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Feature

Development of small-capacity UPS "SANUPS ASD"

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1. Introduction

With the eye-catching development of IT technology in recent years, demand runs high for the reliability of servers and other communications devices related to the Internet.

Against that background, reliability is becoming an extremely important issue not only in communications devices but also in uninterruptible power supplies (UPSs) that power them. Demand is growing for highly reliable UPSs.

In terms of investment in plant and equipment, there is now demand for the development of economical UPSs compatible with system expansions.

To meet those demands, we have added to our line-up the "SANUPS ASD", a UPS that can be run in parallel with an easy method, achieves high reliability, and is compatible with capacity expansions.

This paper is an overview of these "SANUPS ASD".

2. Background of development

2.1 Reliability

(1) To increase the power supply reliability of UPSs, large-capacity systems already use current/spare switching and parallel redundancy. However, with growing demand for small-capacity UPSs due to the downsizing and networking of computers, small-capacity UPSs have now come to require just as high reliability.

(2) To meet these requirements, parallel redundant running is advantageous for small-capacity UPSs. However, a configuration without a common portion is the best when in view of reliability enhancement. However, the non-provision of a common portion in the main circuit is impossible in view of the circuit configuration, so that as much of the common portion as possible should desirably be eliminated from the control circuit by individual control.

2.2 Cost efficiency

(1) If the load equipment had an additional capacity due to an extension or modification of the computer system, and if one needed to introduce a UPS with a larger capacity, one needed to make a major investment in plant and equipment. For that reason, there is now demand for systems that need the smallest investment in plant and equipment and is capable of easily increasing the power supply capacity.

(2) When one is about to adopt a parallel redundant running system, it should desirably be lower in cost than conventional individual capacity units.

3. Features

The "ASD" is a system so designed that up to four units of this model can run in parallel (with an output capacity of 14kVA) on the basis of a UPS that can run singly (with an output capacity of 3.5kVA).

Fig. 1 is an external view of the "ASD" at 14kVA.

3.1 Parallel running by completely individual control

(1) Inverter control

When an inverter is controlled in parallel running, the voltages of the units must be matched in "amplitude", "phase", and "frequency", and the cross-flows, load divisions, and other elements between units must be controlled.

The above requirements can be satisfied by different methods, such as (1) distributing common control signals and control signals of master units, and (2) comparing the currents of other units with those of the own units and controlling the amplitude and phase of the voltage of the own units.

However, in the case of common control and the master-slave system, the system is affected by the common portion and the reliability of the master unit, so that it is suited for the add-on capacity system but not for parallel redundant operation. It is also to be noted that the system of detecting the currents of other units entails complicated circuitry, including the detection of the number of units in operation, thus being unsuitable for small-capacity UPSs.

To overcome these problems, we designed the "ASD" without a common control unit and adopted a "completely individual control system", which incorporates a control circuit for each unit.

(2) Control between units

The "ASD" is so designed that two to four UPSs of 3.5kVA are run in parallel. A standard configuration would require an operation unit, LCD display, and other equipment for each unit. However, when considered as a system, this equipment runs as if it were a single UPS. The operation unit, LCD display, and other equipment must be installed in one place.

Similarly to the parallel run control of the inverter unit, status monitoring and other operations are also individually controlled by each unit. A plurality of UPSs must be regarded as if they were a single UPS, so that one needs signals to organize the system's input/output voltage and current measurements, along with other data.

In this project, therefore, the units were interconnected by serial communications, and the start-up and stop of the equipment, the LCD display of measurements of the system components, the transmission of transfer signals to the outside, and other operations are conducted collectively as a single system.

3.2 Line-up expansion

We expanded the line-up by increasing the output capacity of the "ASA" from 5, 7.5, and 10kVA to 3.5, 7, 10.5, and 14kVA.

Fig. 2 shows the system configuration.

3.3 Network compatibility

Various kinds of communications should be conducted with computers in response to UPS management in the network environment.

The "ASD" comes standard with an RS-232C, which used to be optional in conventional models, and uses a LAN interface card as an option.

The LAN interface card is combined with the UPS control software, the "SAN GUAR IV", developed us, to support the network environment effectively. Here are the functions:

(1) A plurality (up to 10) of computers connected to one UPS can be safely controlled via a network.

(2) The UPS status can be controlled with a Web browser.

(3) UPS control software does not have to be installed on a WS (UNIX or Linux).

(4) The system can be used on clustering and other advanced server systems.

(5) UPS control capability has been greatly enhanced to alleviate the burden of network administrators.

(6) This system cuts power consumption through scheduled running and effective power supply through automatic running, resulting in cuts in total cost ownership (TCO).

Fig. 3 shows a typical LAN interface card, while Fig. 4 shows a typical configuration of network connections.

3.4 Maintainability

A system configuration of the parallel redundant operation type ensures that, if a unit should break down, the remaining normal units will continue to power the inverter. In that case, there must be provision to allow the defective unit to be easily replaced, but the "ASD" is based on the structural method of piling up basic units. This makes it difficult to remove lower units for maintenance work. To counteract that problem, the inner constituents have been modularized (plug-in for the inverter modules and connector connection for battery modules) as shown in Fig. 5 to facilitate removal.

The battery modules can be hot-swapped.

3.5 Cuts in maintenance costs

Batteries have limited lives. We used batteries having a service life of five years. For cooling fans and electrolytic capacitors, we selected long-life products to obviate the need of replacement for the first ten years. This reduces maintenance costs for replacements and other repairs.

3.6 Options

Various options are available to meet user requirements.

Here are typical optional settings:

(1)Long-time batteries (30, 60, and 180-minutes)

(2)Transformers supporting different input and output voltages

(3)Floor fasteners

(4)Rack mounts

(5)LAN interface card

4. Circuit configuration

Fig. 6 is a system diagram of the unit circuitry of the "ASD". Fig. 7 is a diagram of the system circuitry.

4.1 Main circuit configuration

The "ASD" is a system based on a UPS having an output capacity of 3.5kVA consisting of high-power factor converters, inverters, rechargers, output selector switches, bypass circuits, batteries, and other equipment. The "ASD" can be combined with a current collector required in parallel running to enable up to four units to be run in parallel.

Giving a capacity of 3.5kVA to the basic units resulted in the following:

(1) Conventional individual capacity machines used modules for the main switching devices of their high-power factor converter unit and inverter. On the other hand, the "ASD" uses a cheap discreet product to cut costs and size.

(2) Part of the main circuit wiring has been converted to a printed circuit board, resulting in cuts in labor.

(3) The insulation of the inputs and outputs is ensured by a high-frequency transformer of the high-power factor converter, resulting in size reduction.

4.2 Configuration of the control circuit

On the "ASD", the basic control and parallel operation control of the UPS is conducted by a DSP, while the control of monitoring, measurement, LCD display, communications, and other operations is conducted by a CPU.

(1) Parallel operation control

The parallel operation of the UPS requires that the "amplitude" and "phase" of the output voltage be matched as accurately as possible. The "ASD" employs a "completely individual control system", which conducts that operation on an individual basis.

①The output voltage of each UPS is subjected to some differences in amplitude due to errors in initial settings, changes with time, and other factors. On the other hand, using only current detection within the own unit to learn the current difference between the own unit and other units and the load share of the own unit is basically impossible. In this project, therefore, we adopted a system where inverter current is fed back and a control gain in that is selected to suppress the cross-flow due to the voltage difference.

For details of the control system, see the previous issue of this magazine (note).

Note: Hanaoka et al.: "Analysis of the Parallel Operation of a UPS in View of the Effect of Line Resistance", SANYO DENKI Technical Report No. 10, Nov. 2000

②For phase synchronization, we applied the concept of zero-cross reinforced synchronous signals for digital PLL used in conventional UPSs and adopted the synchronous signals of each UPS as bi-directional, common "advance reinforced synchronization".

③Frequency is normally PLL-synchronized with commercial power. In a blackout, a very precise self-running oscillator is used. The result is little difference between the UPSs.

Fig. 8 shows output voltage and current wave forms of the "ASD" running two units in parallel.

(2) Communications between units

As described in 3.1.(2), information between units is connected by serial signals.

Communications between units is so conducted that one of a plurality of units acts as the master station and the master station controls all data transmission with other slave stations.

Each unit is given a specific ID number. ID numbers are used to determine the master and slave stations in the procedure of transmission control and identify the transmittees in the units currently in operation.

Data communicated between units includes breakdown status, input and output voltage and current, battery voltage and current, and battery life expectancy information.

With communications between units, all units follow the same processing procedure for resetting battery information (such as the total battery running hours) and changing beeper sounding conditions.

Should the master station break down, either of the other units automatically takes over as the master station to succeed in the control of communications between units.

4.3 Electrical characteristics

Table 1 shows the standard specifications of the ″ASD″.

Table 1 Standard specifications of the "ASD"

Item			Unit	Standard specifications				Remark
Model No.			–	ASD35S2	ASD70S2	ASD100S2	ASD140S2	
Output capacity (apparent power/ effective power)			kVA/kW	3.5/2.8	7/5.6	10.5/8.4	14/11.2	
System	Operation system		–	On-line UPS system synchronized with commercial line (bypass startup)				
	Cooling system		–	Forced air-cooling				
	Input rectification system		–	High-power factor converter				
	Inverter system		–	High-frequency PWM system, instantaneous wave form control				
AC input	Number of phases, number of lines		–	Single-phase, two-wire				
	Rated voltage		V	200 (fluctuation range ± 15%)				
	Rated frequency		Hz	50 or 60 (fluctuation range ± 15%)				
	Required capacity		kVA	4	8	12	16	
	Power factor		–	0.97 or more				
AC output	Number of phases, number lines		–	Single-phase, two-wire				
	Rated voltage		V	200 (voltage wave form: sine wave)				
	Voltage setting precision		%	Rated voltage ± 5 or less				
	Rated frequency		Hz	50 or 60 (automatic selection)				Same as input frequency
	Synchronization range with commercial line		%	Rated input voltage ± 15 or less, and rated input frequency ± 1 or less				
	Voltage wave form distortion factor	Under a linear load	%	3 or less				While the input and output are in a rated operation
		Under a rectifier load	%	7 or less				While the input and output are in a rated operation
	Rated load power factor		–	0.8 (delay)				0.7 (delay) to 1.0
	Transient voltage fluctuation	When the input undergoes a rapid change	%	Rated voltage ± 10 or less (blackout ⇆ at power return, at quick changes of input voltage ± 15%)				
		When the load undergoes a rapid change	%	Rated voltage ± 10 or less (at quick changes from 0% to 100%, at output switchover)				
	Overload withstand	Inverter	%	105-110 (1 minute), 120 (instantaneous)				
		Bypass	%	200 (30 seconds), 800 (2 cycles)				
Overcurrent protection			–	Automatic switchover to bypass circuit without instantaneous cuts (with auto return)				
Noise			dB	45 or less	50 or less		55 or less	1m on the front of the equipment, characteristic A
Battery	Type		–	Small sealed lead battery				
	Backup time		min.	10 or more (ambient temperature: 25 °C, initial value)				
Operating environmental conditions			–	Ambient temperature: 0-40 °C, relative humidity: 30-90% (non-condensing)				

5. Conclusion

We have so far given an overview of the "ASD".

Computers are expected to become even more reliable and networked, with UPSs being required to become more reliable and functional. Demand is then projected to rise even more for small-capacity UPSs.

We are willing to make quick development efforts to meet these market requirements and supply products that satisfy the users.

We wish to express our thanks to the many personnel involved for their cooperation and advice during the development and commercialization of this series of products.

Reference

Hanaoka et al.: "Analysis of the Parallel Operation of UPSs in View of the Effect of Line Resistance," SANYO DENKI Technical Report No. 10, Nov., 2000

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Fig. 1 External view of the "ASD" (14kVA)

Output capacity (kVA)			
3.5	7	10.5	14
Output capacity in the case of parallel redundancy (kVA)			
–	3.5	7	10.5

Fig. 2 System configuration

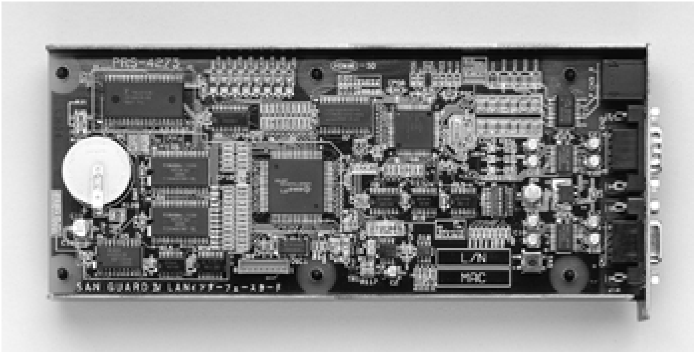

Fig. 3 LAN interface card

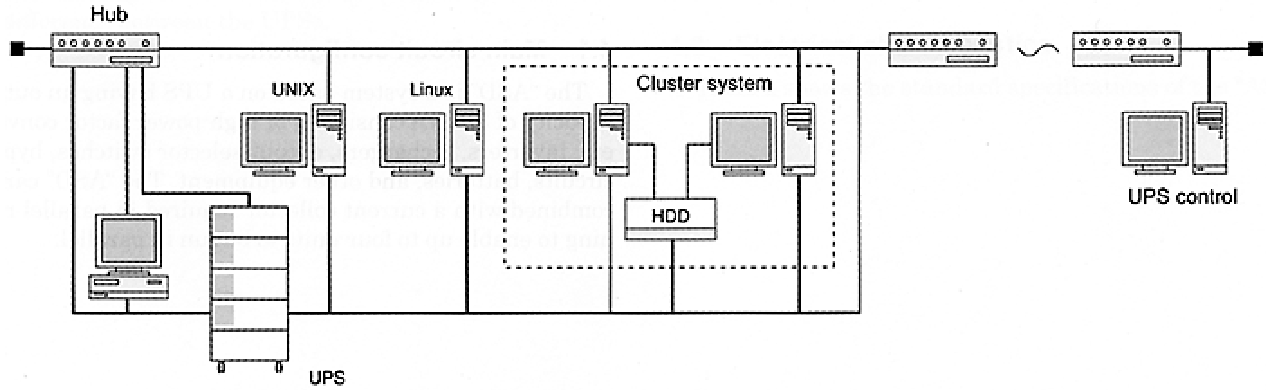

Fig. 4 Typical configuration of network connections

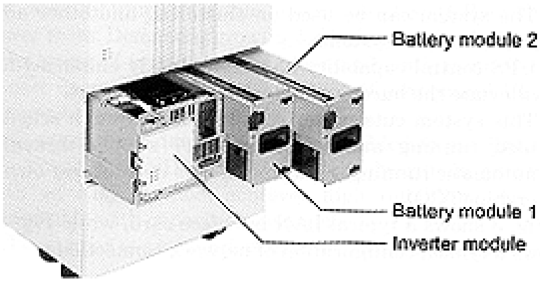

Fig. 5 Typical configuration of network connections

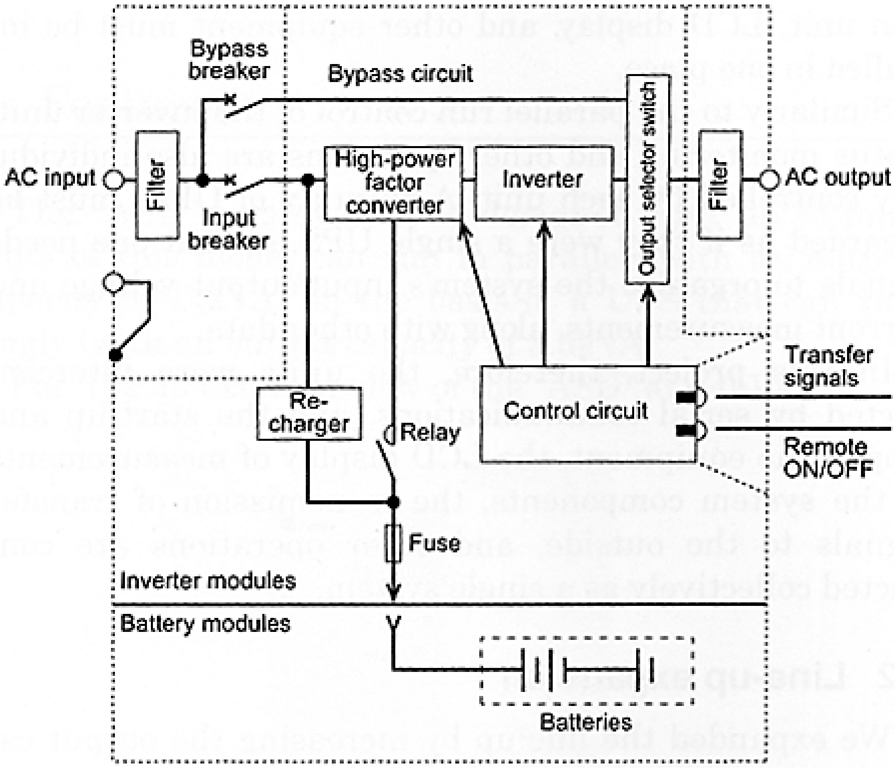

Fig. 6 System diagram of the unit circuit

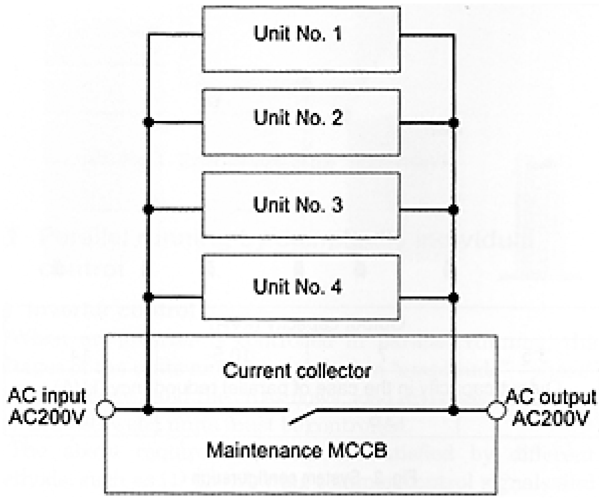

Fig. 7 System diagram of the system circuit

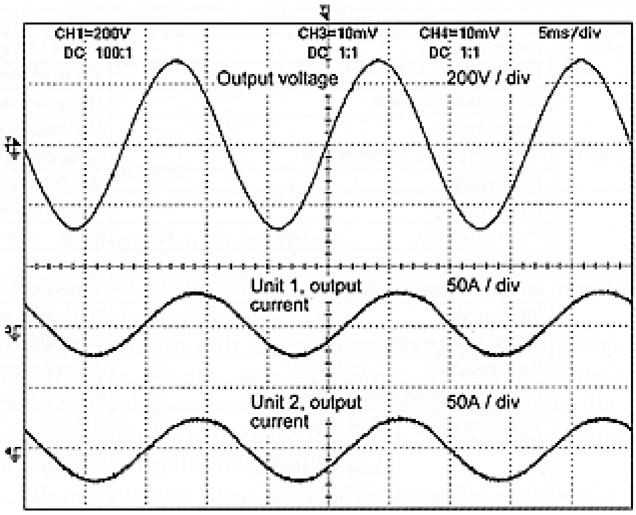

Fig. 8 Wave forms of output voltages and currents