New Power Conditioner for Large-Scale Power Systems

Tomohiro TAKANO*, Takaya HASEBE and Mitsuru MATSUKAWA

It has been three years since the Feed-in Tariff (FIT) for renewable energy was introduced in Japan. While a reasonable number of solar power systems have started operation in Japan, functional improvement and cost reduction are still required for overseas solar power plants. We have provided 100-660 kW solar inverters for domestic use, contributing to the installation of megawatt-class solar power generators. Drawing on the expertise, we have developed a new solar inverter to meet the needs of overseas customers.

Keywords: mega-solar, three-level inverter, heat exchanger

1. Introduction

Renewable energy has been put to commercial use to cope with the potential depletion of future fossil energy sources and to help solve the issue of global warming caused by increasing CO_2 emissions. Recently, photovoltaic power generation has been increasingly introduced. With the rapid expansion of renewable energy use, there has been growing concern about surplus power, voltage increases in power distribution systems, and unnecessary parallel-off.

Power conditioners for photovoltaic power generation are required to increase the power generation efficiency and offer advanced functions such as an output control function (for controlling power generation based on the demand-and-supply balance of the power grid), voltage increase control function (for injecting reactive power into the power grid to cope with voltage increases), and FRT function*[1] (for preventing interruption of power generation in the event of an instantaneous voltage drop). We have developed technologies for the SOLARPACK series to cope with these issues.

While customers need these functions for protecting electric power systems, they increasingly demand technologies for reducing power generation and maintenance costs and ensuring electromagnetic compatibility (i.e. avoiding the influence of electromagnetic waves on surrounding areas including electromagnetic interference).

Manufacturers must take these needs into account.

Against this backdrop, we have significantly improved the conventional design concept and developed a new product series called “Smart Power Conditioner.” Details are presented below.

Table 1. Specifications of Smart Power Conditioner

Item		Specification	Remarks
Output capacity		660 kW / 660 kVA	
Number of input circuits		2, 6, 12, or 16	
DC input	Rated voltage	DC 550 V	
	Input range	DC 0~1000 V	
	MPPT range	DC 460~850 V	
AC output	Number of phases	Three-phase, three-wire	
	Rated voltage, frequency	300 V, 50/60 Hz	
	Power factor	0.95 or more	When rated output / power factor is set to 1.0
	Current distortion factor	5% or less in total, 3% or less for each distortion	Rated current ratio
Efficiency (rated output)		97.8% (JISC8961)	
Maximum efficiency		98.7%	Actual value / power factor 1.0 / 460 VDC
Main circuit		Self-commutation voltage type	Three-level inverter
Switching		High-frequency PWM	
Output control		Output current control type	
Insulation		Utility frequency link type	
Grid protection		Overvoltage (OVR), Undervoltage (UVR), Overfrequency (OFR), Underfrequency (UFR), Islandingoperation detection (passive, active)	
FRT function		Compliant with JEAC 9701-2012	
System stabilization function		Constant power factor control function, voltage increase suppression function	
Output Control function		Yes	
Communication		RS-485, MODBUS	
Cooling		Hybrid	
Other	Installation location	Outdoor	Heavy-duty salt-resistant, dust-proof
	External dimensions	W3580 × D1650 × H1950 (Excluding protrusions)	Excluding grid connection transformers
	Weight	3350 kg	Excluding grid connection transformers

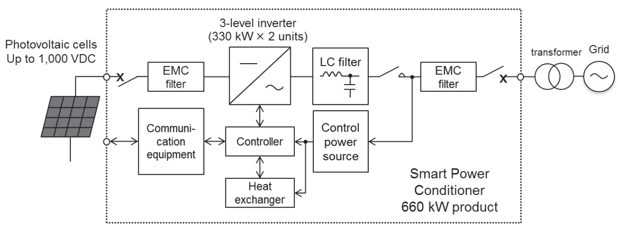

Fig. 1. Internal configuration diagram

2. Specifications of a Smart Power Conditioner

Table 1 shows the specifications of a Smart Power Conditioner (1,000 VDC/660 kW). Figure 1 shows the internal configuration diagram, and Photo 1 shows the appearance. The DC input voltage is between 0 and 1,000 VDC, and the maximum power point tracking (MPPT) range that achieves the rated output is between 460 and 850 VDC. The product lineup offers DC input options of 2-, 6-, 12-, and 16-circuit input. The product also offers the four

Photo 1. Appearance

features below that have been well accepted by customers in the SOLARPACK series:

(1) A built-in DC power collection function;
(2) No external supply of the control power source required;
(3) No need to purchase an outdoor enclosure separately;
(4) EMC*[2] filters provided as a standard feature.

3. Increased Efficiency

An inverter is used to allow the voltage of photovoltaic cells to flow to the power grid. A three-level inverter has been introduced in the Smart Power Conditioner. Figure 2 compares the switching waveform of an ordinary two-level inverter with that of a three-level inverter. The switching voltage height of a three-level inverter is half that of a two-level inverter, helping reduce switching loss and switching noise.

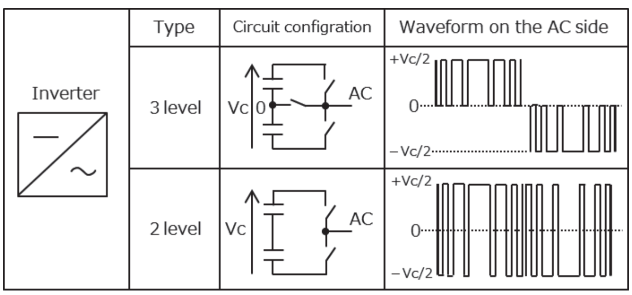

Fig. 2. Comparison of inverter waveforms

Meanwhile, an LC filter is used to smooth the inverter's switching waveform and convert it into a sine wave. In a three-level inverter, the ripple current*[3] that goes through the reactor of the LC filter is small, achieving significant reduction in heating attributed to iron loss.

Due to these advantages, the maximum efficiency is 98.7% (at 460 VDC) in the equipment operating range, 0.3% higher than the conventional our products. The equipment efficiency curve is shown in Fig. 3.

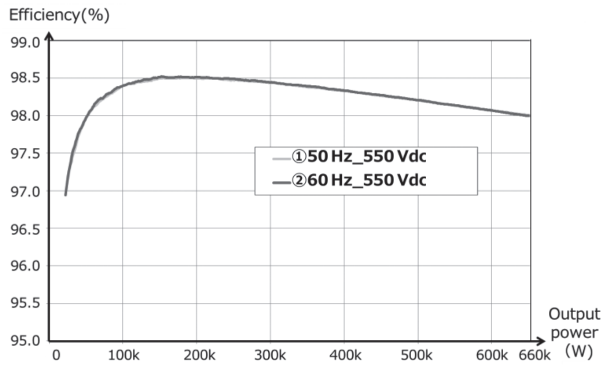

Fig. 3. Efficiency characteristics (at 550 VDC)

Another factor that has helped increase efficiency is the change in the cooling equipment in the cabinet from an air conditioner to a heat exchanger. The key points in its development are as follows.

A heat exchanger is designed to exhaust the heat from inside of the cabinet using a heat transfer element and fan by taking advantage of the temperature difference in and outside the cabinet. While an air conditioner uses a compressor and fan for cooling, a heat exchanger uses only a fan, helping reduce the power consumption.

Unlike an air conditioner, a heat exchanger cannot pinpoint the target area to be cooled in the cabinet. Precautions must be taken to prevent damage to parts attributed to local heating.

We carefully designed and verified the fan circulation route in the cabinet. As in the case of our conventional products, a separate space has been provided to exhaust the heat (loss) of a three-level inverter by force-feeding outside air (i.e. a hybrid cooling method) to reduce the heat exchanger capacity (see Fig. 4). Due to the change in the cooling equipment, the power consumption of auxiliary equipment of the new products is 60% less (at full cooling

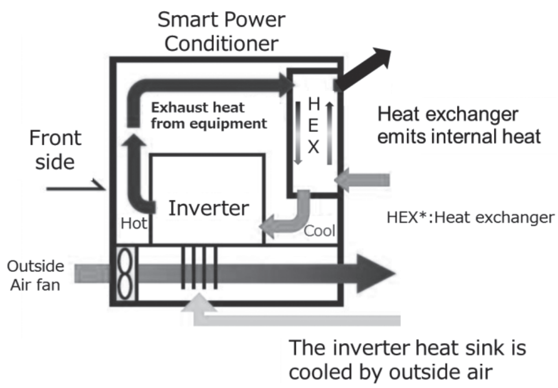

Fig. 4. Hybrid cooling

capacity) than that of our conventional products using an air conditioner.

4. Improved Maintainability

In addition to increased efficiency, the Smart Power Conditioner is also characterized by improved maintainability and reduced maintenance cost because of the three factors below.

(1) Easy handling

The cabinet height has been reduced to about two-thirds of that of the conventional products for easy visual check and part replacement during periodic inspection.

(2) Use of parts with long service life

For the conventional products, the designed service life of the fan is short (five years), incurring high cost for customers to replace the air conditioner. The service life of the Smart Power Conditioner is 10 years because the fan offers a long service life. The maintenance cost has been reduced by eliminating the need for an air conditioner.

(3) Enhanced remote monitoring function

Figure 5 shows a screen that has been verified in-house. We have a mechanism to monitor the internal data of the Smart Power Conditioner. Thus, remote monitoring enables us to analyze the information about power generation and failure as well as the information in the Smart Power Conditioner, predict the remaining service life, and take quick action in the event of a failure.

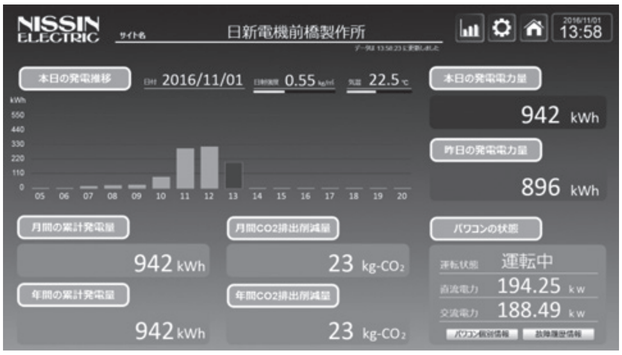

Fig. 5. Remote monitoring screen

5. Construction of Field Demonstration Equipment

We applied the Smart Power Conditioner to a 550 kW demonstration system at the Maebashi Plant in Gunma Prefecture and started operation for long-term verification. Photo 2 shows the appearance of the equipment. This equipment enables long-term verification in combination with photovoltaic cells as well as a conventional shop test. As a system provider and manufacturer, we have been collecting various data.

Photo 2. Appearance of field demonstration equipment

6. Conclusion

This paper has presented the specifications and features of our new power conditioner. We will increase the product lineup of photovoltaic power conditioners and develop applied technologies to stabilize the electric power.

• SOLARPACK is a trademark or registered trademark of Nissin Electric Co., Ltd.

Technical Terms

*1 FRT (fault ride through): When a large capacity of renewable energy, etc. is connected to the power grid, parallel-off occurs due to system disturbance. This is likely to have a significant impact on the quality of electric power. The FRT function helps continue operation of power conditioners in the event of a system disturbance and maintains the quality of the electric power.

*2 EMC (electromagnetic compatibility): During operation, power conditioners must not generate switching noise (electromagnetic waves) that causes electromagnetic interference and hinders operation of other equipment. Power conditioners must have electromagnetic susceptibility so that their operation is not hindered.

*3 Ripple current: A power conditioner uses an LC filter to smooth the output voltage from an inverter (from a rectangular wave to a sine wave) for grid connections. Theoretically, a ripple current of a rectangular wave frequency is generated in the reactor of an LC filter. In general, a ripple current is a high-frequency current. Thus, it may hinder the operation of other equipment or increase the loss in parts and wiring materials.

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