Maxwell Technologies’ 160V module is designed to provide energy storage for emergency pitch control and maximize the energy generation of a wind turbine. Based on ultracapacitor technology, the 160V module can considerably reduce turbine maintenance and life cycle costs, improve reliability and lower the overall cost of energy. 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 their longer operating lifetime, low maintenance requirements and superior cold weather performance when compared to batteries.

**FEATURES AND BENEFITS**
- Rated at 160V, 7.5F
- 2,000 hours DC life at maximum operating temperature and voltage
- Designed for up to 500,000 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

**PRODUCT BLOCK DIAGRAM**

**ORDERING INFORMATION**

<table>
<thead>
<tr>
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<th>BMOD0008 E160 B02</th>
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<tr>
<td>Model Number</td>
<td></td>
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<tr>
<td>Part Number</td>
<td>135401</td>
</tr>
<tr>
<td>Package Quantity</td>
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</table>

*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 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. Additional terms and conditions, including the limited warranty, apply at the time of purchase.

### Symbol | Parameter | Conditions | Min | Typical | Max | Unit
--- | --- | --- | --- | --- | --- | ---
\( C_R \) | Initial Rated Capacitance | Note 1 | 7.5 | 7.9 | 9.0 | F
\( R_S \) | Initial Equivalent Series Resistance (ESR) | Note 1 | – | 200 | 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 | \( \Delta T_{CELL} = I_{RMS}^2 \times R_S \times R_{th} \) - \( \Delta T = 15^\circ C \) - \( \Delta T = 40^\circ C \) | – | – | 7 | A\_RMS
\( I_{PEAK} \) | Maximum Peak Current | | – | – | 200 | A
\( I_{LEAK} \) | Leakage Current | After 72 hours at 25°C | – | – | 30 | mA
\( t_{AGING} \) | Accelerated Aging | At \( V_R = 160V \) and \( T_A = 65^\circ C \) - Capacitance change \( \Delta C \) from min \( C_R \) - Resistance change \( \Delta R \) from max \( R_S \) | – | 2,000 | – | hours
\( t_{LIFE} \) | Projected Life Time | At \( V_R = 160V \) and \( T_A = 25^\circ C \) - Capacitance change \( \Delta C \) from min \( C_R \) - Resistance change \( \Delta R \) from max \( R_S \) | – | 10 | – | years
\( n_{LIFE} \) | Projected Cycle Life | At \( V_R = 160V \) and \( T_A = 25^\circ C \) - Capacitance change \( \Delta C \) from min \( C_R \) - Resistance change \( \Delta R \) from max \( R_S \) | – | 500,000 | – | cycles
\( t_{SHELF} \) | Shelf Life | Stored uncharged, \( T_A = 25^\circ C \) and RH < 50% | – | 4 | – | years
\( P_d \) | Usable Specific Power | Per IEC 62576, \( P_d = \frac{0.12 \times V_R^2}{R_S \times m} \) | – | 2,200 | – | W/kg
\( P_{MAX} \) | Impedance Match Specific Power | | – | 4,600 | – | W/kg
\( E_d \) | Gravimetric Specific Energy | | | 4.4 | – | Wh/kg
\( E_{MAX} \) | Stored Energy | \( E_{MAX} = \frac{0.5 \times C \times V_R^2}{3,600} \) (Note 2) | | 26.6 | – | Wh

### TEMPERATURE & THERMAL

| Symbol | Parameter | Conditions | Min | Typical | Max | Unit |
--- | --- | --- | --- | --- | --- | --- |
\( T_A \) | 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 | – |
PRODUCT SPECIFICATIONS & CHARACTERISTICS (Cont’d)

Values are referenced at $T_A = \text{room temperature}$ and $V_{ni} = \text{160V rated voltage}$ (unless otherwise noted). Min and Max values indicate product specifications. Typical results will vary and are provided for reference. Additional terms and conditions, including the limited warranty, apply at the time of purchase.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Unit</th>
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<td>–</td>
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<tr>
<td>–</td>
<td>Shock</td>
<td>–</td>
<td>IEC 60068-2-27</td>
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<td></td>
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<tr>
<td>–</td>
<td>Insulation Resistance</td>
<td>Per IEC60068-2-78</td>
<td>At $T_A=40^\circ\text{C}$, 90% RH</td>
<td>–</td>
<td>400</td>
<td>mΩ</td>
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CELL VOLTAGE MANAGEMENT

| – | Cell Voltage Monitoring | At Voltage Center Tap – 2 Monitoring Terminals | – |
| – | Cell Voltage Management | Passive | – |

SAFETY

| – | Certifications | RoHS |
| – | $V_{HP}$ High-Pot Capability | Duration = 60 seconds. Not intended as an operating condition. | – | 4,000 | – | VDC |

TEST PROCEDURES

Notes:

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

   $V1 = V_{ni}$
   $V2 = 0.8 \times V_{ni}$
   $V3 = 0.4 \times V_{ni}$
   $C_R = I \times (t_4 - t_3) / (V2 - V3)$

   $t_2 - t_1 = 5 \text{ min}$
   $t_4 - t_3 = 100 \text{ msec}$

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.
**Introduction**
The BMOD0008 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**
Electrochemical double layer capacitors (EDLCs) also known as electric double layer capacitor, supercapacitors or ultracapacitors deliver energy at relatively high rates (beyond those accessible with batteries) because the mechanism of energy storage is by charge-separation. 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 to even millions of times.*

**Detailed Product Description**

**Ultracapacitor Construction**
An ultracapacitor is constructed with symmetric carbon positive and negative electrodes separated by an insulating ion-permeable separator, packaged into a container then 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.

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

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**Typical Performance**

![Figure 3: Accelerated Aging Capacitance Performance](image1)

![Figure 4: Accelerated Aging ESR Performance](image2)

**Ultracapacitor Structure Diagram**

![Figure 5: Ultracapacitor Structure Diagram](image3)
Ultracapacitors can be packaged in different mechanical packages: Prismatic Design, where the positive/seperator/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 450F, 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 BMOD0008 E160 B02 module integrates a total of sixty ultracapacitor cells rated at 2.7V 450F 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
- \(R_S\) = module serial resistance (mΩ)
- \(R_{CELL}\) = cell equivalent series resistance
- \(R_{ACCESS}\) = 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 BMOD0008 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 BMOD0008 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 IEC60068-2-6
- Shock per IEC60068-2-27

**Electrical Terminals**
The BMOD0008 E160 B02 module offers two positive terminals and two negative terminals as well as two monitoring terminals at the center tap.

**Mounting Points**
The BMOD0008 E160 B02 module offers twelve mounting points for securing the module in the application.
MECHANICAL DRAWINGS

DIMENSIONS

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
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<td>378.0</td>
<td>381.0</td>
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<td>Width (W)</td>
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<td>Height (H)</td>
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