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# Development of Small-capacity OFF-LINE UPS

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## 1. Introduction

With the global environmental issues these days, demand is growing for energy-saving and small devices. Of these requirements, the energy-saving requirement has necessitated a shift from constant-inverter-supply type UPSs (ON-LINE UPSs) to constant commercial power supply type UPSs (OFF-LINE UPSs). Under these circumstances, demand grew for UPSs geared to rack mounting, so that we developed OFF-LINE UPSs having a capacity of 2kVA (hereinafter referred to as "this UPS") as server-only UPSs.

In the development process, we concerned with unit efficency, cost performance, operability, maintainability and safety.

## 2. Features

### 2.1 UPSs for 19-inch Racks

With the growth of servers and other networking equipment, demand is growing for mounting them on 19-inch racks. This then increased the necessity of mounting UPSs in 19-inch racks together with other equipment.

This UPS was developed as a special-purpose UPS that can be mounted on a 19-inch rack mount, with the unit height set to 4U (1U = 44.5mm) as illustrated in Fig. 1.

### 2.2 High Efficiency

During normal operation, commercial power is outputted as it is. The result is a small internal loss in the unit, with an operation efficiency as high as 96%.

The unit is devoid of an insulated transformer, so that it can run at high efficiency even during a commercial power fails.

### 2.3 Bi-direction Operation

Traditional OFF-LINE UPSs incorporated an inverter circuit on cold standby. They were thus disadvantageous in that one could not detect a circuit troble until a commercial power fails.

With this UPS, the main circuit can be run bi-directionally to allow a common circuit to run constantly with different roles during normal conditions and during a commercial power fails. This eliminates the defect that traditional models had and increases reliability.

### 2.4 Wide-range Voltage and Sine Wave Output

This UPS is geared to inputs of both AC100V and AC200V, which allows users to make effective use of the power distribution equipment they already have.

The output wave form of inverter outputs during a commercial power fails was set to a sine wave. This is because recent load-side equipment is based on high power factor converters, so that connecting to a rectangular output UPS makes it impossible to compensate for operation

### 2.5 Maintainability and Safety

An increasing number of computers that run around the clock cannot afford to stop being fed for UPS maintenance or checking. Furthermore, rack-mounted equipment cannot be removed easily from their racks.

For that reason, for this UPS, all its internal components were modularized as illustrated in Fig. 2, and the weights of the units were set to about 20kg to allow a service person to work on it alone. What is more, the battery unit was divided into two blocks to set the unit voltage to the safety voltage or lower (≦60V DC). This allows a service person to remove the battery unit and inverter unit safely and easily from the front portion of the unit without stopping feeding the load.

It was so designed that the battery circuit could be electrically shut down when the front cover of the unit is opened, thus ensuring personal safety. To prevent the user from forgetting to connect to the unit when replacing the batteries, the unit was designed to emit a warning when the battery unit was not connected. This prevents human errors.

In the case of an unexpected trouble, the inverter unit can be replaced with the maintenance breaker turned on, without stopping feeding the load. A plug-in system is also adopted to enable hot swap.

### 2.6 Cutting Back on Maintenance expenses

For batteries, which are consumables, we selected a model having a service life of 5 years. For cooling fan and electrolytic capacitor, we selected long-life models, thus obviating the need of replacement for 10 years. The aim was to cut back on maintenance expenses required for replacement and other operations.

### 2.7 Display

This UPS adopts an LED-based status display to facilitate recognition of the unit status. (See Fig. 3.) This allows inexperienced personnel to detect unit status and errors quickly. The unit was also designed to display load currents during a normal run and a commercial power fail by means of a level meter and to display the charge level and balance level of the batteries, thus allowing users to use the UPS under appropriate conditions.

### 2.8 Interface

This UPS comes with a contact signal interface as standard equipment as a status signal for the unit as illustrated in Fig. 4. It then sends UPS information to the computer. This allows users to control the unit from a remote site.

The interface is provided with reinforced insulation (dielectric strength ≧3kV AC) from the main circuit of the unit, and is designed with electric considerations.

## 3. Circuit Configuration

### 3.1 Electric Characteristics

Table 1 shows the characteristics of this UPS.

Table 1 Electrical characteristics of OFF-LINE UPS

| | Item | | Unit | Rating or characteristic | Remark |
|---|---|---|---|---|---|
| Type | Model | | – | 1kVA/2kVA OFF-LINE UPS | By setting switches. |
| | Cooling system | | – | Forced air cooling | |
| | Operation system | | – | Constant commercial power supply | |
| AC input | Rated voltage | | V | 100/200 | Fluctuation range: ± 20% |
| | Rated frequency | | Hz | 50 or 60 | Fluctuation range: ± 3% |
| | Number of phases | | – | Single-phase, 2 wires | |
| | Maximum capacity | | kVA | 1.5/2.6 | Maximum capacity of battery when recharged |
| | Rated capacity | | kVA/kW | 1 (1.0)/2 (1.6) | Apparent power (effective power) |
| AC output | Battery operation | Number of phases | – | Single-phase, 2 wires | |
| | | Rated voltage | V | 200/200 | Sine wave output |
| | | Voltage setting precision | % | Within ± 10 | |
| | | Rated frequency | Hz | 50 or 60 | Automatic selection |
| | | Frequency precision | % | Within ± 1.0 | |
| | | Waveshape distortion | Linear load % | Within 3 | During a rated run |
| | | | Rectifier load % | Within 7 | |
| | | Transient voltage fluctuations | % | Within ± 10 | Load changes, INV startup, etc. |
| | | Response time | cycles | Within 3 | |
| | | Load power factor | – | 1/0.8 (delay) | Fluctuation range: 0.6 (delay) to 1.0 |
| | | Overcurrent protection | % | 105 or more | |
| | | Switching time | ms | Approx. 10 | after power fail is detect |
| | | Backup time | min | Approx. 20 | Ambient temperature 25°C |
| Battery | Rated capacity | | Ah | 12 | Small size sealed, long-life type |
| | Number | | | 8 | |
| | Nominal voltage | | V | 96 | |
| | Recharging time | | hrs | Approx. 24 | |
| Acoustic noise | | | dB | 40 (45) or less | Unit form 1m,characteristic A ( ) durinng a commercial power fails |
| High-frequency noise | | | – | As per VCCI Class A | |
| Unit dimensions | | | mm | 483x174x650 | Front width x height x depth Mountable on a 19-inch rack (4U) |
| Unit weight | | | kg | 65 | |

## 3.2 Circuit Configuration

Fig. 5 is a circuit system diagram.

This UPS consists of a rectifier, inverter, charger, DC/DC converter, battery and direct supply circuit. The battery is normally charged with a rectifier and charger while feeding an AC power input to the load. If the AC input has a commercial power fail or other error, the AC switch is used to shut down the AC input and DC power from the battery is converted to AC power by means of a DC/DC converter and an inverter, and is supplied to the output. The control unit consists of a controller, display and interface and controls the main circuit and monitors input errors and unit status.

Of these, the items that have made the aforementioned features a reality are described below.

The main circuit is devoid of an insulated transformer. This omission of an insulated transformer makes the unit smaller in size, lightweight and efficient.

Fig. 6 illustrates bi-directional action. A general-purpose IGBT module is used for the power conversion element of the main circuit. It is subjected to bi-directional operation to allow a common main circuit to be used during a normal run and during a blackout backup run. This means that, when the same module runs normally, the system is running as a full-bridge rectifier and a step-down charger (Fig. 6①).

During a commercial power fails, the system is battery-powered to run as a boosting DC/DC converter and a full-bridge inverter (Fig. 6②).

This makes the main circuit run during a normal run, so that the user is no longer unable to detect a fault until a commercial power fails. Unit reliability is thus higher and a fewer number of components are involved due to common use.

The selection of main circuit components and the appropriate layout result in a reduction in the snubber circuit in the main circuit by about 70% from traditional models, without generating unneeded surges.

These measures have made this unit efficient and reduced the number of components used. Furthermore, converting most of the circuitry except for the inputs and outputs and battery to printed circuit board has cut back on production labor.

## 4. Conclusion

We developed an OFF-LINE UPS mountable on a 19-inch rack for energy-saving purposes. We made it devoid of a transformer, thus making the unit compact, lightweight and efficient. The power converter was subjected to bi-directional operation to cut back on the number of components and increase reliability.

For this project, we did not improve the power factor by means of this unit because the computer on the load has undergone a rise in input power factor. To meet the market's varied needs, however, we think that it is necessary to have a circuit enhanced in its input power factor to ensure its versatility.

Computers and peripherals will be further downsized and networked, with a further rise in demand for small-capacity UPSs and demand for lower prices and higher efficiency. We intend to provide products that satisfy users by developing products quickly in response to these market requirements.

We wish to express our thanks to many people for their help and advice in developing and commercializing this UPS.

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fig. 1 External view of the unit

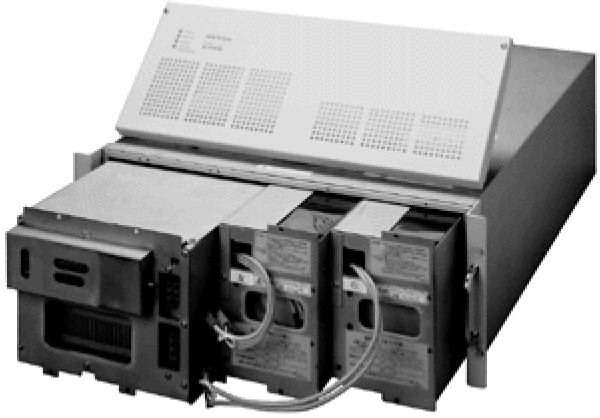

fig. 2 Unit replacement

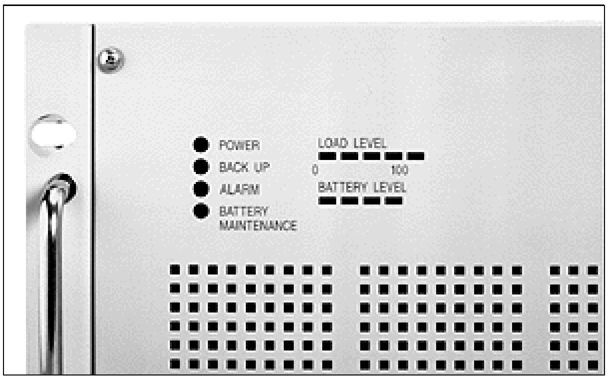


fig. 3 Display

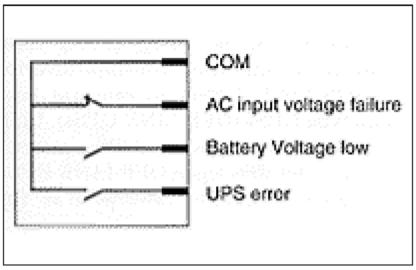


fig. 4 Interface

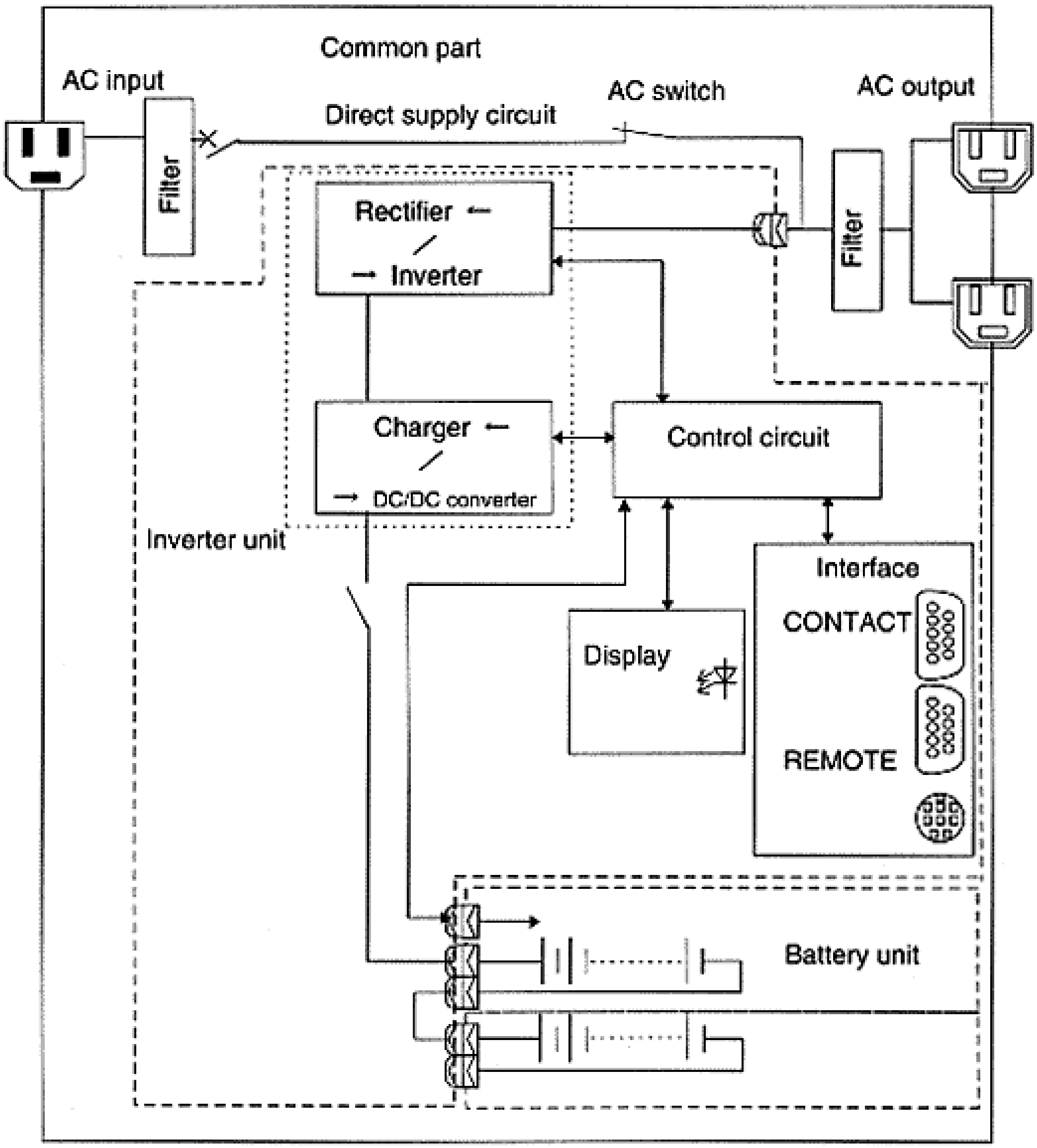


fig. 5 Circuit system diagram

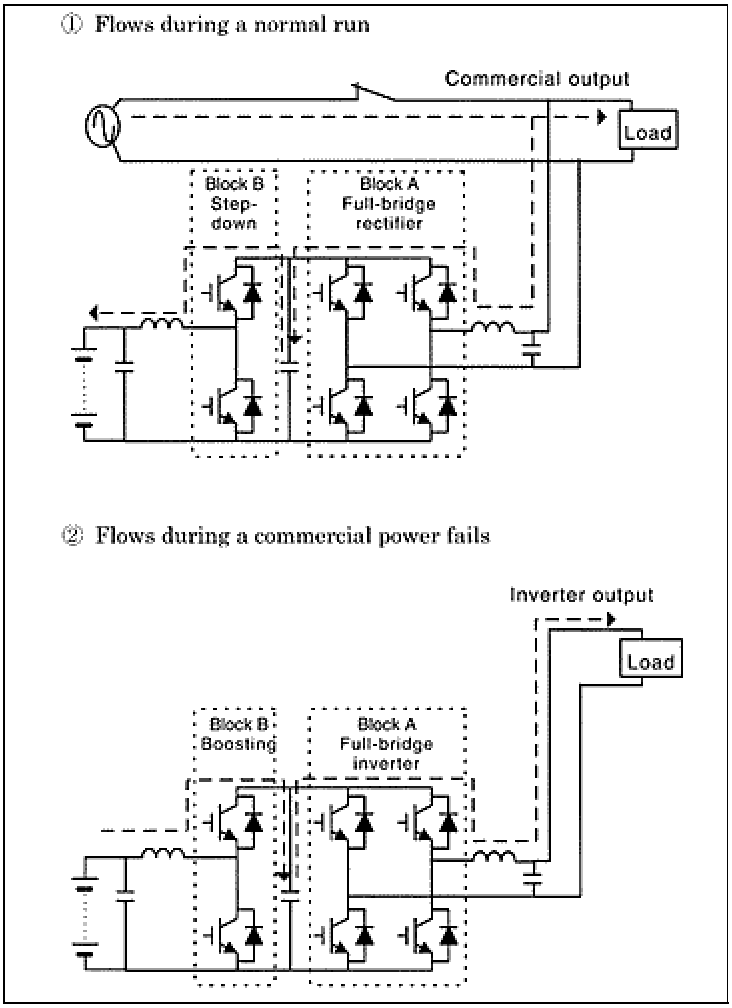


fig. 6 Bi-directional operation