Development of the "SANUPS P73K" Power Conditioner with Peak Power Cut Function

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1. Introduction

Since the Great East Japan Earthquake, there has been an increasing demand from local governments and private companies to install backup power sources as preparation for long-term power outages due to disasters. Amongst the various types of backup power sources, a power generation system which combines photovoltaic panels and lithium ion batteries is attracting attention for its many advantages, such as being able to suppress power during peak times, a local-production/local-consumption approach of using reusable energy where it was generated and the ability to use the system as a stand-alone power source during disasters.

On this occasion, Sanyo Denki has developed the "SANUPS P73K", a power conditioner with a peak power cut function which supports lithium ion batteries, etc. This document provides an overview of this product and introduces its features.

2. Overview and Features of "SANUPS P73K"

2.1 10 – 60 kW system configuration

The "SANUPS P73K" consists of a 10 kW power conditioner unit, 10 kW charger unit and an I/O box, and it is a buildup system that can stack up to six 10 kW power conditioner units. The lineup consists of a grid-connected, isolated, charging operation type and a grid-connected, isolated operation type with a rated output capacity of 10 to 60 kW.

2.2 Circuit configuration and basic operation

Figure 1 shows the grid-connected, isolated, charging operation type and grid-connected, isolated operation type versions of "SANUPS P73K". Figure 2 shows the basic circuit configuration for the grid-connected, isolated, charging operation type, while Figure 3 shows the basic circuit configuration for the grid-connected, isolated operation type.

The grid-connected, isolated, charging operation type has a power conditioner unit with a high-frequency insulation converter and inverter, and feeds power from the photovoltaic panels and storage battery to the grid and general load as well as supports peak power cut. It also feeds AC power to isolated output when the grid is down. The charging unit controls both charging and discharging of the storage battery through a bidirectional converter circuit. The I/O box has an isolated output bypass breaker and enables switching between operating circuits. A power transducer signal to measure the grid is inputted, thus enabling peak-cut to start and stop automatically.

The grid-connected, isolated operation type has a power conditioner unit common with the grid-connected, isolated, charging operation type and is capable of feeding power from the photovoltaic panels and storage battery to the grid and general load. This type also feeds AC power to isolated output when the grid is down.

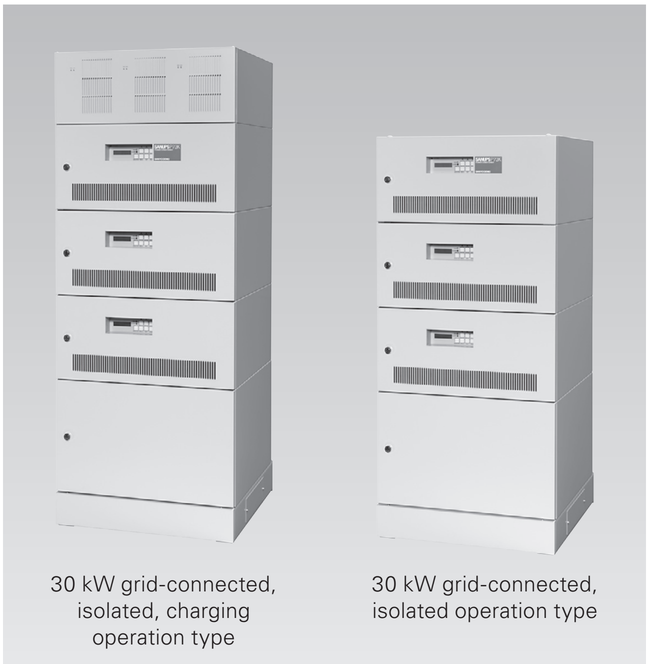

Fig. 1: Photograph of “SANUPS P73K”

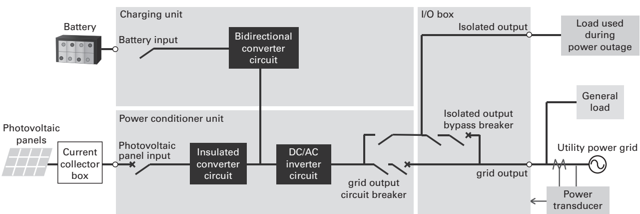

Fig. 2: Basic circuit configuration of the grid-connected, isolated, charging operation type

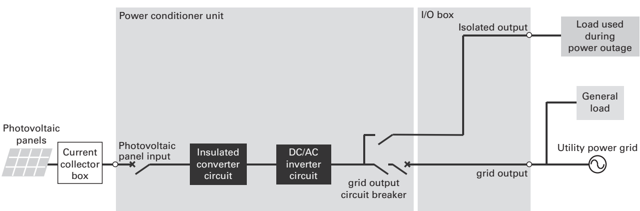

Fig. 3: Basic circuit configuration of the grid-connected, isolated operation type

2.3 Power factor variation function

In order to suppress voltage rise in distribution systems due to the large-scale introduction of photovoltaic power generation equipment, on “SANUPS P73K”, the output power factor can be changed within the range of 0.8 to 1.0 during grid-connected operation and peak-cut operation, therefore the rise in grid voltage can be suppressed without the need for special-purpose equipment or strengthening of the power distribution cable.

2.4 Building of an output control system

Figure 4 shows an example of output control system connection. By using optional “SANUPS PV Monitor E Model” or “Mobile Communication Pack”, it is possible to build an output control system.

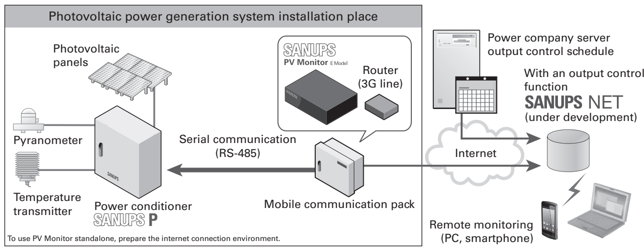

Fig. 4: Example of output control system connection

3. “SANUPS P73K” Operation Modes

The “SANUPS P73K” series has the four operation modes of grid-connected operation, peak-cut operation, isolated operation and charging operation. The below gives an explanation of the operations for each operation mode.

3.1 Grid-connected operation mode

Figure 5 shows the flow of power during grid-connected operation mode. Grid-connected operation mode is executed when all of the following conditions are met.

- Power of the photovoltaic panels is above a certain level
- Grid is normal

During grid-connected operation mode, the power conditioner performs MPPT control and supplies AC power to the grid depending on the power of the photovoltaic panels. During this mode, if the power of the photovoltaic panels is more than the power consumption of general load, the surplus power is fed into the grid (reverse power flow).

Furthermore, the utility power can also be supplied to the equipment used during power outages via the bypass circuit.

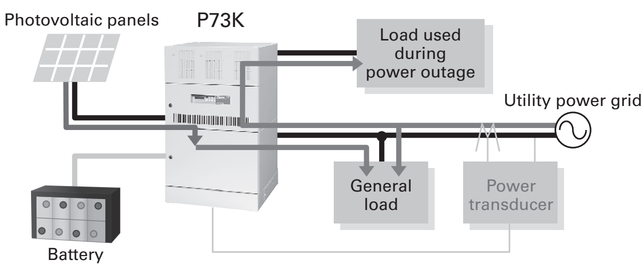

Fig. 5: Grid-connected operation mode

3.2 Peak-cut operation mode

Figure 6 shows the flow of power during peak-cut operation mode. Peak-cut operation mode is executed when all of the following conditions are met.

- When the power conditioner entered to peak-cut operation mode by schedule setting
- Grid is normal
- Power received from the grid is greater than the set value
- When the storage capacity is greater than the setting

During peak-cut operation mode, the DC power of the photovoltaic panels and storage battery is converted to AC power, and adjusts voltage and synchronization to connect with the grid, enabling AC power to be supplied to the general load. This minimizes the increase of received power.

Furthermore, the utility power can also be supplied to the load used during power outages via the bypass circuit.

At this time, if the power received from the grid is less than the pre-configured received power amount, the power conditioner stops discharging power from the storage battery.

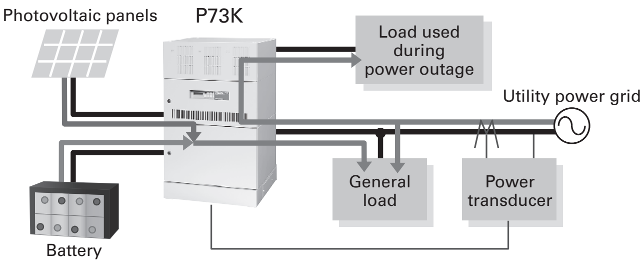

Fig. 6: Peak-cut operation mode

3.3 Isolated operation mode

Figure 7 shows the flow of power during isolated operation mode. Isolated operation mode is executed when all of the following conditions are met.

- The setting is on isolated operation mode
- The grid output circuit breaker and isolated output bypass breaker are open

During isolated operation mode, the DC power of photovoltaic panels and storage battery is converted to AC power, and perform voltage adjustment and waveform shaping, then supplies AC power of constant frequency voltage sine wave to the load used during a power outage. At this time, power from the storage battery can be supplied to the load used during a power outage even if there is no solar radiation. Meanwhile, if the photovoltaic panels generates more power than the power supplied to the load used during a power outage, the excess is used to charge the storage battery.

If isolated operation continues due to a long-time power outage, when the DC voltage falls below the set value due to low battery power, the power conditioner stops isolated operation to conserve the battery.

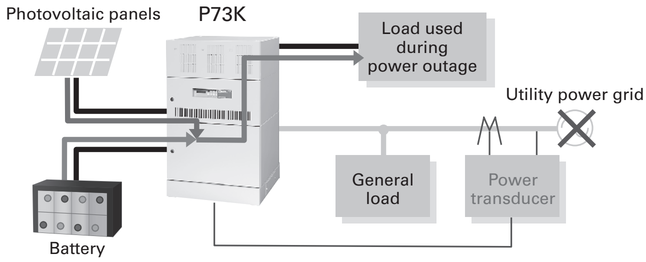

Fig. 7: Isolated operation mode

3.4 Charging operation mode

Figure 8 shows the flow of power during charging operation mode. Charging operation mode is executed when all of the following conditions are met.

- Grid is normal
- When the power conditioner entered to charging operation mode by schedule setting

During charging operation mode, power provided to the utility power grid is converted to DC power and the storage battery is charged along with the photovoltaic panel power.

Furthermore, the utility power can also be supplied to the equipment used during power outages via the bypass circuit.

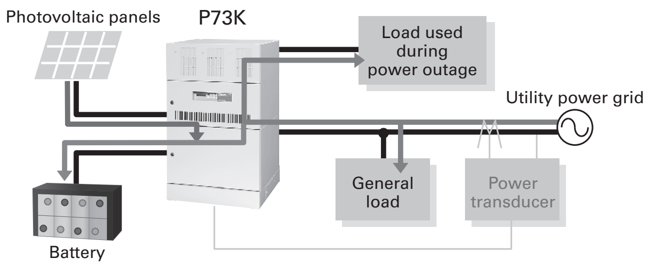

Fig. 8: Charging operation mode

3.5 Switching between each operation mode

Figure 9 shows switching between the modes of grid-connected operation, peak-cut operation, isolated operation and charging operation.

By the schedule setting, it is possible to automatically switch between grid-connected operation mode, peak-cut operation mode and charging operation mode. Moreover, it is possible to manually switch into isolated operation mode.

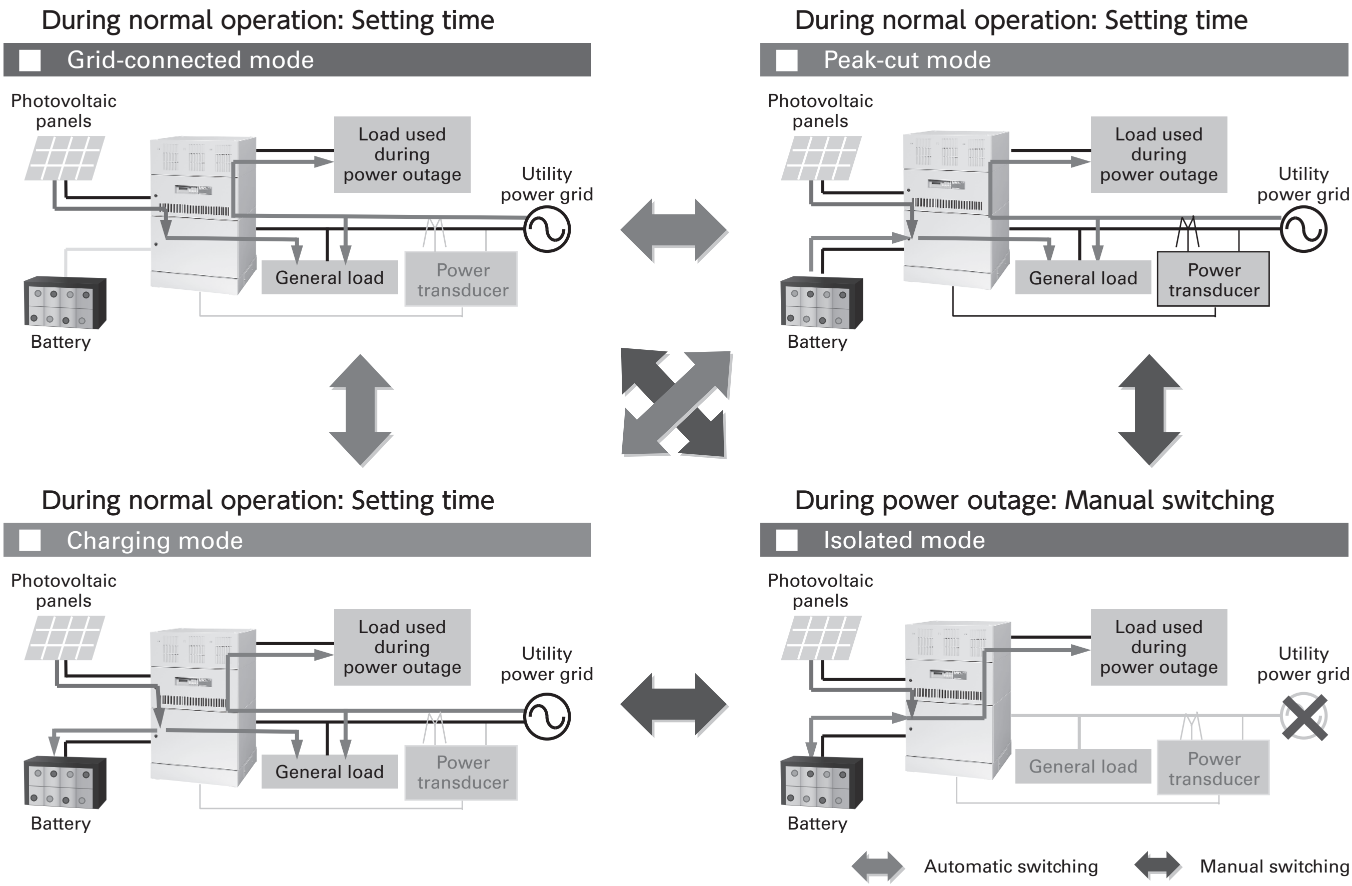

Fig. 9: Switching between each operation mode

4. Specifications

Table 1 shows the electrical specifications of the power conditioner with a peak power cut function, the “SANUPS P73K” grid-connected, isolated, charging operation type, while Figure 10 shows its dimensions.

Table 2 shows the electrical specifications of the power conditioner with a peak power cut function, the “SANUPS P73K” grid-connected, isolated operation type, while Figure 11 shows its dimensions.

Table 1: Electrical specifications of the “SANUPS P73K” grid-connected, isolated, charging operation type

Item	Model	P73K103P	P73K203P	P73K303P	P73K403P	P73K503P	P73K603P
Rated output capacity		10 kW	20 kW	30 kW	40 kW	50 kW	60 kW
Main circuit method		Self-commutation voltage type					
Switching method		High frequency PWM					
Insulation method	Photovoltaic panel input	High frequency insulation method					
	Battery input	Non-insulation method					
Cooling method		Forced air cooling					
Photovoltaic panel input	Rated voltage	400 V DC					
	Maximum allowable input voltage	570 V DC					
	Input operating voltage range	150 to 570 V DC (Rated output range of 250 to 540 V DC)					
	Maximum power point tracking control range	190 to 540 V DC					
Battery input/ output	Fluctuation range	200 to 400 V DC					
	Max. charging/ discharging power*1	10 kW × 1 circuit	10 kW × 2 circuits	10 kW × 3 circuits	10 kW × 4 circuits	10 kW × 5 circuits	10 kW × 6 circuits
	Charge voltage	Factory setting: 296 V DC, Adjustable range: 200 to 400 V DC (1 V increments)					
Grid-connection output	Rated voltage	202 V AC					
	Rated output current	28.6 A AC	57.2 A AC	85.7 A AC	114.3 A AC	142.9 A AC	171.5 A AC
	Rated frequency	50 Hz / 60 Hz					
	No. of phases/wires	Three phase, three wire					
	Output current distortion rate	5% or less of the total current, 3% or less of each next harmonic wave					
	Output power factor	0.95 or higher (at rated output, when power factor is 1.0), Power factor setting range: 0.8 to 1.0 (0.01 step)					
Isolated operation output	Rated output	10 kVA (Load power factor 1.0)					
	No. of phases/wires	Three phase, three wire (It is possible to convert to single-phase output if the optional Scott-connected transformer is used.)					
	Rated voltage	202 V AC					
	Voltage precision	Rated voltage ±5%					
	Rated frequency	50 Hz / 60 Hz					
	Frequency precision	Rated frequency within ±0.1 Hz					
	Output voltage distortion rate	Linear load: Max. 5%					
	Overload capacity	100% continuous					
Efficiency		93% (grid-connected operation mode, efficiency measurement method according to JIS C 8961)					
Utility protection function		Over-voltage (OVR), under-voltage (UVR), over-frequency (OFR), under-frequency (UFR)					
Islanding operation detection	Passive method	Voltage phase jump detection					
	Active method	Reactive power fluctuation method					
Communication method		RS-485					
Operating environment	Ambient temperature	-10 to +40˚C					
	Relative humidity	30 to 90% or less (non-condensing)					
	Altitude	1000 m or lower					
Coating color		Munsell 5Y 7/1 (Semi-glossy)					
Heat generation		1100 W	2200 W	3300 W	4400 W	5500 W	6600 W
Received power measurement function		Yes, 4 to 20 mA					
Mass		185 kg	285 kg	385 kg	570 kg	695 kg	770 kg

*1: Max. current 45 A DC

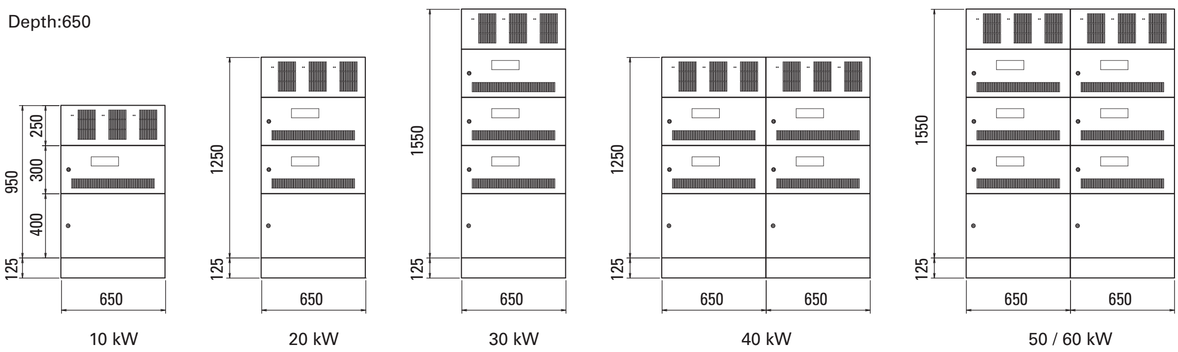

Fig. 10: Dimensions of the “SANUPS P73K” grid-connected, isolated, charging operation type

Table 2: Electrical specifications of the “SANUPS P73K” grid-connected, isolated operation type

Item	Model	P73K103S	P73K203S	P73K303S	P73K403S	P73K503S	P73K603S
Rated output capacity		10 kW	20 kW	30 kW	40 kW	50 kW	60 kW
Main circuit method		Self-commutation voltage type					
Switching method		High frequency PWM					
Insulation method	Photovoltaic panel input	High frequency insulation method					
Cooling method		Forced air cooling					
Photovoltaic panel input	Rated voltage	400 V DC					
	Maximum allowable input voltage	570 V DC					
	Input operating voltage range	150 to 570 V DC (Rated output range of 250 to 540 V DC)					
	Maximum power point tracking control range	190 to 540 V DC					
Grid-connected output	Rated voltage	202 V AC					
	Rated output current	28.6 A AC	57.2 A AC	85.7 A AC	114.3 A AC	142.9 A AC	171.5 A AC
	Rated frequency	50 Hz / 60 Hz					
	No. of phases/wires	Three phase, three wire					
	Output current distortion rate	5% or less of the total current, 3% or less of each next harmonic wave					
	Output power factor	0.95 or higher (at rated output, when power factor is 1.0), Power factor setting range: 0.8 to 1.0 (0.01 step)					
Isolated operation output	Rated output	10 kVA (Load power factor 1.0)					
	No. of phases/wires	Three phase, three wire (It is possible to convert to single-phase output if the optional Scott-connected transformer is used.)					
	Rated voltage	202 V AC					
	Voltage precision	Rated voltage ±5%					
	Rated frequency	50 Hz / 60 Hz					
	Frequency precision	Rated frequency within ±0.1 Hz					
	Output voltage distortion rate	Linear load: Max. 5%					
	Overload capacity	100% continuous					
Efficiency		93% (grid-connected operation mode, efficiency measurement method according to JIS C 8961)					
Utility protection function		Over-voltage (OVR), under-voltage (UVR), over-frequency (OFR), under-frequency (UFR)					
Islanding operation detection	Passive method	Voltage phase jump detection					
	Active method	Reactive power fluctuation method					
Communication method		RS-485					
Operating environment	Ambient temperature	-25 to +60˚C (Operates at output limitation when the temperature exceeds 40°C)					
	Relative humidity	30 to 90% or less (non-condensing)					
	Altitude	2000 m or lower					
Coating color		Munsell 5Y 7/1 (Semi-glossy)					
Heat generation		760 W	1520 W	2280 W	3040 W	3800 W	4560 W
Received power measurement function		None					
Mass		140 kg	215 kg	290 kg	430 kg	530 kg	580 kg

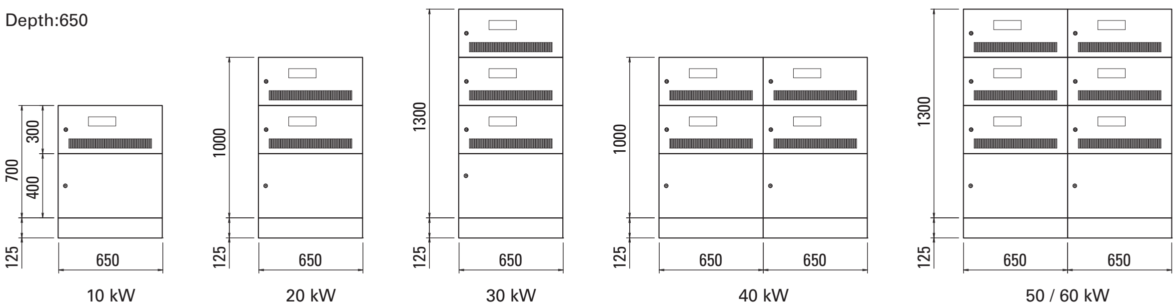

Fig. 11: Dimensions of the “SANUPS P73K” grid-connected, isolated operation type

5. Conclusion

This document introduced an overview and the features of the “SANUPS P73K” power conditioner with the peak power cut function.

In addition to improving the operating rate of power equipment by reducing peak power, this device contributes to environmental conservation through the effective utilization of natural energy and serves as an emergency power source during disasters, etc. We will continue to speedily develop products that can contribute in these fields, supply products that satisfy customers, and contribute to achieve a low carbon society.

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

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