

ELECTRIC DOUBLE LAYER CAPACITORS

■ Application Guidelines for Using Electric Double Layer Capacitor (EDLC)

1. Circuit Design

Ensure that operational and mounting conditions follow the specified conditions detailed in the catalog and specification sheets.

a) Lifetime

EDLC have a longer lifetime than do secondary batteries, but their life is still limited. During use, capacitance decreases and internal resistance rises. The lifetime of a EDLC is greatly affected by ambient temperature, applied voltage and operating current. By reducing these factors as much as possible, capacitor lifetime can be lengthened.

b) Voltage

If a EDLC is used at a voltage exceeding its rated voltage, not only is its lifetime shortened, but depending on the actual voltage, gas generated by electrochemical reactions inside the capacitor may cause it to leak or rupture.

c) Polarity

The anode and cathode of EDLCs are comprised of the same material and theoretically have no true polarity. For manufacturing and consistency purposes, the terminals are marked with polarity.

After EDLCs are completely discharged, the electrodes may maintain a very small amount of charge. Even though catastrophic failure will not occur if the polarity is accidentally reversed, the reverse polarity may cause life reduction in applications.

d) Circuitry

- 1) EDLC is polarized. Do not apply reverse voltage. Reverse polarity may increase leakage current or decrease life span.
- 2) Do not apply any voltage higher than the rated voltage. Over-voltage may damage the EDLC by causing abrupt increase of leakage current, and overheating.
- 3) EDLC has a higher Internal resistance than do electrolytic capacitors and is more susceptible to internal heat generation when exposed to ripple current. Do not use EDLC in ripple current applications.
- 4) When a short circuit occurs, EDLC should be retired if sparking on lead terminals is observed. Please contact us for information when connecting EDLC in series or parallel.

e) Temperature

ULTRACAP have wide operating temperature range (-40°C ~ 65°C) or (-40°C ~ 70°C). DYNACAP have wide operating temperature range (-40°C ~ 60°C) or (-25°C ~ 70°C). The temperature is in direct proportion to the capacitance and resistance of the EDLCs because the raise of the temperature will affect the mobility on electrons within electrolyte.

f) Ambient Temperature

- 1) Capacitor life is affected by operating temperature. In general, lowering ambient temperature by 10°C will double the life of a capacitor. Use the capacitor at the lowest possible temperature under the maximum guaranteed temperature.
- 2) Operation above the maximum specified temperature not only shortens capacitor life, but can also cause serious damage such as electrolyte leakage. Verify the operating temperature of the capacitor by taking into consideration not only the ambient temperature and temperature inside the unit, but also the radiation from heat generating elements inside the unit (power transistors, IC's, resistors, etc.) and self-heating due to ripple current. Be careful not to place heat-generating elements across from the capacitor on the opposite side of the PCB.

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g) Characteristics of constant current and constant (For ULTRACAP)

Resistance discharging The time required for the constant current and constant resistance discharging are respectively represented the equation (1) and (2) below: Discharging time (t) of constant current discharge

$$t = C(V_0 - V_1)/I \dots\dots\dots(1)$$

Discharging time (t) of constant resistance discharge

$$t = -CR \ln(V_1/V_0) \dots\dots\dots(2)$$

t = charging time (s)

V₀ = initial voltage (v)

V₁ = terminal voltage (v)

I = current during back-up (A)

The above equations may not always be accurate, the terminal down voltage must be considered after the start of discharge if load resistance or load current present. Back-up characteristics for IC Also, if the capacitor is used to back-up and IC, the characteristics of the IC must also be considered. It can therefore be said that if the voltage is low, the current is also low and the actual back-up time will be longer than that calculated. To be certain that if the capacitor selected is of sufficient value to maintain the necessary energy and time, it should be checked and measured under actual operating conditions.

h) Voltage Drop During Backup Operation

Take careful notice of the voltage drop caused by the instantaneous operating current and the internal resistance of the EDLCs during the switch from power-failure-detection to backup mode. Because internal resistance varies by product, use the following table to decide the correct operating (discharge) current.

t = charging time (s)

V₀ = initial voltage (v)

V₁ = terminal voltage (v)

I = current during back-up (A)

i) Ripple Current

EDLC have a higher internal resistance than do electrolytic capacitors and are more susceptible to internal heat generation when exposed to ripple current. When the temperature of the element rises, a reaction current flows inside the EDLC, generating reaction products and raising internal resistance even further. This makes it difficult to maintain capacitance. Set the allowable limit for the ripple current-induced rise in capacitor temperature to 3°C measured at the surface of the capacitor.

j) Connecting Capacitors in Series

Taking into consideration the possibility of an imbalance in the voltages across the capacitors, make sure that the voltage applied to each capacitor will not exceed the Maximum operating voltage. If the voltage balance breaks down, an over voltage condition could result. To prevent this from occurring, add a voltage dividing resistor in parallel with each capacitor, allowing for the capacitor's leakage current.

Always consider safety when designing equipment and circuits. Plan for worst case failure modes such as short circuits and open circuits which could occur during use.

- 1) Provide protection circuits and protection devices to allow safe failure modes.
- 2) Design redundant or secondary circuits where possible to assure continued operation in case of main circuit failure.

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2. Mounting Considerations

a) Heat Stress During Soldering

Excessive heat stress may result in the deterioration of the electrical characteristics of the capacitor, loss of air-tightness, and electrolyte leakage due to the rise in internal pressure.

- 1) EDLC is tinned with 1.5 mm of capacitor body. Do not scratch lead terminals. Removal of tin coating on lead terminals may lead to poor solderability.
- 2) EDLC may be soldered or wave soldered. Do not overheat when soldering. Temperature low then 260°C for 5 seconds or less and under 350°C. Solder the capacitor 3 times or less at intervals of 15 seconds or more.
- 3) Never perform reflow soldering on EDLC using infrared heating or atmospheric heating methods.
- 4) Do not apply excessive force to lead terminals. Do not pull or twist terminals. If deforming of lead terminals is necessary, please use a plier to bend the terminals while support the base of the terminals.
- 5) Do not drop EDLC on hard surface and avoid tearing of sleeve label.
- 6) Do not deform or compress EDLC.
- 7) Please request supplemental information related to mounting instructions if necessary.

b) Circuit Board Patterns Under the Capacitor

Avoid circuit board runs under the capacitor as electrolyte leakage could cause an electrical short.

c) Elevate the EDLC Above the PCB For Mounting

If the capacitor is soldered directly to a double-sided PCB, a short circuit may occur between the capacitor body and the wiring pattern. In the case of a through hole board, flux or solder blowing out of the holes can shrink or break the external sleeve and possibly cause internal damage to the capacitor.

d) Circuit Board Cleaning

Circuit boards can be immersed or ultrasonically cleaned using suitable cleaning solvents for up to 5 minutes and up to 60°C maximum temperatures. The boards should be thoroughly rinsed and dried. [Recommended cleaning solvent include] Pine Alpha ST-100S, Sunelec B-12, DK be clear CW-5790, Aqua Cleaner 210SEP, Cold Cleaner P3-375, Telpen Cleaner EC-7R, Clean-thru 750H, Clean-thru 750L, Clean-thru 710M, Techno Cleaner 219, Techno Care FRW-17, Techno Care FRW-1, Techno Care FRV-1, IPA (isopropyl alcohol)] Consult with us if you are using a solvent other than any of those listed above.] The use of ozone depleting cleaning agents are not recommended in the interest of protecting the environment.

3. Precautions for using capacitors

- a) Do not operate EDLC outside the recommended limits.
- b) Do not disassemble EDLC. Electrolyte maybe harmful if come in contact with skin and eyes.
- c) Seek medical attention immediately if EDLC is accidentally ingested or swallowed.
- d) Keep your face and hands away from EDLC. When the temperature of EDLC exceeds recommended limit, EDLC might burst or bum.
- e) Disconnect EDLC immediately when capacitor body is swollen, or gaseous vapor is detected.
- f) Do not combine new and old EDLC. Do not mix and match different types of EDLC.
- g) Do not use EDLC in life support equipments.

4. Emergency Procedures

If the capacitor overheats or starts to smell, immediately switch off the unit's main power supply to stop operation. Keep your face and hands away from the capacitor, since the temperature may be high enough to cause the capacitor to ignite and burn.

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5. Long Term Storage

- a) Store EDLC at a temperature between 20°C-30°C with a relative humidity less than 60%.
- b) Avoid storing EDLC under any of the following conditions:
 - 1) High temperature and high humidity environment
 - 2) Direct contact with water, salt water or oil
 - 3) In acid or alkaline environment
 - 4) In contact with the chemically active gas
 - 5) Exposed to direct sunlight

6. Capacitor Disposal

When disposing of capacitors, follow the instructions below:

- a) Crush or make a hole in the capacitor before burning. If the capacitor is burned "as is," it can explode. If taking apart the capacitor before disposal, wear protective gear such as gloves and goggles.
- b) Because of the capacitor's plastic (polyvinyl chloride) sleeve, burn at high temperature. Low temperature burning will result in the production of toxic gases such as chlorine.
- c) If you choose not to burn used capacitors, consign them to a specialized industrial waste processor for disposal.

The application guidelines above are taken from: Technical Report EIAJ RCR-2370 issued by the Japan Electronic Industry Association, Inc. Guideline of notabilia for fixed electric double layer capacitors with non-solid electrolyte for use in electronic equipment. Refer to this Technical Report for additional details.

■ Precautions for Your Safety

The Electric Double Layers capacitors contain flammable organic solvents. For your safety, please follow following prohibitions.

1. Warning!

a) Do not charge by high current or high voltage.

Doing so may generate gas inside the capacitor, resulting swelling, catching fire, heat generation or bursting.

b) Do not reverse placement of (+) and (-)

The capacitors have polarity. If the (+) and (-) side of the capacitor is reverse inserted, it may cause a short-circuiting or over discharge of the capacitor on some equipment and it may induce overheating, explosion or fire.

c) Do not solder directly to the capacitor

If soldering is performed directly to the capacitor, the capacitor is heated up, consequently cause leakage, explosion or fire due to overheating from internal short-circuiting.

d) Keep capacitors out of children's reach.

If leaked liquid is ingested or a capacitor is swallowed, consult a physician immediately.

e) Do not heat, disassemble nor dispose of in fire

Doing so damages the insulation materials and may cause catching fire, heat generation, leakage or bursting.

f) Do not discharge by force

If the capacitor is discharged by direct connection to an external power supply etc., voltage of the capacitor will decline lower than 0 volts (electrical reversal) and will cause the capacitor case to expand, overheat, leak, explode or burn.

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g) In case of leakage or a strange-smell, keep away from fire to prevent ignition of any leaked electrolyte.

2. CAUTION!

a) If leaked liquid gets in the eyes, wash them with clean water and consult a physician immediately.

b) Do not use nor leave the capacitors in direct sunlight nor in high-temperature areas.

It may cause catching fire, heat generation, leakage or bursting.

c) Do not use new and used capacitors together. Do not use different types of capacitors together.

It may cause catching fire, heat generation, leakage or bursting.

d) If you connect two or more capacitors in series or parallel, please consult us in advance.

It may cause bursting or catching fire due unbalanced load or voltage.

e) Keep capacitors away from direct sunlight, high temperature and humidity.

It may cause heat generation or performance deterioration.

