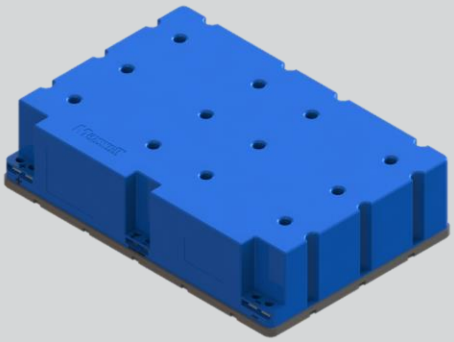
DATASHEET

160V 10F MODULE

Wind Pitch Control Energy Storage



Maxwell Technologies' 160V 10F module is the newest addition to Maxwell's full featured lineup of energy solutions designed to support the latest trends in renewable energy and provide energy storage for emergency pitch control systems. Based on ultracapacitor technology, the 160V 10F module boasts the longest lifetime and greatest energy content out of Maxwell's wind module product portfolio, thereby reducing turbine maintenance and life cycle costs while improving overall system reliability. Scalable in series and parallel configuration, the product can meet majority of the new and existing pitch power delivery requirements.

Ultracapacitor is the technology of choice into electric pitch control systems because of its longer operating lifetime, low maintenance requirements, and superior cold weather performance when compared to batteries.

FEATURES & BENEFITS

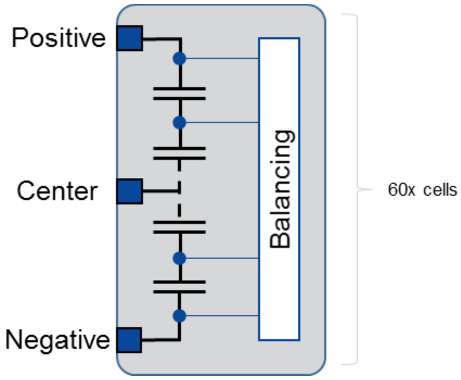
- Rated at 160V, 10F
- 3,000 hour DC life at maximum operating temperature and voltage*
- Designed for up to 500,000 duty cycles*
- Turnkey solution with passive cell balancing
- Compact and lightweight package
- Screw terminals and center voltage tap

TYPICAL APPLICATIONS

- Wind turbine pitch control
- Small UPS systems
- Industrial applications
- Heavy duty machinery

*Typical results may vary. Additional terms and conditions, including the limited warranty, apply at the time of purchase. See the warranty details for applicable operating use and requirements.

PRODUCT BLOCK DIAGRAM



ORDERING INFORMATION

Model Number	BMOD0010 E160 B02
Part Number	**135929**
Package Quantity	3

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PRODUCT SPECIFICATIONS & CHARACTERISTICS

Values are referenced at T_A = room temperature and V_R = 160V rated voltage (unless otherwise noted). Min and Max values indicate product specifications. Typical results will vary and are provided for reference only. Additional terms and conditions, including the limited warranty, apply at the time of purchase. See the warranty details for applicable operating and use requirements.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ELECTRICAL						
C_R	Initial Rated Capacitance	Note 1	10.0	10.6	12.0	F
R_S	Initial Equivalent Series Resistance (ESR)	Note 1	-	160	230	mΩ
V_R	Maximum Rated Voltage		-	-	160	V
V_{MAX}	Absolute Maximum Voltage	Non-repeated. Not to exceed 1 second.	-	-	170	V
V_{STRING}	Maximum String Voltage	For series of modules	-	-	800	V
I_{DCMAX}	Maximum Continuous Current	$\Delta T_{CELL} = I_{RMS}^2 \times R_S \times R_{th}$ - ΔT = 15°C - ΔT = 40°C	 - -	 - -	 7 12	A_{RMS}
I_{PEAK}	Maximum Peak Current		-	-	200	A
I_{LEAK}	Leakage Current	After 72 hours at 25°C	-	-	25	mA
LIFE						
t_{AGING}	Accelerated Aging	At V_R = 160V and T_A = 65°C (Note 1) - Capacitance change ΔC from min C_R - Resistance change ΔR from max R_S	- - -	3,000 -20 +100	- - -	hours % %
t_{LIFE}	Projected Life Time	At V_R = 160V and T_A = 25°C (Note 1) - Capacitance change ΔC from min C_R - Resistance change ΔR from max R_S	- - -	10 -20 +100	- - -	years % %
n_{LIFE}	Projected Cycle Life	At V_R = 160V and T_A = 25°C (Note 1) - Capacitance change ΔC from min C_R - Resistance change ΔR from max R_S	- - -	500,000 -20 +100	- - -	cycles % %
t_{SHELF}	Shelf Life	Stored uncharged, T_A = 25°C and RH < 50%	-	4	-	years
POWER & ENERGY						
P_d	Usable Specific Power	Per IEC 62576, $P_d = \frac{0.12 \times V_R^2}{R_S \times m}$	1.8	2.6	-	kW/kg
P_{MAX}	Impedance Match Specific Power	$P_{MAX} = \frac{0.25 \times V_R^2}{R_S \times m}$	3.8	5.4	-	kW/kg
E_d	Gravimetric Specific Energy	$E_d = \frac{E_{MAX}}{m}$	4.8	5.1	-	Wh/kg
E_{MAX}	Stored Energy	$E_{MAX} = \frac{0.5 \times C_R \times V_R^2}{3{,}600}$ (Note 2)	35.6	37.7	-	Wh
TEMPERATURE & THERMAL						
T_A	Operating Temperature	Cell case temperature	-40	25	65	°C
R_{th}	Thermal Resistance	All cell cases to ambient	-	1.3	-	°C/W
C_{th}	Thermal Capacitance		-	5,500	-	J/°C
-	Cooling			Natural Convection		-

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
PHYSICAL						
m	Mass		-	7.4	-	kg
F_{M5}	Recommended Torque on Power Terminals	M5 thread	-	2.2	4.0	Nm
F_{M4}	Recommended Torque on Monitoring Terminals	M4 thread	-	1.2	2.0	Nm
-	Vibration		IEC 60068-2-6			-
-	Shock		IEC 60068-2-27			-
-	Environmental Protection	Ingress Protection	IP50			
-	Insulation Resistance	Per IEC60068-2-78 At T_A=40°C and 90%RH	-	400	-	MΩ
CELL VOLTAGE MANAGEMENT						
-	Cell Voltage Monitoring		At Voltage Center Tap – 2 Monitoring Terminals			-
-	Cell Voltage Management		Passive			-
SAFETY						
-	Certifications		RoHS, REACH			
V_{HP}	High-Pot Capability	Duration = 60 seconds. Not intended as an operating condition.	-	5,600	-	VDC

TEST PROCEDURES

Notes:

1. Measured at 25°C using specified test current waveform below:

$V1 = V_R$ $t2 – t1 = 15s$ $\mathbf{C_R = I \times (t3 – t2) / (V2 – V3)}$
$V3 = 0.5 \times V_R$ $t4 – t3 = 100ms$ $\mathbf{R_s = (V4 – V3) / I}$

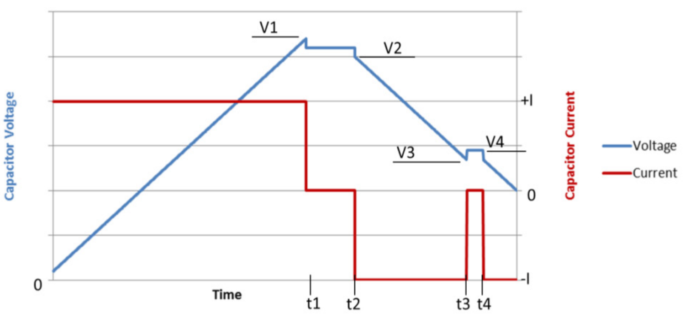

Figure 1: Capacitance & Resistance Measurement Waveform

$V1 = V_R$ $t2 – t1 = 5s$ (I = 0)
$V2 = 0.5 \times V_R$ $t4 – t3 = 15s$ (I = 0)

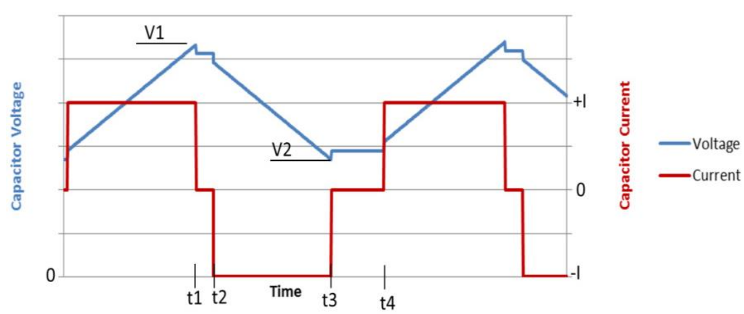

Figure 2: Cycle Life Measurement Waveform

2. Per United Nations material classification UN3499, all Maxwell ultracapacitors have less than 10 Wh capacity to meet the requirements of Special Provisions 361. Both individual ultracapacitors and modules composed of those ultracapacitors shipped by Maxwell can be transported without being treated as dangerous goods (hazardous materials) under transportation regulations.

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TYPICAL PERFORMANCE

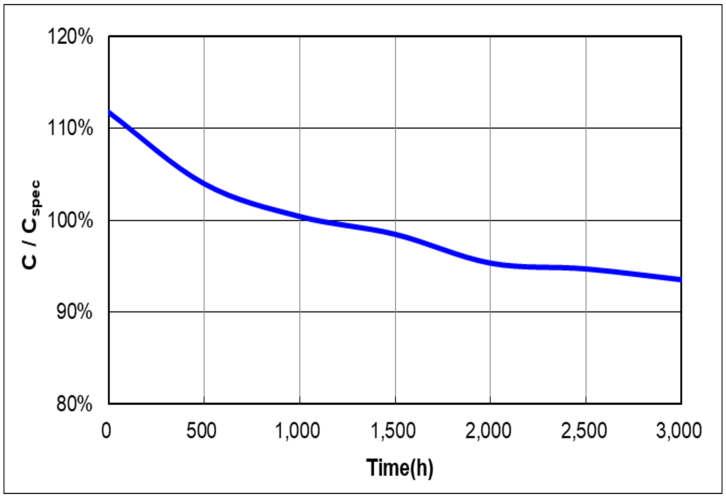


Figure 3: Accelerated Aging Capacitance Performance

V_R= 160V, T_A = 65°C

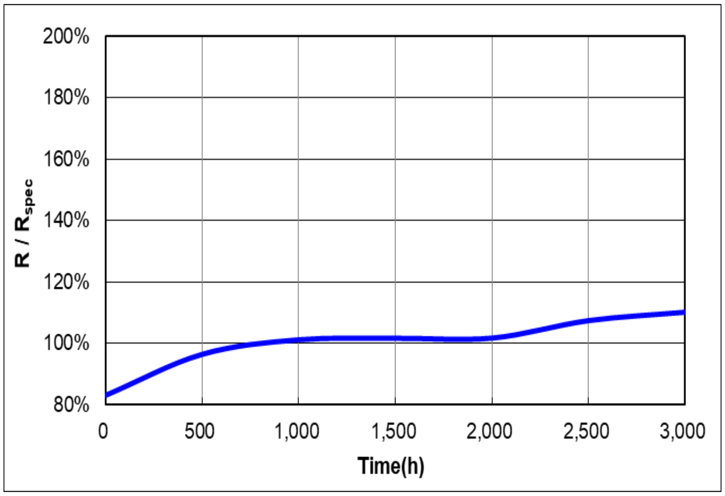


Figure 4: Accelerated Aging ESR Performance

V_R = 160V, T_A = 65°C

DETAILED PRODUCT DESCRIPTION

Introduction

The BMOD0010 E160 B02 energy storage module is built with sixty (60) ultracapacitor cells in series; these board mounted cells are passively balanced and the entire assembly is packaged into a rigid plastic enclosure.

Technology Overview

Ultracapacitor, also known as supercapacitor or electric double layer capacitor (EDLC), delivers energy at relatively high rates (beyond those accessible with batteries). Ultracapacitors store charge electrostatically (non-Faradaic) by reversible adsorption of the electrolyte onto electrochemically stable high surface area carbon electrodes. Charge separation occurs on polarization at the electrode/electrolyte interface, producing a double layer. This mechanism is highly reversible, allowing the ultracapacitor to be charged and discharged hundreds of thousands of times.*

* Results may vary. Additional terms and conditions, including the limited warranty, apply at the time of purchase. See the warranty details for applicable operating use and requirements.

Ultracapacitor Construction

An ultracapacitor is constructed with symmetric carbon positive and negative electrodes separated by an insulating ion-permeable separator and packaged into a container filled with organic electrolyte (salt/solvent) designed to maximize ionic conductivity and electrode wetting. It is the combination of high surface area activated carbon electrodes (typically >1500m²/g) with extremely small charge separation (Angstroms) that results in high capacitance.

Ultracapacitor Energy= ½ CV^2

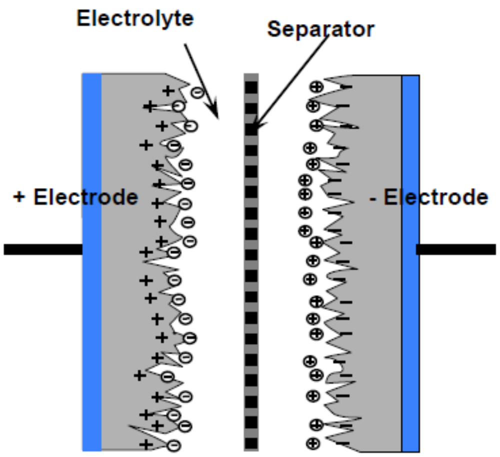


Figure 5: Ultracapacitor Structure Diagram

Ultracapacitors can be packaged in different mechanical packages: Prismatic Design, where the positive-separator-negative electroactive assembly can be wound on a paddle, stacked or Z-folded, then sealed in either a soft pouch cell or a hard shell prismatic can.
For products with round or cylindrical packaging, the electrodes and separator are wound into a jellyroll configuration and sealed into cylindrical aluminum cans.

Ultracapacitor Cell Description
Rated at 2.7V 600F, the ultracapacitor cell in the module integrates Maxwell's most advanced electrode formulation in a compact and reliable cylindrical form factor, with outstanding electrical parameters and life performance. This ultracapacitor cell, with 4-axial, through-hole snap-in terminals is board mountable to achieve reliable and robust electrical and mechanical connectivity which maintains its integrity in high vibration applications.

Module Configuration
The BMOD0010 E160 B02 module integrates a total of sixty (60) ultracapacitor cells rated at 2.7V 600F connected in series to achieve the desired electrical characteristics of the module. This can be calculated using the following formulas:

$$C_R = C_{CELL} \times \frac{\#\ \text{parallel}}{\#\ \text{series}}$$

$$R_S = R_{CELL} \times \frac{\#\ \text{series}}{\#\ \text{parallel}} + R_{ACCESS}$$

Where:
- C_R = module rated capacitance (F)
- C_{CELL} = cell capacitance (F)
- R_S = module serial resistance (mΩ)
- R_{CELL} = cell equivalent series resistance (mΩ)
- R_{ACCESS} = module access resistance
- # parallel = number of parallel string = 1
- # series = number of cells in series = 60

Cell Balancing
To provide an equal voltage distribution amongst all internal sixty ultracapacitor cells, the BMOD0010 E160 B02 features an integrated passive balancing circuitry. Sized to accommodate the slight tolerance in capacitance and leakage current of each individual ultracapacitor cell in the design, the integrated passive balancing circuit ensures that each cell will operate within its normal operating conditions and therefore ensure the longest lifetime of the product.

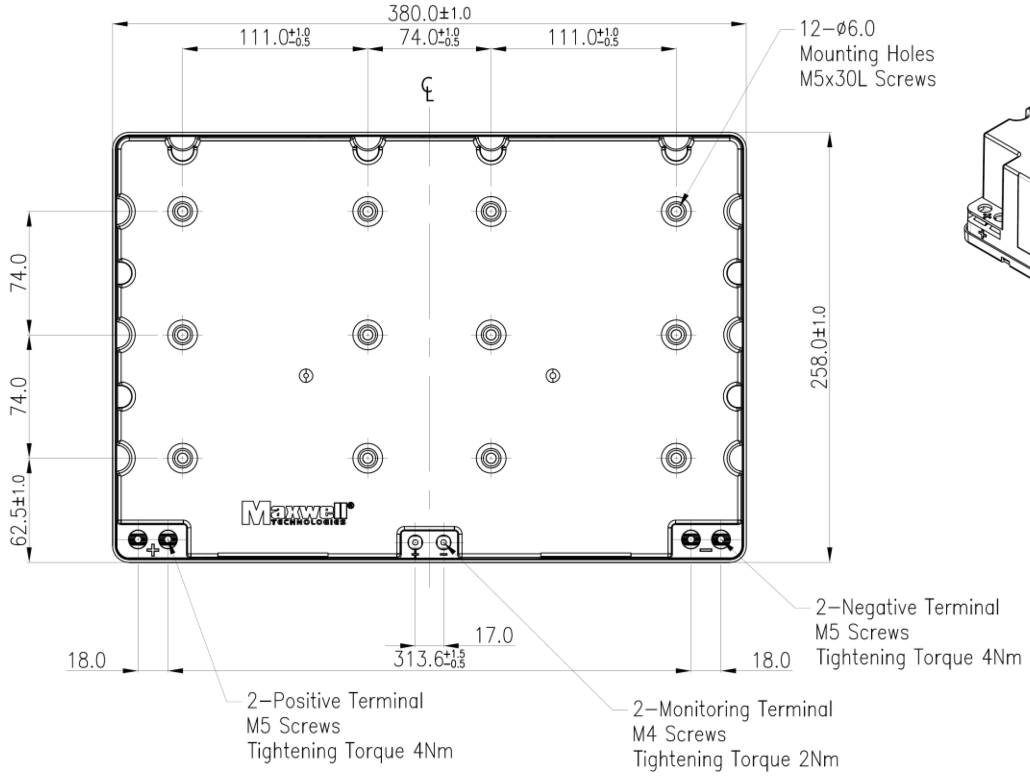
The passive balancing circuit of the BMOD0010 E160 B02 is optimized for stationary, low duty cycle applications. Should there be an interest in higher cycling applications, please consult Maxwell Technologies Applications Engineering.

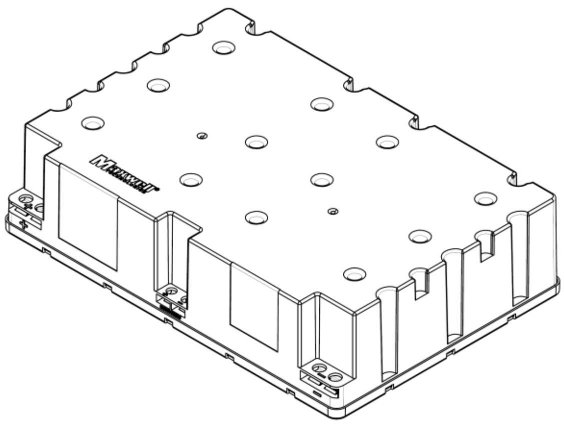
Mechanical Housing
The module packaging is a rigid plastic enclosure rated for the following stress and environmental conditions:
- Vibration per IEC 60068-2-6
- Shock per IEC 60068-2-27

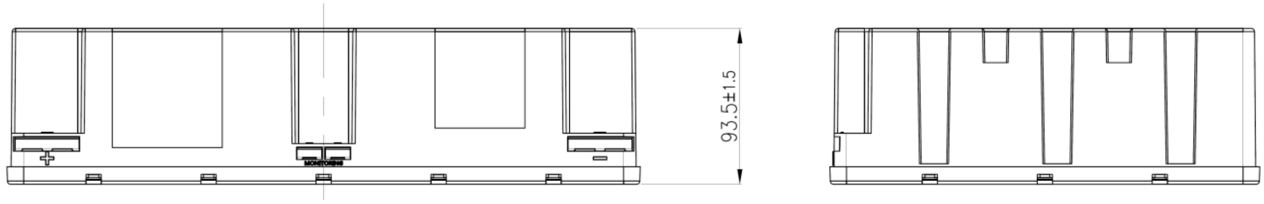
Electrical Terminals
The BMOD0010 E160 B02 module offers two power terminals (one positive, one negative) and one voltage center tap for monitoring purposes.

Mounting Points
The BMOD0010 E160 B02 module offers twelve mounting points for securing the module in the application.

MECHANICAL DRAWINGS







DIMENSIONS	MIN	TYP	MAX	UNIT
Length (L)	379.0	380.0	381.0	mm
Width (W)	257.0	258.0	259.0	mm
Height (H)	92.0	93.5	95.0	mm

Products and related processes may be covered by one or more U.S. or international patents and pending applications. Product dimensions are for reference only unless otherwise identified. Maxwell Technologies reserves the right to make changes without further notice to any products herein. “Typical” parameters which may be provided in Maxwell Technologies datasheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including “Typicals” must be validated for each customer application by customer's technical experts. Please contact Maxwell Technologies directly for any technical specifications critical to application.

UCAP Power, Inc. Global Headquarters
6155 Cornerstone Courte
East, Suite 210
San Diego, CA 92121
USA
Tel: +1 (833) UPOWER 1
Info@ucappower.com

Maxwell Technologies Korea Co., Ltd.
17, Dongtangiheung-ro
681 Beon-gil, Giheung-gu,
Yongin-si, Gyeonggi-do
17102
Republic of Korea
Tel: +82 31 289 0700
Fax: +82 31 286 6767