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Batterityper:

Ni-Cd - Nikkelcadmium:

Den første type, der blev anvendt i mobiltelefoner og bærbare computere, og den første type genopladelige batteri med en acceptabel energitæthed til en rimelig pris. Et robust batteri, der er enkelt at genoplade og sikkert for brugeren.
Ulempen er en stor hukommelseseffekt, dvs. batteriet gradvis mister sin avne til at lagre energi. Cadmium er et miljøproblem. De robuste egenskaber ved batteriet betyder, at det i fremtiden vil finde niche-anvendelse inden for forsvars- og rumindustrien.

Ni-MH – Nikkelmetalhydrid:

Har dobbelt så høj energitæthed som nikkelcadmium og mindre hukommelseseffekt. Det er desuden mindre miljøfarligt, og det er pålideligt med gode sikkerhedsegenskaber. Dets lave pris gør det velegnet til anvendelser, hvor batteriomkostningen er dominerende.

Li-ion – Litium-ion:

Introduceret første gang af Sony i 1991. Har tre gange højere energitæthed end nikkelcadmium. Har ingen eller kun lille hukommelseseffekt. Miljøpåvirkningen er betydeligt mindre end for nikkelcadmium og kviksølv baserede batterier. Mindre mængder af eksempelvis kobolt kan dog være et problem. De høje produktionsomkostninger er faldende, men omkostningerne er stadigvæk ca. 10 procent højere end for nikkelmetalhybrid.

Litium-polymer:

De første litium-polymer batterier er kommet på markedet i år. Tidligere har der været tilløb til brug i forbindelse med bærbare computere, men der har ikke været nogen egentlig storproduktion. Da elektrolytten er i fast form kan batteriet gøres meget tyndt, mindre end 0,2 mm. De kan produceres, så de bliver fleksible og lette at bøje. De fleste producenter baserer sig på en teknik udviklet af Bellcore, hvor elektrolytten er absorberet i et porøst polymer. Produktionsomkostningerne er usikre, men metoden er principielt velegnet til storskala produktion.
Batterimaterialet kan fremstilles i store bånd, hvor batteriet så at sige kan stanses ud. Jo tyndere batteriet er, jo vigtigere er proceskontrollen. Miljømæssigt kan det ligestilles med litium-ion batteriet.

Alkaliske batterier:

Findes både som genopladelige og ikke-genopladelige batterier. Fordelen er først og fremmest lav pris og let tilgængelighed. Kan tåle meget lave opbevaringstemperaturer. Den dominerende type af ikke-genopladelige batterier er alkaline, som produceres med høj lønsomhed. Genopladelige alkaline batterier taber terræn i forhold til andre typer.

Batteri-fakta:	Alkaline	Ni-Cd	Ni-MH	Li-ion	Li-polymer
Specifik energi (Wh / kg)	90-140	20-40	70-80	120-130	110
Vol. Specifik ener-gi (Wh / l)	180-400	40-90	230-250	250-275	230
Miljøvenlighed	Middel	Dårlig	Middel	God	God
Pris / energienhed	Billig	Dyr	Middel	Dyr	Meget dyr
Lagring	Meget god	Dårlig	Dårlig	God	God

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Ni-Cd Nikkel-Cadmium batteries:

1. Charge characteristics

The charge characteristics of Ni-Cd batteries are affected by the current, time, temperature, and other factors. Increasing the charge current and lowering the charge temperature causes the battery voltage to rise. Charge generates heat, thus causing the battery temperature to rise. Charge efficiency will also vary according to the current, time, and temperature.
For rapid charge, a charge control system is required.

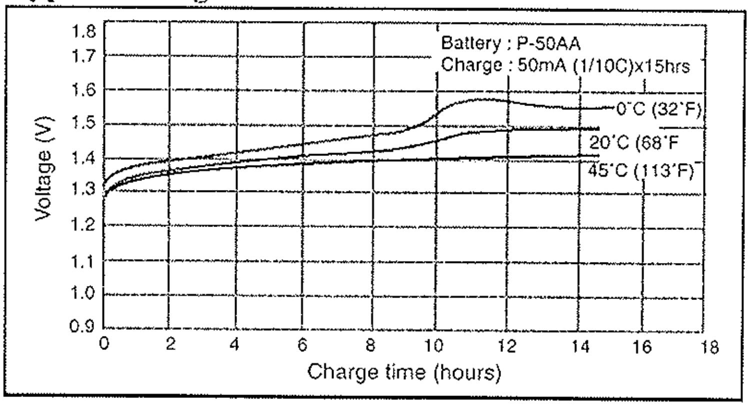
2. Discharge characteristics

The discharge characteristics of Ni-Cd batteries will vary according to the current, temperature, and other factors.
Generally, in comparison with dry-cell batteries, there is less voltage fluctuation during discharge, and even if the discharge current is high, there is very little drop in capacity. Among the various types of Ni-Cd batteries, there are models, which are specifically designed to meet the need for high-current discharge, such as for power tools.

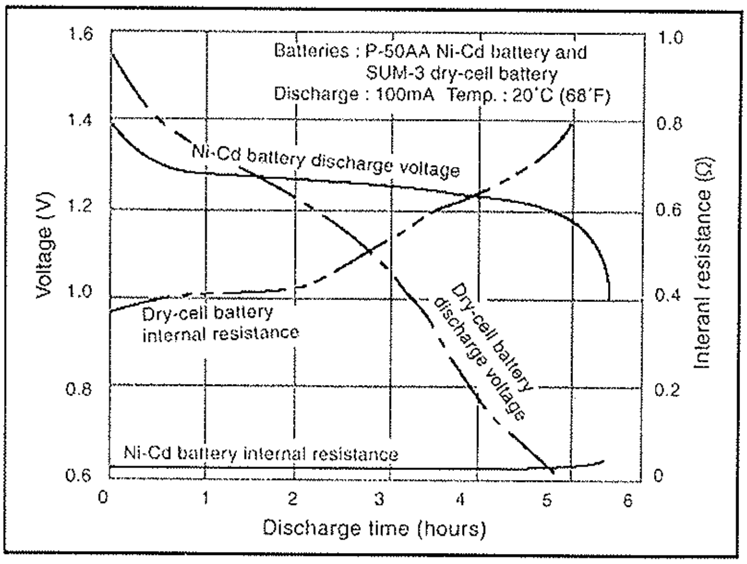
3. Cycle life characteristics

The cycle life of Ni-Cd batteries will vary according to the charge and discharge conditions, the temperature, and other usage conditions. When used in accordance with the IEC charge and discharge specifications, over 500 charge/discharge cycles are possible. The actual cycle life will vary according to which of the various charge formats is used, such as for rapid charge, and also according to how the device powered by the batteries is actually used.

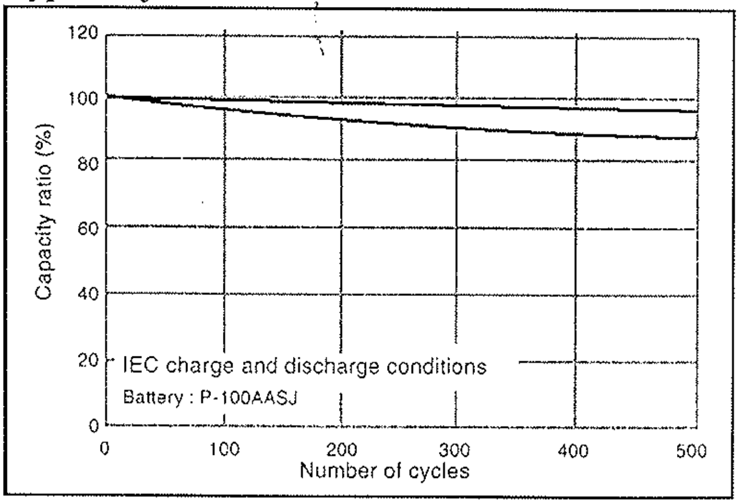
Typical charge characteristics



Typical discharge characteristics (comparison with dry-cell)



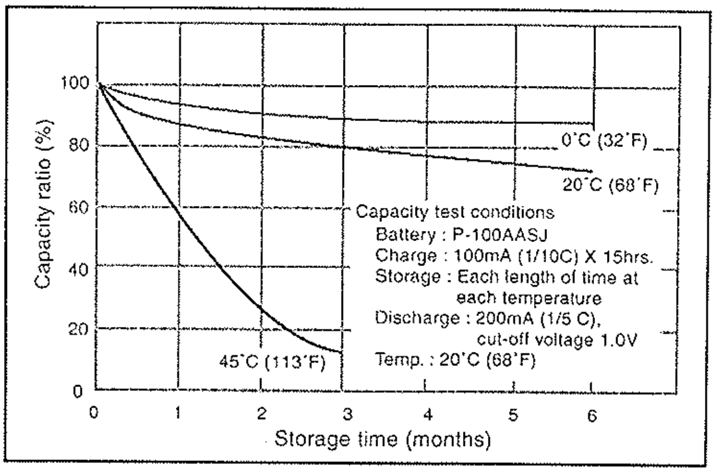
Typical cycle life characteristics



4. Storage characteristics

When Ni-Cd batteries are stored in a charged state, the capacity will gradually decrease (self discharge), and this tendency will be markedly greater at high temperatures. However, the capacity can be subsequently restored by charge. Even if the batteries are stored for an extended length of time, if the storage conditions are appropriate, the capacity will be restored by subsequent charge and discharge.

Typical self-discharge characteristics



5. Safety

If pressure inside the battery rises as a result of improper use, such as overcharge, short-circuit, or reverse charge, a resetable safety valve will function to release the pressure, thus preventing bursting of the battery.

Ni-MH Nikkel-Metal Hydride batteries:

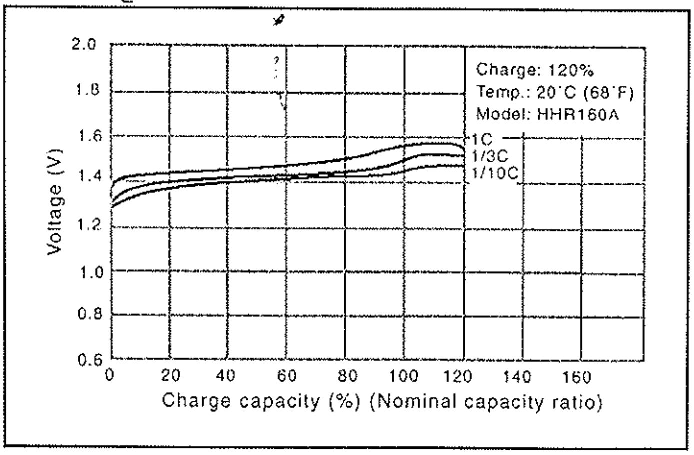
Features:

- **Cycle life equivalent to 500 charge and discharge cycles**
  Like Ni-Cd batteries, nickel-metal hydride batteries can be repeatedly charged and discharged for about 500 cycles.
- **Rapid charge in approx. 1 hour**
  Nickel-metal hydride batteries can be rapidly charged in about an hour using a specially designed charger.
- **Double the energy density of conventional batteries**
  Nickel-metal hydride batteries have approximately double the capacity compared with standard Ni-Cd batteries.

1. Charge characteristics

Like Ni-Cd batteries, the charge characteristics of nickel-metal hydride batteries are affected by current, time and temperature. The battery voltage rises when the charge current is increased or when the temperature is low.
The charge efficiency differs depending on the current, time, temperature and other factors.
Nickel-metal hydride batteries should be charged at a temperature ranging from 0°C to 40°C using a constant current of 1C or less. The charge efficiency is particularly good at a temperature of 10°C to 30°C. Repeated charge at high or low temperatures causes the battery performance to deteriorate. Furthermore, repeated overcharge should be avoided since it will downgrade the battery performance.

- Charge characteristics

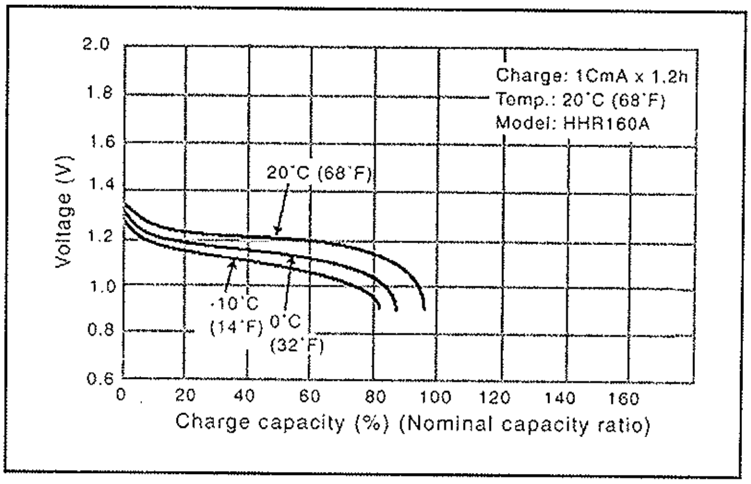


2. Discharge characteristics

The discharge characteristics of nickel-metal hydride batteries are affected by current, temperature, etc., and the discharge voltage characteristics are flat at 1.2V, which is almost the same as for Ni-Cd batteries.

The discharge voltage and discharge efficiency decrease in proportion as the current rises or the temperature drops. Compared with Ni-Cd batteries, nickel-metal hydride batteries have inferior high-rate discharge characteristics, making them less suitable for use in applications requiring high-current discharge.

- Discharge temperature characteristics at 1C discharge



As with Ni-Cd batteries, repeated charge and discharge of these batteries under high discharge cut-off voltage conditions (more than 1.1V per cell) causes a drop in the discharge voltage (which is sometimes accompanied by a simultaneous drop in capacity). The discharge characteristics can be restored by charge and discharge to a discharge end voltage of down to 1.0V per cell.

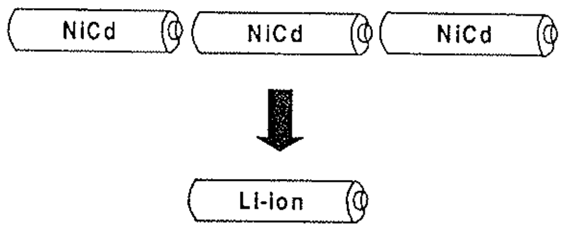
3: Storage characteristics

Self-discharge is affected by the temperature at which the batteries are left standing and the length of time during which they are left standing. It increases in proportion as the temperature or the shelf-standing time increases. Nickel-metal hydride batteries have excellent self- discharge characteristics that are comparable to those of Ni-Cd batteries.

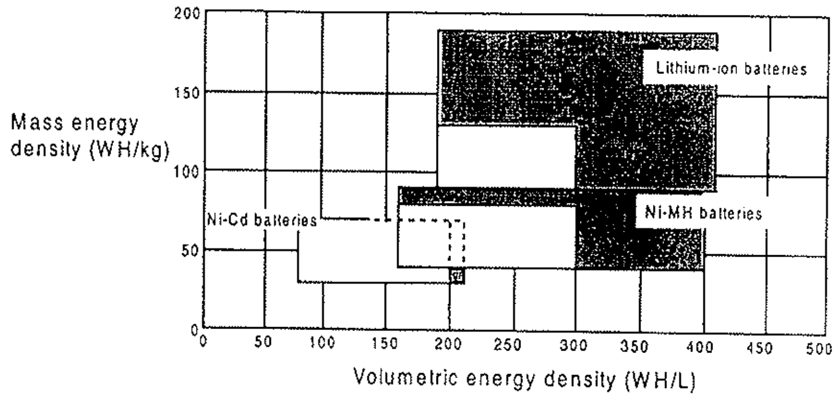
Li-ion Lithium Ion batteries:

Features:

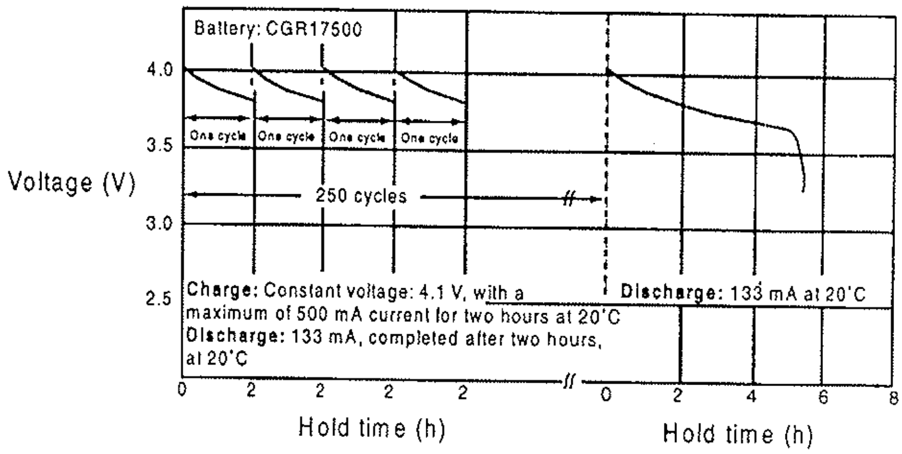
- **High Voltage**
  Lithium ion batteries produce 3,7 volts, approximately three times the voltage of rechargeable Ni-Cd batteries or Ni-MH batteries. This will make it possible to make smaller, lighter equipment.



- **High Energy Density**
  Because the lithium ion batteries are high voltage/light weight batteries, they boast a higher energy density than rechargeable Ni-Cd batteries and Ni-MH batteries.

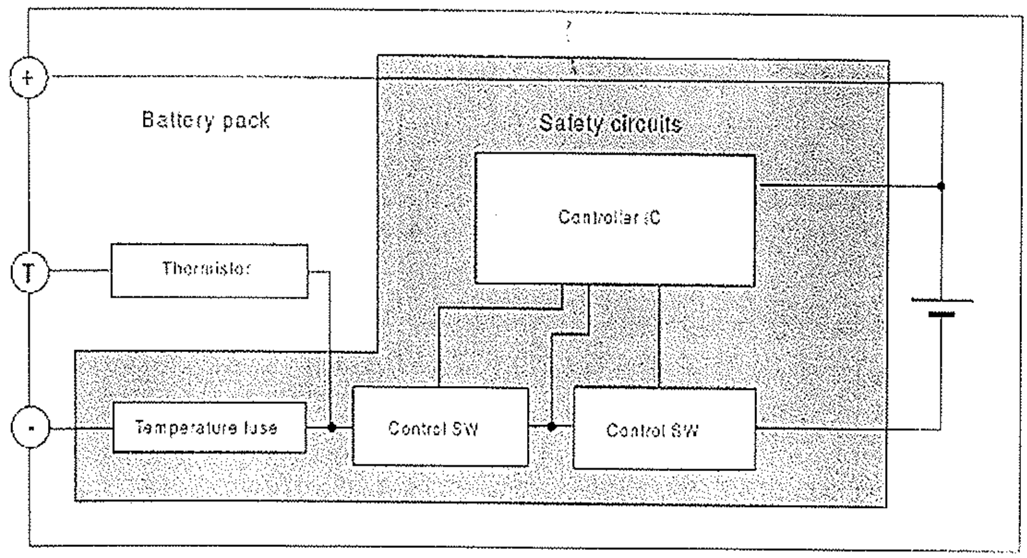


- **No Memory Effect**
  Lithium ion batteries have none of the memory effects seen in rechargeable Ni-Cd batteries ("memory effect" refers to the phenomenon where the apparent discharge capacity of a battery is reduced when it is repetitively discharged incompletely and then recharged).



Battery Pack Block Diagram:

The diagram shows a diagram of a lithium ion battery pack. The battery pack includes the batteries, the safety circuits and thermistors.



The Safety Circuits

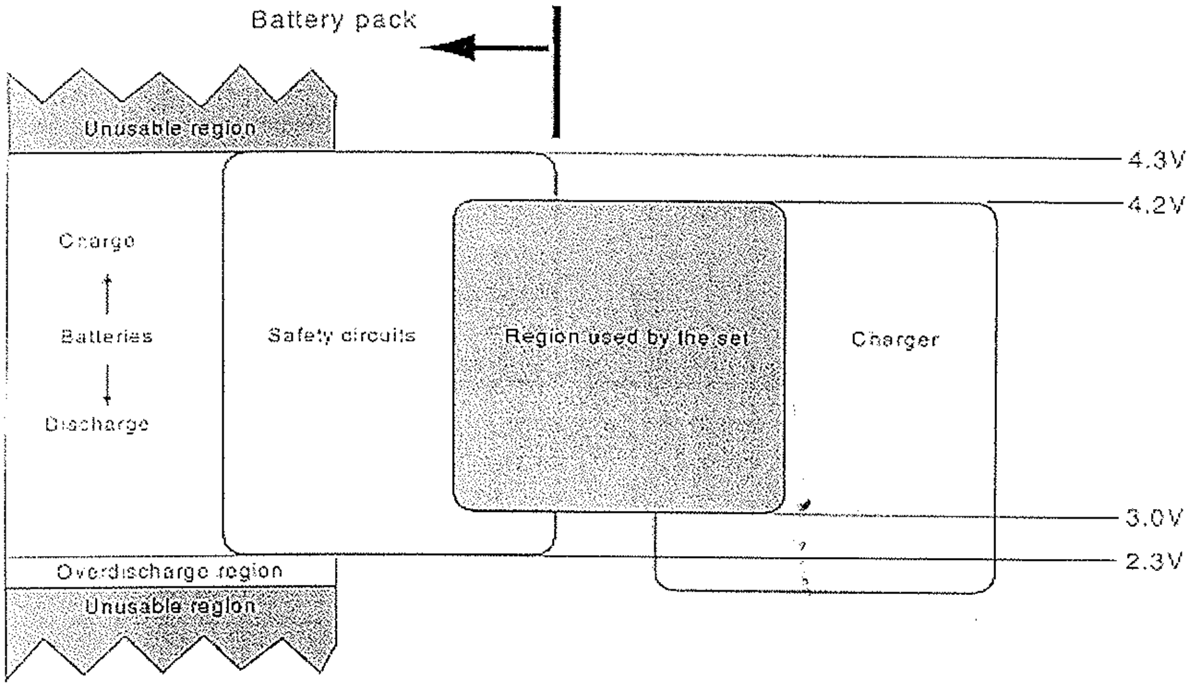
- **The controller IC**
  The controller IC measures the voltage for each cell and shuts off a control switch to either prevent overcharging (if the voltage exceed the specified voltage range) or to prevent overdischarging (if the voltage falls below the specified voltage range).
- **The Control Switches**
  The control switches usually comprise FET structures, and they turn off the charge or discharge depending on the output of the controller IC.
- **The Temperature Fuse**
  If the control switches experience abnormal heating, this fuse cuts off the current (non-restoring).

The Thermistors

The thermistors are included in order to accurately measure the battery temperature within the lithium ion battery packs. The battery charger measures the resistance value of the thermistor between the T-terminal and the negative terminal and during the charging process, controls the charge current along with controlling until the charge is terminated.

<u>The Functions of the Safety Circuits (Typical Functions)</u>

The voltage listed below are typical values and can vary from model to model.



The Overcharge Safety Function:

The charge stops when the voltage per cell rises above 4,30 ±0,05 V.
The charge restarts when the voltage per cell falls below 4,00 ±0,05 V.

The Overdischarge Safety Function:

The discharge stops when the voltage per cell falls below 2,3 ±0,1 V.
The discharge restarts when the voltage per cell rises above 3,0 ±0,15 V.

The Overcurrent Safety Function:

The discharge is stopped when the output terminals are shorted.
The discharge restarts when the shorts is removed.

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Lithium Polymer Batteries:

Next Generation Battery

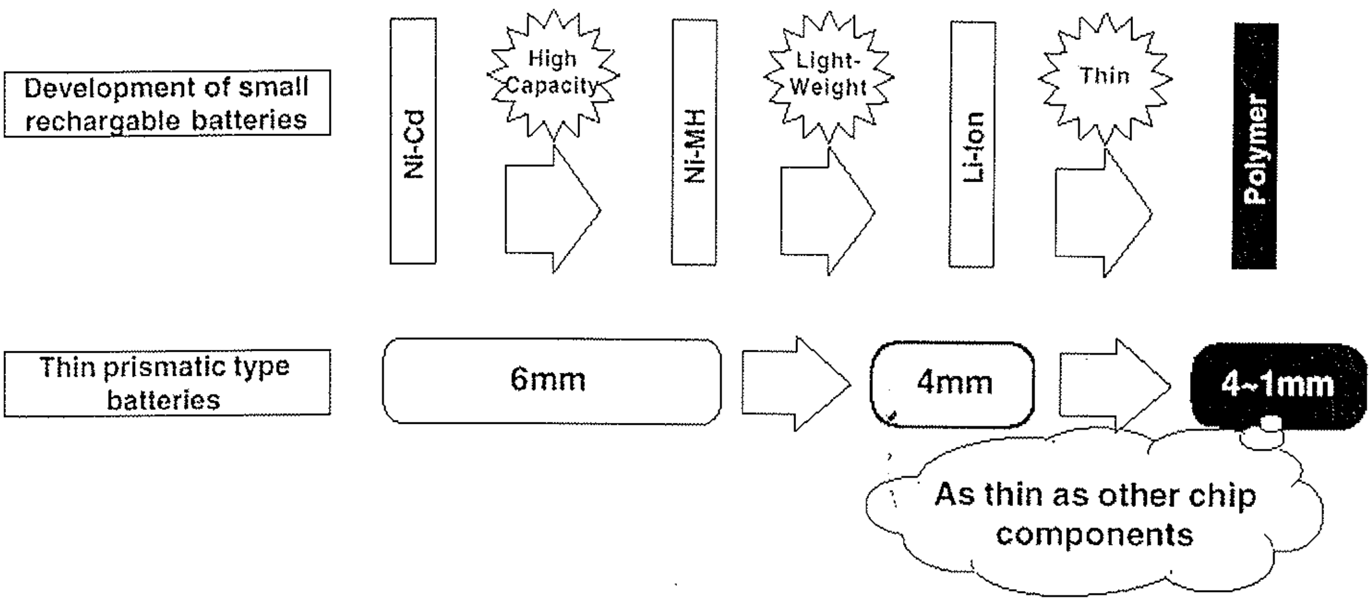
- Laminate exterior allows for a thickness of only 3.6mm
- High energy density similar to Li-ion batteries (135 wh/Kg, 280 wh/l)

As cellular phones become more wide spread and newly designed notebook computers and other portable information devices continue to be released, batteries are now required to be "very thin" in addition to having a large capacity and being light in weight. Panasonic is one of the first companies in the industry to successfully mass produce lithium polymer batteries. This new technology allows us to make lithium polymer batteries less than 4mm thick, thinner than ever before!

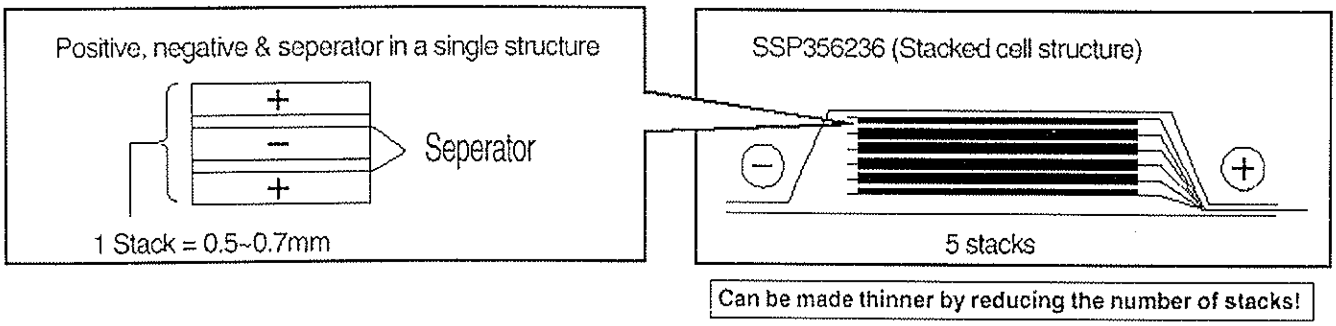
◆ Specifications

Model Number	Nominal Voltage	Average Capacity	Dimensions (mm)	Approx. Weight	Operating Temperature Range
SSP356236	3.7V	550mAh (4.2V Charge)	35 x 62 x 3.6 (W) (H) (T)	15g	-10~60°C

Polymer Battery Features -- The Ultimate Thin Battery



◆ Polymer Battery Structure



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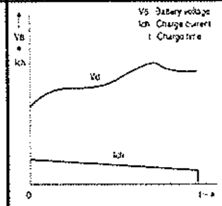
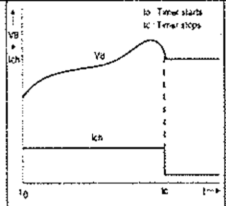
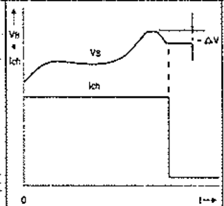
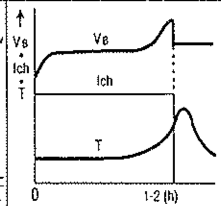
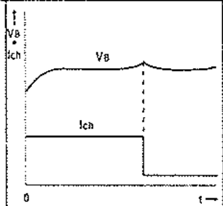
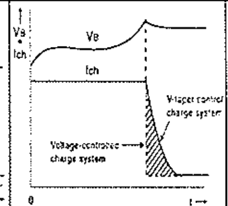
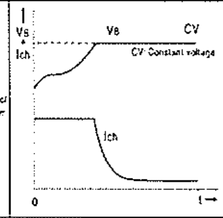
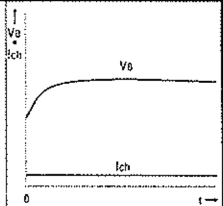
Charge system:	Cycle (repeated) use				For ref.only (Not recommended for the main charge control system for Ni-Cd batteries.)			Standby use
	Semi-constant current charge	Timer controlled charge	- Δ V cut-off charge	dT/dt cut off charge	Voltage controlled charge system	V-taper controlled charge system	Constant-voltage, constant-current controlled charge system	Trickle charge
Operation: VB: Battery voltage Ich: Charge current T: Battery temperature								
Features:	* Most typical charge system * Simple and economical	* More reliable than Semi-constant current charge system * Relatively simple and economical	* Most popular	* Charging circuit costs more than the others but overcharge can be avoided enabling longer life cycle than –ΔV charge method		* Recommended charge control system for sealed lead acid batteries.	* Used for Li-ion batteries.	* Simple and economical * Applicable to the equipment for continuous long charge
No. of terminals:	2	2	2	3	2	2	---	2
Charge time:	15 hours	6 to 8 hours	1 to 2 hours	1 to 2 hours	1 to 2 hours	2 to 3 hours		30 hours or longer
Charge current:	0.1 CmA	0.2 CmA	0.5 to 1 CmA	0.5 to 1 CmA	0.5 to 1 CmA	0.5 to 1 CmA		* frequent charge: 1/20 to 1/30 CmA * less frequent charge: 1/30 to 1/50 CmA
Trickel current:	---	1/20-1/30 CmA	1/20-1/30 CmA	1/20-1/30 CmA	1/20-1/30 CmA	1/20-1/30 CmA		
Charge level at charge control:	---	approx. 120%	approx. 110 to 120%	approx. 100 to 110%	approx. 70%	approx. 80 to 90%		---
Application examples:	* Shavers * Digital cordless phones * Toys	* Notebook PC * Data terminals * Wireless equipment * Cellular phones	* Notebook PC * Data Terminals * Camcorder * Wireless equipment * Cellular phones	* Power Tools * Electric Tools				* Emergency lights * Guide lights * Memory back-up

Methods of charge for Ni-Cd battery:

The methods of charge for Ni-Cd batteries can be classified as follows according to the purpose of use and the charge time.

	Charge time:	Charge control method:
Cycle use: (the battery is repeatedly charged and discharged)	1 to 2 hours	-ΔV cut-off charge system
		dT/dt charge system
	*See note	Voltage-controlled charge system
		V-taper controlled charge system
		Constant-voltage, constant-current controlled charge system
	6 to 8 hours	Timer-controlled charge system
	15 hours	Semi-constant-current charge system
Standby use:	Continuous charge	Trickle charge system

* Not a recommended charge method for Ni-Cd batteries

- Δ V cut-off charge system:

(1) Mechanism

If rapid charge Ni-Cd batteries are charged at a constant current, the battery voltage will increase as charge progresses, peak when charge is completed, and then subsequently decrease. Because this voltage drop occurs regardless of the discharge level or ambient temperature, it can be effectively used to detect the completion of charge. The -ΔV cut-off charge system controls charge by detecting the voltage drop (-ΔV) following the peak.

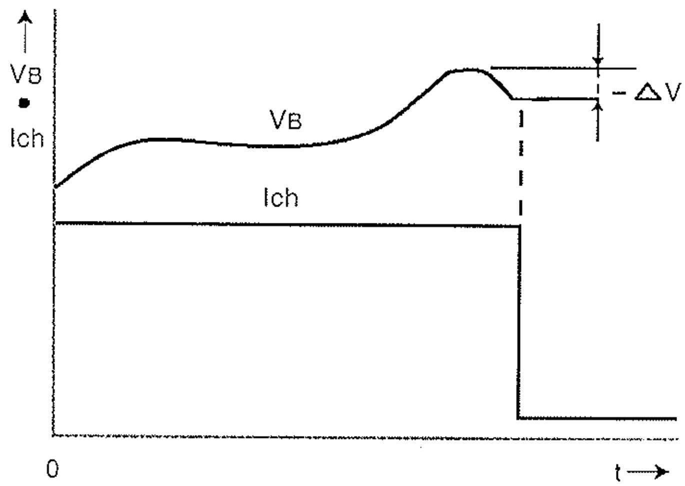


Fig. 5 Charge characteristics of the - ΔV cut-off charge System

(2) Features

- ♦ The most common control method for rapid charge.
- ♦ The most recommended and widely used method for the rapid charge of Ni-Cd batteries for use in high-tech devices (for example, portable VCR, notebook PC, digital cordless and cellular phones, etc.).

(3) Precautions

- ♦ This method is suitable for rapid charge Ni-Cd and Ni-MH batteries.
- ♦ The charge current should be 0.5 CmA ~ 1 CmA. If charged at less than 0.5 CmA, the voltage drop after the peak voltage is reached might be too small for the -ΔV cut-off to function, resulting in overcharge. The maximum charge current will vary according to the specific type of battery, so it is important to select the appropriate charge current. (See (5) in Fig. 6)

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(3) General specifications

	Typical general specifications	Remarks
Number of charger output terminals	2	
Charge current	0.5 to 1.0 CmA	See (5) in Fig. 6.
Charge time	1 to 2 hours	
Charge level at -ΔV cut-off	approx. 110 to 120%	
Trickle charge current	0.05CmA	See (6) In Fig. 6.
-ΔV value	15 to 20 mV/cell	See (3) in Fig. 6.
Charge mode switching (1) (From rapid charge to trickle charge)	1.95 V/cell	See (2) in Fig. 6.
Charge mode switching (2) (From initial charge to rapid charge)	0.8 to 1.0 V/cell	See (4) in Fig. 6.
Initial charge current	approx. 0.2 CmA	See (7) in Fig. 6.
Total timer time	Time corresponding to a 150% charge level of the nominal capacity at the rapid charge current	See (8) in Fig. 6.
Initial delay timer	approx. 5 min.	See (1) in Fig. 6.
Safety device	Thermal protector (included in the battery pack)	See Fig. 7 and 8.

- A constant-current power supply circuit is required. If fluctuations in the charge current occur as a result of fluctuations in the power supply voltage, the charge voltage will change, and faulty operation (stopping of charge before completion) of the charger might occur.
- An initial delay timer is needed in order to prevent faulty operation (stopping of charge before comple-tion) of the charger from being caused by any false -ΔV phenomenon at the beginning of charge.
  False -ΔV phenomenon: When Ni-Cd batteries are left unused for a long period of time or excessively discharged, the charge voltage (false -ΔV) may swing at the beginning of charge. (See (1) in Fig 6)
  Initial delay timer: Prevents the -ΔV detection circuit from functioning for a certain length of time after rapid charge is begun.
- Be sure that the -ΔV value is correct. If it is not, faulty operation (overcharge or insufficient charge) of the charger might occur. (See (1) in Fig. 6)
- A voltage detection switch must be provided in order to change from the rapid-charge current to the trickle charge

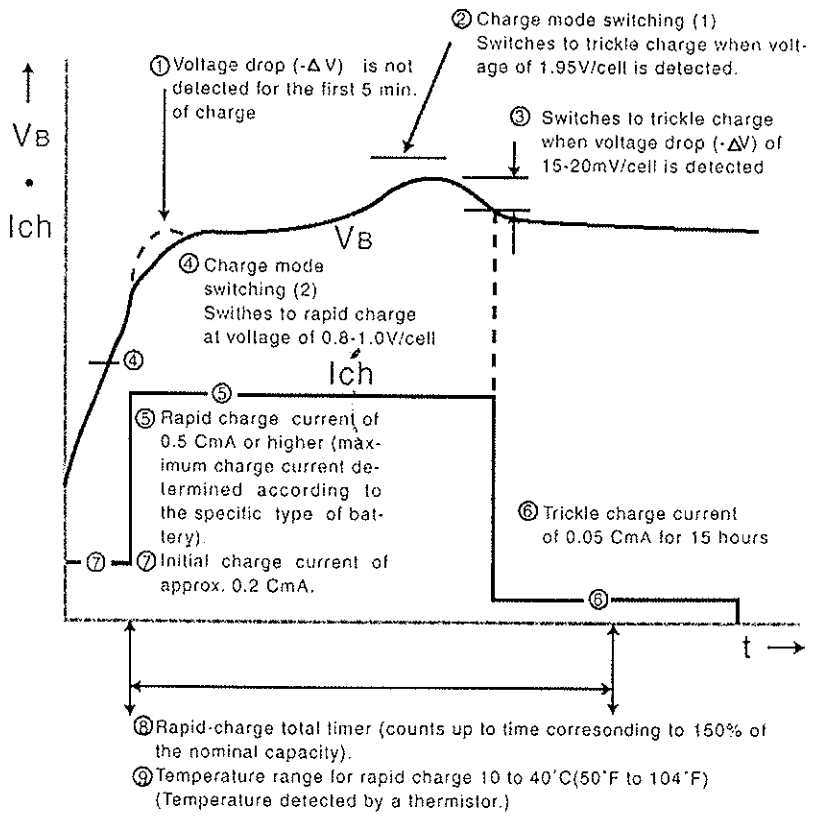


Fig. 6 Typical -ΔV cut-off charge system

current when the charge voltage reaches the predetermined level. This predetermined level varies according to the type of battery. The trickle charge current should be 0.05 CmA. (See (2) and (6) in Fig. 6)

- If a voltage detection switch is provided in order to switch the charger to the rapid charge mode, set the voltage value to 0.8 to 1.0 V/cell. In addition, for the period of initial charge (before the start of rapid charge) until the battery voltage reaches the predetermined level, set the charge current to approximately 0.2 CmA. (See (5) and (7) in Fig. 6) Provide a total timer in the charge circuit as a double-safety control. (See (8) in Fig. 6)
- A thermal protector (thermostat) and other safety devices are needed inside the battery pack to ensure the safety of rapid charge. (See Figs. 7.)
- Especially for devices where charge is frequently performed at high temperatures or low temperatures (for example, chargers designed to be used in an automobile), in order to increase charge reliability, the charger is provided with a function that detects the temperature of the batteries and switches to trickle charge if the temperature is not within the specified range for rapid charge. Therefore, a thermistor or other temperature-detecting element must be provided inside the battery pack, and the battery pack will have a 3-terminal construction. (See (9) in Fig. 6 and Fig. 7)

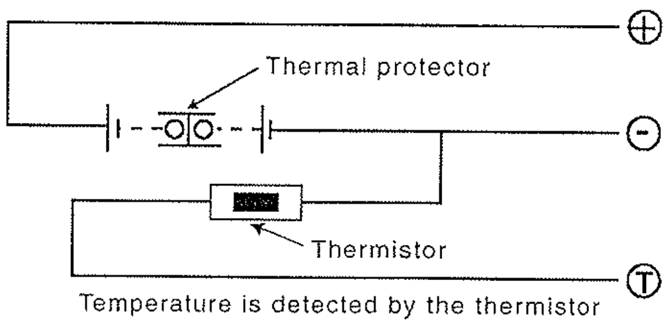
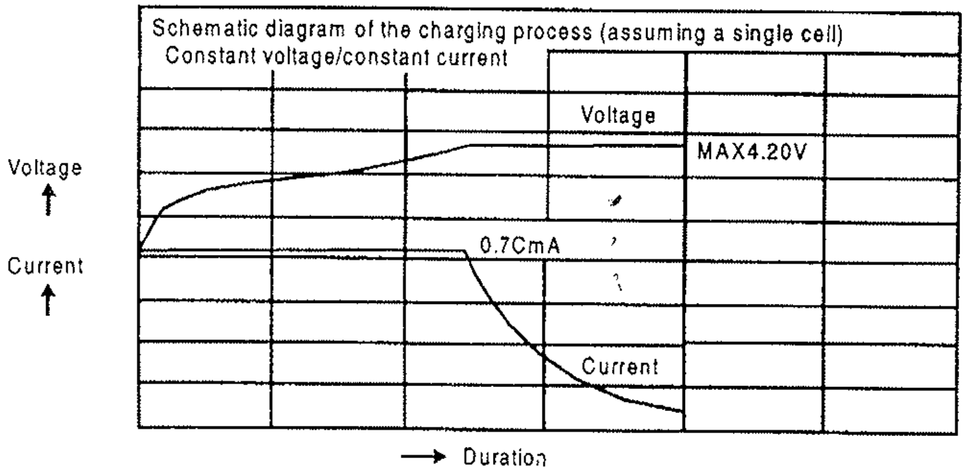


Fig. 7 Battery pack circuit for with thermistor

Methods of charge for Li-ion battery:

1. Charging the Batteries:

The "constant voltage / constant current" method is used to charge lithium ion batteries.



Charge Voltage:
The maximum voltage is 4,2 V x number of cells connected in series.

Charge Current:
Recommended 0,7 CmA.
Use a low charge current of 0,1 CmA for low-voltage charging.

Charge Temperature:
The batteries should be charged at temperatures between 0° C and 45° C.

Reverse-polarity Charging:

Verify the polarity of the batteries before charging to insure that they are never charged with the polarity reversed.

2. Discharging the Batteries:

Discharge Current:

The current should be maintained at 1,0 CmA or less.

Discharge Temperature:

The batteries should be discharged at a temperature between –10° C and +60° C.

Discharge Termination Voltage:

Avoid discharging at voltages less than 3,0 V per cell. Overdischarge can damage the performance of the battery.

CHARGING METHODS

Methods of Charging the Sealed Lead-Acid Battery

For charging the sealed lead-acid battery, a well-matched charger should be used because the capacity or life of the battery is influenced by ambient temperature, charge voltage and other parameters.

Charging methods are dependent on battery applications, and the applications are roughly classified into main power application and stand-by/back-up power applications.

Classification by application
- (1) Main power source (Cycle use)
  - (a) Standard charging (Normal charging)
  - (b) Rapid charging
- (2) Stand-by power source (Trickle use)
  - (a) Trickle charging
  - (b) Float charging

(1) Main Power cycle use

Cycle use is to use the battery by repeated charging and discharging in turn.

(a) Standard charging (Normal charging)

For common applications of the battery, the constant voltage charge method is advantageous as it allows the battery to exert full performance.

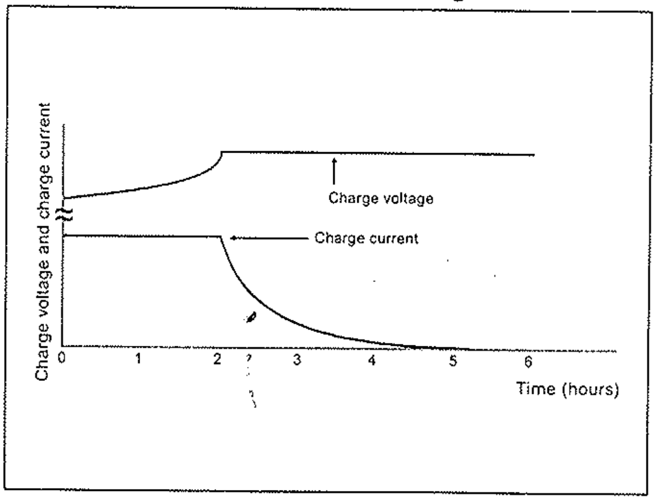
- **Constant voltage charging method**

This method is to charge the battery by applying a constant voltage between the terminals.
When the battery is charged by applying a voltage of 2.45 V per cell (unit battery) at a room temperature of 20°C to 25°C, charging is complete when the charge current continues to be stable for three hours. Sealed lead-acid batteries can be overcharged without constant voltage control. When the battery is overcharged, the water in the electrolyte is decomposed by electrolysis to generate more oxygen gas than what can be absorbed by the negative electrode. The electrolyte is changed to oxygen gas and hydrogen gas, and lost from the battery system. As the quantity of electrolyte is reduced, the chemical reactions of charge and discharge become inefficient and hence the battery performance is severely deteriorated. Therefore, exact voltage control and proper charging time in constant voltage charging are essential for securing the expected life of the battery.

- **Constant-voltage and constant-current charging method**

This method is to charge the battery by controlling the current at 0.4 CA and controlling the voltage at 2.45 V / per cell (unit battery) at a room temperature of 20°C to 25°C. Proper charging time is 6 to 12 hours depending on discharge rate.

Constant-voltage constant-current charge characteristics



(b) Rapid charging

When rapidly charging the battery, a large charge current is required in a short time for replenishing the energy which has been discharged. Therefore, some adequate measures such as the Control of charge current is required to prevent overcharging when the rapid charging is complete. Basic requirements for rapid charging are as follows:

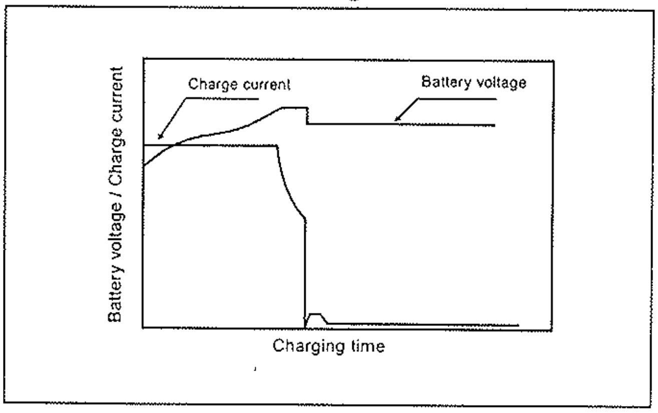
- Sufficient charging should be made in a short time for fully replenishing the amount discharged.
- Charge current should be automatically controlled to avoid overcharge even on prolonged charging.
- The battery should be charged adequately in the ambient temperature range of 0°C to 40°C.
- Reasonable cycle life of charge/discharge should be secured.

Typical methods to control charging so as to satisfy the above requirements follow.

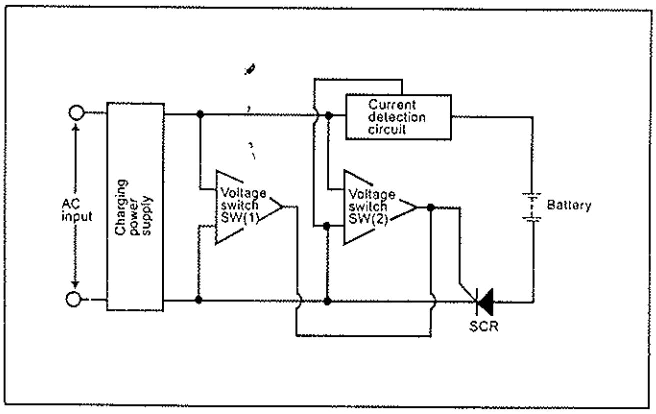
- **Two-step constant voltage charge control method**

Two-step constant voltage charge control method uses two constant-voltage devices. At the initial stage, the battery is charged by the first constant-voltage device SW(1) of high setup voltage (set-up for cycle charge voltage). When the charge current, the value of which is detected by the current-detection circuit, has reduced to the preset value, the device is switched over to the second SW(2) of low set-up voltage (setup for trickle charge voltage). This method has the advantage that the battery in trickle use can be charged in a comparatively short time for the next discharge.

Charging characteristics of the two-step constant voltage control charger



Block diagram of the two-step constant voltage control charger



(1) Stand-by/Back-up use (Trickle use)

The application load is supplied with power from AC sources in normal state. Stand-by/back-up use is to maintain the battery system at all times so that it can supply power to the load in case the AC input is disrupted (such as a power failure). There are two methods of charging for this use.

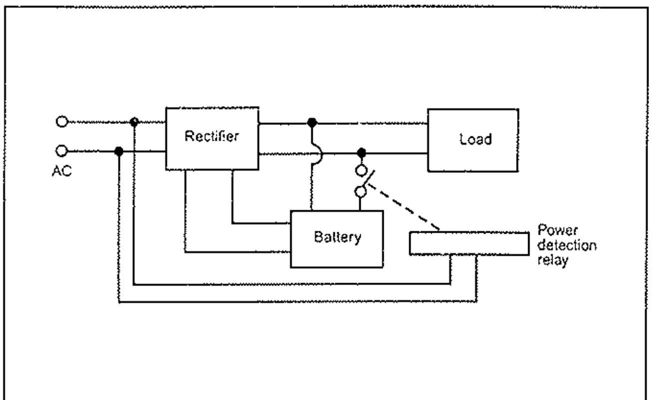
(a) Trickle charge (Compensating charge)

- **Trickle charge**

In this charge system, the battery is disconnected from the load and kept charged with a small current only for compensating self discharge while AC power is alive. In case of power failure, the battery is automatically connected to the load and battery power is supplied. This system is applied mainly as a spare power source for emergency equipment. In this use, if rapid recovery of the battery after discharge is required, it is necessary to consider the recovery charge with a comparatively large current followed by trickle charge, or alternative measures.

While the type and capacity of the battery is determined by the back-up time and the load (current consumption) during power failure, some reserve power should be taken into account considering such factors as ambient temperature, capability of the charger and depth of discharge.

Trickle charge system model



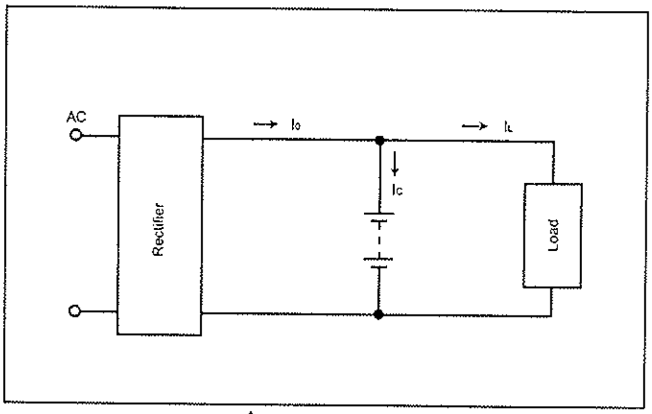
(Precautions on charging)

1. As the battery continues to be charged over a long period, a small difference in charging voltage may result in a significant difference in the battery life. Therefore, charge voltage should be controlled within a narrow range and with little variation for a long period.
2. As charge characteristics of the battery are dependent on temperature, compensation for temperature variation is required when the battery is used over a broad temperature range, and the system should be designed so that the battery and the charger are kept at the same temperature.

- **Float charge**

  Float system is the system in which the battery and the load are connected in parallel to the rectifier, which should supply a constant-voltage current.

Float charge system model



In the above-illustrated model, output current of the rectifier is expressed as:
$I_o = I_c + I_L$ where I_c is charge current and I_L is load current. Consideration should be given to secure adequate charging because, in fact, load current is not constant but irregular in most cases.

In the float system, capacity of the constant-voltage power source should be more than sufficient against the load. Usually, the rectifier capacity is set at the sum of the normal load current plus the current needed in order to charge the battery.

Charging Methods and Applications of SLA Batteries

Application/ Charging Method	Normal charging in 6 or more hours; Constant voltage control	Two-step constant voltage control	Constant current control
Cycle use	Control voltage : 7.25 to 7.45V /6V battery 14.5 to 14.9V /12V battery Initial current : 0.4 CA or smaller		
Trickle use	Control voltage : 6.8 to 6.9V /6V battery 13.6 to 13.8V /12V battery	Initial charging with current of approx. 0.15 CA, followed by switching voltage to trickle charge	
Float use	Control voltage : 6.8 to 6.9V /6V battery 13.6 to 13.8V /12V battery Float charging compensates for load fluctuations.		
Refresh charge (Auxiliary charge)*	When charging two or more batteries at a time, select only those which have been left under the same condition.		Charging with current of approx. 0.1 CA
Application example	General uses, Cellular phones (bag phones), UPS, Lanterns, Electric tools	Medical equipment, Personal radios	

Note * Refresh (auxiliary) charge amount should be 120 to 130 % of self-discharge amount. For details, please contact us.

(Precautions on charging)

1. (a) in constant voltage charging (cycle use): Initial current should be 0.4 CA or smaller (C: rated capacity)
   (b) in V-taper charge control system: Initial current should be 0.8 CA or smaller (C: rated capacity)
   (c) in constant voltage charging (trickle use): Initial current should be 0.15 CA or smaller (C: rated capacity)

2. Relation between standard voltage value in constant voltage charging and temperature is given in the Table.

Relation between standard voltage value in constant voltage charging and temperature

		0°C	25°C	40°C
Cycle use	4V	5.1	4.9	4.7
	6V	7.7	7.4	7.1
	8V	10.2	9.8	9.5
	12V	15.4	14.7	14.2
Trickle use	4V	4.7	4.6	4.5
	6V	7.1	6.8	6.7
	8V	9.4	9.1	8.9
	12V	14.1	13.7	13.4

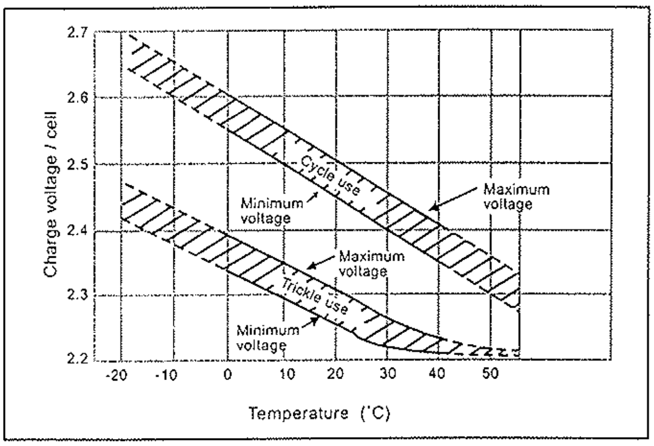
a) Temperature compensation of charge voltage

Charge voltage should be compensated to the ambient temperature near the battery, as shown by the figure below. Main reasons for the temperature compensation of charge voltage are to prevent the thermal runaway of the battery when it is used in high temperature conditions and to secure sufficient charging of the battery when it is used in low temperature conditions. Prolongation of service life of the battery by the above-described temperature compensation is expected as follows

- At 30°C: prolonged by approx. 5 %
- At 35°C: prolonged by approx. 10 %
- At 40°C: prolonged by approx. 15 %

In low temperature zones below 20°C, no substantial prolongation of the battery life can be expected by the temperature compensation of charge voltage.

Compensated voltage value



b) Charging time

Time required to complete charging depends on factors such as depth of discharge of the battery, characteristics of the charger and ambient temperature. For cycle charge, charging time can be estimated as follows:

(1) when charge current is 0.25 CA or greater:
Tch = Cdis / I + (3 to 5)

(2) when charge current is below 0.25 CA:
Tch = Cdis / I + (6 to 10) ,where

Tch : Charging time required (hours)
Cdis : Amount of discharge before this charging (Ah)
I : Initial charge current (A)

Time required for trickle charge ranges from 24 to 48 hours.

c) Charging temperature

(1) Charge the battery at an ambient temperature in the range from 0°C to 40°C.
(2) Optimum temperature range for charging is 5°C to 35°C.
(3) Charging at 0°C or below and 40°C or higher is not recommended: at low temperatures, the battery may not be charged adequately; at high temperatures, the battery may become deformed.
(4) For temperature compensation values, see a).

d) Reverse charging

Never charge the battery in reverse, as it may cause leakage, heating or bursting of the battery.

e) Overcharging

Overcharge is an additional charge after the battery is fully charged. Continued overcharging shortens the battery life. Select a charge method which is specified or approved for each application.

f) Charging before use

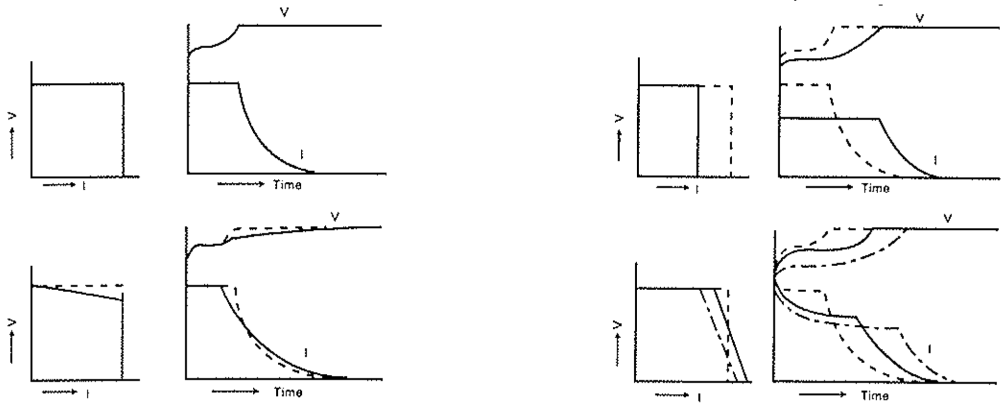
Recharge the battery before use to compensate for capacity loss due to self-discharge during storage. (See "Refresh charge" (auxiliary charge) table on page 22.)

CHARGING METHODS - CONTINUED

- **Characteristics of constant voltage chargers**

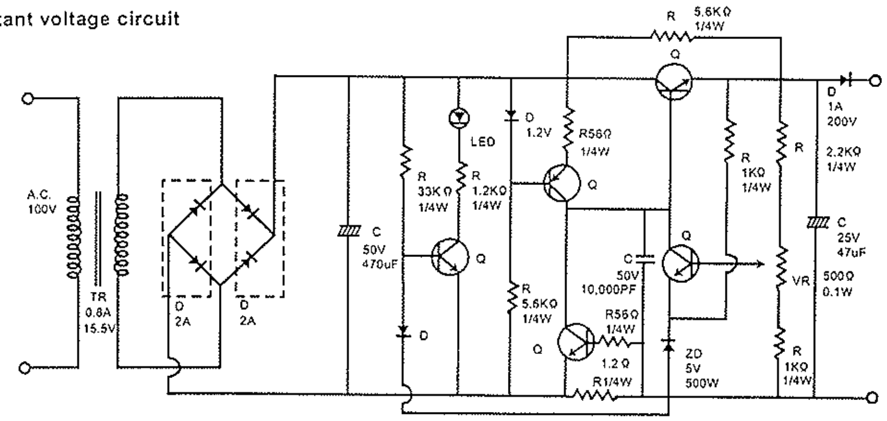
Even with the same voltage set-up, charging time varies with output V-I characteristics.

Output V-I characteristics of the constant voltage charger vs. Charging pattern of the battery



- **Constant voltage charger circuitry (Concept diagram)**

Example of constant voltage circuit



Precautions

1) When adopting charging methods and charging conditions other than those described in the specifications or the brochures, thoroughly check charging/discharging characteristics and life characteristics of the battery in advance. Selection of appropriate methods and conditions of charging is essential for safe use of the battery and for fully utilizing its discharge characteristics.
2) In cyclic use of the battery, use a charger equipped with a charging timer or a charger in which charging time or charge amount is controlled by other means; otherwise, it will be difficult to judge the completion of the charge. Use of a charger as described above is recommended to prevent undercharge or overcharge which may cause deterioration of the battery characteristics.
3) Continue charging the battery for the specified time or until the charge completion lamp, if equipped, indicates completion of charging. Interruption of charging may cause a shortening of service life.
4) Do not recharge the fully charged battery repeatedly, as overcharge may accelerate deterioration of the battery.
5) In cyclic use of the battery, do not continue charging for 24 hours or longer, as it may accelerate deterioration of the battery.
6) In cyclic service of the battery, avoid charging two or more batteries connected in parallel simultaneously: imbalance of charge/discharge amount among the batteries may shorten the life of batteries.

Links på nettet til batterier:

Site med god søgemaskine for batterityper

http://www.batterydirectory.com/formprocessc.php3

Panasonic

http://www.panasonic.com/industrial_oem/battery/battery_oem/batteries_oem_home.htm