

Overcharge/Overdischarge/Overcurrent Safety Circuits

• The Functions of the Safety Circuits (typical functions)

The voltages listed below are typical values and are not guaranteed. The charge voltage varies according to model number.

1. 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 4.10 ± 0.05 V.

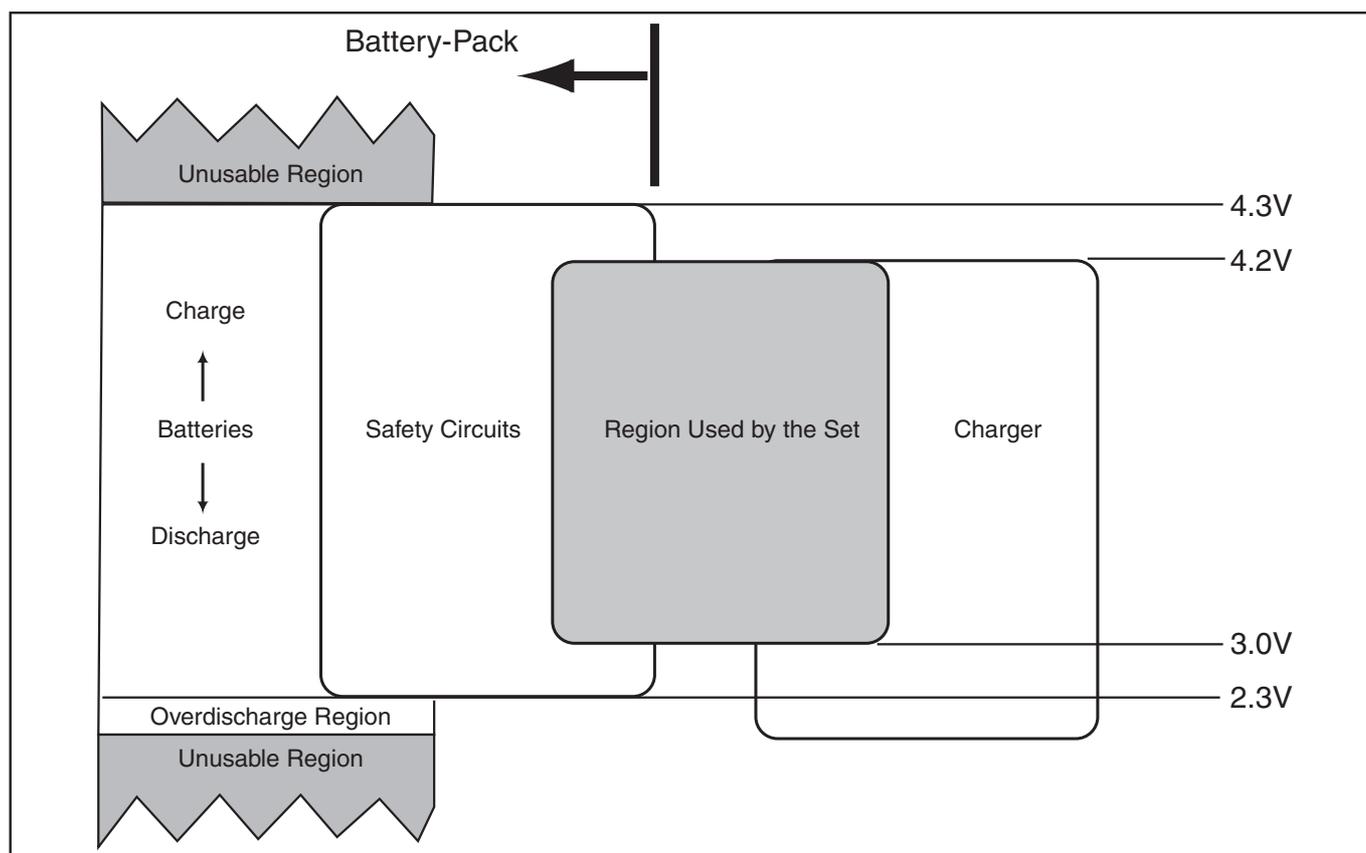
2. The Overdischarge Safety Function

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 ± 0.1 V.
Contact Panasonic for information regarding NNP series.

3. The Overcurrent Safety Function

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

• Reference Example of the Safety Circuits for PSS and Cobalt Acid Series



- The safety circuits in the diagram above are for overcharging, overdischarging, and overcurrent for a single cell battery-pack. Please consult Panasonic when two or more cells are connected or when actually using this or other circuits.

● **Battery-Pack Block Diagram (Reference Example)**

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

1. The Safety Circuits

(1) The Controller IC

The controller IC measures the voltage for each cell (or for each parallel battery block) and shuts off a control switch to either prevent overcharging (if the voltage exceeds the specified voltage range) or to prevent overdischarging (if the voltage falls below the specified voltage range). Moreover, the voltage of the control switch is measured on both ends and in order to prevent overcurrent, control switches are shut off if the voltage exceeds specifications.

(2) The Control Switches

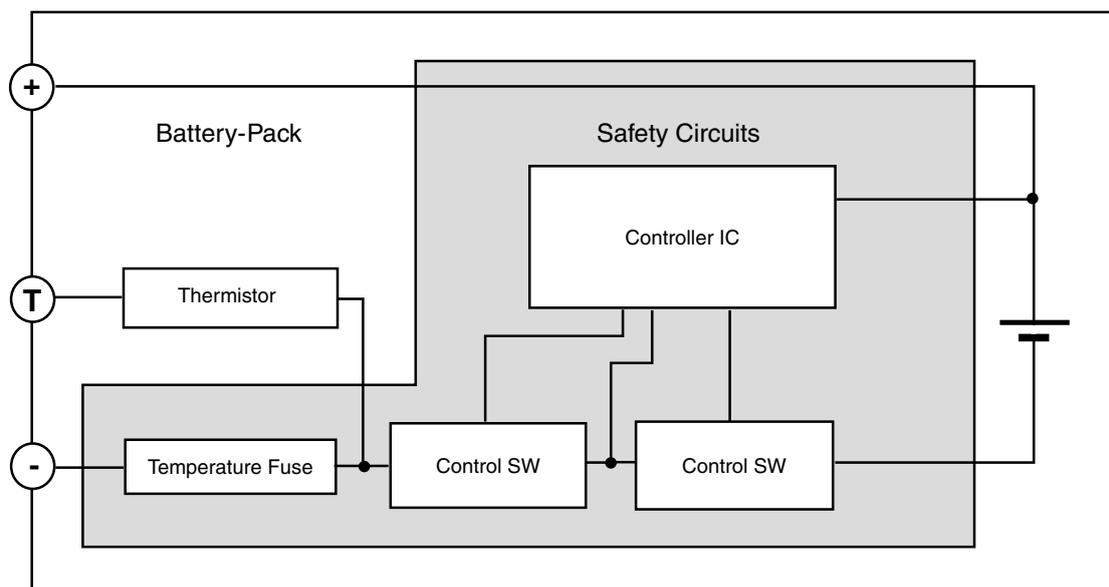
The control switches usually comprise FET structures, and they turn off the charge or discharge depending on the output of the controller IC.

(3) The Temperature Fuse (Reference Materials)

If the control switches experience abnormal heating, this fuse cuts off the current (non-restoring).

2. The Thermistors

The thermistors are included in order to accurately measure the battery temperature within the lithium ion battery-packs. The battery or 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.



- The battery-pack must be equipped with a noise filter at the voltage detectors in the block diagram above to insure that outside noise does not cause the battery to malfunction. Please check against the final product
- Please include a total charge timer and a charge completion timer on the charging circuit in order to provide redundant safety control.

How to Charge the Batteries

We recommend the following charging process to insure the optimal performance of the lithium ion battery.

• Applicable Battery-Packs

The discussion below assumes that the battery-packs are equipped with internal safety circuits to prevent overcharging and overdischarging, and assumes that the battery is a single cell battery.

• Charging Method

The lithium ion battery can be charged by the constant voltage/constant current charging method found in the "Notes and Precautions" at the beginning of this document. (See page 22, "Notes and Precautions")

• Functions and Performance Required in the Charger (Recommendations)

(1) Charge Voltage

The voltage between the charging terminals should be no more than 4.20 V (Set this at 4.20 V (max) after taking into account fluctuations in power supply voltages, temperature deviations, etc.).

(2) Charge Current

Please refer to the following charge current standards by series.

NNP series Cylindrical type : 0.7 It (or 0.3 It for certain models) , Prismatic type : 0.7 It.

PSS and Cobalt acid series Cylindrical type : 0.7 It , Prismatic type : 1.0 It. (or 0.7 It for certain models)

(3) Ambient Temperature of the Battery-Pack During Charge

10°C to 45°C (Consult Panasonic if the battery-pack is to be used outside of this temperature range).

(4) Low-Voltage Battery-Pack Charge

When the voltage per cell is 2.9 V or less, charge using a charge current of 0.1 It or less.

(5) Termination of Charging

The system will determine that the battery is full by detecting the charge current.

Stop charging once the current has reached 0.1 It to 0.07 It. Note that there will be some degree of variation for each individual battery.

(6) Charge Timer

A total charge timer and a charge completion timer should be included.

(7) Countermeasures for Battery Problems

Select an overvoltage guard in the power supply so that there will be no excessive voltage applied to the battery even if there is a problem with the power supply.

- The discussion above assumes a single cell battery. If two or more cells will be used or if there are other situations, please consult with Panasonic.

Lithium Ion Battery-Pack Charge Flowchart (example)

Reference example of charging a single-cell lithium ion battery-pack

OCV: Battery-pack load open voltage

T ₁	: Charge total timer count
t _{min}	: Low temperature threshold setting value
t _{bat}	: Battery temperature
t _{max}	: High temperature threshold setting value
CV	: Constant voltage
ichg	: Charge current
iset1	: Electrical current set value
iset2	: Electrical current set value
T ₂	: Charge complete timer count
T ₃	: Recharge timer count

