1. Application

This product specification describes the performance indicators of super capacitor DPTC Series

2. Part Number System

CEE 155 B 0X H TM 2 1721 RR --

- -- Suffix(2.10)
- RR Packaging (2.9)
- 1721 Case Length (2.8)
- 2 Diameter (2.7)
- TM Series (2.6)
- H Environmental requirements（2.5）
- 0X Voltage (2.3)
- B Tolerance (2.4)
- 155 Capacitance (2.2)
- CEE Product Type(2.1)

2.1 Product Type

Code	CEE
Product Type	EDLC

2.2 Capacitance code

Code	104	155	106	107
Capacitance (F)	0.1	1.5	10	100

2.3 Rated voltage code

Code	05	0X
Voltage (WV)	5.5	6.0

2.4 Capacitance tolerance

Code	M	B	Z
Tolerance Range	±20%	-10% ~ +30%	-20%~+80%

2.5 Environmental requirements

Code	R	H
Environmental requirements	ROHS Requirements	ROHS Requirements and Halogen Free

2.6 Products Series Code

Code	TM
Series	UPTM

2.7 **Diameter**

Code	2	3	E	F	G	I	J	K	L	M
Diameter	8.5	10.5	6.3	8	10	12.5	13	16	18	20

2.8 **Wide & Long**

（1）When the code is number, it represent the actual height.(e.g. The code 07 indicates that the height is 7mm; The code 10 indicates that the height is 10mm)

Code	1217	1717
Wide & Long (mm)	1217	1717

（2）When the code is number + alphabet, please check the following the table:

Code	1N21	1D1F	1A1B	1D2A	2E3A
Wide & Long (mm)	10.521	14.516.5	11.512.5	14.521.5	25.531.5

2.9 **Packaging**

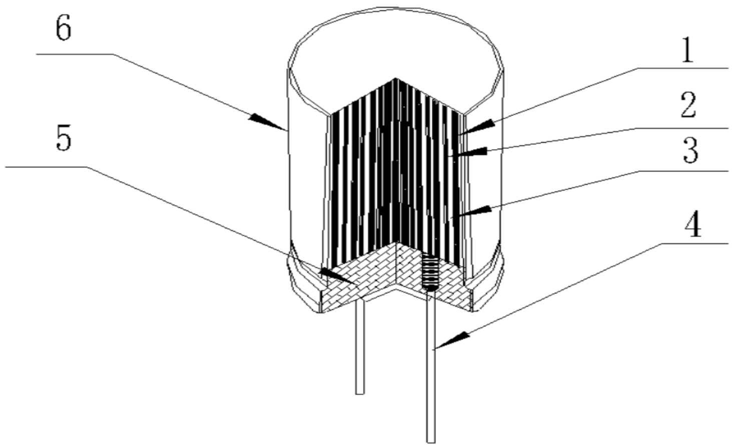
Code	RR	CA	CB	CC	CD
Packaging	Bulk	Cutting the feet long=3.0mm	Cutting the feet long=3.5mm	Cutting the feet long=4.0mm	Cutting the feet long=4.5mm

Note: The length of the product's cut feet starts from A=3.0mm. Every time it increases by 0.5mm, the English word is pushed forward one place, as shown in the following table:

Cutting length(mm)	Code
3.0±0.5	CA
3.5±0.5	CB
4.0±0.5	CC
4.5±0.5	CD
5.0±0.5	CE
6.0±0.5	CG
And so on--------	

2.10 **Suffix: Inner Code**

3.Product Structure Diagram



No	Component	Material
1	Al-Foil (+)	High pure aluminum carbon foils
2	Al-Foil (-)	High pure aluminum carbon foils
3	Separator	Cellulose fibre/acrylic fiber
4	Lead line	High pure aluminum,lead is tin copper clad steel wire
5	Sealing	Rubber
6	Case	High purity aluminum

4. Characteristics

Standard atmospheric conditions

Unless otherwise specified, the standard range of atmospheric conditions for making measurements and tests is as follows:

Ambient temperature	:5°C to 35°C
Relative humidity	: < 85%
Air Pressure	: 86kPa to 106kPa

If there is any doubt about the results, measurement shall be made within the following conditions:

Ambient temperature	: 25°C ± 2°C
Relative humidity	: 25% to 75%
Air Pressure	: 86kPa to 106kPa

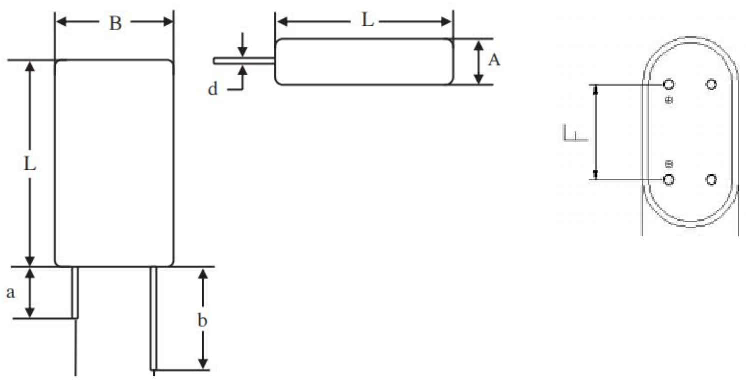
Operating temperature range

The ambient temperature range at which the capacitor can be operated continuously at rated voltage is (5.5WV) -40°C to 65°C.

As to the detailed information, please refer to table 1 and table 2.

4.1 Dimensions

Unit:mm



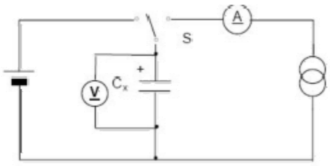
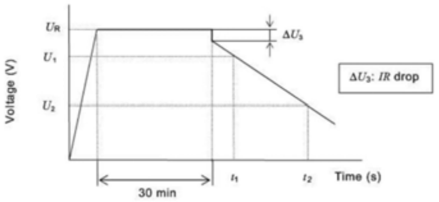
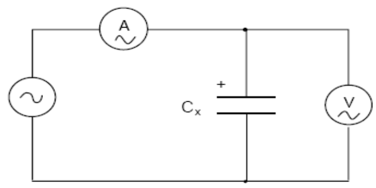
Size Code	A±1	B±1	L±1	d±0.05	a Min	b Min	F±0.5
21721	8. 5	17	21	0.60	15.0	19.0	8. 5

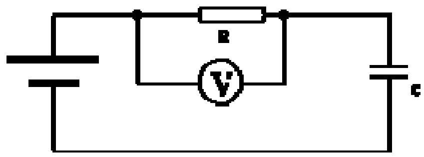
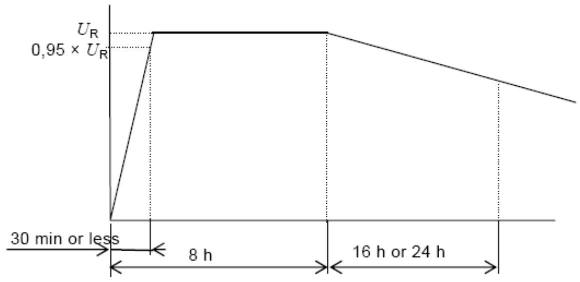
4.2 CEE155B0XHTM21721RR Specifications(table 1)

Refer to IEC 62391-1, GB/T34870.1 -- 2017 test standards

No.	Characteristics	Spec	Unit	Description
(1)	Temperature range	-40 to65	℃	
(2)	Capacitance	1.5	F	Product nominal capacity, test frequency: 120Hz, within the specified capacity tolerance 25℃ ΔV=2.16-1.08 I=50mA
(3)	Capacitance Tolerance	-10~+30 etc.	%	/
(4)	Working voltage	6.0	V	Rated working voltage at 25°C
(5)	Surge Voltage	6.9	V	/
(6)	ESR Max AC	160	mΩ	Equivalent series resistance, test frequency 1kHz
(7)	ESR Max DC	320	mΩ	
(8)	Nominal Current	0.75	A	Charge to rated voltage U_0, 5S discharge to $1/2U_0$, at 25℃
(9)	Leakage Current	10	μA	at 72h at 25℃
(10)	Self Discharge Characteristics	The voltage between the positive and negative electrode ⩾ 4.2V		Charging process: normal temperature,non-loaded,charge at rated voltage for 8h Lay aside process:temperature less than 25°C,relative humidity less than 60%RH,lay aside 24h at open circuit

Table 2

Item		PERFORMANCE
4.3	Nominal capacitance (Tolerance)	**<Condition>** Constant Current Discharge of Measure 1.Set the DC voltage source to the rated voltage (U_R). 2.Sets constant current values of a specified constant current discharge device. 3.Switch the switch S to DC power supply , constant voltage charge for 30min after the voltage reachs to rated voltage. 4.After charging 30min , transform the switch S to constant current discharge devicethe to discharge at constant current. 5. Measure the discharge time from U_1 to U_2 (t_1 、 t_2), Calculate capacitance using the following formula:   $C = \frac{I \times (t_2 - t_1)}{U_1 - U_2}$ **<Criteria>** Shall be within the specified capacitance tolerance.
4.4	Internal Resistance	**<Condition>** After 2 minutes applications of rated working voltage at 20˚C Equivalent series resistance: ESR shall be measured from the circuit below： ESR Ra can be calculated from the formul: $R_a = \frac{U}{I}$ Equivalent series resistance (mΩ/Ω) ； U_{Ac} voltage valid values (V r.m.s) ； I_{Ac} current valid values（V r.m.s）。  **<Criteria>** Refer to Table 3.

4.5	Leakage Current	Leakage Current shall be measured from the circuit below: 1.Discharge：Before the start of the measurement, supercapacitor should be fully discharge, discharge process for 1 h to 24 h. 2.Leakage current measurement shall be carried out under the rated temperature and voltage rating(U_R).The voltage of product reached 95% rated voltage after the biggest charging time for 30min，Charging time chooses from 30min(≤1F)，1h(≥1F)，2h(≥10F)，4h(≥20F)，72h(≥120F). 3.Should use a stable power supply, such as DC regulated power supply. 4.Charge process should be through the protection under 1000Ω resistance.  **<Criteria>** Refer to Table 3.
4.6	Self discharge	Before the start of the measurement ,super capacitor should be fully discharge, discharge process for 1 h to 24 h.Charge the super capacitor to rated voltage without protection resistance,charging time for 8h(include the voltage of product reached 95% rated voltage after the biggest charging time for 30min).Disconnect the super capacitor from the power supply.Super capacitor should be placed in the standard atmospheric pressure conditions for 24 h. Dc voltmeter internal resistance should be greater than 1 mΩ. 

4.7 Temperature characteristic

<Condition>

Step	Testing Temperature (℃)	Time	Test project
1	20±2	Time to reach thermal equilibrium	Cap.\ESR
2	-40±2	2H	Cap.\ESR

Step	Testing Temperature (℃)	Time	Test project
1	20±2	Time to reach thermal equilibrium	Cap.\ESR
2	70±2	16H	Cap.\ESR

<Criteria>

The characteristic shall meet the following requirements:

At -40℃ Compared with the initial value	Capacitance Change	Within ±30% of initial value.
	Internal Resistance	≤4 times of initial specified value
At 70℃ Compared with the initial value	Capacitance Change	Within ±30% of initial value.
	Internal Resistance	≤ Initial specified value

4.8 Load Life test

<Condition>

The capacitor shall be subjected to 1000 hours application of rated voltage at +70˚C, Then the product should be tested after 16 hours recovering time at atmospheric conditions. The result should meet the following table:

<Criteria>

The characteristic shall meet the following requirements:

Capacitance Change	Within ±30% of initial value.
Internal Resistance	≤4 times of initial specified value
Appearance	There shall be no leaked electrolyte or other mechanical damage

4.9 Shelf Life test

<Condition>

The capacitor shall be stored at +70˚C temperature specified below for 1000 hours. During which time no voltage shall be applied. Then the product should be tested after 16 hours recovering time at atmospheric conditions. The result should meet the following table:

<Criteria>

The characteristic shall meet the following requirements:

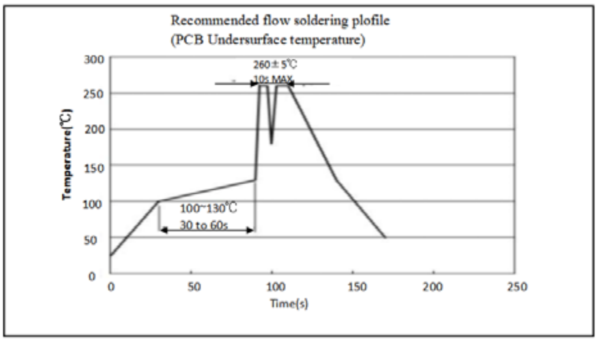
Capacitance Change	Within ±20% of initial value.
Internal Resistance	≤3 times of initial specified value
Appearance	There shall be no leaked electrolyte or other mechanical damage

<table>
<tr><td>4.10</td><td>Damp heat test</td><td>
<Condition>
The capacitor shall be stored at a temperature of 40±2℃ and relative huidity of 90 to 95% for 240±8hours。And then the capacitor shall be subjected to standard atmospheric conditions for 1 to 2hours, after which measurements shall be made.

<Criteria>
<table>
<tr><td>Capacitance Change</td><td>Within ±30% of initial value.</td></tr>
<tr><td>Internal Resistance</td><td>≤2 times of initial specified value</td></tr>
<tr><td>Appearance</td><td>There shall be no leaked electrolyte or other mechanical damage</td></tr>
</table>
</td></tr>
<tr><td>4.11</td><td>Cyclic life</td><td>
<Condition>
The capacitor shall be cycles between specified voltage and half rated voltage under constant current at +25˚C (500,000 cycles)And then the capacitor shall be subjected to standard atmospheric conditions for 6 to 8 hours, after which measurements shall be made:

<Criteria>
<table>
<tr><td>Capacitance Change</td><td>Within ±30% of initial value.</td></tr>
<tr><td>Internal Resistance</td><td>≤4 times of initial specified value</td></tr>
<tr><td>Appearance</td><td>There shall be no leaked electrolyte or other mechanical damage</td></tr>
</table>
</td></tr>
</table>

<table>
<tr>
<td>4.12</td>
<td>Welding condition</td>
<td>
The recommendation soldering conditions of the product in which flow soldering is possible are as graph

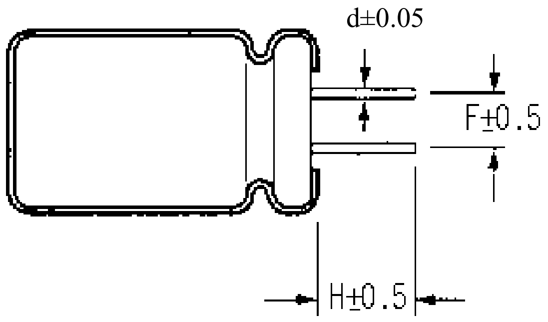


Pay attention when welding：

(1) Do not dip the capacitor into melted solder；
(2) Do not touch other part except the terminals；
(3) If there is a direct contact between the sleeve of the capacitor and the printed circuit pattern or a metal part of another component such as a lead wire, it may cause shrinkage of crack；
(4) If the application is for extended use, understand and manage the soldering characteristics firstly to avoid abnormal current caused by a contact failure between the capacitor and the PCB；
(5) Please refer to product specifications about other notes.
</td>
</tr>
</table>

5. Forming Dimension

Cutting Type



Unit: mm

Shape Code	ΦD	Φ5	Φ6.3	Φ8	Φ10~Φ13	Φ16~Φ18
CB Cutting-3.5mm	F	2.0	2.5	3.5	5.0	7.5
	H	3.5	3.5	3.5	3.5	3.5
	d	0.5	0.5	0.5	0.6	0.8

Shape Code	ΦD	Φ5	Φ6.3	Φ8	Φ10~Φ13	Φ16~Φ18
CC Cutting-4.0mm	F	2.0	2.5	3.5	5.0	7.5
	H	4.0	4.0	4.0	4.0	4.0
	d	0.5	0.5	0.5	0.6	0.8

Shape Code	ΦD	Φ5	Φ6.3	Φ8	Φ10~Φ13	Φ16~Φ18
CD Cutting-4.5mm	F	2.0	2.5	3.5	5.0	7.5
	H	4.5	4.5	4.5	4.5	4.5
	d	0.5	0.5	0.5	0.6	0.8

Shape Code	ΦD	Φ5	Φ6.3	Φ8	Φ10~Φ13	Φ16~Φ18
CE Cutting-5.0mm	F	2.0	2.5	3.5	5.0	7.5
	H	5.0	5.0	5.0	5.0	5.0
	d	0.5	0.5	0.5	0.6	0.8

Application Guidelines

1.Life Time

EDLC has a longer life time than secondary batteries, but their life time is not infinite. The basic end-of life failure mode for an EDLC is an increase in equivalent series resistance (ESR) and/or a decrease in capacitance. The actual end-of-life criteria are dependent on the application requirements. Prolonged exposure to elevated temperatures, high applied voltage and excessive current will lead to increased ESR and decreased capacitance. Reducing these parameters will lengthen the life time of a supercapacitor. In general, cylindrical EDLC have a similar construction to electrolytic capacitors, they have a liquid electrolyte inside an aluminum can sealed with a rubber bung. Over many years, the EDLC will dry out, similar to an electrolytic capacitor, causing an increase in ESR and eventually end-of-life.

2.Voltage

EDLC are rated with a nominal recommended working or applied voltage. The values provided are set for long life at their maximum rated temperature. If the applied voltage exceeds the recommended voltage, the life time will be reduced. If the applied voltage is excessive for a prolonged time period, gas generation will occur inside the EDLC and may result in leakage or rupture of the safety vent. However, short-term over voltage can usually be tolerated by the EDLC.

3.Polarity

EDLC are designed with symmetrical electrodes, meaning they are similar in composition. When an EDLC is first assembled, either electrode can be designated positive or negative. Once the EDLC is charged for the first time during the 100% QA testing operation, the electrodes become polarized. Every EDLC has a negative stripe or sign denoting polarity. Although they can be shorted to zero volts, the electrodes maintain a very small amount of charge. Reversing polarity is not recommended, however previously charged EDLC have been discharged to –2.5V with no measurable difference in capacitance or ESR.

Note: The longer they are held charged in one direction, the more polarized they become. If reversely charged after prolonged charging in one direction, the life of the EDLC may be shortened.

4. Ambient Temperature

Temperature in combination with voltage can affect the life time of an EDLC. In general, raising the ambient temperature by 10˚C will decrease the life time of an EDLC by a factor of two. As a result, it is recommended to use the EDLC at the lowest temperature possible to decrease internal degradation and ESR increase.
At temperature lower than normal room temperature, it is possible to apply voltages slightly higher than the recommended working voltage without significant increase in degradation and reduction in life time. Raising the applied voltage at low temperatures can be useful to offset the increased ESR. Increased ESR at higher temperatures will result in permanent degradation/electrolyte decomposition inside the EDLC. At low temperatures, however, increased ESR is only a temporary phenomenon due to the increased viscosity of the electrolyte and slower movement of the ions.

5.Discharge Characteristics

EDLC discharges with a sloping voltage curve. When determining the capacitance and ESR requirements for an application, it is important to consider both the resistive and capacitive discharge components. In high current pulse applications, the resistive component is the most critical. In low current and long duration applications, the capacitive discharge component is the most critical.

The formula for the voltage drop, Vdrop, during a discharge at I current for t seconds is:

Vdrop = I (R+t/C)

To minimize voltage drop in a pulse application, use an EDLC with low ESR (R value).

To minimize voltage drop in a low current application, use an EDLC with large capacitance (C value).

6.Charge Methods

EDLC can be charged using various methods including constant current, constant power, constant voltage or by paralleling to an energy source, i.e. battery, fuel cell, DC converter, etc. If an EDLC is configured in parallel with a battery, adding a low value resistor in series will increase the life of the battery. If a series resistor is used, ensure that the voltage outputs of the EDLC are connected directly to the application and not through the resistor; otherwise the low ESR of the EDLC will be nullified. Many battery systems exhibit decreased life time when exposed to high current discharge pulses.

The maximum recommended charge current I, for an EDLC where Vw is the charge voltage and R is the EDLC ESR is calculated as below:

I = Vw/5R

Overheating of the EDLC can occur from continuous overcurrent or overvoltage charging. Overheating can lead to increased ESR, gas generation, decreased life time, leakage, venting or rupture. Contact the factory if you plan to use a charge current or voltage higher than specified.

7.Self Discharge and Leakage Current

Self discharge and leakage current are essentially the same thing measured in different ways. Due to the EDLC construction, there is a high-resistance internal current path from the anode to the cathode. This means that in order to maintain the charge on the capacitor a small amount of additional current is required. During charging this is referred to as leakage current. When the charging voltage is removed, and the capacitor is not loaded, this additional current will urge the EDLC to discharge and is referred to as the self discharge current.

In order to get a realistic measurement of leakage or self discharge current the EDLC must be charged for an excess of 100 hours. This is also due to the capacitor construction. The EDLC can be modeled as several capacitors connected in parallel, each with an increasing value of series resistance. The capacitors with low values of series resistance are charged quickly thus increasing the terminal voltage to the same level as the charge voltage. However, if the charge voltage is removed these capacitors will discharge into the parallel capacitors with higher series resistance if they are not fully charged. The result of this is that the terminal voltage will fall, giving the impression of high self discharge current. It should be noted that the higher the capacitance value is, the longer it will take for the device to be fully charged.

8. Series Configurations of EDLC

As many applications require higher voltages, EDLC can be configured in series to increase the working voltage. It is important to ensure that the individual voltage of any single EDLC does not exceed its maximum recommended working voltage as this will result in electrolyte decomposition, gas generation, increased ESR and reduced life time.

Vcap2 = Vsupply x (Ccap1/(Ccap1+Ccap2))

Vcap2 = 5V x (1.2/(1.2+0.8)) = 3V

Capacitor voltage imbalance is caused, during charge and discharge, by differences in capacitance value and, in steady state, by differences in capacitor leakage current. During charging, series connected capacitors will act as a voltage divider so higher capacitance devices will receive greater voltage stress. For example, if two 1F capacitors are connected in series, one at +20% of nominal capacitance, the other at –20%, the worst-case voltage across the capacitors is given by:

Vcap2 = Vsupply x (Ccap1/(Ccap1+Ccap2))

where Ccap1 has the +20% capacitance.

So for a Vsupply = 5V,

Vcap2 = 5V x (1.2/(1.2+0.8)) = 3V

From above, it can be seen that in order to avoid exceeding the EDLC surge voltage rating of 3V , the capacitance values of series connected parts must fall in a ±20% tolerance range. Alternatively a suitable active voltage balancing circuit can be employed to reduce voltage imbalance due to capacitance mismatch. It should be noted that the most appropriate method of voltage balancing depends on the specific application.

9. Passive Voltage Balancing

Passive voltage balancing uses voltage-dividing resistors in parallel with each EDLC. This allows current to flow from the EDLC at a higher voltage level into the EDLC at a lower voltage level, thus balancing the voltage. It is important to choose balancing resistors values that provide for higher current flow than the anticipated leakage current of the EDLC, bearing in mind that the leakage current will increase at higher temperatures. Passive voltage balancing is only recommended for applications that don't regularly charge and discharge the EDLC and that can tolerate the additional load current of the balancing resistors. It is suggested that the balancing resistors be selected to give additional current flow of at least 50 times the worst-case EDLC leakage current (3.3kΩ to 22kΩ depending on maximum operating temperature). Although higher values of balancing resistors will work in most cases they are unlikely to provide adequate protection when significantly mismatched parts are connected in series.

10. Active Voltage Balancing

Active voltage balancing circuits force the voltage at the nodes of series connected EDLC to be the same as a fixed reference voltage, regardless of how many voltage imbalances occur. To ensure accurate voltage balancing, active circuits typically draw much lower levels of current in steady state and only require larger currents when the capacitor voltage goes out of balance. These characteristics make active voltage balancing circuits ideal for applications that charge and discharge the EDLC frequently as well as those with a finite energy source such as a battery.

11. Reverse Voltage Protection

When series connected EDLC are rapidly discharged, the voltage on low capacitance value parts can potentially become negative. As explained previously, this is not desirable and can reduce the operating life of the EDLC. One simple way of protecting reverse voltage is to add a diode across the capacitor, configured so that it is normally reverse bias. By using a suitably rated zener diode in place of a standard diode the EDLC can also be protected against overvoltage events. Care must be taken to ensure that the diode can withstand the available peak current from the power source.

12. Soldering Information

Excessive heat may cause deterioration of the electrical characteristics of the EDLC, electrolyte leakage or an increase in internal pressure. Follow the specific instructions listed as below:

• Do not dip EDLC body into melted solder.
• Only flux the leads of the EDLC.
• Ensure that there is no direct contact between the sleeve of the EDLC and the PC board or any other component. Excessive solder temperature may cause sleeve to shrink or crack.
• Avoid exposed circuit board runs under the EDLC to prevent electrical shorts.

13. Manual Soldering

Do not touch the EDLC's external sleeve with the soldering rod, or the sleeve will melt or crack. The recommended temperature of the soldering rod tip is less than 350˚C and the soldering duration should be less than 4 seconds. Minimize the time that the soldering iron is in direct contact with the terminals of the EDLC, as excessive heating of the leads may lead to higher equivalent series resistance (ESR).

14. Wave Soldering

Use a maximum preheating time of 60 seconds for PC boards 0.8mm or thicker. Preheating temperature should be limited to less than 100˚C.

Use the following table for wave soldering on leads only:

焊锡温度 (˚C) Solder Bath Temperature (˚C)	建议焊锡时间 (秒) Recommended Solder Exposure (seconds)	最大焊接时间 (秒) Maximum Solder Exposure (seconds)
220	7	9
240	7	9
250	5	7
260	3	5

15. Ripple Current

EDLC have a very low resistance compared to other supercapacitors but have a higher resistance than aluminum electrolytic capacitors. EDLC are more susceptible to internal heat generation when exposed to ripple current. In order to ensure long life time, the maximum ripple current recommended should not increase the surface temperature of the EDLC by more than 3˚C, as heat generation leads to electrolyte decomposition, gas generation, increased ESR and reduced life time.

16. Circuit Board Design

Cleaning of the circuit board should be avoided. If the circuit board must be cleaned use static or ultrasonic immersion in a standard circuit board cleaning fluid for no more than 5 minutes and a maximum temperature of +60˚C. Afterwards thoroughly rinse and dry the circuit boards. In general, treat EDLC in the same manner you would an aluminum electrolytic capacitor.

17. Long Term Storage

Do not store EDLC in any of the following environments:

• High temperature and/or high humidity
• Direct contact with water, salt water, oil or other chemicals
• Direct contact with corrosive materials, acids, alkalis or toxic gases
• Direct exposure to sunlight
• Dusty environment
• Environment subject to excessive shock and/or vibration

18. Emergency Procedures

If an EDLC is found to be overheating or if you smell a sweet odor, immediately disconnect any power or load to the EDLC. Allow the EDLC to cool down, then dispose it properly. Do not expose your face or hands to an overheating EDLC. Contact the factory for a Material Safety Data Sheet if an EDLC leaks or vents.

If exposed to electrolyte:

Skin Contact: Wash exposed area thoroughly with soap and water.

Eye Contact: Rinse eyes with water for 15 minutes and seek medical attention.

Ingestion: Drink milk/water and induce vomiting; seek medical attention.

19. General Safety Considerations

EDLC may vent or rupture if overcharged, reverse charged, incinerated or heated above 150˚C. Do not crush, mutilate, nail penetrate or disassemble. High case temperature (burn hazard) may result from abuse of EDLC.

Disposal Procedures:

Do not dispose of unit in trash. Dispose of according to local regulations.

20. Thermal Performance

Low internal resistance of the energy storage units enables low heat generation within the units during use. As with any electronic components, the cooler the operating environment the longer the service life. In most applications, natural air convection should provide adequate cooling. In severe application requiring maximum service life some forced airflow may be required.

The thermal resistance, Rth of the units have been experimentally determined assuming free convection at ambient temperature (–25˚C). The Rth value provided on the data sheet is useful for determining the operating limits for the units. Using the Rth value, a module temperature rise can be determined based upon any current and duty cycle.

The temperature rise can be expressed by the following equation:

$\Delta T = Dc \cdot Rth \cdot I2 \cdot Resr$

where Dc = Duty Cycle

Rth = Thermal Resistance (˚C/W)

I = Current AC or DC (A)

Resr = Equivalent Series Resistance, (Ohms) (dc value used)

This temperature rise, ΔT, plus ambient temperature should remain below the specified maximum operating temperature for the EDLC. If forced cooling methods are employed, it is possible to operate the units at higher currents or duty cycles.

21. Features

- Can be used as a rechargeable battery and ideal for back up purposes.
- Capable of several hundreds of thousands of charge/discharge cycles; free from throwaway disposal.
- Does not contain toxic materials such as nickel and cadmium.