Development of the *SANUPS P73L* PV Inverter with a Peak Cut Function

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1. Introduction

Since the Great East Japan Earthquake, there is an increasing demand for local governments and private businesses to install backup power sources in preparation for prolonged power outages during disasters. Of the available systems, power generation systems combining PV panels and Li-ion storage batteries are attracting interest due to their numerous advantages, such as the ability to be used as a "local-production, local-consumption" decentralized power source during disasters to minimize power consumption during peak times.

SANYO DENKI already offers the *SANUPS P73K* as a PV inverter with a peak cut function supporting Li-ion storage batteries. However, now we have developed the *SANUPS P73L*, which maintains the functions and performance of the *SANUPS P73K* while gaining functions that further meets market demands. This article will introduce the features of this new product.

2. Overview and Features of the *SANUPS P73L*

2.1 System configuration from 10 to 60 kW

The *SANUPS P73L* is comprised of a 10 kW PV inverter unit, 10 kW charging unit and I/O box, with the ability to add up to six 10 kW PV inverters as a scalable system. This product comes in the "grid-connected, isolated, charging type" and "grid-connected, isolated type," with output capacities ranging from 10 to 60 kW.

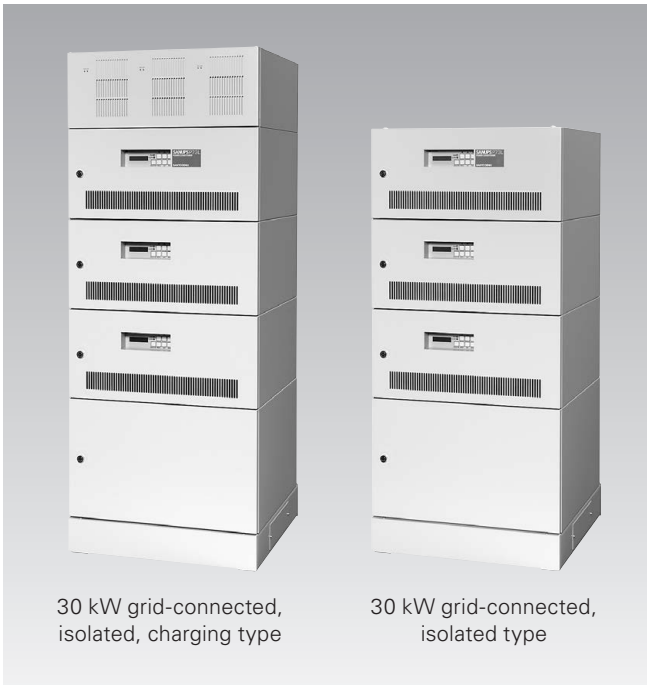
2.2 Circuit configuration and basic operations

Figure 1 shows the appearance of the *SANUPS P73L* grid-connected, isolated, charging type and grid-connected, isolated type. Figures 2 and 3 show the block diagrams for the grid-connected, isolated, charging type and the grid-connected, isolated type respectively.

The grid-connected, isolated, charging type is comprised of a PV inverter unit, charging unit and I/O box. The grid-connected, isolated type is comprised of a PV inverter unit and I/O box. The PV inverter unit is common with that of the grid-connected, isolated, charging type.

The grid-connected, isolated, charging type supports peak power cut by supplying the power of its PV panel and storage battery to a general load via the isolated converter circuit and inverter circuit equipped in the PV inverter unit. Moreover, it can supply AC power to the isolated operation output during power outages on the grid. The charging unit controls the charging and discharging of the storage battery through a bi-directional converter circuit. The I/O box has an isolated operation output bypass breaker and can switch between power circuits. It automatically starts and stops peak cut through the input of a power transducer signal that measures the power grid.

The grid-connected, isolated type supplies the power of its PV panel to a general load and the power grid via the isolated converter circuit and inverter circuit in the PV inverter unit. Moreover, it can supply AC power to the isolated operation output during power outages on the grid. The I/O box has an isolated operation output bypass breaker and can switch between power circuits.



30 kW grid-connected, isolated, charging type

30 kW grid-connected, isolated type

Fig. 1: The *SANUPS P73L*

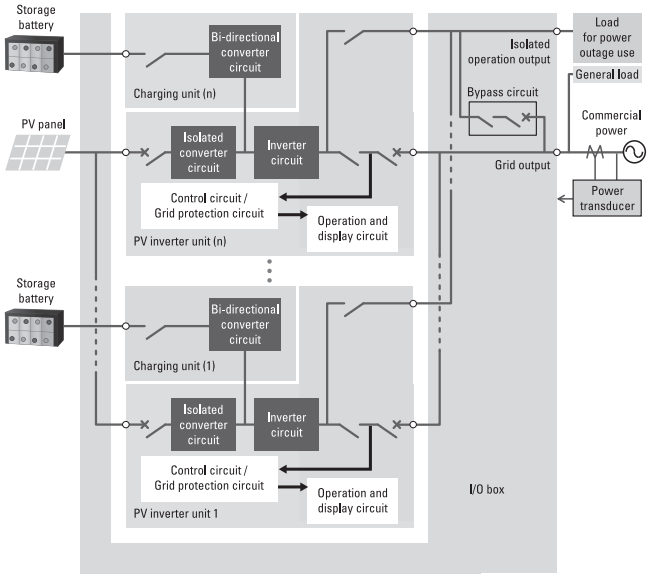


Fig. 2: Block diagram for the grid-connected, isolated, charging type

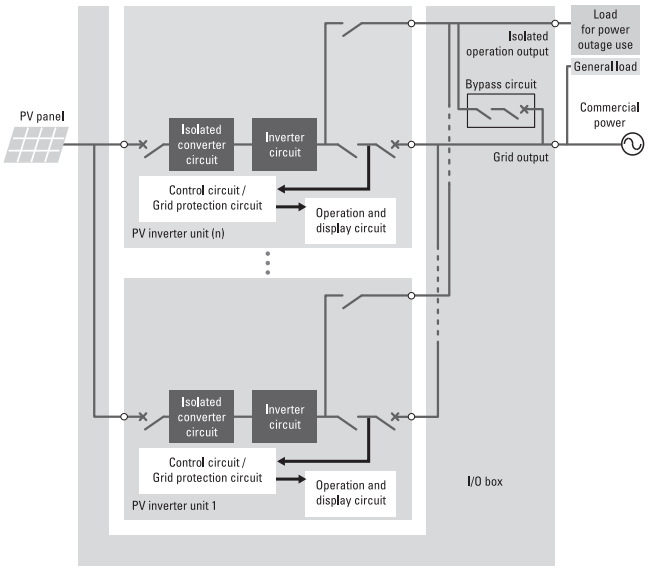


Fig. 3: Block diagram for the grid-connected, isolated type

2.3 Parallelization of isolated operation output

The existing model, the *SANUPS P73K*, has an isolated operation output capacity of up to 10 kVA. However, in the new model, the *SANUPS P73L*, the circuit configuration of the isolated operation output has been revised and by enabling parallel operation capacities to the isolated operation output, it has become possible to supply power up to 60 kVA. With the *SANUPS P73L*, it is possible to offer more flexible proposals meeting needs for systems requiring isolated operation output capacities exceeding 10 kVA.

2.4 Single circuit connection of the PV panel input

The PV panel input for the existing model *SANUPS P73K* require an input circuit for every 10 kW, and thus wiring for multiple circuits in total. Multi-circuit wiring has the disadvantages of an increased number of wires and complicated installation due to the need to wire PV panel inputs to the I/O box terminal blocks individually for each 10 kW. However, the new *SANUPS P73L* enriches the lineup with the added specification of single circuit connection for the PV panel input, thus making wiring work easy.

2.5 Benefits of a bi-directional converter

Just as the *SANUPS P73K*, the *SANUPS P73L* grid-connected, isolated, charging type is equipped with a bi-directional converter in its storage battery input. The bi-directional converter eliminates the need to make the PV panel and storage battery voltages equal, thus reducing

overall system cost.

Furthermore, for PV inverters with a circuit type based on direct connection between the PV panel and storage battery, the PV panel's operating point is the terminal voltage of the storage battery, therefore MPPT control is not possible. However, with the newly-developed control method adopted on the *SANUPS P73L*, it is possible to maximize the PV panel output through maximum output tracking control even during charging/discharging of the storage battery or isolated operation. As such, the power generation amount is expected to increase significantly.

2.6 Function to switch to isolated operation mode

In regards to switching to isolated operation mode, the *SANUPS P73L* has been equipped with switchover functions that can be activated manually, automatically, and remotely.

This makes it possible to propose more flexible systems.

3. The *SANUPS P73L* Operation Modes

The *SANUPS P73L* has the following four operation modes: grid-connected operation mode, peak cut operation mode, charging operation mode and isolated operation mode. Below is a description of each operation mode.

3.1 Grid-connected operation mode

Figure 4 shows the flow of power during grid-connected operation mode. Grid-connected operation mode is activated when all of the following conditions are met.

- Schedule settings start grid-connected operation mode
- The PV panel power exceeds a set value
- The power grid is normal

During grid-connected operation mode, the *SANUPS P73L* converts the PV panel-generated DC power into AC power, adjusts voltage, and synchronizes frequency to connect with the grid, enabling the AC power to be supplied to the grid. Moreover, the PV inverter performs MPPT control and supplies AC power to the power grid depending on the amount of the PV-generated power. In such case, if the PV-generated power is larger than the general load power consumption, this product sends the surplus power to the grid.

Also, commercial power is supplied to the load for power outage use via a bypass circuit.

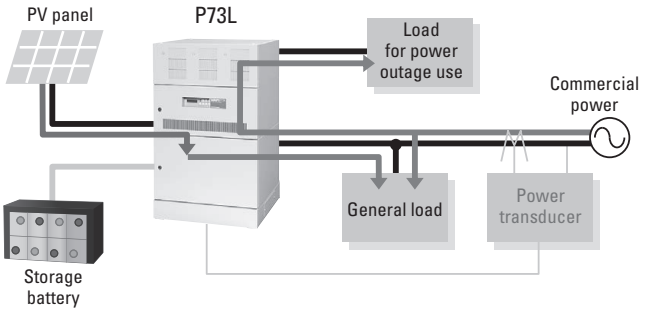


Fig. 4: Grid-connected operation mode

3.2 Peak cut operation mode

Figure 5 shows the flow of power during peak cut operation mode. Peak cut operation mode is activated when all of the following conditions are met.

- Schedule settings start peak cut operation mode
- The power grid is normal
- The power being received from the power grid exceeds a pre-set value
- The remaining capacity of the storage battery is above a set value

During peak cut operation mode, the *SANUPS P73L* converts DC power generated by PV panels and storage batteries into AC power, adjusts voltage, and synchronizes frequency to connect with the grid, enabling AC power to be supplied to a general load. This suppresses the increase in the received power.

Also, commercial power is supplied to the load for power outage use via a bypass circuit.

In such case, if the received power being received from the power grid is below the pre-set value, the PV inverter will stop discharging the storage battery.

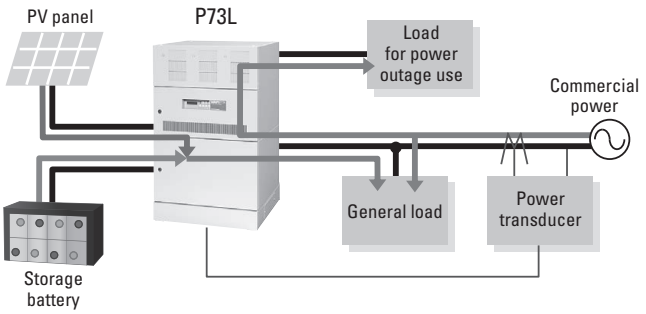


Fig. 5: Peak cut operation mode

3.3 Charging operation mode

Figure 6 shows the flow of power during charging operation mode. Charging operation mode is activated when all of the following conditions are met.

- Schedule settings start charging operation mode
- The power grid is normal

During charging operation mode, the *SANUPS P73L* converts commercial AC power into DC power and charges the storage battery with the power specified using the schedule function. Power from the PV panels supplement the charging commercial power, and if PV panel power is larger than the charging power, it will be supplied to the grid.

Also, commercial power is supplied to the load for power outage use via a bypass circuit.

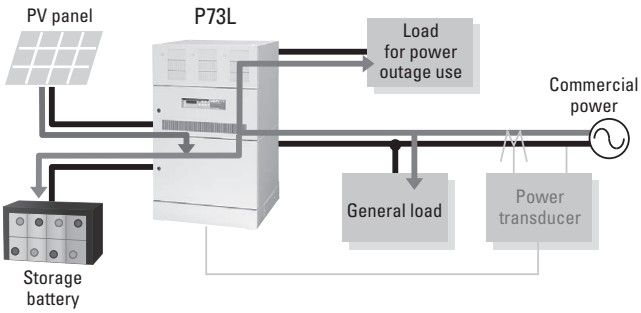


Fig. 6: Charging operation mode

3.4 Isolated operation mode

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

- Isolated operation mode is enabled via manual switchover, automatic switchover, or remote switchover.
- The remaining capacity of the storage battery is above a set value

During isolated operation mode, the DC power of the PV panel and storage battery is converted to AC power while voltage adjustment and waveform conditioning are performed, and AC power of a constant-frequency, constant-voltage sine wave is supplied to the load for power outage use. In such case, the power of the storage battery is supplied to the load for power outage use even when there is no sunlight. Meanwhile, if the power generated by the PV panel is larger than the power supplied to the load for power outage use, the surplus power will be used to charge the storage battery.

Also, in cases of ongoing isolated operation due to prolonged power outages, if the DC voltage falls below a set value due to a decrease in storage battery power, the PV inverter will stop isolated operation in order to protect the storage battery.

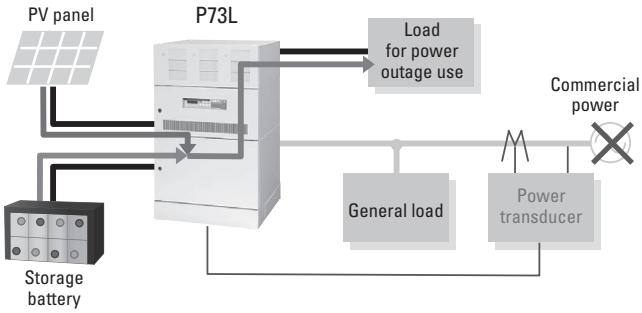


Fig. 7: Isolated operation mode

3.5 Switching to each operation mode

Figure 8 shows the switchover to each of the operation modes: grid-connected operation mode, peak cut operation mode, charging operation mode, and isolated operation mode.

Through schedule settings, automatic switchover to grid-connected operation mode, peak cut operation mode, or charging operation mode can be performed.

The automatic switchover function for isolated operation mode automatically switches to isolated operation mode when a power grid outage is detected. The remote switchover function for isolated operation mode switches the operation mode to isolated operation mode with an isolated operation command inputted from an external contact.

Both the manual and automatic switchover functions can be selected with PV inverter unit settings. The remote switchover function is valid when manual switchover is set.

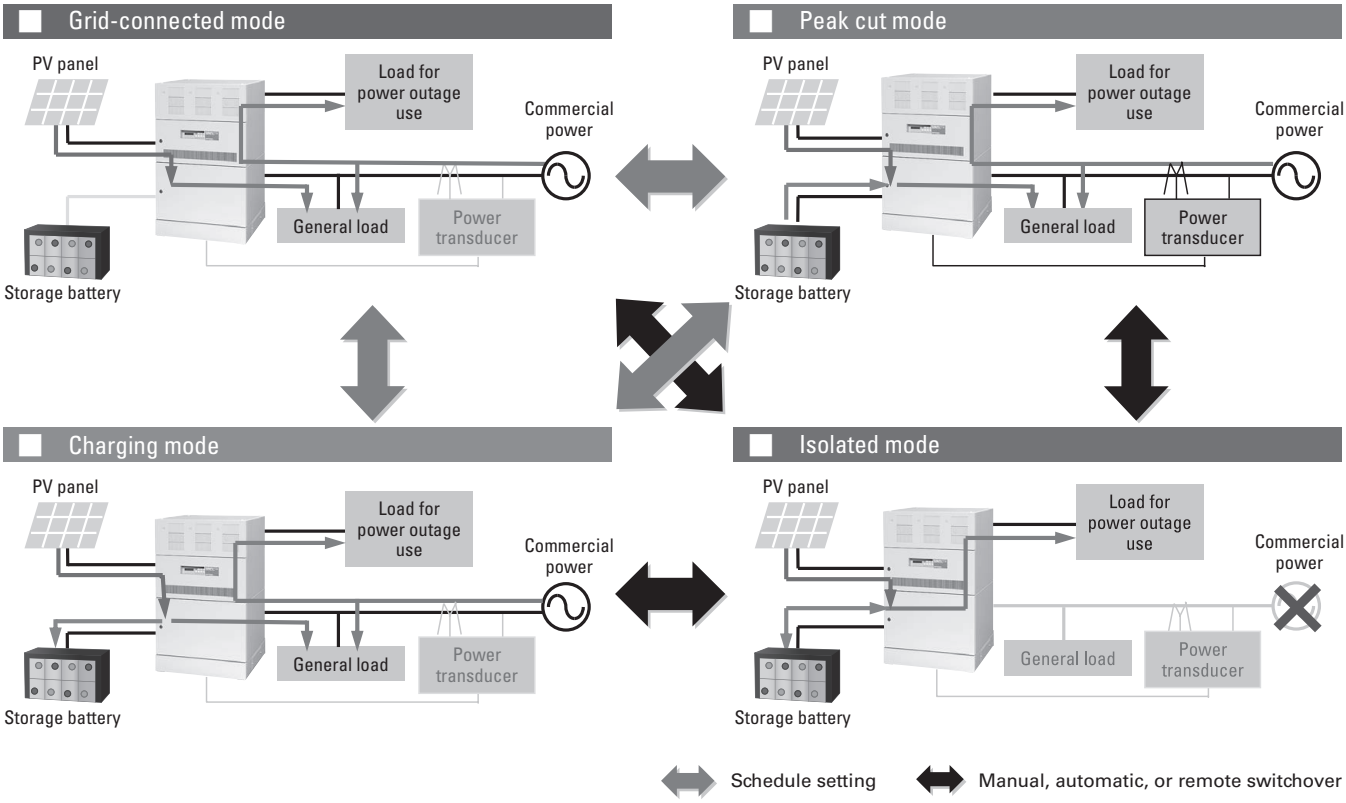


Fig. 8: Switching to each operation mode

4. Specifications

Table 1 shows the electrical specifications of the *SANUPS P73L* PV inverter with peak cut function (grid-connected, isolated, charging type), while Figure 9 shows its external dimensions.

Table 2 shows the electrical specifications of the *SANUPS P73L* PV inverter with peak cut function (grid-connected, isolated type), while Figure 10 shows its external dimensions.

Table 1: Electrical specifications of the *SANUPS P73L* grid-connected, isolated, charging type

Item \ Model		P73L103P	P73L203P	P73L303P	P73L403P	P73L503P	P73L603P
Rated output capacity		10 kW	20 kW	30 kW	40 kW	50 kW	60 kW
Main circuit type		Self-commutated voltage type					
Switching method		High-frequency PWM					
Isolation method	**PV input**	High-frequency isolation type					
	Battery input	Non-isolation type					
Cooling method		Forced air cooling					
PV input	**Rated voltage**	400 VDC					
	Maximum allowable input voltage	570 VDC					
	Input operating voltage range	150 to 570 VDC (rated output range: 250 to 540 VDC)					
	Maximum power point tracking range	190 to 540 VDC					
Battery input/output	**Fluctuation range**	200 to 400 VDC					
	Max. charge/ discharge power*	10 kW x 1 circuit	10 kW x 2 circuits	10 kW x 3 circuits	10 kW x 4 circuits	10 kW x 5 circuits	10 kW x 6 circuits
	Charging voltage	Factory settings: 296 VDC, Adjustment range: 200 to 400 VDC (1 V increments) (rated range: 250 to 400 VDC)					
Grid output	**Rated voltage**	202 VAC					
	Rated output current	28.6 AAC	57.2 AAC	85.7 AAC	114.3 AAC	142.9 AAC	171.5 AAC
	Rated frequency	50/60 Hz					
	No. of phases/wires	3-phase 3-wire					
	Output current harmonic distortion	Total current: 5% or less, individual harmonic order: 3% or less					
	Output power factor	0.95 or greater (at rated output, power factor 1.0 setting), power factor setting range: 0.8 to 1.0 (0.01 increments)					
Isolated operation output	**Rated output**	10 kVA (at 1.0 p.f.)	20 kVA (at 1.0 p.f.)	30 kVA (at 1.0 p.f.)	40 kVA (at 1.0 p.f.)	50 kVA (at 1.0 p.f.)	60 kVA (at 1.0 p.f.)
	No. of phases/wires	3-phase 3-wire (possible to convert to single-phase output using the optional Scott-connected transformer)					
	Rated voltage	202 VAC					
	Voltage accuracy	Within ±8% of rated voltage					
	Rated frequency	50/60 Hz					
	Frequency accuracy	Within ±0.1 Hz of rated frequency					
	Output voltage harmonic distortion	Linear load: 5% or less					
	Overload capability	100% continuous					
Efficiency		93% (at grid-connected operation mode, with efficiency measurement method in accordance with JIS C 8961)					
Grid protection		Overvoltage (OVR), undervoltage (UVR), overfrequency (OFR), underfrequency (UFR)					
Islanding detection	**Passive method**	Voltage phase jump detection					
	Active method	Reactive power variation method					
Communication		RS-485					
Operating environment	**Ambient temperature**	-10 to +40˚C					
	Relative humidity	30 to 90% max. (No condensation)					
	Altitude	1000 m or lower					
Paint color		Munsell 5Y7/1 (semi-gloss)					
Heat dissipation		1100 W	2200 W	3300 W	4400 W	5500 W	6600 W
Received-power measurement function		Yes, 4 to 20 mA					
Mass		190 kg	290 kg	390 kg	580 kg	705 kg	780 kg

* Maximum current 40 ADC

Table 2: Electrical specifications of the *SANUPS P73L* grid-connected, isolated type

Item \ Model		P73L103S	P73L203S	P73L303S	P73L403S	P73L503S	P73L603S
Rated output capacity		10 kW	20 kW	30 kW	40 kW	50 kW	60 kW
Main circuit type		Self-commutated voltage type					
Switching method		High-frequency PWM					
Isolation method	**PV input**	High-frequency isolation type					
Cooling method		Forced air cooling					
PV input	**Rated voltage**	400 VDC					
	Maximum allowable input voltage	570 VDC					
	Input operating voltage range	150 to 570 VDC (rated output range: 250 to 540 VDC)					
	Maximum power point tracking range	190 to 540 VDC					
Grid output	**Rated voltage**	202 VAC					
	Rated output current	28.6 AAC	57.2 AAC	85.7 AAC	114.3 AAC	142.9 AAC	171.5 AAC
	Rated frequency	50/60 Hz					
	No. of phases/wires	3-phase 3-wire					
	Output current harmonic distortion	Total current: 5% or less, individual harmonic order: 3% or less					
	Output power factor	0.95 or greater (at rated output, power factor 1.0 setting) power factor setting range: 0.8 to 1.0 (0.01 increments)					
Isolated operation output	**Rated output**	10 kVA (at 1.0 p.f.)	20 kVA (at 1.0 p.f.)*	30 kVA (at 1.0 p.f.)*	40 kVA (at 1.0 p.f.)*	50 kVA (at 1.0 p.f.)*	60 kVA (at 1.0 p.f.)*
	No. of phases/wires	3-phase 3-wire (possible to convert to single-phase output using the optional Scott-connected transformer)					
	Rated voltage	202 VAC					
	Voltage accuracy	Within ±8% of rated voltage					
	Rated frequency	50/60 Hz					
	Frequency accuracy	Within ±0.1 Hz of rated frequency					
	Output voltage harmonic distortion	Linear load: 5% or less					
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Efficiency		93% (at grid-connected operation mode, with efficiency measurement method in accordance with JIS C 8961)					
Grid protection		Overvoltage (OVR), undervoltage (UVR), overfrequency (OFR), underfrequency (UFR)					
Islanding detection	**Passive method**	Voltage phase jump detection					
	Active method	Reactive power variation method					
Communication		RS-485					
Operating environment	**Ambient temperature**	-25 to +60˚C (Operates with derated output above 40˚C)					
	Relative humidity	30 to 90% (No condensation)					
	Altitude	2000 m or lower					
Paint color		Munsell 5Y7/1 (semi-gloss)					
Heat dissipation		760 W	1520 W	2280 W	3040 W	3800 W	4560 W
Received-power measurement function		None					
Mass		145 kg	220 kg	295 kg	440 kg	540 kg	590 kg

* Model with 10 kVA isolated operation output is also available.

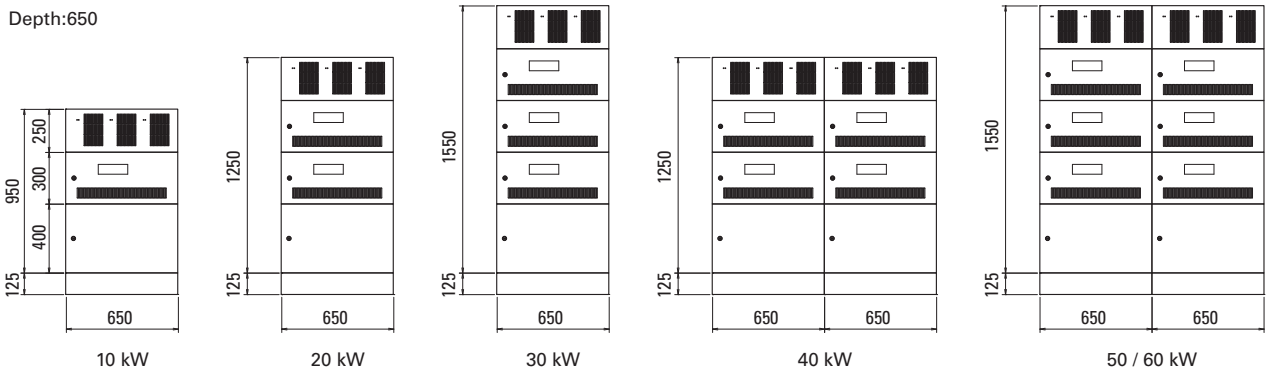

Fig. 9: External dimensions of the *SANUPS P73L* grid-connected, isolated, charging type

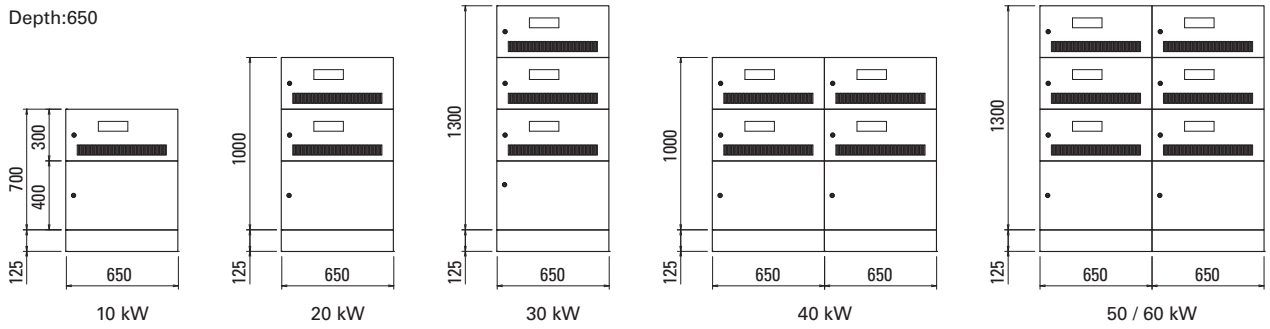

Fig. 10: External dimensions of the *SANUPS P73L* grid-connected, isolated type

5. Conclusion

This article has briefly introduced the overview and features of the *SANUPS P73L* PV inverter with peak cut function.

In addition to improving operating rate of power equipment by reducing peak demand, this product is expected to contribute to fields such as environmental conservation through effective utilization of natural energy and emergency power source during disasters. Moreover, as a PV inverter with even richer functions than existing products, this new product is expected to enable the building of optimal systems and be introduced to a wider market. SANYO DENKI will continue swift product development responding to these fields to provide products which win customer satisfaction and contribute to the realization of a low-carbon society.

We wish to express our appreciation to all those who cooperated and offered advice in the development and production of this product.

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