

Title of the Invention

ELECTRIC POWER CONVERTER APPARATUS FOR CONVERTING
ELECTRIC POWER BETWEEN DIRECT CURRENT AND ALTERNATING CURRENT

5 Background of the Invention

The present invention relates to an improvement of the main circuit construction in an electric power converter apparatus such as an inverter apparatus using self-arc-extinguishing switching elements.

10 In the past, the constructions of snubber circuit provided to a self-arc-extinguishing switching element in an inverter apparatus having a comparatively large capacity are disclosed in, for example, (1) Japanese Utility Model Application Laid-Open No.59-149489, (2) Japanese Utility Model Application
15 Laid-Open No.61-156490, (3) Japanese Utility Model Application Laid-Open No.62-41389, (4) Japanese Patent Application Laid-Open No.62-217864 and (5) Japanese Patent Application Laid-Open No.5-284731. That is, the snubber circuit is constructed by connecting a series-connected body of a capacitor and a
20 diode to a switching element in parallel, and connecting a resistor between a direct current lines in the opposite side of the junction point of the capacitor and the diode. Therewith, surge energy generated at switching-off time of the switching element is absorbed with the capacitor and the
25 absorbed surge energy is consumed by the resistor, which is called as a polarized snubber circuit.

In the above conventional technology, it is necessary that

all the surge energy generated at switching-off time of the switching element is absorbed with the capacitor in the polarized snubber circuit. Therefore, there is a disadvantage in that the capacity of the capacitor becomes large and the capacity of the resistor for consuming the absorbed energy
5 also becomes large.

Summary of the Invention

The object of the present invention is to realize a
10 compact electric power converter apparatus such as an inverter apparatus and a snubber by reducing the snubber capacity.

In an inverter apparatus comprising self-arc-extinguishing switching elements in each positive arm and each negative arm of each phase connected to a direct current power source, an
15 inverter for converting a direct current electric power to a variable voltage and variable frequency alternating electric power, a polarized snubber containing a series-connected body of a first capacitor and a diode connected to a self-arc-extinguishing switching element in each of the arms in
20 parallel, a resistor connected between the direct current power lines in the opposite side of the series junction point of the first capacitor and the diode, the inverter apparatus according to the present invention is characterized, in one aspect, by comprising a second capacitor connected between the
25 positive and negative lines of the direct current power in parallel source so as to stride across the positive and the negative arms in series for each phase.

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In another aspect, the present invention is characterized by containing the first series-connected body of capacitor and diode and the second capacitor for one phase in a package together.

5 By adding the second capacitor in addition to the polarized snubber, the first and the second capacitors share to absorb the surge energy generated at switching-off time of the switching element, and the capacity of the polarized snubber can be decreased. In this case, as to increasing the
10 capacity, it is better to connect and arrange the first and the second capacitors separately than to simply increasing only number of the first capacitors. Because, in the case of separate arrangement, the wiring distance from the switching element to the capacitor can be decreased, and the capacity
15 of each element in the snubber circuit can be effectively decreased. Therefore, the apparatus can be decreased in size and in weight.

Further, by containing the first capacitor, the diodes and the second capacitor in a package to form a module, the
20 wiring distance between the switching element and the snubber circuit element can be minimized, Therefore, the capacity of the snubber circuit element can be effectively decreased.

Brief Description of the Drawings

25 FIG.1 is a diagram showing an embodiment of an inverter circuit in accordance with the present invention.

FIG.2 is a perspective view showing an embodiment of a

snubber module in accordance with the present invention.

FIG.3 is a plan view showing an embodiment of an inverter apparatus in accordance with the present invention.

FIG.4 is a side view showing an embodiment of an inverter apparatus in accordance with the present invention.

FIG.5 is a front view showing an embodiment of an inverter apparatus in accordance with the present invention.

Detailed Description of the preferred Embodiment

FIG.1 is a diagram showing an embodiment of an inverter circuit in accordance with the present invention.

A direct current electric power is supplied to an inverter 4 from a direct current power source 1, 2 through a smoothing capacitor 3. The inverter 4 converts the direct current into a variable voltage and variable frequency (VVVF) alternating electric power to be supplied to a three phase induction motor 5. The induction motor 5 rotates a sheave 7 through a gearbox 6 to drive an elevator car 8 and a counterweight 9 upward and downward.

The inverter 4 has a positive and a negative arms for each phase with self-arc-extinguishing switching elements, for example, self-arc-extinguishing switching elements (IGBTs) 101-106. These IGBTs are PWM controlled by a gate signal generating circuit 11.

The self-arc-extinguishing switching element requires a snubber for absorbing energy at arc-extinguishing (switching-off) time. As the same as a construction in the prior art,

series-connected bodies of capacitors 201-206 and diodes 301-306 are connected to the self-arc-extinguishing switching elements (IGBTs) 101-106 in parallel, respectively. The series junction points of these series-connected bodies are connected
5 to the direct current electric power source line N or P through resistors 401-406, respectively.

Further, in this embodiment according to the present invention, second capacitors 501-503 for respective phase are connected between the positive and the negative lines P, N of
10 the direct current electric power source so as to stride across the series-connected positive and negative arms for respective phase in parallel.

Function of the snubber will be described below, taking U-phase as an example.

15 Now, taking a case where the switching element 101 is to be arc-extinguished under a condition that the switching element 101 is in an arcking state and the switching element 102 is in an arc-extinguishing state. The current flowing in the switching element 101 is rapidly cut off, and a serge
20 voltage generated between the both terminals of the switching element 101. Then, the same voltage is applied to the series-connected body of the capacitor 201 and the diode 301, and the diode 301 immediately becomes conducting to absorb the serge energy in the capacitor 201. That is, the capacitor 201 is
25 charged in the direction shown by +, - in the figure. Then, when the switching element 101 is turns on again, the energy absorbed in such a manner is consumed while flowing through

the route, the capacitor 201 (+) → the direct current line P
 → IGBT 101 → the alternating current line U → the induction
 motor 5 → the alternating current line V → IGBT 104 (or, the
 alternating current line W → IGBT 106) → the direct current
 5 line N → the resistor 401 → the capacitor 201 (-).

Similarly, when the switching element 102 is arc-
 extinguished under a condition that the switching element 101
 is in an arcking state and the switching element 102 is in an
 arc-extinguishing state, the current flowing in the switching
 10 element 102 is rapidly cut off, and a surge voltage generated
 between the both terminals of the switching element 102. Then,
 the same voltage is applied to the series-connected body of
 the capacitor 202 and the diode 302, and the diode 302
 immediately becomes conducting to absorb the surge energy in
 15 the capacitor 201. That is, the capacitor 202 is charged in
 the direction shown by +, - in the figure. Then, when the
 switching element 102 is turns on again, the energy absorbed
 in such a manner is consumed while flowing through the route,
 the capacitor 202 (+) → the resistor 402 → the direct current
 20 line P → IGBT 103 → the alternating current line V (or, IGBT
 105 → the alternating current line W) → the induction motor
 5 → the alternating current line U → IGBT 102 → the direct
 current line N → the capacitor 202 (-).

In the above cases, when the charged voltage of the
 25 capacitor 201 or 201 exceeds the voltage of the electric power
 source, the surge energy is absorbed in the capacitor 501 at
 the same time in either case. Then the energy is returned to

the power source or consumed in the whole circuit wiring. That is, the charge of the capacitor 201 exceeding the electrical power source voltage of the direct current source 1, 2 is absorbed in the capacitor 501 through the capacitor 201 (+) → the capacitor 501 → the direct current line N → the resistor 401 → the capacitor 201 (-). On the other hand, the charge of the capacitor 202 exceeding the electrical power source voltage of the direct current source 1, 2 is absorbed in the capacitor 501 through the capacitor 202 (+) → the resistor 402 → the direct current line P → the capacitor 501 → the capacitor 202 (-).

Then, the energy absorbed in the capacitor 501 is resonated between the smoothing capacitor 3 in the direct current power source side with the inductance contained in the wiring to be dispersed in the whole circuit wiring, and is consumed and disappears.

Therein, not only the capacity of the capacitors 201, 202 can be decreased by the amount corresponding to the energy absorbed by the capacitor 501, but also the capacity of the diodes 301, 302 can be decreased since the in-flow energy decreases by the decreased capacity of the capacitors 201, 202. Further, since the amount of energy to be consumed is decreased, the capacity of the resistors 401, 402 can be also decreased.

FIG.2 is a perspective view showing a snubber module 601 in which the capacitors 201, 202, 501 and the diodes 301, 302 are contained in a package. The module 601 has terminals 741,

751 for connecting to the resistors as well as the direct current terminals 711, 721 and the alternating current terminals 731 shown in FIG.1. By minimizing the wiring distance between the elements in such a manner, the inductance of the wiring can be decreased, the capacitor 501 effectively absorbs energy, and consequently the capacity of each of the elements can be further decreased.

FIG.3 to FIG.5 are a plan view, a side view and a front view showing the construction of the inverter shown in FIG.1.

IGBT modules 81 to 83 are fixed to and mounted on a cooling fin 80 with spacing. Further, snubber modules 601 to 603 are mounted on the IGBT modules 81 to 83, respectively. Specifically, three terminals of the snubber modules 601 to 603, that is, the direct current terminals 711, 721 and the alternating current terminal 731 are used as screws for fixing. By doing so, the wiring distance between each of the switching elements and the snubber can be minimized, and the snubber can be decreased in capacity and in size.

The snubber resistors 401-406 are contained in a resistor box 84 together and cooled separately.

According to the present invention, the capacity of the snubber apparatus can be decreased and the main circuit of an electric power converter apparatus such as an inverter can be decreased in size.



WHAT IS CLAIMED IS;

1. An electric power converter apparatus for converting an electric power between a direct current and an alternating current by connecting two arms having a self-arc-extinguishing type switching element in series between direct current lines for each phase, junction points of the series connection being used as alternating current terminals, which comprises
 - a capacitor connected to each of said self-arc-extinguishing switching elements in parallel; and
 - 10 a capacitor connecting between said direct current lines in parallel for each phase.

2. An electric power converter apparatus for converting an electric power between a direct current and an alternating current by connecting two arms having a self-arc-extinguishing type switching element in series between direct current lines for each phase, junction points of the series connection being used as alternating current terminals, which comprises
 - a capacitor connected to each of said arms in parallel;
 - 20 and
 - a capacitor connecting between said direct current lines in parallel for each phase.

3. An electric power converter apparatus for converting an electric power between a direct current and an alternating current by connecting two arms having a self-arc-extinguishing type switching element in series between direct current lines



for each phase, junction points of the series connection being used as alternating current terminals, which comprises

a snubber connected to each of said arms in parallel; and

a capacitor connecting between said direct current lines
5 in parallel for each phase.

4. An electric power converter apparatus for converting a direct current electric power to a variable voltage and variable frequency alternating current by connecting two arms
10 having a self-arc-extinguishing type switching element in series between direct current lines for each phase, junction points of the series connection being used as alternating current terminals, which comprises

a series-connected body of capacitor and diode connected
15 to a self-arc-extinguishing element in each arm in parallel;

a resistor connected between the junction point of the series connection of capacitor and diode and said direct current power line in the opposite side of the junction point of the series connection; and

20 a second capacitor connected between said direct current lines in parallel so as to stride across a positive and a negative arms connected in series for each phase.

5. An electric power converter apparatus for converting a
25 direct current electric power to a variable voltage and variable frequency alternating current by connecting two arms having a self-arc-extinguishing type switching element in



series between direct current lines for each phase, junction points of the series connection being used as alternating current terminals, which comprises

a polarized snubber connected to a self-arc-extinguishing
5 element in each arm in parallel; and

a capacitor connected between said direct current lines in parallel so as to stride across said polarized snubbers in a positive and a negative arms for each phase.

10 6. An electric power converter apparatus for converting a direct current electric power to a variable voltage and variable frequency alternating current by connecting two arms having a self-arc-extinguishing type switching element in series between direct current lines for each phase, junction
15 points of the series connection being used as alternating current terminals, which comprises

a resistor connected between a first series-connected body of capacitor and diode connected to a self-arc-extinguishing element in each of said arms in parallel and a resistor
20 connected between the junction point of the first series connection of capacitor and diode and said direct current power line in the opposite side of the junction point of the series connection;

a second capacitor connected between said direct current
25 lines in parallel so as to stride across a positive and a negative arms connected in series for each phase; and

a package for containing two set of said first series-



connected bodies of capacitor and diode, and said second capacitor for one phase together.

7. An electric power converter apparatus for converting a
5 direct current electric power to a variable voltage and
variable frequency alternating current by connecting two arms
having a self-arc-extinguishing type switching element in
series between direct current lines for each phase, junction
points of the series connection being used as alternating
10 current terminals, which comprises

a polarized snubber circuit containing a capacitor, the
polarized snubber circuit being connected to a self-arc-
extinguishing element in each arm in parallel;

a second capacitor connected between said direct current
15 lines in parallel so as to stride across said polarized snubber
circuits in a positive and a negative arms for each phase; and

a package for containing said capacitor in said polarized
snubber circuit and said second capacitor for one phase
together.

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8. An electric power converter apparatus as defined in claim
1, further comprising a snubber constructed with a series-
connected body of a first capacitor, a first diode, a second
diode and a second capacitor; and a third capacitor connected
25 to the series-connected body in parallel.

9. An electric power converter apparatus as defined in claim



1, further comprising a snubber constructed with a series-connected body of a first capacitor, a first diode, a second diode and a second capacitor; and a third capacitor connected to the series-connected body in parallel; and a package for
5 containing the series-connected body and the third capacitor together, two end terminals of said series-connected body and three terminals of the junction points of each series-connected body being led out of the package as connecting terminals.

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10. An electric power converter apparatus for converting a direct current electric power to a variable voltage and variable frequency alternating current by connecting two arms having a self-arc-extinguishing type switching element in
15 series between direct current lines for each phase, junction points of the series connection being used as alternating current terminals, which comprises

a snubber connected to a self-arc-extinguishing element in each arm;

20 a first package for containing said two sets of self-arc-extinguishing switching elements for one phase;

a cooling fin mounting three of said first packages for three phase;

a second capacitor connected between said direct current
25 power lines in parallel so to stride across a positive and a negative arms of each phase; and

a second package for containing said snubber and said



second capacitor for one phase together, the second package being mounted on said corresponding first package.

11. An electric power converter apparatus according to claim
5 10, which comprises a third package for containing three sets of resistors, each set of the resistors being connected to the second package for each phase.