Maxwell TECHNOLOGIES

Enabling Energy's Future™

USER MANUAL

Notes on Using Pseudocapacitor Cells

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Pseudocapacitors have higher energy densities compared to conventional electrolytic capacitors and approximately double the energy density of typical ultracapacitors. Comprised of stable crystalline metal oxides on the positive (+) electrode and high porosity activated carbon on the negative (-) electrode, pseudocapacitors store energy electrostatically and electrochemically at the same time. With their low ESR (equivalent series resistance) and high energy, pseudocapacitors are being utilized in an expanding list of applications that require combination of power and energy.

Environmental Considerations

1. Pseudocapacitor cells are wound into a jelly roll configuration using asymmetric metal oxide electrode and high surface area carbon electrode with insulating separator material which separates these two 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. Although usable under a wide range of operating conditions, Maxwell recommends avoiding use of pseudocapacitors 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 above 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 pseudocapacitor. 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 pseudocapacitor cell.

2. All pseudocapacitors 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 pseudocapacitor cells.

3. **Do not** discharge pseudocapacitors below 0.9V during normal operation. Pseudocapacitor cell may be irreversibly damaged and/or its lifetime may be compromised when discharged below 0.9V.

4. The tolerance range of capacitance of pseudocapacitors is –10% to +20% of rated capacitance. This means that the maximum capacitance difference between cells can be ~33%. Prior to shipment, pseudocapacitor cells are packaged into narrower capacitance groups designated as J, K, L, M, etc. Maxwell refers to these letter designations as binned grades.

5. Multiple pseudocapacitor 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 pseudocapacitor 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 pseudocapacitor cells for string connections, Maxwell recommends fully discharging every cell once before soldering. Out-of-box open circuit voltage of pseudocapacitors should be around 0.4V. Aside from this one-time full discharge before soldering and PCB assembly, pseudocapacitor cells should not be kept shorted or discharged below 0.9V during normal operation. Exercise caution when assembling multiple pseudocapacitors in series as the string voltage will increase as each cell is connected.
    - Voltage of each pseudocapacitor cell 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. It is recommended that cell balancing is implemented with a minimum "cut-off voltage" of 0.9V, where the balancing becomes deactivated once the individual cell voltage reaches this cut-off voltage during discharge or rest. For applications requiring complex duty cycles, contact Maxwell's technical team for balancing recommendations.

6. Thermal conditions must be considered when designing pseudocapacitor systems for repeated rapid charge and discharge cycles. Ohmic self-heating may cause the cell to overheat leading to rapid degradation of performance.

7. Pseudocapacitor 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.

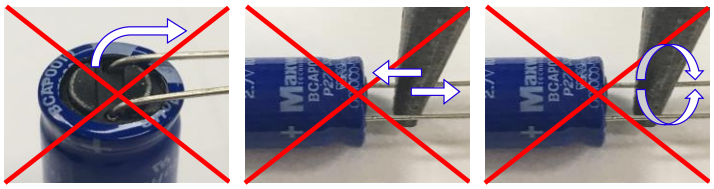
Handling / Mounting

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. Solder temperature 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 pseudocapacitor 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 (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 pseudocapacitor and may also cause corrosion and/or short-circuits in PCB components nearby.



A B C

5. **(Radial type only)** Maxwell cells with radial, through-hole terminals are PCB mountable. For best practice, avoid connecting wires directly to pseudocapacitor cells and also avoid locating cells near heat generating components on the PCB.

Signs of Failure

Any of the following listed phenomena may be an indication that the pseudocapacitor cell has failed. Please disconnect the cell from 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 with swelling of the cell
- When the cell shows visible bulging or is mechanically deformedswollen
- When electrical sparks are observed at the terminals under high current conditions.

Cleaning

1. Do not wash pseudocapacitor 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 pseudocapacitor cells.

Storage

1. Do not store pseudocapacitor cells in high temperature and/or in a high humidity environment. Maxwell recommends storing cells at temperature between 5°C and 30°C and where the relative humidity is less than 50%. 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 keeping pseudocapacitor cells at their open circuit voltage level without fully discharging the cells or shorting the terminals.

3. Do not store pseudocapacitor cells 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.

Disposal

Comply with all local, regional, federal, and national requirements for disposal of pseudocapacitor cells. In most jurisdictions, pseudocapacitor disposal can be handled by industrial waste handling organizations.

Download

Notes on Using Maxwell Pseudocapacitor Cells is also available on Maxwell's website **www.maxwell.com** for download.