NEW TYPE MINI-UPS

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1. INTRODUCTION

In recent years, the importance of small, high-performance computers has continued to increase due to advances in computer downsizing and networking. Use of an uninterruptible power supply (UPS) has become necessary even for small computers. Accordingly, the demand for relatively small capacity UPS (Mini-UPS) has been increasing.

While superior output performance of the UPS is a natural requirement for use as a computer power source, recent demands for miniaturization, light weight, and low cost have grown stronger. In addition, not only output performance, but also input performance has become important. That is, the reduction of harmonic components in the input current and improvement of the input power factor have led to efforts to avoid harmonic trouble extending to the power supply system and to reduce the required input capacity.

Using the latest power electronics technology, Fuji Electric has developed UPS's in response to user needs. Recently, improvements to the conventional Mini-UPS series (1 to 10 kVA), led to the development of a small size, light weight and high performance 1 kVA model (M-UPS 01F), which is seen as the first level of the next generation series. The features, specifications and characteristics are described below.

2. FEATURES

The New Mini-UPS 1 kVA model (M-UPS 01F) has the following features.

2.1 Small size, light weight

Small size and light weight were achieved through the use of high-frequency MOSFET AC/DC and DC/AC converters, and the elimination of commercial frequency insulating transformers which had been an obstacle for size and weight reduction.

This has led to an approximately 40% reduction in both size and weight, compared to Fuji Electric's previous models. With its compact size and light weight, the New Type Mini-UPS may be easily set up on a desk top (or underneath).

2.2 Clean input current waveform

By replacing the conventional diode or thyristor rectifying circuit with a MOSFET high frequency switch-mode rectifier, a sinewave input current with almost no harmonic components is produced. In addition, an input power factor of approximately 1.0 is maintained.

This eliminates the fear of harmonic trouble at the power supply system and simultaneously reduces the required input power capacity (refer to section 2.4).

2.3 Clean output voltage waveform and excellent transient characteristics

Using a MOSFET based high frequency PWM inverter, the output voltage waveform is directly compared to a reference sinewave signal and any distortion in the output waveform is quickly compensated. In other words, instantaneous voltage control is performed.

This virtually eliminates output voltage waveform distortion which becomes a problem when a capacitor-input rectifying load is connected and the current is greatly distorted. At the same time, transient voltage characteristics are improved for cases of sudden load change, input power failure or recovery. For these reasons, the Mini-UPS is well suited for connection to a 100% capacitor-input rectifying load (computer load).

2.4 Energy efficient operation

As a result of making each part more efficient, the total generated loss is about 50% lower than that of previous models. This high efficiency coupled with the fact that the input power factor is maintained at almost 1.0, means that the required input power capacity is significantly decreased (approximately 60% of the previous model) and energy efficient operation is obtained.

2.5 Natural air cooling

Due to the reduction of generated loss and an efficient cooling structure, the forced air cooling fan, used previously, is no longer necessary. This is the first realization of natural air cooling in this class of continuous inverter supply type UPS.

The result is reduced audible noise, and at the same time, both trouble caused by dust intake, and the need for cooling fan maintenance are eliminated.

2.6 Easy battery maintenance

Sealed lead-acid small batteries requiring no maintenance are used. These are assembled as one unit and is located inside the UPS. This battery unit may be safely and easily replaced.

3. SPECIFICATIONS

The main specifications are shown in **Table 1**. A highly reliable continuous inverter supply system is employed. A computer load (capacitor-input rectifying load) is assumed on the output side. The switch-mode rectifying circuit on the input side forms the basis for a harmonic reduction function which produces a high quality input current with almost no harmonic components.

4. EXTERNAL APPERARANCE AND DIMENSIONS

Figure 1 shows the exterior and **Fig. 2** lists the external dimensions and mass of the Mini-UPS 1 kVA model (M-UPS 01F). This model was designed to fit on an office desktop or underneath. With its small size and light weight, the exterior was designed to be suitable for the office workplace.

5. CIRCUIT CONSTRUCTION

Figure 3 shows the construction of the main circuit. It consists of a switch-mode rectifier circuit, a PWM inverter circuit, a battery unit, and a battery charging circuit. All the necessary functions for a UPS are included.

Special features of each of these elements are described below.

5.1 High frequency switch-mode rectifier

The high frequency switch-mode rectifier converts AC input voltage to stable DC voltage and supplies power to the PWM inverter of the final stage.

Fig. 1 Exterior view of New Mini-UPS 1 kVA

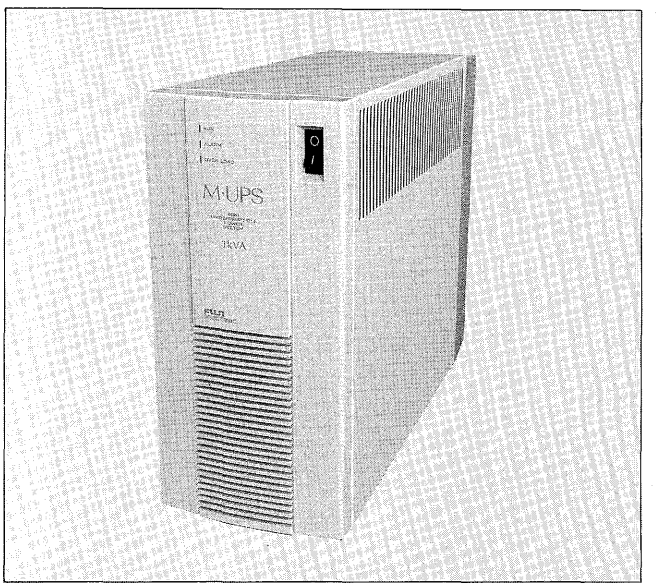


Table 1 Specifications of New Mini-UPS 1kVA

Items \ Model No.		M-UPS 01F
AC output	Rated capacity	1kVA / 0.8kW
	Number of phase	Single-phase, 2-wires
	Rated voltage	100 V
	Frequency	50/60 Hz
	Load conditions	Linear load or capacitor-input rectifying load with a crest-factor of 3.0 or less
	Voltage accuracy	Within ±2%
	Voltage waveform distortion	4% or less (at above load conditions)
	Transient voltage variation	• 0% ⟷ 100% sudden load change : ±5% or less • Input power failure or recovery : ±5% or less • ±12% sudden input voltage change : ±5% or less
AC input	Voltage	100V ±12%
	Frequency	50 or 60 Hz
	Number of phase	Single-phase, 2-wires
	Capacity	Less than 1.0 kVA
	Current waveform distortion	10% or less (at rated input and output conditions)
Others	Battery backup time	5 minutes (at 25°C and load power factor: 0.7)
	Ambient temperature	0 to 40°C
	Cooling method	Natural air cooling
	Audible noise	Less than 40 dB(A)

Figure 4 shows the main circuit diagram of the high frequency switch-mode rectifier. One arm of the full-wave rectifier diode bridge in the main circuit is replaced by a switching element to realize a low loss rectifying circuit. FRED-MOSFETs (Fuji Electric's 2SK1277 250 V 30 A) are used for the switching elements. The switching is PWM controlled by a 20 kHz carrier frequency. A quiet and compact inductor and high frequency filter are realized by high frequency switching which exceedes the audible range.

Fig. 4 Switch-mode rectifier main circuit

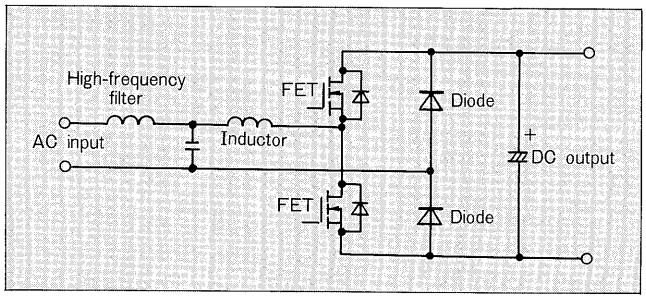


Fig. 2 External dimensions and mass

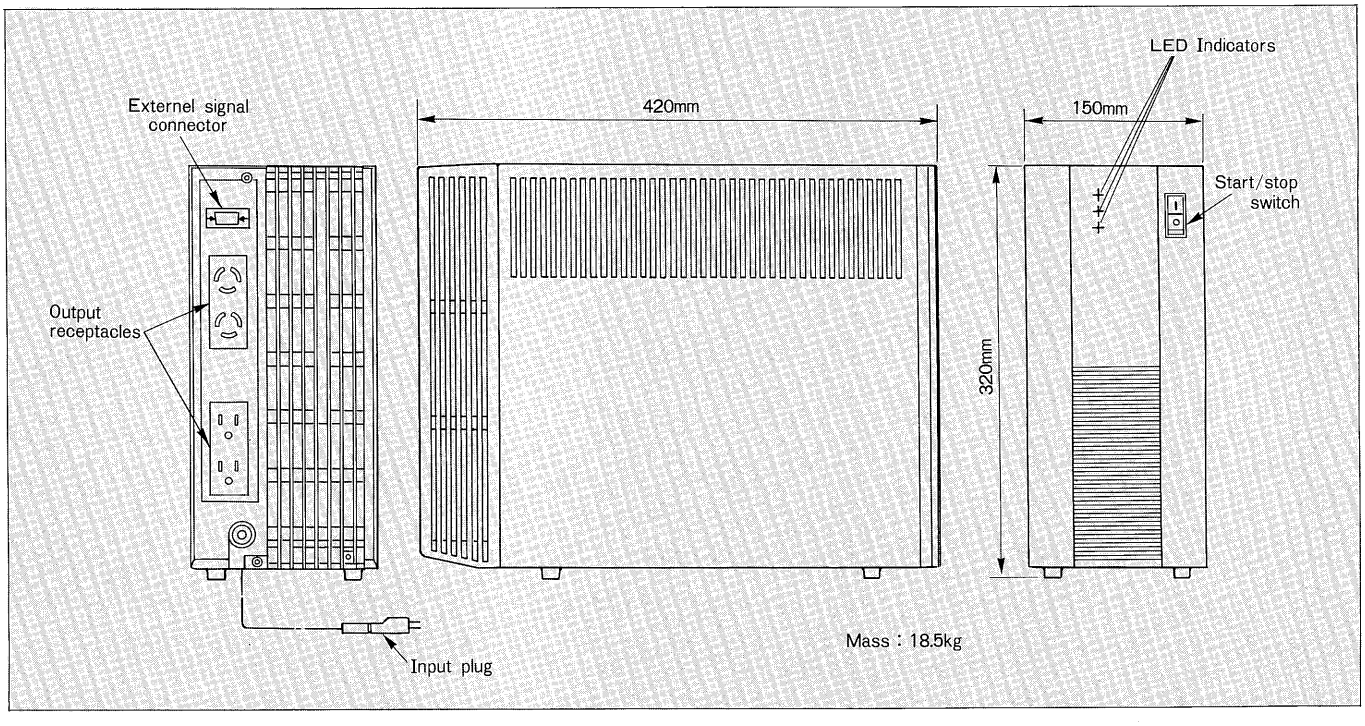
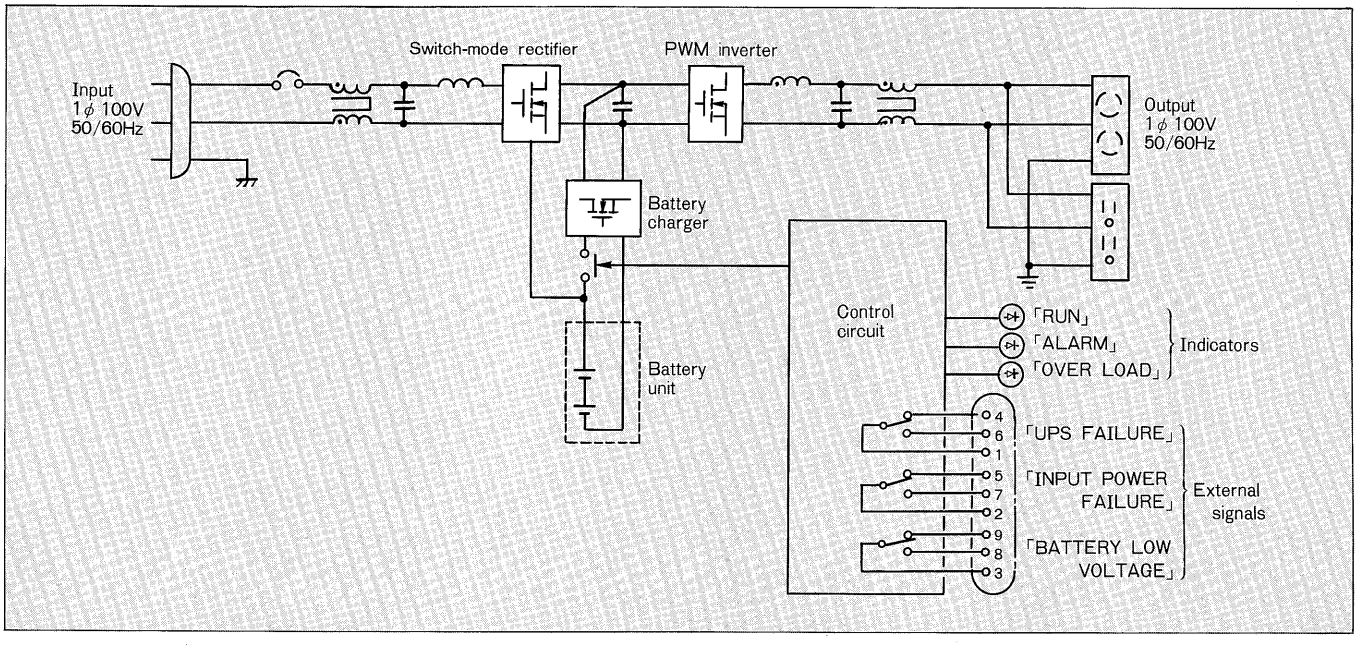


Fig. 3 Circuit diagram of New Mini-UPS 1 kVA



PWM control is performed to stabilize the DC output voltage at a constant value and to simultaneously match the input current waveform to the input voltage waveform. The result is that the input current is made a sinewave of the same phase as the input voltage. Harmonic components in the input current are reduced and the input power factor is maintaned at almost 1.0.

5.2 High frequency PWM inverter

The PWM inverter consists of a full-bridge circuit, using FRED-MOSFETs of the same rating as that of the previously described high frequency switch-mode rectifier. It is driven by a 16 kHz carrier signal that is sinewave modulated. With this high frequency switching, it was possible to make the sinewave shaping filter of the final stage smaller.

In addition to operation at high frequencies as discussed above, instantaneous voltage control is used and the circuit was designed to have the error between the output voltage and the reference sinewave signal compensated at every carrier cycle. This surpresses distortion in the output voltage waveform to a low value even when there is a distorted current with many harmonic components. Transient characteristics are also greatly improved.

6. CHARACTERISTIC TEST RESULTS

Test results of the Mini-UPS 1 kVA (M-UPS 01F) representative characteristics are described below.

6.1 Input characteristics

Figure 5 shows both the input current waveform and the input voltage waveform when the load is at its rated value. It can be seen that the input current waveform is maintained as a sinusoidal waveform having the same phase as the input voltage due to the previously mentioned high frequency switch-mode rectifier circuit. The distortion factor of the input current waveform was 5.8% and the input power factor was 0.99 or greater.

In addition, since the total conversion efficiency from AC input to AC output reached 87.8% and the input power factor was maintained at approximately 1.0, the required input power reduced and efficient operation was achieved.

6.2 Output characteristics

(1) Output voltage waveform

Figure 6 shows the output voltage waveform and output current waveform when a 100% capacitor-input rectifying load is connected. As mentioned before, since high frequency PWM control with instantaneous voltage control function is performed, distortion in the output voltage waveform is surpressed even when there is a distorted current with peak values reaching three times the root mean square value. The Mini-UPS can be used without any problems even with loads which have a high speed power failure detection circuit.

(2) Output voltage transient characteristic

Transient characteristics of the output voltage for the cases of 100% sudden load change and AC input power failure are shown in **Fig. 7** and **Fig. 8** respectively. Both cases demonstrate favorable characteristics, and the transient change is limited to 2 - 3% or less.

Fig. 6 Output voltage and current waveforms for capacitor-input rectifying load

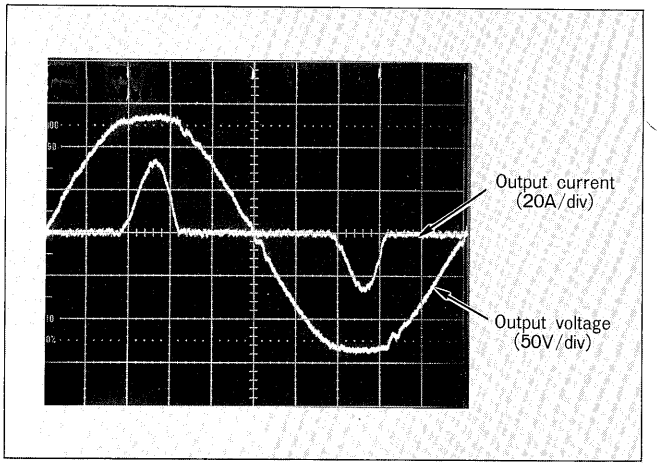


Fig. 5 Input voltage and current waveforms

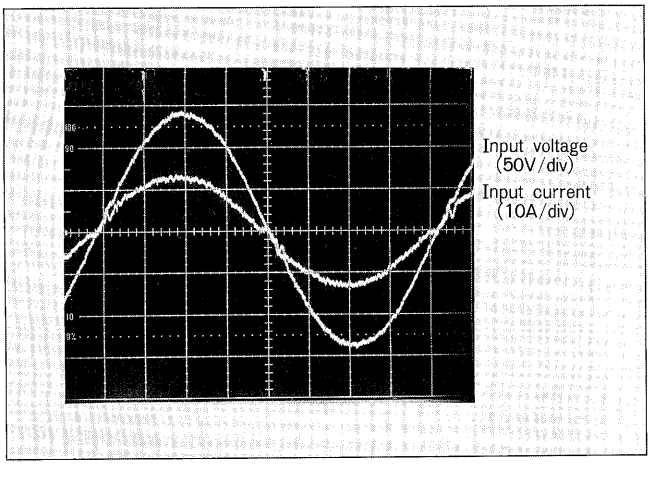


Fig. 7 Sudden load change characteristics

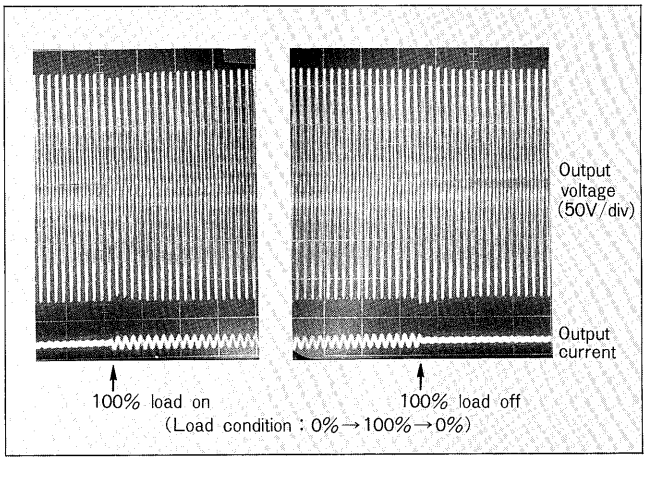
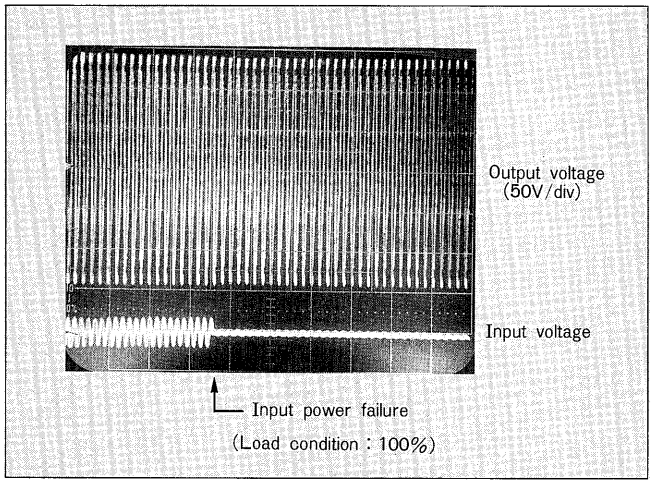


Fig. 8 Output voltage change during power failure



7. CONCLUSION

This article introduced the small size, light weight and high performance New Type Mini-UPS 1 kVA. Constructed from a high frequency switch-mode rectifying circuit using MOSFETs and a high frequency PWM inverter circuit, this device has excellent output characteristics for use as a power source for computer loads. The Mini-UPS 1 kVA can be used even for loads with a large inrush current or rectifying loads without any reduction in capacity. It provides, at the same time, an input current with low harmonic content and an improved power factor.

In the future, trends towards downsizing of computer equipment and increased networking are sure to steadily increase the demand for relatively small capacity UPSs. To expand the application of this type of UPS, Fuji Electric plans to pursue means to increase reliability and performance, lower cost, improve ease of handling/operation, and to realize these in the next generation 2 to 10 kVA series.