
ESD-SCAP
SAMWHA CAPACITOR Co., Ltd.
Inside All The E-devices
E : Electronic, Electric, Environmantal, Eco, Energy

CHAPTER


ESD-SCAP
ESD SCAP
CB 30000F 2.7V
CB 20000F 2.7V
CB 12000F 2.7V

SAMWHA: Inside ALL The *E*-devices

E : Electronic, Electric, Environmental, Eco, Energy

SAMWHA CAPACITOR

- Samwha Capacitor
- Samwha Thailand
- PT.SAMCON

SAMWHA ELECTRIC

- Samwha Electric
- Tianjin Samwha Electric

SAMWHA ELECTRONICS

- Samwha Electronics
- Qingdao Samwha Electronics

SAMWHA TECOM

- Samwha Tecom
- PT. Samwha INDONESIA

KOREA JCC

- KOREA JCC

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Website_ http://www.samwha.com/capacitor

Products_
Energy Storage Capacitor
Multilayer Ceramic Capacitor
Disc Ceramic Capacitor
Varistor
EMI Filter
Bead & Inductor
Shunt Power Capacitor
Ceramic Capacitors for Inverter

Other Affiliated Companies

- Samwha Enterprise

Overseas Sales Office

- Samwha USA
- Samwha Europe
- Samwha Hongkong
- Samwha Poland
- Samwha India

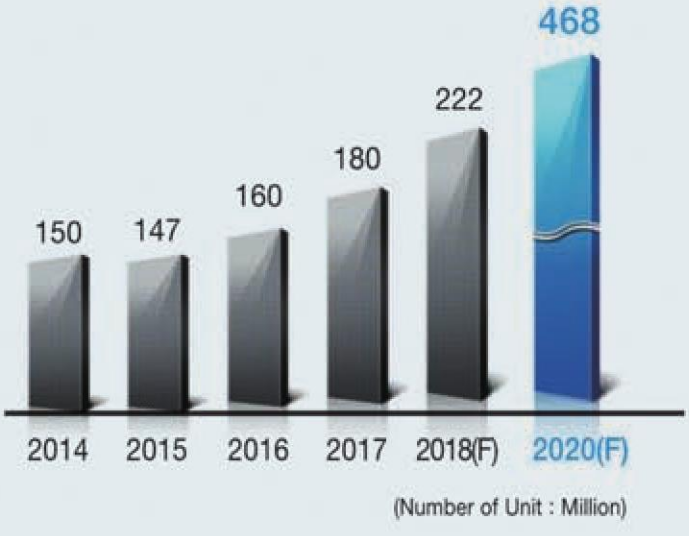
Global Customer

SAMSUNG, KEPCO, SK hynix, HYOSUNG, POSCO, HYUNDAI HEAVY INDUSTRIES, LG, HYUNDAI, KIA MOTORS, HYUNDAI MOBIS, Apple, TENAGA NASIONAL, Eskom, EGAT, DENSO, KERI, EVN, BMW, hp, DELL

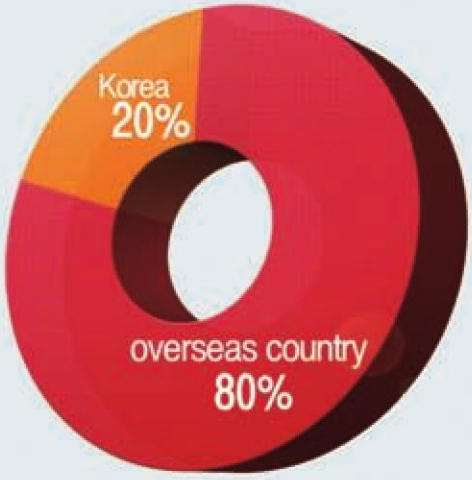
Core Value

Trust | Originality | Passion | Speed

Global Sales



(Number of Unit : Million)



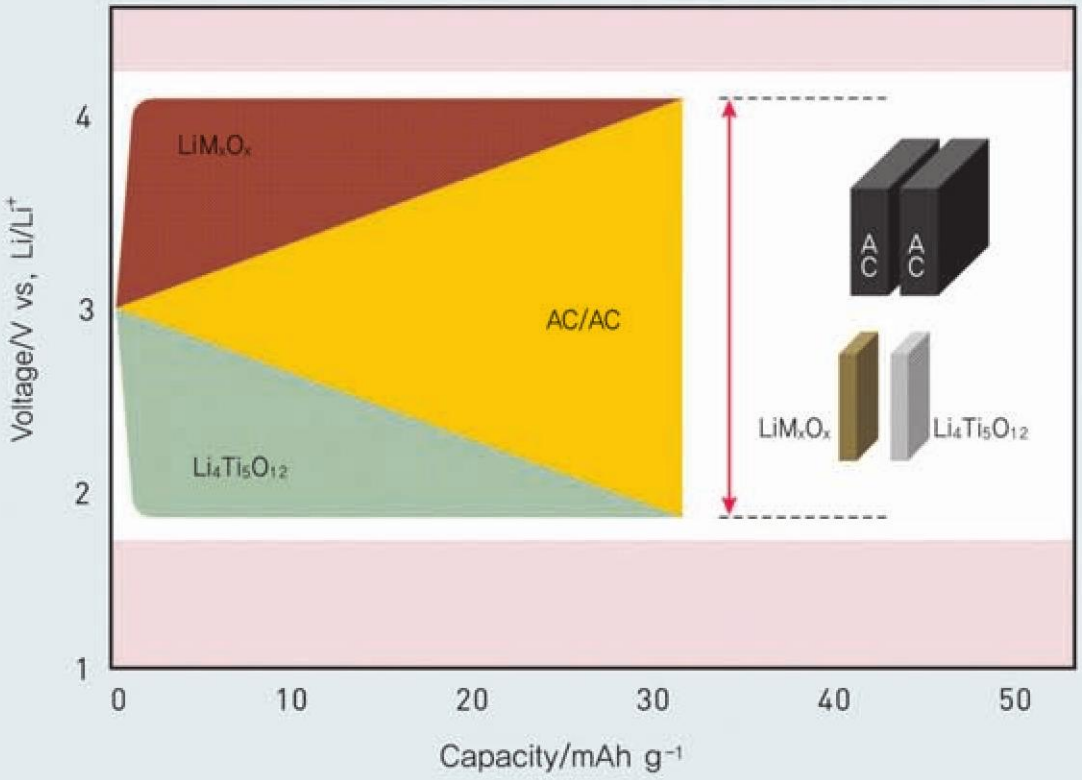
INTRODUCTION

SAMWHA ESD-SCAP is promising energy storage device that positioned between conventional EDLC and Li-ion battery. High energy, high power, and long-term reliability feature of the hybrid capacitors and battery capacitors enables this component to use in various applications

- Rated Voltage : 2.8V(Hybrid caps) and 2.7V(Battery caps)
- Long Cycle Life : >50,000(Hybrid caps) and >20,000(Battery caps) cycles
- High Power Performance : Vs. Conventional Li-ion Battery
- High Energy Density : 2.5(Hybrid caps) and 10(Battery caps) times higher than EDLC with same volume
- Environmentally Safe : No Explosion

SAMWHA manufactures from 100 to 70,000F in capacitance with operating voltage of 2.7V. Furthermore, SAMWHA develops and provides capacitor module to offer attuned solutions for the use of it through direct collaboration with client

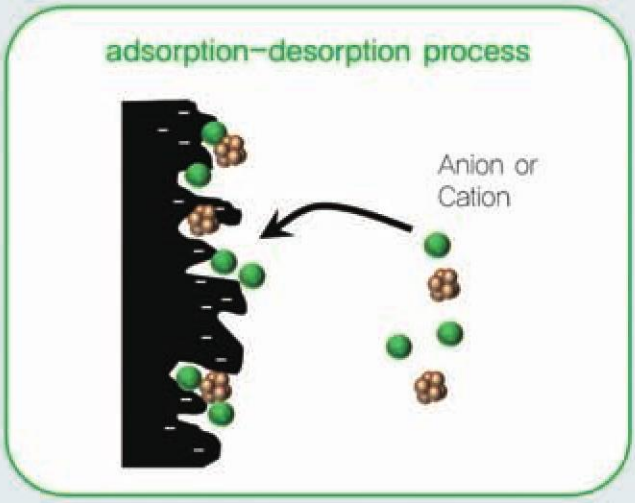
INTRODUCTION

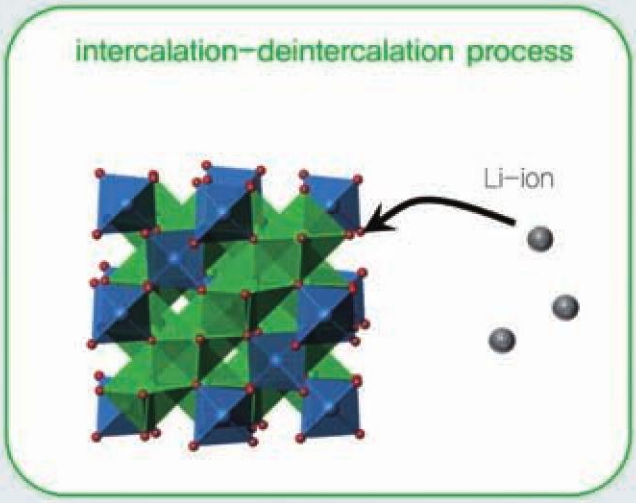


≫Battery-capacitor(CB Series) is one of the most advanced supercapacitors and is representative of an Li-ion based LIB-EDLC hybrid system. It utilizes the negative LTO electrode and the positive Li transition metal oxide electrode employing Li^+ intercalation-deintercalation process.

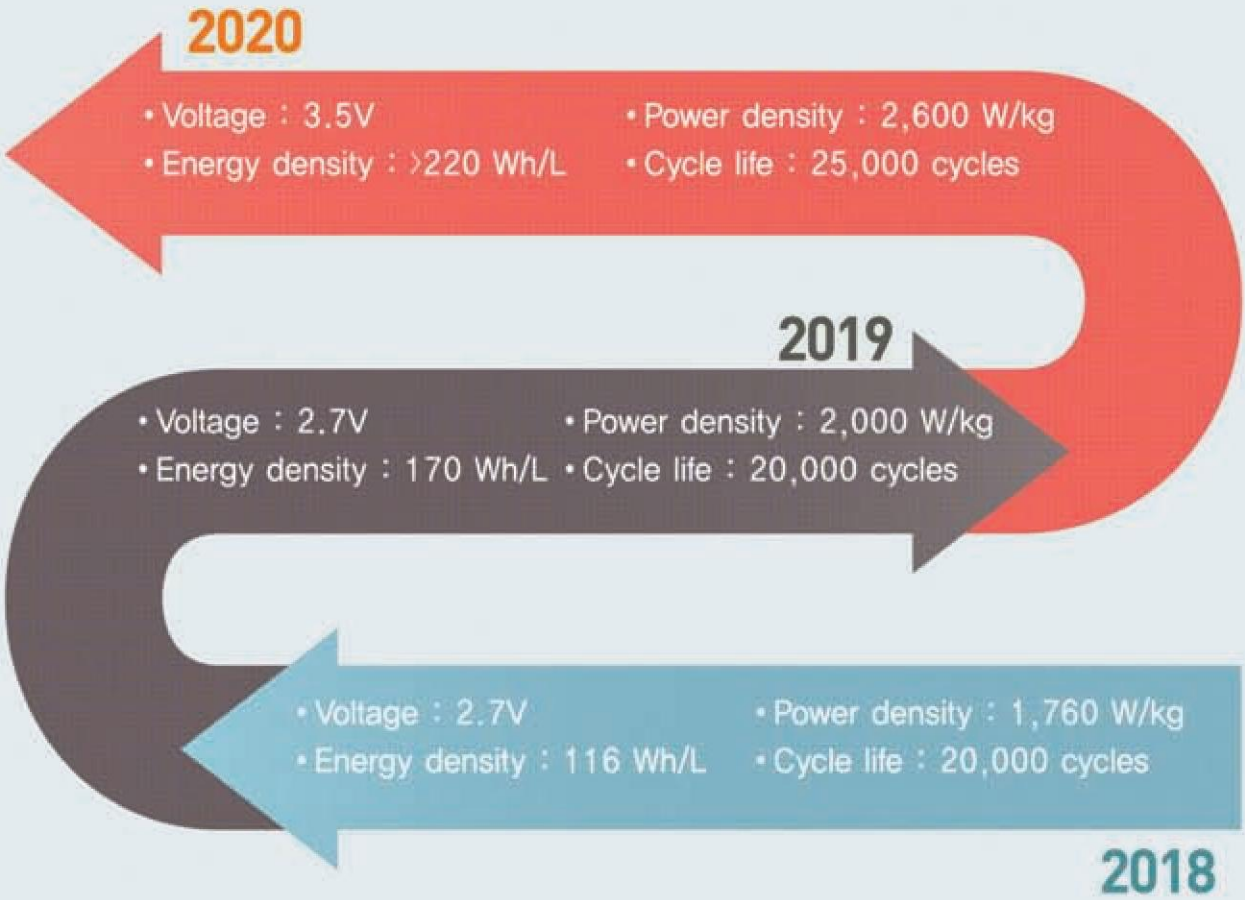
≫Hybrid-capacitor(CL Series) is a well-balanced hybrid system with a highly accelerated Li^+-intercalating LTO electrode and a non-faradaic AC electrode employing an anion adsorption-desorption process.

≫Super-capacitor(CE Series) utilizes activated carbon (AC) for both their positive and negative electrodes employing an anion adsorption-desorption process.

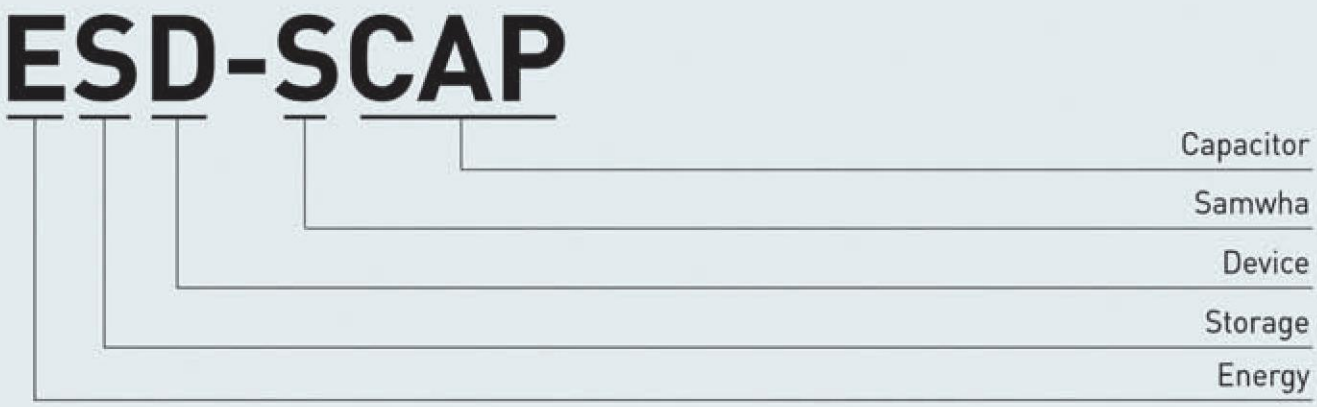




- SAMWHA battery capacitor exhibits excellent input/output characteristics over a wide state of charge(SOC) range of 0 to 100%.
- The capacity of battery capacitor remains at 70% after 15,000cycles.
- The battery capacitor can accept large current input and output during charging and discharging. Thus, it provide rapid charging to 80% of the capacity in 6 minutes(10 C-rate).
- In case of safety issues, There is no risk of fire or explosion because the lithium titanium oxide(LTO) is applied as an anode material.
- SAMWHA is constantly researching and developing high capacity and high voltage characteristics of battery capacitors.



TYPE DESIGNATION



CB 2R7 408 W 35 060 SN B HE

❶ ❷ ❸ ❹ ❺ ❻ ❼ ❽ ❾

❶ Type & Series name

Code	Type
C	Can
P	Pouch
M	Module

Code	Series Name
E	Super-capacitor (EDLC)
L	Hybrid capacitor
B	Battery capacitor

❷ Rated Voltage Code

Code	2R5	2R7	2R8	120	300	480
Voltage	DC 2.5V	DC 2.7V	DC 2.8V	DC 12V	DC 30V	DC 48V

❸ Nominal Capacitance

The nominal Capacitance Value in μF is expressed by three digit numbers.

The first two digits represents significant figures and the last digit denotes the number of zero.

ex) 107 = 100000000 μF = 100 F

308 = 3000000000 μF = 3000 F

❹ Capacitance Tolerance Code

Code	Cap. Tolerance
K	±10%
M	± 20%
W	0~+20%

❺ Diameter Code (Can type)

The two digits are Diameter

ex) 22 : Φ22

60 : Φ60

❻ Height Code (Can type)

The three digits are height.

ex) 045 : 45mm

137 : 137mm

❼ Terminal Configuration

ex) SN : Snap-in

SC : Screw

AT : Axial Threaded

AW : Axial Weldable

❽ Packing Code

Mark	Packaging Style
B	Bulk
T	Carrier Taping

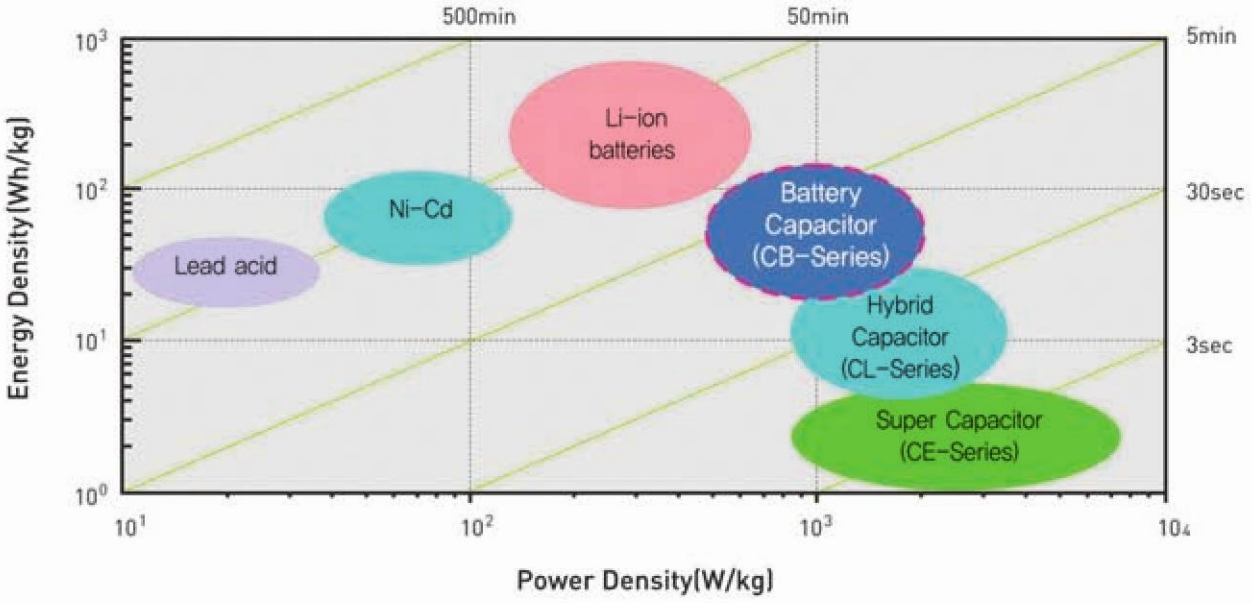
❾ Type Code (Battery capacitor)

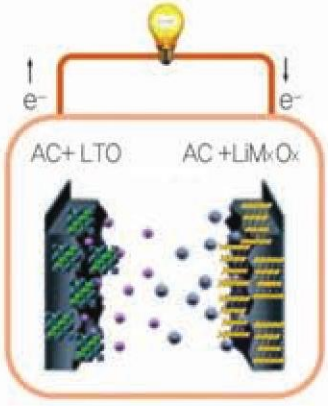
Code	Type	Reference
HP	High Power type	Battery capacitor(CB-series)
HE	High Energy type	
LT	LTO type	Hybrid capacitor(CL-series)
LM	LMO type	
ST	Standard type	Super capacitor(CE-series)
HT	High Temperature type	

BATTERY CAPACITORS for High Energy Density

Features

- High Energy Density
- Low Current/Long time back up application
- Exceptional shock and vibration resistance
- Easy Build-up Design for High Voltage Module
- Environmentally Safe





Charging Mechanism : Chemical + Physical

Energy density : 50~120Wh/L

Power density : 1600~3200W/L

Cycle Life : 15,000~20,000cycles

To meet consumer demand for both high energy and power density with greater efficiency andfunctionality, SAMWHA has been focusing on R&D of battery capacitors.

Battery-capacitor(CB Series) is one of the most advanced energy storage devices and is representative of the energy storage technology based lithium ion battery and super capacitor hybrid system. It utilizes the negative LTO electrode and the positive Li transition metal oxide electrode employing Li^+ intercalation-deintercalation process.

Feature

- High Energy Density
- Linear Charge/Discharge Curve
- Low Current/Long Time Back up Application
- Exceptional Shock and Vibration Resistance
- Easy Build-up Design for High Voltage Module
- Environmentally Safe

Applications

- Solar System
- Emergency Lighting
- Industrial Machinery
- Consumer Machines and Tools
- Automotive
- Uninterruptible Power Supply(UPS)

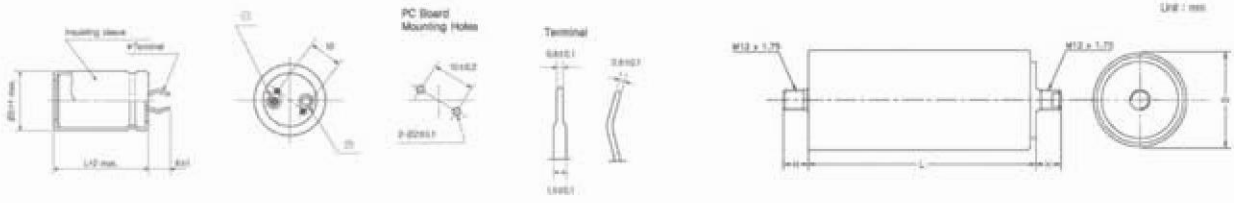
HIGH POWER TYPE

A perfect combination of Lithium ion battery and super capacitor technology by SAMWHA is possible to simultaneously achieve, high power density (>1.7kW/kg), high energy density(>65Wh/L), long cycle-life and safety

Specifications

Item	Characteristics	
Operating temperature range	-20 ~ +50℃	
Rated Voltage(Surge)	2.7VDC (2.8V)	
Cut-off voltage	1.6V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ±40% of initial value at +20℃
	Internal resistance	Less than 200% of initial at +20℃
Endurance	Test time	1000 hours
	Capacitance change	Within ±40% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	20,000 cycles	[1] I△CI<40% and △ESR<200% of initially specified value, respectively and LC<specified value [2] Cycle : between rated voltage and half rated voltage under constant current at 25℃

Drawing(not to scale)



Product list

Type	Rated Voltage(V)	Capacity(1.6~2.7V) (F)	Capacity(1.6~2.7V) (mAh)	ESR, 1kHz (mΩ)	ESR, DC (mΩ)	LC(72hours) (mA Max.)	Specific Energy (Wh/kg)	Specific Energy (Wh/L)	Weight (g)	Dimension ΦD×L(mm)
Snap-in	2.7	1000	330	10	18	2	24.3	38.6	27	22×45
		2000	650	7	14	4	28.5	39.0	46	35×35
		4000	1400	5	10	8	30.9	45.3	85	35×60
		5800	2500	5	8	12	34.6	49.4	110	35×82
Axial	2.7	6000	2100	0.8	1.4	4	10.6	26.8	370	60×52
		12000	4100	0.5	1.3	7	17.5	37.5	450	60×74
		20000	6600	0.5	0.9	9	23.8	45.3	550	60×102
		40000	12000	0.4	0.7	12	37.0	67.3	710	60×138

* For the special capacitance or design, please contact our sales representatives or product engineers.

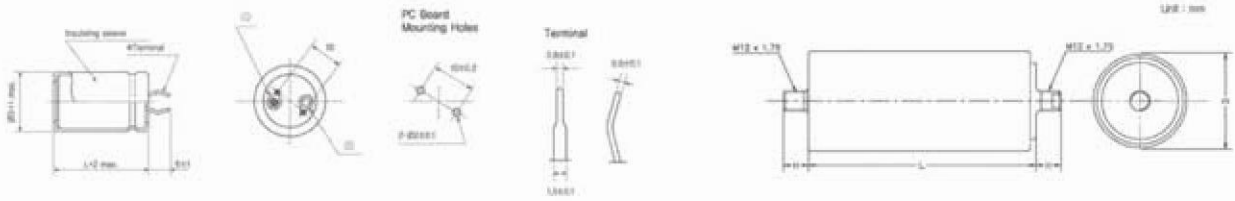
HIGH ENERGY TYPE

A perfect combination of lithium ion battery and super capacitor technology by SAMWHA is possible to simultaneously achieve high energy density (>110Wh/L),high power density(>1kW/kg), long cycle-life and safety

Specifications

Item	Characteristics	
Operating temperature range	-20 ~ +50℃	
Rated Voltage(Surge)	2.7VDC (2.8V)	
Cut-off voltage	1.6V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ± 40% of initial value at +20℃
	Internal resistance	Less than 200% of initial at +20℃
Endurance	Test time	1000 hours
	Capacitance change	Within ± 40% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	15,000 cycles	(1) I △CI < 40% and △ESR < 200% of initially specified value, respectively and LC < specified value (2) Cycle : between rated voltage and half rated voltage under constant current at 25℃

Drawing(not to scale)

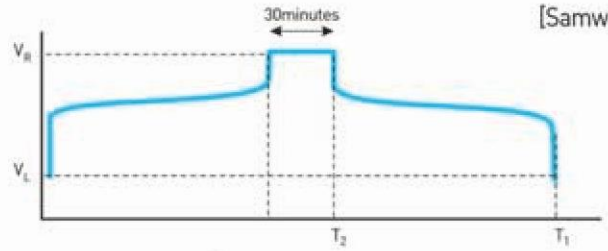
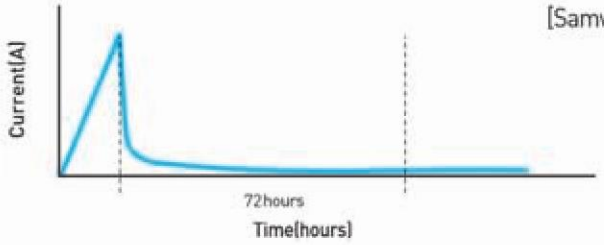
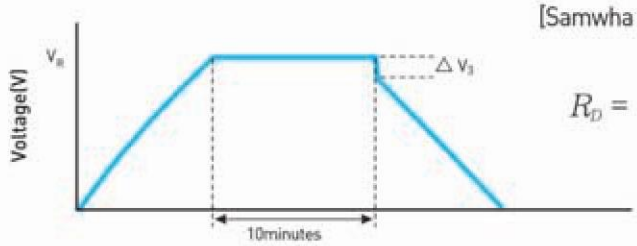
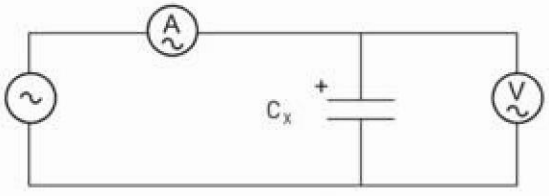


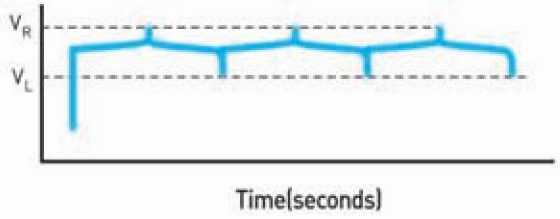
Product list

Type	Rated Voltage(V)	Capacity(1.6~2.7V) (F)	Capacity(1.6~2.7V) (mAh)	ESR, 1kHz (mΩ)	ESR, DC (mΩ)	LC(72hr) (mA Max.)	Specific Energy (Wh/kg)	Specific Energy (Wh/L)	Weight (g)	Dimension ΦD×L(mm)
Snap-in	2.7	1500	600	20	24	4	31.7	57.9	31	22×45
		3300	1100	17	20	6	40.1	63.7	54	35×35
		6500	2200	11	17	10	43.5	73.6	98	35×60
		9000	3900	8	14	15	45.4	76.7	130	35×82
Axial	2.7	9500	3300	1.3	1.5	6	14.5	42.4	430	60×52
		20000	6400	1.1	1.3	9	25.2	62.5	520	60×74
		33000	9800	1.0	1.2	11	34.4	74.7	630	60×102
		70000	19000	0.9	1.1	15	56.7	116.8	810	60×138

* For the special capacitance or design, please contact our sales representatives or product engineers.

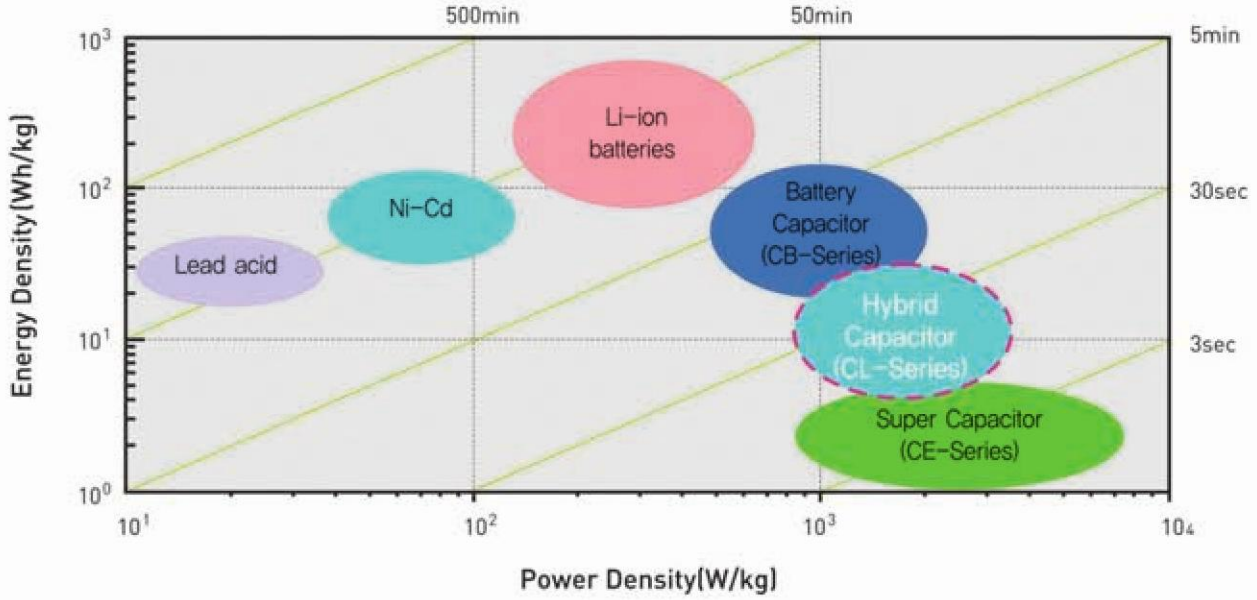
BATTERY CAPACITORS

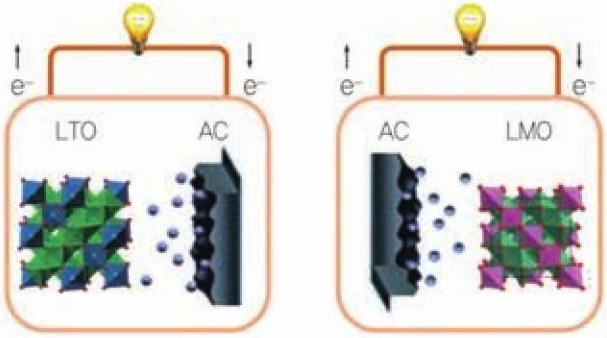
No	Item		Unit	Test Conditions and Methods
1	Capacitance at 20℃		F	[Samwha Standard]  $E = \frac{\frac{1}{2} \times C \times (V_R)^2}{3600} (Wh)$ 1] Charging is performed by constant current of 1mA/F. 2] Charging is performed for duration of 30 minutes a rated voltage. 3] Discharge use a constant current load device and measure the time for the terminal voltage from V_R to V_L at the current density of 1mA/F.
2	Leakage current after 72 hours		mA	[Samwha Standard]  The battery capacitor is charged with the rated voltage for 72hours. Then, leakage current is measured by current measurement equipment.
3	Internal resistance (ESR)	DC	mΩ	[Samwha Standard]  $R_D = \frac{\Delta V_3}{I}$
		AC 1kHz	mΩ	[IEC 62391-1]  $R_A = \frac{\Delta V}{I}$ 1] The internal resistance R_a of a capacitor shall be calculated by the above formula. 2] The frequency of the measuring voltage shall be 1kHz. 3] The AC current shall be from 1mA to 10mA.

<table>
<tr><th>No</th><th>Item</th><th></th><th>Unit</th><th>Test Conditions and Methods</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Temperature Characteristic</td><td>Capacitance change</td><td>%</td><td rowspan="2">[Samwha Standard]
<table><tr><th>Temperature(℃)</th><th>Keep Time</th></tr><tr><td>+20±2</td><td>-</td></tr><tr><td>-20±2</td><td>2hours</td></tr><tr><td>-20±2</td><td>15minutes</td></tr><tr><td>-20±2</td><td>2hours</td></tr></table>Measure electrical characteristics after exposing capacitor to each temperature atmosphere for 2 hours or 15minutes.</td></tr>
<tr><td>Internal resistance change</td><td>%</td></tr>
<tr><td>5</td><td>Shelf life after 1000 hours no load test same as endurance</td><td></td><td>%</td><td>[Samwha Standard]
Temperature : 50±2℃
Duration : 1000 +72/-0 hours</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Cycle life (at 25℃)</td><td>Cycle</td><td>Cycle</td><td rowspan="3">[Samwha Standard]
 

where V_R is the rated voltage of 2.7V
V_L is the low voltage of 1.6V
Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at V_L(1.6V). Then charge the capacitor at a rated current to V_R Maintain voltage V_R on the capacitor for 10±0.50 s. Then discharge the capacitor to V_L at rated current. Hold at V_L for 10±0.50 s. This defines a cycle(see Figure). Repeat this cycle throughout the testing.</td></tr>
<tr><td>Capacitance change</td><td>%</td></tr>
<tr><td>Internal resistance (ESR)</td><td>%</td></tr>
</table>


HYBRID CAPACITORS
for All Around Performance
Features
>High Energy Density
>High Current/Middle time back up application
>Exceptional shock and vibration resistance
>Easy Build-up Design for High Voltage Module
>Environmentally Safe





LTO Type LMO Type

Charging Mechanism : Chemical + Physical

Energy density : 10~14Wh/L

Power density : 2500~4000W/L

Cycle Life : 40,000~50,000cycles

To meet consumer demand for both high energy and power density with greater efficiency and functionality, SAMWHA has been focusing on R&D of hybrid capacitors.

Hybrid-capacitor(CL Series) is promising energy storage device that positioned between conventional EDLC and Li-ion battery. It utilizes the lithium titanium oxide (LTO) or lithium manganese oxide (LMO) electrode employing Li+ intercalation-deintercalation process and activated carbon electrode employing a electric double-layer attributed to the electrostatic adsorbing-desorbing process of cations or anions.

Feature

- All Round Performances
- Linear Charge/Discharge Curve
- Low Current/Middle Time Back up Application
- Exceptional Shock and Vibration Resistance
- Easy Build-up Design for High Voltage Module
- Environmentally Safe

Applications

- Solar System
- Emergency Lighting
- Industrial Machinery
- Consumer Machines and Tools
- Audio system
- Uninterruptible Power Supply(UPS)

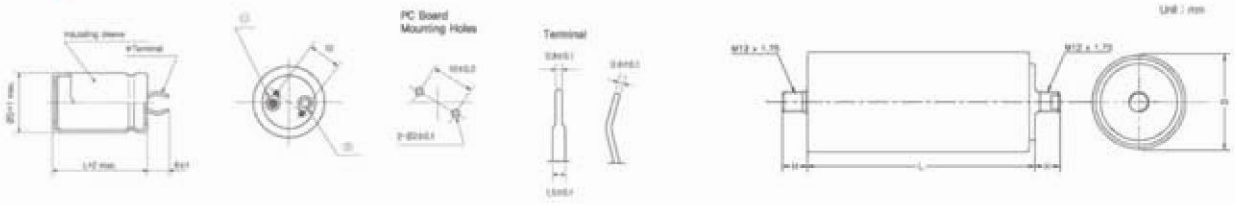
LTO HYBRID TYPE

LTO type product line is asymmetric electrochemical capacitors in which energy storage predominantly is achieved by oxidation-reduction behavior of LTO anode and electrostatic adsorbing-desorbing behavior on activated carbon cathode.

Specifications

Item	Characteristics	
Operating temperature range	-20 ~ +40℃	
Rated Voltage(Surge)	2.7VDC (2.8V)	
Cut-off voltage	1.6V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ±40% of initial value at +20℃
	Internal resistance	Less than 200% of initial at +20℃
Endurance	Test time	1000 hours
	Capacitance change	Within ±30% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	50,000 cycles	[1] I△CI〈30% and △ESR〈200% of initially specified value, respectively and LC〈specified value
		[2] Cycle : between rated voltage and half rated voltage under constant current at 25℃

Drawing(not to scale)



Product list

Type	Rated Voltage[V]	Capacity(1.6~2.8V) [F]	Capacity(1.6~2.8V) [mAh]	ESR, 1kHz [mΩ]	ESR, DC [mΩ]	LC(72hours) [mA Max.]	Specific Energy [Wh/kg]	Specific Energy [Wh/L]	Weight [g]	Dimension ΦD×L[mm]
Snap-in	2.8	250	90	14	19	0.9	9.4	10.7	19	22×45
		500	160	4.5	9	2.5	10.1	11.5	36	35×35
		1000	350	3.5	6	5.0	11.1	13.4	66	35×60
Axial	2.8	1500	550	0.8	1.6	6	5.0	7.7	220	60×52
		3000	1100	0.7	1.3	11	6.8	10.9	320	60×74
		5000	1900	0.6	1.0	17	8.7	13.3	420	60×102
		7500	2800	0.55	0.8	21	9.8	14.8	560	60×138

* For the special capacitance or design, please contact our sales representatives or product engineers.

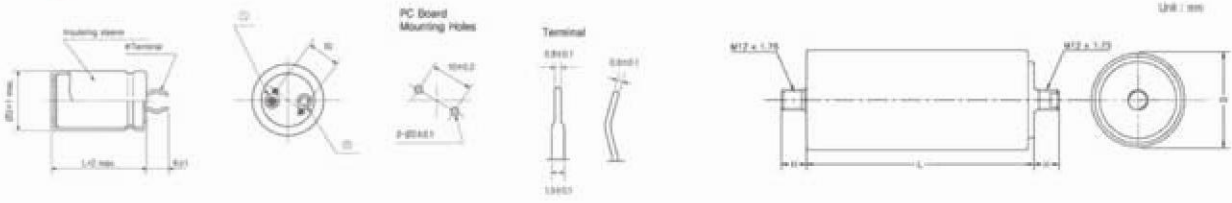
LMO HYBRID TYPE

LMO type product line, also known as pseudo capacitor is asymmetric electrochemical capacitors in which energy storage is achieved by redox reactions or intercalation on the surface of the electrode by specifically adsorbed ions that results in a reversible faradaic charge-transfer on the electrode.

Specifications

Item	Characteristics	
Operating temperature range	-20 ~ +50℃	
Rated Voltage(Surge)	2.7VDC (2.8V)	
Cut-off voltage	0.9V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ±30% of initial value at +20℃
	Internal resistance	Less than 200% of initial at +20℃
Endurance	Test time	1000 hours
	Capacitance change	Within ±30% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	50,000 cycles	(1) I△CI〈30% and △ESR〈200% of initially specified value, respectively and LC〈specified value
		(2) Cycle : between rated voltage and half rated voltage under constant current at 25℃

Drawing(not to scale)

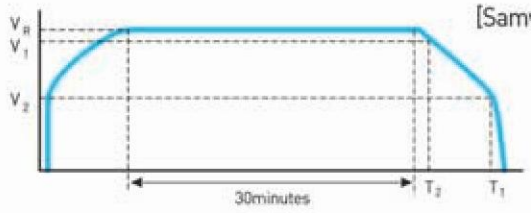
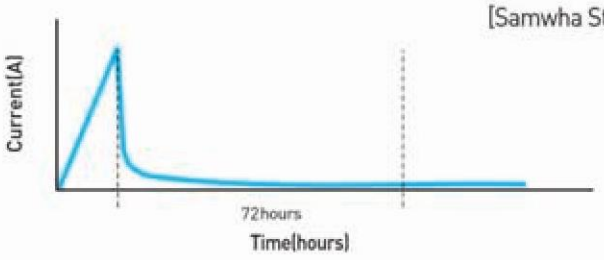
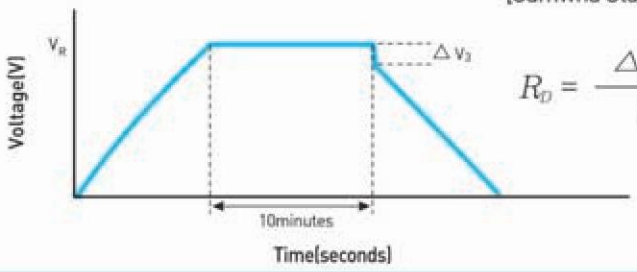
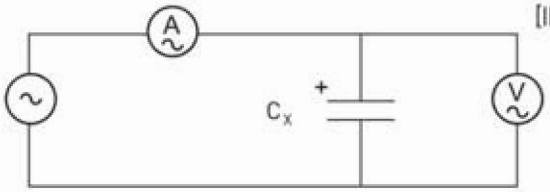


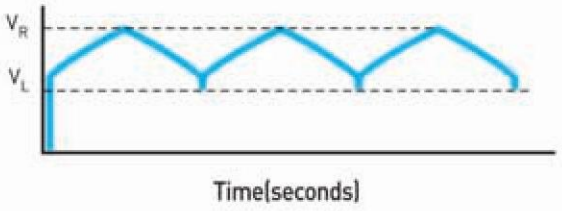
Product list

Type	Rated Voltage(V)	Capacity(0.9~2.7V) (F)	Capacity(0.9~2.7V) (mAh)	ESR, 1kHz (mΩ)	ESR, DC (mΩ)	LC(72hours) (mA Max.)	Specific Energy (Wh/kg)	Specific Energy (Wh/L)	Weight (g)	Dimension ΦD×L(mm)
Snap-in	2.7	200	80	10	18	1	7.5	10.5	24	22×45
		400	150	7	14	2	8.3	10.5	40	35×35
		800	340	5	10	4	9	12.4	80	35×60
Axial	2.7	1200	40	0.8	1.5	5	4.1	7.3 2	60	60×52
		2400	1000	0.5	1.3	10	5.6	10.2	380	60×74
		4000	1800	0.45	0.9	16	7.2	12.4	500	60×102
		6000	2600	0.4	0.7	19	8.0	13.8	670	60×138

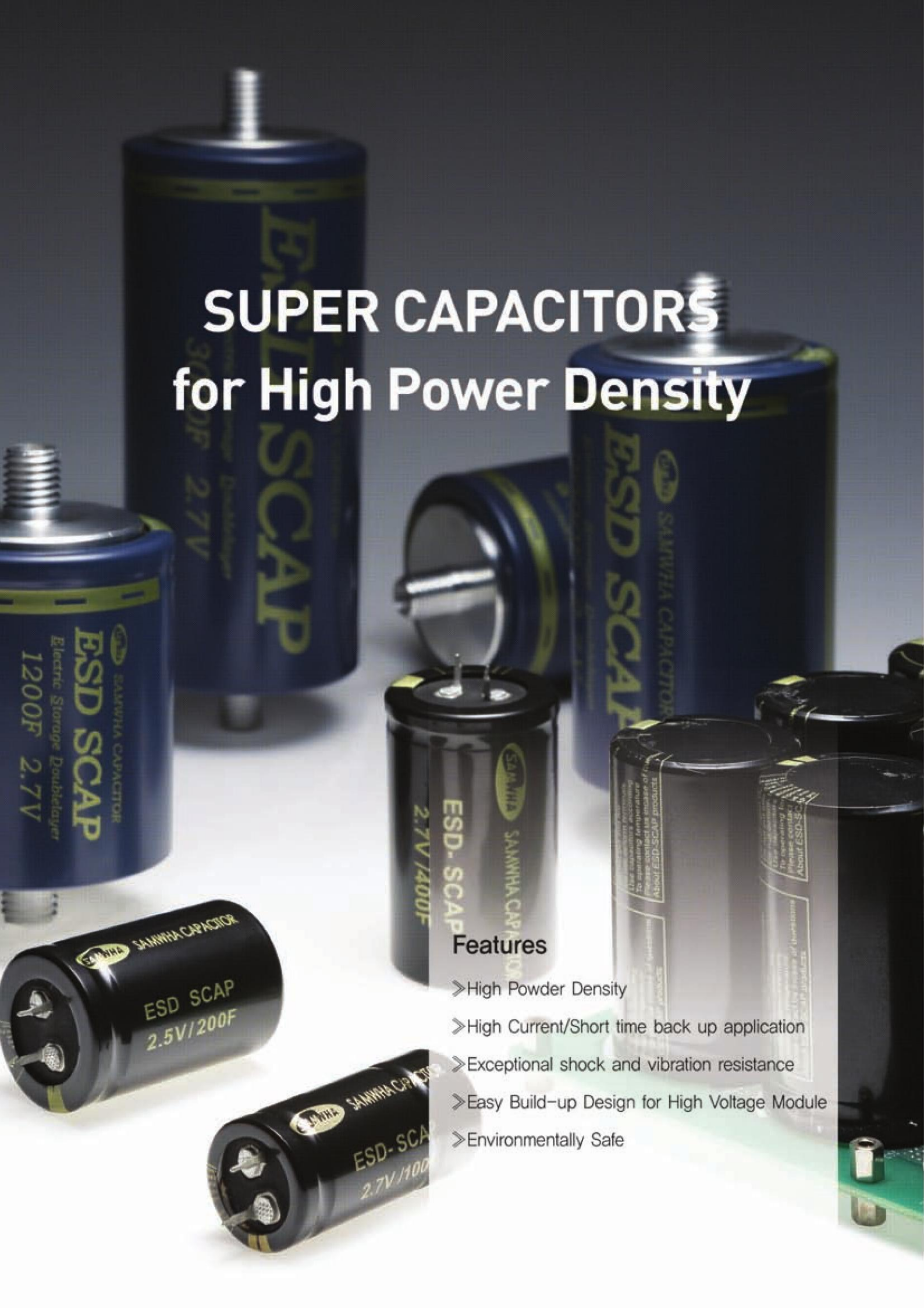
* For the special capacitance or design, please contact our sales representatives or product engineers.

HYBRID CAPACITORS

No	Item		Unit	Test Conditions and Methods
1	Capacitance at 20℃		F	[Samwha Standard]  $C = \frac{I \times (T_1 - T_2)}{V_1 - V_2}$ (F) 1) Charging is performed by constant current followed by constant voltage charging. 2) Charging is performed for duration of 30 minutes a rated voltage. 3) Discharge use a constant current load device and measure the time for the terminal voltage to drop from V_1 to V_2 upon discharge at 1mA/F.
2	Leakage current after 72 hours		mA	[Samwha Standard]  The Hybrid-capacitor is charged with the rated voltage for 72hours. Then, leakage current is measured by current measurement equipment.
3	Internal resistance (ESR)	DC	mΩ	[Samwha Standard]  $R_D = \frac{\triangle V_3}{I}$
		AC 1kHz	mΩ	[IEC 62391-1]  $R_A = \frac{\triangle V}{I}$ 1) The internal resistance R_a of a capacitor shall be calculated by the above formula. 2) The frequency of the measuring voltage shall be 1kHz. 3) The AC current shall be from 1mA to 10mA.

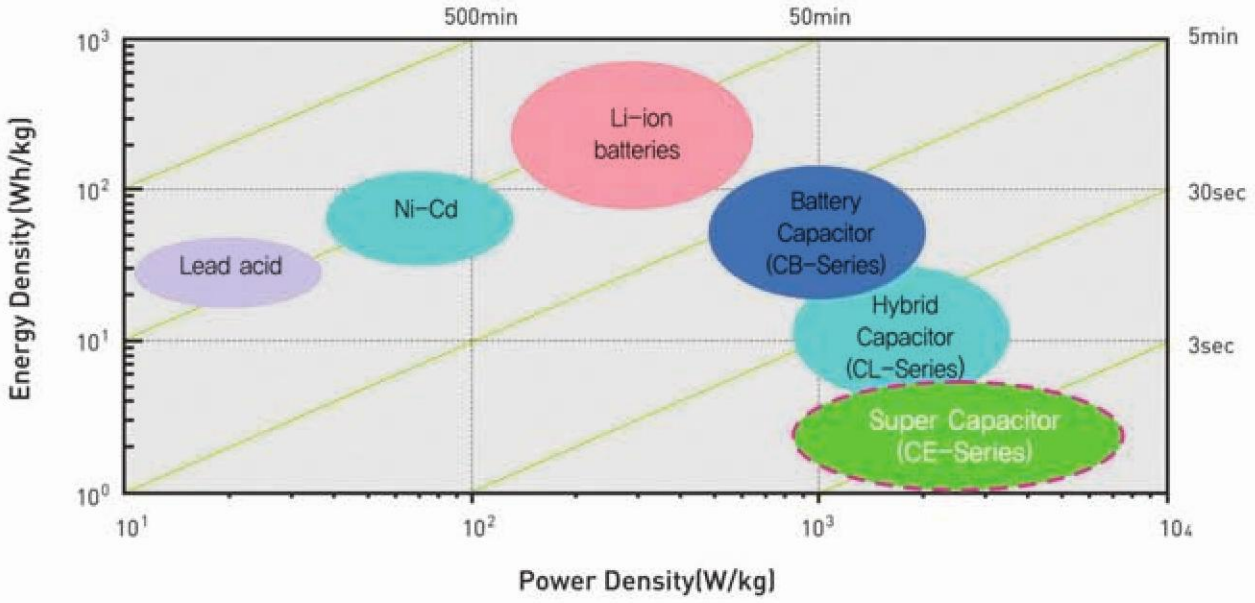
<table>
<tr><th>No</th><th colspan="2">Item</th><th>Unit</th><th>Test Conditions and Methods</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Temperature Characteristic</td><td>Capacitance change</td><td>%</td><td rowspan="2">[Samwha Standard]
<table><tr><th>Temperature(℃)</th><th>Keep Time</th></tr><tr><td>+20±2</td><td>-</td></tr><tr><td>-20±2</td><td>2hours</td></tr><tr><td>+20±2</td><td>15minutes</td></tr><tr><td>+40±2</td><td>2hours</td></tr></table>Measure electrical characteristics after exposing capacitor to each temperature atmosphere for 2 hours or 15minutes.</td></tr>
<tr><td>Internal resistance change</td><td>%</td></tr>
<tr><td>5</td><td colspan="2">Shelf life
after 1000 hours no load
test same as
endurance</td><td>%</td><td>[Samwha Standard]
Temperature : 40±2℃
Duration : 1000 +72/-0 hours</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Cycle
life
(at 25℃)</td><td>Cycle</td><td>Cycle</td><td rowspan="3">[Samwha Standard]
 
where V_R is the rated voltage of 2.8V(2.7V)
V_L is the low voltage of 1.6V(0.9V)
(V) : LMO hybrid type
Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at V_L(1.6V). Then charge the capacitor at a rated current to V_R Maintain voltage V_R on the capacitor for 10±0.50 s. Then discharge the capacitor to V_L at rated current. Hold at V_L for 10±0.50 s. This defines a cycle(see Figure). Repeat this cycle throughout the testing.</td></tr>
<tr><td>Capacitance change</td><td>%</td></tr>
<tr><td>Internal resistance change</td><td>%</td></tr>
</table>

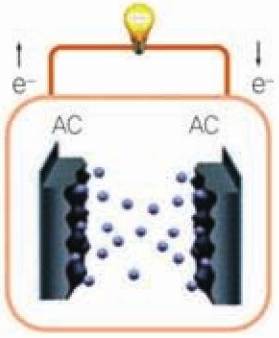
SUPER CAPACITORS for High Power Density



Features

- High Powder Density
- High Current/Short time back up application
- Exceptional shock and vibration resistance
- Easy Build-up Design for High Voltage Module
- Environmentally Safe





Charging Mechanism : Physical

Energy density : 〉5~8Wh/L

Power density : 〉8,000W/L

Cycle Life : 1,000,000cycles

To meet consumer demand for both high power density and high temperature performance with greater efficiency and functionality, SAMWHA has been focusing on R&D of super capacitors.

A super capacitor (also called electric double-layer capacitor(EDLC) or ultracapacitor) is a highcapacity capacitor with capacitance values much higher than other capacitors that bridge the gap between electrolytic capacitors and Lithium ion batteries. They typically store 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries.

Feature

- Low ESR (equivalent series resistance)
- Rapid charging and discharging in the order of amperes
- Instantaneous charge and discharge
- Excellent low and high temperature features
- Environmentally Safe (RoHS compliant)

Applications

- Industrial Machinery
- Consumer Machines and Tools
- Transportation
- Automotive
- Renewable Energy Systems
  (Solar Generator, Wind Generator)

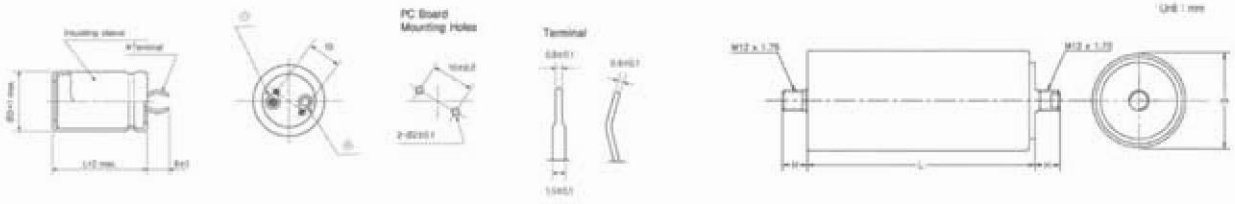
STANDARD TYPE

EDLC, also known as super-capacitor is symmetric electrochemical capacitors in which energy storage is achieved by means of the physical adsorption of ions to the large specific surface area of activated carbon. EDLC consists of active carbon and an organic solvent. To meet consumer demand for higher current, SAMWHA produces EDLC which features higher power density and longer cycle life.

Specifications

Item	Characteristics	
Operating temperature range	-20 ~ +60℃	
Rated Voltage(Surge)	2.7VDC (2.8V)	
Usable Voltage range	2.7 ~ 0V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ±30% of initial value at +20℃
	Internal resistance	Less than 200% of initial at +20℃
Endurance(2.7:60℃)	Test time	1000 hours
	Capacitance change	Within ±30% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life(2.7:60℃)	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	1,000,000 cycles	(1) I△CI〈30% and △ESR〈200% of initially specified value, respectively and LC〈specified value (2) Cycle : between rated voltage and half rated voltage under constant current at 25℃

Drawing(not to scale)



Product list

Type	Rated Voltage(V)	Capacity(0~2.7V) (F)	Capacity(0~2.7V) (mAh)	ESR, 1kHz (mΩ)	ESR, DC (mΩ)	LC(72hours) (mA Max.)	Specific Energy (Wh/kg)	Specific Energy (Wh/L)	Weight (g)	Dimension ΦD×L(mm)
Snap-in	2.7	100	75	10	13	0.27	5.0	5.9	20	22×45
		200	155	7	9	0.52	5.6	6.3	36	30×45
		200	155	5	7	0.54	5.9	5.9	34	35×35
		400	290	3.5	5	1.08	6.2	6.9	65	35×60
Axial	2.7	1200	900	0.45	0.60	3.1	4.1	5.7	290	60×74
		2000	1500	0.3	0.35	5.3	5.0	6.9	400	60×102
		3000	2200	0.24	0.29	8.1	5.7	7.7	525	60×138

* For the special capacitance or design, please contact our sales representatives or product engineers.

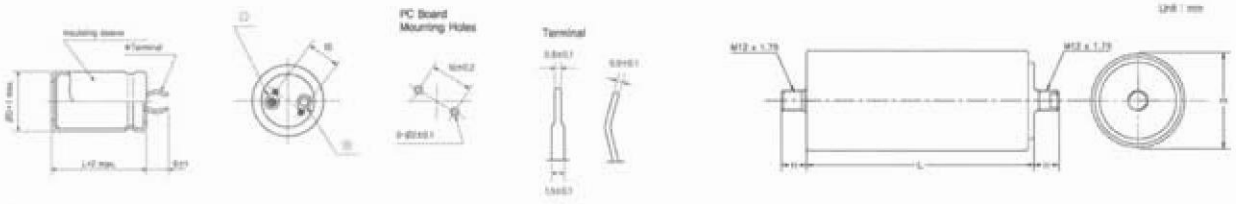
HIGH TEMPERATURE TYPE

"HIGH TEMPERATURE TYPE" product line enhances high temperature operation characteristics compared to standard type EDLC product line.
It consists of environmentally friendly active carbon and an organic.

Specifications

Item	Characteristics	
Operating temperature range	-40 ~ +80℃	
Rated Voltage(Surge)	2.5VDC (2.6V)	
Usable Voltage range	2.5~ 0V	
Capacitance tolerance	-10 ~ +20% at 20℃	
Low temperature characteristics	Capacitance change	Within ± 20% of initial value at +20℃
	Internal resistance	Less than 100% of initial at +20℃
Endurance(2.7:80℃)	Test time	1000 hours
	Capacitance change	Within ± 30% of initial value
	Internal resistance	Less than 200% of initial at specified value
Shelf life(2.7:60℃)	After 1000 hours no load test same as endurance	
Cycle Life (25℃) [1][2]	500,000 cycles	(1) I △CI〈30% and △ESR〈200% of initially specified value, respectively and LC〈specified value (2) Cycle : between rated voltage and half rated voltage under constant current at 25℃

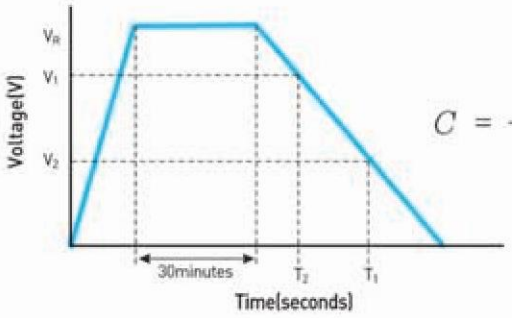
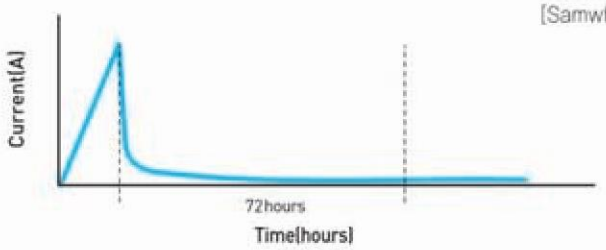
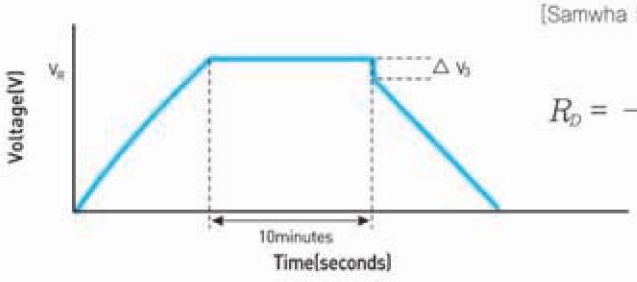
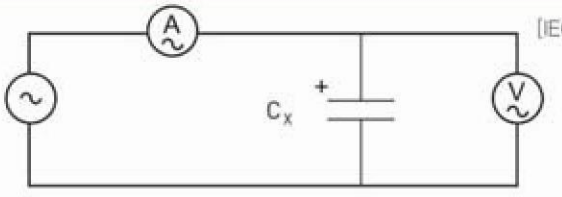
Drawing(not to scale)

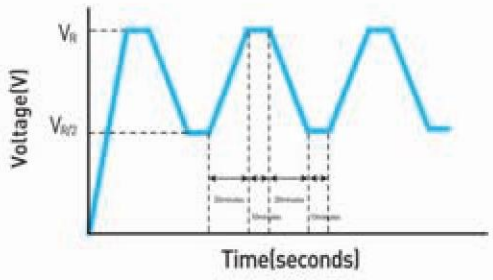


Product list

Type	Rated Voltage(V)	Capacity(0~2.7V) (F)	Capacity(0~2.7V) (mAh)	ESR, 1kHz (mΩ)	ESR, DC (mΩ)	LC(72hours) (mA Max.)	Specific Energy (Wh/kg)	Specific Energy (Wh/L)	Weight (g)	Dimension ΦD×L(mm)
Snap-in	2.5	100	70	9	11	0.27	4.3	5.1	20	22×45
		200	145	8	10	0.52	4.8	5.4	36	30×45
		200	145	7	9	0.54	5.1	5.1	34	35×35
		400	270	3	5	1.08	5.3	5.9	65	35×60
Axial	2.5	1200	840	0.4	0.5	3.1	3.5	4.9	295	60×74
		2000	1400	0.3	0.4	5.2	4.3	5.9	400	60×102
		3000	2000	0.2	0.3	7.6	4.9	6.6	525	60×138

* For the special capacitance or design, please contact our sales representatives or product engineers.

No	Item		Unit	Test Conditions and Methods
1	Capacitance at 20℃		F	[IEC 62391-1]  $C = \frac{I \times (T_1 - T_2)}{V_1 - V_2}$ (F) 1) Charging is performed by constant current followed by constant voltage charging. 2) Charging is performed for duration of 30 minutes a rated voltage. 3) Discharge use a constant current load device and measure the time for the terminal voltage to drop from V_1 to V_2 upon discharge at 1mA/F.
2	Leakage current after 72 hours		mA	[Samwha Standard]  Supercapacitor is charged with the rated voltage for 72hours. Then, leakage current is measured by current measurement equipment.
3	Internal resistance (ESR)	DC	mΩ	[Samwha Standard]  $R_D = \frac{\Delta V_3}{I}$
		AC 1kHz	mΩ	[IEC 62391-1]  $R_A = \frac{\Delta V}{I}$ 1) The internal re R_a of a capacitor shall be calculated by the above formula. 2) The frequency of the measuring voltage shall be 1kHz. 3) The AC current shall be from 1mA to 10mA.

<table>
<tr><th>No</th><th colspan="2">Item</th><th>Unit</th><th>Test Conditions and Methods</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Temperature
Characteristic</td><td>Capacitance
change</td><td>%</td><td rowspan="2">[Samwha Standard]
<table><tr><th>Temperature(℃)</th><th>Keep Time(hours)</th></tr><tr><td>+20</td><td>2</td></tr><tr><td>-20</td><td>2</td></tr><tr><td>-40</td><td>2</td></tr><tr><td>+20</td><td>2</td></tr><tr><td>+40</td><td>2</td></tr><tr><td>+60</td><td>2</td></tr><tr><td>+80[1]</td><td>2</td></tr></table>Measure electrical characteristics after exposing capacitor to each temperature atmosphere for 2 hours.
1] For 80℃ testing, the temperature is only applicable in the high temperature type products.</td></tr>
<tr><td>Internal
resistance
change</td><td>%</td></tr>
<tr><td>5</td><td colspan="2">Shelf life
after 1000 hours no load
test same as
endurance</td><td>%</td><td>[Samwha Standard]
Temperature : 60(80)±2℃
Duration : 1000 +72/-0 hours</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Cycle
life
(at 25℃)</td><td>Cycle</td><td>Cycle</td><td rowspan="3">[DOE/ID-10491]
 
where V_R is the rated voltage
$V_{R/2}$ is half of the rated voltage
Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at $V_{R/2}$.
Then charge the capacitor at a current In = (V_R /40) to V_R or at the value of In determined experimentally so that the voltage reaches V_R in 20(±1)s. Maintain voltage V_R on the capacitor for 10±0.50s. Then discharge the capacitor to $V_{R/2}$ at current In.
Hold at $V_{R/2}$ for 10±0.50 s. This defines a cycle (see Figure).
Repeat this cycle throughout the testing, adjusting In as needed in order to maintain the initial charge/discharge times.

* life time is provision value</td></tr>
<tr><td>Capacitance
change</td><td>%</td></tr>
<tr><td>Internal
resistance
change</td><td>%</td></tr>
</table>

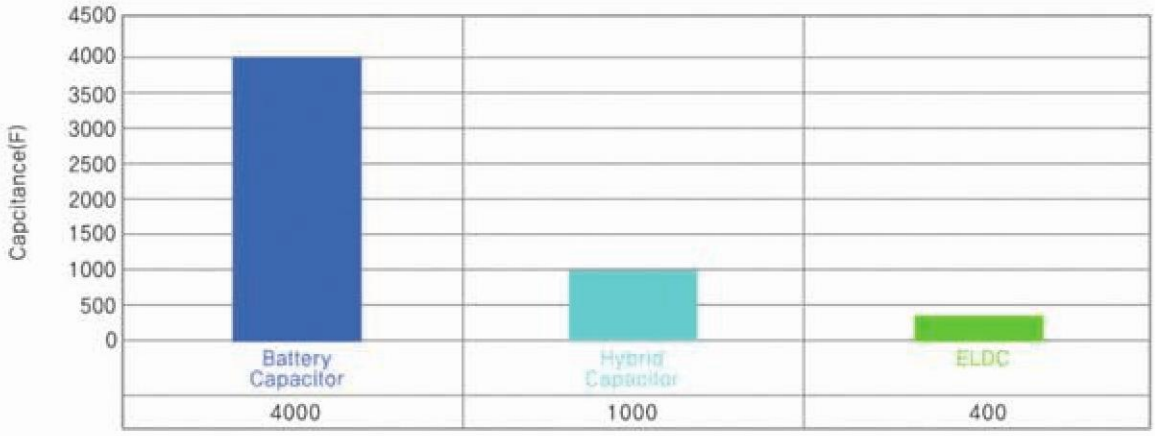
ELECTRICAL CHARACTERISTICS

Energy density

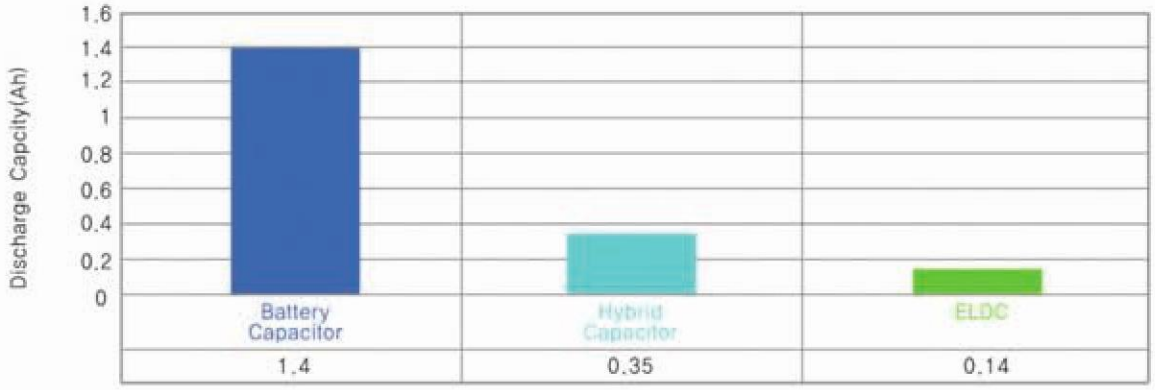
Test conditions

- Test cells : 3560 Snap-in
- Current : 1A
- Voltage : 1.6~2.7V
- Temp. : R. T.

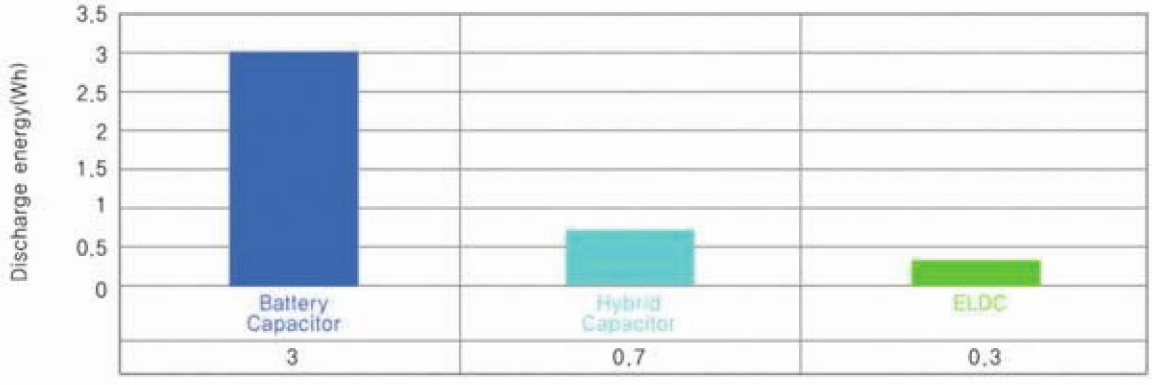
Capacitance(F)



Discharge capacity(Ah)



Discharge energy(Wh)



! All specifications in this paper are subject to change without notice for production improvement.

! Please request for a data sheet for detailed product data prior to the purchase

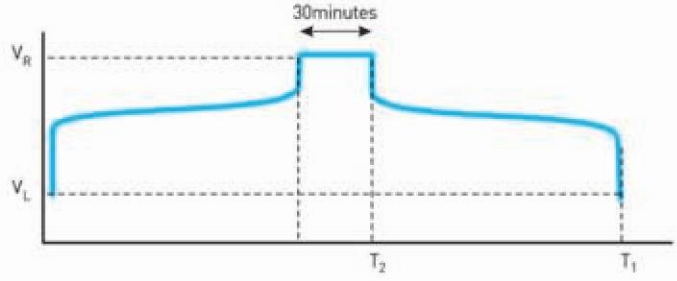
Capacitance

Formula 1: $C = \frac{I \times (T_1 - T_2)}{V_1 - V_2} \ (F)$

Formula 2: $E = \frac{\frac{1}{2} \times C \times (V_R)^2}{3600} \ (Wh)$

Battery capacitor(Formula 2)

[Samwha Standard]



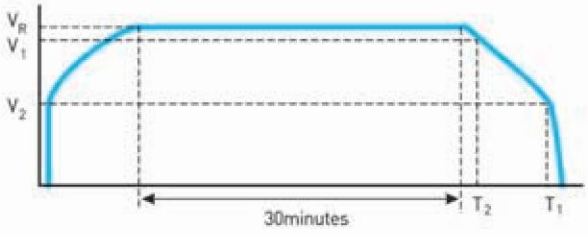
Where

- C is the capacitance (F)
- E is the stored energy (Wh)
- V_R is the rated voltage (V)
- V_L is the measurement end voltage (V) : 1.5 V
- T_1 is the time from discharge start to reach 1.5V (s)
- T_2 is the discharge start time (s)

The stored energy(Wh) is measured value from instrument

Hybrid capacitor(Formula 1)

[Samwha Standard]

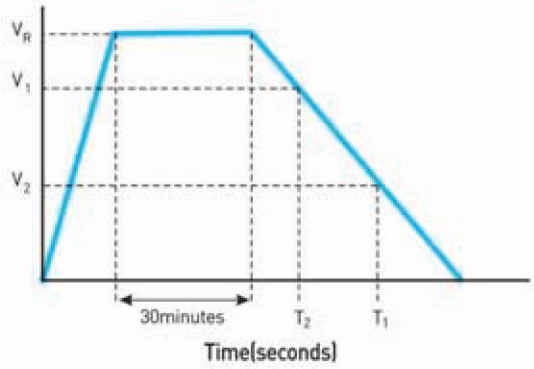


Where

- C is the capacitance (F)
- I is the discharge current (A)
- V_R is the rated voltage (V)
- V_1 is the measurement starting voltage (V) : 2.5V
- V_2 is the measurement end voltage (V) : 1.5 V
- T_1 is the time from discharge start to reach V_2 (s)
- T_2 is the time from discharge start to reach V_1 (s)

EDLC(Formula 1)

[IEC 62391-1]



Where

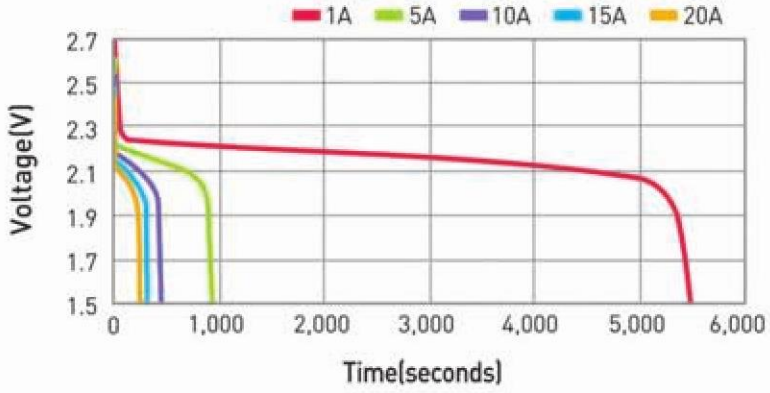
- C is the capacitance (F)
- I is the discharge current (A)
- V_R is the rated voltage (V)
- V_1 is the measurement starting voltage (V) : $0.8 \times V_R$
- V_2 is the measurement end voltage (V) : $0.4 \times V_R$
- T_1 is the time from discharge start to reach V_2 (s)
- T_2 is the time from discharge start to reach V_1 (s)

ELECTRICAL CHARACTERISTICS

Power density(CC Discharge)

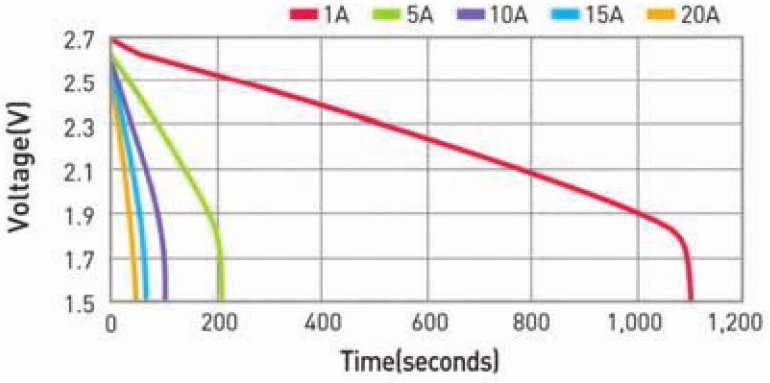
Test conditions
- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Temp. : R. T.

Battery capacitor



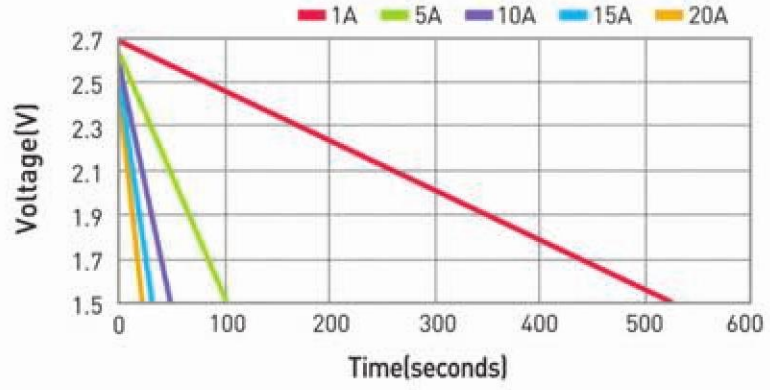
Amp. / Unit	1A	5A	10A	15A	20A
Time (seconds)	5477	931	447	307	244
Max. Temp(℃)	22	24	28	33	39

Hybrid capacitor



Amp. / Unit	1A	5A	10A	15A	20A
Time (seconds)	1100	212	102	66	49
Max. Temp(℃)	22	23	25	27	30

EDLC



Amp. / Unit	1A	5A	10A	15A	20A
Time (seconds)	530	102	49	32	23
Max. Temp(℃)	22	22	23	24	25

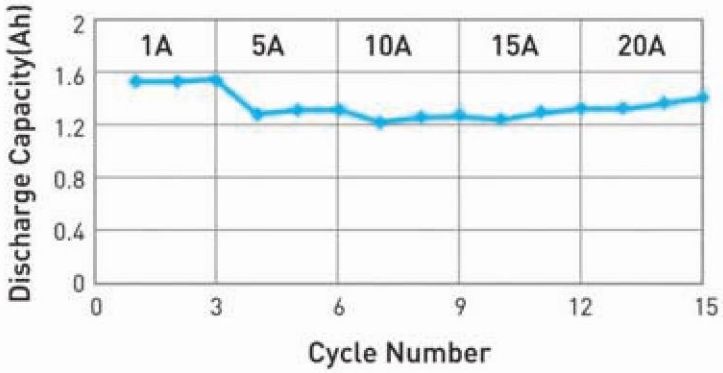
! All specifications in this paper are subject to change without notice for production improvement.

! Please request for a data sheet for detailed product data prior to the purchase

Power density(CC Discharge)

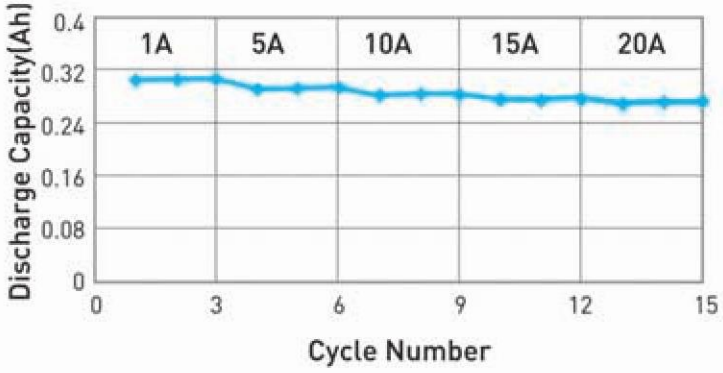
Test conditions
- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Temp. : R. T.

Battery capacitor



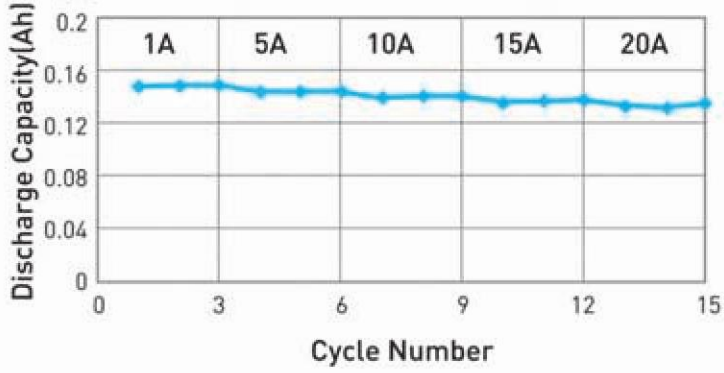
Amp. / Unit	1A	5A	10A	15A	20A
Capacity (Ah)	1.520	1.276	1.203	1.230	1.308
Retention (%)	100	85	82	86	89

Hybrid capacitor



Amp. / Unit	1A	5A	10A	15A	20A
Capacity (Ah)	0.304	0.295	0.284	0.277	0.272
Retention (%)	100	97	94	92	90

EDLC



Amp. / Unit	1A	5A	10A	15A	20A
Capacity (Ah)	0.147	0.143	0.139	0.135	0.132
Retention (%)	100	97	94	92	90

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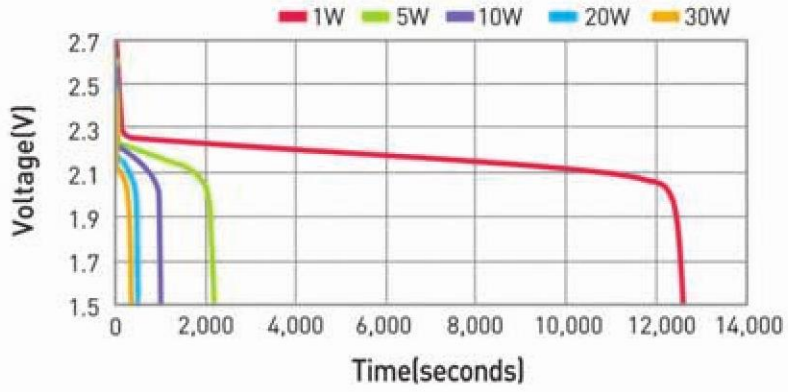
! Please request for a data sheet for detailed product data prior to the purchase

ELECTRICAL CHARACTERISTICS

Power density(Watt Discharge)

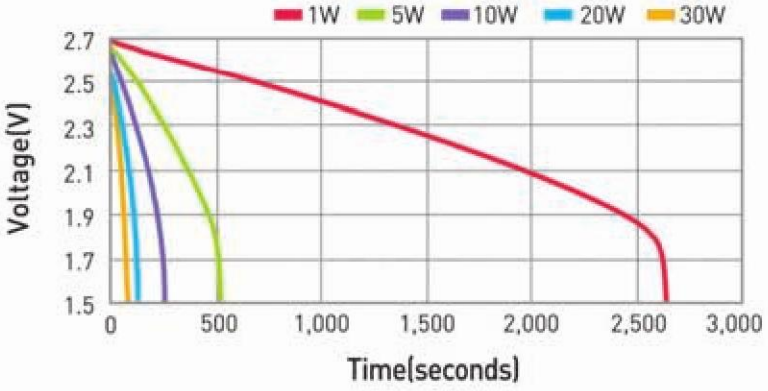
Test conditions
- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Temp. : R. T.

Battery capacitor



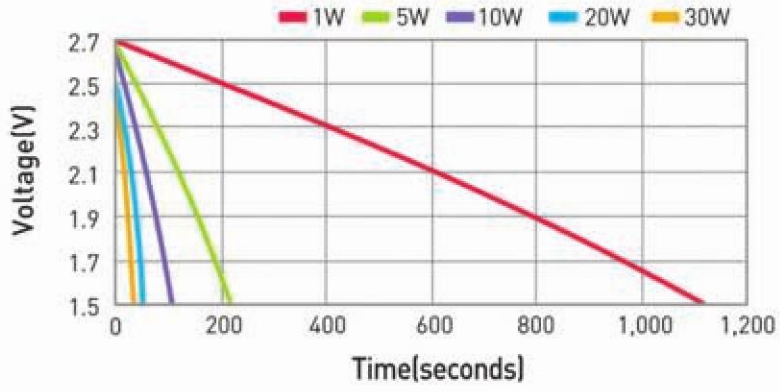
Watt / Unit	1w	5w	10w	20w	30w
Time (seconds)	12611	2161	992	466	315
Max. Temp(℃)	22	22	23	27	32

Hybrid capacitor



Watt / Unit	1w	5w	10w	20w	30w
Time (seconds)	2624	509	247	117	75
Max. Temp(℃)	22	22	23	24	26

EDLC



Watt / Unit	1w	5w	10w	20w	30w
Time (seconds)	1109	218	106	51	32
Max. Temp(℃)	22	22	22	23	24

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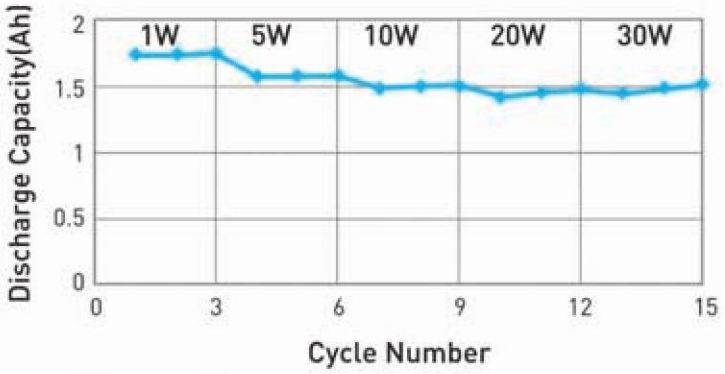
Power density(Watt Discharge)

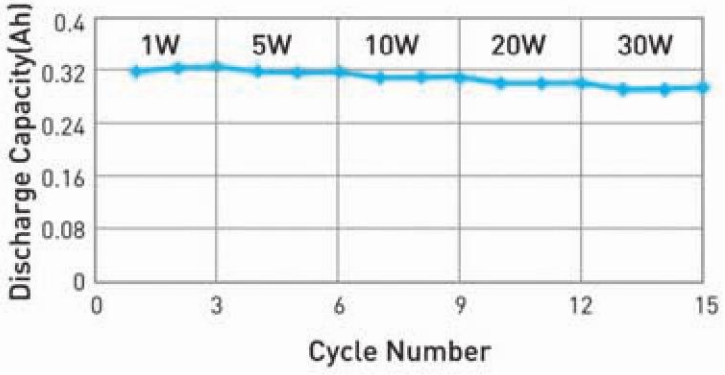
Test conditions
- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Temp. : R. T.

Battery capacitor



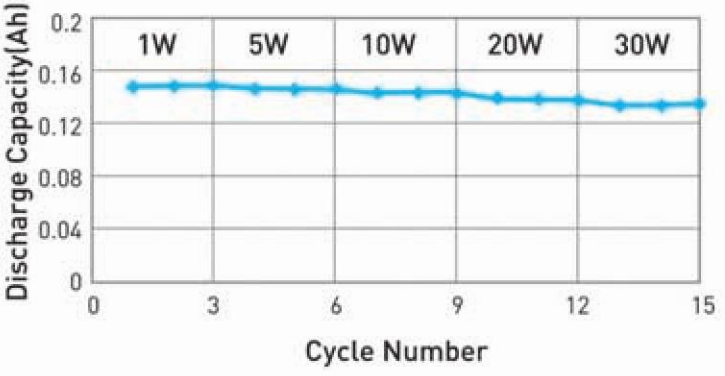
Watt / Unit	1w	5w	10w	20w	30w
Capacity (Ah)	1.608	1.386	1.283	1.190	1.219
Retention (%)	100	86	80	77	78

Hybrid capacitor



Watt / Unit	1w	5w	10w	20w	30w
Capacity (Ah)	0.318	0.316	0.309	0.298	0.291
Retention (%)	100	99	97	94	91

EDLC



Watt / Unit	1w	5w	10w	20w	30w
Capacity (Ah)	0.147	0.145	0.142	0.137	0.133
Retention (%)	100	99	97	93	90

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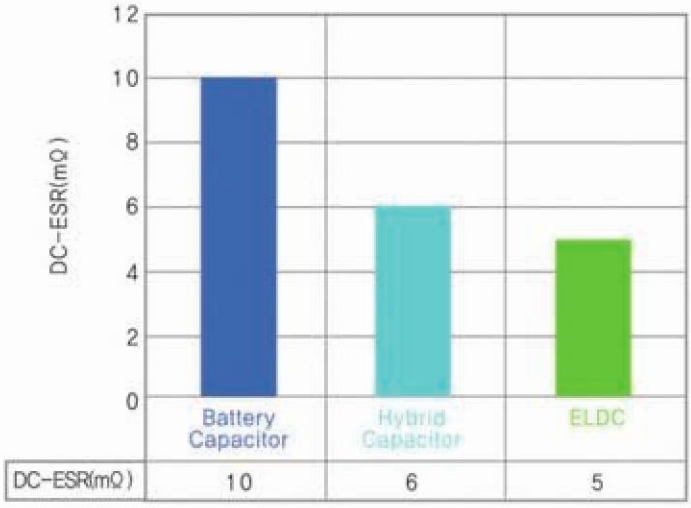
ELECTRICAL CHARACTERISTICS

Resistance

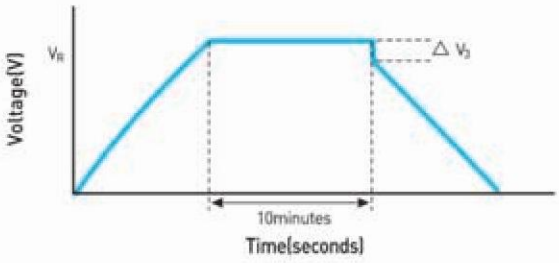
Test conditions
- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Temp. : R.T.

DC-ESR(mΩ)

[Samwha Standard]



DC-ESR(mΩ)	Battery Capacitor	Hybrid Capacitor	ELDC
	10	6	5



1) Constant current charge with 10mA/F to V_R

2) Constant voltage charge at V_R for 10minutes

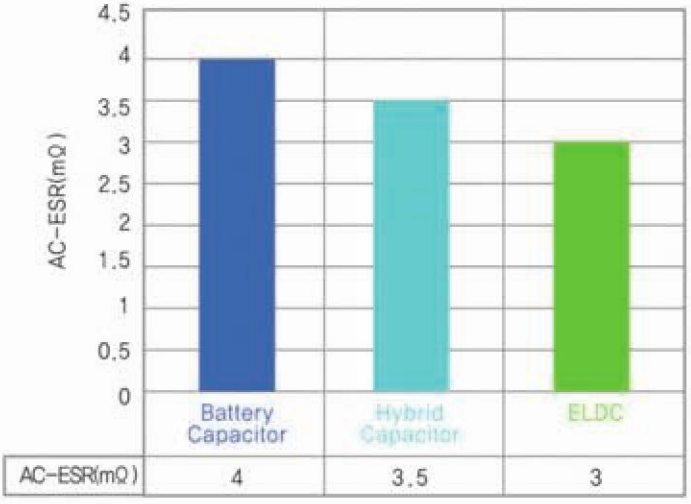
3) Constant current discharge with 10mA/F to 0.1V

4) ΔV_3 is measured by measurement equipment

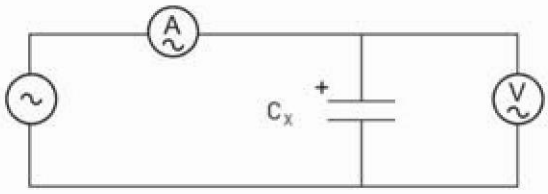
$$R_D = \frac{\Delta V_3}{I}$$

AC-ESR(mΩ)

[IEC 62391-1]



AC-ESR(mΩ)	Battery Capacitor	Hybrid Capacitor	ELDC
	4	3.5	3



1) The internal resistance R_a of a capacitor shall be calculated by the below formula.

2) The frequency of the measuring voltage shall be 1kHz.

3) The AC current shall be from 1mA to 10mA.

$$R_A = \frac{\Delta V}{I}$$

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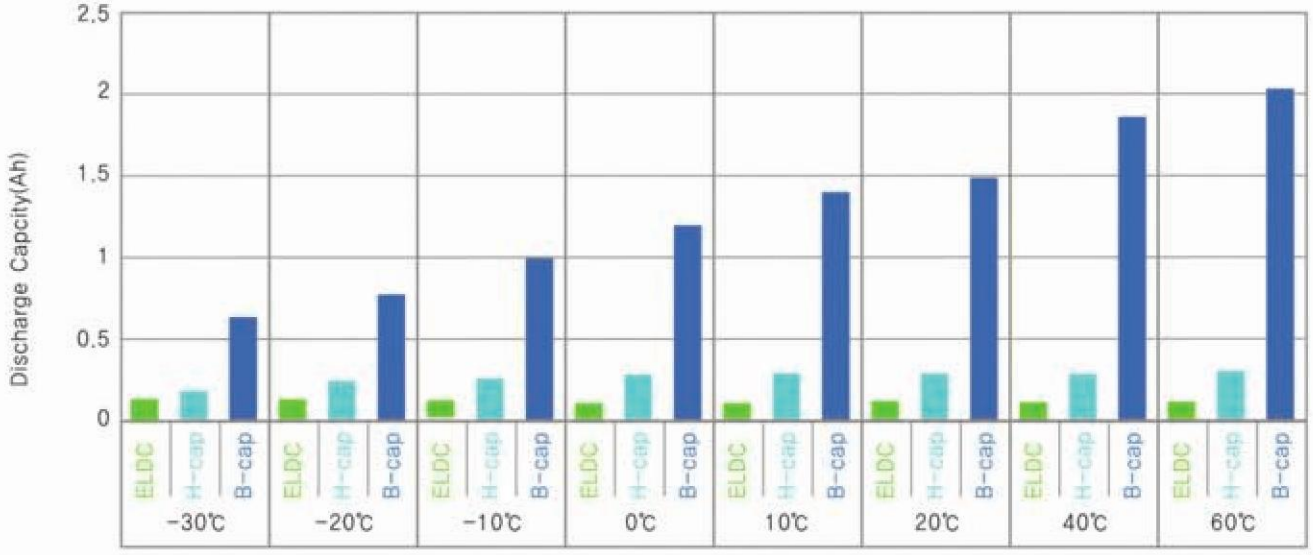
Operating Temperature

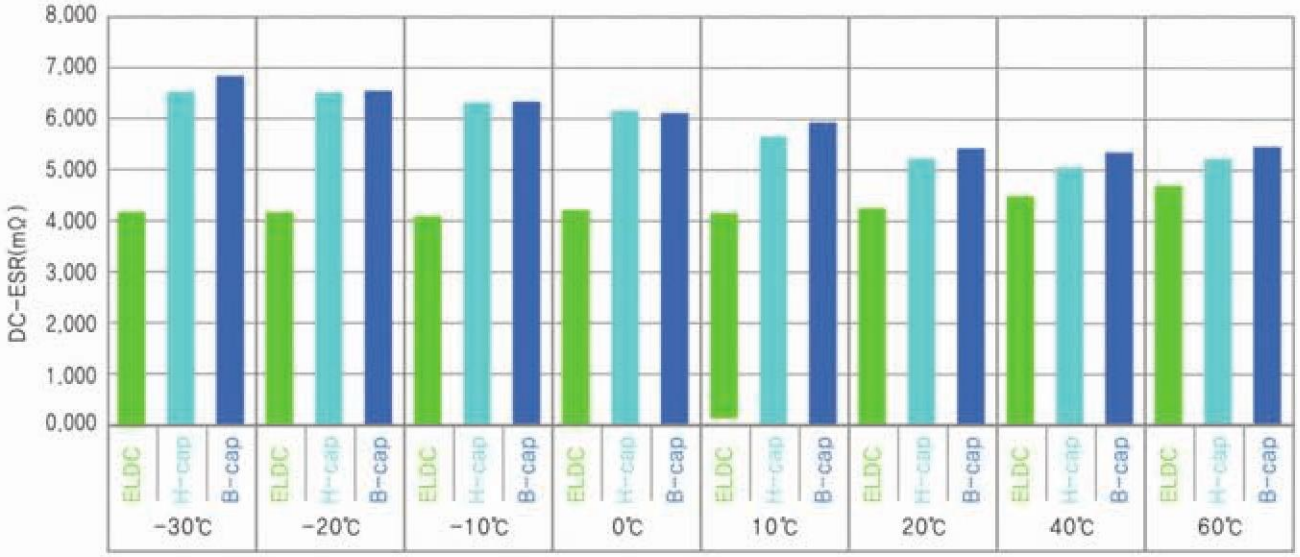
Test conditions

- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Current. : 1A

Discharge Capcity



DC-ESR(mΩ)



The capacitor's capacity that is the amount of electric charge it can deliver at the rated voltage is changed according to ambient temperature. The capacity changes in proportion to the ambient temperature. Basically, it shows the greater capacity at the higher temperature and the lower capacity below zero degrees Celsius.

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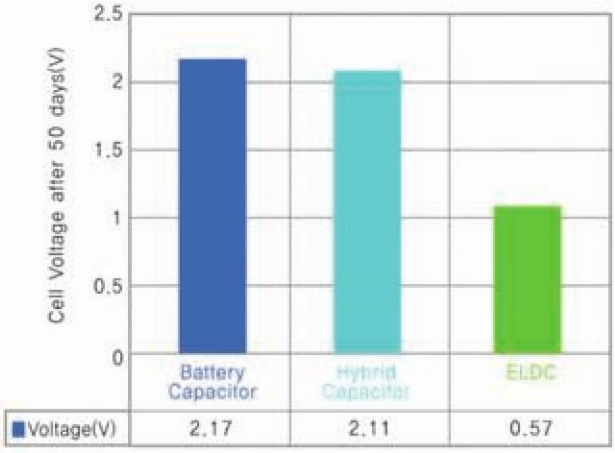
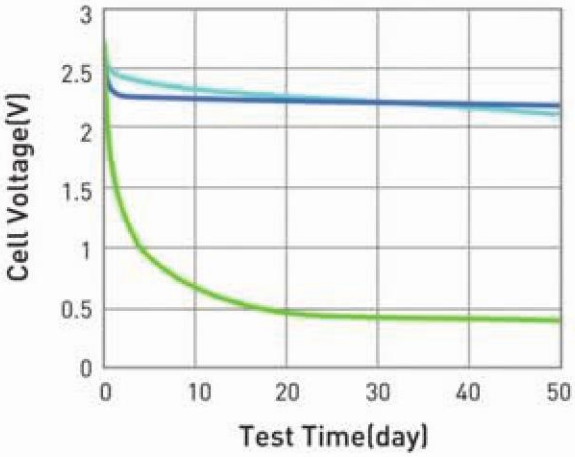
Self discharge



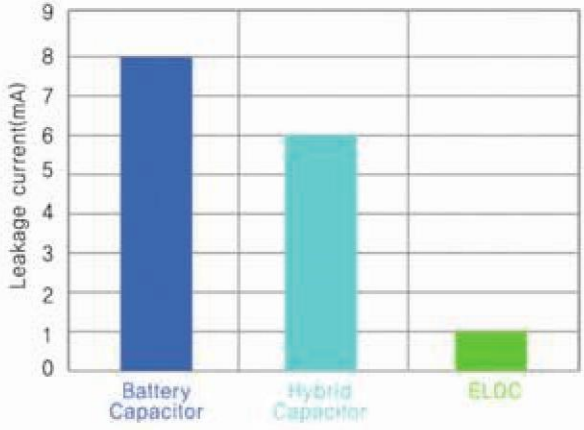


Self-discharge is a phenomenon in capacitors in which internal chemical reactions reduce the stored charge of the capacitors without any connection between the electrodes. Self-discharge decreases the shelf life of capacitors and causes them to initially have less than a full charge when actually put to use.

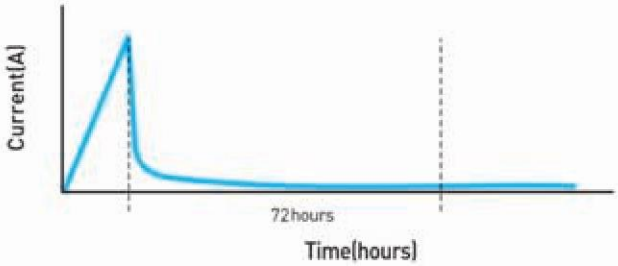
How fast self-discharge in a capacitor occurs is dependent on the type of capacitor, state of charge, charging current, ambient temperature and other factors.

Hybrid capacitors and Battery capacitors, which show the self-discharge rates of 22% and 19% after 50days, respectively have much lower self-discharge rates than EDLC

Leakage current



[Samwha Standard]



The ESD-SCAP is charged with the rated voltage for 72hours.

Then, leakage current is measured by currentmeasurement equipment.

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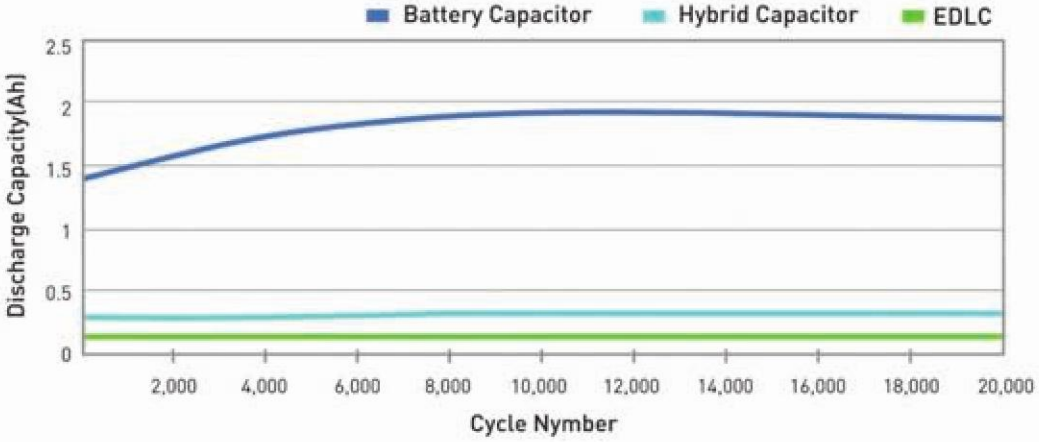
Cycle Performance

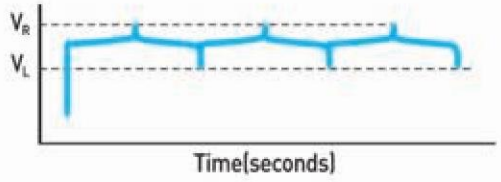
Test conditions

- Test cells : 3560 Snap-in
- Voltage : 1.6~2.7V
- Current. : 10A
- Temp. : R. T.



Battery capacitor(Formula 2)

[Samwha Standard]

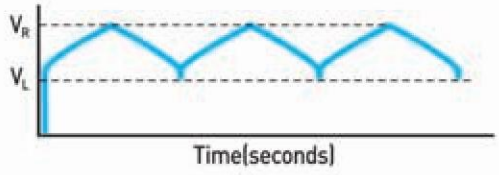


where V_R is the rated voltage of 2.7V
V_L is the low voltage of 1.6V

Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at V_L(1.6V). Then charge the capacitor at a rated current to V_R. Maintain voltage V_R on the capacitor for 10±0.50 s. Then discharge the capacitor to V_L at rated current. Hold at V_L for 10±0.50 s. This defines a cycle. Repeat this cycle throughout the testing.

Hybrid capacitor

[Samwha Standard]

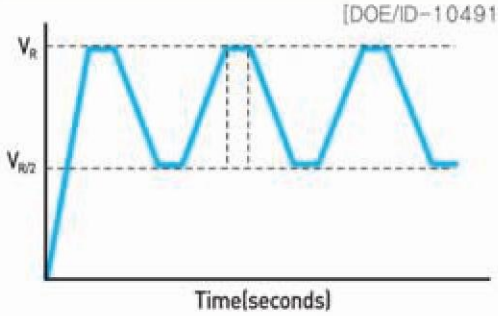


where V_R is the rated voltage of 2.8V(2.7V)
V_L is the low voltage of 1.6V(0.9V)
(V) : LMO hybrid type

Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at V_L. Then charge the capacitor at a rated current to V_R. Maintain voltage V_R on the capacitor for 10±0.50 s. Then discharge the capacitor to V_L at rated current. Hold at V_L for 10±0.50 s. This defines a cycle. Repeat this cycle throughout the testing.

EDLC

[DOE/ID-10491]



where V_R is the rated voltage
$V_{R/2}$ is half of the rated voltage

Condition the capacitor at 25±3℃ until thermal equilibrium is reached. Initialize the voltage on the capacitor at $V_{R/2}$. Then charge the capacitor at a current In = (V_R /40) to V_R or at the value of In determined experimentally so that the voltage reaches V_R in 20(±1)s. Maintain voltage V_R on the capacitor for 10±0.50 s. Then discharge the capacitor to $V_{R/2}$.

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