1. Small li-ion rechargeable batteries

1-1 Structure of small li-ion rechargeable batteries for use in devices where L and W dimensions are limited.

The table below provides an overview of the SLB.

Table 1–1. Product specifications

Category		Function
Product number		SLB03070LR35
Nominal capacity*[1]		0.35mAh
ESR@1kHz*[2]		Max. 12Ω
Voltage	Average operating voltage	2.4V
	Maximum charging voltage	2.8V
	Minimum discharge voltage	1.8V
Current	Maximum charging current	7mA
	Maximum discharging current	7mA
Temperature	Operational temperature range	–30°C to +60°C
	Storage temperature range	–30°C to +60°C

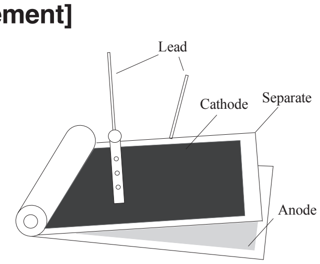
*[1] Nominal capacity measurement direction

(1) Pre-discharging: Discharging at 1C (0.35mA) to the lower-limit voltage of 1.8V
(2) Charging: After charging at 1C (0.35mA) to the upper-limit voltage of 2.8V, constant-voltage charging* at 2.8V
*Constant-voltage charging occurs until nominal capacity x 5% (mA) is reached.
(3) Resting: 30 minutes
(4) Discharging: Discharging at 1C (0.35mA) to the lower-limit voltage of 1.8

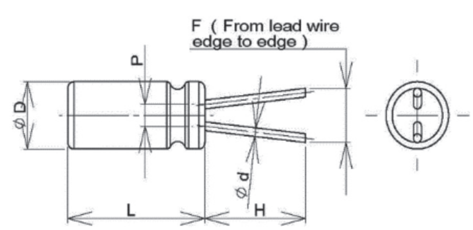
*[2] ESR measurement direction:

(1) Pre-discharge: Discharging at 1C (0.35mA) to the lower- limit voltage of 1.8V
(2) Charging: After charging at 1C (0.35mA) to 2.4V, charging at rated capacity x 5% (mA) at 2.4V
(3) Measuring: AC impedance measurement used to check actual resistance at 1kHz

[Winding element]



[Product exterior]



[Product dimensions]

Size	φD_0	L_0	φd	P
φ3×7L	3.1±0.1	6.8+0.2/–0.1	0.40±0.05	1.0±0.3

Figure 1-1. Shape and dimensions of small li-ion rechargeable batteries

1-2 Materials in small li-ion rechargeable batteries

Small li-ion rechargeable batteries are manufactured by applying the electrode technology utilized in Toshiba Corporation's SCiB™ rechargeable batteries. The most distinctive feature in the design of our small li-ion rechargeable batteries is the use of lithium titanate ($Li_4Ti_5O_{12}$) rather than graphite as the anode active material. As is discussed in "2. Features of small li-ion rechargeable batteries", The selection of the optimal electrolyte and separator combined with the lithium titanate electrode is key to realizing the battery's superior functionality.

The cathode and anode reactions during charging and discharging of small li-ion rechargeable batteries is described below.

In electric double-layer capacitors, the electrode surface and ions in the electrolyte form an electric double layer that forms the energy storage mechanism. By comparison, small li-ion rechargeable batteries use an electrochemical storage mechanism that utilizes electrochemical reactions. Battery capacity is realized through the adsorption and release of lithium ions in the electrodes. Self-discharge is limited as a result.

Standard lithium-ion rechargeable batteries use electrolytes comprised of lithium salts dissolved in an organic solvent. The lithium ions in the electrolytes remain suspended in the organic solvent. When a designated voltage is applied, the lithium ions migrate, resulting in them becoming stacked within the anode.

On the surface of the anode's active material is a solid electrolyte interphase (SEI) coating—a compound in which electrolytes undergo reductive decomposition and possess high lithium conductivity. As Figure 1-2 shows, when the anode undergoes the electrochemical reaction, the disassociated lithium ions pass through the SEI coating and begin to stack up.

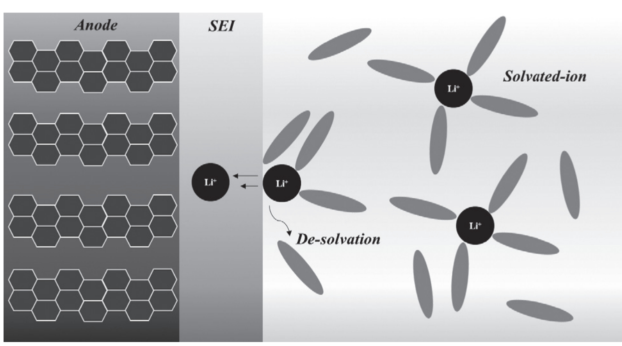


Figure 1-2. Reaction mechanism on the anode of lithium-ion rechargeable batteries

However, the passage of lithium ions through the SEI coating on the surface of the anode active material generates significant resistance, and that resistance becomes larger as SEI coatings grow thicker. In addition, lithium ions are consumed in the electrolyte when SEI coatings are formed. An effective way to form a thin SEI coating is to select anode materials that have a reaction potential higher than the electrolyte's decomposition rate.

Graphite is typically used as the anode material for standard lithium-ion rechargeable batteries. The potential for reaction with the lithium ions is extremely small, at 0.1V vs. Li/Li+, which is one reason for the decomposition of electrolytes, and the formation of thick SEI coatings. This results in higher levels of resistance. By contrast, using lithium titanate in the anodes the lithium ions reaction voltage is 1.55V vs. Li/Li+, reactions at a higher potential result in the formation of a thin SEI coating that reduces electrolyte decomposition. The lower resistance means fewer lithium ions are consumed in the electrolyte, and superior life properties are acheived.

Optimizing the electrode, separator, and electrolyte results in superior high-temperature tolerance and cycle life performance. Using highly safe active materials results in superior product safety.

2. Features of small li-ion rechargeable batteries

2-1 Key features of small li-ion rechargeable batteries

Small li-ion rechargeable batteries have higher capacity and less leakage current than electric double-layer capacitors. Compared with standard lithium-ion rechargeable batteries, they have higher-speed charging and discharging, longer life, and better safety. The SLB batteries are capable of high-power discharge, which is extremely difficult to achieve with standard lithium-ion rechargeable batteries. They can be discharged over longer periods of time, which is not possible with electric double-layer capacitors.

2-2 Comparison with electric double-layer capacitors

Small li-ion rechargeable batteries contain nearly 50 times as much energy as its electric double-layer capacitors of the same size. Our small li-ion rechargeable batteries can be used in place of electric double-layer capacitors to power devices for longer periods of time.

* The following data are not guaranteed values.

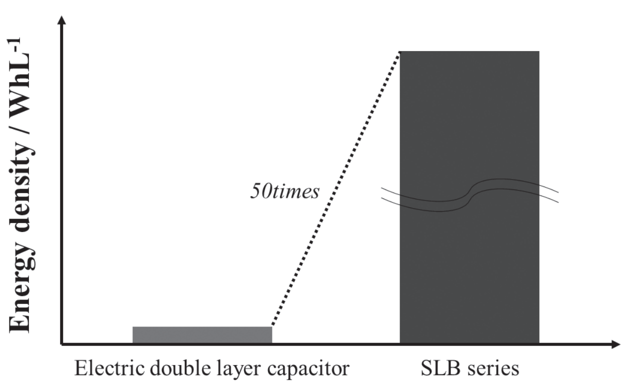


Figure 2-1. Comparison of volume energy densities of NICHICON's electric double-layer capacitors and its small li-ion rechargeable batteries

Materials in small li-ion rechargeable batteries store and release electrical energy through the electrochemical reactions of lithium ions in the electrode active materials and the electrolyte. In the charged state, the self-discharge of the battery is low, as the electrode active materials are chemically stable by the charged voltage. The anode active material, lithium titanate, has excellent thermal stability, and resists self-discharge at high-temperature. Figure 2-2 shows the self-discharge behavior of a fully charged ϕ3x7L; 0.35mAh products at different ambient temperatures.

After being charged to 2.7V and stored at 60°C for 30 days, NICHICON's electric double-layer capacitors drop in voltage to 1.97V. By contrast, after being charged to 2.8V, Small li-ion rechargeable batteries (ϕ3x7L) drop in voltage to 2.6V, indicating the leakage current is small.

* The following data are not guaranteed values.

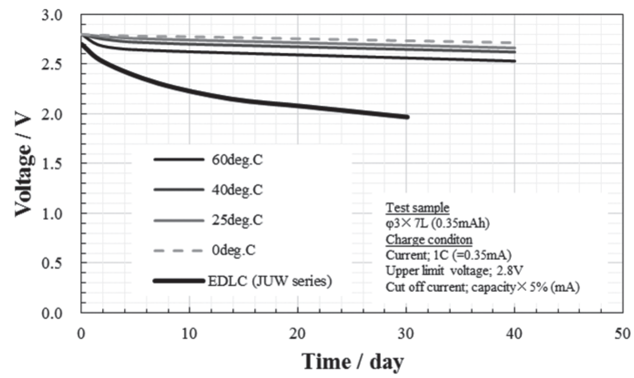


Figure 2-2. Changes in voltage on the ϕ3x7L; 0.35mAh when stored fully charged at different temperatures

Because this product demonstrates little self-discharge, they can be used for a long period of time without charging. This allows them to be used in conjunction with energy-harvesting technology, improving efficiency as they can store energy for a long period of time after being charged.

2-3 Comparison with general lithium-ion rechargeable batteries

2-3-1 Ultra-fast charge/discharge function

Small li-ion rechargeable batteries are superior to standard lithium-ion rechargeable batteries in their charge/discharge characteristics. Standard lithium-ion rechargeable batteries typically take about 1 hour to charge, while product can be charged and discharged at up to 20C (20 times the current value needed for charging in one hour; for the ϕ3x7L; 1C=0.35mA, 20C=7mA). Figure 2-3 shows the charging time and charging rate for different C rates on the ϕ3x7L. If charged at 20C, the battery could be charged to 80% of a full charge in around three minutes.

The ability to charge the batteries rapidly optimizes their use in devices that require short charging times and when charging is interrupted or forgotten.

* The following data are not guaranteed values.

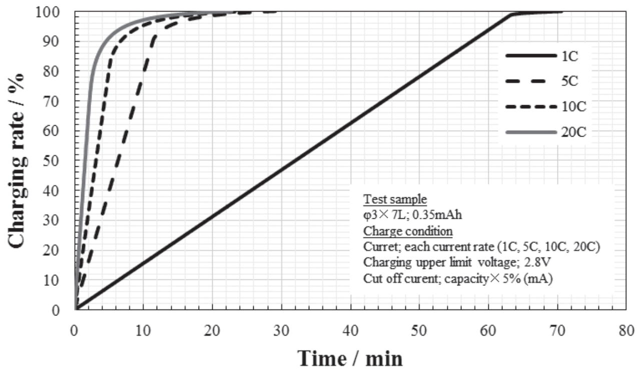


Figure 2-3. Relationship between charging time and charging rate of ϕ3x7L at different charging current rates

Figure 2-4 shows discharging time versus remaining capacity for the ϕ3x7L at different C rates. If discharged at a current value of 20C, the maximum guaranteed discharging current value, the battery could be discharged completely in approximately 3 minutes. Due to the extremely large discharge current given the product's size, the battery is well suited for use in devices that require high power and a small size.

* The following data are not guaranteed values.

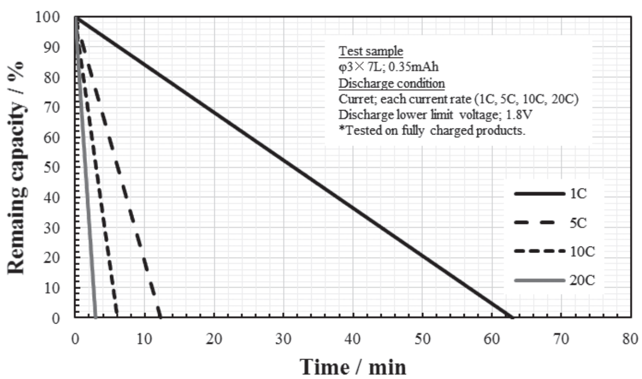


Figure 2-4. Relationship between discharging time and remaining capacity of ϕ3x7L at different discharging current rates

2-3-2 Low-temperature characteristics

Small li-ion rechargeable batteries have excellent low-temperature characteristics. Standard lithium-ion rechargeable batteries charging at temperatures significantly below 0°C becomes difficult, because lithium ions are less likely to be adsorbed by the anode (graphite) and tend to condense as lithium metal. Also, if the temperature is extremely low, dendrites form when lithium metal condenses, which can penetrate through the separator between the cathode and anode, causing an internal short circuit. If an internal short circuit occurs, an extremely high current passes through the short-circuit area, generating heat. Next the anode and electrolyte react causing decomposition within the electrolyte followed by the cathode and electrolyte reacting. Sparks from the short circuit and the release of oxygen due to the collapse of the cathode's crystal structure can result in an oxygen combustion reaction. Various exothermic reactions occur one after another resulting in thermal runaway and fire. The SLB use of lithium titanate for the anode, does not suffer thermal runaway due to its low resistance and can be charged and discharged at extremely low temperatures (-30°C).

Figure 2-5 shows charging curves for the ϕ3x7L being charged at 1C for various ambient temperatures. Figure 2-6 shows the discharging curves. At low temperatures, the reaction resistance increases for the electrolyte within the device and between the electrode and electrolyte, necessitating a higher voltage to initiate the charge (discharge), and capacity decreases. At -30°C, charge capacity decreases to around 52% of the level at room temperature, and discharge capacity falls to around 46%. Standard lithium-ion rechargeable batteries have higher resistances, so operation at extremely low temperatures can result in overcharge/over-discharge voltages. Thermal runaway can result in ruptures or fires, so in many cases temperature management in cells that contain thermistors within battery packs is designed to prevent low-temperature operation. The SLB, however, can be used in cold climates and remain safe to use.

* The following data are not guaranteed values.

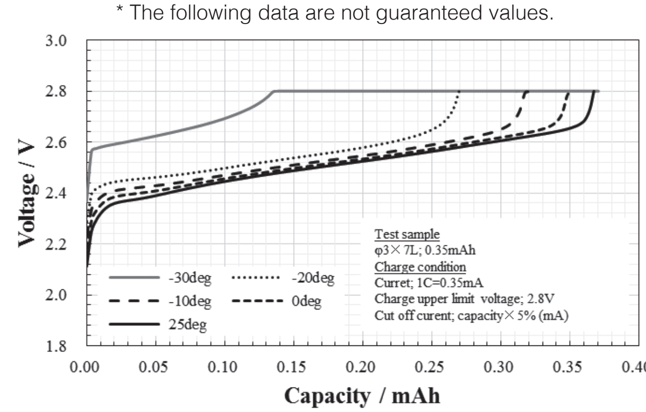


Figure 2-5. Charging curves for ϕ3x7 at a current value of 1C for different ambient temperatures

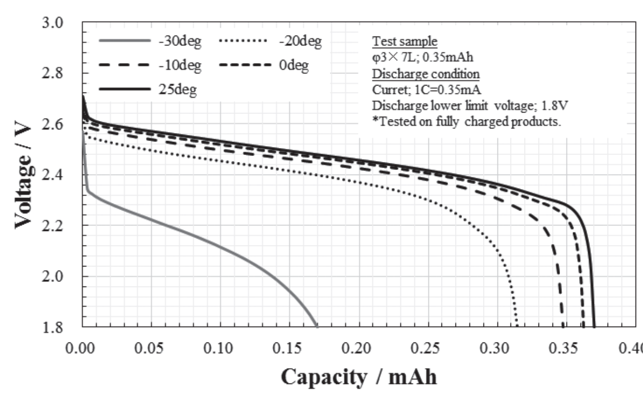


Figure 2-6. Discharging curves for ϕ3x7L at a current value of 1C for different ambient temperatures

2-3-3 Overcharge resistance

Small li-ion rechargeable batteries are more resistant to overcharging than standard lithium-ion rechargeable batteries. Product characteristics for this battery indicate its maximum rated voltage at 2.8V, but no significant capacity degradation was observed in charge/discharge cycle tests involving repeated charging to more than 2.8V. Figure 2-7 shows the results of a charge/discharge cycle test conducted on the ϕ3x7L, where the battery is repeatedly charged to 3.3V at a current value of 10C and discharged to 1.8V, indicating the retention rate for 1C discharge capacity based on the number of cycles. Even when repeatedly overcharged to 3.3V for 1,500 cycles, the retention rate was 98% of initial capacity.

These results suggest that even when operating in conditions where the charging voltage is not controlled no sudden degradation in the product's characteristics occurs.

* The following data are not guaranteed values.

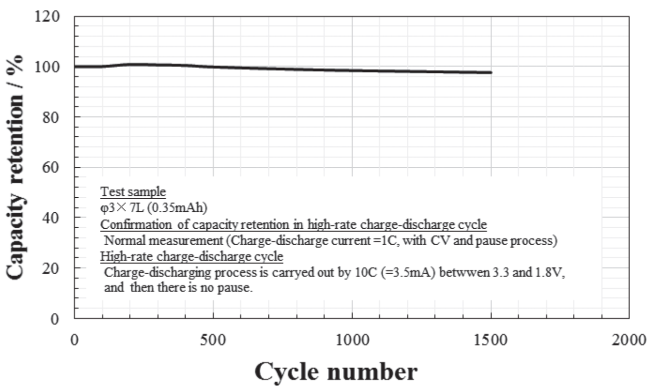


Figure 2-7. Capacity retention rate versus number of charge/discharge cycles when ϕ3x7L charged to 3.3V

2-3-4 Over-discharge resistance

Small li-ion rechargeable batteries are more resistant to over-discharging than standard lithium-ion rechargeable batteries. Product characteristics for this battery indicate its rated minimum voltage at 1.8V, but when subjected to a fully discharged cycle test where the battery is short-circuited for a long period of time, it could again be charged and discharged.

For example, the SLB could be used in temperature sensors for clean-energy applications. If used in energy harvesting of solar power, it could remain uncharged for a long period of time. Figure 2-8 indicates changes in discharge capacity if the ϕ3x7L is attached to a resistor (15Ω) and stored at different ambient temperatures. No significant decline in capacity was observed at different temperatures even when stored fully charged for 1,000 hours.

* The following data are not guaranteed values.

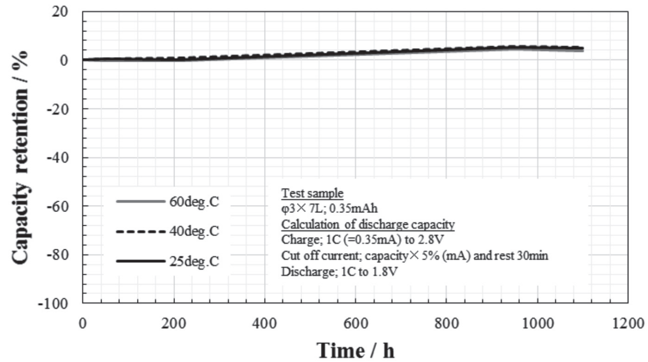


Figure 2-8. Rate of change in discharge capacity when stored fully charged at different ambient temperatures

Figure 2-9 shows the rate of change in discharge capacity for the ϕ3x7L following charge/discharge cycles between 2.8V to 0V at different ambient temperatures. Although the decrease in capacity was more significant than in a test where the battery was stored fully discharged, after 1,800 cycles the battery's capacity decreased by approximately 30% at 60°C and by 22% at 40°C, indicating the product would not suddenly fail.

* The following data are not guaranteed values.

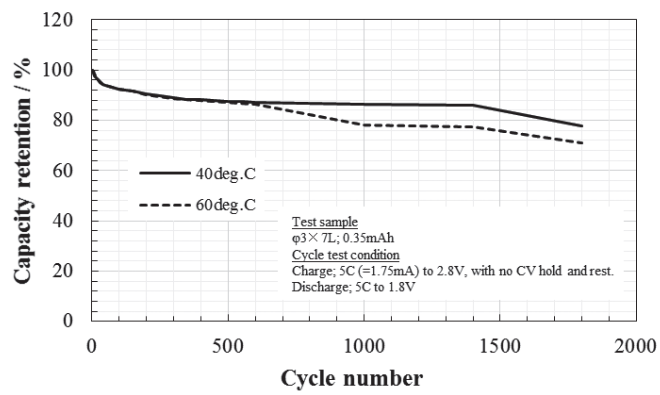


Figure 2-9. Rate of change in discharge capacity at different ambient temperatures following a full discharge cycle to 0V

3. How to use small li-ion rechargeable batteries

3-1 How to charge small li-ion rechargeable batteries

The recommended charging method is to first charge to the maximum rated voltage of 2.8V using constant-current charging, and then maintain the charge at the rated voltage of 2.8V (constant-voltage charging). Figure 3-1 shows the voltage and charging current value when the ϕ3x7L is charged at a current value of 5C (1.75mA). After being charged using constant-current charging to the maximum rated voltage of 2.8V, the battery was held at its rated voltage of 2.8V. Charging was halted when current value reached 5% of current value capacity (0.0175mA).

* The following data are not guaranteed values.

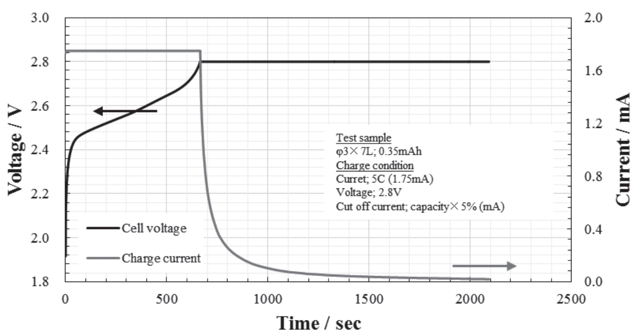


Figure 3-1. Constant current-constant voltage charging curve for ϕ3x7L

3-2 How to discharge small li-ion rechargeable batteries

The cycle properties deteriorates when the charge on the SLB falls below 1.8V. Figure 3-2 shows the discharge capacity relationship for various discharge current values. When the ϕ3x7L is discharged at 1C (0.35mA), the discharge takes approximately 1 hour. At 20C (7mA), discharging occurs in around 3 minutes. As the discharging current increases, the internal resistance causes the voltage to drop substantially, so as the discharge capacity decreases, the discharge current increases.

* The following data are not guaranteed values.

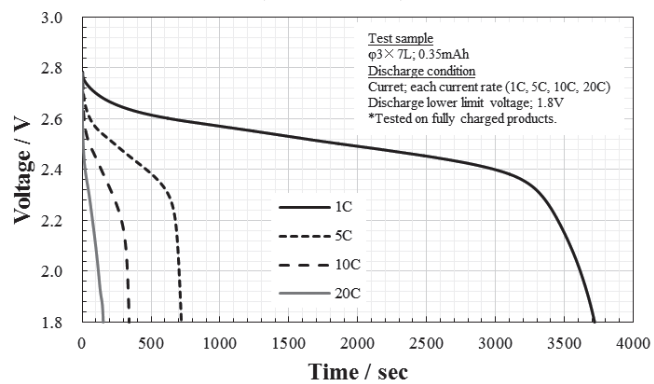


Figure 3-2. Relationship between discharging current value and discharging time for ϕ3x7L

3-3 Recommended ICs for charging/discharging

Because a maximum charging voltage and minimum discharge voltage have been set for small li-ion rechargeable batteries, voltage control is required. Table 3-1 gives examples of ICs that can be used in monitoring the charging and discharging of the SLB series. NICHICON does not guarantee the operation of the ICs listed in the table, so please check with their manufacturers when considering the use of these ICs. For details on control ICs, please check the data sheets provided by the ICs' manufacturers.

Table 3–1. Recommended ICs

No.	Supplier	Part No.	Feature	Nichicon type No.
1	Analog Devices	LTC4079	Linear Charger	SLB08115L140 SLB12400L151
2	Analog Devices	LTM4661	μModule Regulator	SLB08115L140 SLB12400L151
3	Renesas Electronic	RE01	Renesas MCU	SLB03070LR35 SLB08115L140 SLB12400L151
4	RICOH Electronic Devices	R1800 R1801	Buck DC/DC Converter	SLB03070LR35 SLB08115L140
5	RICOH Electronic Devices	RP604 RP605	Buck-Boost DC/DC Converter	SLB03070LR35 SLB08115L140
6	ROHM	BD99954GW /MWV	Battery Manager	SLB12400L151
7	ROHM	BD71631QWZ	Linear Charger	SLB03070LR35 SLB08115L140
8	TOREX SEMICONDUCTOR	XC8109	High Function Power Switch	SLB03070LR35 SLB08115L140 SLB12400L151
9	TOREX SEMICONDUCTOR	XC6504	LDO	SLB03070LR35 SLB08115L140 SLB12400L151
10	TOREX SEMICONDUCTOR	XC6240	LDO	SLB03070LR35 SLB08115L140 SLB12400L151

11	TOREX SEMICONDUCTOR	XC6140C	Reset IC	SLB03070LR35 SLB08115L140 SLB12400L151
12	TOREX SEMICONDUCTOR	XCL103	DC/DC Converter	SLB03070LR35 SLB08115L140 SLB12400L151
13	e-peas	AEM10330 AEM30330 AEM00330	AEM10330 – Solar Energy Harvesting - Buck Boost AEM30330 – Vibration/RF Energy Harvesting - Buck Boost AEM00330 – Ambient Energy Manager with Source Voltage Level Configuration	SLB03070LR35 SLB08115L140 SLB12400L151
14	e-peas	AEM10300 AEM30300 AEM00300	AEM10300 – Solar Energy Harvesting - Storage Charger only - Buck boost AEM30300 – Vibration/RF Energy Harvesting - Storage Charger only - Buck boost AEM00300 – Ambient Energy Manager - Storage Charger only - Buck boost	SLB03070LR35 SLB08115L140 SLB12400L151
15	e-peas	AEM10941	AEM10941-Solar Energy Harvesting with boost and LDO	SLB03070LR35 SLB08115L140 SLB12400L151
16	e-peas	AEM20940	AEM20940 - AmbientThermal energy harvesting-Buck boost and LDO	SLB03070LR35 SLB08115L140 SLB12400L151

The data sheet for each recommended IC are as follows.

○**LTC4079**
https://www.analog.com/media/en/technical-documentation/data-sheets/4079f.pdf

○**LTM4661**
https://www.analog.com/media/en/technical-documentation/data-sheets/LTM4661.pdf

○**RE01(with 256KB flash memory)**
https://www.renesas.com/jp/ja/document/dst/re01-group-256-kb-flash-memory-datasheet?language=en

○**RE01(with 1.5MB flash memory)**
https://www.renesas.com/jp/ja/document/dst/re01-group-products-15-mbyte-flash-memory-datasheet-0?language=en

○**R1800**
https://www.n-redc.co.jp/en/pdf/datasheet/r1800-ea.pdf

○**R1801**
https://www.n-redc.co.jp/en/pdf/datasheet/r1801-ea.pdf

○**RP604**
https://www.n-redc.co.jp/en/pdf/datasheet/rp604-ea.pdf

○**RP605**
https://www.n-redc.co.jp/en/pdf/datasheet/rp605-ea.pdf

○**BD99954GW/MWV**
https://fscdn.rohm.com/en/products/databook/datasheet/ic/power/battery_management/bd99954xxx-e.pdf

○**XC8109**
https://www.torexsemi.com/file/xc8109/XC8109.pdf

○**XC6504**
https://www.torexsemi.com/file/xc6504/XC6504.pdf

○**XC6240**
https://www.torexsemi.com/file/xc6240/XC6240.pdf

○**XC6140C**
https://www.torexsemi.com/file/xc6140/XC6140.pdf

○**XCL103**
https://www.torexsemi.com/file/xcl103/XCL102-103.pdf

○**AEM10330**
https://e-peas.com/product/aem10330

○**AEM30330**
https://e-peas.com/product/aem30330

○**AEM00330**
https://e-peas.com/product/aem00330-ambient-energy-manager-with-source-voltage-level-configuration

○**AEM10300**
https://e-peas.com/product/aem10300-solar-battery-charger-up-to-7-cells

○**AEM30300**
https://e-peas.com/product/aem30300-rf-battery-charger

○**AEM00300**
https://e-peas.com/product/aem00300-ambient-energy-manager-battery-charger

○**AEM10941**
https://e-peas.com/product/aem10941

○**AEM10240**
https://e-peas.com/product/aem20940

4. Reliability of small li-ion rechargeable batteries

4-1 Features of the charge/discharge cycle

Small li-ion rechargeable batteries have an excellent charge/discharge cycle life. For general lithium-ion batteries, significant capacity degradation occurs after several hundred to several thousand cycles. But for SLB, the use of lithium titanate in the anode results in long life, as lithium ions are less likely to be consumed by the electrolyte when forming the SEI. Figure 4-1 shows the rate of change in 1C capacity for the ϕ3x7L at a given number of cycles following a charge/discharge cycle test at a current value of 10C. The figure shows that 1C discharge capacity remains at 90% or higher of the initial level even after around 25,000 cycles, confirming the SLB demonstrates extremely favorable cycle properties.

Given the product's excellent cycle properties, it is well suited for use in devices that are charged/discharged several times a day.

* The following data are not guaranteed values.

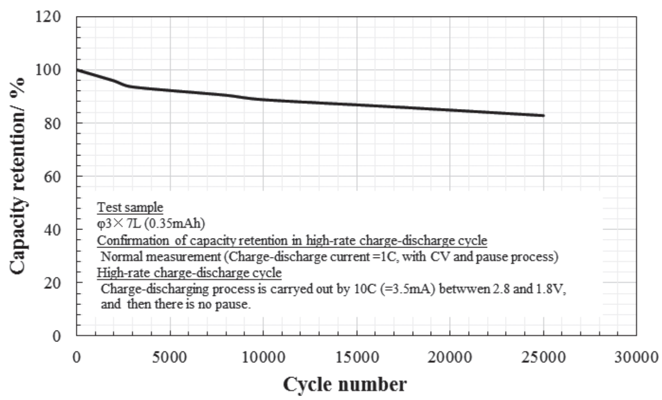


Figure 4-1. Rate of change in capacity of ϕ3x7L during charge/discharge cycle test at current value equivalent to 10C

4-2 Shelving characteristics

Shelving characteristics refer to a product's capacity characteristics when stored for a long period of time in a charged state and left as an open circuit, with no load attached. In general lithium-ion batteries, degradation occurs as the result of chemical reactions. Usually, storing a battery can cause a decrease in capacity, an increase in internal resistance, or other form of degradation. However, if a battery is stored at a high temperature in a fully charged state, this high-voltage storage can place even more stress on the battery, accelerating its degradation. Figure 4-2 shows the rate of change in 1C capacity when the ϕ3x7L is stored in a fully charged state in high temperature (65°C) and high-temperature/high-humidity (65°C and 95% RH) conditions. When the battery is charged to 100% of capacity and is stored at 65°C, it retains nearly 80% of its initial capacity after 2,000 hours has elapsed. However, when a battery charged to 100% of capacity is stored in high-temperature/high-humidity conditions (65°C and 95% RH), its capacity fell to about 60% of the initial figure after 1,000 hours. This confirms that capacity degradation accelerates significantly when the battery is stored in high-temperature/high-humidity conditions.

The SLB can easily be stored in a highly charged state at high ambient temperatures for an extended period of time. Moisture in the environment will reduce product life significantly, so storage in such conditions is not recommended. If you need to use the SLB in the environment with high temperature and high humidity, please contact NICHICON beforehand.

* The following data are not guaranteed values.

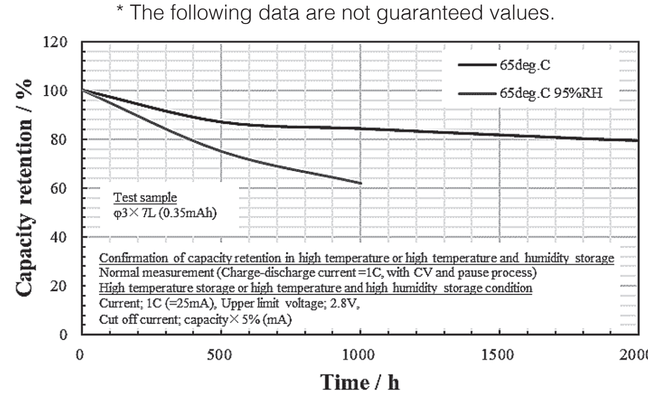


Figure 4-2. Rate of change in capacity of ϕ3x7L in high-temperature and high-temperature/high-humidity conditions

5. Safety of small li-ion rechargeable batteries

5-1 Safety settings of small li-ion rechargeable batteries

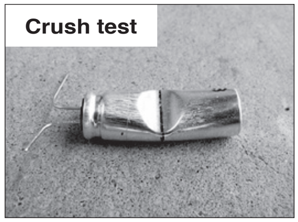
Lithium titanate is used as the active material in the anodes of small li-ion rechargeable batteries. Selection of a highly safe active material as the anode results in excellent safety. For this reason, the SLB exhibits a high degree of safety and has passed a variety of safety tests, including external short-circuit, overcharge, forced discharge, and nail penetration tests.

5-2 Safety testing of small li-ion rechargeable batteries

Table 5-1 indicates the safety tests small li-ion rechargeable batteries have passed.

Table 5–1. Safety test categories for small li–ion rechargeable batteries

No.	Test parameter	Reference standard	Test details	Judgment criteria	Proof of safety
1	Crushing	JIS C 8712	After charging fully, a semicircular indenter (10mm) is used to indent a cylindrical battery's vertical axis, crushing it to 50% of its height before the test.	Does not explode or burst into flame	No explosion or flames
2	Nail penetration	Safety assessment standards and guidelines of the Battery Association of Japan	After fully charging, a nail of ϕ3.0mm is inserted vertically into the center of the battery at a speed of 5.5mm/s, piercing through the battery.	Does not explode or burst into flame	No explosion or flames
3	Blunt nail test	UL	Pressure is applied to a blunt nail approaching fully charged battery at a speed of 0.1mm/s. A short circuit is deemed to occur if battery voltage drops by 0.5V or more, and the lowering of the nail is halted.	Does not explode or burst into flame	No explosion or flames
4	Exterior short circuit	JIS C 8712	A battery's cathode and anode are connected to an external resistance of approximately 1mΩ, causing a short circuit.	Does not explode or burst into flame	No explosion or flames
5	Overcharge	JIS C 8712	Using a battery that can be used at 10V or more, charge from a discharged state at 1C (or 2–10C) to 250% of the battery's rated capacity.	Does not explode or burst into flame	No explosion or flames
6	Forced discharge	JIS C 8712	Conduct a reverse charge of a battery from its discharged state (SOC of 0%) for 90 minutes at 1C.	Does not explode or burst into flame	No explosion or flames



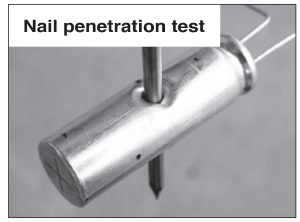


Figure 5-1. Safety test examples
(left: crush test; right: nail penetration test)

Table 5-2 indicates the safety tests with the recommended United Nations tests for goods to be transported (UN38.3). The SLB has passed all of these tests, indicating it can be shipped overseas.

Table 5–2. Details of implemented UN standards and results

.	Test parameter	Requirements	Result
T1	High-speed simulation	No leaks, valve operation, rupturing, cleavage or fires and, except for batteries that are fully discharged, the open circuit voltage is 90% or more than the level just before the test.	Pass
T2	Temperature test	No leaks, valve operation, rupturing, cleavage or fires and, except for batteries that are fully discharged, the open circuit voltage is 90% or more than the level just before the test.	Pass
T3	Vibration	No leaks, valve operation, rupturing, cleavage or fires during or after the test and, except for batteries that are fully discharged, the average voltage is 90% or more than the level just before the test.	Pass
T4	Impact	No leaks, valve operation, rupturing, cleavage or fires and, except for batteries that are fully discharged, the open circuit voltage is 90% or more than the level just before the test.	Pass
T5	External shortening	External temperature does not exceed 170°C, and no rupture, cleavage or fire occurs during testing or within six (6) hours afterward.	Pass
T6	Crushing	External temperature does not exceed 170°C, and no rupture, cleavage or fire occurs during testing or within six (6) hours afterward.	Pass
T7	Overcharge	Does not apply, as for secondary batteries only	—
T8	Forced discharge	No bursting or fires occur during testing or within seven days afterward.	Pass

6. Precautions on use

6-1 Limits on use

Because an accident or malfunction of the SLB could result in injury or damage to property, NICHICON requests you confer with NICHICON in advance if you are considering using the product in a situation requiring a high degree of reliability, such as those indicated below.
(1) Aircraft, (2) spacecraft, (3) generator control equipment, (4) medical instrument, (5) transport equipment, (6) traffic signaling device, (7) fire protection, or (8) crime prevention equipment

- When using the SLB, please design the equipment based on the delivery specifications. NICHICON is not liable for any problems that may occur in your equipment without checking the delivery specifications.
- In addition, NICHICON is not liable for any incidental or indirect damages related to the customer's product that uses our product.
- Since it is difficult to prevent failures by testing only individual parts, be sure to perform the necessary evaluation tests after incorporating the SLB into your device to make sure that no problems may occur.
- If the SLB does not conform to the specifications, NICHICON will provide repair and replacement for free, or compensate for the amount equivalent to the sales price of the subject product.
- If you have any objections or doubts about the contents of this technical note, please contact NICHICON before ordering. If you have not contacted Nichicon before placing the order, NICHICON will assume that you have accepted the contents of the delivery specifications.

6-2 Storage conditions

The SLB should be stored in an environment where condensation is not present and within the recommended temperature range for storage (5 to 35°C). The SLB has a low rate of self-discharge. If the voltage drops below 2.15V, please apply a supplementary charge to 2.4V across the terminals. If the voltage across the terminals falls below 2.0V, do not use a supplementary charge, but contact NICHICON.

6-3 Precautions on settings

1. The SLB has a limited life.
2. A range for the operation and storage of the SLB has been set. Degradation of its electrical characteristics increases substantially if the SLB is used in temperatures that exceed the maximum level.
3. If the discharge current is large, a voltage drop occurs when discharge is initiated. Please confirm the circuit discharge current and the SLB internal resistance values (DCR).
4. When the SLB is connected in series, a voltage imbalance can cause the voltage on certain cells to exceed their rated upper or lower voltages. We recommend the use of overcharge/over-discharge countermeasures, such as voltage monitoring circuit devices.
5. The SLB is polarized. Do not apply a reverse voltage.
6. Avoid placing heat generating components in the SLB's vicinity or on the back surface of the printed wiring board.
7. When mounting, provide insulation to the contact parts such as the board.

6-4 Solder mounting

1. The SLB is not compatible with flow mounting or reflow solder mounting. When mounting, take care to avoid mounting methods such as solder mounting or connector mounting in which the main part of the SLB would exceed the warranted temperature range.
2. When mounting this product, please avoid excessive mechanical stress, vibration, or pressure, as this could result in degradation of electrode terminals or electrical characteristics.
3. If solder mounting, we recommend mounting under these conditions.
   Solder: Core thread solder (recommended: ϕ1.2mm)
   Solder type: Lead-free solder Sn-3.0Ag-0.5Cu
   Soldering temperature: 350°C±10°C
   Solder time: Within 5s per terminal
   Times soldering: 2 or less per terminal
4. Do not wash after mounting.

6-5 Resin coating

If the SLB is coated with resin, metal corrosion may occur, depending on the coating resin type. The risk also exists: the terminals or the aluminum case could change shape due to shrinkage when the resin cures. Please select a resin that allows the reliability of this product to be maintained.

6-6 Disassembly

Do not disassemble the SLB, as liquid leaks and accidents could result.

6-7 Hazard

Since the chemical components are sealed in the SLB, its hazard is extremely low. However, if used improperly, the SLB may be deformed, leak, burst, generate heat, or generate irritating gas or corrosive gas. Take extreme care when using it.

6-8 Stability and reactivity

(1) If two or more SLBs are allowed to touch without insulating the terminals, from each other, there is a possibility of explosion or sudden heat generation due to a short circuit.
(2) If the SLB is overcharged, heated, or dropped in a fire, the electrolyte may spurt out rapidly.
(3) If the SLB is disassembled, there is a possibility of sudden heat generation due to a short circuit.

6-9 Electrolyte leak

The electrolyte of the SLB is flammable. It may irritate the eyes, skin and mucous membranes. Please refer to the following if an electrolyte leak occurs.

- If the electrolyte gets on your skin, immediately wash the skin with soap and lukewarm water. Seek medical attention immediately if you notice any changes in your skin or if there is persistent pain.
- If the electrolyte get in your eyes, immediately rinse your eyes with water for 15 minutes then seek medical attention immediately.
- If smoke or fire occurs, extinguish the fire with carbon dioxide fire extinguisher, powder fire extinguisher, or a large amount of water.

6-10 Storage

- Do not allow the terminals to touch each other or make the terminals touch a conductor.
- Avoid storing in the following environment.

(A) Environments that are directly exposed to water, or environments with high-temperature and high-humidity, or environments where condensation occurs
(B) Environments directly exposed to oil, or environments filled with oil in a gaseous state.
(C) Environments directly exposed to salt water, or environments full of salt.
(D) Environments filled with toxic gases (hydrogen sulfide, sulfite, nitrite, chlorine, bromine, methyl bromide, ammonia, etc.).
(E) Environments exposed to direct sunlight, ozone, ultraviolet rays or radiation.
(F) Environments exposed to acidic or alkaline solvents.

6-11 Others

- Do not short-circuit the SLB.
  Overheating of the cell may cause electrolyte leakage, explosion, or heat generation.
- Do not apply reverse voltage to the SLB.
  Abnormalities may occur inside the SLB, which may cause leakage, rupture, and heat generation.
- Do not apply excessive force to the SLB.
  If excessive force is applied, the parts may become damaged, and electric shock, short circuit, or liquid leakage may occur.
- Do not perform the following tests.
  Overcharge test, over discharge test, nail penetration test, crush test, drop test, chemical resistance test, high temperature exposure test.
- The long-term storage performance is still under test.

7. Transport and return

7-1 Product transport

Small li-ion rechargeable batteries pass the individual tests of the United Nations' recommended tests on product transport (UN Manual of Test and Criteria, Part III, subsection 38.3). In addition, for air transport, packaging standards are in accordance with IATA's regulations on the transport of dangerous goods (IATA-DGR), in accordance with the Section II of PI965 (Packing Instruction 965). If the weight changes or excessive packaging is applied, the applicable rules (Section) may change. Please consult with NICHICON in advance with regard to air transport.

Figure 7-1. Lithium battery handling label

Figure 7-2. Cargo Aircraft Only label

7-2 Return of damaged or defective products

The air transport of lithium-ion rechargeable batteries that are damaged or defective is a violation of IATA's Dangerous Goods Regulations. When considering a product return, please contact NICHICON beforehand.

8. Disposal

Please dispose of the SLB in accordance with the laws and regulations that apply to your region. The SLB uses volatile electrolytes, so do not dispose of the SLB by burning.