Becoming #1 Power Conversion Efficiency in the Industry

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1. Introduction

Computer and various information and communication equipment becoming more important in the highly information society, high stability and reliability are also required for these power supply equipment.

Meanwhile, energy saving is becoming more important in the perspective of preventing the global warming, making the efficiency of the power supply equipment more and more important.

We have conventionally been making the uninterruptible power supply equipment (UPS hereafter), power conditioner for the photovoltaic power generation, and inverter equipment for communication power supply more efficient.

This section will explain previous measures to raise the efficiency, and how the inverter equipment for communication power supply, which was one of the most successful one lately, was made high in efficiency.

2. Measures of making high efficiency until now

2.1 UPS

(1) Small capacity UPS

Fig. 1 shows the efficiency transition of the small capacity UPS.

The “SANUPS ASC” developed in 1997 was developed to be small in size, and the efficiency remained around 85%.

An environmental problem such as global warming has become closer scrutiny from around 2000, making the requirement of high efficiency for the UPS stronger.

To achieve high efficiency of the UPS, there was a system such as “line interactive system / offline power supply system”, but we have developed “SANUPS ASE” with 3-arm continuous inverter power supply system*(1) that can achieve high efficiency with conventionally proven continuous inverter power supply system. This equipment has increased 6% efficiency compared with the conventional “SANUPS ASC”, reaching high efficiency of 91%.

Trend for high efficiency became active from this time, and it was necessary for us to challenge for further efficiency. It was hard to become more efficient than 3-arm system used with the “SANUPS ASE” Series with the continuous inverter system, so new system was considered. As a result, high efficiency was achieved by the reconsidering the circuit system, system to switch the operation mode such as 3-mode system, selecting the parts with less loss, and using the part optimally.

3-mode system can be controlled to operate at optimal condition in it environment such as power supply or load, and it will automatically select the efficiency priority mode, active filter mode, or quality priority mode.

Efficiency priority mode of the 3-mode system is shown in Fig. 2.

Efficiency priority mode has achieved 95% efficiency in the operation mode with high quality commercial power supply and operation mode with good power factor for the output.

This system was adopted in the “SANUPS E11A”, and it is made in to a series of high efficiency UPS.

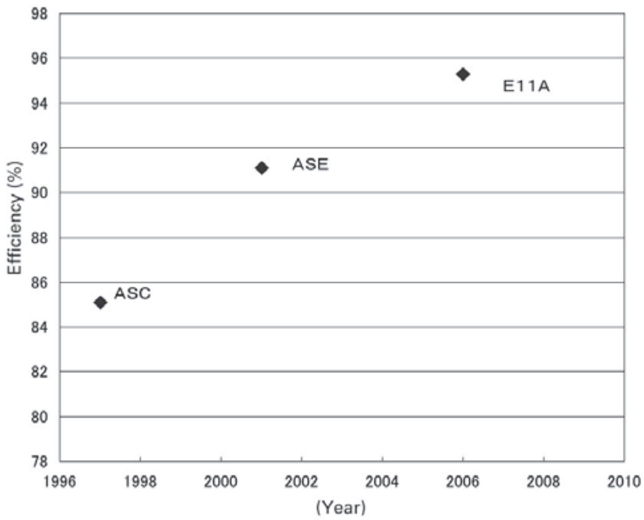

Fig. 1: Efficiency transition of the small capacity UPS

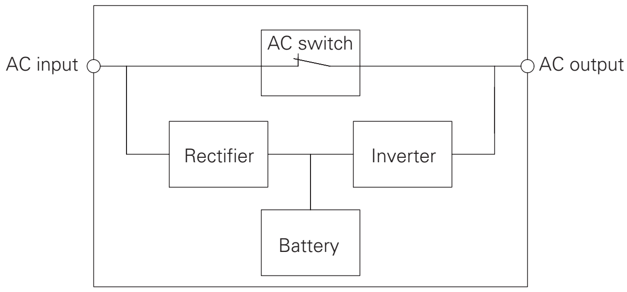

Fig. 2: 3-Mode system (efficieny priority mode)

※(1) 3-arm system

A system with number 1 arm for an input converter, number 3 arm for the output inverter, and number 2 arm as a common arm for both. High conversion efficiency can be achieved.

(2) Medium to large capacity UPS

Fig. 3 shows the efficiency transition of the medium to large capacity UPS.

The "SANUPS AMB" that was developed in 1999 was a product developed to be small in size, just like the small capacity UPS, and its efficiency remained around 85%.

Development for an UPS that can realize high efficiency while supplying high quality power supply comparable to constant inverter system has started around 2000 to fulfill the request of high efficiency for the medium to high capacity UPS. As a result, the "SANUPS E23A" was developed achieving both high efficiency and small size by constructing the power converter as one piece, and adopting the parallel processing system that will secure the reliability of the power supply by new control system.

Fig. 4 is showing the parallel processing system. With this equipment, inverter is connected and running parallel to the commercial power supply, and major power is supplied in a path with only an AC switch. High efficiency was achieved because the constant inverter is only functioning as an active filter to control the higher harmonic current. It has achieved the efficiency of 97%.

A 20 kV / 400 V power distribution system that reduces the loss in power distribution path is increasing lately to achieve high efficiency for the power distribution system, and the "SANUPS E33A" with 400 V parallel processing system which is compatible was developed, and this has expanded the Series. It has achieved the industry leading 98% efficiency.

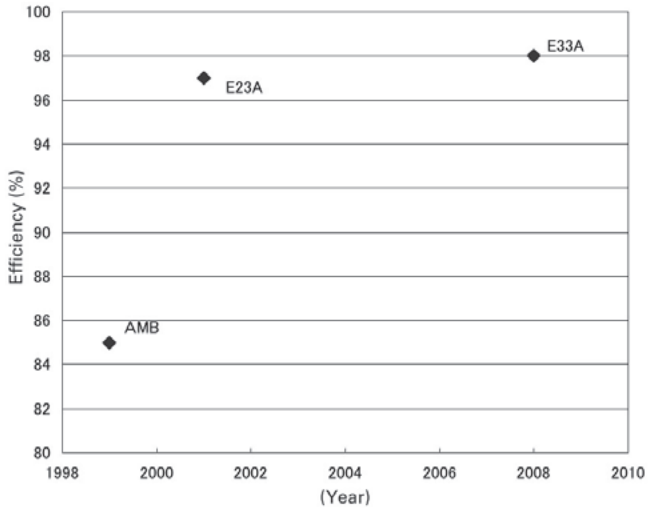

Fig. 3: Efficiency transition of the medium to large capacity UPS

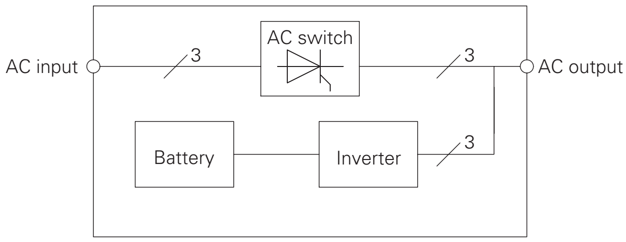

Fig. 4: Parallel processing system

2.2 Photovoltaic power generation power conditioner

Fig. 5 shows the efficiency transition of the photovoltaic power generation power conditioner, and Fig. 6 shows the circuit architecture of the power conditioner.

The "SANUPS PMA" developed in 1995 was an isolation transformer system, and had efficiency of approximately 90%. The "SANUPS PMB" and the "SANUPS PMC" adopting the semiconductor isolation system was developed later to cope with the request for small size and light weight. Efficiency has risen to 92%.

Reexamination of the main circuit system and optimization of the conversion frequency was performed with the "SANUPS P73D" that was developed in 2004, enclosing the connection box that was located outside of the equipment conventionally, and achieved an efficiency of 92%.

With the prevalence of the Mega Solar, we have challenged to increase the capacity, and its first large capacity "SANUPS P83A" for 100 kW was developed in 2005. This equipment has optimized the main circuit commercial isolation transformer and conversion frequency, and used the low loss parts in the main circuit, achieving the top in industry at that time of 93%.

With the improvement of the photovoltaic panels in recent years, request for higher efficiency has rise, effort to raise the efficiency is made by reexamining the main circuit system, consideration of the auxiliary circuit to lower the loss of the main circuit, etc.

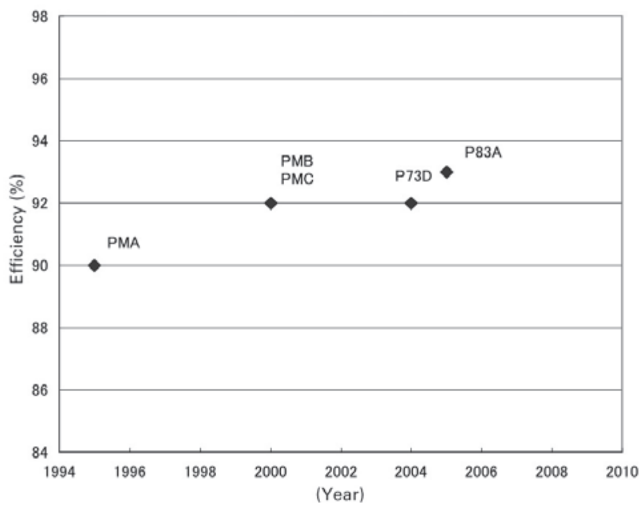

Fig. 5: Efficiency transition of the photovoltaic power generation power conditioner

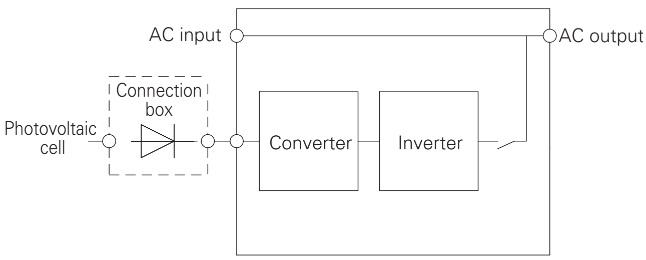

Fig. 6: Power conditioner circuit architecture

2.3 Communication power supply inverter equipment

Fig. 7 shows the efficiency transition of the communication power supply inverter equipment.

Communication power supply inverter equipment is power supply equipment used in the DC power supply system necessary for the communication business, and it was commercialized for long time. Insulation of the DC input and AC output is necessary for the inverter equipment, and it was hard to improve the efficiency since it is necessary to control high current due to low DC input voltage. Products at that time were using a low frequency insulation transformer, and its efficiency was approximately 65%.

The “SANUPS DA” using high frequency insulation transformer was developed in 2001. Efficiency was 80%, which was top class in industry at that time.

With the request from the communication market to raise the efficiency of the inverter equipment as like the UPS, we have tackled raise the efficiency of the inverter equipment, and developed the “SANUPS D11A”, which as improved the efficiency vastly to 86%.

Following is the measures taken to raise the efficiency of the communication power supply inverter equipment.

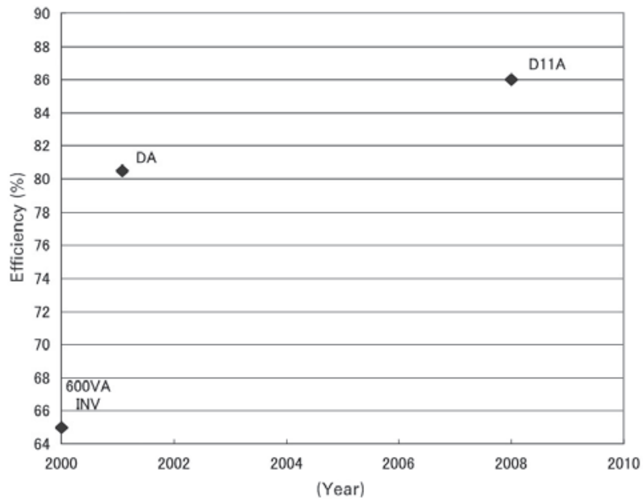

Fig. 7: Efficiency transition of the communication power supply inverter equipment

3. Measures to raise the efficiency of the inverter equipment

Fig. 8 shows the circuit architecture of the inverter equipment. Inverter equipment is constructed with insulating converter unit (DC/DC conversion), inverter unit (DC/AC conversion), and control unit.

To achieve the high efficiency of the inverter equipment, loss analysis was performed on the conventional “SANUPS DA” at 1 kVA.

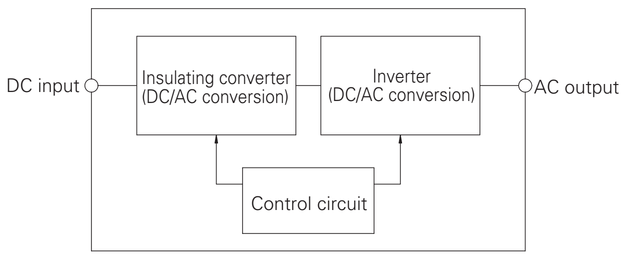

Fig. 8: Circuit architecture of the inverter equipment

As a result of the analysis, there was large loss in the insulating converter unit, where most of the loss was resulting from the semiconductor relating to the insulation conversion. Therefore, circuit and control system to reduce the switching loss of the DC/DC converter unit was necessary.

Circuit system for the DC/DC converter was considered, and adopted the resonance converter that can reduce the switching loss vastly over the conventional circuit system. The loss generated in the semiconductor was reduced by adopting the resonance converter. Efficiency of 86% or higher was achieved also by adopting a parts for the circuit, such as semiconductors, with less loss.

4. Deployment of technology of new product "SANUPS D11A"

4.1 Outline

The "SANUPS D11A" was developed using the high efficiency resonance converter mentioned in Section 3.

This equipment is an inverter equipment with inverter unit of output capacity of 1 kVA (1 kW) as a basic unit, which can be operated in parallel or redundant parallel. To operate in parallel, units are mounted in the cabinet dedicated to the parallel operation, and to operate as single unit, unit is mounted in the cabinet dedicated to the single operation.

Fig. 9 shows the operation example of the parallel operation (6 units), and Fig. 10 shows the external dimensions of the inverter unit.

Fig. 9: Operation example of the parallel operation (6 units)

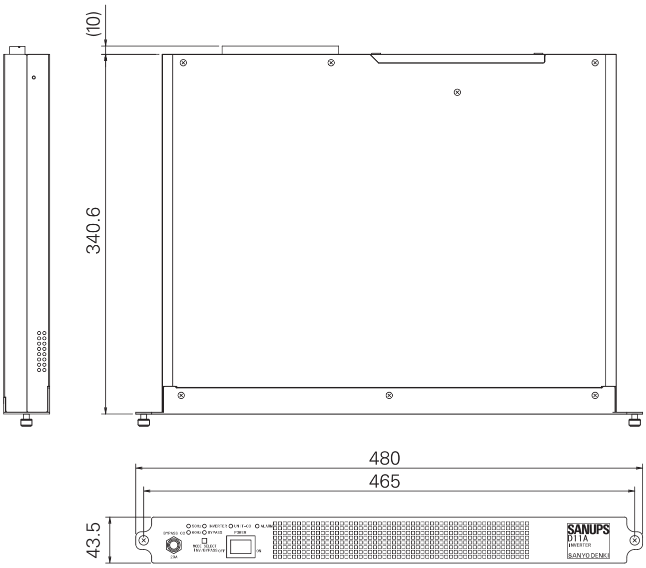

Fig. 10: External dimensions of the inverter unit

4.2 High efficiency

Conventional 1 kVA model "SANUPS DA" had efficiency of 80%, but by adopting the resonance converter, the "SANUPS D11A" has achieved the industry top class efficiency of 86%. Fig. 11 shows the efficiency comparison with the conventional model.

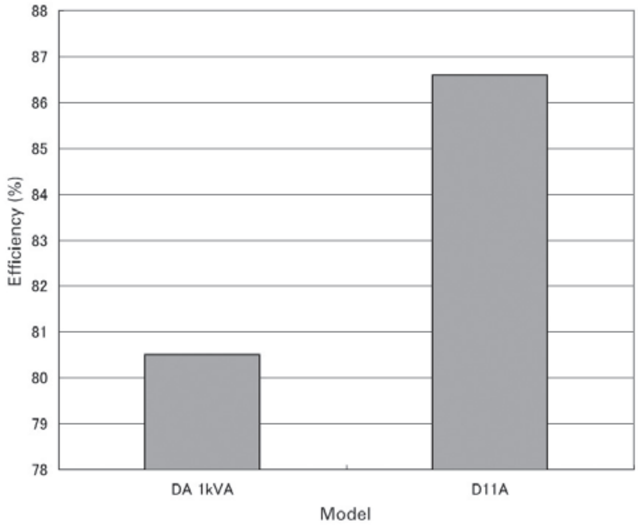

Fig. 11: Efficiency comparison

4.3 Miniaturization

Conventional 1 kVA model "SANUPS DA" had 1 kVA (0.8 kW) output capacity inverter unit in 2U size, volume of 10,406 cm^3, and mass of approximately 9.5 kg. In comparison, "SANUPS D11A" was able to achieve high efficiency, for the output capacity of 1 kVA (1 kW), it had 1U size, volume of 6,360 cm^3, and mass of approximately 7.5 kg, reducing approximately 39% of volume and approximately 21% in mass. Fig. 12 shows the volume comparison with the conventional model.

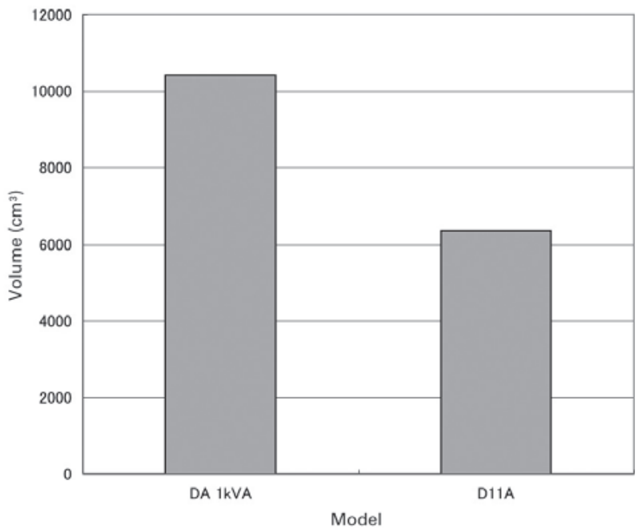

Fig. 12: Volume comparison

4.4 Parallel operation

The "SANUPS D11A" can operate up to 6 units in parallel with 2 kVA (1 kW) as a basic unit, so the capacity of the inverter equipment can be set between 2 and 6 kVA in accordance to the capacity of the load equipment. It is also possible to add units in plug-in method when the capacity of the load equipment increases.

Fig. 13 shows the system architecture.

By changing the setting of the equipment, it is also possible to operate as parallel redundant of N + 1 unit configuration (5 kVA).

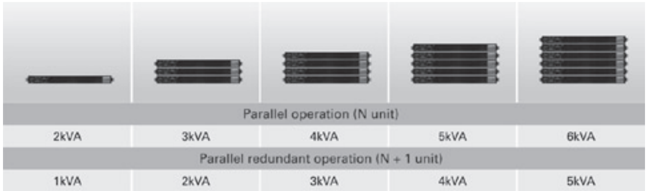

Fig. 13: System architecture

Reliability is raised by lining up the Series with a bypass switching function, allowing supplying of the power from AC input.

5. Conclusion

A measure to achieve the #1 conversion efficiency in the industry for the UPS, photovoltaic power generation system power conditioner, and inverter equipment for communication power supply was explained here. As a representative example, the "SANUPS D11A" that has achieved high efficiency for the communication power supply inverter equipment which was considered to be hard to achieve the high efficiency was introduced.

This DC/DC conversion technology will be applied to the battery operation circuit of the UPS, photovoltaic power generation system power conditioner that needs insulation, and power supply with DC input, such as fuel cell inverter. We will also challenge to develop products with higher efficiency and higher reliability by making the inverter unit more efficient.

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