# Lightweight, Long-Life Lithium-ion Secondary Battery Pack for Communications Equipment

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## Abstract

NEC Energy Devices has developed a lightweight, long-life lithium-ion secondary battery pack suitable for use in power supply systems of communications equipment installed in areas that experience power supply difficulties. The battery pack features a high level of safety and long life due to the manganese cathode material and stacked electrode structure. These are implemented by making full use of our experience in the development/production of lithium-ion secondary battery (LIB) with laminated exteriors for use in electric vehicles (EVs) and large power storage devices, the battery management system (BMS) and the battery pack structure design and the control software. This paper introduces a 19-inch rack mountable 48 V battery pack developed based on the above technologies for use in the power supply systems of communications equipment.


Keywords

lithium-ion secondary battery, manganese, laminated, power supply, 48 V, 19-inch rack, communications equipment

## 1. Introduction

The secondary battery is an environment-friendly battery featuring a high energy density, freedom from use of environmentally regulated substances including cadmium, lead and mercury, and low energy losses during charging and discharging. Due to the compact size and light weight, its usage is increasing for power supplies to small-size mobile equipment including notebook PCs and smartphones, as well as for drive power supplies for power-assisted bicycles, electric bikes (E-Bikes) and electric vehicles (EVs).

More recently, the high energy efficiency (discharged power/charged power) of the secondary battery is accelerating its applications for various purposes, aiming at implementation of an energy-saving society and the effective utilization of renewable energies, such as for households and industrial electricity storage systems. Also supported are measures dealing with demand fluctuation and frequency adjustments in power supply systems (**Fig. 1**).

In this report, we introduce a 19-inch rack mountable 48 V battery pack for use in power supply systems for communications equipment. This equipment has been developed based on the battery technology possessed by NEC Energy Devices.

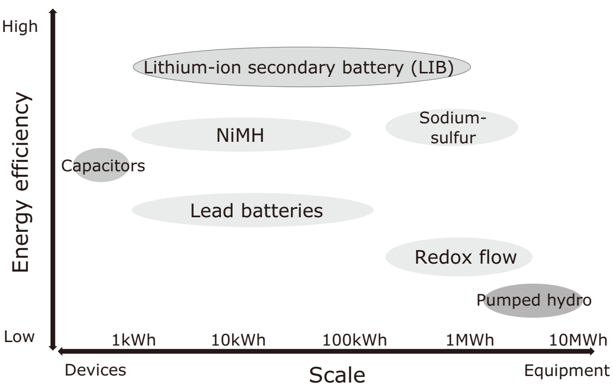



Fig.1 Energy efficiencies of electricity storage devices.

## 2. Configuration of Power Supply Systems for Communications Equipment

**Fig. 2** shows the skeleton configuration of a power

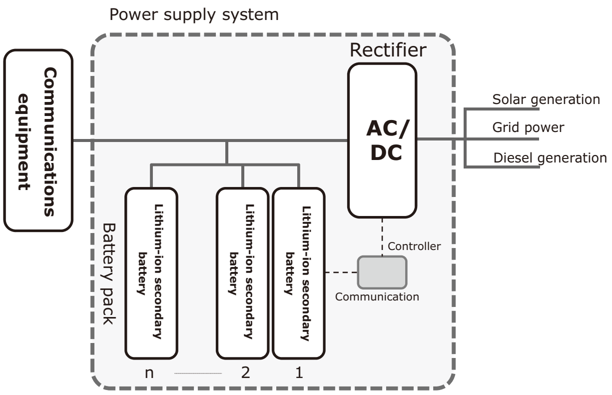



Fig. 2 Power supply system configuration.

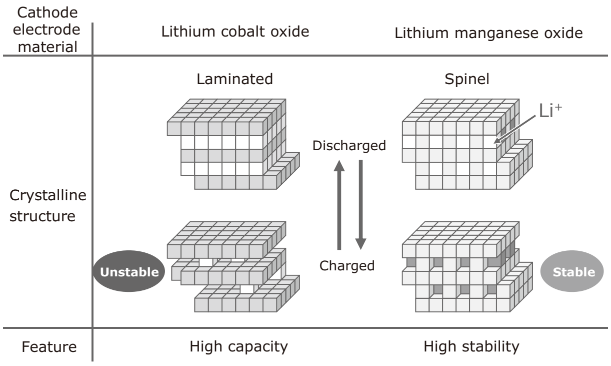



Fig. 3 Crystalline structures of positive-electrode active materials.

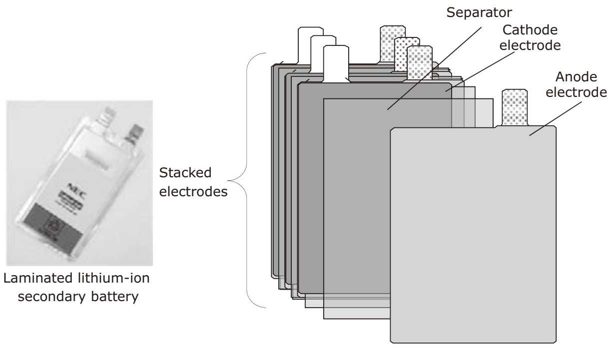



Fig. 4 Cell electrode structure.

system for communications equipment that employs the newly developed battery pack. The system is composed of a rectifier that converts AC from the power supply system or diesel generator into DC, a battery pack that supplies power to the communications equipment in the case of a power outage, and a controller to manage communication between the rectifier and battery pack.

At present, lead-acid storage batteries are usually used in power systems for communications equipment. The lead-acid battery is widely disseminated because of its ease of use, low price and easy availability, but the low energy density and the difficulty of weight and size reduction are influencing expectations for its replacement with the lithium-ion secondary battery. The new battery pack presented in this paper features the use of a lithium-ion secondary battery in the power supply system by replacing the previously used lead battery.

## 3. Laminated Lithium-ion Secondary Battery

The newly developed lithium-ion secondary battery (LIB) is a result of our experience in the fabrication of electrodes for the LIBs employed in EV "LEAF" launched by Nissan Motor Co., Ltd. in December 2010. The technology thus acquired is fully applied from the battery material procurement to production stages and assures the high reliability of the new LIB.

### 3.1 Manganese Cathode Electrode Material

NEC Energy Devices use lithium manganese oxide with a spinel structure as the active positive-electrode material. The spinel structure features a stable crystalline structure even in the charged state (in which lithium-ions are removed) (**Fig. 3**), which means that the battery will not cause thermal runaway even in an overcharged state.

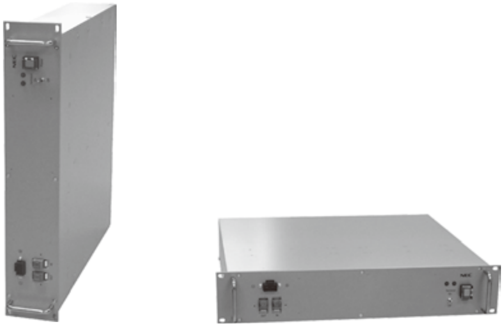
### 3.2 Stacked Electrode Structure

The lithium-ion secondary battery of NEC Energy Devices has a stacked structure in which the positive and negative electrodes are stacked alternately (**Fig. 4**). This structure provides the battery with lower internal resistance and heat generation than for the winding-type structure, which is used mainly in cylindrical and prismatic batteries. Consequently, the stacked structure makes it easy to implement a power supply system without using a fan and to simplify the heat radiation structure.

## 4. Lithium-ion Secondary Battery Pack for Communications Equipment

### 4.1 Outline of LIB Pack for Communications Equipment

**Photo 1** shows an external view of a lithium-ion



Lengthwise Widthwise

Photo 1 Battery pack.

Table 1 Battery pack specifications.

| Items | Spec. |
|---|---|
| Configuration | 13S4P |
| Width | 418mm |
| Depth | 482.6mm |
| Height | 88mm |
| Weight | App.23kg |
| Energy | 40Ah/1.97kWh |
| Nominal Voltage | 50.3V |
| Operating Voltage | 39Vdc – 53.3V |
| Operating Temperature | -20℃ – 60℃ |
| Max. Charge/Discharge Current | 40A |
| IP Code | IP30 |
| Enclosure Material | Sheet Metal |

battery pack for communications equipment, of a size mountable in 2U of a 19-inch rack. **Table 1** shows its main specifications. The lithium-ion batteries (single cells) have an average voltage of 3.8 V – 10 Ah. In consideration of the operating voltage range of communications equipment, thirteen single cells are connected in series in order to cover a voltage range from 39 to 53.3 V. The battery pack is given a capacity of about 2 kWh by connecting four 10 Ah cells in parallel. Other provided facilities include the monitoring of a total of 52 single cells and a battery management system (BMS) for use in communications with the rectifier.

This battery pack is designed to control all operations on the front panel, which has a battery start switch (with a cover), output terminals (+, -) and LED indicators (running, error, etc.). It can be installed either vertically or horizontally according to the power supply system configuration.

### 4.2 Single Cells

**Table 2** shows the main specifications of the single cell and **Photo 2** shows its external view.

By optimizing the electrode design and mixing an additive originally developed by NEC that forms a stable, low-resistance film on the electrode, the single cell is capable of 4,000 cycles of 4.1 V charging and 0.2 C discharging (70% remaining capacity). The operating life is expected to be about 10 years.

### 4.3 Assembled Battery Structure

**Fig. 5** shows a battery configuration in which thirteen

Table 2 Single cell specifications.

| Item | Spec. | Remarks |
|---|---|---|
| Rated Capacity | 10.0Ah | |
| Nominal Voltage | 3.8V | |
| Maximum Charge Voltage | 4.25V | Standard Charge Voltage：4.2V |
| Minimum Discharge Voltage | 2.5V | Standard Discharge Voltage：3.0V |
| Maximum Continuous Charge Current | 10A | Temperature：25℃ |
| Maximum Continuous Discharge Current | 30A | Temperature：25℃ |
| Cycle Life | 1000cycles | Temperature：25℃ |
| Dimensions | 150mm×82mm×11.2mm | |
| Mass | Approximately 245g | |


Photo 2 External view of single cell with a holder.

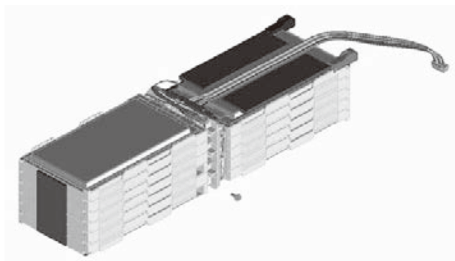


Fig. 5 Assembled battery.

single cells are assembled in series. The assembled battery adopts the design studied for the battery pack for E-Bike that supports the single cells with a holder (frame) (patent pending). We have designed the optimum frame structure using structural analysis, prototyping with the 3D printer of NEC Energy Devices and by drop/impact testing. We adopted this holder to improve the workability and accuracy of the assembly as well as for the resistance of the battery pack to vibration and impact during transport and installation. NEC Energy Devices will in future use this holder in the standard configuration of its battery packs.

### 4.4 BMS

**Fig. 6** shows the block diagram of the BMS and **Table 3** shows its main specifications. The functions of the BMS include: monitoring of single cells (voltage, current, temperature, remaining capacity, etc.), battery protection against overcharge, over-discharge and over-current, communication for noticing rectified battery states, and providing warning for notification of battery errors.

The newly developed BMS can connect up to 16 battery packs in parallel (max. capacity 32 kWh). The number of connected battery packs can be adjusted according to the power required by the communications equipment so that an optimum system can be built.

The BMS monitors the voltages of all of the 52 single cells through the four analog front ends (AFEs). If differences are detected between voltages across the single cells, the BMS controls the cell voltages to eliminate the differences. This function makes it possible to obtain the full performance of the battery packs and use them for a long period. The BMS also incorporates a lightning surge countermeasure in consideration of its outdoor installation.

### 4.5 CAN Communication

The traditional lead battery-based power supply systems of communications equipment do not control the battery charge current. Meanwhile, the power supply system based on the present battery packs is capable of notifying the rectifier of the battery pack data via communication to optimize the charge current according to the output power of the communications equipment.

Communication uses the CAN (Controller Area Network) to transmit/receive detailed information including the battery pack status with a flexible configuration. This enables optimum system control with regard to the information on the battery pack, even for an application other than the system described herein.

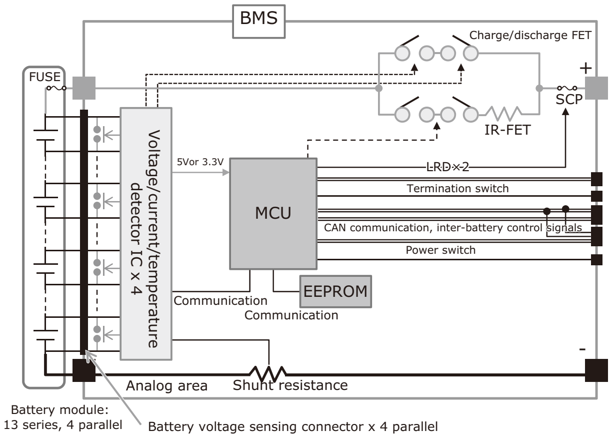



Fig. 6 Block diagram of BMS.

Table 3 Functions of BMS.

| No. | Item | Control functions/operations |
|---|---|---|
| 1 | Startup | The battery pack is started by either condition below.<br>• Power switch ON<br>• Charged voltage confirmation |
| 2 | Shutdown | The battery pack is shut down by either condition below.<br>• Power switch OFF<br>• Shutdown command reception through external communication<br>• Battery over-discharge detection |
| 3 | Battery information acquisition | Measurements of battery voltage, current, temperature and BMS temperature |
| 4 | SOC calculation | SOC management |
| 5 | Battery pack status detection | Detection of abnormalities inside battery pack |
| 6 | Battery protection | Control of FET inside BMS to protect battery and battery pack |
| 7 | Communication | Transmission of battery information through CAN communication |
| 8 | Auto CAN ID setting | The battery packs decides the CAN ID automatically after startup. |
| 9 | Parallel battery pack control | Control of parallel battery packs through CAN communication. |
| 10 | User interface | Operation status indication using two LEDs. |
| 11 | History log | Log of cycles, error history, highest/lowest operating temperatures, etc. |
| 12 | FW updating | FW updating through CAN communication |
| 13 | Inspection/shipping command execution | For use in correction before board shipment, writing of manufacturing No., etc. |

## 5. Conclusion

In the above, we introduce a battery pack for use in a power supply system for communications equipment that has been developed based on the proprietary battery technology of NEC Energy Devices. The battery pack incorporates technology accumulated from experience gained in the development/manufacturing of EV electrodes and the development of packs for motor driving application and we are satisfied that it achieves the performance and quality requirements of users of communications equipment.

Additionally, CAN communication is used to facilitate information transmission from the battery packs to the system, thereby improving its reliability. We believe that the application of the battery pack is not limited to communications equipment but is also usable in the backup power supply system for servers, camera, monitoring equipment or lighting equipment as well as for the motor drive power supply of mobile equipment, etc.

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* LEAF is a registered trademark of Nissan Motor Co., Ltd.

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