxidation. Apply a layer of high conductivity anti-oxidant joint compound between the mating surfaces (IDEAL Noalox[®] Anti-Oxidant Compound or equivalent). The positive terminal is threaded for M8 x 1.25 steel bolts. The negative terminal is threaded for M10 x 1.5 steel bolts. Lock washers are required for long term, reliable connections. For additional performance, a thread locking compound such as Loctite[®] 425 may be used. However, care should be taken that the thread locking compound does not come in contact with the electrical mating surfaces.

When tightening the terminal bolts, a torque of 20 N-m / 14.8 ft-lbs for the M8 and 30 N-m / 22.1 ft-lbs for the M10 bolts should be used. Do not exceed recommended torque.

As in any electrical system, proper cable dress is required for trouble-free operation. The cables used for attachment are large, and improperly constrained cables can place bending stress on the terminals and terminal bolts. Cables should be installed so that they do not exert bending or twisting torque on the power terminals, and should be routed away from the module so that they are parallel to the top surface of the terminal and constrained within 50 cm of the terminal before bending the cable in any direction. High vibration environments may require additional restraints.

Attachment to the output terminals should be made with ring lugs or bus bars of an appropriate size for the application current. If bus bars are used, brackets should be installed to interconnect the tops of adjacent modules to prevent undesirable lateral forces on the terminals.

The energy storage modules have low ESR. As a result, the resistance of the wires connecting the energy storage module to the application can easily exceed the ESR of the module. Connection of modules in series or parallel should utilize the same gauge wire (or equivalent bus bar) as determined for final output connections. When connecting in series connect the positive output terminal of one module to the negative output terminal of the next module. Two possible orientations are illustrated in Figure 1.

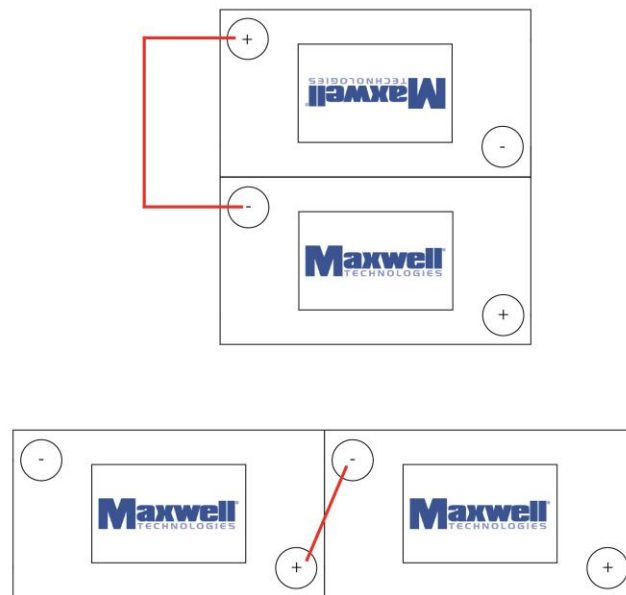


Figure 1 – Possible series connection arrangements

Full UL810a compliance is satisfied for up to three (3) BMOD0165 P048 (certain BMOD0165 P048 B09 models may not be UL810a compliant) modules in series or nine (9) BMOD0500 P016 modules in series (maximum operating voltage of 150V).

When several modules are connected in series for operating at higher voltage, care must be taken to ensure proper creepage and clearance distances in compliance with national safety standards for electrical equipment.

3.2.2 Module to Module Connections

The 16 V and 48 V modules are equipped with the active voltage management circuit that protects and monitors every cell within the module. Module-to-module balancing is not required.

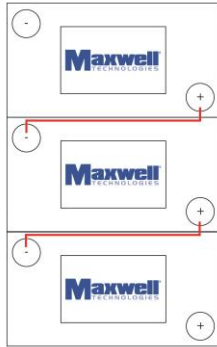


Figure 2 – Series Connection of 48V Modules

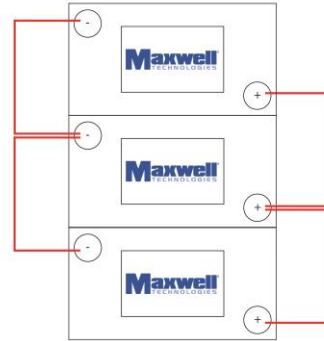


Figure 3 – Parallel Connection of 48V Modules

3.2.3 Logic outputs

A single open collector logic output is available for overvoltage monitoring. This output will indicate if any cell in the module has gone into an overvoltage condition. In addition, the output of the NTC thermistor is also available for module temperature monitoring. The overvoltage signal and temperature signal are available via the connector supplied with the module. Note: The passive version (suffix "B02") of the BMOD0500 only provides the output of the NTC thermistor for the temperature monitor signal. There is no voltage monitoring signal in this module.

The logic outputs are isolated from the capacitor voltages and from chassis ground. The logic outputs may be operated individually or wire-or'd to provide a single fault line. A table indicating the pin out, indication and maximum current is provided below.

Pin #	Wire Color	Pin out designation	Output (16 V)	Output (48 V)	Maximum current
1	Black	GRND			
2	White	Overvoltage Alarm	High – Inactive Low - Active	High – Inactive Low - Active	5 mA
3	Red	Not used	N/A	N/A	N/A
4	Green	TEMP			

NOTES:

- Pin #2 is not used for the BMOD0500 P016 B02 model with passive balancing.
- The Overvoltage Alarm will be asserted if any individual cell goes into an over voltage condition. The range of the alarm threshold is as follows:

2.73V minimum
2.80V nominal

2.86V maximum

3. The Overvoltage Alarm Signal (Pin 2) is an open collector output indicating when the voltage management electronics are active. In order to use the signal, the user must connect a pull-up resistor ($\geq 1k\Omega$) between Pin 2 and a nominal 5V (maximum 5.5V) supply. In this configuration, the voltage at Pin 2 will be $\sim 5V$ when the circuit is not active. When a cell in the module goes into an overvoltage condition, the output of Pin 2 goes low. The Overvoltage Alarm can be used as a signal to the system electronics to stop charging in order to protect cells from damage. When an acceptable cell voltage is reached, the output goes high again and can be used as a signal to resume charging. Figure 4 shows a typical connection to use this system.
4. The Overvoltage Alarm circuit can sink up to 5 mA with a V_{OL} of no more than 0.4V. The leakage current when the output is off is 50 nA. The proper value of the pull-up resistor should be calculated based upon overall system circuit design.

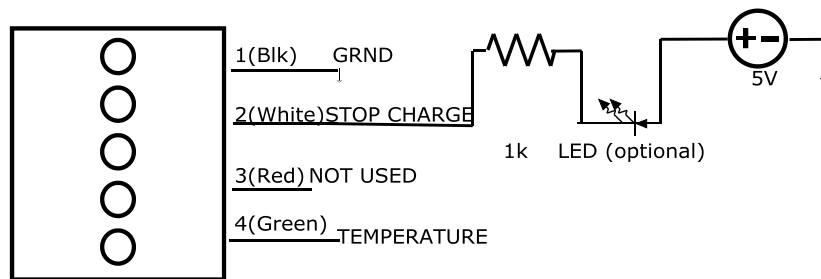


Fig. 4 – Typical connection to the monitor cable. (Users to verify values based on their circuit design)

The temperature output operates at any module voltage including zero volts.

The TEMP output is via a NTC thermistor and can be measured between pin 4 and pin 1 (GND) of the connector. The resistance of the thermistor varies with temperature to provide the actual temperature of the module. The thermistor is located inside the module. Under normal operating conditions the temperature output should represent the module's hottest location. The resistance measured through the thermistor relates to temperature according to a US Sensor thermistor with a nominal value of $10K\Omega$ @ $25^{\circ}C$ (reference temperature chart for the 103JM1A.)

http://www.ussensor.com/rt_charts/103JM1A.htm

A mating connector for these signals is provided with 6" (15 cm) of cable length. Additional 22 gauge wire may be spliced for longer wire length up to 6 feet (1.8 m). For lengths longer than 6 feet (1.8 m) shielded 4 conductor wire is recommended.

3.3 Thermal Performance

Low internal resistance of the energy storage modules enables low heat generation within the modules during use. As with any electronic component, the cooler the part operates the longer the service life. In most applications natural air convection should provide adequate cooling. In severe applications requiring maximum service life, forced airflow or a liquid-cooled cold plate may be required.

The thermal resistance, R_{TH} , of the units has been experimentally determined assuming free convection at ambient temperature ($\sim 25^{\circ}C$). 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 ($^{\circ}\text{C}/\text{W}$)

d_f = duty cycle fraction

The ΔT value calculated above plus ambient temperature should remain below the specified maximum operating temperature for the module (please refer to the module datasheet) as measured by the thermistor output. If active cooling methods are employed, it is possible to operate at higher currents or duty cycles than if only passive cooling is utilized.

4. Operation

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

5. Safety

DANGER



HIGH VOLTAGE HAZARD

Never touch the power terminals as the module can be charged and cause **fatal electrical shocks**. Always verify that the module is fully discharged before manipulating the module. Refer to the instructions below for the manual discharge procedure.

- Do not operate unit above the specified voltage.
- Do not operate unit above the specified temperature rating.
- Do not touch terminals with conductors while charged. Serious burns, shock, or material fusing may occur.
- Protect surrounding electrical components from incidental contact.
- Provide sufficient electrical isolation when working above 50 V DC.
- Prior to installation on or removal from the system, it is mandatory to fully discharge the module to guarantee the safety of all personnel.

WARNING



A fully discharged module may “bounce back” if it is stored without a shorting wire connected to the + and – terminals. This bounce back can be as much as 6V for the 48V module and is enough to cause dangerous electrical shocks.

5.1 Discharge Procedure

To discharge an individual module:

1. Using a voltmeter, measure the voltage between the two power terminals.
2. If the voltage is above 2V, a power resistor (not supplied with the module) may be connected between the terminals to discharge the module. Proper care needs to be taken in the design and construction of such a resistor. Resistor value will change discharge time, current, power and temperature.

Note: Customers may instead wish to consider using a DC electronic load tool to support the safe/controlled discharge of individual modules prior to service (for example, the BK Precision DC Electronic Load Model 8500 or a similar tool).



3. If the voltage is under 2V, connect the shorting wire provided by Maxwell to the + and – connectors.
4. The module is now safe for handling. However, leave the shorting wire connected **at all times** until the module is installed in the system and the power cables are connected.

6. Maintenance

Prior to removal from the system, cable removal, or any other handling ensure that the energy storage module is completely discharged in a safe manner. The stored energy and the voltage levels may be lethal if mishandling occurs. Maintenance should only be conducted by trained personnel on discharged modules (see “[Discharge Procedure](#)” above).

6.1 Routine Maintenance

1. To improve power dissipation performance, clean the exterior surface of dirt/grime. Use a cleaning cloth dampened with a water/soap solution. Do not use high-pressure sprays or immersion. Keep excess amounts of water away from the PCBA cover and power terminals. For outside use, do this every 6 months, or as needed. For inside use, you can do this

- annually.
2. To avoid mechanical damage, check mounting fasteners for proper torque. In high-vibration environments, do this every 6 months. In low-vibration environments, do this annually.
 3. Regularly inspect housing for signs of internal damage. Do this every 6 months for outside use, and annually for inside use.
 4. Check signal/ground connections to avoid false signals or shock hazards. In high-vibration environments, do this every 6 months, and in low-vibration environments, do this annually.

7. Storage

The discharged module can be stored in the original package in a dry place. Discharge a used module prior to stock or shipment. A shorting wire across the terminals is strongly recommended to maintain a short circuit after having discharged the module.

8. Disposal

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

9. Specification

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

Maxwell[®] TECHNOLOGIES



Maxwell Technologies, Inc.
Global Headquarters
3888 Calle Fortunada
San Diego, CA 92123
USA
Phone: +1 858 503 3300
Fax: +1 858 503 3301



Maxwell Technologies SA
Route de Montena 65
CH-1728 Rossens
Switzerland
Phone: +41 (0)26 411 85 00
Fax: +41 (0)26 411 85 05



Maxwell Technologies GmbH
Leopoldstrasse 244
80807 München
Germany
Phone: +49 (0)89 4161403 0
Fax: +49 (0)89 4161403 99



Maxwell Technologies Korea Co., Ltd.
Room 1524, D-Cube City
Office Tower, 15F #662
Gyeongin-Ro, Guro-Gu,
Seoul, 152-706
South Korea
Phone: +82 10 4518 9829



**Maxwell Technologies
Shanghai Trading Co., Ltd.**
Unit A2, C 12th Floor
Huarun Times Square
500 Zhangyang Road,
Pudong New Area
Shanghai 200122,
P.R. China
Phone: +86 21 3852 4000
Fax: +86 21 3852 4099



**Maxwell Technologies
Shanghai Representative Office**
Unit B 12th Floor
Huarun Times Square
500 Zhangyang Road,
Pudong New Area
Shanghai 200122,
P.R. China
Phone: +86 21 3852 4000
Fax: +86 21 3852 4099

www.maxwell.com