Development of the Single Phase PV Inverter "SANUPS P61A"

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1. Introduction

With the global warming being recognized as a major crisis in recent years, even more than low-energy equipment, the growth of renewable energy is considered to be a major step towards realizing a low carbon society. Photovoltaic power generation has the most potential possible yield among forms of renewable energy. According to the "Action Plan for Establishing a Low Carbon Society" established by the Japanese government, the amount of power generated by photovoltaic power generation in 2008 is expected to increase to 10 times that amount by 2020, and 40 times that amount by 2030.

National policies such as the FIT (*1) Policy in EU countries like Germany and Spain have promoted photovoltaic power generation. With these policies, the annual installation worldwide has increased more than 10 times in the 5 years up to 2008. The EU market continues to expand, but it is expected that Chinese, South East Asian, and Oceania markets will lead the market in the future.

The PV inverter is an essential element of the photovoltaic power system along with the photovoltaic cell. The market demands a PV inverter with high efficiency, high performance, long life expectancy, and high reliability.

This document introduces the features of the single-phase PV inverter "SANUPS P61A" for overseas market developed to answer these demands.

2. Background of the Development

The main method for power supplies overseas is the 3-phase 4-wire method, and single-phase equipment is connected between the neutral wire and each phase. The most commonly used voltages are 220 V or 230 V.

Previously, Sanyo Denki did not offer a lineup of single-phase output PV inverters, so with the goal of increasing product lineups for the expanding overseas market, we have developed a single-phase PV inverter "SANUPS P61A." We have made two types of series for different output volumes: 3 kW and 5 kW.

3. Product Overview

Fig. 1 shows a photograph of the "SANUPS P61A302" (3 kW) and Fig. 2 shows a photograph of the "SANUPS P61A502" (5 kW). Both the 3 kW and 5 kW models are wall-hanging types, and the width and depth are the same dimensions. Appearance is based on a straight line, and it is designed to match the surroundings even with multiple units installed.

The unit is silver in color with the brand logo centered in red, which is the "SANUPS" brand color. Also, the LCD

Fig. 1: "SANUPS P61A302" 3 kW

Fig. 2: "SANUPS P61A502" 5 kW

Fig. 3: LCD and operation area

panel and operation switches are placed compactly around the brand logo, making it a design that is functional and sophisticated.

Fig. 3 shows a photograph of the LCD and operation area.

4. Features

4.1 High efficiency

The “SANUPS P61A” has adopted a non-insulation method, which does not use an insulating transformer for the input and output. Also, the converting circuit is constructed with a boost chopper circuit and a full-bridge inverter circuit. With this method, the “SANUPS P61A” achieves a maximum efficiency of 96%, which is the top in the industry.

Fig. 4 shows the load factor versus conversion efficiency characteristics. The 3 kW type has achieved a maximum efficiency of 96% at a load factor 100%, while the 5 kW type achieves the maximum efficiency at a load factor of 60%. The output voltage and output power of the solar cell change greatly depending on the external environment, such as the solar radiation conditions and external temperature. PV inverters require characteristics to maintain high conversion efficiency regardless of changes in input voltage and load factor.

Fig. 5 and Fig. 6 show the conversion efficiency distributions for the 3 kW type and the 5 kW type respectively. Fig. 5 and Fig. 6 are characteristic charts that show the distribution of the conversion efficiency with the load factor of the PV inverter along the horizontal axis, and DC input voltage of the PV inverter along the vertical axis.

The 3 kW type achieved an efficiency of 94% or higher with operation conditions of load factor 65% or higher and DC input voltage of 280 V or higher. Similarly, the 5 kW type achieved an efficiency of 94% or higher with operation conditions of load factor 40% or higher and DC input voltage of 280 V or higher.

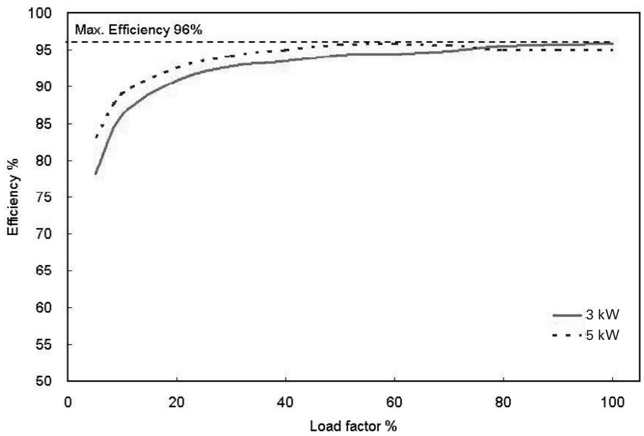


Fig. 4: Load factor vs. efficiency characteristics

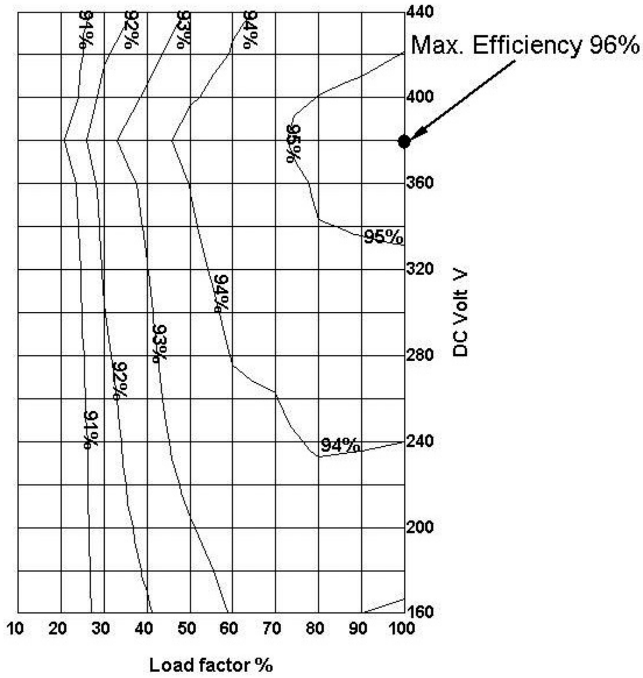


Fig. 5: Efficiency distribution (3 kW)

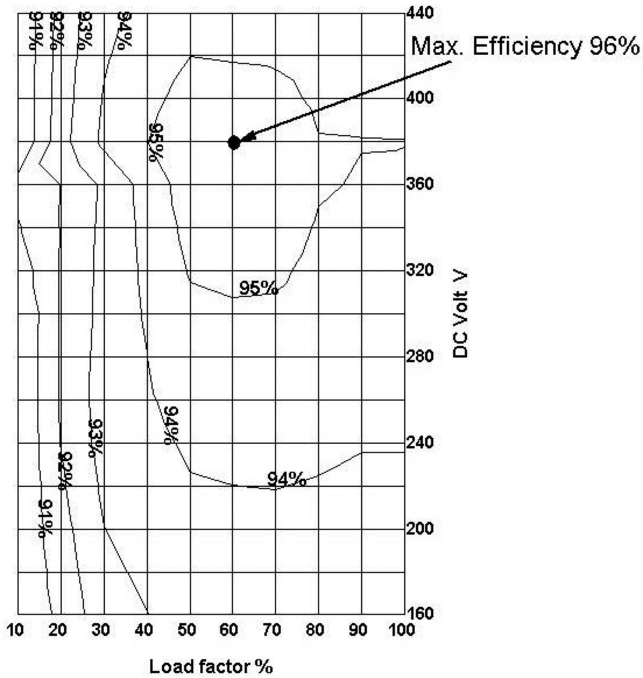


Fig. 6: Efficiency distribution (5 kW)

4.2 High level of dust and water protection

The “SANUPS P61A” has adopted a natural cooling method that does not use a fan for cooling with a sealed body housing. As a result, the “SANUPS P61A” has a dust and water protection that can withstand operation outdoors, achieving the protection class IP65.

The covers of the housing are made as a double structure, and waterproof seals are installed between each cover and housing. Also, the entire external wiring interface is centrally placed on the bottom panel of the housing, and waterproof parts are used for all the connectors and terminal blocks.

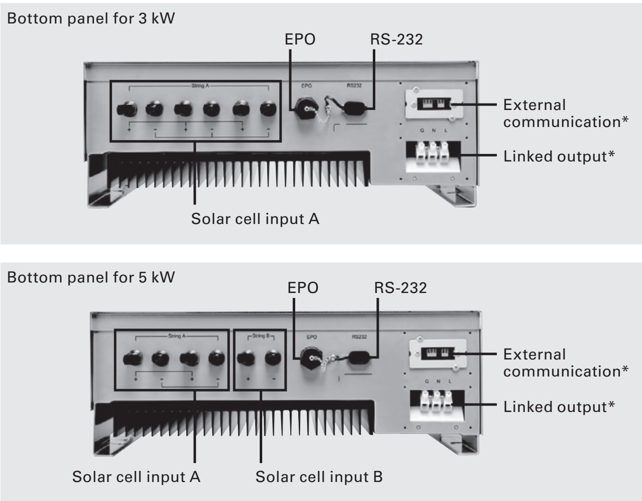
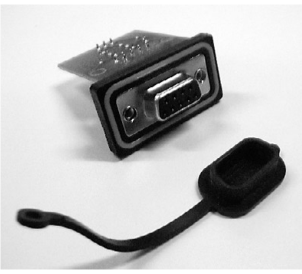


Fig. 7: I/O interface layout on the bottom plate of the housing



(a) RS-232 connector

(b) EPO connector

(c) Solar cell input connector

(d) Linked output/ communication cap

Fig. 8: Adopted waterproof parts

Fig. 7 shows the layout for the bottom panel of the housing. Also, Fig. 8 shows the waterproof parts used.

4.3 Long life expectancy

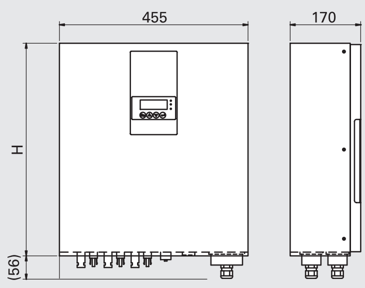
By adopting a natural cooling system that does not use a cooling fan and by using long life parts, the “SANUPS P61A” does not require parts replacement for 10 years.

Furthermore, the “SANUPS P61A” can be used for 20 years by replacing the parts.

4.4 Small size

The “SANUPS P61A” has achieved smaller size even with the adoption of natural cooling. Volume output density of the conventional model P73D103 (10 kW) is 0.0992 W/cm^3, but the “SANUPS P61A” 5 kW type is 0.1266 W/cm^3, and it is 22% smaller compared to the conventional model.

Fig. 9 shows the dimensions and mass of the “SANUPS P61A.”



Output	H	Mass
3 kW	436	24 kg
5 kW	511	29 kg

Fig. 9: Dimensions and mass of the “SANUPS P61A”

5. Circuit Architecture

5.1 Circuit block diagram

Fig. 10 and Fig. 11 show the circuit block diagrams of the "SANUPS P61A."

The "SANUPS P61A" is constructed with a main circuit unit containing circuits that include the boost chopper circuit, the inverter circuit, and the filter circuit, and a control circuit unit containing circuits that include the control circuit that controls the main circuit, the interactive protection circuit, and the external communication circuit.

The following describes each of the circuit constituent elements.

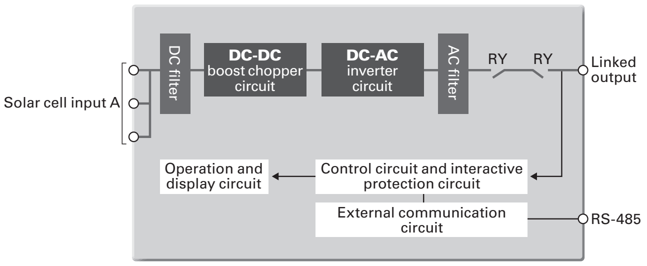


Fig. 10: Circuit block diagram (3 kW)

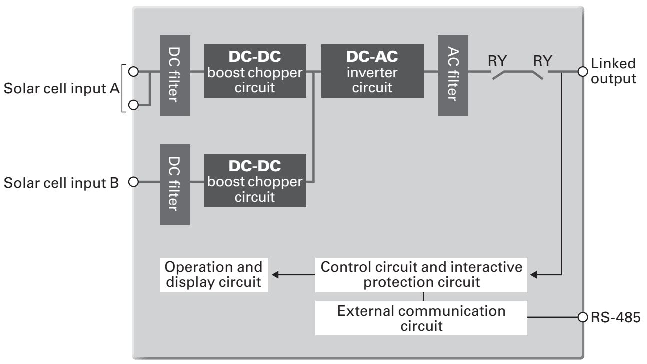


Fig. 11: Circuit block diagram (5 kW)

5.2 Boost chopper circuit

Boost chopper circuit is a circuit that boosts the input voltage to the inverter circuit when the output voltage of the solar cell is low in order for the inverter circuit to output adequate voltage to the linked system.

The input voltage range for the "SANUPS P61A" to perform rated output operation is DC 150 to 450 V. The boost chopper circuit will boost the input voltage to the inverter circuit to 380 V when the voltage input from the photovoltaic cell is less than 380 V, and it will stop operation when the voltage input from the photovoltaic cell exceeds 380 V, thus supplying a relatively constant voltage as the input from the solar cell to the inverter input. IGBT is adopted as the conversion element.

The 5 kW type has 2 boost chopper circuits built in. The 5 kW type can distribute the input from the two solar cell panels in series parallel structure into solar cell inputs A and B. With this method, MPPT (*2) control can be performed individually, so even when the solar radiation condition is different for the solar cells connected to A and B, the 5 kW type can generate output close to the maximum output point for each of the solar cells. The solar cells can also be used as a single circuit input by connecting A and B as a multiple connection when setting up the unit.

5.3 Inverter circuit

The inverter circuit converts the DC power to AC power, and it supplies a stable AC power to the system. The "SANUPS P61A" uses a single-phase full bridge structure for the circuit method, and parts are shared by using the same type of IGBT that is also used by the boost chopper circuit for the conversion element.

5.4 Control circuit

The "SANUPS P61A" adopts digital control as the control method and uses a DSP (Digital Signal Processor) that can perform fast processing. The control power supply that drives the control circuit is supplied only from photovoltaic cell input, and the unit achieves nighttime stand-by power consumption of 0.2 W.

5.5 External communication circuit

The "SANUPS P61A" adopts RS-485 as the communication method for the external communication circuit, and it is compatible for connection to the remote monitoring equipment "SANUPS PV Monitor." The

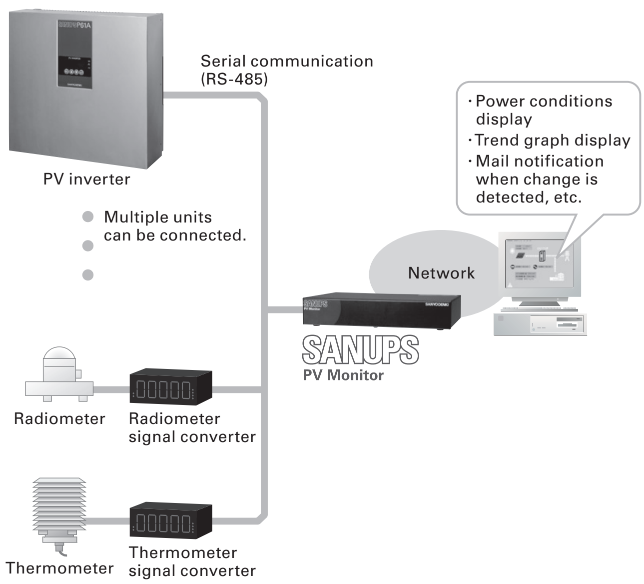


Fig. 12: PV Monitor connection image

communication rate is set to 9600 bps to maintain compatibility with general measuring equipment.

By connecting the "SANUPS PV Monitor," operators can remotely monitor the "SANUPS P61A" or collect and analyze the radiometer or external thermometer data.

Fig. 12 shows an image with remote monitoring connected using the "SANUPS PV Monitor" .

5.6 Electrical specifications

Table 1 shows the specifications for the "SANUPS P61A."

Table 1: Main specifications for "SANUPS P61A"

Item / Model		P61A302	P61A502	Remarks
Rated output		3 kW	5 kW	
Method	**Main circuit type**	Self commutation voltage type		
	Switching method	High-frequency PWM method		
	Isolation method	Transformerless type (non-isolation)		
DC input	**Maximum allowance input voltage**	DC 500 V		
	Input operation voltage range	DC 120 to 500 V		
	Rated output range	DC 150 to 450 V		
	Maximum power point tracking control range	DC 150 to 450 V		
	MPPT (*2) tracker	1	2	
AC output	**No. of phases/wires**	Single-phase, two-wire		
	Rated voltage	AC 230 V		
	Voltage range	AC 184 to 264.5 V		
	Rate frequency	50 or 60 Hz		
	Rated output current	AC 13 A	AC 21.7 A	
	AC output current distortion factor	Total harmonic current:5% or less, Single harmonic current:3% or less		Rated output current ratio
	Output power factor	0.99 or more		At rated output
Efficiency	**Max. efficiency**	96%		
	EU efficiency	94%		
Grid connected protective function		Over-voltage (OVR), Under-voltage (UVR), Over-frequency (OFR), Under-frequency (UFR)		
Islanding operation detecting functions	**Passive-type device**	Voltage phase jump detection method		
	Active-type device	Reactive power variation method		
External communications method		RS-485 Modbus		RTU mode
Environment	**Installation location**	Outdoors		
	Ambient temperature	−25 to 60°C		When ambient temperatures are above +40°C , the output power is limited
	Relative humidity	0 to 90%		Non-condensing
	Altitude	2,000 m or less		
Protection code		IP65		
Cooling method		Natural air-cooling		
Connection		AC output: Terminal block, DC input: Connector (MC4)		

6. Conclusion

This document introduced an overview of the "SANUPS P61A."

The development of this product expanded the lineup of inverters for photovoltaic power generation that can be used internationally to 3 kW - 100 kW.

With the expected future growth of photovoltaic power generation, we believe that the demand will increase for PV inverters that have high efficiency, high performance, high reliability and low cost.

We will continue to quickly develop products that can handle the requirements from the market, supply products that satisfy customers, and contribute to the realization of the low carbon society.

We sincerely thank the many people involved in the development and realization of this product for their advice and support.

(*1) FIT (Feed-in Tariff): A fixed price buyback program.
This method has gained attention as a method to disseminate renewable energy such as photovoltaic power generation.

(*2) MPPT (Maximum Power Point Tracking): Also called "maximum power point tracking control". The operation point of the solar cell to output maximum power constantly changes depending on the external environment such as irradiation and external temperature. This operation point is constantly tracked.

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