

BIGCAP[®]

supercapacitor

Liaoning Brother Electronic Technology Co.,Ltd

BIGCAP[®] Datasheet

Product Type: 扣式系列 (Coin Type)

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编制 Prepared	审核 Checked	批准 Approved
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■ 适用范围 Scope

本产品规格书对产品性能，测试方法进行了规范，作为技术确认的依据。

This product specification specifies the product performance and test methods as the basis for technical confirmation.

■ 标准测试条件 Standard Test Conditions

一般情况下，在标准大气压下，温度 15~35℃，湿度 ≤85%RH，大气压 86Kpa~106Kpa 条件下进行测试。

In General, the features of EDLC should be tested under room temperature 15~35 °C , humidity ≤ 85%RH and atmospheric pressure 86Kpa~106Kpa.

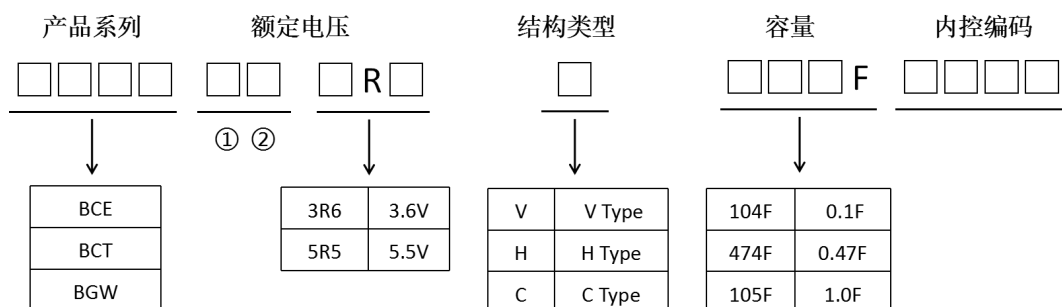
如对结果有疑问时，应按照温度为 25±2℃，湿度 60~70%RH，标准大气压 86Kpa~106Kpa 条件测量。

If there is any doubt about the results, please test the samples under temperature 25 ± 2 °C , humidity 60~70%RH, atmospheric pressure 86Kpa~106Kpa.

■ 产品依据标准 Product Standard

- IEC 62391-1-2015 《电子设备用固定双电层电容器 第一部分通用规范》
IEC 62391-1-2015 《Fixed electric double-layer capacitors for use in electronic equipment-Part 1 Generic specification》
- DL/T1652-2016 《电能计量设备用超级电容器技术规范》
DL/T1652-2016 《Technical specifications of supercapacitors use in electric energy metering device》
- QC/T741-2015 《车用超级电容器》
QC/T741-2015 《Ultra-capacitor for electric vehicles》
- GB/34870.1-2017 《超级电容器 第一部分：总则》
GB/34870.1-2017 《Super capacitors-Part 1:General》

■ 型号命名规则 Product Code System

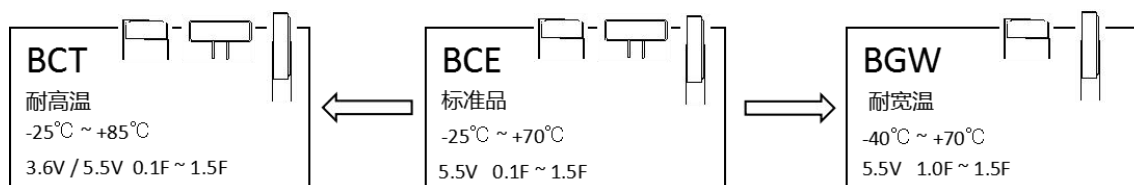


注：1、额定电压中①和②为占位用，均用“0”表示，可同时存在，也可忽略一位或者都忽略；

2、表示容量的代码由三个数字组成，第一个和第二个数字表示容量的有效数字，单位为微法拉（μF），

第三个数字代表有效数字后面的零的个数。1F=10⁶μF。例：474F：47×10⁴μF×10⁻⁶=0.47F；

■ 产品系列图 Series diagram of products



■ 产品一览图 Overview of products

系列 series	特性 features	温度范围 temperature range	容量范围 Capacitance Range	产品示意图片 Product diagram
BCE	标准品 Standard product	$-25^{\circ}\text{C} \sim +70^{\circ}\text{C}$	0.1F ~ 1.5F	
BCT	耐高温 High temperature resistance	$-25^{\circ}\text{C} \sim +85^{\circ}\text{C}$	0.1F ~ 1.5F	
BGW	耐宽温 Wide temperature	$-40^{\circ}\text{C} \sim +70^{\circ}\text{C}$	1.0F ~ 1.5F	

➤ BCE 系列 BCE Series

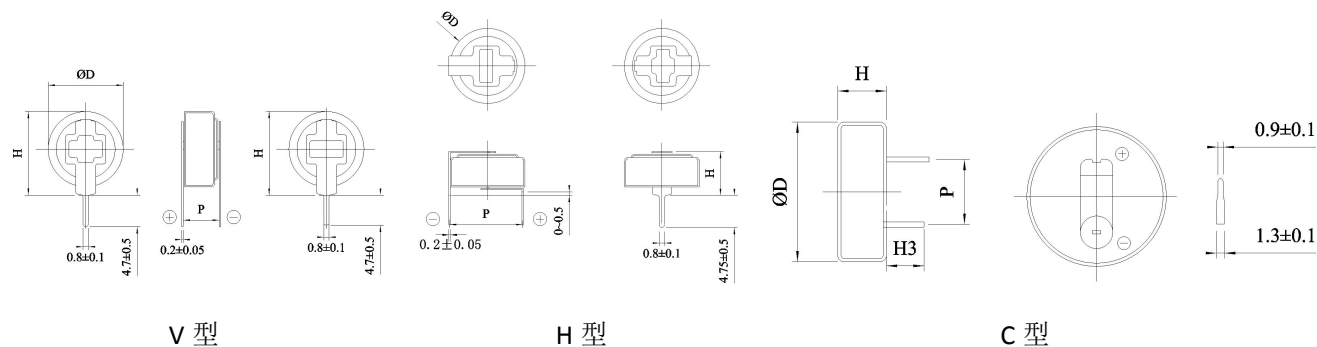
1. 产品特点 Features

- 环形设计, 产品结构稳定, 性能更加可靠;
Circular design, product structure is stable, performance more reliable;
- 符合 ROHS 标准, 无 Cd、Pb 等污染物质;
Comply with ROHS standards, no Cd, Pb and other pollutants;
- 充放电循环寿命长;
Long charge-discharge cycle life;
- 漏电流低, 适合时钟芯片数据保持。
Low leakage current, suitable for keeping the clock chip data.

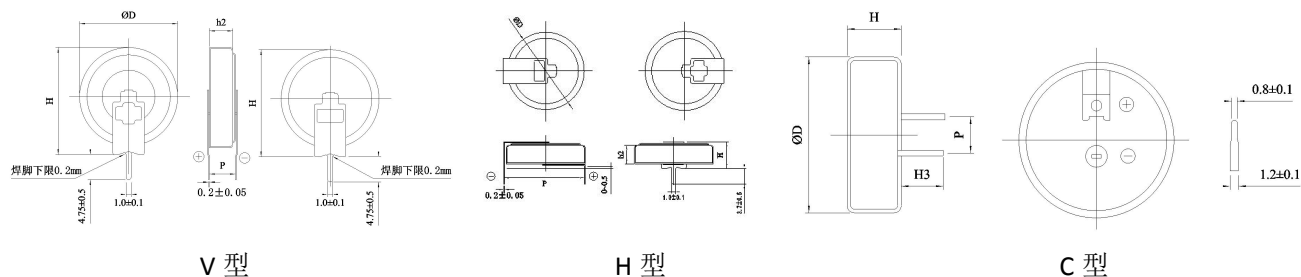
2. 主要技术参数 Main Technical Parameters

项目	特性	
额定工作电压 Rated Operating Voltage	5.5VDC	
工作温度范围 Operating Temperature Range	-25℃~+70℃	
容量范围 Rated Capacitance Range	0.1F~1.5F	
容量允许偏差 Permitting Capacitance Tolerance	-20%~+20%, -20%~+80%, -20%~+100%	
温度特性 Temperature Characteristics	-25℃	$ \Delta C/C \leq 50\%$, $ESR \leq 4$ 倍初始值
	+70℃	$ \Delta C/C \leq 30\%$, $ESR \leq$ 初始值
	-40℃ (I=1mA)	$ \Delta C/C \leq 50\%$, $ESR \leq 7$ 倍初始值
湿热特性 Humidity Characteristics	40℃, 90~95RH, 240h	$ \Delta C/C \leq 30\%$, $ESR \leq 2$ 倍初始值
高温寿命 High Temperature Life	5.0V, 70℃, 1000h	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
循环寿命 Cycle Life	5.5V, 25℃, 500000 次	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
自放电特性 Self Discharge Characteristics	无负载, 额定电压充电 8h, 开路放置 24h non-loaded, charge at rated voltage for 8h, lay aside 24h at open circuit	正负极间电压大于等于 4.2V The voltage between the positive and negative electrode $\geq 4.2V$

3. 产品结构和规格 Product Construction And Specification



型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance, F	最大内阻 ESR(Max), Ω		尺寸 Size, mm		
			AC@1kHz	DC	ΦD±1.0	H±1.0	P±0.5
BCE005R5C104FS	5.5	0.1	40	60	13.5	7.3	5
BCE005R5H104FS	5.5	0.1	40	60	11.5	6.0	10
BCE005R5V104FS	5.5	0.1	40	60	11.5	12.5	5
BCE005R5C224FS	5.5	0.22	40	60	13.5	7.3	5
BCE005R5H224FS	5.5	0.22	40	60	11.5	6.0	10
BCE005R5V224FS	5.5	0.22	40	60	11.5	12.5	5
BCE005R5C334FAS	5.5	0.33	50	75	13.5	7.3	5
BCE005R5H334FAS	5.5	0.33	50	75	11.5	6.0	10
BCE005R5V334FAS	5.5	0.33	50	75	11.5	12.5	5
BCE005R5C474FS	5.5	0.47	40	60	13.5	7.3	5
BCE005R5H474FS	5.5	0.47	40	60	11.5	6.0	10
BCE005R5V474FS	5.5	0.47	40	60	11.5	12.5	5



型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance, F	最大内阻 ESR(Max), Ω		尺寸 Size, mm		
			AC@1kHz	DC	$\Phi D \pm 1.0$	$H \pm 1.0$	$P \pm 0.5$
BCE005R5C105FS	5.5	1.0	15	22.5	20.5	7.6	5
BCE005R5H105FS	5.5	1.0	15	22.5	19	6.5	20
BCE005R5V105FS	5.5	1.0	15	22.5	19	20.5	5
BCE005R5C155FS	5.5	1.5	10	15	20.5	7.6	5
BCE005R5H155FS	5.5	1.5	10	15	19	6.5	20
BCE005R5V155FS	5.5	1.5	10	15	19	20.5	5

➤ BCT 系列 BCT Series

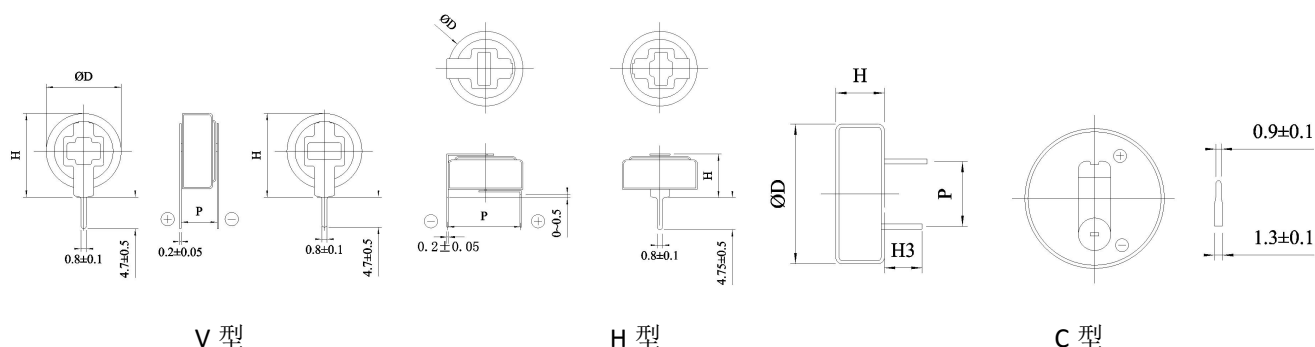
1. 产品特点 Features

- 环形设计, 产品结构稳定, 性能更加可靠;
Circular design, product structure is stable, performance more reliable;
- 符合 ROHS 标准, 无 Cd、Pb 等污染物质;
Comply with ROHS standards, no Cd Pb and other pollutants;
- 充放电循环寿命长;
Long charge-discharge cycle life;
- 漏电流低, 适合时钟芯片数据保持;
Low leakage current, suitable for keeping the clock chip data;
- 耐温高, 可在+85℃的环境下使用。
High temperature resistant, can be used in +85℃ environment.

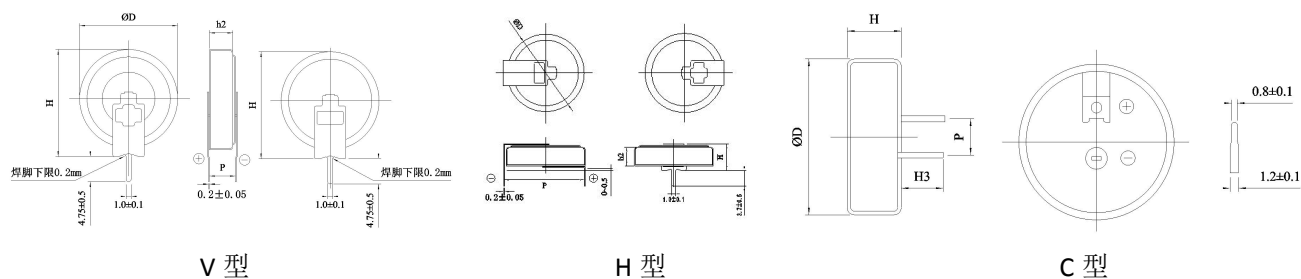
2. 主要技术参数 Main Technical Parameters

项目	特性	
额定工作电压 Rated Operating Voltage	3.6VDC/5.5VDC	
工作温度范围 Operating Temperature Range	-25℃~+85℃	
容量范围 Rated Capacitance Range	0.1F~1.5F	
容量允许偏差 Permitting Capacitance Tolerance	-20%~+20%, -20%~+80%, -20%~+100%	
温度特性 Temperature Characteristics	-25℃	$ \Delta C/C \leq 50\%$, $ESR \leq 4$ 倍初始值
	+85℃	$ \Delta C/C \leq 30\%$, $ESR \leq$ 初始值
湿热特性 Humidity Characteristics	40℃, 90~95%RH, 240h	$ \Delta C/C \leq 30\%$, $ESR \leq 2$ 倍初始值
高温寿命 High Temperature Life	3.6V/5.5V, 85℃, 1000h	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
循环寿命 Cycle Life	3.6V/5.5V, 25℃, 500000 次	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
自放电特性 Self Discharge Characteristics	无负载, 额定电压充电 8h, 开路放置 24h non-loaded, charge at rated voltage for 8h, lay aside 24h at open circuit	正负极间电压大于等于 3.0V/4.2V The voltage between the positive and negative electrode $\geq 3.0V/4.2V$

3. 产品结构和规格 Product Construction And Specification



型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance, F	最大内阻 ESR(Max), Ω		尺寸 Size, mm		
			AC@1kHz	DC	$\Phi D \pm 1.0$	$H \pm 1.0$	$P \pm 0.5$
BCT003R6C104FS	3.6	0.1	40	60	13.5	7.3	5
BCT003R6H104FS	3.6	0.1	40	60	11.5	6.0	10
BCT003R6V104FS	3.6	0.1	40	60	11.5	12.5	5
BCT003R6C224FS	3.6	0.22	40	60	13.5	7.3	5
BCT003R6H224FS	3.6	0.22	40	60	11.5	6.0	10
BCT003R6V224FS	3.6	0.22	40	60	11.5	12.5	5
BCT003R6C334FAS	3.6	0.33	50	75	13.5	7.3	5
BCT003R6H334FAS	3.6	0.33	50	75	11.5	6.0	10
BCT003R6V334FAS	3.6	0.33	50	75	11.5	12.5	5
BCT003R6C474FS	3.6	0.47	40	60	13.5	7.3	5
BCT003R6H474FS	3.6	0.47	40	60	11.5	6.0	10
BCT003R6V474FS	3.6	0.47	40	60	11.5	12.5	5



型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance, F	最大内阻 ESR(Max), Ω		尺寸 Size, mm		
			AC@1kHz	DC	$\Phi D \pm 1.0$	$H \pm 1.0$	$P \pm 0.5$
BCT003R6C105FS	3.6	1.0	15	22.5	20.5	7.6	5
BCT003R6H105FS	3.6	1.0	15	22.5	19	6.5	20
BCT003R6V105FS	3.6	1.0	15	22.5	19	20.5	5
BCT003R6C155FS	3.6	1.5	10	15	20.5	7.6	5
BCT003R6H155FS	3.6	1.5	10	15	19	6.5	20
BCT003R6V155FS	3.6	1.5	10	15	19	20.5	5
BCT005R5C684FS	5.5	0.68	30	45	20.5	10	5
BCT005R5V684FS	5.5	0.68	30	45	19	20.5	8
BCT005R5C105FS	5.5	1.0	20	30	20.5	10	5
BCT005R5V105FS	5.5	1.0	25	37.5	19	20.5	8

➤ BGW 系列 BGW Series

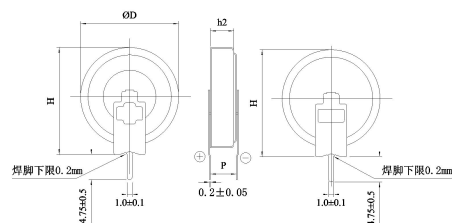
1. 产品特点 Features

- 环形设计, 产品结构稳定, 性能更加可靠;
Circular design, product structure is stable, performance more reliable;
- 符合 ROHS 标准, 无 Cd、Pb 等污染物质;
Comply with ROHS standards, no Cd Pb and other pollutants;
- 长期充电使用可靠性高;
High reliability for long-term charging;
- 漏电流低, 适合时钟芯片数据保持.
Low leakage current, suitable for keeping the clock chip data.

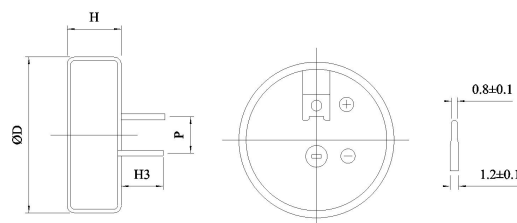
2. 主要技术参数 Main Technical Parameters

项目	特性	
额定工作电压 Rated Operating Voltage	5.5VDC	
工作温度范围 Operating Temperature Range	-40℃~+70℃	
容量范围 Rated Capacitance Range	1.0F~1.5F	
容量允许偏差 Permitting Capacitance Tolerance	-20%~+20%	
温度特性 Temperature Characteristics	-25℃	$ \Delta C/C \leq 50\%$, $ESR \leq 4$ 倍初始值
	+70℃	$ \Delta C/C \leq 30\%$, $ESR \leq$ 初始值
	-40℃ (I=1mA)	$ \Delta C/C \leq 50\%$, $ESR \leq 7$ 倍初始值
湿热特性 Humidity Characteristics	40℃, 90~95%RH, 240h	$ \Delta C/C \leq 30\%$, $ESR \leq 2$ 倍初始值
高温寿命 High Temperature Life	5.0V, 70℃, 1000h	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
循环寿命 Cycle Life	5.5V, 25℃, 500000 次	$ \Delta C/C \leq 30\%$, $ESR \leq 4$ 倍初始值
自放电特性 Self Discharge Characteristics	无负载, 额定电压充电 8h, 开路放置 24h non-loaded, charge at rated voltage for 8h, lay aside 24h at open circuit	正负极间电压大于等于 4.2V The voltage between the positive and negative electrode $\geq 4.2V$

3. 产品结构和规格 Product Construction And Specification

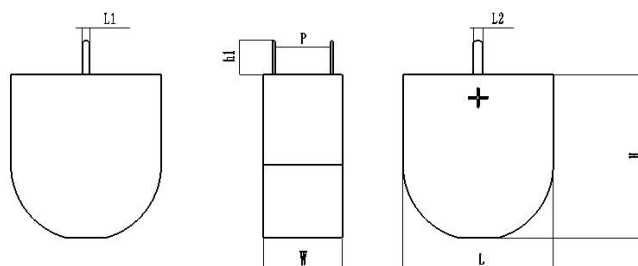


V 型



H 型

型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance, F	最大内阻 ESR(Max), Ω		尺寸 Size, mm		
			AC@1kHz	DC	ΦD±1.0	H±1.0	P±0.5
BGW5R5V105FAS	5.5	1.0	15	22.5	19	20.5	5
BGW5R5V155FAS	5.5	1.5	10	15	19	20.5	5
BGW5R5H155FAS	5.5	1.5	10	15	19	6.5	20
BGW5R5H105FAS	5.5	1.0	15	22.5	19	6.5	20
BGW5R5V105FCS	5.5	1.0	15	22.5	19	20.5	5
BGW5R5V105FBS	5.5	1.0	15	22.5	19	20.5	5
BGW5R5V155FCS	5.5	1.5	10	15	19	20.5	5



型号 Part Number	额定电压 Nominal Voltage,V	容量 Capacitance,F	最大内阻 ESR(Max), Ω		尺寸 Size, mm						
			AC@1kHz	DC	L±1.0	W±1.0	H±1.0	P±0.5	h1±0.5	L1±0.1	L2±0.1
BGW5R5V155FASW	5.5	1.5	10	15	20.8	7.6	21.7	5	3.5	1.0	1.0
BGW5R5V155FCSW	5.5	1.5	10	15	20.8	7.6	21.7	5	3.5	1.0	1.4
BGW5R5V155FDSW	5.5	1.5	10	15	20.8	7.6	21.7	5	3.5	1.0	2.0

■ 超级电容器测试方法 Measuring Method Of BIGCAP

表 1

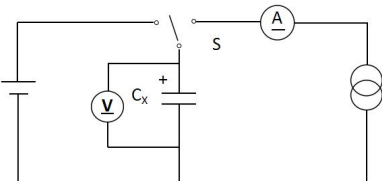
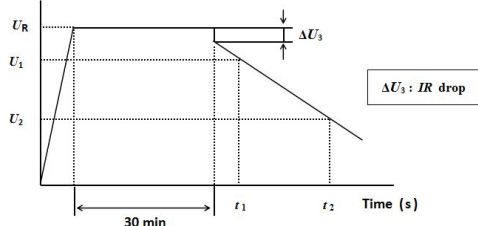
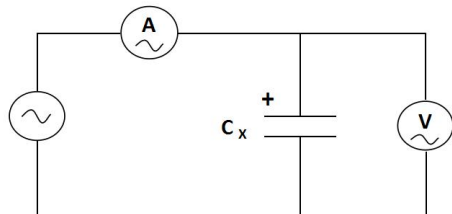
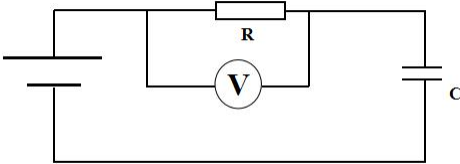
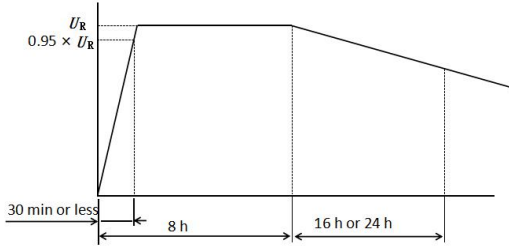
容量 (Capacitance)	恒流放电法测量 Constant current discharge of measure 1、恒流/恒压源的直流电压设定为额定电压 (U_R)。 Set the DC voltage source to the rated voltage (U_R). 2、设定规定的恒电流放电装置的恒定电流值。 Set constant current values of a specified constant current discharge device. 3、将开关S切换到直流电源，在恒流/恒压源达到额定电压后恒压充电30min。 Switch the switch S to DC power supply, constant voltage charge for 30min after the voltage reaches to rated voltage. 4、在充电30min结束后，将开关S变换到恒流放电装置，以恒定电流进行放电。 After charging 30min, transform the switch S to constant current discharge device, to discharge at constant current. 5、测量电容器两端电压从U_1到U_2的时间t_1和t_2，如图所示，根据下列等式计算电容量值： Measure the discharge time from U_1 to U_2 (t_1, t_2), calculate capacitance using the following formula:  恒流放电装置  $C = \frac{I \times (t_2 - t_1)}{U_1 - U_2}$
内阻 (Resistance)	交流阻抗方法测量 Equivalent series resistance: 采用如下图所示的电路进行测量 ESR shall be measured from the circuit below:  电容器的内阻R_a应通过下式计算： ESR R_a can be calculated from the formula $R_a = \frac{U}{I}$ R_a 交流内阻 (mΩ / Ω) Equivalent series resistance (mΩ / Ω) U 交流电压有效值 (V r.m.s) U Ac voltage valid values (V r.m.s) I 交流电流有效值 (V r.m.s) I Ac current valid values (V r.m.s)

表 2

漏电流 (Leakage Current)	直流漏电流的测量原理如下 Leakage Current shall be measured from the circuit below:  1、放电：该测量开始前，电容器应进行充分放电。 Discharge: Before the start of the measurement, super-capacitor should be fully discharge . 2、漏电流的测量应在常温（25℃）、额定电压（U_R）下，保持电容器在额定电压U_R下持续充电72h，记录最终电流为漏电流。 Leakage current measurement shall be carried out under the temperature (25℃) and voltage rating (U_R). The capacitor is continues to charge for 72h at the rated voltage U_R, record the terminal current as leakage current .
自放电 (Self discharge)	测量开始前，电容器应进行充分放电，在电容器两端直接施加额定电压U_R，不使用保护电阻，充电时间为8h（包括电压达到施加电压95%的最大30min充电时间），将电容器两端从电压源断开。电容器应置于标准常温常压条件下放置24h。直流电压表的内阻应大于1MΩ。 Before the start of the measurement, super capacitor should be fully discharge.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 1MΩ . 

■ 使用注意事项 Cautions For Use

(1) 超级电容器极性问题 The polarity of super capacitor

与普通电解电容器或电池不同的是，由于超级电容器正负极采用的是同种材质，从理论上讲是不存在极性的；而超级电容器所标识的极性是生产商在生产工艺过程制定的，当电容使用中不小心短期反向使用，不会造成电容器实质性破坏，调整为正向可保证使用，但不可长期反向使用，会造成电容寿命特性衰减。

Unlike ordinary electrolytic capacitor or battery, the material of positive and negative polarity of super capacitor is same, so theoretically super capacitor has no polarity; the polarities marked on super capacitor are established by manufacturers in the production process, when the polarities are used reversely in short-term, it won't cause substantial damage on capacitor, and it can be used normally after adjusting to the right polarities. But if reversely use for a long time, the life of super capacitor will decay .

(2) 关于超级电容器充电问题 Super capacitor charging information

超级电容器充电需要采用不超过额定电压的直流电压，可采用限流、恒流、恒功率、恒电压等多种充电方式；超级电容器充电时可能会拉低充电电源电压，直到电容器充满维持电压平衡。

To charge a super capacitor requires DC voltage that no more than the rated voltage. It can be charged by a variety of methods such as current limit, constant current, constant power, constant voltage; when charging, the super capacitor may lower the voltage of charging power supply until the capacitor is full to maintain voltage balance.

(3) 工作电压、温度和寿命 Operating temperature and product

一般情况，BIGCAP®超级电容器在额定电压、低温条件下工作，漏电流更小、备用时间更长、寿命更长。反之在额定电压、较高温度条件下，则漏电流增大、备用时间缩短、寿命变短。当工作温度一定的条件下，BIGCAP®超级电容器在额定电压以下工作，寿命会增长。

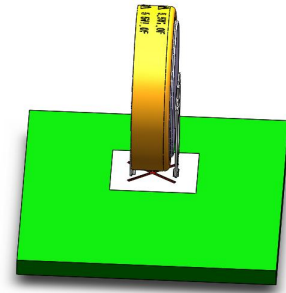
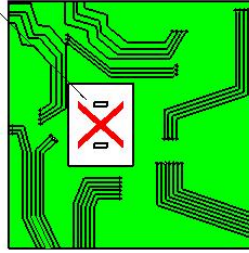
Generally, when BIGCAP® supercapacitors work at rated voltage and low temperatures, the leakage current will be less, the standby time and life will be longer. On the contrary, under the condition of rated voltage and higher temperature, the leakage current increases, the standby time is shortened, and the life is shortened. When the operating temperature is certain, the life will increase when working at the rated voltage.

(4) 安装与焊接 Installation and welding

超级电容器用于双面电路板上时，要注意连接处不可经过电容器可触及的地方，否则会导致产品短路过压及电容器损坏。安装过程及安装后，不可强行扭动或倾斜电容器，不得用力拉拽引线，应先断针及折弯后焊接。在焊接过程中要避免使电容器过热（1.6mm 的印刷线路板，焊接时应为 260℃，时间不超过 5s），焊接后，线路板和电容器要清洗干净。

When super capacitors are used for double-sided circuit boards, must pay attention the joint should not contact the capacitor, otherwise it will lead to short circuit, over-voltage and damage of capacitor. During the process of installation and after installation, do not twist or tilted the capacitor, do not be forcibly pull the wires. Capacitors should be welded after cutting off and bending the leads. In the welding process, pay attention to avoid overheating of the capacitor (for a 1.6 mm thickness printed circuit board, the welding temperature should be 260℃, time is not more than 5 s), circuit board and the capacitor should be clean after welding.

焊接区域尽量不要布线
Do not wire the welding area as much as possible



(5) 串联及并联使用问题 Use in series and parallel

相同超级电容器串联使用时，总电压=串联个数×单体耐压；总容量=单体容量÷串联个数；总能量=串联个数×单体能量，总内阻=串联个数×单体内阻。

三个及以上串联存在单体间的电压均衡问题，需要考虑采用均衡电路，用于保证长期使用过程中电容不能过电压使用，从而引起电容器寿命衰减及损坏。客户在自行串联使用时，建议同批次产品一起使用，不建议不同批次产品混用。

超级电容器进行并联使用时，可以不同容值的并联，采用相同电压充电，但要注意各个电容之间的电流平衡问题以及相互隔离，避免由于放电后电势差产生的相互反向充电。

When same super capacitors used in series, the total voltage = capacitor number x capacitor voltage; the total capacitance =single capacitor capacitance /capacitor number; Total energy = capacitor number x single capacitor's energy; total resistance = capacitor number x single capacitor's resistance.

There is a voltage balance problem when 3 pcs or above capacitors used in series,so an equalization circuit is required to ensure the capacitor will not over-voltage in long term use process, as over-voltage will cause decay and damage of capacitor. When customers use the product in series by themselves, we recommend that using the same batch of products, and don't mix up different batches of products.

Super capacitors in different capacitance value can be used in parallel, theses capacitors should be charged by the same voltage, but should pay attention to the current balance problem between the capacitors and mutual isolation, to avoid potential difference happened after discharge.

(6) 使用环境：超级电容器不可处于相对湿度大于 85%RH 或含有有毒气体的场所，这些环境下会导致引线及超级电容器壳体腐蚀，导致断路；

Operating emvintonment: Do not use the EDLC in humidity>85% or toxic emvintonment.

(7) 超级电容器的存放：超级电容器不能置于高温、高湿的环境中，应在温度 15-35℃、相对湿度在 40-70%RH 的环境下储存，避免温度骤升骤降，这样会导致产品损坏；

Storage: EDLC should not be stored in high humidity or high temperature. The suitable temperture is 15-35℃,humidity 40-70%.

(8) 请注意：产品使用时不允许接触其他有机溶剂，容易造成外部套管的不可逆损伤。

Please note that the product is not allowed to come into contact with other organic solvents during use, as it may cause irreversible damage to the external sleeve.

(9) 规格书若有更改我司不另行通知, 我司保留可能出现的各种更改权利, 最终解释权归辽宁博艾格电子科技有限公司所有。

If there is any change in the specification without prior notice, our company reserves the right to make any possible change, and the final interpretation right belongs to liaoning brother electronic technology co., LTD.

■ 保存要求 Storage Requirement

(1) 不可存放于相对湿度大于 85%或含有有毒气体的场所和高温、高湿的环境中。应储存在温度-30℃~50℃、相对湿度小于 60%的环境中。

Do not store in places where the relative humidity is greater than 85% or contains toxic gases, and in high temperature and humidity environment. Should be stored at -30℃~50℃, When the relative humidity is less than 60%.

(2) 避免以下环境中保存超级电容器:

Avoid storing supercapacitors in the following environments:

a) 直接溅水、盐水及油的环境、或处于结露状态、充满着气体状的油分或盐分的环境。

An environment in which water, salt water and oil are splashed directly, or in a dewy state, filled with gaseous oil or salt.

b) 充满着有害气体(硫化氢、亚硫酸、氯、氨、溴、溴化甲基等)的环境。

An environment full of harmful gases (hydrogen sulfide, sulfite, chlorine, ammonia, bromine, methyl bromide, etc.).

c) 溅上酸性及碱性溶剂的环境。

Environment splashed with acidic and alkaline solvents.

d) 阳光直射或有粉尘的环境。

Direct sunlight or dust environment.

e) 遭受过度的振动及冲击的环境。

An environment subjected to excessive vibration and shock.