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User Manual

Super Capacitors

(CNP Series User Manual White Paper)

To ensure safe assembly, storage, and testing of supercapacitors, avoid using conductive surfaces. Supercapacitors can short-circuit on conductive surfaces.
If fully charged supercapacitors are stacked on a conductive surface, sparks and short circuits may occur, resulting in a fire.

1. Purpose

This product instruction white paper is prepared to ensure the safe use of CNP series products.

2. Scope of Application

This product instruction manual applies only to supercapacitor cells manufactured and shipped by CDA (Zhifengwei Technology).

3. Operating Instructions

3.1 Residual Voltage and Handling of Supercapacitors

During the final stages of production, after quality control testing (i.e., capacitance conditioning), supercapacitors are discharged to 0V. However, due to the charge redistribution effect, the supercapacitor voltage will recover to approximately 300mV.

To ensure the safe assembly, storage, and testing of supercapacitors, the use of conductive surfaces is prohibited. Supercapacitors may short-circuit on conductive surfaces. If fully charged supercapacitors are stacked on conductive surfaces, sparks and short circuits may occur, resulting in fire.

3.2 Overvoltage

The rated voltage of a supercapacitor is the upper limit of the system degradation rate within an acceptable range for long-term use. The stability of the electrolyte is the primary limiting factor. For example, the rated voltage is 2.7V. If the capacitor is charged above the rated voltage, i.e., under overvoltage, the degradation rate increases. In most cases, this does not pose a safety hazard, as capacitors are capable of withstanding brief periods of overcharge. If a capacitor is accidentally overcharged, for example, by 0.15V above the rated voltage for 12 hours at room temperature, there will be no significant negative impact. The worst-case scenario is that the capacitor is continuously charged without voltage control, leading to severe overvoltage. Overvoltage causes gas to form inside the sealed supercapacitor case, especially near or above the maximum operating temperature limit (CDA (Zhifengwei Technology) is +65° C). This leads to increased pressure buildup and ultimately failure of the safety valve on the supercapacitor case. Destruction of the safety valve can take anywhere from minutes to weeks, depending on the charging current and the degree of overvoltage.

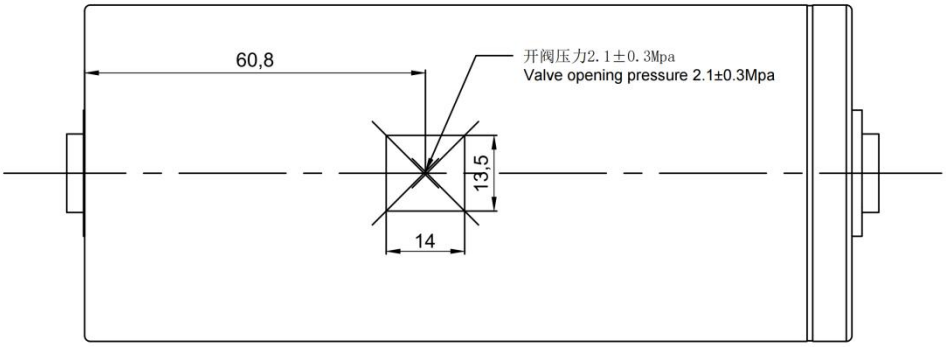
3.3 Overtemperature

CDA (Zhifengwei Technology) defines an operating temperature range of -40° C to +65° C. Within this temperature range, the energy storage process is efficient and long-term. The safety hazard associated with excessive temperatures (above +65° C) is related to the pressure level within the capacitor case. The rated maximum temperature is limited by the boiling point of the electrolyte, but more importantly, by the electrochemical instability of the electrolyte at high voltages above the upper temperature limit. Exceeding the specified upper operating temperature limit will cause internal pressure to build up in the capacitor, especially when charged at (or near) the rated voltage. When the temperature drops below -40° C, the electrolyte in the capacitor freezes, rendering the capacitor inoperable. Upon returning to the specified temperature range, the capacitor's functionality will recover, but with some performance loss.

It is important to note that due to the internal resistance of supercapacitors, heat will be generated during long-term continuous operation or short-term operation. The temperature difference between the capacitor and the operating environment depends on the applied current and the thermal characteristics of the capacitor and must be considered when designing the system.

3.4 Safety Valve

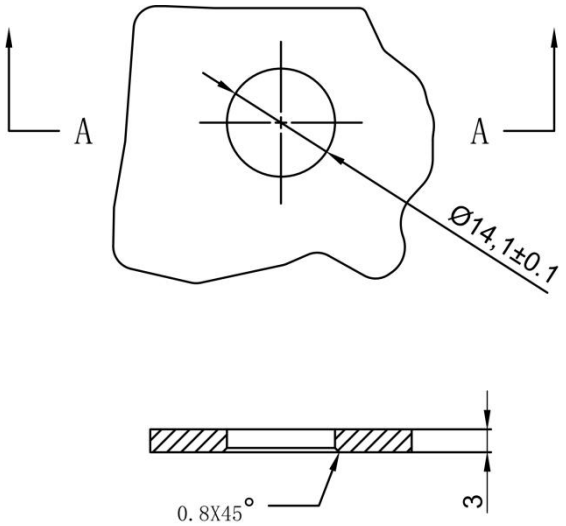
A safety valve is located in the middle of the capacitor housing, as shown in Figure 1. Its purpose is to release pressure that has accumulated within the capacitor after a period of misuse. The safety valve will rupture when the internal pressure exceeds 2.1 ± 0.3 MPa. When designing the system, the safety valve point should be located away from any sensitive components and away from direct exposure to personnel, as electrolyte vapor may be released when the safety valve is opened. It is worth noting that there is still a small amount of free-flowing bulk electrolyte (i.e., electrolyte that is not absorbed by the carbon or separator) inside the capacitor.



（Figure 1）

3.5 Module Welding

When welding modules, pay attention to the pressure applied to the capacitor cell's terminal caps. The pressure should be less than 500N (severe short circuit risk occurs). The applied pressure should be evenly distributed across the end caps to avoid localized deformation. Figure 2 shows the dimensions of the connector holes that match the terminal posts.



（Figure 2）

3.6 Short Circuits

Short-circuiting a charged supercapacitor must be avoided. A short circuit can generate currents in the thousands of amperes range. If a short circuit occurs in a series-connected module, the high current generated by the short circuit can cause severe heating of high-resistance components within the module.

Short circuits can damage wires and welds, causing the wires or wire insulation to melt or catch fire. Furthermore, the welds on the capacitor's aluminum casing can heat up enough to melt, causing the capacitor to crack and causing electrolyte vaporization and combustion. Therefore, the cause of the module short circuit must be eliminated as quickly as possible while ensuring safety. Short-circuited capacitors should be immediately disconnected from the power supply system.

Incidental or temporary short circuits may generate sparks and, rarely, cause small pieces of molten aluminum to separate from the capacitor/module. If maintenance is required, the module/capacitor cell must be discharged and short-circuited before servicing.

3.7 Connecting Live or De-Charged Supercapacitors to the DC Bus

Never connect supercapacitor cells or modules directly to the DC bus or other equipment when the voltage difference between the two systems exceeds 10%. If the voltage difference exceeds 10%, there is a risk of damaging cables, fuses, contactors, switches, or other power electronics. Use appropriate pre-chargers and other devices to limit inrush current to protect equipment.

3.8 Discharge Instructions

Supercapacitor cells can be discharged to 0V without affecting their service life.

Capacitor cells and modules have two safe discharge methods:

Capacitor cells/modules can be connected to a circuit with a variable resistor to regulate the load from the cell/module (passive load). With this method, the polarity of the capacitor cannot be reversed because there is no active current supply. Additionally, this method is slower in low-voltage areas.

Capacitor cells/modules can be discharged using an active constant-current discharger. However, a constant-current discharger can completely discharge the capacitor and then continue to negative voltage, causing polarity reversal. This can cause problems with unbalanced or poorly balanced modules or systems, where one capacitor cell may discharge much faster than the others, causing the former to have a negative voltage.

It is recommended to use a circuit-breaking resistor sized to allow a discharge time of 3 minutes or longer (in the case of cells or modules). Care should be taken to correctly calculate the power, voltage, and thermal capacitance of the resistor to avoid burning the resistor. If the discharge time needs to be controlled within 3 minutes, the temperature rise calculation must be performed to avoid exceeding the specified temperature limit.

3.9 Polarity Reversal

Unlike batteries, the positive and negative electrodes of supercapacitors are made of the same material. Furthermore, the terminals and casing of supercapacitors are generally composed of similar materials. Therefore, under standard quality control, capacitors have no true polarity before the first charge.

All capacitors undergo electrical performance testing before shipment from the manufacturing facility. During this testing, the capacitor polarity is defined and marked on the capacitor label with "+" and "-." For optimal performance, the positive and negative polarity of the capacitor should be defined, as should the initial charge direction, i.e., the initial polarity.

Reversing polarity has an immediate and irreversible negative effect on the capacitor's capacitance and resistance (and also affects its lifespan). The magnitude of the negative effect depends on the magnitude of the reverse polarity voltage applied to the capacitor. Users are advised to avoid reversing polarity.

3.10 Flammability

If a capacitor ruptures due to internal pressure buildup or mechanical damage, the electrolyte may leak. It is important to note that the electrolyte is a volatile and flammable liquid that can ignite with a spark (or other ignition source). Under fire conditions, the internal pressure of the capacitor increases until the safety valve opens. Most of the electrolyte in the capacitor is absorbed by the activated carbon and separator, making it relatively inert to flammability even if the capacitor ruptures. The amount of free electrolyte in the capacitor is less than a few milliliters; therefore, the likelihood of a large-scale fire is very low. If the electrolyte in a ruptured capacitor ignites, it will burn out within seconds.

3.11 Cycle Life and Lifespan

CDA (Zhifeng Micro) defines the end of life of capacitors as a 20% decrease in capacitance from the rated value or a 100% increase in resistance from the rated value. The cycle life of a supercapacitor is the number of cycles between rated voltage and half-rated voltage until end of life (1,000,000 cycles at 25° C). Lifespan is the number of hours of operation at rated voltage and maximum operating temperature until end of life (minimum 1,500 hours).

At rated voltage and +65° C, the service life of a supercapacitor or module is at least 1,500 hours. At 25° C, the service life of a supercapacitor is 10 years.

4. Other Usage Precautions

To ensure proper use of capacitors, please read these instructions carefully before use:

- Do not crush, smash, or disassemble capacitors.
- Do not operate or use capacitors outside the specified operating voltage and temperature ranges.
- During long-term storage, avoid high temperatures, high humidity, direct sunlight, shock, vibration, and direct contact with water, corrosive and toxic substances, or other chemicals.
- Do not immerse capacitors in water. When not in use, store them in a cool, dry environment.
- Do not use or store capacitors near heat sources such as fire or heaters.
- When using this product, use only dedicated charging and discharging equipment.
- Do not use this product if the explosion-proof valve is damaged or cracked.
- Do not physically impact, vibrate, knock, throw, or step on the product. Do not pierce the capacitor with nails or other sharp objects. Do not use this product if it is deformed.
- In the event of a malfunction, the metal casing of the capacitor may be electrically charged. Arc current or human load current can cause harm. Do not place any objects or tools on top of the capacitor. When near capacitors, be sure to remove any metal objects such as rings, watches, or clothing.
- If the product becomes dirty, wipe it clean with a dry cloth before use. Failure to do so may result in poor contact and malfunction.
- Do not use capacitors with modified or damaged charging and discharging equipment or devices.
- Do not use with other different types of products.
- Do not use in areas with strong static electricity or magnetic fields, as this may damage the product's safety features and pose a safety hazard.
- Do not use products that are leaking, dropped, short-circuited, or otherwise damaged.
- If the product develops an odor, becomes hot, leaks, changes color, deforms, or exhibits any other abnormalities during use or storage, immediately remove it from the holder or device and discontinue use.
- If a capacitor leaks and electrolyte enters your eyes, do not rub them. Rinse with clean water and seek medical attention immediately if necessary. Failure to do so may cause eye damage.

5. Transportation and Storage

5.1 During transportation, protect the product from severe vibration, impact, and compression. Protect it from sunlight and rain, and do not store it upside down.

5.2 During loading and unloading, handle the product with care, and avoid dropping, tumbling, or heavy pressure.

5.3 Storage Environment: Store the product in a clean, dry, and well-ventilated place with an ambient temperature of -20° C to 40° C and a relative humidity no greater than 64%. Avoid direct sunlight.

5.4 During storage, keep the product out of direct sunlight, away from corrosive media, and away from sources of fire and heat.

5.5 Capacitors should be placed on electrically insulating material.