Development of the Enhanced Function Version "SANUPS P61B" Series,

Power Conditioner for Photovoltaic Generation Systems with an Output Control Function

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1. Introduction

As a result of the feed-in tariff, which was introduced to promote the usage of renewable energy, there has been a dramatic increase in the number of power generation equipment which utilizes renewable energy. However, because the increase in such equipment has exceeded expectations, many electricity utilities are refraining from connecting to renewable energy as it is not possible to maintain a balance between demand and supply with the current output control rules and power systems would become unstable. As such, the Agency for Natural Resources and Energy promulgated a ministerial order in January and March of 2015 to partially revise The Act on Special Measures concerning the Procurement of Renewable Electric Energy by Operators of Electric Utilities, as part of an effort to achieve the maximum introduction of renewable energy. As a result, a requirement emerged for a function to comply with the new output control rules which is able to suppress the output of power generating equipment by time.

In order to comply with these new output control rules, Sanyo Denki developed enhanced function of the "SANUPS P61B" series power conditioner for photovoltaic power generation. This document introduces its overview.

2. Requirements of the New Output Control Rules

As specifications of the new output control rules, the Japan Photovoltaic Energy Association, Japan Electrical Manufacturers' Association and Federation of Electric Power Companies of Japan compiled the "Technical Specifications for PCS* with an Output Control Function" (PCS is the abbreviation for "power conditioner"). According to the specifications, the photovoltaic power generation equipment which complies with the new output control rules is called an "output control system" and the three fundamental principles of configuring such a system are shown below.

(1) Only have the minimum necessary output control for system stabilization
(2) Secure fairness between the power producers who are the target of output control
(3) Secure the operation execution ability of the output control system

Based on these fundamental principles, many requirements of photovoltaic power generation systems have been defined. Below is an overview of such requirements.

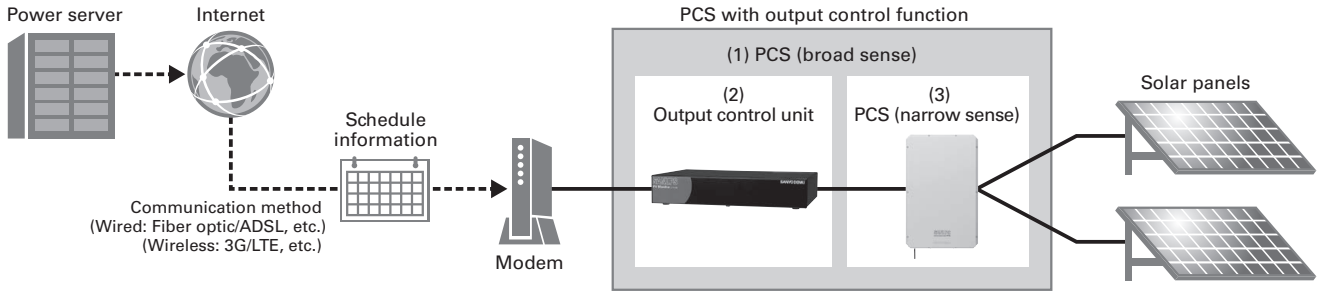


Fig. 1: Configuration of a PCS system with an output control function

2.1 PCS system configuration with an output control function

Fig. 1 shows the configuration of the PCS system with an output control function.

(1) PCS (broad sense)

The PCS which possesses a function to obtain output control schedule information instructed by power companies or distributors, and controls the power generating output to suit that schedule. Essentially it is configured from (2) Output control unit, and (3) PCS (narrow sense), which are discussed below.

(2) Output control unit

The control unit which possesses a function to obtain output control schedules from power servers and controls (3) PCS (narrow sense) based on this schedule. This controls (3) PCS (narrow sense) by using the fixed schedule stored within the unit even when there is no external communication function.

In the case of Sanyo Denki, our enhanced function version "SANUPS PV Monitor" applies.

(3) PCS (narrow sense)

A PCS which, in addition to conventional functions, possesses a function to receive output control information from the (2) Output control unit and controls photovoltaic power generation output (upper limit).

The power conditioner with enhanced function "SANUPS P61B" series and the "LCD Panel TYPE III C" are applied.

2.2 Main technical specifications

(1) Partial control

(a) Increasing/decreasing output

- It shall be possible to adjust the output change time of PCS rated output decreasing from 100 to 0% or increasing from 0 to 100% output in 1 minute increments between 5 and 10 minutes (±5% error at ordinary temperature). Change rate to be constant.
- Instead of making the change rate to linear, a method of controlling with a constant step (ramp control) shall also be recognized. The control step should be 10% or less.

(b) Control resolution

- It should be controlled in 1% increments of rated output.

  (Accuracy should be within ±5% of rated output at ordinary temperature)

(c) Contract capacity conversion function

- It has a function to input the panel and PCS capacities, converts the output control volume from contract capacity base to PCS capacity base, and fulfill the function to be able to command to PCS (narrow sense).

  Security must be secured for capacity input by setting a password, etc.

(2) Communication error

(a) PCS (broad sense) communication error

- In a case of communication error from host system, the specification should be output controllable based on the latest output control schedule information before the error.

(b) PCS (narrow sense) communication error

- Stop the generating output within 5 minutes after a fault occurred with internal communication of PCS (broad sense). However, recovery must be possible in both automatic and manual mode when communication is resumed.

(3) Online control

- The output control schedule shall be able to updated a minimum 30 minutes increments.
- Make it possible to designate a refresh cycle (next access) from the power server.

(4) Schedule

- Able to set output control volume for 400 days (1 year +α) x 48 points (24 hours/30 minutes).
- It shall be possible to rewrite the schedule portion for an arbitrary period (in units of days, etc.)

2.3 Overview of output control operation

The output control unit sends output control values to the PCS (narrow sense) in accordance with the output control schedule obtained from the power server (30 minutes increments, rated output control value in increments of 1%). PCS (narrow sense) calculates the output change time from the set change rate, and increases or decreases the output.

Fig. 2 shows an example of output control operation.

Time (hours)	0 to 9	9 to 11	11 to 13	13 to 15	15 to 24
Output upper limit (%)	100%	40%	0%	40%	100%

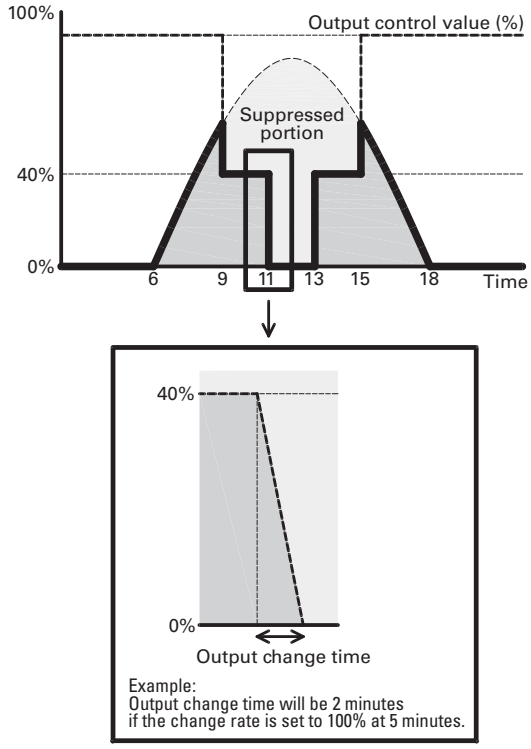


Fig. 2: Example of output control operation

3. Product Overview

3.1 Power conditioner

Fig. 3 shows the 5 kW and 5.5 kW models for the enhanced function version "SANUPS P61B" series.

Function enhancement was achieved by changing software therefore the new product is identical to the conventional "SANUPS P61B" series in appearance.

Fig. 3: The enhanced function version "SANUPS P61B" series

3.2 LCD panel

Two types of LCD panels can be used in the enhanced function version "SANUPS P61B" series; "LCD Panel TYPE II C" which can only be used for setting the output control function and the "LCD Panel TYPE III C", which can be used for both setting and operation of the output control function. The appearance is the same as the conventional product.

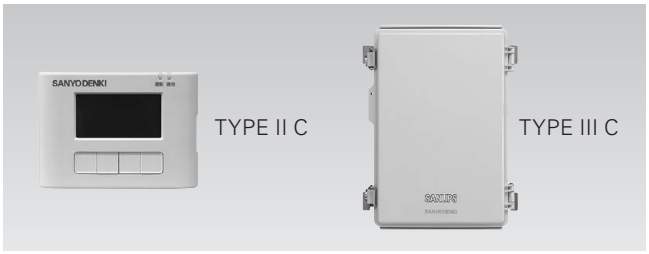


Fig. 4: LCD panels

Table 1 shows the functions of the LCD panels.

Table 1: LCD panel functions

Functions	TYPE II C	TYPE III C
Output control function setting	○	○
Output power factor fixing function setting	○	○
Operation with output control system	×	○*1
Operation with system not using output control	○*2	○*2

*1: Displays output control value, displays/stores history of output control system unique errors
*2: Host compatibility of TYPE II and TYPE III

3.3 SANUPS PV Monitor

The enhanced function version "SANUPS PV Monitor" can be used as an output control unit for the enhanced function version "SANUPS P61B" series. The appearance is the same as the conventional product.

Fig. 5: Enhanced function version "SANUPS PV Monitor"

At the same time, we also developed an enhanced function version of the "Mobile Communication Pack".

3.4 Configuration of the output control system

In the case of the enhanced function version "SANUPS P61B" series, up to 10 power conditioner units can be used simultaneously as a PCS system with an output control function.

Fig.6 shows the main system configuration of the enhanced function version "SANUPS P61B" series (the power conditioners shown in Fig.6 are 5.5 kW model). It is possible to configure the system that distributes the output control schedule through the Internet connection as required, and the system updates the fixed output control schedule regularly by service personnel.

3.5 Output control function

Below are the basic operations relating to output control.

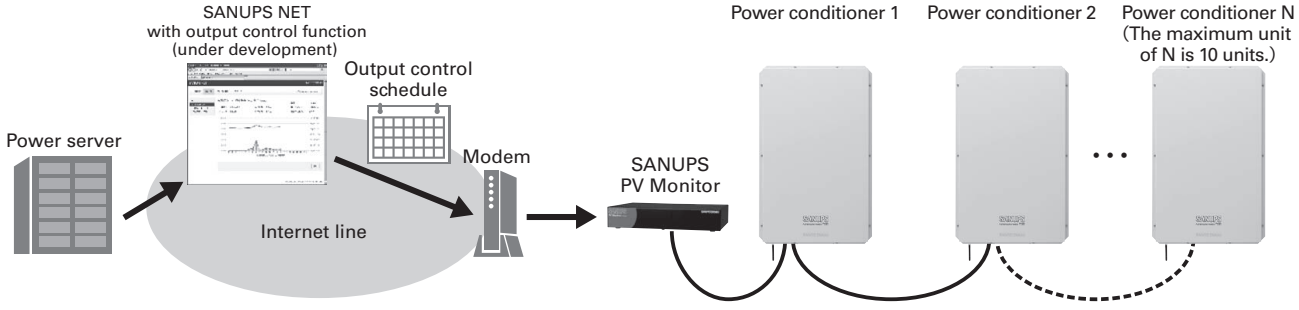
(1) The output control unit "SANUPS PV Monitor" (or "Mobile Communication Pack" sends the output control value by communication, the power conditioner calculates the output power target value when received the output control value, and operates following with this.

(2) Contract capacity kW value is set to "SANUPS PV Monitor". The "SANUPS PV Monitor" converts the contract capacity kW value into the power conditioner rated kW value, and sends an output control value to the power conditioner. As such, even if the contract capacity kW value is less than the power conditioner rated kW value, it can be controlled by the output control value for the contract capacity kW value.

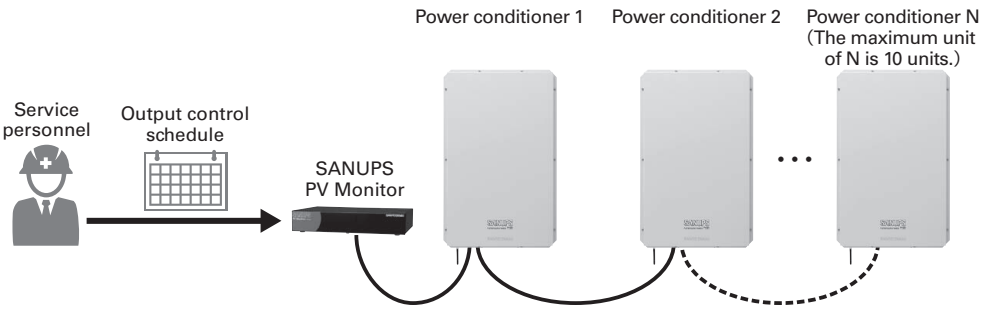
(3) In areas such as remote location with no access to the Internet, output can be controlled by the output control schedule stored inside the "SANUPS PV Monitor". Even when the output control command value is 0%, the power conditioner will continue grid-connected operation at the target of 0 kW.

(4) The communication interval from the "SANUPS PV Monitor" is approximately 10 seconds. The power conditioner will deem that communication has been cut if there is no communication for four minutes and 30 seconds. The system will stop power conditioner output within five minutes and release the interconnection relay.

(5) The below output control function settings can be performed from the LCD panel.
(a) Enable/disable the output control function (Factory setting: Disabled)
(b) Change time until output control (See Table 2)



(1) System to operate in the schedule updated as required



(2) System to operate in the fixed schedule

Fig. 6: Main system configuration of the enhanced function version "SANUPS P61B" series

Table 2 shows the specifications relating to output control.

Table 2: Specifications relating to output control

Item	Setting
Communication cut-off detection time	4.5 min (within 5 min)
Output control setting range	0 to 100%
Output control setting increments	1% of rated output power
Output control setting accuracy	Within ±5% of rated output power (ordinary temperature)
Change time until output control value (when 0→100%, 100→0%)	5, 6, 7, 8, 9, 10 min (Factory setting: 5 min)
Accuracy of change time until output control value	Within ±5% of the setting (ordinary temperature)

3.6 Function for fixing the output power factor

This is a function that required from some electricity utilities in order to suppress the voltage rise of system.

The output power factor can be set for grid-connected operation by our LCD panel.

Power factor setting range: 1.00 to 0.80 (Factory setting: 1.00)

Power factor setting step: 0.01

Further, JET[*1] certification still does not have a provision related to power factor fixing therefore it will not be applicable for JET certification if the power factor is changed to value other than 1.00.

4. Features

The enhanced function version "SANUPS P61B" series is inherited the below superior features from the conventional product.

4.1 Superior environment resistance characteristics

With a sealed structure and the elimination of operation functions from the main body, the new model offers superior dust and water resistance. This structure protects the device from ingression of rain, dust, small bugs, or animals to make a highly reliable product that customers can use for long periods of time outdoors with great security.

The model has achieved a protection level of IP65[*2] in a protection performance test conducted by the Research Institute of Marine Engineering.

4.2 High conversion efficiency

The main circuit uses a non-insulating method that does not use an insulation transformer. Moreover, heat loss has been reduced and high efficiency achieved through optimal component selection and circuit design.

Generally speaking, the switching frequency must be lowered in order to reduce switching loss, and this is the reason for high frequency noise, but the new model offers both high efficiency and quietness to be discussed later through optimal design.

As a result, the new model has achieved top class conversion efficiency in the industry at 95%[*3].

4.3 High quietness

In order to achieve high quietness, we eliminated the fans and reduced inverter high frequency noise (mosquito noise). We also introduced a heat analysis tool from the initial development phase. As a result, development time was shortened, and higher quietness than the conventional product was achieved through optimal design of performance and cost.

As the model offers high quietness, there is no need for customers to position power conditioners far from residential areas, offering freedom in regards to installation location.

4.4 Acquisition of JET certification

The enhanced function version "SANUPS P61B" series has acquired JET certification as a power conditioner for photovoltaic power generation with an output control function. Customers can reduce the time and money spent on discussions concerning utility connected systems with power companies.

5. Specifications

Table 3 shows the general specifications of this device.

Table 3: Standard specifications of the enhanced function version "SANUPS P61B" series

Item \ Model			P61B502SJC	P61B552SJC	Remarks
Rated output capacity		During utility connected system operation	5.0 kW	5.5 kW	
		During isolated operation	2.5 kW		
Insulation method			Non-insulation		Transformer-less system
DC input	Rated voltage		280 V DC		
	Input voltage range		0 to 450 V DC		
	Input operating voltage range		60 to 400 V DC	60 to 450 V DC	Startup voltage: 80 V DC Rated output range 5.0 kW: 150 to 400 V DC 5.5 kW: 200 to 400 V DC (Output may be suppressed depending on temperature)
	No. of input circuits		4 circuits (with batch input)		
	No. of MPPT circuits/mode		2 circuits/batch mode, individual mode		
	Max. current Capacity	Overall/MPPT circuit	35 A / 18 A	32 A / 16 A	
		Overall/input circuit	35 A / 9 A	32 A / 9.5 A	
AC output	Rated voltage	During utility connected system operation	Single-phase, three-wire 202 V AC		
		During isolated operation	Single-phase, two-wire 101 V AC		
	Rated frequency		50 Hz / 60 Hz		
	AC output current distortion rate		5% or less of the total current, 3% or less of each next harmonic wave		Rated output current ratio
	Output power factor		Can be changed from 0.80 to 1.00 using the function for fixing output power factor		During utility connected system operation
Efficiency			95% (excluding the junction box function)		Efficiency measurement method based on JIS C 8961
Cooling system			Natural air-cooling		
Utility 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	Frequency feedback with step injection		
Output control function			Yes		
Acoustic noise			28 dB or less		A characteristic 1 m from front
Operating ambient temperature			-20 to +60˚C		Output may be suppressed depending on temperature
Protection class			IP65		

6. Conclusion

The number of power generation equipment which utilize renewable energy will continue to rise, and greater impact will be had on systems, therefore the demands regarding the functions and configuration of photovoltaic power generation systems will diversify and it will be necessary to expand more power conditioner lineup. Moreover, it is likely that power conditioners with higher reliability, higher efficiency, higher functionality and low cost will be required.

We will continue to quickly develop products to meet these market demands and provide products that fulfill our customers' needs.

We would like to express our deep gratitude for the cooperation and guidance of working group and all related persons who related to achieve success in this development and commercialization project.

*1: JET: Japan Electrical Safety & Environment Technology Laboratories
*2: Classification defined in "JIS C 0920 Degrees of protection provided by enclosures (IP Code)".
IP65: No ingress of dust and water jets from any direction shall have no harmful effects.
*3: Rated load efficiency based on "JIS C 8961 Measuring procedure of power conditioner efficiency for photovoltaic systems".

Reference

(1) "Technical Specifications for PCS with an Output Control Function", Japan Photovoltaic Energy Association, Japan Electrical Manufacturers' Association and Federation of Electric Power Companies of Japan (2015)
(2) Makoto Kitazawa, et al.: Development of a Power Conditioner for Photovoltaic Power Generation "SANUPS P61B" SANYO DENKI Technical Report No. 36

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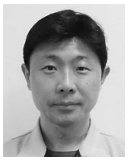

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