Development of the 3-phase PV Inverter "SANUPS P83D"

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1. Introduction

According to the May 2010 report "Global Market Outlook for Photovoltaics until 2014" (issued by EPIA) (*1), the amount of energy from newly introduced photovoltaic power systems in 2009 in the EU reached 5.6 GW, lead by Germany with 3.8 GW and countries such as Italy with 711 MW. Photovoltaic power systems also grew in other regions besides the EU, with 484 MW introduced in Japan and 477 MW introduced in the USA for a total of 7.2 GW newly introduced around the world. Even in a year affected by the worldwide recession, policies to help the growth of photovoltaic power systems in countries around the world resulted in a growth of 15% over the previous year. The accumulated amount of energy introduced from photovoltaic power systems by the end of 2009 was 15.9 GW in the EU (9.8 GW from Germany) and 2.6 GW in Japan, reaching 22.9 GW around the world, and the yearly amount of power generated by PV systems around the world reached 25 TWh.

The report also predicted that the amount of energy introduced from photovoltaic power systems in 2014 would be at least 8 GW in the EU (with 4 GW in Germany) and 1.2 GW in Japan for a total of 13.7 GW around the world. Furthermore, the report predicted that the accumulated amount of energy introduced from photovoltaic power systems by the end of 2014 would be 51.4 GW in the EU (with 28.8 GW in Germany) and 7.5 GW in Japan for a total of 76.5 GW around the world. These figures are more than twice the capacity compared to the amount of energy introduced from photovoltaic systems by 2009, indicating that in the five years starting from 2010, many new systems will be introduced, so active technological development and product development are expected in the future for fields related to photovoltaic power generation.

This document introduces an overview of the 3-phase PV inverter "SANUPS P83D" for international markets that was developed in order to respond to these expectations.

2. Background of the Development

In 2009, Sanyo Denki started sales of the 100 kW output capacity 3-phase PV inverter "SANUPS P83C" , officially entering the international PV inverter market. Photovoltaic power systems can involve an entire building with photovoltaic battery panels on the roof or walls of the building, photovoltaic battery panels installed on a large plot of land, or power plant systems known as "mega solar" with a capacity of several MW or higher. In recent years, many countries have planned large-scale photovoltaic power systems for use in idle farming land or unused space, especially in regions with expected high solar radiation.

The PV inverters for international markets from Sanyo Denki came with output capacity of up to 100 kW, but the market desired a larger capacity PV inverter lineup that could handle large-scale systems.

3. Product Overview

Fig. 1 shows the appearance of the “SANUPS P83D” .

The “SANUPS P83D” is a 250 kW output capacity, utility connected system type, indoor installation stationary model. The appearance emulates the “SANUPS P83C” design, using a color scheme with a black base color and red, the “SANUPS” brand color, on the left side door.

Furthermore, the large, vertical brand logo sticker is positioned on the upper left end. The LCD display panel and operation switches are located on the upper part of the right side door for a compact design that emphasizes functionality.

Fig. 2 shows the appearance of the LCD display operation panel.

Fig. 1: “SANUPS P83D254”

Fig. 2: LCD display operation panel

4. Features

4.1 High efficiency

The “SANUPS P83D” is a 250 kW PV inverter with a built-in insulation transformer that achieves conversion efficiency of 97% (maximum), which is among the top of its class in the industry. Fig. 3 shows the load factor versus conversion efficiency characteristics. The “SANUPS P83D” has characteristics of maximum efficiency within a high load range with a load factor of 50% to 100%. This characteristic is suitable for installations in regions with high solar radiation that will often operate with high load. Furthermore, even in low load factor ranges, the P83D operates without dramatically reducing efficiency, thus realizing an efficiency of 96.2% for EU efficiency that emphasizes low load factor.

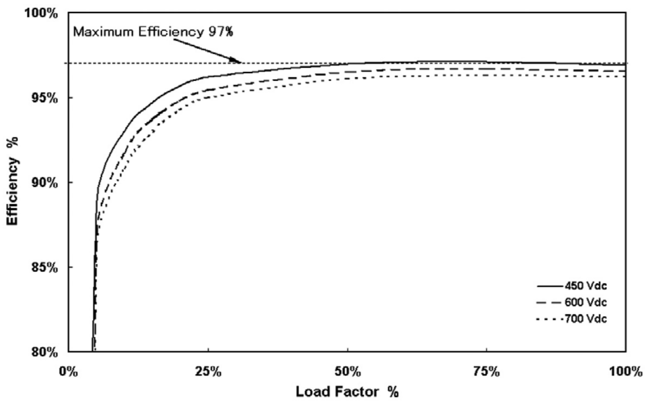

Fig. 3: Load factor vs. efficiency characteristics

4.2 Wide operation range

Fig. 4 shows the possible operation range for the “SANUPS P83D” DC input. The operating range of this product is DC input 430 V to 900 V. Furthermore, the maximum power point tracking range is 450 V to 850 V, and rated output operations are possible within this range.

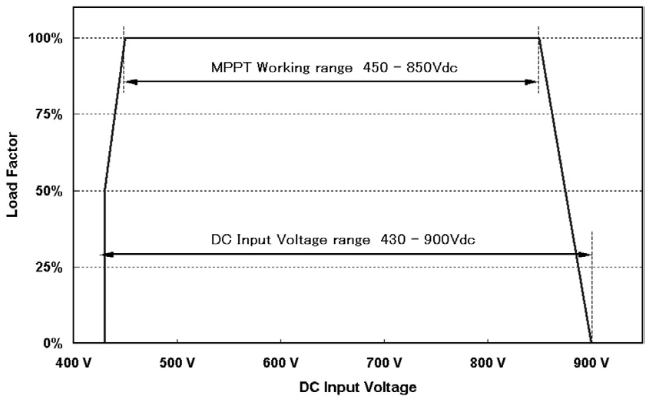

Fig. 4: DC input operation range for P83D

4.3 Built-in insulation transformer

The “SANUPS P83D” is an insulating type PV inverter with a transformer built into the unit. This structure electrically insulates the DC input and AC output to realize high safety.

4.4 Small size and space saving

Fig. 5 shows the dimensions and mass of the “SANUPS P83D” . This product is a PV inverter with built-in insulation transformer, but it realizes small size and space saving characteristics with an installation area of 1.2 m^2 and a size of 2.34 m^3.

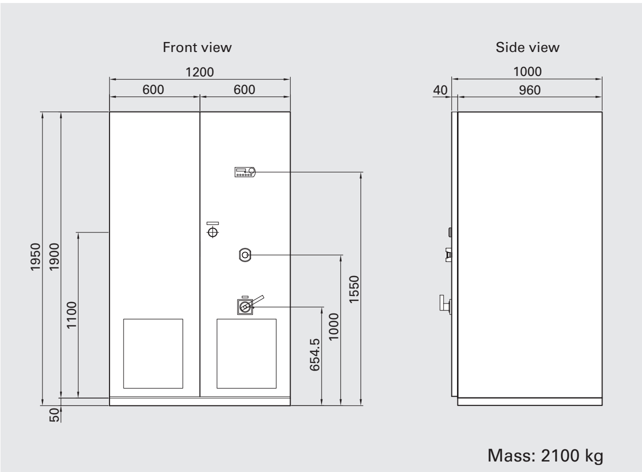

Fig. 5: Dimensions and mass of P83D

4.5 Safety and security

The design of the “SANUPS P83D” includes Sanyo Denki’s abundant consideration for fool-proof and fail-safe design to realize high safety.

In order to operate the AC circuit breaker without opening and closing the door on the unit, an operation lever is placed on the outside of the door and the front door cannot be opened and closed without first switching the operation level for the AC circuit breaker into the “OFF” position. Furthermore, a limit switch is installed to detect opening and closing of the front door for a structure where operations cannot be performed when the door is open, and a function is included to stop safely if the door happens to open during operations.

An EMS (Emergency Stop) switch is installed in the center of the front door, and a function is included to open all circuit breakers during an emergency to stop operations. Fig. 6 shows the appearance of the EMS switch.

In consideration of security, a removable handle is used as the front door handle for a structure that helps prevent unnecessary opening and closing. Fig. 7 shows the appearance of the door handle.

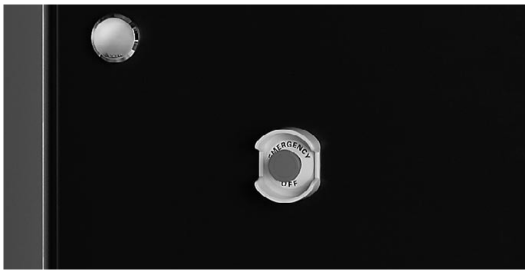

Fig. 6: Appearance of the EMS switch

Fig. 7: Appearance of the door handle

5. Circuit Architecture

5.1 Circuit block diagram

Fig. 8 shows the circuit block diagram of the “SANUPS P83D”.

The “SANUPS P83D” is constructed with a main circuit unit including the DC input circuit, inverter circuit, and AC output circuit; a control circuit unit including the control circuit, LCD display operation circuit, and external communication circuit; and an auxiliary circuit unit including circuits for the cooling fan and control power.

The following introduces in detail each of the circuit constituent element.

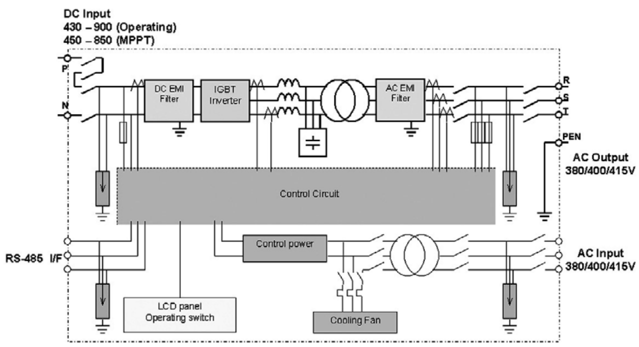

Fig. 8: Circuit block diagram

5.2 DC input circuit

The DC input circuit consists of the DC input circuit breaker and DC EMI filter. The DC input circuit breaker employs the electrical spring charge mechanism with specifications whereby the circuit is closed or opened in connection with the PV inverter.

5.3 Inverter circuit

The inverter circuit is positioned on top of the unit and it employs an IGBT as the main conversion element. The AC filter circuit consists of a 3-phase reactor and 3-phase capacitor.

5.4 AC output circuit

The AC output circuit consists of the insulation transformer, AC EMI filter, AC contactor, and AC circuit breaker. After the voltage of the AC power converted from the inverter circuit is raised by the insulation transformer and then common mode noise is eliminated by the EMI filter, the AC power passes through the contactor and circuit breaker to be supplied as AC output.

5.5 Control circuit

The control circuit consists of three PWB: the control circuit for the unit, the ground detection circuit, and the interface circuit. The LCD display control circuit is constructed as a module that combines the LCD display with the control switch and large operation knob.

5.6 External communication circuit

The external communication circuit uses the RS-485 communication method, and therefore it can be connected to the remote monitoring device “SANUPS PV Monitor”. The communication speed is 9600 bps.

When connected to the “SANUPS PV Monitor”, this allows remote monitoring, plus data acquisition and analysis from radiometers and outdoor thermometers for “SANUPS P83D”.

Fig. 9 shows an image of the connections when using “SANUPS PV Monitor” for remote monitoring.

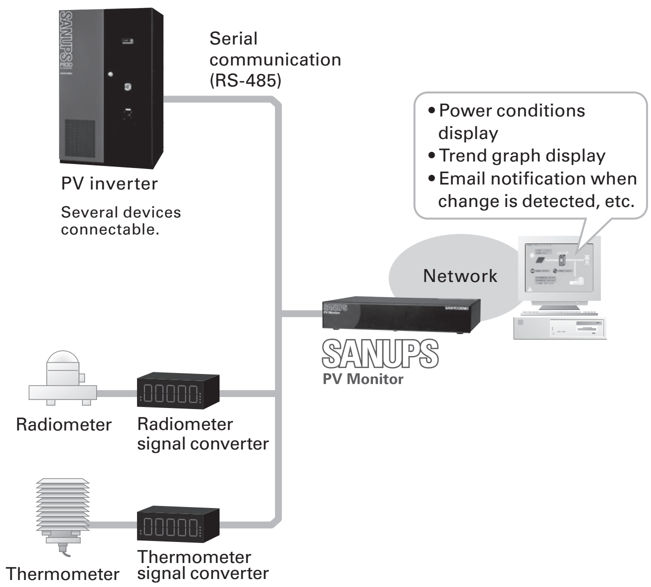

Fig. 9: Image of connection to PV Monitor

5.7 Electrical specifications

Table 1 shows the electrical specifications for the “SANUPS P83D”.

Table 1: Main specifications of “SANUPS P83D”

Item	Model	SANUPS P83D254	Remarks
Output capacity		250 kW	
Method	Main circuit method	Self-exciting voltage method	
	Switching method	High-frequency PWM method	
	Insulation method	Commercial frequency insulation method	
DC input	Maximum allowance input voltage	DC 950 V	
	Input operation voltage range	DC 430 to 900 V	
	Rated output range	DC 450 to 850 V	
	Maximum power point tracking control range	DC 450 to 850 V	
AC output	No. of phases/wires	Three phase, three wire	TN-C grounding method
	Rated voltage	AC 380/400/415 V	
	Voltage range	±10%	
	Rated frequency	50 Hz or 60 Hz	
	Rated output current	AC 380/361/348 A	
	AC output current distortion rate	3% or less of the total current	Rated output current ratio
	Output power factor	0.99 or higher	During rated output
Efficiency	Max. efficiency	97%	
	EU efficiency	96.2%	
Grid connected protection function		Over-voltage (OVR), under-voltage (UVR), over-frequency (OFR), under-frequency (UFR)	
Islanding operation detection	Passive method	Voltage phase jump detection method	
	Active method	Reactive power variation method	
Communication method		RS-485 Modbus	RTU mode
Environment	Installation location	Indoors	
	Ambient temperature	-5 to 40˚C	
	Relative humidity	15 to 85%	No condensation
	Altitude	2,000 m or lower	However, output is reduced 0.5% for every 100 m over 1,000 m
Protection code		IP20	
Cooling method		Forced air cooling	

6. Conclusion

This document described the overview of the “SANUPS P83D”.

The development of this product expanded the lineup of PV inverters for international use to 3 kW - 250 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 UPS product for their advice and support.

Reference

(*1) “Global Market Outlook for Photovoltaics until 2014”, issued by EPIA (European Photovoltaic Industry Association), May 2010

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