Development of the *SANUPS W73A* Grid-Connected Isolated Type

Makoto Ishida Hirofumi Nishizawa Tetsuya Fujimaki Katsutoshi Tanahashi

1. Introduction

An outcome of the 21st yearly session of the Conference of the Parties "United Nations Climate Change Conference" (COP21) held in late 2015, was the adoption of the Paris Agreement, whereby member states declared their commitment to suppressing temperature increase to less than 2°C above pre-industrial levels and ongoing efforts to limit the temperature increase to 1.5°C.

In Japan, the Strategic Energy Plan was revised in 2018 and the 5th Strategic Energy Plan was established.(1) This plan aims to make renewable energy "an economically self-supporting, decarbonized main source of electricity" by 2050. Moving forward, it is expected that introduction of renewable energy will be promoted further.

Against such a backdrop, wind power and hydroelectric power generation are expected to grow more than others; wind power generation is more popular than photovoltaic power generation in terms of the capacity that has been applied for connection request to power companies, and hydroelectric power generation has a relatively high purchase price in the renewable energy feed-in tariff (FIT).

As such, we have newly developed the *SANUPS W73A* grid-connected isolated type as a power conditioner for wind power and hydro power generation systems that can be used as an emergency power supply. This article will provide an overview of the new model and its features.

2. Development Background

In 2017, we released the *SANUPS W73A*, a 9.9 kW grid-connected type power conditioner (renewable energy inverter) for wind power and hydro power generation systems.

However, grid-connected type power conditioners cannot provide power in the event of a power outage in the grid.

As represented by the Hokkaido Eastern Iburi Earthquake and the 2018 Japan floods, large-scale power outages due to natural disasters have occurred across Japan in recent years, and in each case it took several days to restore power. As such, there is an increasing number of customers considering the installation of power conditioners with an isolated operation function to secure a power supply for emergency situations.

There is also a demand for independent power supplies in non-electrified areas such as remote islands. As such, we developed the *SANUPS W73A* grid-connected isolated type, by adding an isolated operation capability to the existing *SANUPS W73A* grid-connected type.

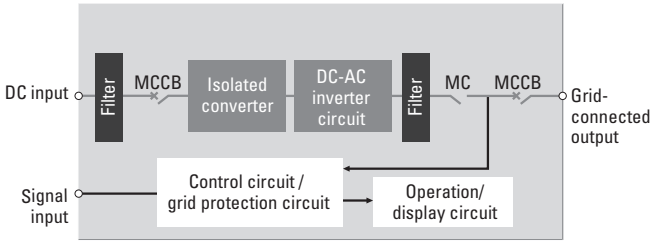
3. Specifications of the *SANUPS W73A*

Figure 1 shows the appearance of the *SANUPS W73A*, Figure 2 shows its basic circuit configuration, and Table 1 provides its main specifications.

We designed the new *SANUPS W73A* grid-connected isolated type to feature an isolated operation capability by adding parts to, changing the parts layout of, and changing the control program of the existing *SANUPS W73A* grid-connected type without changing the dimensions.

Fig. 1 *SANUPS W73A*

■ Grid-connected type



■ Grid-connected isolated type

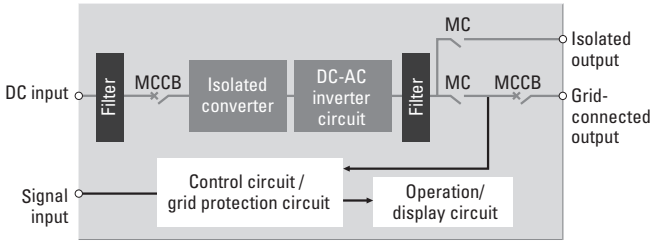


Fig. 2 Basic circuit configuration

Table 1 Main specifications

Item \ Model		Grid-connected type	Grid-connected isolated type	Remarks
		W73A992R	W73A992S	
Output capacity		9.9 kW		
Main circuit type		Self-commutated voltage type		
Switching method		High-frequency PWM		
Isolation method		High-frequency isolation		
Cooling method		Forced air cooling		
DC 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
	No. of input circuits	1 circuit		
Grid-connected output	No. of phases/wires	3-phase 3-wire		
	Rated voltage	202 VAC		
	Rated frequency	50/60 Hz		
	Rated output current	28.3 AAC		
	Current harmonic distortion	Total current: 5% or less, individual harmonic order: 3% or less		Percentage of rated output current
	Output power factor	0.95 or greater		At the rated output and a power factor of 1.0 Power factor setting range: 0.8 to 1.0 (in increments of 0.01)
	Efficiency	93%		Efficiency measurement method in accordance with JIS C 8961 With a power factor setting of 1.0
Isolated output	Rated output	—	9.9 kVA	
	No. of phases/wires	—	3-phase 3-wire	
	Rated voltage	—	202 VAC	
	Voltage regulation	—	Within ±8% of rated voltage	
	Rated frequency	—	50/60 Hz	
	Frequency regulation	—	Within ±0.1 Hz of rated frequency	
	Voltage harmonic distortion	—	Linear load: 5% or less	
	Overload capability	—	100% continuous	
	Efficiency	—	93%	Efficiency measurement method in accordance with JIS C 8961
Operation mode (grid-connected operation/ isolated operation) switchover setting		—	Automatic or manual (Factory setting: Manual)	
Grid protection		Overvoltage (OVR), undervoltage (UVR), overfrequency (OFR), and underfrequency (UFR)		An overvoltage ground relay (OVGR) shall be externally connected to the factory-configured normally-closed dry contact input.
Islanding detection	Passive method	Voltage phase jump detection		
	Active method	Frequency feedback method with step injection		
Communication		RS-485		
Acoustic noise		50 dB or less		A-weighting, 1 m from front of unit
Operating environment	Ambient temperature	-25 to +60˚C		Operates at derated output above 40°C during grid-connected operation
	Relative humidity	90% or less (non-condensing)		
	Altitude	2000 m max.		
Paint color		Munsell 5Y7/1 (semi gloss)		
Heat dissipation		745 W		
Mass		64 kg		

4. Features

4.1 Isolated operation function

The *SANUPS W73A* grid-connected isolated type can perform isolated operation when in isolated operation mode.

Isolated operation is an operation mode used during grid power outages. Power generated by a wind power generator or hydroelectric power generator is rectified to DC power, then converted to AC power with a constant frequency, constant voltage, and sinusoidal waveform, before being supplied to emergency equipment.

The new model delivers 9.9 kW, 3-phase 3-wire 202 VAC output power during isolated operation, supplying power to emergency equipment even in the event of a power outage. Moreover, it can supply power as an off-grid power supply in non-electrified areas such as remote islands.

Figure 3 illustrates the isolated operation of the *SANUPS W73A* grid-connected isolated type.

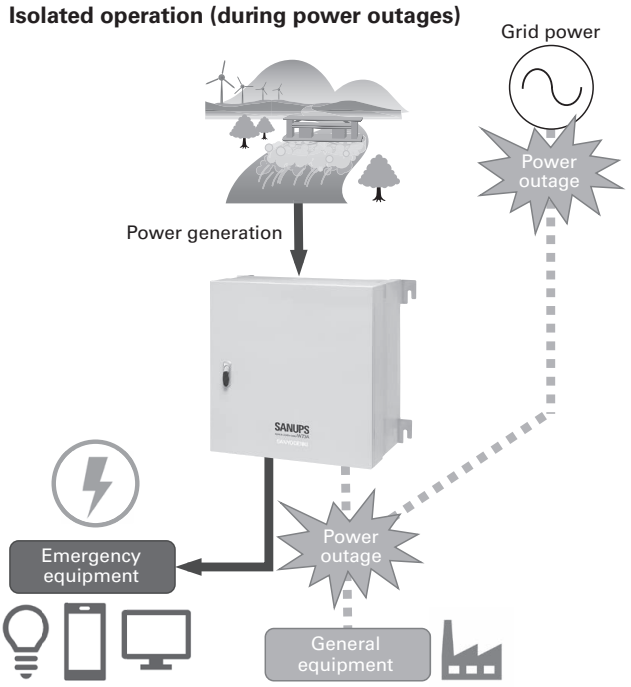


Fig. 3 Illustration of isolated operation

4.2 Switchover to isolated operation

The *SANUPS W73A* grid-connected isolated type can be set to either manually or automatically switch between operation modes as follows: from grid-connected operation to isolated operation when an outage occurs in the grid, or from isolated operation to grid-connected operation when grid power is restored after an outage.

Moreover, manual switchover between grid-connected and isolated operation modes has been simplified and can be done by merely turning the grid output circuit breaker on or off, rather than the conventional method of selecting operation modes.

This enables customers to switch over to isolated operation without having to perform difficult operations.

4.3 Soft start method

When connecting transformers and pumps to the isolated output of a power conditioner, the following issues arise. First, to excite the transformer, an excitation inrush current approximately ten times the regular current flows. Also, a large starting current occurs when starting the motor that drives the pump. This might activate the protection function of the power conditioner (overcurrent detection), often leaving the isolated operation not activated.

Against such a load, the transformer's excitation inrush current can be suppressed by starting up the power conditioner's isolated output from a low voltage (0 V) and rising gradually to the rated voltage. This type of soft start is referred to as a VVCF (variable voltage, constant frequency) soft start.

Furthermore, it is possible to suppress the pump's starting current by raising it to the rated value with the ratio of start voltage and frequency fixed to a constant. This type of soft start is known as VVVF (variable voltage, variable frequency).

The *SANUPS W73A* offers both the VVCF and VVVF soft start methods, and customers can also choose from the four startup time options of 2, 5, 10, and 20 seconds. This allows the power conditioner to perform isolated operation with the starting current suppressed regardless of the load connected.

4.4 DC input voltage - DC input power characteristics settings

For the *SANUPS W73A*, customers can freely select a minimum of 2 to a maximum of 32 DC input voltage - DC input power characteristics (hereinafter "power characteristics") settings to match the output characteristics of a specific wind power or hydroelectric power generator.

Moreover, operation-start/stop voltage can be set freely for use with various systems.

This enables efficient use of the power generated by wind power or hydroelectric power generators.

Figure 4 shows an example of power characteristics settings.

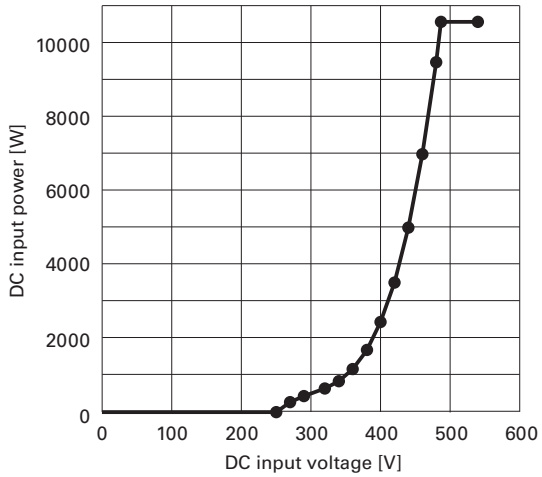


Fig. 4 Example of power characteristics settings

4.5 Voltage rise control standby function

The power conditioner is equipped with a voltage rise control function to maintain power grid voltage within the appropriate range as well as prevent breakdowns and reduced life of electrical products.

The two types of voltage rise control function are phase-advance reactive power control and output control. If the AC output voltage of the power conditioner exceeds the preset value during the grid-connected operation, phase-advance reactive power control will be activated. If the AC voltage does not stop rising, the output control will limit the output power and voltage. As such, if the output control of the voltage rise control function is activated, the power conditioner will generate less power.

This marks the first time the voltage rise control standby function was featured on a power conditioner for 3-phase output wind power generation and hydro power generation.*

From the 2016 version of the grid-interconnection code (JEAC 9701-2016), it became acceptable to have an operation time limit in the voltage rise control. As such, we set a 200-second operation time limit for the voltage rise control to come into action.** With this, grid voltage increases within 200 seconds will not cause the voltage rise control function to suppress the power conditioner's output.

This function can contribute to reducing the power generation loss from voltage rise control.

4.6 Power factor correction function

As a countermeasure to the problem of increased electrical current in the power distribution grid due to the large-scale introduction of renewable energy, the *SANUPS W73A* comes with a power factor correction function for grid-connected operation as standard.

This can correct the output power factor to a value between 0.8 and 1.0 during grid-connected operation, which means increases in grid voltage can be suppressed without the need to install special-purpose equipment or reinforced wiring.

4.7 Adoption of frequency feedback method with step injection of reactive power

The *SANUPS W73A* uses an active islanding detection method of a frequency feedback method with step injection of reactive power (hereinafter "new active method") which detects the frequency change caused by injecting the reactive power calculated from the frequency deviation that occurs when there is a power outage.

In principle, the new active method is characterized by not causing interference with other active methods, which is useful when connecting multiple renewable energy inverter units.

4.8 Remote monitoring service

The *SANUPS W73A* can be combined with our *SANUPS PV Monitor* for remote monitoring and data collection/analysis via a network.

Furthermore, by using the *SANUPS NET* status monitoring service, the *SANUPS W73A* system status can be monitored via the internet from computers and smartphones.

SANUPS NET users can select either a power visualization service or system information management service, depending on their needs.

The power visualization service displays the power generation status and collects data. In addition to power visualization, the system information management service also provides notifications of operational status, the occurrence of trouble or alarms, and equipment fault recovery. It also provides alarm and fault recovery history for reference.

Figure 5 illustrates a remote monitoring system configuration using the *SANUPS PV Monitor* and *SANUPS NET*.

* Based on our own research as of March 27, 2019, among power conditioners for wind power and hydro power generation systems.

** The 200-second standby time limit was stipulated as the standard value from the maximum value of an SVR (step voltage regulator) with the longest operation time limit among voltage regulators in power distribution grids. This was the result of an investigation by the Federation of Electric Power Companies in Japan in accordance with the view that operation time limit should be coordinated with voltage regulators in power distribution as per grid connection regulations.

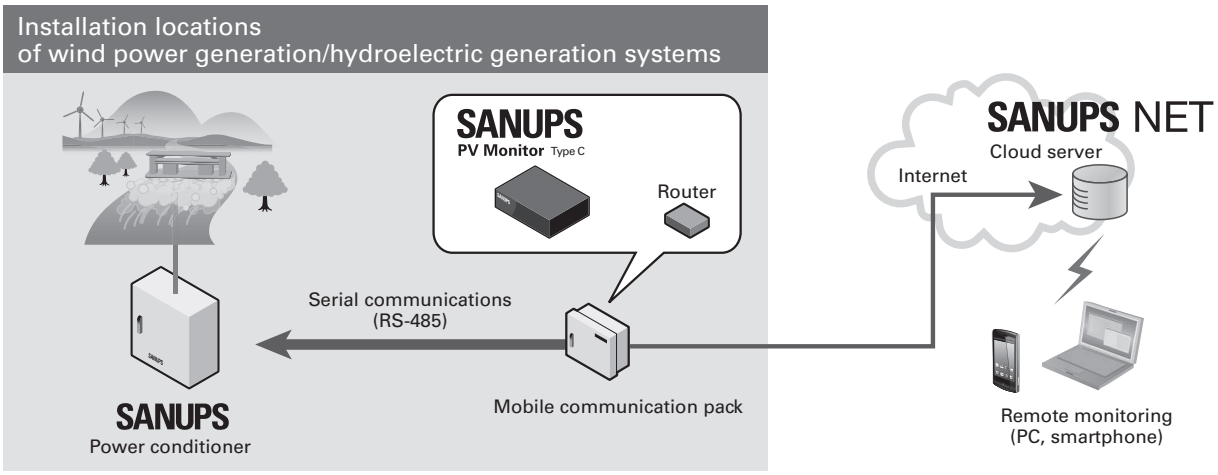


Fig. 5 Example of remote monitoring system configuration

4.9 Dustproof/waterproof performance

The *SANUPS W73A* has a protection rating of IP65 and a sealed structure with excellent dustproof and waterproof performance for outdoor use. This protects the product from the ingress of rain, dust, and small insects, and makes for a highly-reliable product that can be used with greater peace of mind.

4.10 Salt damage countermeasure

Assuming use in environments susceptible to salt damage, we verified that the *SANUPS W73A* would not have its functionality and performance impacted by performing a salt spray test (Severity 6 test in accordance with the IEC 60068-2-52 salt spray test method). As such, we have designed the product to be salt resistant so it can be installed in locations 500 meters or more away from a coastline.

5. Conclusion

This article has provided an overview of the *SANUPS W73A* grid-connected isolated type power conditioner for wind power and hydro power generation systems, and introduced its features.

The new model can meet the needs of customers who wish to use electrical power even in environments with no grid power or to secure power supply in times of emergency.

Moving forward, in addition to the development of new technologies such as smart grids for solving problems arising from the mass introduction of renewable energy, SANYO DENKI will swiftly develop products that use these new technologies and offer products that use all forms of renewable energy to contribute to a low-carbon society.

Reference

(1) "The 5th Strategic Energy Plan," Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry https://www.enecho.meti.go.jp/en/category/others/basic_plan/5th/pdf/strategic_energy_plan.pdf (2019.9.17)

Authors

Makoto Ishida
Power Systems Div., Design Dept.
Works on the development and design of PV power systems.

Hirofumi Nishizawa
Power Systems Div., Design Dept.
Works on the development and design of PV power systems.

Tetsuya Fujimaki
Power Systems Div., Design Dept.
Works on the development and design of PV power systems.

Katsutoshi Tanahashi
Power Systems Div., Design Dept.
Works on the mechanical design of PV power systems.