Development of the Mid-Capacity UPS "SANUPS E"

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1. Introduction

The ability to supply reliable power has always been a requirement for an uninterruptable power supply (hereafter, UPS). This is especially true when serving as a power supply for information and telecommunication equipment including the computers that run our information oriented society. In addition, the demands for high efficiency, space-saving, and noise reduction are increasing from the global and environmental perspective.

Based on this background, we developed the "SANUPS E", as a highly effective, compact, and lightweight next generation UPS without any sacrifice in reliability.

The new "SANUPS E" has achieved high efficiency and reduced size by using one power converter and increased reliability with the use of a new control method. This document provides an overview of the basic operation and features of the new "SANUPS E".

2. Background of the Development

There are many types of UPS architectures but they can be roughly divided into 2 system configurations types. These are the "continuous inverter power supply system" UPS (on-line UPS) that uses 2 power converters and the "continuous commercial power supply system" UPS (off-line UPS) consisting of 1 power converter. Table 1 shows the comparison of the respective characteristics.

Table 1 Comparison of UPS Power Supply Method

Item \ Method	"On-line" UPS	"Off-line" UPS
Output Power Supply Quality	◎ No power break	△ With power break
Power Loss	△ 2 converters	◎ Continuous commercial
Operation Reliability	◎ Continuous operation	△ Non-continuous operation
Product Price	△ 2 converters	◎ 1 converter

The off-line UPS is compact and low cost since it contains only one converter. In addition, the off-line UPS normally supplies power from the commercial source so normal operation power loss is minimized. However, a break in power is inevitable because the inverter starts up after a power problem is detected. Therefore, use is limited and depends on the application. Meanwhile, the on-line UPS is capable of supplying high quality power all the time without power breaks during power failure. This is because the commercial power is converted from AC→DC→AC through 2 power converters. However, as mentioned before, use of 2 power converters does increases the power loss.

Reliability used to be regarded as the most important feature of a UPS so the on-line UPS was the mainstream product. However, from an environmental perspective, the UPS that has high reliability, high efficiency (energy-savings), and low cost favors the characteristics of the off-line UPS which is now in great demand.

3. Outline of "SANUPS E"

3.1 Basic Configurations and Operation

"SANUPS E" UPS uses the new parallel processing method. This has the advantages of both the on-line UPS and the off-line UPS as described in the previous section.

Fig.1 shows the basic configurations. As seen in Fig.1, the "SANUPS E" consists of an ACSW (AC Switch) that is detached when the commercial power supply is interrupted and also one power converter (inverter).

The inverter is working while connected in parallel with the commercial power supply through the ACSW. At this time, the inverter is generating the same voltage as that of the commercial power supply. In addition, the inverter is able to generate only the distorted current from the load side using an active filter function while the commercial power supply provides sine wave current without distortion. At the same time, the inverter is charging the storage battery with regenerated current via a charging function. The active power of the load was passing through two converters in the on-line UPS, but in this parallel processing method, since the active power of load doesn't go through a converter, power loss is small and power can be efficiently supplied to the load.

Moreover, this UPS is very reliable because it can detach from the commercial power supply to continue supplying power to the load via the inverter if the commercial power supply is in trouble or vice versa. This is possible because the commercial power supply and the inverter are in a parallel redundant configuration.

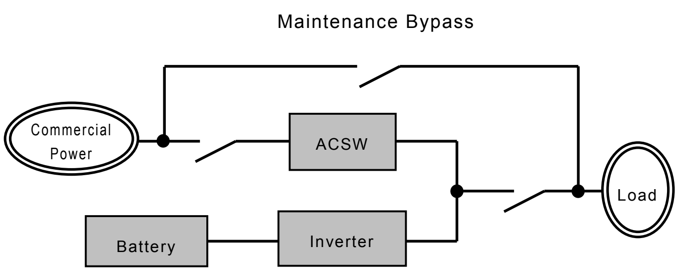

Fig.1 Basic Configurations of "SANSUP E"

Operation is explained as follows.

Normal operation (During commercial parallel redundant operation)

As the Fig.2 (A) shows, the inverter works as an active filter and charger while supplying power to the load in combination with the ACSW and commercial power supply during normal operation. Harmonic current generated from the load equipment is controlled, reactive power of the load is compensated, and input current is controlled as a sine wave with power factor close to 1.0 due to the active filter function. Fig.2 (B) shows the I/O waveform at this time.

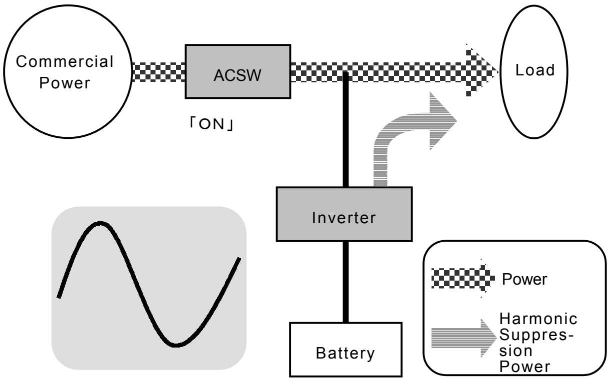

Fig.2 (A) Normal Operation

(During Commercial Parallel Power Supply)

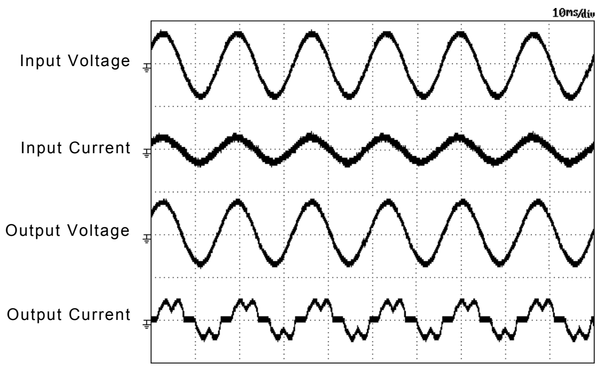

Fig.2 (B) I/O Waveform During Normal Operation

Abnormal AC Input

(Power failure within half a cycle)

When the AC input is interrupted, as shown in Fig.3 (A), the ACSW gate turns off. However, the thyristor turns off only when input voltage drops lower than the voltage of the inverter due to the characteristic of the thyristor. Even with the instantaneous voltage drop as when the ACSW turns off, the electrolytic capacitor inside the inverter temporarily supplies power to the load if it recovers within half a cycle. Operation and the I/O waveform in this case is shown in Fig.3 (B) and (C).

(Power failure longer than half a cycle)

The inverter operates with the full inverter function, and supplies power from the storage battery to the load. Operation and the I/O waveform of this operating condition is shown in Fig.4(A) and (B).

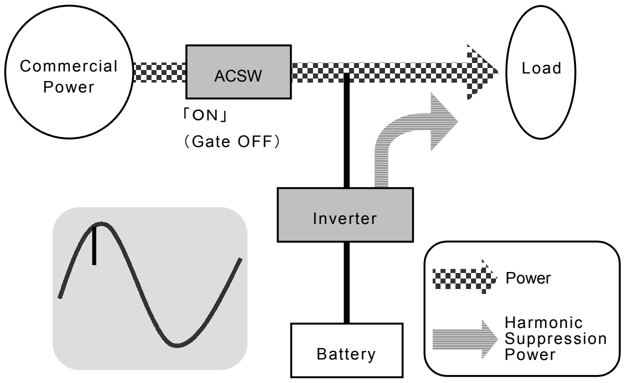

Fig.3(A) Normal Power Detection Circuit Operation

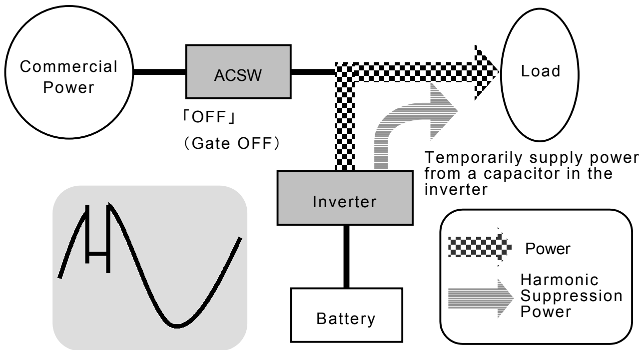

Fig.3 (B) Power Failure Within Half A Cycle

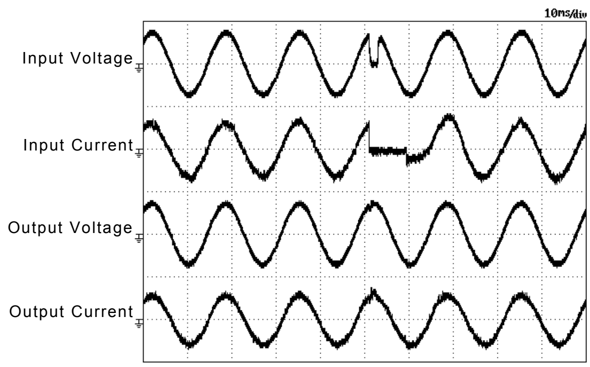

Fig.3(C) Power Failure Waveform Within Half A Cycle

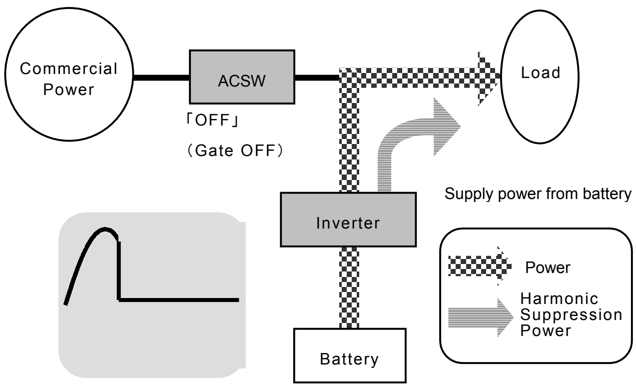

Fig.4 (A) Power Failure Longer Than Half A Cycle

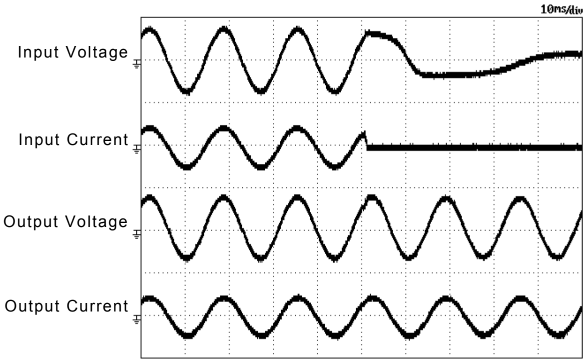

Fig.4 (B) Power Failure Longer Than Half A Cycle

3.2 Characteristics

○ Improvement of the Operation Efficiency

During normal operation, the power loss generated inside the UPS is small and the operating costs can be reduced by more than 10% as compared with the on-line UPS. This is because the fundamental wave power is supplied to the load from the commercial power supply and the inverter is only compensating for the harmonic power.

○ High Reliability

(1) The commercial power supply and the inverter are operated redundantly in parallel. This allows the commercial power supply to be rapidly disconnected without momentary loss of power.
(2) The storage battery doesn't need to supply power during short power interruptions because the inverter's internal capacitor supplies power during any instantaneous voltage drops (within half a cycle) This prevents unnecessary discharge and consumption of the storage battery.
(3) In the power supply verification test, normal function of the storage battery and the ACSW can be checked in the following manner. Use the storage battery to supply power with the ACSW in the ON state. This is safe even if the storage battery is disconnected because the ACSW is ON. Now, after the battery is determined to be normal, turn the ACSW OFF and check if there is any trouble with the ACSW. Using this procedure, the actual load operation can be checked and the resulting inverter operation during a power failure will be reliable.

○ Improvement of the Overload Capacity

The overload capacity of this system is 800% (over 500ms) which compares to our conventional model (800% over 2 cycles). As a result, the UPS can handle a large overload current on the load or power side.

○ Size and Weight Reduction

The "SANUPS E" was designed around one power converter as previously described and the circuit configurations were simplified to decrease the number of parts. This allowed us to achieve a decrease in mass of about 50% and decrease in volume by approximately 40% as compared with our conventional model at 20kVA.

Fig.5 shows the "SANUPS E".

Fig.5 "SANUPS E"

○ Improvement of the Maintainability

In any UPS, there are parts that need to be exchanged regularly, such as the batteries and the cooling fans. In the SANUPS E, the serviceability was improved by designing the unit to allow easy exchange of parts during repair and maintenance.

Additionally, as shown in Fig.1, the UPS is safely maintained because the maintenance by-pass circuit for voltage shut-off is included inside the equipment.

○ Supporting Network

The "SANUPS E" can be connected to a computer or network using the serial interface or optional LAN interface card.

Also, in support of a networking requirement, functions such as "auto shutdown upon power failure", "scheduled operation", "display of operating state", and "display of measurement values" can be accessed by utilizing Sanyo's UPS management software, "SAN GUARD IV LITE".

○ Specifications

This system is an I/O three-phase, three wire 200V system and the capacity is 20~200kVA. Table 2 shows the main specifications of the 20kVA unit.

Table 2 Standard Specifications

Item			Standard Specifications
Rated Capacity			20kVA/16kW
AC Input	Rated Frequency		50/60Hz
AC Input	Number of Phases		3-phase, 3 wire
AC Input	Rated Voltage		200V±10%
AC Input	Power Factor		0.97 or higher
AC Input	Compensation of Distorted Current	Compensation Capacity	Within the rated capacity
AC Input	Compensation of Distorted Current	Compensation Order	2～20^{th} Harmonics
AC Input	Compensation of Distorted Current	Compensation Rate	85% or higher
DC	Rated Floating Voltage		382.2V
DC	No. of Cells of Storage Battery		168 cells
DC	DC Voltage Fluctuation		266.8～382.2V
AC Output	Rated Frequency		50/60Hz
AC Output	Number of Phases		3-phase, 3 wire
AC Output	Rated Voltage		200V
AC Output	Voltage Accuracy	Commercial Parallel Supply	Within ±10%
AC Output	Voltage Accuracy	Storage Battery Supply	Within ±2%
AC Output	Voltage Waveform Distortion Factor		Linear load 2% or lower
AC Output	Voltage Waveform Distortion Factor		Non-linear load 5% or lower
AC Output	Load Power Factor		0.8（delay）
AC Output	Overload Capacity	Commercial Parallel Supply	800%: 500msec, 200%: 30sec
AC Output	Overload Capacity	Storage Battery Supply	150%: 60sec, 125%: 10min
Internal Storage Battery		Model	Small sealed lead-acid battery
Internal Storage Battery		Backup Time	8 minutes
Others		Noise	59dB or lower
Others		Cooling Method	Forced air cooling
Others		Outside Dimensions	500(W)×700(D)×1400(H)mm
Others		Weight	Approx. 400kg

4. Conclusion

An overview of the parallel processing method UPS “SANUPS E” series was provided in this document.

We will continue to work on improving the reliability of the parallel operation technology as in our “SANUPS E”. The resulting future products will further increase our customer satisfaction.

We very much appreciate the guidance and cooperation of the many parties concerned in the planning, development, and manufacturing of this product.

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