Development of Power Conditioner with a Lithium Ion Battery "SANUPS PMC-TD"

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1. Introduction

Since the Great East Japan Earthquake, there has been an increase in the number of local councils considering installing backup power and demand from private industry in order to prepare for long-term power outages in the event of disasters. Among this, disaster prevention photovoltaic power generation systems consisting of photovoltaic batteries and storage batteries have gained attention as backup power sources that use natural energy and yet can be used as stand-alone power sources during a disaster.

Sanyo Denki has been selling the "SANUPS PMC-TD" series, which is a disaster prevention photovoltaic power generation system consisting of photovoltaic batteries and storage batteries, for some time now. The "SANUPS PMC-TD" series is highly regarded by the market and consists of a lineup with grid-connected operation and isolated operation functions, isolated operation and charging operation functions and peak-cut function.

This time, we have enhanced the lineup by developing a model which incorporates a lithium ion battery on the models with isolated operation and charging operation functions and peak-cut function. Compared with conventional lead batteries, lithium ion batteries have longer life and a high energy density, therefore achieving longer life systems which are both smaller and lighter.

This document provides an overview of the features of the "SANUPS PMC-TD" power conditioner with a lithium ion battery.

2. Overview of the "SANUPS PMC-TD"

The "SANUPS PMC-TD" consists of a 10 kW power conditioner unit and an I/O box, and it is a build-up system that can stack up to five 10 kW power conditioner units. The lineup includes models with system capacities ranging from 10 to 50 kW.

Fig. 1 shows the "SANUPS PMC-TD" (50 kW) and Fig. 2 shows the basic circuit architecture.

The power conditioner unit has an isolated operation output circuit and a charge circuit to the storage battery, enabling it to supply power to isolated operation output if the electrical utility grid goes down.

The I/O box has a storage battery input switch, a power conditioner output switch, and an isolated operation output bypass switch. Switching between operation modes and turning the output circuit on and off causes the power supplies to switchover.

Fig. 1: A photo of "SANUPS PMC-TD" (50 kW)

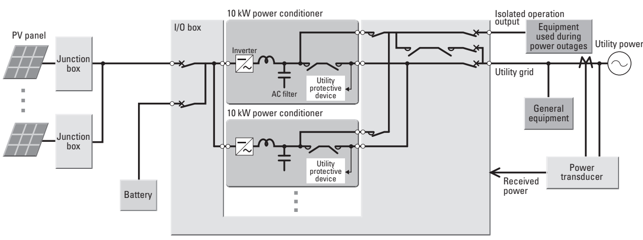

Fig. 2: Basic circuit architecture of "SANUPS PMC-TD"

3. Features of the Lithium Ion Battery Model

Compared with lead batteries, lithium ion batteries have high energy density, meaning that energy can be extracted efficiently. As such, if a battery of equal capacity is equipped, lithium ion batteries make downsizing, weight-saving and space-saving possible. Moreover, the charge/discharge cycle of lithium ion batteries is long, therefore they are advantageous in applications such as isolated, charging and peak-cut operation in which charge/discharge are repeated and offer longer life than lead batteries.

Fig. 3 is a photo of the lithium ion battery panel. A protection function is required for lithium ion batteries to protect the safety of the battery and power system when a battery fault, such as overcharging and overdischarging, occurs. Table 1 gives an outline of the battery panel and a description of the protection function. If a battery fault is detected, the power conditioner disconnects the battery to protect it. Fig. 4 shows the system configuration when a lithium ion battery is equipped.

Fig. 3: A photo of the lithium ion battery panel

Table 1: Outline of battery panel

Item	Specifications
Battery capacity (nominal)	23 kWh
Rated voltage	310.8 V
Dimensions	W: 1100 mm D: 700 mm H: 2075 mm (including protruding objects)
Protection function (Outgoing signals)	Overcharge Over-discharge Battery temperature fault Cell controller failure BCU failure

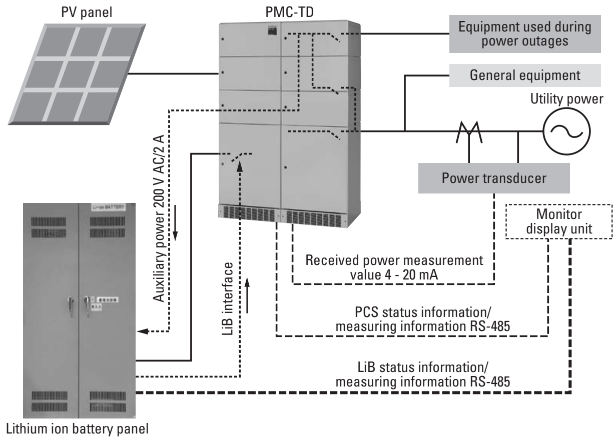

Fig. 4: Basic configuration when lithium ion battery is equipped

4. "SANUPS PMC-TD" Operation Mode

The "SANUPS PMC-TD" series has four operation modes: "grid-connected operation", "peak-cut operation", "isolated operation" and "charging operation" .

This chapter provides an overview of the operation of each operation mode and the protection operation of each operation mode in the event that a battery fault is detected.

4.1 Grid-connected operation mode

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

- · Power generated from the PV panels is above a certain amount
- · Utility grid is normal

During grid-connected operation, the power conditioner tracks maximum power points and supplies AC power to the electrical utility grid depending on the power generated from the PV panels. If the power generated from the PV panels is more than the power consumption of the general equipment, the surplus power is fed back to the electrical utility grid.

The utility power is supplied to the equipment used during power outages via the bypass circuit, as well as the general equipment.

If a battery fault occurs during grid-connected operation, grid-connected operation will continue.

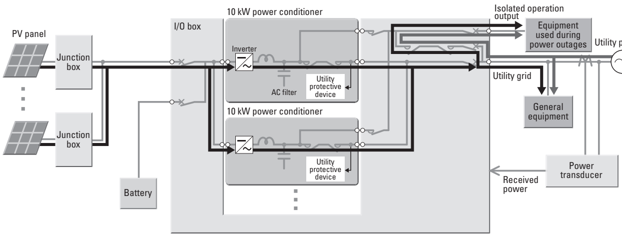

Fig. 5: Grid-connected operation mode

4.2 Peak-cut operation mode

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

- · Power conditioner is in grid-connected operation or standby
- · Utility grid is normal
- · Power received from the utility grid is greater than or equal to the predetermined value

During peak-cut operation, the power conditioner connects the battery to the DC input and supplies AC power to the general equipment, depending on the power generated from the PV panels and the battery discharge power.

The utility power is supplied to the equipment used during power outages via the bypass circuit, as well as the general equipment.

When the power received from the electrical utility grid falls below the predetermined value, the power conditioner disconnects the battery and automatically switches to grid-connected operation.

Because the power conditioner starts and stops peak-cut operation while monitoring the power received from the electrical utility grid, the power output from the power conditioner is not fed back to the electrical utility grid during peak-cut operation.

If a battery fault is detected during peak-cut operation, the power conditioner disconnects the battery and switches to grid-connected operation.

As long as a battery fault continues during grid-connected operation, even when the necessary conditions for peak-cut are met, the power conditioner does not switch to peak-cut operation.

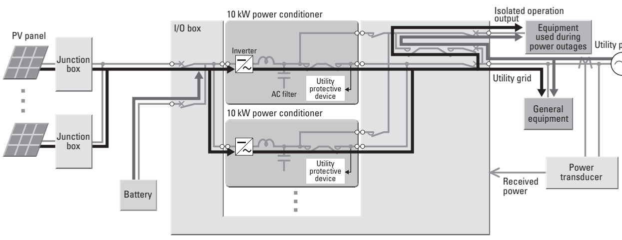

Fig. 6: Peak-cut operation mode

4.3 Isolated operation mode

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

- · Power conditioner is in operation or standby
- · During a power outage

During isolated operation, after checking a continued power outage for a certain period of time, the power conditioner connects the battery to the DC input and supplies AC power to the equipment used during power outages with power from the PV panels and the battery. If the amount of power generated from the PV panels is greater than the power supplied to the equipment used during power outages, the surplus power may be used to charge the battery.

If isolated operation continues due to a long power outage, when the DC voltage falls below a certain value due to battery consumption, the power conditioner stops isolated operation to conserve the battery.

During isolated operation, if a battery fault is detected when a certain amount of power is generated from the PV panels, the power conditioner disconnects the battery and continues isolated operation using only the power generated from the PV panels.

In isolated operation, for situations where a battery fault is detected during isolated operation with only the lithium ion battery as the power supply (e.g. power outages when the amount of power generated from the PV panels during the day is insufficient or at night), the power conditioner disconnects the battery and stops isolated operation. Once the battery fault recovers, the power conditioner reconnects with the battery and isolated operation will be resumed using power supplied by the battery.

If battery faults occur and recover three times repeatedly within a 20 minute period after isolated operation is stopped, the power conditioner will stop due to failure.

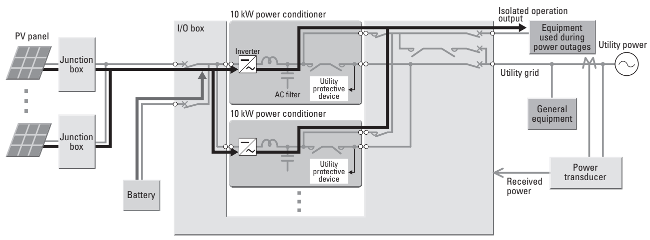

Fig. 7: Isolated operation mode

4.4 Charging operation mode

Charging operation is executed when all the following conditions are met. Fig. 8 shows the flow of power during charing operation.

(1) Charging operation mode (night)

· Power conditioner is in operation or standby

· Utility grid is normal

· Charging operation command is received from the timer in the power conditioner

In charging operation mode, the power conditioner connects the battery to the DC input and uses the utility power to charge the battery.

The utility power is supplied to the equipment used during power outages via the bypass circuit, as well as the general equipment.

During charging operation, when the charge current to the battery falls below a certain value (charging completed), the power conditioner disconnects the battery from the DC input and switches to grid-connected operation mode.

If a battery fault is detected during charging operation, the power conditioner disconnects the battery and switches to grid-connected operation mode.

(2) Charging operation mode (at the time of restoration of utility grid)

· Switching from isolated operation mode

During isolated operation, after checking a power recovery of a certain period of time, the power conditioner switches to charging operation mode (standby). The utility power is supplied to the equipment used during power outages through the bypass circuit.

Normally, the utility power is used to charge the battery, but if a certain amount of power is generated from the PV panels, power from the PV panels may also be used. Furtheremore, if the power generated from the PV panels exceeds the charge power for the battery, then the power generated from the PV panels is supplied to the general equipment.

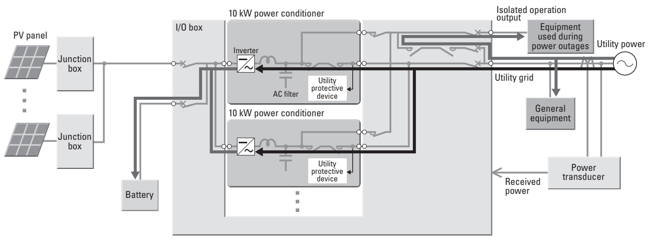

Fig. 8: Charging operation mode

4.5 Switching between each operation mode

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

Operation mode is normally switched automatically, but it can also be switched manually.

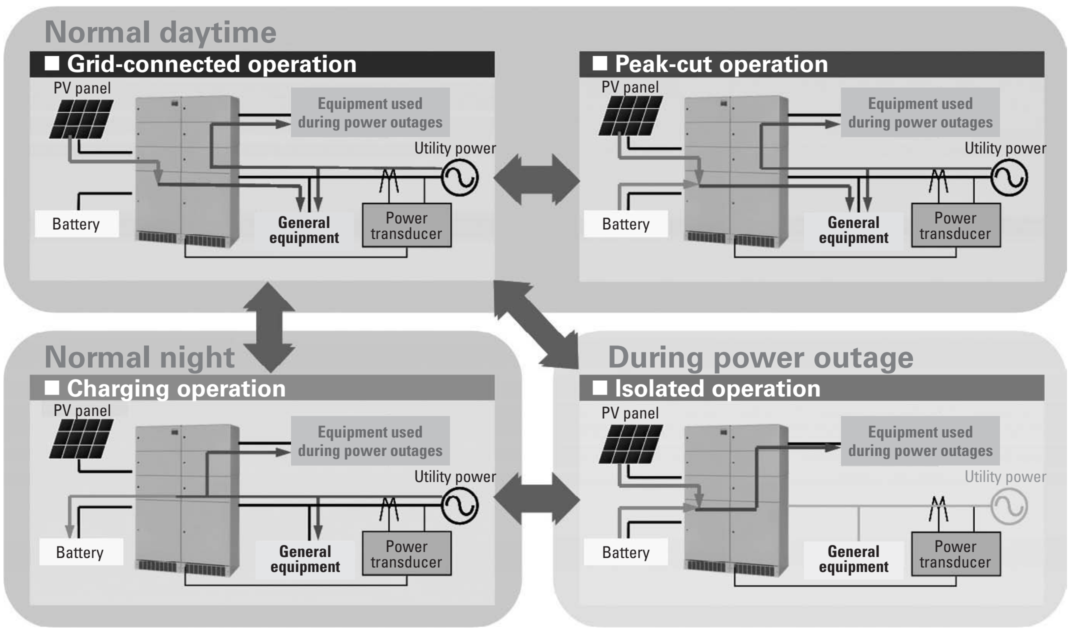

Fig. 9: Switching between each operation mode

5. Specifications

Table 2 shows the electrical specifications of the “SANUPS PMC-TD” power conditioner with a lithium ion battery. Fig. 10 shows the dimensions.

Table 2: Electrical specifications

Item			PMC100TD	PMC200TD	PMC300TD	PMC400TD	PMC500TD
System capacity			10 kW	20 kW	30 kW	40 kW	50 kW
Input	PV panel input	Rated voltage	300 V DC				
		Maximum allowable input voltage	500 V DC				
		Input operating voltage range	200 to 500 V DC				
		Maximum power point tracking control range V	200 to 450 V DC				
		Max. current	45 A	90 A	135 A	180 A	225 A
	Battery input	Fluctuation range	0 to 450 V DC				
		Max. discharge current	45 A DC	90 A DC	135 A DC	180 A DC	225 A DC
Output	Charge output	Charge output capacity	8 kW	16 kW	24 kW	32 kW	40 kW
		Charge voltage	Lead battery: 321 V DC / Lithium ion battery: 345 V DC (Setting range: 250 - 450 V DC)				
		Drooping start current	Lead battery: 25 A DC / Lithium ion battery: 23 A DC (Setting range: 1 to 40 A DC) Per one unit				
	Grid-connected operation output	Rated voltage	200 V AC				
		Rated current	28.9 A AC	57.7 A AC	86.6 A AC	115.5 A AC	144.3 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				
	Isolated operation output	Rated voltage	200 V AC				
		Rated current	28.9 A AC	57.7 A AC	86.6 A AC	115.5 A AC	144.3 A AC
		Rated frequency	50 Hz / 60 Hz				
		No. of phases/wires	Three phase, three wire				
		Voltage precision	Rating: Within ±8%				
		Frequency precision	Rating: Within ±0.1 Hz				
		Voltage distortion rate	5% max.				
		Output power factor	1.0 to 0.8 (Lag)				
Conversion efficiency			92%				
Utility protection function			Over-voltage (OV), under-voltage (UV), over-frequency (OF), under-frequency (UF)				
Islanding operation detection	Passive method		Voltage phase jump method				
	Active method		Reactive power conversions method				
Communication method			RS-485				
Acoustic noise			60 dB or less				
Operation environment	Ambient temperature		-10 to +50°C				
	Relative humidity		30 to 90% (non-condensing)				
	Altitude		2000 m or lower				
Coating color			Munsell 5Y 7/1				
Heat generation			870 W	1740 W	2610 W	3480 W	4350 W
Operation mode			Grid-connected operation, isolated operation, charging operation, peak-cut operation				
Received power measurement function			Yes, 4 to 20 mA				

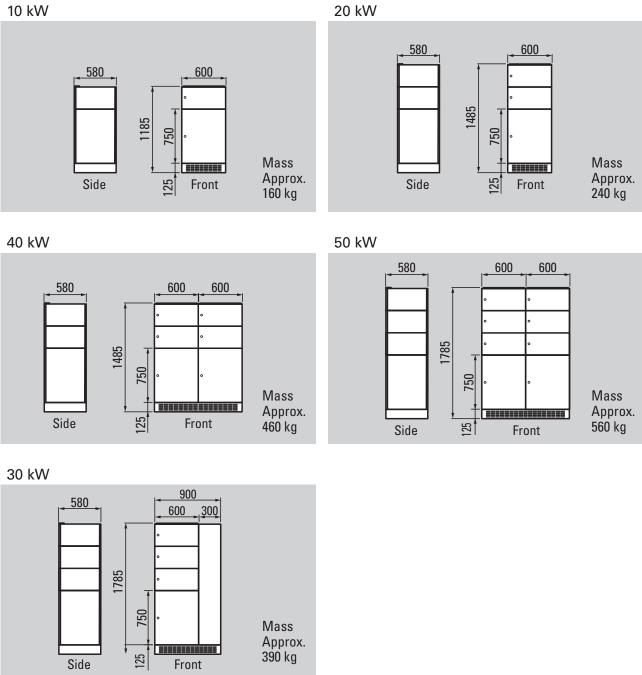

Fig. 10: Dimensions of “SANUPS PMC-TD”

6. Conclusion

This document introduced an overview and the features of the “SANUPS PMC-TD” power conditioner with a lithium ion battery.

This device, in addition to being environmentally-friendly through effective utilization of natural energy, also provides emergency power during disasters by incorporating a battery, and contributes to the improvement of electrical equipment operability by reducing peak power.

This time, in addition to the conventional lead battery, we have added a model featuring a lithium ion battery to our lineup to enable overall systems to be smaller and have longer life. If users select the type of battery to suit their specific applications, we anticipate that the power conditioner will play a significant role in even more markets.

Sanyo Denki will continue to realize various functions demanded of power conditioners and meet customer expectations.

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