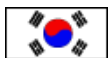


# USER MANUAL

## Notes on Using Ultracapacitor Cells

**Maxwell Technologies**



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Ultracapacitors, also known as supercapacitors or electric double layer capacitors (EDLC), have unusually high energy densities compared to conventional electrolytic capacitors, typically in the order of thousands of times greater than a high-capacity electrolytic capacitors. Ultracapacitors store energy electrostatically, thus their performance is not hampered by the electrochemical charge transfer kinetics exhibited by batteries. Consequently, ultracapacitors are capable of rapid charge-discharge cycles with high efficiency (>97%). With their low ESR (equivalent series resistance) and wide operating temperature range, ultracapacitors are being utilized in an expanding list of applications.

### **Environmental Considerations**

1. Ultracapacitor cells are wound into a jelly roll configuration using (symmetric) high surface area carbon electrodes with insulating separator material, which separates positive and negative electrodes. The entire assembly is inserted in an aluminum can, filled with organic electrolyte and sealed with a polymeric lid. Typical small to medium cells are designed with board-mountable radial through-hole type terminals; with larger cells designed with axial threaded or weldable terminals. Although usable under a wide range of operating conditions, Maxwell recommends avoiding the use of ultracapacitors under the following environmental conditions:
  - in direct contact with water, salt water/brine or oil
  - under direct sunlight
  - in high temperature and/or high humidity with the likelihood of moisture ingress
  - in direct contact with chemically active gas(es)
  - stored or used in acidic or alkaline conditions

Please contact Maxwell for appropriate recommendations before operating under the listed conditions.

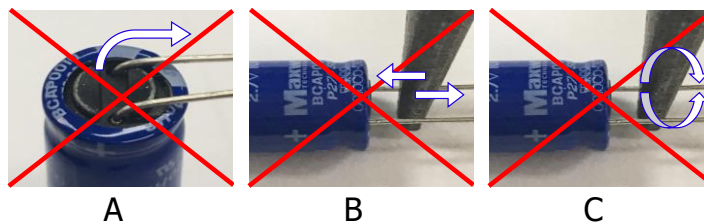
### **Electrical Considerations**

1. Please review the datasheet for detailed product specification limits prior to use. **Do not** exceed the rated voltage and/or specified maximum operating temperature on the ultracapacitor. Prolonged exposure to overvoltage and high temperature may cause overheating, sudden leakage current increase, decrease in capacitance, and/or ESR rise, all of which can lead to permanent damage of the ultracapacitor cell.
2. All ultracapacitors have a positive and negative polarity. Please check the polarity indicated on the label before use and do not reverse the polarity when electrically connecting the ultracapacitor cells.

3. The tolerance range of capacitance of ultracapacitors is –10% (or 0%) to +20% of rated capacitance. This means that the maximum capacitance difference between cells can be up to 33%. Prior to shipment, ultracapacitor cells are packaged into narrower capacitance groups designated as J, K, L, M, etc. Maxwell refers to these letter designations as binned grades.
4. Multiple ultracapacitor cells can be connected in series, parallel, or combination of series and parallel configurations to achieve the desired performance parameters. Cells connected in series may exhibit voltage variations. Charging a string of ultracapacitor cells without addressing such variations will lead to one or more cells in the string being overcharged. When a cell is overcharged (or exposed to overvoltage conditions), rapid performance degradation may result. This further exacerbates the voltage variations, potentially causing a failure of the entire string.
  - When preparing multiple ultracapacitor cells for string connections, Maxwell recommends fully discharging every cell before soldering or welding. This will eliminate the possibility of sparking or other electrical discharge when the ultracapacitors are connected. Ultracapacitors can be discharged down to near 0 volts with a resistor or with adequate shorting wires.
  - The voltage of each capacitor in a string should be checked before and after charging to ensure that it is being used within the designed voltage range. Appropriate cell balancing strategies, i.e. active or passive balancing, must be implemented in strings with more than two cells in series, especially if the application requires numerous and rapid charge and discharge cycles. For applications requiring complex duty cycles, contact Maxwell's technical team for recommendations.
5. Thermal conditions must be considered when designing ultracapacitor systems that will be used for repeated rapid charge and discharge cycles. Ohmic self-heating may cause the cell to overheat and will lead to rapid degradation of performance.
6. Ultracapacitor lifetime is governed by operating temperature and voltage. Maxwell recommends maintaining cell temperatures below the maximum operating temperature specified in the datasheet. If the application requires periodic high temperature operation, Maxwell recommends de-rating the operating voltage to maximize lifetime. Please contact Maxwell to discuss the details of the operating environment and specific voltage de-rating guidelines for your application.

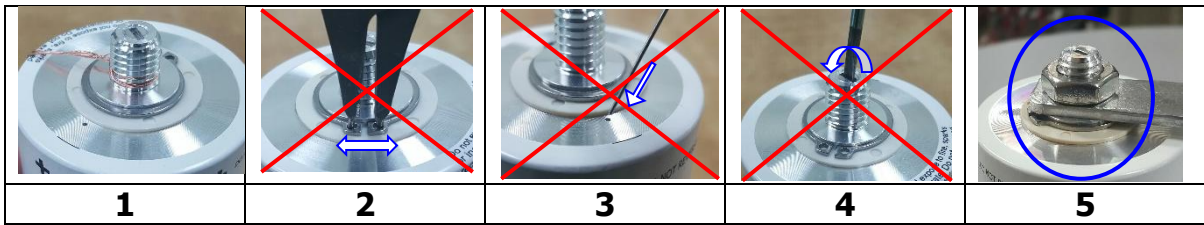
## Handling / Mounting

1. Do not scratch or file the lead/snap-in terminals. The terminals are plated to ensure good wetting of solder. Physically or chemically altering the surface will affect the solderability of the lead/snap-in terminal parts.
2. Do not overheat when soldering. The solder temperature is lower than 260°C and solder time of under 5 seconds are recommended. Please refer to the Soldering Guide (Doc. No. **3002180**) on the Maxwell website.
3. Avoid mechanical impact, such as dropping cells on the floor. Do not exceed the vibration and shock ratings of the ultracapacitor cell. Please contact Maxwell to discuss application details and potential vibration/shock damping recommendations.
4. **(Radial type only) DO NOT deform** (Picture A), **pull** (Picture B) **or twist** (Picture C) **the terminals or lead wires**. The terminals or lead wires are attached to the electrodes in the interior of the aluminum case and sealed with a (electrolyte) leak proof rubber seal. Repeated or forceful bending, pulling or twisting of the lead wire may compromise the integrity of sealing and allow electrolyte to leak out. Electrolyte leakage will shorten the useful life of the ultracapacitor and may also cause corrosion and/or short-circuits in PCB components nearby. Please contact Maxwell for bent lead cell purchase options.



5. **(Radial type only)** Maxwell cells with radial, through-hole terminals are PCB mountable. For best practice, avoid connecting wires directly to ultracapacitor cells and avoid locating cells near heat generating components on the PCB.
6. **(Large Cylindrical type only)** Large cylindrical type ultracapacitor cells are supplied with terminals short-circuited by shorting wires (as shown in Picture 1 below). This is to discharge any residual charge and to ensure that the cells are ready for assembly in a uniform discharged state. Please remove and dispose of the shorting wire when the cell is ready to be used for assembly or test.

7. **(Large Cylindrical type only)** Large cylindrical cells are available with threaded or weldable type terminals. Factory-installed snap-rings are not intended to be removed by users (Picture 1). Avoid physical damage (e.g. physical impact) to the terminals. Avoid damaging the hole on the top plate where the rupture vent is located (Picture 3). Do not loosen the bolt at the top of the terminal (Picture 4). Failure to comply with any of these precautions may shorten the life of the cell and/or cause electrolyte leakage. Use appropriate size nuts to tighten busbars which would be used to connect the threaded terminals of large cylindrical cells (Picture 5). Use washers as necessary to prevent loosening of bolts due to vibration. Please contact Maxwell for information regarding torque that needs to be applied for fastening nuts on the terminals. Please be sure to secure enough free space near the cell's vent hole for gas release. This is to release gas through the safety vent hole in case of excessive gassing and/or swelling.



### Signs of Failure

Any of the following listed phenomena may be an indication that the ultracapacitor cell has failed. Please disconnect the cell from the power supply immediately:

- When the surface temperature of the cell exceeds the upper limit of the allowable operating temperature range within the first few minutes of use.
- When there is an audible sound of vent rupture or perceivable odor from the cell. This is usually accompanied by swelling of the cell.
- When the cell is visibly swollen.
- When electrical sparks are observed at the terminals under high current conditions.

### Cleaning

1. Do not wash ultracapacitor cells in cleaning solutions as they may cause contamination, corrosion, degradation of seals, and/or short-circuit paths.
2. Please contact Maxwell if cleaning is needed after soldering. Certain types of solvents may cause damage to rubber seals on ultracapacitor cells.

## Appearance

Some product appearance issues (such as dents) are managed according to Maxwell's internal specifications. These do not affect product performance, and production can be used normally.



## Storage

1. Do not store ultracapacitor cells in high temperature and/or in high humidity environment. Maxwell recommends storing cells at a temperature between 5°C and 30°C and where the relative humidity is less than 60%. Avoid abrupt temperature changes, which may lead to water condensation and degradation of the cell. Avoid exposure to direct sunlight for extended periods as it may cause deterioration and discoloration of the label.
2. For longer-term storage, Maxwell recommends fully discharging the cell and shorting the terminals with short wires.
3. Do not store the cell in an atmosphere containing water-droplets or toxic gases.
4. Avoid exposure to acidic or alkaline liquids/vapor.
5. If traces of electrolyte are seen on the surface of the cell, use protective gloves and proper personal protection in handling of the product in accordance with applicable regulation and industrial practices. Refer to the MSDS sheet for additional instructions.

## Disposal

Refer to the MSDS for material composition of ultracapacitor cells. Comply with all local, regional, federal, and national requirements for disposal of ultracapacitor cells. In most jurisdictions, ultracapacitor disposal can be handled by industrial waste handling organizations.

## Download

“Notes on Using Ultracapacitor Cells” is also available on Maxwell’s website [www.maxwell.com](http://www.maxwell.com) for download.

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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](http://www.maxwell.com/patents) for more information.

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