Development of obtaining oversea certification (TÜV certification) to the 100kW Power Conditioner

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Synopsis

The expectation to the PV system which is one of the leading figures of the CO_2 reduction expands rapidly all over the world and we believe the growth of PV system installation with the rating more than 100kW in the near future.

And the acquisition of overseas certification (TÜV certification) is becoming required to sell them in overseas markets (in particular, Europe and China).

This paper describes development of obtaining oversea certification (TÜV certification) to the 100kW power conditioner.

1. Introduction

Energy shortage will become a reality in the near future, due to exhaustion of fossil fuel, and the earth is warming due to increasing CO_2 concentration resulting from the continued use of fossil fuels. To cope properly with these problems and thereby ensure the sustainable development of humankind in the future, it is a matter of urgency to expand the use of renewable energy sources.

One solution to the above problems is photovoltaic power systems that convert solar energy to electric energy. Nissin Electric developed and commercialized 10 kW, 100 kW and 250 kW power conditioners, and has supplied them to many public and industrial facilities in Japan.

Recently, many European countries have introduced the Feed-In-Tariff system, which requires that electric power companies purchase photovoltaic power system-generated electricity at higher than regular rates. The Feed-In-Tariff system has accelerated the installation of both household and large-scale photovoltaic power systems. The Japanese Government is also considering introduction of the same system (net metering system), which is expected to dramatically increase the number of photovoltaic power system installations.

Photovoltaic power systems are also becoming popular in China and Middle Eastern countries.

Market conditions in many Asian and European countries differ from those in Japan. Overseas markets require that photovoltaic power systems comply with EMC, IEC, European Product Safety Directive (Low Voltage Directive) and other specific international standards/specifications. Most of these systems must also be certified by a third-party organization.

Nissin Electric has obtained certification for its 100 kW power conditioners from TÜV, a well-known independent international certification body in Germany, in the field of photovoltaic power systems. The purpose of obtaining certification is to participate in overseas photovoltaic power markets (see certification flow depicted in **Figure 1**).

This paper outlines the certification process.

2. Specifications of Power Conditioners for Overseas Sale

External view, system configuration and basic specifications of a power conditioner for an overseas market are shown in **Figure 2**, **Figure 3**, and **Table 1**, respectively. To cope with market conditions in Europe, China and other countries, the maximum allowable DC input voltage has been raised from 600 V (specification for domestic sale) to 800 V. The standard AC output voltage

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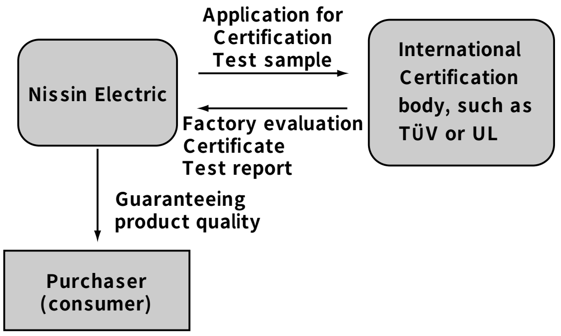


Figure 1 Certification System Flow

has been set at 400 V, to facilitate interconnection with commonly used low-voltage three-phase power distribution systems. The input voltage operating range (MPPT range) has been set ranging from 450 V to 820 V, considering the change in maximum allowable DC input voltage and the corresponding maximum output of the associated solar cell.

For power conditioners for overseas sale, the DC voltage was raised to reduce the conduction loss attributable to current, and the AC reactor and transformer were replaced with a high-efficiency hybrid transformer. As a result, the maximum efficiency of power conditioners for overseas sale has been enhanced approximately 1.5% in average from the 94.5% (at rated output power) for conditioners for domestic sale to 97%. (See the Efficiency Curve shown in **Figure 4**.)

The output current controller has been improved, to minimize current harmonic distortion and improve the power factor.

Figure 2 External View of Power Conditioner

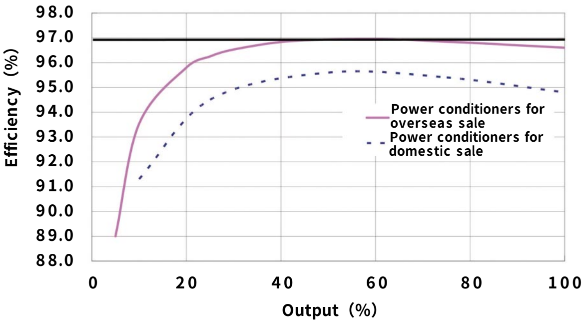


Figure 4 Efficiency Curve

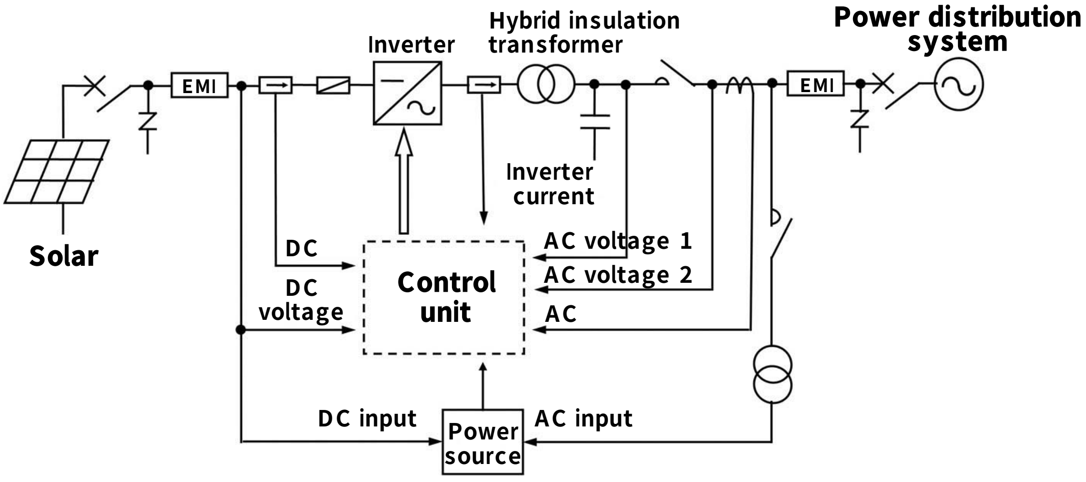


Figure 3 Construction of 100 kW Power Conditioner for Overseas Sale

Table 1 Basic Specifications of Power Conditioners (Comparison with Those for Domestic Sale)

	Specifications for overseas sale	Specifications for domestic sale	Features of specifications for overseas sale
Input voltage range	DC0 - 880 V	DC0 - 600 V	High input voltage
Input voltage operating range (MPPT range)	DC450 - 820 V	DC320 - 600 V	Wide input voltage operating range
Max. efficiency	97%	94.5% (at rated output)	High efficiency
Euro efficiency	96%	—	—
Output voltage	AC400 V -15%+12.5%	AC202 V±10%	Wide output voltage range
Output frequency	50/60 Hz (47 - 61.5 Hz)	50/60 Hz (48.5 - 61.8 Hz)	—
Insulation system	Utility frequency link type		—
Rated output capacity	100 kW		—
Output current harmonic distortion	Total: 3% max.	Total: 5% max.; each order: 3% max.	Low current harmonic distortion
Power factor	0.99 min.	0.95 min.	High power factor
Ambient temperature	−20-50℃	−10-40℃	Wide ambient temperature range
Altitude	2,000 m max.	1,000 m max.	Available for operation at high elevation
Communication system	RS-485		—
Dimensions	W:1,000 mm×H:2,000 mm×D:900 mm		—

3. International Standards to Be Applied

Since our purpose in obtaining certification was to enter the European and Asian markets outside Japan with power conditioners, we decided to select a European certification body from among UL, TÜV and many other international certification bodies. Our power conditioners would thus have to comply with both the Low-voltage Directive and the EMC Directive, and particularly with the standards shown in **Table 2**. The EN50178 (Electric equipment for use in power installations), which is a European low-voltage directive, specifies the minimum necessary requirements for protection from electric shock, testing of the electric equipment and its components in their entirety, and design and fabrication of the equipment so as to simplify installation in an electric power system.

After taking power conditioners specifications into account, we decided to apply EN61000-6-4 (Part 6-4: Generic standards Emission standard for industrial environments) for emission requirement of the EMC Directive. These standards are usually applied to equipment to be operated in industrial environments. We developed test specifications in compliance with applicable basic standards.

For power conditioner immunity, we applied EN61000-6-2 (Part 6-2: Generic standards Immunity for industrial environments), which is usually applied to equipment to be operated in industrial environments. Each specification was tested as per the requirements of the applicable basic standards.

Table 2 Overseas Standards (Comparison with Domestic Standards)

		Products for overseas sale	Products for domestic sale
Product safety standards		EN50178	JISC8980
EMC standards	Emission	EN61000-6-4 └EN55011	
	Immunity	EN61000-6-2 ├EN61000-4-2 ├EN61000-4-3 ├EN61000-4-4 ├EN61000-4-5 ├EN61000-4-6 └EN61000-4-8	

4. Application of Safety Standards to Power Conditioner Design

Before applying the safety standards to power conditioner design, we clarified which product specifications had to comply with the Low Voltage Directive. We then selected the safety-related items to be reviewed, and clarified how they differed from conventional conditioner specifications. The product specifications necessary for determining insulation distance are shown in **Table 3**, major changes in control panel fabrication specifications are shown in **Table 4**, and major changes in equipment specifications are shown in **Table 5**.

Control panel safety was improved on the basis of EN50178 Standards, with particular emphasis on

Table 3 Product Specifications for Determining Insulation Distance

Pollution degree	3
Overvoltage category	III
Insulating material group of PCB	I (CTI≧175) for 900V
Betwee any primary part and earth the highest recurring peak voltage was Assumed as 1000V_{peak}.	
Betwee any primary part and earth the highest working voltage was measured as 1000$V_{r.m.s}$	

Table 4 Changes in Control Panel Fabrication Specifications

Changed item	Major change
Protective bonding and earthing	• Replacement of earthing wire with IEC-compliant wire • Change in earthing wire color • Change in earthing wire size for each device • Change in earthing bus bar size
Device interconnecting wire	• Replacement of wire with IEC-compliant wire • Change in wire color • Change in wire size • Change in wiring method and route • Additional installation of wire protector
Protection from electric shock	• Change in air vents and other openings protection level
Discharge from capacitor	• Additional installation of warning display system for capacitor discharge time after power OFF
Protection conductor connection method	• Change in protective earthing conductor terminal mark
EMC measure	• Optimization of EMI filter position

Table 5 Changes in Major Device and Parts

Changed item	Major change
Coil	• Type test of device in accordance with IEC Standards. • Reduction of overall loss by hybridizing transformer and reactor.
Switches/circuit breakers	• Use of TUV-certified device. Type test of uncertified device.
PWB	• Sufficient insulation distance provided between main circuit potential and SELV circuit potential. Impulse withstand voltage upgraded. • Replacement of insulation elements with certified ones. Type test of uncertified elements.
Control source	• DC input voltage raised (700 V ? 900 V). • Sufficient insulation distance provided between main circuit input terminal and each control source output terminal. Impulse withstand voltage upgraded. • Type test of insulation parts.
Inverter	• DC input voltage was raised (800 V ? 900 V). • Sufficient insulation distance provided between main circuit potential and SELV circuit potential. Impulse withstand voltage upgraded. • Replacement of insulation parts with certified parts.
EMI filter	• Damping property reinforced.

improvement of protective earthing, protection from electric shock at charge unit, protection of electric wires from thermal and physical stresses, and insulation of control wires. As an EMC measure, a filter with damping property meeting the allowable upper limit specified by the Standards was selected and positioned so that filtered signals would be kept free of noise.

As much TÜV-certified equipment as possible was used. For equipment not yet certified, the certification body carried out type approval tests in compliance with respective applicable product standard (EN or IEC Standard. The approval test confirmed that all tested equipment were acceptable.

Insulation distance was also reviewed for all equipment and devices. Some of the review results are shown in **Table 6**.

Table 6 Clearance and Creepage Distance at Each Portion

Clearance and creepage distance at/of		Insulation type	Working voltage (V) peak	Impulse withstand voltage (kV)	Clearance Requirement (mm)	Creepage distance Requirement (mm)
Equipment						
1	Busbar to enclosure	B	DC900V	8	8	16
2	PWB to Enclosure	B	DC900V	8	8	16
3	IGBT to U–V–W bus bar	B	DC900V	8	8	16
PWB						
1	400V pattern to 15V pattern	R	AC565V	8	8	8
2	900V pattern to 15V pattern	R	DC900V	12	14	14
Transformer						
1	DC900V to AC400V	B	DC900V	8	8	16
2	DC900V to DC24V	R	DC900V	12	14	32
Voltage transducer						
1	DC900V to DC15V	R	DC900V	12	14	14
Terminal Block						
1	DC24V to AC200V	R	DC900V	12	14	32
2	DC24V to AC200V	R	DC900V	12	14	32

Insulation type B :basic insulation , R:reinforced insulation

The minimum insulation distances (clearance and creepage distance) between main circuit and grounding potential, between main circuits and between main circuit and control circuit were determined in compliance with the applicable standards; the results were incorporated into the control panel and PWB designs. In particular, all portions requiring reinforced insulation were subjected to impulse withstand voltage tests specified in the applicable standards. Test results confirmed that these portions would pose no problems in practical operation.

5. Type Tests

5.1 Test under Normal Conditions

On the basis of applicable safety standards, the independent certification body (TÜV) and Nissin Electric carried out safety tests for items applicable to the power conditioner specifications. Test results confirmed that all test samples met all test criteria. Principal test items are shown in **Table 7**.

Table 7 Items to Be Tested under Normal Conditions

Items to be tested under normal conditions
Construction Check
Working voltage measurement
Capacitor discharge test
Verification procedure
Dry heat test (until saturation)
Dry heat test (16 hours)
Damp heat test
Vibration test
Creepage distances and clearances
Enclosure test
Impulse voltage test
A.C. or D.C. voltage test
Partial discharge test
Insulation resistance in the power installation
Short-circuit withstand capability

5.2 Single-failure Test

In the single-failure test, major equipment and devices were subjected artificially to a fatal failure, to observe whether or not the power conditioners could detect such failure and stop safely. A fuse or circuit breaker was additionally installed in over-current positions; the protective interlocking sequence was reviewed and modified as needed. Results confirmed that the power conditioners will stop safely in the event of fatal trouble. Principal test items are shown in **Table 8**.

Table 8 Single-failure Test Items

Single-failure test items
Short-circuiting DC input terminals
Short-circuiting secondary terminals of insulation transformer
Short-circuiting AC output terminals
Short-circuiting MCCT-ON relay output contacts
Forced stoppage of ventilation/cooling fan
Short-circuiting auxiliary relay output contacts
Clogging intake port
Overload operation
Short-circuiting PWB photo-coupler output terminals
Short-circuiting PWB output contacts

5.3 EMC Test

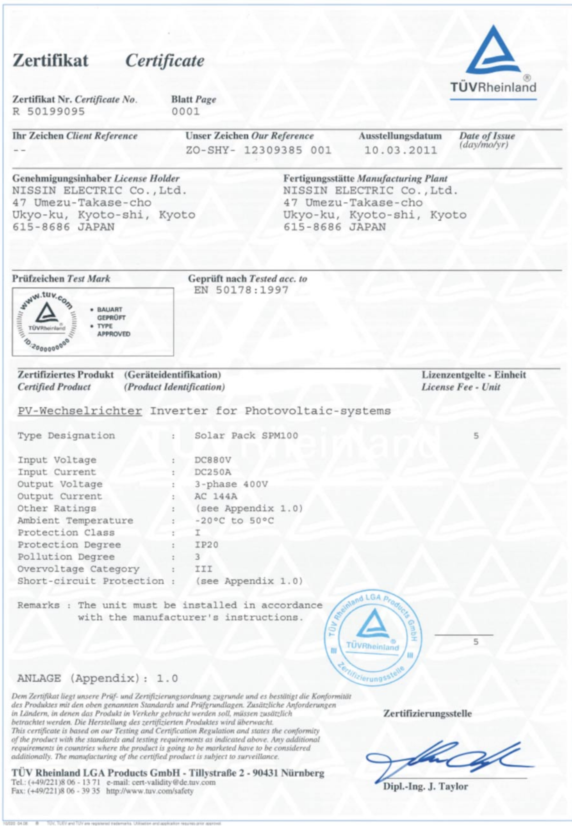
Test items shown in Table 9 were selected for power conditioners and tested in compliance with EMC standards.

For emissions, the damping property of the filters installed in the conditioners was improved to meet the criteria for the disturbance voltage test. Control panel construction was modified to meet the criteria for the radiation field test. For immunity, radiation field testing revealed that backlight brightness changed slightly in the area very close to the LCD touch panel, but that no preventive measure was required, since it remained below the maximum allowable limit (10V/m). Conducted RF test results revealed the need to reinforce power conditioner immunity. In response, we improved the shielded wire earthing.

Table 9 EMC Test Items

EMC test item	
Emission	Disturbance voltage
	Radiation field
Immunity	Electrostatic immunity
	Radiation field immunity
	Conducted RF immunity
	Power frequency field immunity
	EFT/Burst immunity
	Surge immunity

The above type test results showed that the 100 kW power conditioners met the requirements of all applicable standards. TÜV certified the conditioners on March 10, 2011.



Zertifikat Certificate

TÜVRheinland

Zertifikat Nr. Certificate No. R 50199095 | Blatt Page 0001

Ihr Zeichen Client Reference -- | Unser Zeichen Our Reference ZO-SHY- 12309385 001 | Ausstellungsdatum Date of Issue (day/mo/yr) 10.03.2011

Genehmigungsinhaber License Holder
NISSIN ELECTRIC Co.,Ltd.
47 Umezu-Takase-cho
Ukyo-ku, Kyoto-shi, Kyoto
615-8686 JAPAN

Fertigungsstätte Manufacturing Plant
NISSIN ELECTRIC Co.,Ltd.
47 Umezu-Takase-cho
Ukyo-ku, Kyoto-shi, Kyoto
615-8686 JAPAN

Prüfzeichen Test Mark

Geprüft nach Tested acc. to
EN 50178:1997

Zertifiziertes Produkt (Geräteidentifikation) Certified Product (Product Identification) | Lizenzentgelte - Einheit License Fee - Unit

PV-Wechselrichter Inverter for Photovoltaic-systems

Type Designation	:	Solar Pack SPM100
Input Voltage	:	DC880V
Input Current	:	DC250A
Output Voltage	:	3-phase 400V
Output Current	:	AC 144A
Other Ratings	:	(see Appendix 1.0)
Ambient Temperature	:	-20°C to 50°C
Protection Class	:	I
Protection Degree	:	IP20
Pollution Degree	:	3
Overvoltage Category	:	III
Short-circuit Protection	:	(see Appendix 1.0)

Remarks : The unit must be installed in accordance with the manufacturer's instructions.

ANLAGE (Appendix): 1.0

Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

Dipl.-Ing. J. Taylor

Figure 5　Attestation Certificate from TÜV

TÜV Rheinland LGA Products GmbH
Member of TÜV Rheinland Group
Tillystrasse 2
90431 Nürnberg
Germany

TÜVRheinland

Certificate

No. 081-00-2495-1103

Regarding the inspection of manufacturing facilities according to the General Agreement with the Certification Body of TÜV Rheinland LGA Products GmbH (TRLP)

the Certificate Holder

NISSIN ELECTRIC Co., Ltd.
47 Umezu-Takase-cho
Ukyo-ku, Kyoto-shi, Kyoto 615-8686
Japan

has successfully demonstrated that an internal quality control and necessary tests are being carried out for those products approved by TRLP and produced at the manufacturing facility:

NISSIN ELECTRIC Co., Ltd.
47 Umezu-Takase-cho
Ukyo-ku, Kyoto-shi, Kyoto 615-8686
Japan

An inspection of the facility's quality assurance system and test procedures, including internal records was conducted by an inspector, appointed by TRLP, on

2011-01-24

This certificate is valid until the next scheduled inspection or up to 12 months, at the discretion of TRLP.

Report No.: 12022355 001

Certification Body

Dipl.-Ing. R. Keller

Figure 6　Attestation Certificate from TÜV for Factory Evaluation

6. Conclusions

This report has presented an outline of the procedures we followed to obtain 100 kW photovoltaic power conditioner certification from an international certification body (TÜV). On January 24, 2011, TÜV also certified our power conditioner production system. Photographs of the attestation certificate for the power conditioners and production system, both issued by TÜV, are shown in **Figures 5** and **6**, respectively. We will continue to work toward 250 kW power conditioner certification from TÜV and other international certification bodies.

Reference

(1) Yamada, Kobayashi, et al., " Development of Power Conditioner for Mega-Solar Power Generation Use " The Nissin Electric Review Vol. 54 (132nd volume of set), 2009

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