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Power converter device

Abstract

This power converter device is appropriately configured. Accordingly, a power converter device comprises, for each phase of a three-phase AC, an AC wiring through which AC terminals of a plurality of power conversion units are series-connected along a second direction. Among the power conversion units, power conversion units that correspond to a first phase are series-connected from a first phase line toward a neutral line in a first direction along the second direction. Among the power conversion units, power conversion units that correspond to a second phase adjacent to the first phase are series-connected from a second phase line toward the neutral line in a second direction opposite to the first direction.

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Background/Summary

TECHNICAL FIELD

(1) The present invention relates to a power converter device.

BACKGROUND ART

(2) As a background art of the present technical field, the abstract of the following PTL 1 describes “An input transformer 1 having a plurality of secondary windings; a transformer panel 10 that houses: the input transformer 1; a three-phase inverter each phase of which is configured such that a plurality of series-connected unit inverters 2 that are each connected to the secondary windings on a one-to-one basis and each output a single-phase AC voltage of a desired frequency and in which three of the phases are Y-connected; and a converter panel 20 that houses the unit inverters 2 constituting the three-phase inverter, wherein the converter panel 20 has a plurality of support

pillars 22 made of insulator and a plurality of metal shelf plates 23 that laterally fasten neighboring support pillars of the plurality of support pillars 22, and the unit inverters 2 are each placed and fixed on the shelf plates 23.”.

(3) The abstract of PTL 2 below describes “a power conversion device according to an embodiment includes: a power converter including a leg that includes a plurality of unit converters connected in series and in which respective capacitors are charged and discharged by switching; a first disconnecter connected between one end of the leg and a ground; a second disconnecter connected between the other end of the leg and the ground; and a disconnection signal generation unit that supplies a disconnection signal to the first disconnecter and the second disconnecter. Each of the unit converters includes a first resistor and a second resistor connected in series to the first resistor. The capacitor is connected in parallel to a series connection body of the first resistor and the second resistor. After the power converter is stopped, the disconnection signal generation unit causes the first disconnecter and the second disconnecter to be conductive, by the disconnection signal.”.

CITATION LIST

Patent Literatures

(4) PTL 1: JP 2004-357436 A PTL 2: JP 2018-170832 A

SUMMARY OF INVENTION

Technical Problem

(5) Incidentally, there is a demand for more appropriately configuring the power converter device in the above-described technology.

(6) The present invention has been made in view of the above circumstances, and an object of the invention is to provide a power converter device that can be appropriately configured.

Solution to Problem

(7) In order to solve the above issue, a power converter device includes: a plurality of power conversion units each including a pair of alternating-current terminals and a power conversion circuit that performs power conversion on power input or output from the alternating-current terminals, the plurality of power conversion units being arranged along a first direction and a second direction different from the first direction; and alternating-current wires that connect in series along the second direction the alternating-current terminals, of the plurality of power conversion units, for each phase of three-phase alternating current, wherein power conversion units, of the power conversion units, corresponding to a first phase are connected in series in a first orientation along the second direction from a first phase line toward a neutral line, power conversion units, of the power conversion units, corresponding to a second phase adjacent to the first phase are connected in series in a second orientation opposite to the first orientation from a second phase line toward the neutral line, and power conversion units, of the power conversion units, corresponding to a third phase adjacent to the second phase are connected in series in the first orientation from a third phase line toward the neutral line.

Advantageous Effects of Invention

(8) The present invention enables the power converter device to be appropriately configured.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. 1 is a diagram illustrating a circuit configuration of a power conversion unit applied to a first embodiment.

(2) FIG. 2 is a schematic perspective view of the power conversion unit as viewed from the front side.

(3) FIG. 3 is a schematic perspective view of the power conversion unit as viewed from the back side.

- (4) FIG. 4 is a schematic perspective view of the power converter device according to the first embodiment as viewed from the front side.
- (5) FIG. 5 is a schematic perspective view of the power converter device as viewed from the back side.
- (6) FIG. 6 is a schematic vector diagram illustrating a voltage appearing on alternating-current wires.
- (7) FIG. 7 is a schematic perspective view of a power converter device according to a comparative example as viewed from the front side.
- (8) FIG. 8 is a schematic vector diagram illustrating a voltage appearing on alternating-current wires in the comparative example.

DESCRIPTION OF EMBODIMENTS

Outline of Embodiment

(9) When the contents of PTLs 1 and 2 described above are applied, it is considered that a multi-level power conversion device that mutually converts three-phase power and direct-current power can be configured by connecting power conversion units in series. The three-phase alternating-current voltage applied to this type of power conversion device is often a high voltage of about several kV to several tens of kV. Therefore, particularly regarding input and output points of the three-phase alternating current, an insulation design needs to be performed in consideration of voltages between lines, and there arises a problem that the power conversion device is accordingly larger. Therefore, an embodiment to be described later is intended to downsize the power conversion device by reducing the voltages between adjacent power conversion units.

First Embodiment

- (10) FIG. 1 is a diagram illustrating a circuit configuration of a power conversion unit **10** applied to a first embodiment.
- (11) In FIG. 1, the power conversion unit **10** includes an alternating current to direct current (AC/DC) conversion circuit **11** (power conversion circuit), a direct current to direct current (DC/DC) conversion circuit **12** (power conversion circuit), a pair of alternating-current (AC) terminals **14A** and **14B**, and a pair of direct-current (DC) terminals **16P** and **16N**. In the following description, the power conversion unit **10** is sometimes simply referred to as “unit”. The AC/DC conversion circuit **11** and the DC/DC conversion circuit **12** are each sometimes simply referred to as “circuit”. In addition, the alternating-current terminals **14A** and **14B** and the direct-current terminals **16P** and **16N** are each sometimes simply referred to as “terminal”.
- (12) When a power flow is directed from the terminals **14A** and **14B** to the terminals **16P** and **16N**, the AC/DC conversion circuit **11** converts single-phase alternating-current power supplied from the terminals **14A** and **14B** into direct-current power and supplies the direct-current power to the DC/DC conversion circuit **12**. In addition, the DC/DC conversion circuit **12** steps down the DC voltage supplied from the AC/DC conversion circuit **11** and outputs the stepped-down DC voltage from the direct-current terminals **16P** and **16N**. Conversely, when the power flow is directed from the terminals **16P** and **16N** to the terminals **14A** and **14B**, the circuit **12** steps up direct-current power input from the terminals **16P** and **16N** and supplies the stepped-up direct-current power to the circuit **11**. In addition, the circuit **11** converts the supplied direct-current power into alternating-current power and outputs the alternating-current power from the terminals **14A** and **14B**.
- (13) The DC/DC conversion circuit **12** is an insulation type conversion circuit. That is, although not illustrated, the DC/DC conversion circuit **12** includes: an isolation transformer; and bridge circuits each connected to one of a primary side and a secondary side of the transformer. These bridge circuits function as an inverter or a synchronous rectifier circuit in accordance with the direction of the power flow.
- (14) FIG. 2 is a schematic perspective view of the power conversion unit **10** as viewed from the front side.
- (15) In FIG. 2, an X-axis (first direction), a Y-axis (second direction), and a Z-axis are axes

orthogonal to each other. For example, the X axis is a horizontal direction, the Y axis is a vertical direction, and the Z axis is a depth direction. The unit **10** is formed in a substantially rectangular parallelepiped shape, and a front face plate **22** (first face) is formed in a substantially rectangular plate shape. On the front face plate **22** there are arranged the alternating-current terminals **14A** and **14B** along the Y-axis direction.

(16) FIG. **3** is a schematic perspective view of the power conversion unit **10** as viewed from the back side.

(17) Back face plate **24** (second face) of the unit **10** is also formed in a substantially rectangular plate shape. On the back face plate **24** there are also arranged the direct-current terminals **16P** and **16N** along the Y-axis direction.

(18) FIG. **4** is a schematic perspective view of the power converter device **100** according to the first embodiment as viewed from the front side.

(19) The power converter device **100** includes a plurality of the units **10**. These units **10** are two-dimensionally arranged along the X-axis direction (first direction) and the Y-axis direction (second direction). In the illustrated example, the power converter device **100** includes totally 12 number units **10** in three rows in the X-axis direction and four rows in the Y-axis direction. The positions of these units **10** are expressed in a format of “4xy”. Here, x is a coordinate value (1, 2, or 3) in the X-axis direction, and y is a coordinate value (1, 2, 3, or 4) in the Y-axis direction.

(20) A wire **401** (first phase line) and a wire **403** (third phase line) are respectively connected to the terminals **14A** of the units **10** on the left position **414** and the right position **434** on the uppermost end. A wire **402** (second phase line) is connected to the terminal **14B** of the unit **10** at the central position **421** on the lowermost end. In the present specification, the term “wire” has a meaning including a coated cable, a non-coated cable, a bus bar, and the like.

(21) A wire **404** (neutral line) is connected to the terminals **14B** of the units **10** at the left position **411** and the right position **431** on the lowermost end. The wire **404** is also connected to the terminal **14A** of the unit **10** at the central position **424** of the uppermost end. In addition, a total of nine (3×3) wires **406** are provided between the wires **404** and the wires **401** and **403**. These wires **406** connect the terminal **14B** on the upper stage side (for example, at the position **434**) and the terminal **14A** on the lower stage side (for example, at the position **433**).

(22) As a result, the unit **10** at the positions **411** to **414** are sequentially connected in series between the wire **404**, which is the neutral line, and the wire **401** of a U phase via the terminals **14A** and **14B** provided on the front face plates **22**. Similarly, the units **10** at the positions **431** to **434** are sequentially connected in series between the wire **404** and the wire **403** of a W phase via the terminals **14A** and **14B** provided on the front face plates **22**.

(23) The units **10** at the positions **421** to **424** are sequentially connected in series between the wire **402** of a V phase and the wire **404**, which is the neutral line, via the terminals **14A** and **14B** provided on the front face plates **22**. That is, the connection order of the units **10** at the positions **421** to **424** related to the V phase is opposite to the connection orders of the units **10** at the positions **411** to **414** and the positions **431** to **434** related to the U phase and the W phase. The above-described wires **401** to **406** are sometimes collectively referred to as “alternating-current wires **40**”. As illustrated in the drawing, the alternating-current wires **40** are arranged in parallel and linearly along the Y-axis direction.

(24) FIG. **5** is a schematic perspective view of the power converter device **100** as viewed from the back side.

(25) In FIG. **5**, regarding the units **10** at the positions **411**, **421**, and **431** at the lowermost stage, the terminals **16P** on the positive sides on the back face plates **24** are connected to a wire **51P**, and the terminals **16N** on the negative sides are connected to a wire **51N**. Similarly, regarding the units **10** at the second positions **412**, **422**, and **432** from the lowermost stage, the terminals **16P** on the positive sides on the back face plates **24** are connected to a wire **52P**, and the terminals **16N** on the negative sides are connected to a wire **52N**.

(26) Similarly, regarding the units **10** at the third positions **413**, **423**, and **433** from the lowermost stage, the terminals **16P** on the positive sides on the back face plates **24** are connected to a wire **53P**, and the terminals **16N** on the negative sides are connected to a wire **53N**. Similarly, regarding the units **10** at the positions **414**, **424**, and **434** on the uppermost stage, the terminals **16P** on the positive sides on the back face plates **24** are connected to a wire **54P**, and the terminals **16N** on the negative sides are connected to a wire **54N**. The wires **51P** to **54P** and **51N** to **54N** described above are sometimes collectively referred to as “direct-current wires **50**”.

(27) In the example illustrated in FIGS. **4** and **5**, the number of stages of the units **10** connected in series to each of the U, V, and W phases is “four”, but the number of stages of the units **10** is not limited to “four”. In the example described above, with respect to each of the units **10**, the alternating-current terminals **14A** and **14B** are disposed on the front face plate **22**, and the direct-current terminals **16P** and **16N** are disposed on the back face plate **24**. However, the surface on which the terminals **16P** and **16N** are arranged only needs to be a surface different from the surface on which the terminals **14A** and **14B** are arranged and is not limited to the above example.

(28) FIG. **6** is a schematic vector diagram illustrating a voltage appearing on the alternating-current wires **40**.

(29) The voltage V_{m1} shown in the drawing is a voltage appearing between the alternating-current terminals **14A** of the two units **10** at the positions **424** and **434** adjacent in the X-axis direction. As illustrated in the drawing, the voltage V_{m1} has a value equal to a phase voltage. The voltages other than the voltage V_{m1} are not illustrated; however, with respect to any of the alternating-current wires **40** adjacent in the X-axis direction, the voltage appearing in the adjacent pair of alternating-current wires **40** has a value equal to the phase voltage or a value equal to or less than the phase voltage.

Comparative Example

(30) Next, in order to clarify the effect of the above embodiment, a comparative example will be described. Note that, in the following description, portions corresponding to respective ones of the portions of the above-described embodiment are denoted by the same reference numerals, and the description thereof is sometimes omitted.

(31) FIG. **7** is a schematic perspective view of a power converter device **200** according to the comparative example as viewed from the front side.

(32) The power converter device **200** includes totally 12 number of units **10** similarly to the power converter device **100** (see FIG. **4**) according to the first embodiment. The connection state of the alternating-current wires **40** with respect to the units **10** of the U phase at the positions **411** to **414** and the units **10** of the W phase at the positions **431** to **434** of the power converter device **200** are similar to that in the above power converter device **100**.

(33) However, the connection state of the alternating-current wires **40** with respect to the units **10** of the V phase at the positions **421** to **424** is opposite to that of the power converter device **100**. That is, the wire **402** of the V phase is connected to the alternating-current terminal **14A** of the unit **10** at the central position **424** at the uppermost end. The wire **404** at a neutral point is connected to the terminal **14B** of the unit **10** at the central position **421** on the lowermost end. The configuration of the power converter device **200** other than that described above is similar to that of the power converter device **100** of the first embodiment.

(34) FIG. **8** is a schematic vector diagram illustrating a voltage appearing on alternating-current wires **40** in the comparative example.

(35) The voltage V_{m2} shown in the drawing is a voltage appearing between the alternating-current terminals **14A** of the two units **10** at the positions **424** and **434** adjacent in the X-axis direction. As illustrated in the drawing, the voltage V_{m2} has a value equal to 3 times the phase voltage. That is, the voltage V_{m2} is 3 times the voltage V_{m1} in the first embodiment. Accordingly, in the comparative example, it is necessary to set a distance between each unit **10** in the X-axis direction so as to secure an insulation distance in accordance with the voltage V_{m2} . As a result, the power

converter device **200** of the comparative example has a problem of being larger than the power converter device **100** of the first embodiment.

Effects of Embodiment

(36) As described above, in the power converter device **100** of the above embodiment, power conversion units **10**, of the power conversion units **10**, corresponding to the first phase (U phase) are connected in series in the first orientation (−Y) along the second direction (Y) from the first phase line (**401**) toward the neutral line (**404**), power conversion units **10**, of the power conversion units **10**, corresponding to the second phase (V phase) adjacent to the first phase (U phase) are connected in series in the second orientation (+Y) opposite to the first orientation (−Y) from the second phase line (**402**) toward the neutral line (**404**), and power conversion units **10**, of the power conversion units **10**, corresponding to the third phase (W phase) adjacent to the second phase (V phase) are connected in series in the first orientation (−Y) from the third phase line (**403**) towards the neutral line (**404**).

(37) As a result, the maximum value of the voltage difference generated between the alternating-current wires **40** can be suppressed, and the power converter device **100** can be appropriately configured, for example, the power converter device **100** can be downsized. For example, as compared with the power converter device **200** according to the above-described comparative example, the maximum value of the voltage difference generated between the alternating-current wires **40** can be reduced to “ $1/\sqrt{3}$ ” in the above-described embodiment. As a result, a creepage distance and a spatial distance for securing insulation can be reduced as compared with the comparative example, and the power converter device **100** can be downsized.

(38) Furthermore, it is more preferable that the alternating-current wires **40** be arranged in parallel and linearly along the second direction (Y). As a result, the creepage distance and the spatial distance for securing insulation can be efficiently utilized, and the power converter device **100** can be further downsized.

Modified Example

(39) The present invention is not limited to the above-described embodiment, and various modifications can be made. The above-described embodiment is exemplified for easy understanding of the present invention, and the present invention is not necessarily limited to an embodiment including all the described configurations. Furthermore, another configuration may be added to the configuration of the above embodiment, and a part of the configuration can be replaced with another configuration. In addition, the control lines and the information lines illustrated in the drawings indicate what is considered to be necessary for the description, and do not necessarily indicate all the control lines and the information lines necessary for the product. Actually, it may be considered that almost all the components are connected to each other.

Examples of a possible modification to the above embodiment include the followings.

(40) (1) In each of the above embodiments, the power conversion units **10** perform bidirectional power conversion between the alternating-current terminals **14A** and **14B** and the direct-current terminals **16P** and **16N**. However, the power conversion units **10** may perform unidirectional power conversion. Furthermore, the power conversion units **10** may input and output a single-phase alternating current and perform frequency conversion and voltage conversion.

REFERENCE SIGNS LIST

(41) **10** power conversion unit **11** AC/DC conversion circuit (power conversion circuit) **12** DC/DC conversion circuit (power conversion circuit) **14A**, **14B** alternating-current terminal **40** alternating-current wire **100** power converter device **401** wire (first phase line) **402** wire (second phase line) **403** wire (third phase line) **404** wire (neutral line) X axis (first direction) Y axis (second direction)

Claims

1. A power converter device comprising: a plurality of power conversion units each including a pair of alternating-current terminals and a power conversion circuit that performs power conversion on power input or output from the alternating-current terminals, the plurality of power conversion units being arranged along a first direction and a second direction different from the first direction; and alternating-current wires that connect, in series along the second direction, the alternating-current terminals, of the plurality of power conversion units, for each phase of three-phase alternating current, wherein power conversion units, of the power conversion units, corresponding to a first phase are connected in series in a first orientation along the second direction from a first phase line toward a neutral line, power conversion units, of the power conversion units, corresponding to a second phase adjacent to the first phase are connected in series in a second orientation opposite to the first orientation from a second phase line toward the neutral line, and power conversion units, of the power conversion units, corresponding to a third phase adjacent to the second phase are connected in series in the first orientation from a third phase line toward the neutral line.

2. The power converter device according to claim 1, wherein the alternating-current wires are arranged in parallel and linearly along the second direction.
