ORIGINAL

ABSTRACT

The present invention provides a multi-terminal power conversion device, a multi-terminal power transfer device, and a power network system which allows an existing power grid to be divided into a plurality of power grids that can be interconnected together and operated stably via existing or new transmission lines. An inter-power grid asynchronous interconnection network system includes a multi-terminal power conversion device characterized by connecting together a plurality of asynchronous power grids including a bulk power grid and controlling power so that the sum of inflow power and outflow power is zero. An intra-power grid synchronous network system includes a power apparatus control terminal device with means for controlling power for a power apparatus installed in an autonomous power grid. A plurality of inter-power grid asynchronous interconnection network systems are connected to an intra-power grid synchronous network system to integrate the power control with communication control. Thus, a power network system is constructed which enables power interchange between power apparatuses in different power grids and simultaneous and asynchronous power interchange between a plurality of power grids.

CLAIMS

1. A multi-terminal power conversion device characterized by comprising:

at least three power conversion units each comprising a self-commutated converter that converts power in a bidirectional manner and a voltage, current, and power measuring instrument that measures voltage, current, and power passing through the self-commutated converter;

a common bus that connects first ends of the power conversion units together in parallel; and

a control unit that controls a plurality of the power conversion units so that the power conversion units cooperatively set, to zero, a sum of power flowing from the power conversion units into the common bus and power fed out from the common bus to the power conversion units, based on measured values from the voltage, current, power measuring instruments, so that power is asynchronously interchanged among external circuits to which second ends of the power conversion units are connected.

2. The multi-terminal power conversion device according to claim 1, characterized in that the control unit further comprises a communication control unit connected to the control unit to enable control information about power interchange to be communicated between the control unit and an external apparatus.

3. The multi-terminal power conversion device according to claim 1, characterized by further comprising a power transceiver with a first terminal connected to the external circuit and a second terminal that is connectable to the second terminal of the power conversion unit of the multi-terminal power conversion device via an electric line.

4. A multi-terminal power transfer device characterized by comprising:

a plurality of power transceivers each with a first terminal connected to an external circuit and a second terminal that is connectable, via an electric line, to a second terminal of the power conversion unit of the multi-terminal power conversion device according to claim 2; and

a power transfer communication control unit that enables control information about power interchange to be communicated between the multi-terminal power transfer device and a communication control unit of the multi-terminal power conversion device.

5. A power network system characterized by comprising:

a first power router that is the multi-terminal power conversion device according to claim 2 or claim 3;

a second power router that is at least one of the multi-terminal power conversion device according to claim 3 and the multi-terminal power transfer device according to

claim 4;

an interconnecting electric line connecting a second terminal of a power conversion unit of the multi-terminal power conversion device that is the first router to a second terminal of a power transceiver of the multi-terminal power conversion device or the multi-terminal power transfer device that is the second router; and

a WAN configured by connecting a communication control unit or a power transfer communication control unit of the first and second power routers so as to provide communication addresses to second terminals of the first and second power routers, and

in that for power interchange between external circuits connected to the first and second power routers, information including a magnitude, a direction, and a start and end times of a power conversion carried out by each of the power conversion units is transmitted and received based on the communication addresses between the first and second power routers on a transmission line including the interconnecting electric line connecting the external circuits that carry out power interchange.

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DESCRIPTION

MULTI-TERMINAL POWER CONVERSION DEVICE, MULTI-TERMINAL POWER TRANSFER DEVICE, AND POWER NETWORK SYSTEM

Technical Field

[0001]

The present invention relates to a multi-terminal power conversion device, a multi-terminal power transfer device, and a power network system, and in particular, to a multi-terminal power conversion device, a multi-terminal power transfer device, and a power network system which allow a plurality of power grids to be asynchronously connected together via a multi-terminal power conversion device and a multi-terminal power transfer device both installed at each of the power grids, thus enabling specified power to be interchanged among specified power grids for a specified time.

Background Art

[0002]

Electric power is mostly supplied by power grids of a power company through a transmission network of a bulk power grid. The frequency of a power grid results from the balance between demand (load) and supply (generated output). Thus, the power company matches the supply and demand on a moment-by-moment basis by controlling load fluctuation of

at most several tens of seconds by a governor-free power generator, load fluctuation of at most 20 minutes by a power plant with a frequency control (AFC) function, and a load fluctuation of the order of several hours by scheduled increases and decreases in the output of a steam turbine power plant. A power generator in the grid includes a group of synchronous power generators and has a control characteristic called drooping. The control adjusts the output so as to increase the rotation of the power generators with decreased grid frequency, while reducing the rotation of those with increased grid frequency. Thus, owing to the drooping characteristic, all the power generators cooperate with one another in maintaining constant frequency. Furthermore, these synchronous power generators are rotating machines with a large inertia force and thus have the ability to stabilize the frequency in the area without being affected by slight fluctuations in grid frequency. This is expressed by the phrase "synchronizing power of the power generators".

[0003]

In Japan, the power supply is separated into two grids, a 50-Hz grid for the eastern region and a 60-Hz grid for the western region, therefore demand control for frequency stabilization is performed independently in the respective regions. This control allows the frequency to be synchronized to a single value in all locations within each of the two regions.

[0004]

On the other hand, in recent years, renewable energy power sources such as wind power generation, solar power generation, and biofuel power generation have been introduced at an accelerated rate as a means for dealing with the problem of global warming and as a result of the rapid rise in fossil fuel costs.

[0005]

The Japanese government has established the goal of introducing 28,000,000 kW of solar power generation by 2020 and 53,000,000 kW of solar power generation by 2040, however on the other hand, as reported in "Report of Workshop on Low Carbon Power Supply Systems" in July, 2009 the current power grid, if not improved, could support only about 13,000,000 kW of solar power generation.

[0006]

This limitation is because renewable energy power sources such as solar power generation and wind power generation cannot provide synchronizing power.

[0007]

These power sources provide power through inverters which detect the frequency of the grid and feed current synchronously by following other power sources on the grid. The power sources thus have the tendency of impairing the frequency stability of the system by magnifying normal power fluctuations. Thus, the introduction of large amounts of renewable power that fluctuates severely impairs

the synchronization capability of the existing grid. This may lead to a catastrophe such as cascading massive power failure.

[0008]

To solve this problem and introduce a large amount of renewable power, it is necessary to design a new power grid not supported by conventional concepts and to present a procedure for migrating the current grid to the new system without critical difficulties. However, the conventional art includes no document or report regarding such a system or procedure.

[0009]

To deal with problems occurring when a large amount of unstable power is connected to a synchronous grid, several conventional techniques as described below have been proposed. The techniques are roughly classified into the following three methods.

[0010]

A first conventional method is to enhance bulk power grids. That is, fluctuations in renewable energy power generation is remediated by enhancing high-voltage interconnection lines, installing back-to-back (BTB) loop controllers, increasing the capacity of frequency converter stations, increasing the capacity of DC interconnection lines between Hokkaido and Honshu, Japan, and increasing the number of gas turbine power generation facilities and variable speed hydroelectric power generation facilities as