Power Technology for Protecting People

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1. Introduction

There have been frequent natural disasters in recent years that threaten the safety of people. The frequency of these disasters is expected to increase in the furure. The major natural disasters that have occurred in Japan since 2018 are listed below. (1)

- 2018: Torrential rains in West Japan in July
- 2019: Typhoon No. 15 (Boso Peninsula)
- 2019: Typhoon No. 19 (East Japan)

The average annual temperature over land has been high over much of the world, and this is also true throughout Japan. The 2020 deviation from the reference value for average air temperature in Japan (30-year average from 1991 to 2020) was the highest since statistics began being recorded in 1898. Experts have indicated a strong link between the increase in natural disasters and global warming.

In October 2020, the Japanese government announced its goal of becoming "carbon neutral" by 2050, which means essentially zero emissions of greenhouse gases, setting a goal of increasing the use of renewable energy to around 50% to 60%.

This article introduces some of our Power Systems products: products that protect people from increasingly severe and frequent natural disasters, products that protect people during power outages caused by natural disasters, and products that promote carbon neutrality and protect people from global warming.

2. Outdoor UPS *SANUPS N11B-Li*

In December 2020, the Japanese government made a cabinet decision on the "Five-year Acceleration Plan to Prevent and Mitigate Disasters, and Improve National Resilience." Since then, the government has continued to accelerate plans and initiatives to enhance road network functionality and to increase emergency preparedness of vital infrastructure (such as railroads, harbors, and airports).

We have developed, based on the *SANUPS N11B-Li* UPS equipped with lithium-ion batteries for outdoor use, a custom UPS that can be used in Fundamental Plan for National Resilience projects with compliance with "Outdoor Uninterruptible Power Supply Device Specifications"(2) defined by Japan's Ministry of Land, Infrastructure, Transport and Tourism.

This product differs from our standard specifications in several points: we revised the storage battery layout and circuit so that power backup can be provided for the specified time in -20°C environments; the sheet metal material was changed from standard SUS430-KD to SUS304 to improve resistance to corrosion.

Operable in extreme environments, this product is now used as power backup for surveillance cameras and display devices that maintain infrastructure such as roads, rivers, ports, and water and sewerage systems.

This product contributes to enhancing the emergency preparedness of public infrastructure, keeping people safe from increasingly severe natural disasters.

Figure 1 shows the appearance of the *SANUPS N11B-Li*, while Table 1 provides its product specifications.

Fig. 1 *SANUPS N11B-Li*

Table 1 *SANUPS N11B-Li*'s ratings eligible for use in MLIT's "Fundamental Plan for National Resilience" projects

Model no.		N11BL152AK11TST44HP	N11BL102AK31TST44HP
Load		70 W	140 W
Backup time(1)		24 h	
Topology		Passive standby	
Transfer time		10 ms or less	
Efficiency (AC-AC)		95%	
AC input/output	**Rated frequency**	50/60 Hz (auto-sensing)	
	No. of phases/wires	Single-phase 2-wire	
	Rated voltage	100/110/120 V	
Load power factor		0.8 (lagging)	
Battery type		Lithium-ion battery	
Operating environment		Temperature: -20 to +50°C, humidity: 10 to 90% RH (non-condensing)	
Protection rating		IP44(2)	

(1) At a -20°C ambient temperature
(2) Standard models come with IP65 protection

2.1 Technology for use in extreme environments

(1) Use of LIB (lithium-ion batteries)

We used lithium-ion batteries (hereinafter, "LIB") so that the product could be used in extreme environments.

LIBs have high energy density and could cause smoke or fire if used improperly. We ensured the safety of the product with dual safety systems: the LIB's battery management system (hereinafter, "BMS") and the UPS's LIB status monitoring functionality.

- Protection by BMS
  The BMS monitors LIB current, cell voltage, and cell temperature, and turns the switch off to disconnect and protect the LIB if it detects an error.

- Protection by UPS
  The UPS communicates with the BMS and monitors LIB status during operation. If the UPS detects an error or can no longer communicate with the BMS, it stops charging/discharging to protect the LIB.

(2) High dust and water protection

To operate outdoors safely for a long period of time, the UPS housing has a sealed structure with IP65-rated dust and water protection (in the case of our standard products).

In designing the sealed housing, we used thermal fluid analysis to simulate the internal heat flow and optimized the structure and layout design to effectively circulate and discharge internal heat to the outside by using the entire housing.

This ensured IP65 dust and water protection, while also preventing internal heat from rising in concentrated areas, enabling us to develop a UPS that can be used outdoors safely without sacrificing performance or reliability.

3. Emergency Diesel Generator *SANUPS G53A*

The supply of quality power is crucial to keep electrical facilities running normally. The Japanese power grid is extremely stable and power outages are rare.

However, if a fire or large-scale natural disaster occurs and the power supply from the power company is interrupted, it could prevent emergency equipment from operating.

The *SANUPS G53A* generator is compliant with Japan's Fire Service Law, which is a mandatory requirement for building disaster management. With this compliance, it can be used as an emergency power source (for indoor firefighting equipment and sprinklers) defined in the law or as a backup power source (for emergency lighting and smoke ventilation equipment) defined by Japan's Building Standard Law.

If a fire or large-scale natural disaster occurs, the UPS protects people's livelihoods as a backup power source to allow work to continue and to maintain safety. It also keeps people safe by providing backup power for emergency equipment as an emergency power source as defined by the Fire Service Law or as a backup power source as defined by the Building Standard Law.

Figure 2 shows the appearance of the *SANUPS G53A*.

Fig. 2 *SANUPS G53A*

3.1 Technology to comply with Japan's Fire Service Law

Compared to a standard generator, the *SANUPS G53A* emergency diesel generator has the following additional features to comply with the Design Requirements for Emergency Use Engine-driven Power Generators (NEGA C 311 Standard) defined by the Nippon (Japan) Engine Generator Association.

- Earthquake-resistant structure for the engine and generator
- Cubicle materials and structure
- Charger compliant with Japan's Fire Service Law

We also used an engine from a new (to us) manufacturer and combined it with a newly designed generator.

In designing the engine and generator combination, we needed to satisfy standard requirements such as shaft strength versus torsional vibration and dynamic characteristics, while ensuring that the capacity of each would not be excessive.

In developing this product, we determined the engine and generator combination by using simulations to calculate the resonance points, stress on the shaft, and engine speed characteristics when an engine and generator are combined. We then checked the results of assessing this on actual equipment. This allowed us to optimize the combination selection quickly.

4. Power Conditioner (PV Inverter) with Peak Cut Function *SANUPS P73L*

The *SANUPS P73L* power conditioner is capable of charging and discharging LIBs.

The grid-connected isolated charging type can be used as a storage battery system. Thanks to the bi-directional converter installed in the storage battery input part, it can perform maximum power point tracking control (hereinafter, "MPPT control") even during the storage battery charge/discharge or isolated operation, making maximum use of PV-generated power. It promotes carbon neutrality and protects people from global warming by making effective use of PV-generated power.

Figure 3 shows the appearance of the grid-connected isolated charging type and the grid-connected isolated type, while Figure 4 shows the circuit block diagram for the grid-connected isolated charging type.

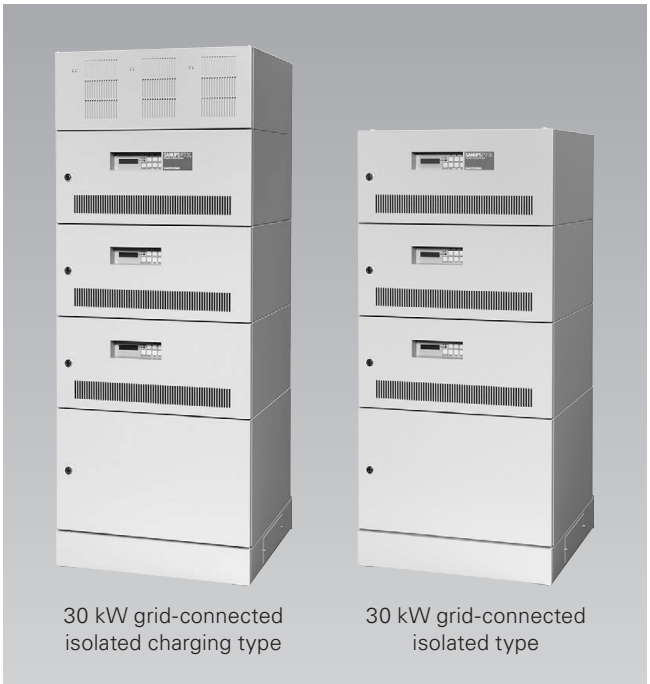

Fig. 3 *SANUPS P73L*

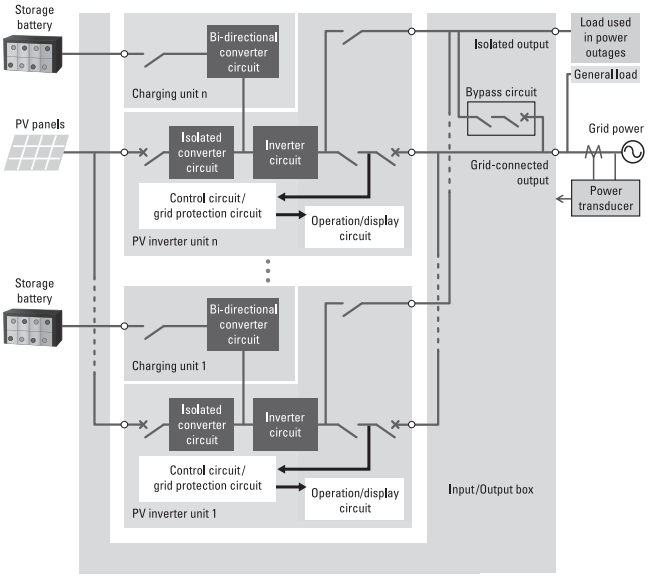

Fig. 4 Block diagram for grid-connected isolated charging type

4.1 Technology for making effective use of PV-generated power

MPPT control cannot be performed with power conditioners whose storage battery is directly connected to solar cells because the voltage of the solar cell is fixed to the voltage of the storage battery, preventing the full use of the PV-generated power.

The *SANUPS P73L* has a bi-directional converter installed in the storage battery input part, which allows it to manage the storage battery charge/discharge while continuing to perform MPPT control even during the storage battery charge/discharge. The maximum power of the solar cell can therefore always be output, resulting in a significant increase in power generated.

We also used a non-isolated buck-boost chopper in the bi-directional converter to support a wide range of storage battery voltages while maintaining high efficiency.

This made it possible to combine storage batteries and solar cells flexibly, which had conventionally been limited with PV inverters that are directly connected to solar cells, making system design easier.

5. Conclusion

This article introduced several products from Power Systems Division: products that protect people from increasingly severe and frequent natural disasters, products that protect people during power outages caused by natural disasters, and products that promote carbon neutrality and protect people from global warming.

We will continue to develop products that bring safety to people's lives.

References

(1) National Resilience Promotion Office, Cabinet Secretariat: "Building National Resilience" pamphlet (version R3.3) https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/pdf/kokudo_pamphlet_r3.pdf (April 1, 2021)

(2) Japan's Ministry of Land, Infrastructure, Transport and Tourism: "Outdoor Uninterruptible Power Supply Device Specifications" https://www.mlit.go.jp/tec/it/denki/kikisiyou/touitusiyou_17okugaimuteidenR0203.pdf (March 2020)

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