Development of the “SANUPS K23A M Type Host Communications Function Support”

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1. Introduction

Since the Great East Japan Earthquake, there is a heightened level of interest in environmental issues. The introduction of renewable natural energies such as photovoltaic power generation is continuing but the influence to the power grid is concerned due to an unstable power generation that are affected by the weather. Therefore, further energy conservation and smart grid which to achieve a stable power supply is progressing in Japan’s power supply system. [*1]

For smart grid power supply systems, there are many cases where the energy management of buildings or entire factories is carried out by a host device (EMS - Energy Management System) called a BEMS (Building Energy Management System) or a FEMS (Factory Energy Management System), and there is a growing demand for power supply systems and system devices with a communication function to exchange various information with an EMS.

To respond to these kinds of market requirements, we developed the grid management device, “SANUPS K23A M Type Host Communications Function Support”. This document describes the features.

2. Background of the Development

Previously, we had commercialized and sold the grid management device “SANUPS K23A M Type”, which used a storage battery to well-balanced and efficiently utilized the power of the distributed power supply and utility grid from renewable energy such as photovoltaic power generation. [*2 to 3]

We received a request to be able to switch between operation modes of the grid management device using communication from an EMS as well as a request to manage power information, however the grid management device did not have a port for communication with an EMS and was only able to support minimal operation mode switching by a contact signal.

For this reason, we developed the grid management device “SANUPS K23A M Type Host Communications Function Support” which corresponds communication with an EMS.

Regarding the specifications of the newly developed communication function, we used “RS-485 (Modbus protocol)” which is widely adopted in measurement instruments, power meters, etc. as a general protocol.

3. Operation modes

3.1 Basic configuration of a grid management device

Fig. 1 shows the basic configuration of the grid management device. The device achieves a stable power supply system by connecting an AC switch (ACSW) in series on the bus bar between the utility grid and power consuming device, and a storage battery via a bi-directional inverter connected in parallel to the utility grid, then connecting the distributed power supply such as power consuming device and the power conditioner for photovoltaic power generation on the output side (local area) of the grid management device.

Grid management device suppresses the sudden fluctuations of the distributed power supply in local area and power fluctuations caused by load fluctuation of the power consuming device by charging and discharging to the storage battery.

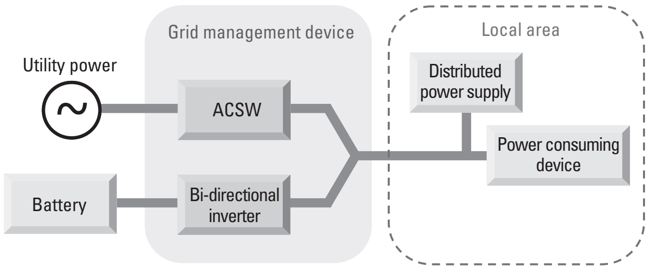

Fig. 1: Basic configuration
of a grid management device

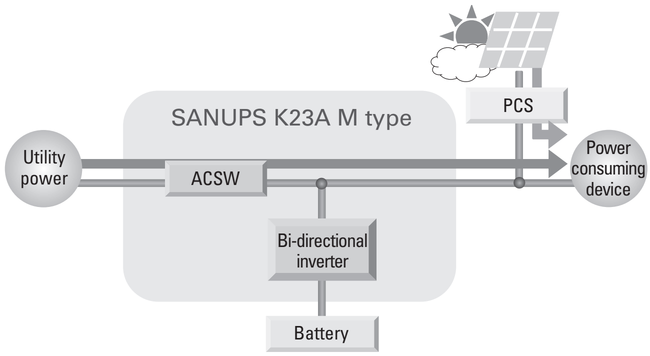

Fig. 2: Underpower
in local area ≤ peak-cut setting

3.2 Operation modes of a grid management device

The grid management device has the below five operation modes. The grid management device switches between different operation modes due to switching command received from an EMS, contact signal or the existence of a power outage in the utility grid.

(1) Peak-cut mode
(2) Charging mode
(3) Isolated operation mode
(4) Standby mode
(5) Operations during a power outage

3.2.1 Peak-cut mode

Peak-cut mode is a mode which suppresses power fluctuation within a local area by charging and discharging the storage battery, and contributes to the equalization of the utility power.

Peak-cut mode is a basic mode of the grid management device and is activated when conditions for other operation modes are not met. Peak-cut mode operations follow one of the below three patterns, depending on the amount of power generation and power consumption of a distributed power supply in local area.

(1) Underpower in local area ≤ peak-cut setting

Fig. 2 shows the state of power feeding in a grid management device when the underpower in a local area is less than the peak-cut setting.

In this state, the underpower in the local area is supplied from the utility grid, and the power of distributed power supply and the utility grid is supplied to the power consuming devices. In such cases, discharge from the storage battery is not performed.

(2) Underpower in local area > peak-cut setting

Fig. 3 shows the state of power feeding in a grid management device when the underpower in a local area is greater than the peak-cut setting.

In such a state, part of the underpower in the local area will be supplied from the utility grid and the power receiving will be limited by the power volume of the peak-cut setting. At this time, the remaining local area underpower will be compensated by discharging from the storage battery.

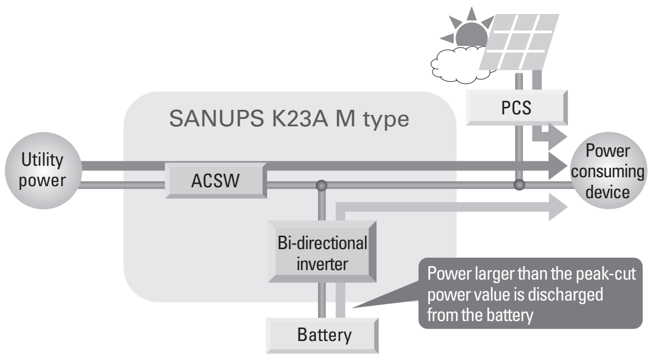

Fig. 3: Underpower
in local area > peak-cut setting

(3) If there is surplus power in the local area

Fig. 4 shows the state of power feeding in a grid management device if there is surplus power in the local area.

In this state, distributed power supply is directly supplied the power to the power consuming device, and any surplus power is charged to the storage battery.

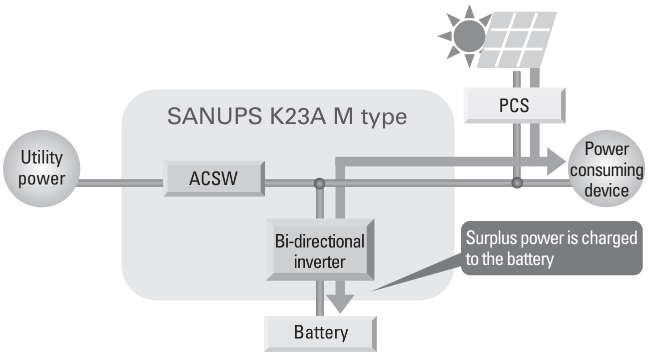

Fig. 4: In cases of surplus power in the local area

3.2.2 Charging mode

The charging mode, if the power generation is not expected from the distributed power supply such as at night, it is a mode for charging from utility grid to storage batteries.

Charging mode is activated when any of the following three conditions are met.

(1) The charging mode command has been received from an external source (EMS, etc.)
(2) It reaches the time set in the schedule charging function to start charging.
(3) During peak-cut mode, the SOC (State of Charge) of the storage battery drops under the SOC lower limit as a result of discharging.

If any of these conditions are met, the grid management device will switch to charging mode and the storage battery will be charged until its SOC reaches the preset value for charging to stop. Fig. 5 shows the power feeding status at this time.

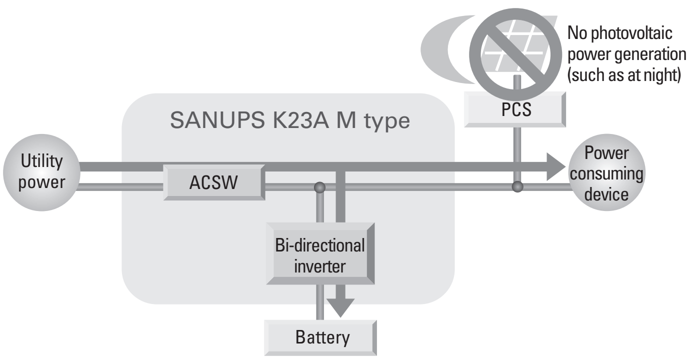

Fig. 5: Charging mode

3.2.3 Isolated operation mode

Isolated operation mode is the mode in which the grid management device operates independently from the utility grid by turning the ACSW off and switching to inverter operation uninterruptedly.

Isolated operation mode is activated by receiving an isolated operation mode command from an EMS, etc. In isolated operation mode, the utility grid and grid management device are completely independent, therefore power in the local area is secured in the event of a problem arising in the utility grid. As such, this is also an effective operation mode for BCP (Business Continuity Plan). Fig. 6 shows the power feeding status at this time.

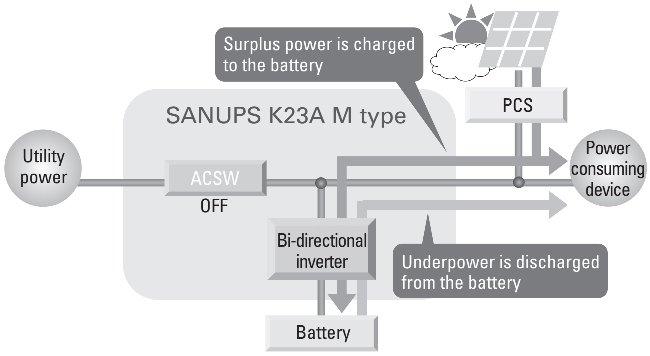

Fig. 6: Isolated operation mode

3.2.4 Standby mode

Standby mode is a mode which the storage battery is not charged and discharged by the bi-directional inverter is stopped and the storage battery is disconnected.

Standby mode is activated by receiving a standby mode command from an EMS, etc. In standby mode, the bi-directional inverter is stopped, therefore the amount of power consumed by the grid management device is smaller compared with other modes. Fig. 7 shows the power feeding status at this time.

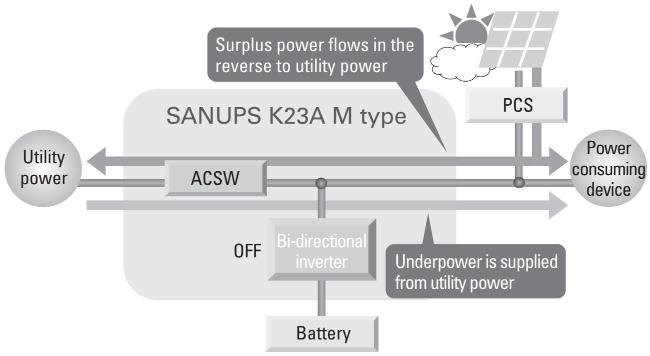

Fig. 7: Standby mode

3.2.5 Operations during power outages

Grid management devices which are either in peak-cut mode or charging mode when a power outage occurs on the utility grid, perform the operations described in 3.2.3 and enable to continue operation independently from the utility grid by turning off the ACSW, and the grid management device is switching to inverter operation uninterruptedly, thereby disconnecting the utility grid and local area.

4. Communication Descriptions and Operation Examples with EMS

The expanded content of the newly developed communication feature uses Modbus communication protocol through RS-485 (RTU mode). Below shows the descriptions of communication data with an EMS and grid management device.

4.1 Measurement data

Table 1 shows an example of the device measurement data and storage battery information communicated between an EMS and a grid management device.

The EMS can determine the status of the grid management device and send commands to switch operation modes by receiving "device measurements" from the grid management device and "storage battery information" from the storage battery.

Table 1: Examples of measurement data

Measurement data	Information description	Units
Device measurement	AC input voltage	V
	AC output voltage	V
	AC input current	A
	AC output current	A
	DC voltage	V
	DC current	A
	DC power	kW
	AC input frequency	Hz
	AC output frequency	Hz
Storage battery information	Battery voltage	V
	Battery current	A
	Battery SOC	%

4.2 Device status information

The device status information that an EMS can receive is the "operation mode" of the grid management device and "error information" of the grid management device and storage battery.

4.3 Information on various settings

Setting information which can be changed from an EMS are "SOC setting", "peak-cut setting", and "scheduled charging setting".

By changing these types of setting information in real-time, it is possible to control power in more detail to suit the status of the power consuming device or the grid management device.

4.3.1 SOC setting

The SOC settings able to be set on an EMS are the SOC lower limit, SOC upper limit and charge stop SOC. Fig. 8 shows the SOC range of storage battery and the operation image of the grid management device.

Moreover, when the SOC of the storage battery has dropped below the SOC lower limit, either of the below two operation patterns can be selected from.

(1) Perform the power supply to the power consuming device from the utility grid or the distributed power supply by stopping the discharge from the storage battery as continuing the peak-cut mode.
(2) Stop discharging from the storage battery, switch to charging mode automatically and charge the storage battery until reaches the charge stop SOC.

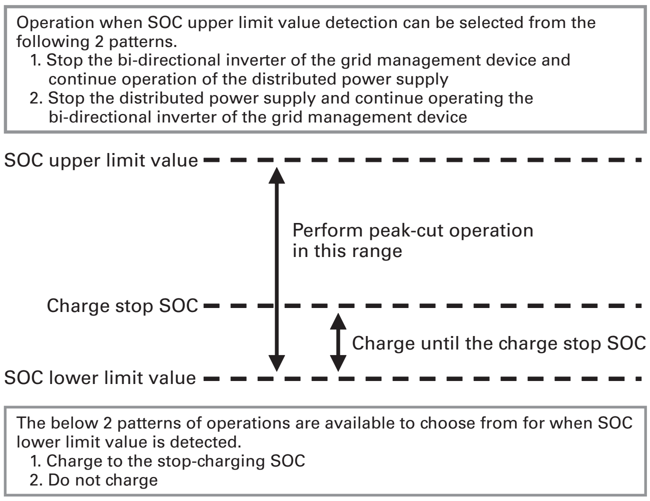

Fig. 8: SOC range and operation image

Moreover, when the SOC of the storage battery exceeds the SOC upper limit, either of the below two operation patterns can be selected.

(1) Stop the bi-directional inverter of the grid management device and stop charging to the storage battery by disconnecting the storage battery.
On such occasions, surplus power from the

distributed power supply will flow in the reverse to the utility grid, therefore enabling the power generated by the distributed power supply to be effectively utilized.

(2) Output the stop signal from the grid management device to the distributed power supply, and stop the distributed power supply, this will enable to stop charging of surplus power.
On such occasions, the bi-directional inverter of the grid management device will continue to operate, therefore power can be supplied to the power consuming device uninterruptedly even in the event of a power outage.

4.3.2 Peak-cut setting

The peak-cut setting which can be set on an EMS is a percentage (%) of the device capacity. Table 2 shows an example of peak-cut setting and peak-cut start power depending on the device capacity.

Table 2: Examples of peak-cut start power

Device capacity	Peak-cut setting	Peak-cut start power
20 kW	30%	6 kW
50 kW	30%	15 kW
100 kW	30%	30 kW

4.3.3 Scheduled charging setting

The “scheduled charging setting” which can be set on an EMS is a function to charge power from the utility grid to the storage battery at a set scheduled time.

With this function, scheduled setting enables to set the charging start time and the charging interval. Charging interval can be set once in several days.

4.4 Operation mode switching command from an EMS

An EMS can send an operation mode switching command to the grid management device. The grid management device will switch to any of four operation modes with operation mode switching command sent from EMS.

Below is a description of each mode.

4.4.1 Peak-cut mode

The grid management device will switch to peak-cut mode if it does not receive the operation mode switch command from EMS to other operation mode. In peak-cut mode, it is possible to adjust the peak-cut setting in real-time depending on factors such as the present grid receiving power, load equipment power and the SOC of the storage battery.

4.4.2 Charging mode

When the grid management device receives the charging mode command from an EMS, it will switch to charging mode. In charging mode, the storage battery can be charged from the utility grid at the set charging current.

4.4.3 Isolated operation mode

When a grid management device receives an isolated operation mode command from the EMS, it will switch to isolated operation mode. In isolated operation mode, it will be the independent operation condition that is disconnected from the utility grid.

4.4.4 Standby mode

When a grid management device receives a standby mode command from the EMS, it will switch to standby mode. In standby mode, the device will be in standby mode (low power state) with the bi-directional inverter stopped.

4.5 Benefits of introducing the EMS

As an example of grid management device operation using the EMS, Fig. 9 shows the transition in power throughout a day when the daytime peak receiving power is suppressed.

In the operation example, the storage battery is charged at night time, when power consumption is minimal. Then, during the daytime, when there is a high amount of load equipment power, the peak-cut setting is changed, and the amount of power received from the utility grid is limited in order to suppress the daytime peak power. This makes it possible to equalize the amount of power used in a day and reduce the cost of power receive contract.

By using the EMS, and the like by looking at the situation, such as SOC of the storage battery is changed to “peak-cut setting”, this will enables the more detailed power control, thus achieving higher energy conservation and a stable power supply.

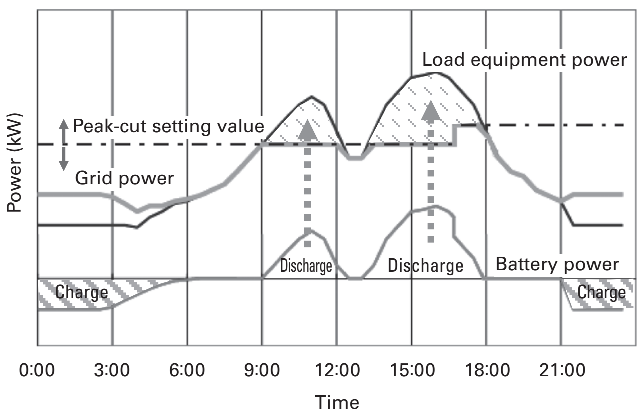

Fig. 9: Operation example of grid management device using EMS

Reference

*1 Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy: “Momentum of the Smart Community in Full Swing – Observations Made Possible Through Verifications”, Next-Generation Energy/Social System Committee, 13th distribution material 2-1, page 2 (2011)

*2 Furihata and Others: Development of the Grid Management Device “SANUPS K23A (M Type)”, Sanyo Denki Technical Report No. 35, pages 17-22 (2013)

*3 Okui and Others: “Power Supply System using Parallel Processing Method in Distributed Energy Resource” Journal of Institute of Electrical Engineers B (Electric/Energy Department Journal) Vol. 129, No. 11, pages 1349-1356 (2009).

5. Conclusion

This document has provided an overview of the “SANUPS K23A M Type Host Communications Function Support”, which entails a grid management device that enables balanced control and efficient utilization of power from a distributed power supply by renewable energy and power from utility grid, with an added feature to communicate with EMS using RS-485 (Modbus protocol).

This product is anticipated to contribute to further energy conservation and stable power supply in a smart grid society, and by supporting communication with EMS, we would like to continue expanding into the smart grid market.

The grid management device was developed based on the joint research on micro grids conducted with Aichi Institute of Technology and NTT Facilities between 2006 to 2010. Based on this joint research, the functions of the grid management device were further improved this time to make this device even more compatible with smart grids. We would like to express our gratitude to all those who contributed to this achievement.

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