

# “LX Series”: Mini-UPS Products with NIMH Batteries for Data Centers

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## ABSTRACT

To increase power usage efficiency, data centers continue to reduce the power usage of their cooling equipment and use outdoor temperatures for their cooling methods. This has increased the demand for longer life of devices used inside in high-temperature environments. Fuji Electric has developed and released the “LX Series” of Mini-UPS products, which use nickel-metal hydride batteries and are intended for data centers. This uses Fuji Electric’s unique dual conversion method to increase battery life in high-temperature environments, decreases equipment size, and realizes high-performance through high-frequency PWM control. A wide range of optional products is available and the series complies with the RoHS directive.

## 1. Introduction

In recent years, the growth of the information services has led to a rapid increase in the volume of information processed. This has resulted in efforts to increase the processing capacity at data centers and the power consumption of ICT equipment such as servers is increasing. In addition, in order to achieve stable operation of the servers, air-conditioning systems have been introduced to maintain the ambient temperature environment at 25 °C. The electricity consumption by these air-conditioning systems is also increasing because of the increasing amount of heat generated by the servers. The raising of a data center's power usage effectiveness (PUE\*<sup>1</sup>) is essential as a measure for energy conservation and environmental problems. As the ratio of electricity consumption in air-conditioning systems is high, the method of avoiding their use as much as possible is being considered. For ICT equipment, this will lead to demands for operation and longer service life in even higher temperature environment.

At data centers, uninterruptible power supplies (UPS) are used to avoid the halting of services, for example, through system malfunction caused by power failure. In addition to conventional demands for higher efficiency of these UPS, there are demands for space-saving through miniaturization and for longer service life in high-temperature environments (at ambient temperature 35 °C). However, one key component is the storage battery, and the lead storage batteries conventionally used only have a short lifespan in a high-temperature environment, and they could not satisfy the demands of data centers.

\*1: PUE: See “Explanation 3” on page 217

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Based on the highly efficient “GX200 Series” of mini-UPS, Fuji Electric has developed and released the “LX Series” of low profile, rack-mountable UPS using nickel-metal hydride batteries to achieve miniaturization of the equipment and longer service life of the battery in high-temperature environments.

## 2. Characteristics

Figure 1 shows the external appearance of the LX Series. The LX Series uses Fuji Electric's unique dual conversion method, which combines both the voltage stability of a normal inverter type UPS and the high efficiency of a line interactive type. It has the five characteristics of space-saving miniaturization, high performance, longer service life, support for a wide range of options and support for environmental measures.

### 2.1 Space-saving miniaturization

Figure 2 shows the external appearance when mounted on a 19-inch rack. This device was designed



Fig.1 “LX Series”



Fig.2 LX Series mounted on 19-inch rack

as a model specifically for mounting on 19-inch server racks in data centers.

Compared with the output power of 10 kVA/ 8 kW of the standard model GX200 Series (M-UPS100 AD2B), there is approximately a 12% increase to 10 kVA/9 kW with load power factor 0.9. As the energy density per volume of nickel-metal hydride batteries is twice or more than that of lead storage batteries, it is possible to miniaturize compared to lead storage batteries of equivalent capacities. It was possible to reduce the volume to 85% and the mass to 70% compared to standard models. As a 10 kVA class uninterruptible power supply, it realizes first-rate high output power, miniaturization and weight reduction. When mounting on a 19-inch rack, it can be mounted in a space of 5 U (1 U  $\approx$  44.5 mm), realizing space-saving when it is mounted on a rack.

## 2.2 High performance

During normal operation, the LX Series suppresses power supply fluctuations and supplies the load with a low distortion sine wave voltage through high-frequency pulse width modulation (PWM) control at a switching frequency of approximately 16 kHz using insulated gate bipolar transistors (IGBT). It achieves an output voltage accuracy of 2% or less and a distortion factor of 4% or less for rated linear load. Figure 3 shows an example of the output waveform when the input power supply voltage to the device is fluctuating. For the input current, the use of the high power factor control system means that the outflow of harmonic current and reactive current generated by the load equipment is suppressed. Furthermore, as shown in Fig. 4, when a power failure occurs, the unusual input voltage is judged instantaneously and a switching of the output voltage without interruption is achieved. When the power returns, the operation is switched from the battery to normal operation once the input voltage has stabilized, and the output voltage is switched with-

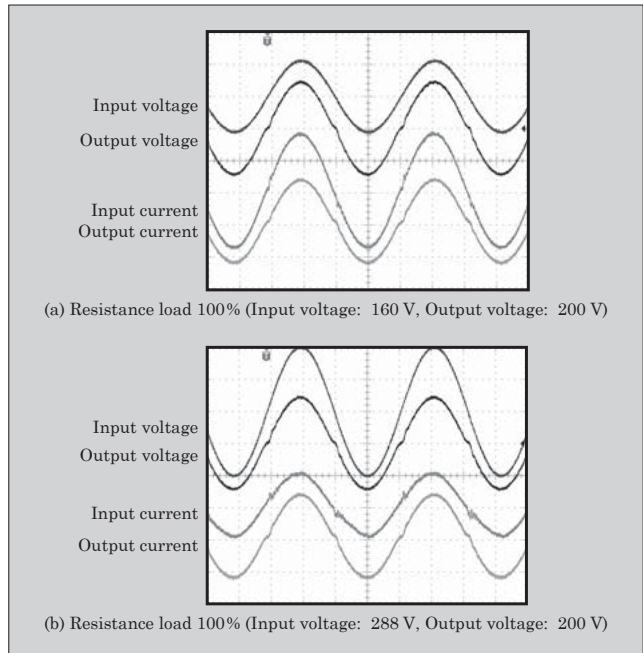


Fig. 3 Input and output waveforms (200 V/div, 50 A/div, 4 ms/div)

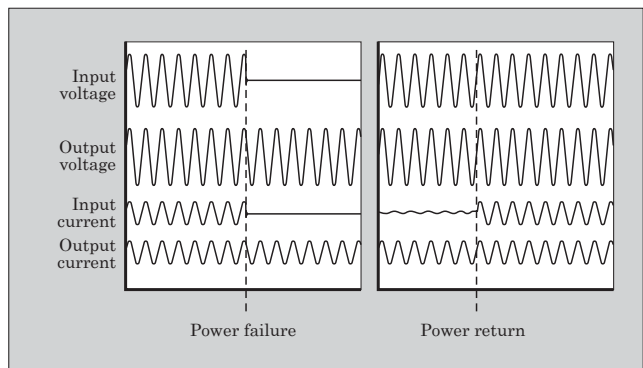


Fig.4 Switch-over waveforms at power failure and power return

out instantaneous interruption to the same voltage as when the power failure occurred. It is also equipped with various alarm output functions, including for input voltage abnormalities and battery abnormalities.

## 2.3 Longer service life

In order to extend the service life of nickel-metal hydride batteries to be used in high-temperature environments (at ambient temperature 35°C), optimal charge/discharge control is essential. A long-service life performance cannot be expected on nickel-metal hydride batteries if the same charging method is used as that for lead storage batteries.

On nickel-metal hydride batteries, a continuation of the charging after the full charge is reached results in an over-charged state and heat generation. The rise in temperature due to this heat generation has a great effect on the lifespan of the battery. For this reason, it is important to have full charge detection to stop

the charging before this over-charged state is reached. Furthermore, because capacity is lost due to the self-discharging which occurs on nickel-metal hydride batteries when the charging is stopped, it is essential to perform supplementary charging periodically.

In order to implement optimal control of the charging and discharging of the battery, dedicated control circuits were built in to monitor the voltage, the temperature and the charge-discharge capacity, providing communication links with the UPS control. This realized charge/discharge control which prevents over-charging and over-discharging. Furthermore, in order to suppress the degradation due to internal heat generation during the charging and discharging of the battery, a cooling fan was installed on the battery part to suppress the increase in internal temperatures. As a result, whereas lead storage batteries used in an environment of ambient temperature 25°C have a lifespan of 4 years, a lifespan of 8 years was achieved for these nickel-metal hydride batteries used in the same temperature environment. A lifespan of 4 years was also achieved for an environment of an ambient temperature 35°C. For the cooling fan too, a long-service life in a high-temperature environment was realized with the use of a long-service life fan.

## 2.4 Support of extensive options

### (1) Optional cards

#### (a) Standard interface card

As an external interface, an interface card using D-SUB 9 pin connection is provided as standard. This card supports the output of abnormality information signals and UPS automatic shut-down signal and also the input/output of RS-232C serial communication, etc.

#### (b) USB card

An example of USB card in use is shown in Fig. 5. With this USB card, the connection of a USB cable makes it possible to perform shutdowns and stop the UPS during a blackout from a standard

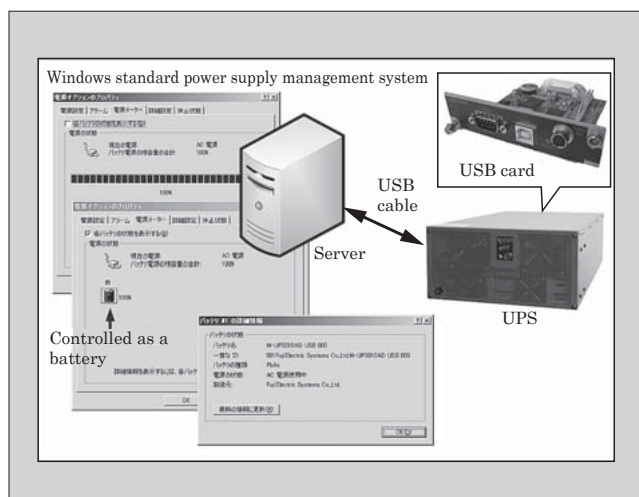


Fig.5 An example of USB card in use

power supply control system in Windows, without needing to install applications and drivers on the server. There is also a function for storing the UPS event log and data log into internal memory. By simply connecting a card to the server, this memory is allotted to a drive, and the log data can be easily retrieved.

### (c) “Web/SNMP card”

The Web/SNMP card makes it possible to use a Web browser, etc., to perform power supply management and operations of multiple servers from a remote location.

#### (i) Real-time monitoring function

Through the Web/SNMP card connected to a network, it is possible to manage the status of the UPS with a general purpose browser from client PC without needing to install any special software.

#### (ii) Multi-server shutdown function

When performing a backup of the entire network, multiple servers are connected to the UPS load. When stopping these multiple servers during a power failure or in accordance with a schedule, it is essential to shut down them safely.

When a power failure occurs, the Web/SNMP card sends a shutdown instruction via the network to multiple servers which have the shutdown instruction software module “Netshut” installed. The servers which receive the shutdown instruction then transfer the shutdown instruction to other servers. Using this shutdown instruction, it is possible to safely shut down each server which is receiving a power supply from the UPS.

By repeating this transfer, it is possible to configure a system to shut down multiple servers.

### (2) Step-down transformer box

Figure 6 shows the external appearance of the step-down transformer box. Some servers and peripheral equipment mounted on the racks require a 100 V power supply. The 200 V output from the UPS is converted to 100 V using a step-down transformer and used as the power supply for 100 V equipment. The output apparent power is 2 kVA and there are 5 electrical outlets for 100 V. The transformer load is displayed on indicators on the front of the device.

For mounting on a 19-inch rack, the transformer box is extremely low profile and uses a high efficiency transformer. It therefore achieves an occupied height of 2 U (86.25 mm) on a 19-inch rack. It also has various alarm outputs such as excessive load warnings and



Fig.6 Step-down transformer box

a ground fault alarm.

### 2.5 Support for environmental measures

The standard model complies with the RoHS directive\*2 as it uses components which comply with the RoHS directive and lead-free solder is used in the printed circuit board assembly. This device uses nickel-metal hydride batteries instead of small valve regulated lead storage batteries, and the entire device is a lead-free product.

### 3. Product Specifications

Table 1 shows the LX Series specifications. The device supports a wide range of AC input voltages, from 160 to 288 V. The output voltage can be easily set to 220, 230 or 240 V from the outside using a dip switch, and the device can support the power supply circum-

Table 1 "LX Series" specifications

Model		M-UPS100AN2V
Operation method		Dual conversion method
Cooling method		Forced air-cooling
Input	Voltage	160 to 288 V
	Number of phases/wires	Single phase/ 2 wires
	Frequency	50/60 Hz
	Maximum current	50 A
Output	Output power	10 kVA/9 kW
	Number of phases/wires	Single phase/ 2 wires
	Voltage	200/208/220/230/240 V
	Voltage accuracy	±2%
	Waveform	Sine wave
	Switch-over time at power failure	Uninterrupted
	Distortion factor	6% or less
Switching to commercial power		Uninterrupted (thyristor switching method)
Efficiency		96%
Battery	Type	Nickel-metal hydride battery (NiMH battery)
	Backup time	5 minutes
	Nominal voltage	259.2 V
External dimensions		W436.4×D780×H212 (mm)
Space occupied in 19-inch rack		5U
Mass		89 kg
External connections	Input	Terminal block (M6)
	Output	Terminal block (M6) NEMA L6-30×2
Usage environment	Ambient temperature	0 to 40°C
	Sound noise	55 dB (A) or below
	Relative humidity	20 to 95%

\*2: RoHS directive: An EU (European Union) directive restricting the use of limited hazardous substances in electrical and electronic equipment

stances in both Japan and overseas.

### 4. Circuit Structure and Operation

Figure 7 shows a comparison among the conventional normal inverter type UPS, the line interactive type and Fuji Electric's original dual conversion method.

With the dual conversion method, even if there is fluctuation in the AC input voltage, the fluctuating part of the power supply voltage is compensated with a series converter. As a result, a stable voltage is supplied to the load. At this time, whilst the parallel converter is compensating just for the energy used by the series converter in the voltage compensation, it controls the DC intermediate voltage to a constant value. Compared with the line interactive type, on which voltage compensation for the input voltage is done with a transformer and others, the voltage is steadier with the dual conversion method because the output voltage is compensated with the series converter. Also, compared with the on-line type, in which all the power output is converted with converters and inverters, in the dual conversion method, only the energy needed for the voltage compensation is converted in the parallel converter part, and the conversion losses are greatly reduced and a higher efficiency is achieved which is equivalent to that on line interactive types.

If a power failure occurs in the AC power supply, at the same time as the input side is opened, the series converter is used to supply stable power continuously

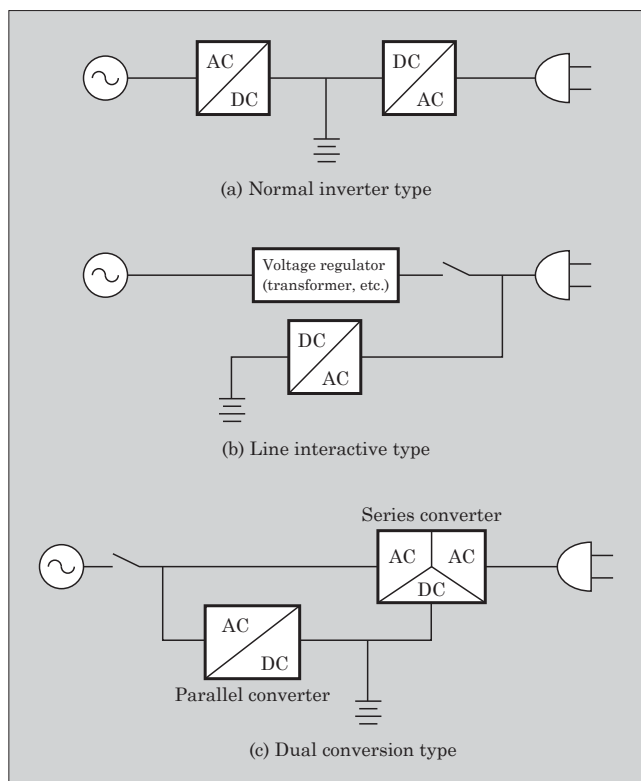


Fig.7 Comparison of main circuit block diagrams

from the battery to the load. Furthermore, there is also a built-in bypass circuit which makes it possible to switch without interruption to the AC input power supply if there is excessive load or a UPS abnormality.

## 5. Postscript

The “LX Series” mini-UPS for data centers with nickel-metal hydride batteries was presented. Both a longer battery service life in high-temperature environments and miniaturization of the equipment were

achieved with this product and it is capable of responding to the environment demanded in data centers. Furthermore, by making use of the fact that this UPS is a 200 V system, it is expected that it will not only be used in data centers, but will also be extended to embedding in various types of manufacturing equipment. We will continue to work on an expansion of the range of capacity models and further improvements to reliability, and we will make efforts to develop and commercialize UPS to reply to a wide range of customer requirements.





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