USER MANUAL

Maxwell Technologies, Inc.
240V 3.7F Ultracapacitor Module

Model:

- BMOD0004 B240 B02

Associated Datasheet

- 3001973-EN

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

Maxwell Technologies Korea Co., Ltd.
17, Dongtangiheung-ro
681 Beon-gil, Giheung-gu,
Yongin-si, Gyeonggi-do 17102
Republic of Korea
Phone: + +82 31 289 0721
Fax: +82 31 286 6767

Maxwell Technologies (Shanghai) Trading Co., Ltd
Room 1005, 1006 and 1007
No. 1898, Gonghexin Road,
Jing An District, Shanghai 200072
P.R. China
Phone: +86 21 3680 4600
Fax: +86 21 3680 4699

Maxwell Technologies Shanghai Representative Office
Rm 1008
No. 1898, Gonghexin Road,
Jing An District, Shanghai 200072
P.R. China
Phone: +86 21 3680 4600
Fax: +86 21 3680 4699

TABLE OF CONTENTS

1 Introduction

The BMOD0004 B240 B02 energy storage module is self-contained energy storage device comprised of individual ultracapacitor cells connected in series. The module includes integrated cell balance voltage management circuitry.

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.

Features of the BMOD0004 B240 B02 energy storage module include:

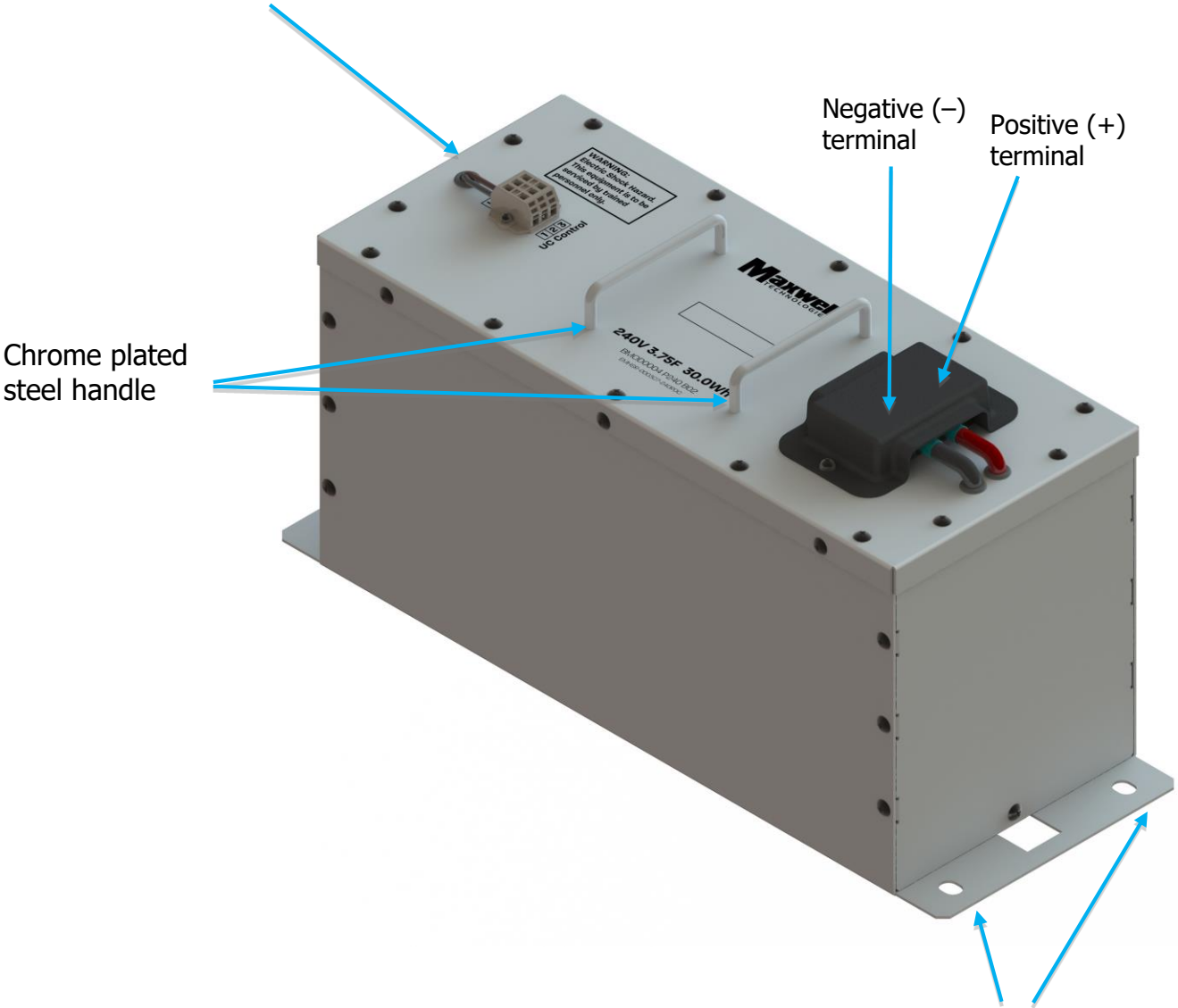
- ✓ Maximum stored energy of 29.6Wh with 240V/3.7F ultracapacitor module
- ✓ Passive balancing with 100ohm resistor connected to each capacitor
- ✓ Lead-free wave soldering
- ✓ Ingress Protection compliant (IP 30)
- ✓ Steel enclosure
- ✓ Connector type terminal block

1.1 Module Components and terminology

For reference only. The module exterior is shown below.

User Interface Connector (UIC)

1. 1/3 Voltage of module
2. 2/3 Voltage of module
3. NC



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 stack modules once they have been removed from their shipping packaging
- Do not drop modules. Internal damage may occur that will not be visible from the module exterior
- Do not step on modules
- Protect the module from impact

3 Installation

3.1 Mechanical installation

3.1.1 Mounting

Modules can be mounted and operated in any orientation. The module must be mounted using the bottom surface. This bottom plate is designed to support the module..

For best results, mount the modules in locations where they are not directly exposed to harsh environments. In particular, always avoid areas of direct splash.

Use one high-quality mounting bolt per corner:

- Metric: Class 8.8 or 10.9, M8
- Standard: Grade 5 or 8, 5/16”

Each bolt should reach completely through the mounting bolt pass-through on the module corner. Use the appropriate bolt length for the specific installation; include length for the use of lock washers or lock nuts.

Installation should not exert bending or twisting torque to the module enclosure. Torque may be caused by uneven mounting points or surfaces. Ensure that the module’s mounting points are all flat within ±1 mm.

The figure below illustrates flatness.

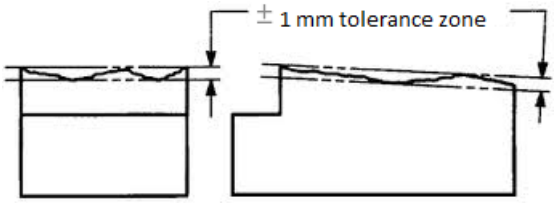


Figure 1. Flatness example

3.1.2 Vibration and shock

To ensure successful, long-life operation, please ensure that the vibration and shock experienced by the module is compatible with the accelerated vibration and shock qualification standard referenced on the module datasheet.

3.2 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**.

Module-to-module cabling must be sized for the application's 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. Refer to 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 bolt pass-through holes. Refer to applicable ground wiring guides and standards for the application.

3.2.1 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.

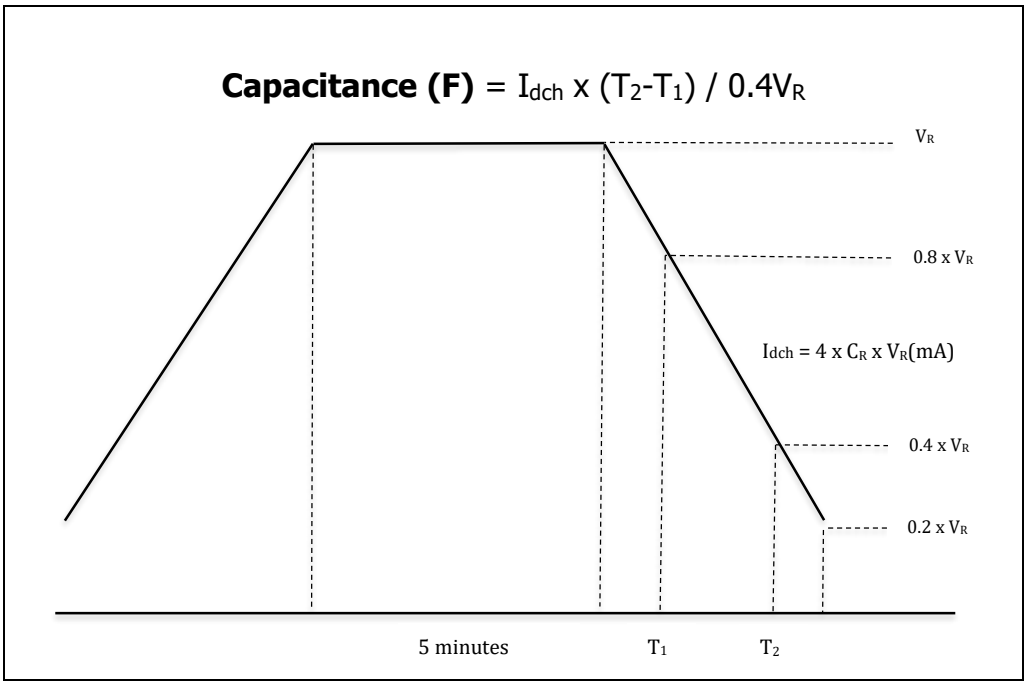


Figure 2. Capacitance Measurement

3.2.2 Internal Resistance (ESR) Measurement

Internal resistance of 240V/3.7F module is measured using an impedance analyzer. The parameters used are as follows:

Voltage at measurement: Open Circuit Voltage
Amplitude: 5mV
Frequency: 100Hz

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 AC-ESR measurements are made.

3.2.3 Self-Discharge Trend

The 240V module is passively balanced. Self-discharge characteristics of Maxwell 240V/3.7F ultracapacitor module is shown in Figure 3. If the ultracapacitor module is kept at open-circuit voltage, just after 3A constant current charge to 240V , at room temperature, the module voltage will decrease gradually over time due to the resistors connected in parallel to each cell. The charged to 240V module self-discharge will be about 15% of initial voltage over a period of 100 minutes.

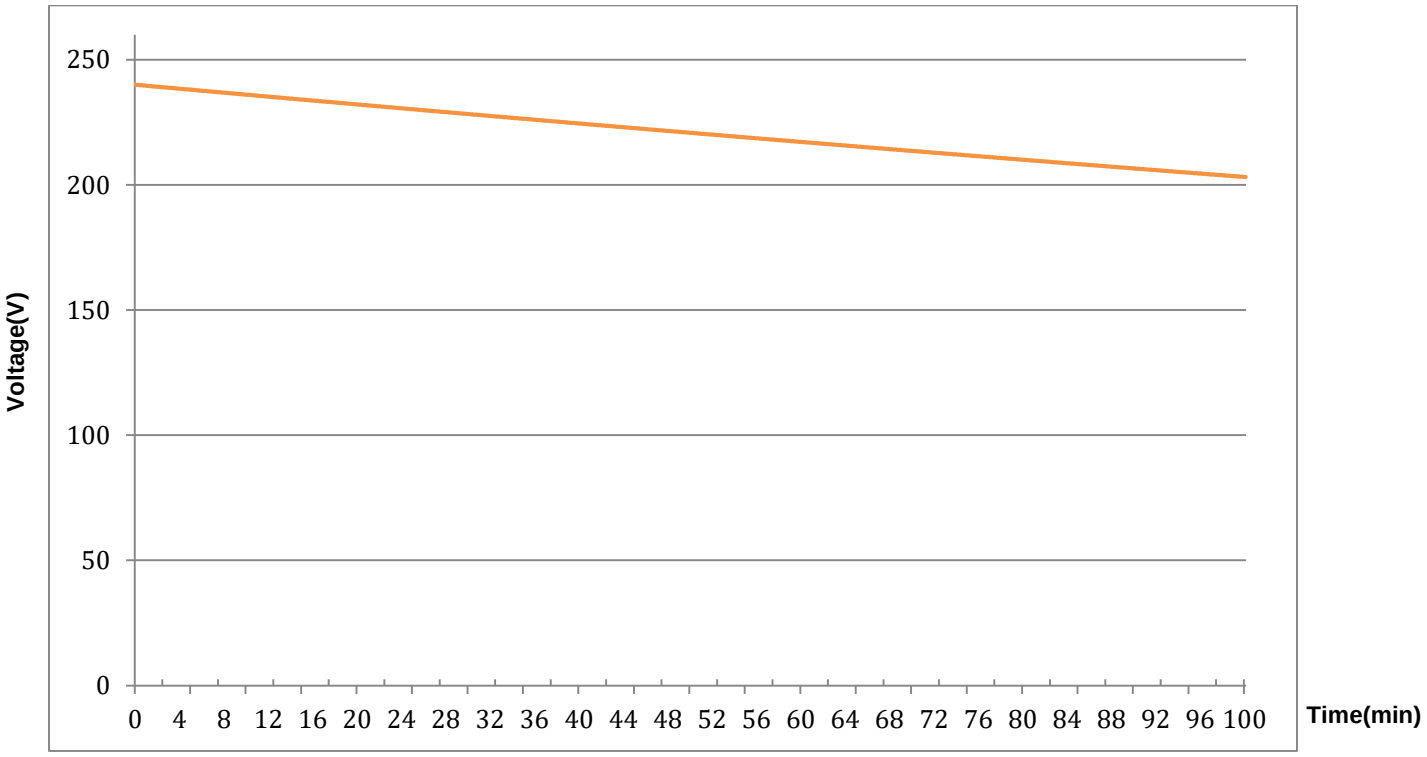


Figure 3. Self-Discharge profile of 240V/3.7F module

3.2.4 Simulated Electrical Performance

Simulated constant current discharge voltage and current profiles of a 240V 3.7F configuration are shown in Figure 4.

Simulated constant power discharge voltage profiles of a 240V 3.7F configuration are shown in Figure 5.

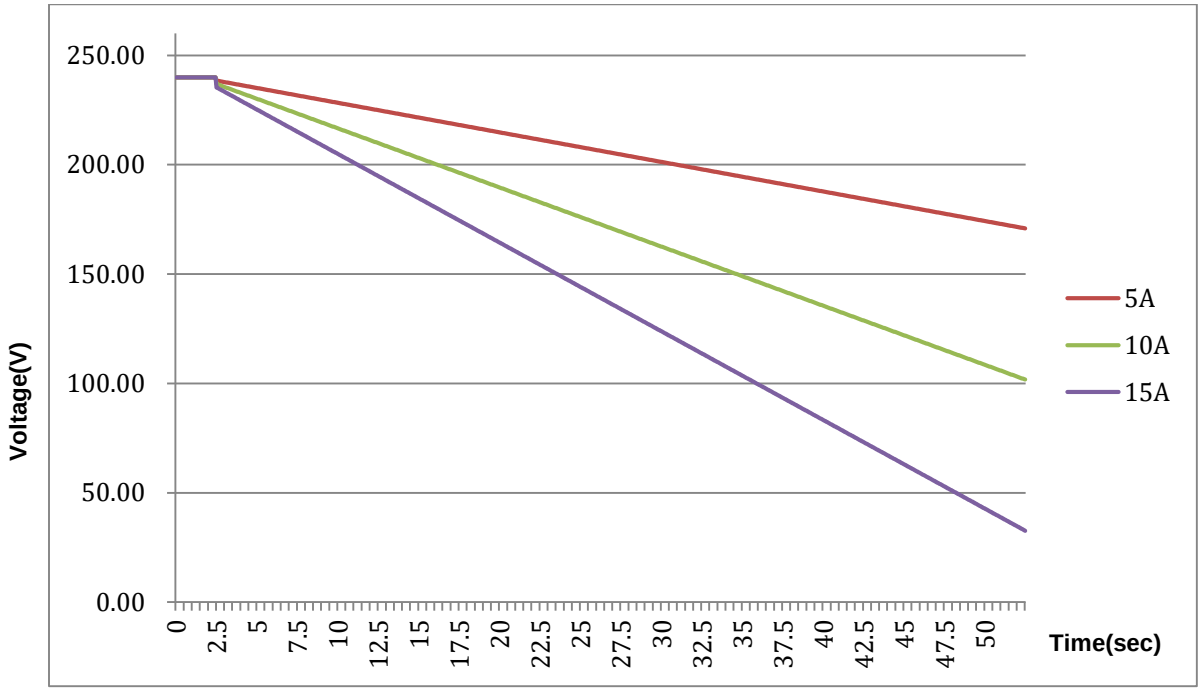


Figure 4. Constant Current Discharge Profile of 240V/3.7F

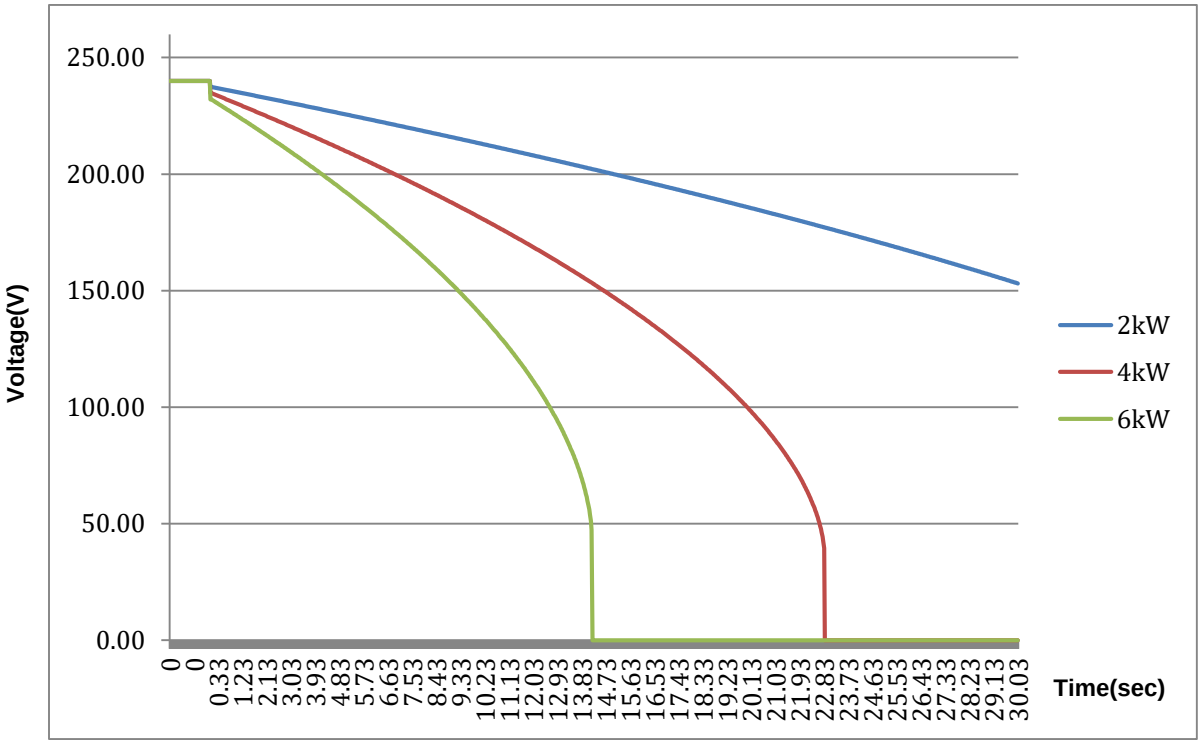


Figure 5. Simulated constant power discharge of 240V/3.7F

3.3 Functional Description of Terminal

3.3.1 Connecting to the Power Terminal

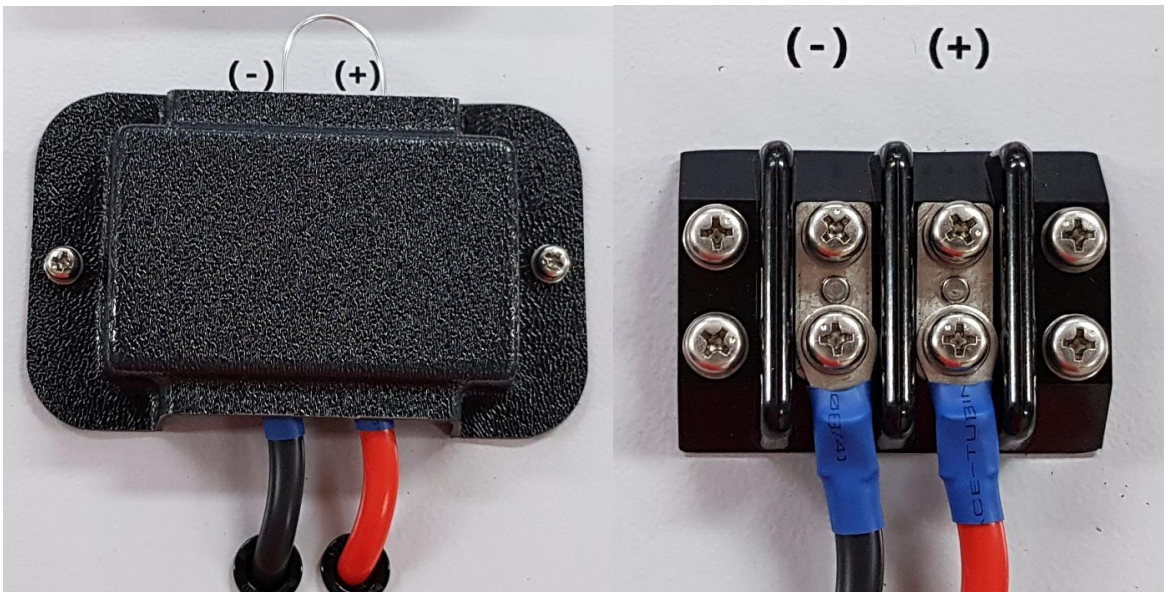


Figure 6. Main Power Terminal

Unscrew the cover and remove the shorting wire from the main terminal block. Check the polarity of the terminals and then connect power cables (AWG 8 to AWG 12) to connector accordingly. Connect the No.1 and the No.2 poles to the charger, respectively. Once connected, reattach the plastic cover. The slot assignment and the markings are summarized in Table 1.

Table 1. Pin Assignment of Main Power Terminal

No	Marking	Function	Color
1	(+)	Capacitor "+"	Red
2	(–)	Capacitor "–"	Black

3.3.2 Connecting to the User Interface Connector

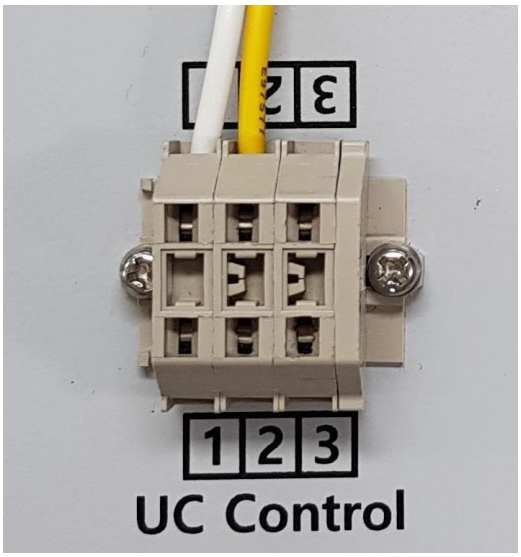


Figure 7. Monitoring Signal Output Terminal

The spring-type 3-pin connector, located on the opposite side of power terminal, is connected to the charger to transmit information about the module. As shown in Figure 7. check the pin number of the connector for monitoring and then insert cables (AWG 14 to AWG 18) to the correct corresponding slots.

The pin assignment for the monitoring signal output is summarized in Table 2.

Table 2. Pin Assignment of Monitoring Connector

No	Marking	Function	Color	Ref.
1	1	1/3 voltage of module	White	30th cell voltage of the module
2	2	2/3 voltage of module	Yellow	60th cell voltage of the module
3	3	Not used	N/A	

Pin #1 is connected to the 30th cell of the module. This point can be used with (–) pole of the main power terminal.

Pin #2 is connected to the 60th cell of the module. This point can be used with (–) pole of the main power terminal.

Pin #3 is not used.

3.4 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) as measured by the thermistor output. If supplemental cooling methods are employed, it may be possible to operate at higher currents or duty cycles than if cooling occurs 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 specified voltage and temperature ratings specified on the datasheet. 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 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. Refer to the instructions in section 5.1 below for the manual discharge procedure. 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
- Provide sufficient electrical isolation when working above 50 V_{DC}
- Prior to installation in or removal from the system, fully discharge the module to guarantee the safety of all personnel

5.1 Discharge procedure

To discharge an individual module:

1. Using a voltmeter, measure the voltage between the positive (+) and negative (–) terminals.
2. If the voltage is above 2 V, a power resistor (not supplied with the module) may be connected between the terminals to discharge the module. Proper care must be taken in the design and construction of such a resistor. The discharge time, current, power and temperature will depend on the resistor value and the amount of energy to be discharged.

NOTE	Customers may also use 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).  300 W

3. If the voltage is under 2 V, connect a shorting wire between the positive (+) and negative (–) terminals.
4. The module is now safe for handling. However, leave the shorting wire connected **at all times** until installing the module and connecting power cables to the terminals.

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 mishandled. Maintenance should only be conducted by trained personnel on discharged modules (see the "Discharge procedure" section 5.1 above).

6.1 Routine maintenance

WARNING
 Do not use high-pressure sprays or immersion to clean the module. Keep excess amounts of water away from the Ultracapacitor Management Unit cover and power terminals.

	Outside use / dirty / dusty / high-vibration environment	**Inside use / clean / low-vibration environment**
Use a damp cloth to clean the exterior of the module and remove dirt and grime	At least every 6 months (more frequently in very dusty-dirty environments)	Annually
Use a calibrated torque wrench to check mounting fasteners for proper torque		
Inspect housing for signs of internal damage.		
Check signal/ground connections for false signals or shock hazards.		

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. After discharging the module, connect a shorting wire between the positive (+) and negative (–) terminals to maintain a short circuit.

For more information about discharging a module, see the "Discharge procedure" section 5.1.

8 Disposal

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

9 Specification

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

10 Installation checklist

The following checklist details best practices and requirements for the 240V energy storage module. Requirements are highlighted in the table for easy identification.

MOUNTING MODULES	
⚠ REQUIREMENT	Modules must be fastened to a flat mounting surface using all 4 mounting bolt pass-through holes available on the module. No deformation of the module's bottom or top plates should be allowed.
BEST PRACTICE	Maxwell suggests that each module be fastened using high-quality fasteners. • Metric: Class 8.8 or 10.9, M8 • Standard: Grade 5 or 8, 5/16” Use the appropriate bolt length for the specific installation; include length for the use of lock washers or lock nuts.

CABLING CONNECTIONS	
⚠ REQUIREMENT	Maxwell requires that the main positive (+) and negative (–) power cables are properly restrained to prevent movement and stress to the terminals of the module.
BEST PRACTICE	When connecting the power terminal to the ring terminal, strip cable sheath 1 to 2 mm longer than crimp area of the ring terminal. Insert the cable until it reaches the ring terminal. The bolts must be tightened with a specified force. It is recommended to use an appropriate torque wrench or other similar tool. • Max. 1.8Nm, 18kgf Over-tightening may damage the terminal. Under-tightening may cause the cable to become loose.
BEST PRACTICE	Maxwell recommends that each module case be grounded to the chassis ground for optimal safety.