Multi-source Power Conditioner Enables Highly Efficient Use of Various Energy Systems

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Abstract

The key to realize a low-carbon society is the efficient use of a variety of energy systems.

We would like to introduce the functional specifications and technical details of a multi-source power conditioner that combines optimally storage batteries and solar power generation etc.

Keywords

smart grid, bidirectional inverter, grid-interconnection code, MPPT, V2H, V2G, BEMS, HEMS

1. Introduction

In consideration of environmental pressures over the recent years, the introduction of renewable energy such as wind power and solar power generation has been significantly expanded and the U.S. has set a target of renewable energy of 25% of its total energy supply by 2025.

In Japan, electric power shortages are of great concern. Due to power outages at generation facilities affected by the Great East Japan Earthquake there is a need to accelerate the introduction of alternatively sourced renewable energy. The development of a smart grid is becoming more and more important in preventing further deterioration in the quality of electric power by the distributed power generation (**Fig. 1**).

The smart grid controls the system efficiently, i.e., the unidirectional electric power network (or grid) from the power plant is converted into a bidirectional one by which electric power is supplied from the renewable energy sources of solar power and wind power for use in a home or business environment. Such a large system concept is regarded holistically as one equipment for converting various renewable energies

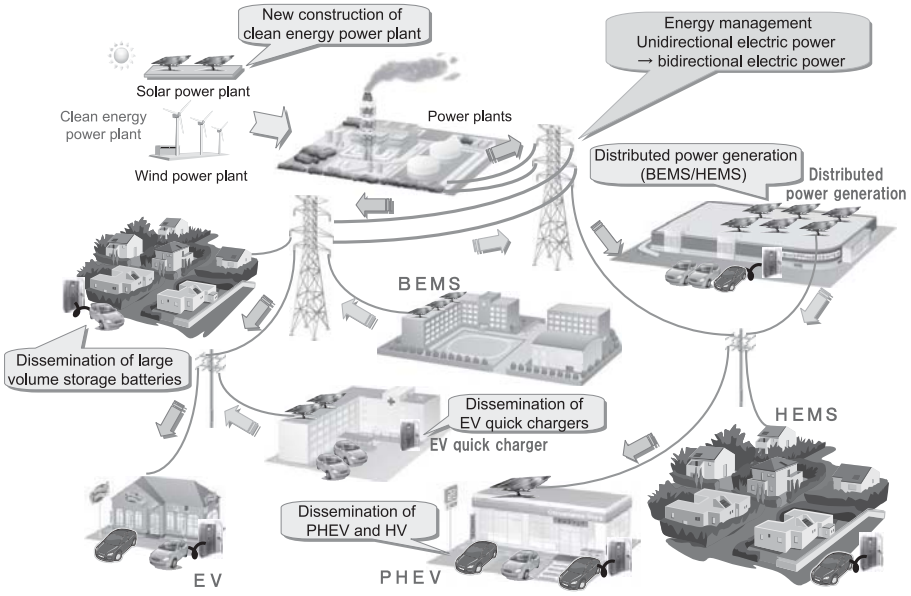

Fig. 1 Smart grid (simulated display).

efficiently into electric power and our own contributory efforts as introduced below are aimed at a basic energy system that is routed via “anytime, anywhere, and for anyone.”

2. Overview of the Multi–Source Power Conditioner System

The following describes the basic configuration of the multi-source power conditioner system. It incorporates a grid-interconnection bidirectional inverter, a bidirectional converter unit for energy storage, a solar battery interface unit, an EV interface unit, etc. and also a PMS (Power Management System) to control these units that are connected via a DC bus. The grid-interconnection bidirectional inverter is connected to the grid, the bidirectional converter unit for energy storage is connected to the storage device typically known as a lithium-ion battery, the solar battery interface unit is connected to the solar batteries and the EV interface unit is connected to the electric vehicles (**Fig. 2**).

Since the present system incorporates the storage device and PMS that are not incorporated in the conventional power conditioners, electricity demand may now be fully-comprehended in real time and energy can be supplied flexibly and optimally, including at times of peak shifts and cuts as required.

In addition, since a smart function is added to the PMS, programming functions and various solutions based on usage predictions and climate change are enabled.

Furthermore, in the conventional system, the DC power supplied by the power generator was converted into AC power and was used after re-converting it into DC power. Since the present system can be used via DC conversion only from the DC bus, it can reduce the number of stages of conversion to achieve a low-loss system.

3. Technology Components

This section describes the technology components consisting of the multi-source power conditioner.

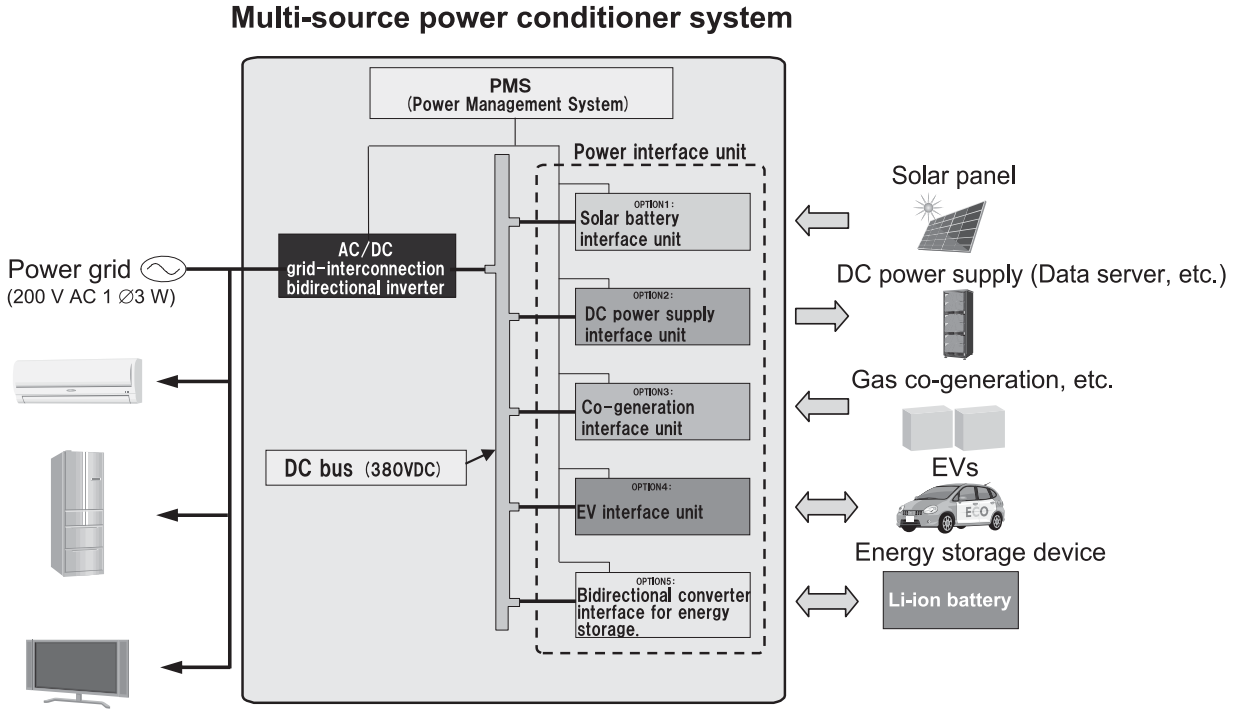

Fig. 2 Configuration of the multi-source power conditioner system.

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3.1 Grid–interconnection Bidirectional Inverter

The electric power is supplied to the DC bus via the grid-interconnection bidirectional inverter of the power grid as and when required. The supply depends on the load status and power generation status connected to each interface unit (**Fig. 3**).

On the other hand, when the surplus happens in the generated electric power, it is supplied to the grid from the DC bus (**Fig. 4**). The mode status may be seamlessly switched via the original software control.

In addition, the system is equipped with a safety device based on the Grid-interconnection regulations if required to connect with a commercial power supply system, including an islanding prevention function. Accordingly, when anything abnormal occurs in the grid, the safety device is operated automatically.

Furthermore, a clean power supply is achieved that features a high power factor and low distortion.

3.2 Bidirectional Converter for Energy Storage

The bidirectional converter for energy storage consists of bidirectional isolated DC/DC converters. It charges and discharges the storage device via the DC bus by sending the specified protocols according to information transmitted from the BMU (Battery Management Unit) (**Fig. 5**).

While the conventional bidirectional converter for energy storage used to be of the non-isolated type, the present bidirectional converter is isolated and smooth current switching between the charge and discharge mode is enabled.

Moreover, the technology accumulated via the charge and discharge evaluation system products in the various secondary batteries is applied so that the various storage devices can be charged and discharged as required.

3.3 Solar Battery Interface Unit

The solar battery interface unit has the ability to boost the voltage of the DC power generated by the solar batteries up to that of the DC bus (**Fig. 6**). In this case, MPPT (Maximum Power Point Tracking) constantly controls and maximizes the power generation that varies according to the illumination or temperature conditions.

By using original software, the MPPT is able to efficiently show how much power has been extracted from the electric power stored in the solar batteries up to 99% or more.

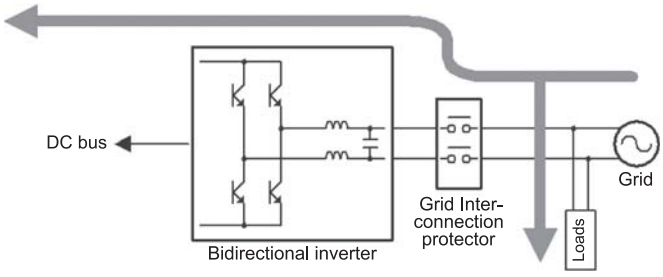

Fig. 3 Basic operation of bidirectional inverter (Grid to DC bus).

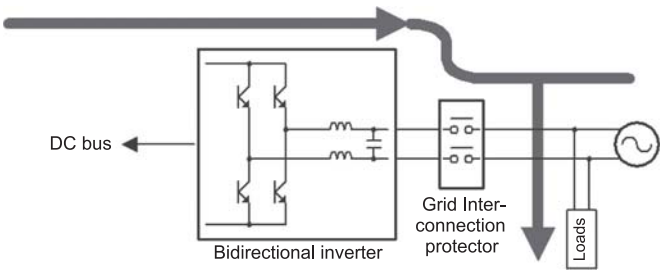

Fig. 4 Basic operation of bidirectional inverter (DC bus to Grid).

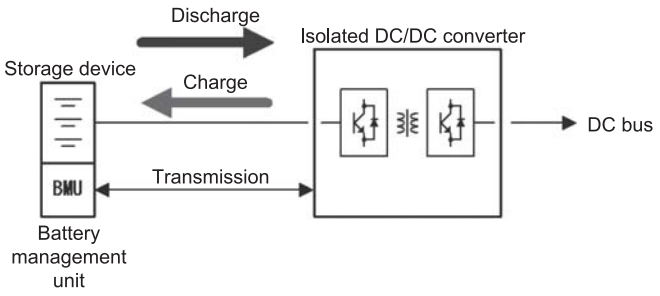

Fig. 5 Basic operations of the bidirectional converter for enabling energy storage.

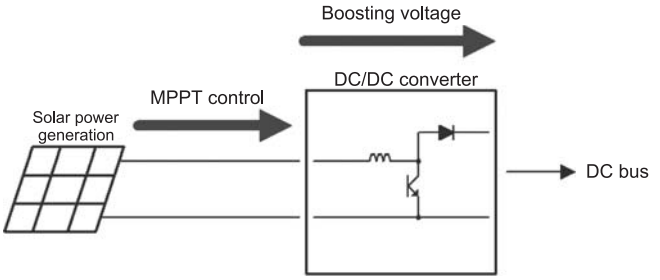

Fig. 6 Basic operation of the solar battery interface unit.

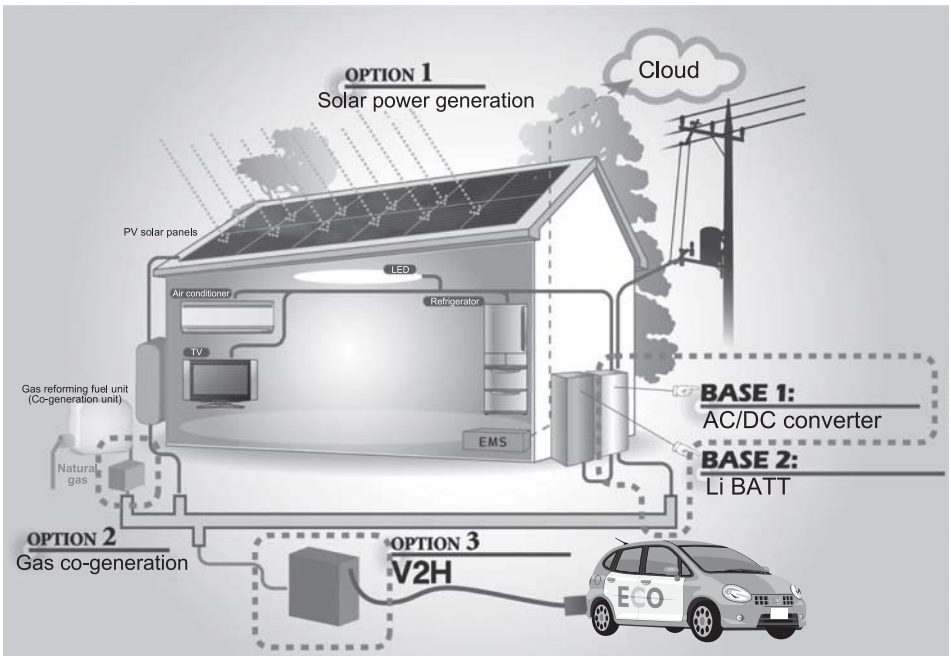

Fig. 7 Future development of HEMS (simulated display).

3.4 Future Development

When various interface units are connected to the DC bus, a variety of connections can be developed for future usages.

For example, when the interface units for DC power supply are combined, electric power can be supplied to various DC loads via the DC bus, including to data servers and portable base stations.

Also, when an electric vehicle (EV) is connected, V2H (Vehicle to Home) and V2G (Vehicle to Grid), by the use of the storage battery mounted in the electric car, is enabled.

Furthermore, business-use BEMS (Building Energy Management System) and home-use HEMS (Home Energy Management System) controlling the optimal electric power supply according to the conditions of energy usages may be considered for further expansion (**Fig. 7**).

4. Conclusion

While we express concern over the implications of electric power outages as the various energy applications are being accelerated, it is believed that the multi-source power conditioner system will play an important role in future solutions.

From now on, it will be essential to manage suitable electric power sources by converting renewable energy power supplies efficiently according to life style needs and in line with well considered predictions.

As a power supply manufacturer, we hope to contribute to society by applying technologies that have been accumulated up to the present, such as solar and wind power generation systems, power storage units for storing the electric power thus generated and power management systems for electric vehicles (EVs) and to effectively satisfy the contingencies of electricity demand.

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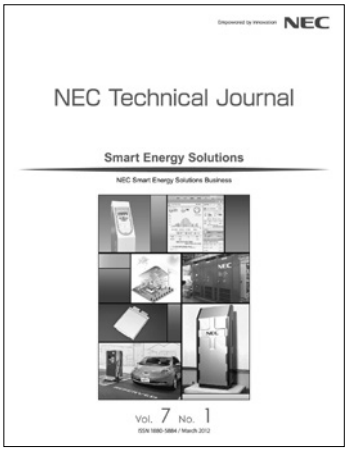

Vol.7 No.1
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Special Issue TOP