Development of the Low Energy, High Quality, and High Reliability Large-capacity UPS "SANUPS E33A"

Yoshiaki Okui Shouichi Ohta Naoya Nakamura Minoru Yanagisawa
Hiroshi Hirata Daisuke Yamaguchi Katsutoshi Tanahashi

1. Introduction

We have developed the large capacity uninterruptible power supply system (UPS) with 400 V input / output called "SANUPS E33A", which is able to operate each UPS unit in parallel. The parallel control system is an individual operation by each UPS unit, so that the "SANUPS E33A" has high reliability. Moreover, because main circuit structure is parallel processing type UPS with high efficiency as well as "SANUPS E23A" with 200 V input / output developed in 2002. "SANUPS E33A" is not only high reliability but also is high efficiency. This parallel operation system by parallel processing type UPS is the first time in industry. We have lined up the "SANUPS E33A" as parallel type for 100 to 300 kVA, and parallel redundant type for 100 + 100 kVA and 200 + 100 kVA by using the 100 kVA for base unit.

This section will explain about the characteristics of the "SANUPS E33A".

2. Background of the development

Promotion of the Cool Earth is becoming more popular in various fields reflecting the global warming issues. Innovation of the basic technology has also become one of major challenges for the power supply infrastructure. High efficiency is that not to use unnecessary energy, and now the expectations for high efficiency of uninterruptible power supplies (UPS) is getting high. We have challenged the development of the high efficiency UPS from the early stage, and we have released UPS with parallel processing type without momentary power breaks in 2002 [1]. This parallel processing type UPS has vastly improved its efficiency compared to conventional double conversion UPS. Its efficiency improved from around 90% to 97%. Also it has active filter function and without momentary power break switching characteristics [2] which passive standby does not have. This means that is high quality and is active as a new UPS in the energy saving era.

Recently, for not only an equipment itself, there is also consideration of the 20 kV class / 400 V power distribution systems that will reduce the loss in power distribution path too, instead of just the equipment itself [3]. With this system, user will be receiving 400 V directly instead of 6.6 kV, and there will be following advantages by distributing 400 V within the installation.

1) By receiving the power from service voltage, power reception cost is reduced by reduction and simplification of the transformers.
2) Maintenance cost is reduced since the electrical facilities for maintenance become low-pressure.
3) Electrical loss is reduced by decreasing the size of the power distribution cable.

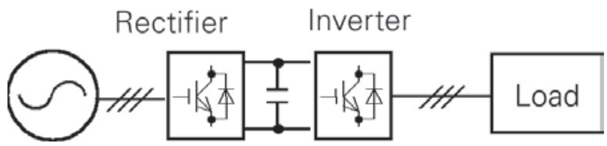
From the state of society trying to realize these low carbon society, voltage required for the equipment will not be only 200 V, but 400 V is estimated to increase too. Therefore, we have developed the 400 V parallel processing UPS, expanding the "SANUPS E" Series. Also, this series is strong in backing up the power equipment, which conventional UPS was weak, so it is expected as not only the information communication fields, but also as the backup power supply for the production installation at the factories and other facilities. Many of these power equipment requires large capacity electricity, so the concept is to construct the system as parallel easily, and to be able to increase the capacity flexibly. So, this development has established high reliability technology with completely individual parallel operation control, and challenged the developing of the energy saving, high quality, and high reliability 400 V large capacity parallel processing UPS.

3. Characteristics of the "SANUPS E33A"

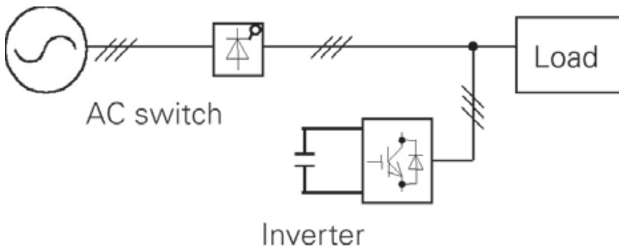
Characteristics of the newly developed "SANUPS E33A" are explained in this section.

3.1 Basic structure

Fig. 1 shows the basic circuit structure of the UPS. (a) is the double conversion UPS, and (b) is the parallel processing type. The parallel processing type is adopted in the "SANUPS E33A", which the inverter is connected in parallel with the commercial power supply, and main electricity is supplied in the path with AC switch only. At this time, inverter is operated as the parallel redundant operation with the commercial power supply, and at the same time it is performing active filter function to control the harmonic current and charging function to the battery simultaneously. That is to say, "power is supplied from the commercial power supply, and the quality is from the inverter", where only the "quality" part is going through the inverter at the normal operation, so the electrical loss is significantly small compared to the constant inverter power supply system, shown in Fig. (a), which goes through 2 convertors constantly, making it possible to supply the electricity with high efficiency and high quality.



(a) Basic circuit structure of the double conversion UPS



(b) Basic circuit structure of the parallel processing type

Fig. 1: Basic circuit structure of the UPS

To be able to enlarge the capacity efficiently and easily, the "SANUPS E33A" is using the parallel processing type UPS as a base unit, that is to be able to construct a parallel system. In general, when the UPS is operated parallel, it is necessary to match the voltage magnitude, the phase, and the frequency since the output of each UPS unit is AC. If there are any differences in these, there will occur voltage differences between each unit. Also, since each UPS units are connected with wiring only, impedance between them are very small, but with the relationship of "current = voltage difference / impedance", there will be excessive current running between each UPS units (this is called cross current) even if the voltage difference is a small amount. In this case, each UPS unit will not be able to supply this excessive current, and so it will stop. The most secure way to control this cross current is, as figure 2 (a), perform the parallel operation by making control unit and distribute the common voltage, phase, and frequency commands to each UPS unit. But if there is a control circuit that is common to all, the whole system will halt when there is any malfunction in this control unit. So, even if the reliability of each UPS is very high, but the reliability of this common control unit is not as high, the reliability of the whole system will be low. Therefore, as shown in Fig. 2 (b), if each of the UPS unit can operate in parallel without constructing common control unit, it is able to make the high reliability of the whole system without the dominance of the common control unit reliability. For high reliability of whole system, it is necessary to raise the reliability of each UPS unit. But the parallel processing type that was adopted this time, has less parts compared to continuous inverter power supply and also the malfunction rate is low, therefore it is able to construct more reliable system.

3.2 Main characteristics

Main characteristics providing high quality and high reliability is explained here.

(1) Without momentary power break characteristics and soft start function

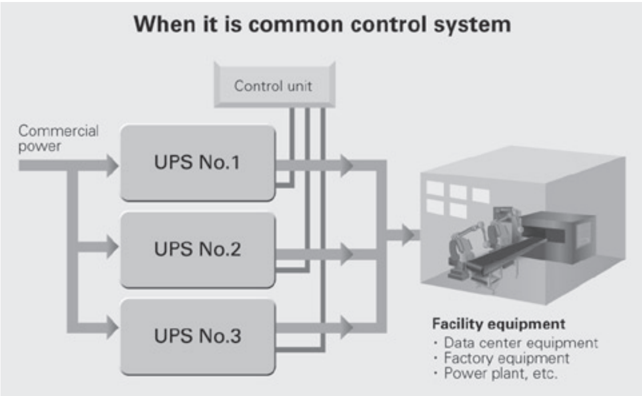
Control the commercial power supply and inverter like constantly performing the parallel redundant operation [2], disconnect the commercial power supply in high speed by AC switch using the unique switching technology when there is problem with the commercial power supply [4], then it is able to supply the electricity without momentary power break as shown in Fig. 3. Also at the power return, input current has a soft start function as shown in Fig. 4, so transient variation will not occur by looking from the input power supply. Therefore, it will not cause unnecessary voltage or frequency variations even if there is an engine generator.

(2) Active filter function

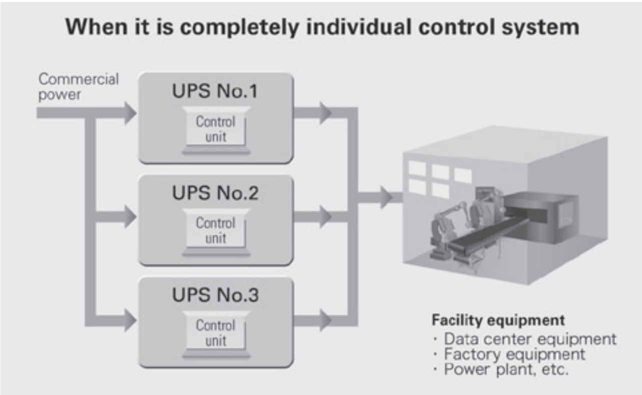
Active filter function is to inverter to compensate the harmonic current and reactive power that occurred from load equipment, and also control the input current to be sine wave and power factor to be 1. Fig. 5 (a) shows the I/O waveform when the active filter is turned on. Fig. 5 (b) shows the waveform when the active filter is turned off. You can see that the input voltage (commercial power supply) is distorted when active filter function is turned off. Since the passive standby does not have this function, this voltage distortion may affect other equipment that is connected to same system, or it may cause malfunction of the power outage detection at the UPS.

(3) Parallel operation characteristics and selectable disconnection characteristics

In case of parallel redundant UPS, even if there is a failure in one of the UPS, it is possible to continue the power supply to other parallel UPS by disconnecting the failed one immediately. Fig. 6 (a) shows the waveform when the UPS No. 3 is failed at the 3 UPS structure. UPS No. 3 is disconnected immediately when it fails, and you can see that UPS No. 1 and No. 2 is equally handling the load without affecting the total output current. Also, the load is divided equally with 3 UPS immediately after the recovery as shown in Fig. 6 (b).



(a) Common control system



(b) Completely individual control system

Fig. 2: Control system for parallel operation

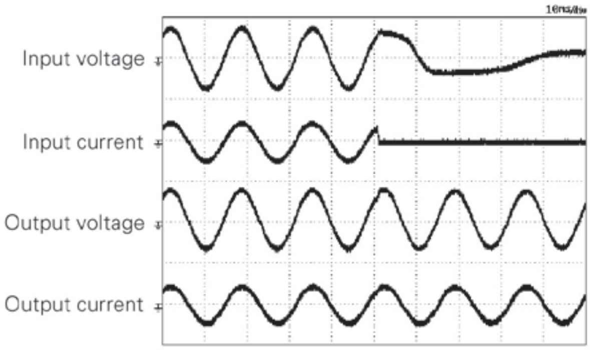


Fig. 3: Without momentary power break waveform

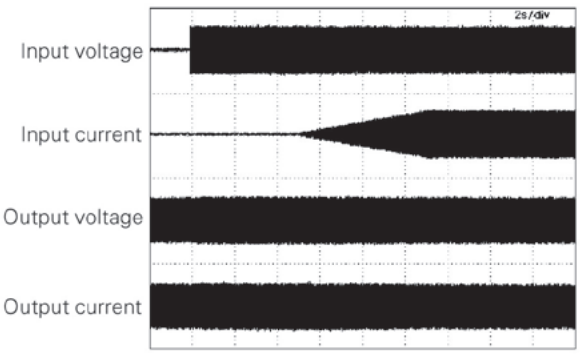
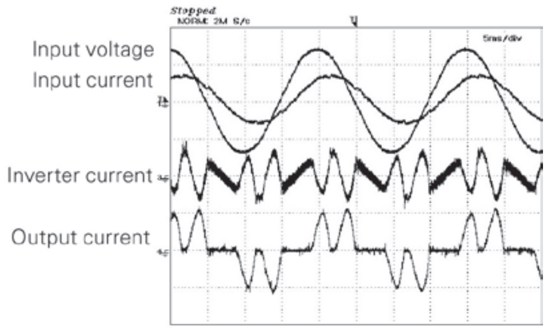
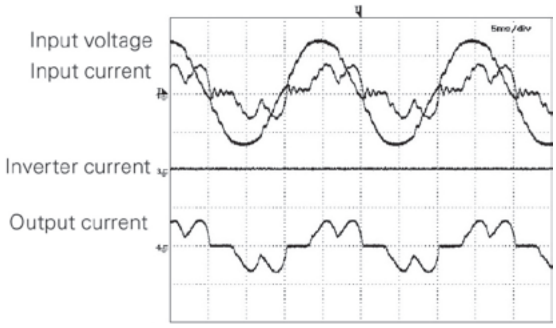


Fig. 4: Waveform when power return

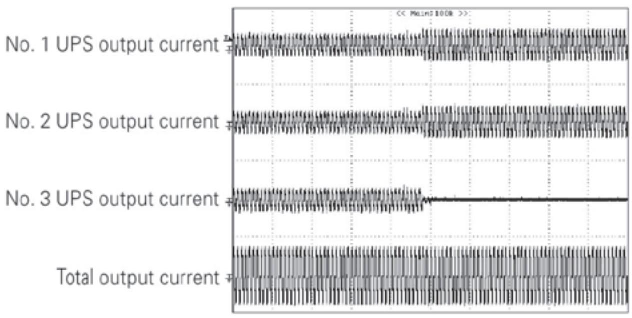


(a) Waveform when active filter is operating

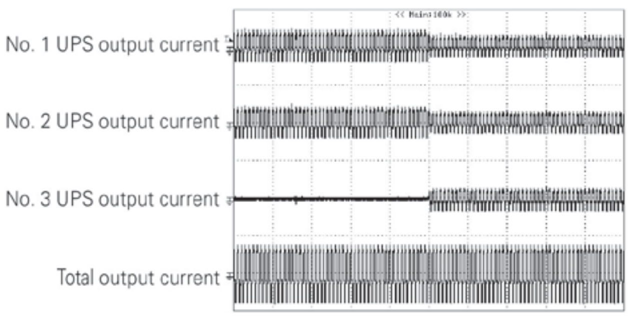


(b) Waveform when active filter is not operating

Fig. 5: Effect of the active filter



(a) Waveform when 1 unit fails (UPS No. 3)



(b) Waveform when restoring from failure (UPS No. 3)

Fig. 6: Characteristics of UPS unit disconnection and recovery (restore)

4. Specifications

Table 1 shows the standard specification. Also, Fig. 7 shows the photograph of the newly developed parallel redundant type (200 + 100 kVA).

We have lined up the "SANUPS E33A" as parallel type for 100 to 300 kVA, and parallel redundant type for 100 + 100 kVA and 200 + 100 kVA by using the 100 kVA for base unit. Except for the single unit, it is constructed with the I/O power board combining the n numbers of UPS and the UPS units. If the I/O power board for the maximum power supply capacity is installed at the beginning, it is possible to install each UPS units separately in accordance to the plan. The battery board is also constructed, and it is compatible to both individual batteries which is installed for each UPS unit, and also centralized battery where the battery is shared by all UPS units.

Fig. 7 Photograph of newly developed "SANUPS E33A" (parallel redundant type: 200 + 100 kVA)

5. Conclusion

We had explained the product outline of 400 V large capacity parallel processing type "SANUPS E33A". In this development, we had established the completely individual parallel operation control system that is able to perform parallel operation easily, so we are planning to improve the series by expanding the equipment capacity.

Reference

1) Hirata, Okui, Ohta, Kaneko, Nakamura: Development of the medium capacity UPS "SANUPS E", SANYO DENKI Technical Report Issue 14, pages 24-27 (2002).

2) Y.Okui, S.ohta, N Nakamura, H.Hirata and M. Yanagisawa, "Development of Line Interactive type UPS using a Novel Control System", Proceedings of IEEE International Telecommunications Energy Conference (INTELEC'03), pages 796-801, 2003.

3) Suzuki, Iwafune: "Energy saving by raising voltage of power distribution, evaluation of CO_2 reduction effect", The Japan Electrical Manufacturers' Association Publication "Denki" June issue, Vol. 647, The Japan Electrical Manufacturers' Association Energy Saving by Raising Voltage of Power Distribution Promotion Committee, pages 39-44 (2002).

4) Yanagisawa: Creating One of a Kind Product - Hybrid UPS "SANUPS E23A" for an energy saving era -, SANYO DENKI Technical Report Issue 24, pages 6-10 (2007).

Table 1 Standard specification

Item			E33A104	E33A204	E33A304	E33AR104	E33AR204	Remarks
System			Parallel operation			Parallel redundant operation		
Rated output capacity	Apparent power		100 kVA	200 kVA	300 kVA	100 kVA	200 kVA	
	Effective power		90 kW	180 kW	270 kW	90 kW	180 kW	
Operation system			Parallel processing type					
AC input	Number of phases / wires		3 phase 3 wires / 3 phase 4 wires					
	Rated voltage		415 V (380, 400, 420 V)					
	Rate frequency		50 / 60Hz					
	Required capacity		120 kVA	240 kVA	360 kVA	120 kVA	240 kVA	
	Distorted current compensation	Compensation capacity	Within rated capacity					
		Compensation order	2 to 20 order harmonic					
		Compensation rate	75%					In case of 3 phase 3 wires
	Input power factor		0.97 or higher					At rated operations
AC output	Number of phases / wires		Same as AC input					
	Rated voltage		415 V (380, 400, 420 V)					Same as AC input
	Voltage precision	At commercial parallel operation	Within +10% and -8%					
		At battery operation	Within ±2%					
	Rate frequency		50 / 60 Hz					Same as AC input
	Rated frequency precision	At commercial parallel operation	Within ±5%					
		At battery operation	Within ±0.5%					
	Load power factor	Rating	0.9 (slow)					
		Variation range	1.0 to 0.7 (slow)					
	Voltage wave form distortion factor	At linear load	2% or less					At battery operation
		At rectifier load	5% or less					
	Instantaneous voltage variation	Variation rate	Within ±5%					At battery operation
	Overload capacity	At commercial parallel operation	200% (30 seconds), 800% (0.5 seconds)					
		At battery operation	150% (1 minute), 125% (10 minutes)					
	Switching to battery operation		Without momentary power break					
Efficiency (commercial parallel operation)			98% or higher					Single UPS unit characteristics, load power factor 1.0
Acoustic noise			70 dB	73 dB	76 dB	73 dB	76 dB	1 m from front, height 1 m
Environment	Installation		Indoor					
	Ambient temperature		0°C to 40°C					
	Relative humidity		20% to 90% (no condensation)					
	Altitude		1000 m or below					

Yoshiaki Okui

Joined Sanyo Denki in 1992.
Power System Division, First Designing Dept.
Worked on the development and design of UPS.
Doctor (Engineering).

Hiroshi Hirata

Joined Sanyo Denki in 1985.
Power System Division, First Designing Dept.
Worked on the development and design of UPS.

Shouichi Ohta

Joined Sanyo Denki in 1992.
Power System Division, First Designing Dept.
Worked on the development and design of UPS.

Daisuke Yamaguchi

Joined Sanyo Denki in 2005.
Power System Division, First Designing Dept.
Worked on the development and design of UPS.

Naoya Nakamura

Joined Sanyo Denki in 1998.
Power System Division, First Designing Dept.
Worked on the development and design of UPS.

Katsutoshi Tanahashi

Joined Sanyo Denki in 1990.
Power System Division, First Designing Dept.
Worked on the structural design of UPS.

Minoru Yanagisawa

Joined Sanyo Denki in 1980.
Power System Division, First Designing Dept.
Worked on the development and design of the power supply equipment.