[0005] In the techniques introduced in these documents, however, a period of charge from a rectifying circuit to a capacitor, and a period of discharge from the capacitor to the inverter are set alternately at each 1/4 of a cycle of an input AC voltage. For this reason, a magnitude of an output voltage remains at $1/\sqrt{2}$ times a crest value of the input AC voltage.

[0006] Further, an operation of the boost chopper is performed in a so-called non-continuous mode, and thus a peak current to flow in an inductor included in the boost chopper tends to be large.

[0007] ~~It is, therefore, an objeet~~Embodiments of the present invention seek to reduce a peak current to flow in an inductor included in a boost chopper. Further, ~~it is another objeet~~ embodiments of the present invention seek to provide a technique that makes an output voltage from a direct AC power converter higher than a conventional technique.

Means for Solving the Problems

[0007a] According to a first aspect of the present invention, there is provided a direct AC power converter comprising: a DC link having a first power supply line and a second power supply line, an electric potential lower than an electric potential of said first power supply line being applied to said second power supply line; a first rectifying circuit having a plurality of input terminals that input an AC voltage and a pair of output terminals, each of which is connected to said DC link; an inverter that converts a voltage applied to said DC link into another AC voltage; a boost chopper having a capacitor at an output stage; and a switch that performs discharge/non-discharge from said capacitor to said DC link, wherein in said boost chopper, charge into said capacitor is performed at least at a first period being a part of a period during which a discharge duty as a time ratio of continuity of said switch is larger than 0.

[0008] A direct AC power converter in embodiments of the present invention includes a DC link (7), a first rectifying circuit (5, 51), a boost chopper (3), and a switch (41).

[0009] The DC link has a first power supply line (L1), and a second power supply line (L2) to which an electric potential lower than an electric potential of the first power supply line is applied.

[0010] The first rectifying circuit has a plurality of input terminals into which an AC voltage is input, and a pair of output terminals (51c and 51d) each of which is connected to the DC link.

[0011] The inverter converters the voltage applied to the DC link into another AC voltage.

[0012] The boost chopper has a capacitor (34) at an output stage.

[0013] The switch performs discharge/non-discharge from the capacitor to the DC link.

[0014] ~~In a first aspect of a direct AC power converter according~~ According to embodiments of the present invention, charge into the capacitor is performed in the boost chopper at least at a first period that is a part of a period during which a discharge duty (dc) is larger than 0.

[0015] The discharge duty is a time ratio at which the switch is conductive.

[0016] ~~In a second aspect of the direct AC power converter according to the present invention, in the first aspect~~ In an embodiment, the capacitor is charged in the boost chopper at the first period, and a part or entire of the period during which the discharge duty is 0.

[0017] ~~In a third aspect of the direct AC power converter according to the present invention, in any one of the first and second aspects~~ In an embodiment, the capacitor (34) is charged/discharged by a charge power (Pci) and a discharge power (Pco) at the first period, and the first period has a period during which the charge power is larger than the discharge power, and a period during which the discharge power is larger than the charge power.

[0018] ~~In a fourth aspect of the direct AC power converter according to the present invention~~ In an embodiment, ~~in any one of the first to third aspects,~~ a virtual DC link voltage (Vdc) is larger than $1/\sqrt{2}$ times the rectified voltage.

[0019] The virtual DC link voltage is expressed by a sum of a product (dc • Vc) of the discharge duty (dc) and a voltage between both ends (Vc) of the capacitor (34), and a product (dr • Vrec) of a rectifying duty (dr) and a rectified voltage (Vrec) of the AC voltage.

[0020] The rectifying duty takes a value obtained by subtracting a sum of the discharge duty and a zero voltage duty (dz) from 1.

[0021] The zero voltage duty is a time ratio for the inverter (6) to adopt a zero voltage vector regardless of a magnitude of a voltage to be output from the inverter (6).

[0022] ~~In a fifth aspect of the direct AC power converter according to the present invention, in any one of the first to fourth aspects~~ In an embodiment, the discharge duty for that makes the zero voltage duty (dz) minimum is set based on a command value (irec*) of a rectified current (irec) being a sum of an electric current (ib) flowing in the boost chopper (3) and an electric current (idirect) flowing from the first rectifying circuit to the inverter (6), a command value (Vdc*) of the virtual DC link voltage (Vdc), the voltage between both ends (Vc) of the capacitor, the rectified voltage (Vrec), and an electric current (idc) to be input into the inverter (6).

[0023] Desirably, when the virtual DC link voltage (Vdc) is larger than the rectified voltage (Vrec) and the command value (irec*) of the rectified current (irec) is a predetermined value (dr_max) or more, the rectifying duty (dr) takes the predetermined value, and the discharge duty (dc) takes a value obtained by subtracting the predetermined value from 1.

[0024] The predetermined value is a value ((Vdc*-Vc)/(Vrec-Vc)) obtained by dividing a value obtained by subtracting the voltage between both ends (Vc) of the capacitor from the command value (Vdc*) of a virtual DC link voltage (Vdc) by a value obtained by subtracting the voltage between both ends (Vc) from the rectified voltage (Vrec).

[0025] ~~In a seventh aspect of the~~ The direct AC power converter may ~~according to the present invention, in any of the first to sixth aspects,~~ further includes a second rectifying circuit (52) for inputting the rectified voltage (Vrec) into the boost chopper (3).

[0026] ~~In an eighth aspect of the direct AC power converter according to the present invention, in any of the first to sixth aspects~~ In an embodiment, the pair of output terminals of the first rectifying circuit is connected to an input side of the boost chopper.

[0027] ~~In a ninth aspect of the direct AC power converter according to the present~~

~~invention, in any of the first to eighth aspects~~ In an embodiment, the discharge duty ~~(de)~~ is always positive.

[0028] ~~A tenth aspect of the~~ The direct AC power converter may ~~according to the present invention, in any of the first to ninth aspects,~~ further includes a diode parallel with the switch (41), the diode making a direction of charging the capacitor (34) from the DC link (7) being a forward direction.

Effects of the Invention

[0029] The capacitor is charged in the boost chopper at least at a part of the period during which the discharge duty is larger than 0, so that an average value of a maximum value of a voltage capable of being output from the inverter at a cycle of controlling the switching of the inverter can exceed $1/\sqrt{2}$ time a crest value of an AC voltage.

[0030] In another manner, even when the average value does not exceed $1/\sqrt{2}$ times the crest value of the AC voltage, a period of charging the capacitor can be set to be longer than the period in a conventional technique, thus, a peak value of an electric current to flow in an inductor included in the boost chopper can be reduced so as to be smaller than the value in a conventional technique.

[0031] Objects, features, aspects and advantages of the present invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings.

Brief Description of Drawings

[0032] [Fig. 1] A circuit diagram illustrating a configuration of a direct AC power converter according to this embodiment.

[Fig. 2] A circuit diagram illustrating another configuration of the direct AC power converter according to the embodiment.

CLAIMS

1. A direct AC power converter comprising:

a DC link ~~(7)~~ having a first power supply line ~~(L1)~~ and a second power supply line ~~(L2)~~, an electric potential lower than an electric potential of said first power supply line being applied to said second power supply line;

a first rectifying circuit ~~(5, 51)~~ having a plurality of input terminals that input an AC voltage and a pair of output terminals ~~(51c, 51d)~~, each of which is connected to said DC link;

an inverter ~~(6)~~ that converts a voltage applied to said DC link into another AC voltage;

a boost chopper ~~(3)~~ having a capacitor ~~(34)~~ at an output stage; and

a switch ~~(41)~~ that performs discharge/non-discharge from said capacitor to said DC link,

wherein in said boost chopper, charge into said capacitor is performed at least at a first period being a part of a period during which a discharge duty ~~(dc)~~ as a time ratio of continuity of said switch is larger than 0.

2. The direct AC power converter according to claim 1, wherein said capacitor ~~(34)~~ is charged in said boost chopper at said first period and a part or an entire of the period during which said discharge duty ~~(dc)~~ is 0.

3. The direct AC power converter according to claim 2, wherein

said capacitor ~~(34)~~ is charged/discharged by a charge power ~~(Pei)~~ and a discharge power ~~(Peo)~~ at said first period, and

said first period has a period during which said charge power is larger than said discharge power, and a period during which said discharge power is larger than said

charge power.

4. The direct AC power converter according to claim 2, wherein

a virtual DC link voltage ~~(Vdc)~~ represented by a sum of a product ~~(dc*Vc)~~ of said discharge duty ~~(dc)~~ and a voltage between both ends ~~(Vc)~~ of said capacitor ~~(34)~~ and a product ~~(dr*Vrec)~~ of a rectifying duty ~~(dr)~~ and a rectified voltage ~~(Vrec)~~ of said AC voltage is larger than $1/\sqrt{2}$ times said rectified voltage,

said rectifying duty takes a value obtained by subtracting a sum of said discharge duty and a zero voltage duty ~~(dz)~~ from 1,

said zero voltage duty is a time ratio for said inverter ~~(6)~~ to take on a zero voltage vector regardless a magnitude of a voltage output from said inverter ~~(6)~~.

5. The direct AC power converter according to claim 3, wherein

a virtual DC link voltage ~~(Vdc)~~ represented by a sum of a product ~~(dc*Vc)~~ of said discharge duty ~~(dc)~~ and a voltage between both ends ~~(Vc)~~ of said capacitor ~~(34)~~ and a product ~~(dr*Vrec)~~ of a rectifying duty ~~(dr)~~ and a rectified voltage ~~(Vrec)~~ of said AC voltage is larger than $1/\sqrt{2}$ times said rectified voltage,

said rectifying duty takes a value obtained by subtracting a sum of said discharge duty and a zero voltage duty ~~(dz)~~ from 1,

said zero voltage duty is a time ratio for said inverter ~~(6)~~ to take a zero voltage vector regardless a magnitude of a voltage output from said inverter ~~(6)~~.

6. The direct AC power converter according to claim 2, wherein

said discharge duty that makes said zero voltage duty ~~(dz)~~ minimum is set based on a command value ~~(irec*)~~ of a rectified current ~~(irec)~~ being a sum of an electric current ~~(ib)~~ flowing in said boost chopper ~~(3)~~ and an electric current ~~(idirect)~~ flowing from said first rectifying circuit to said inverter ~~(6)~~, a command value ~~(Vdc*)~~ of said virtual DC link voltage ~~(Vdc)~~, the voltage between both ends ~~(Vc)~~ of said capacitor, said rectified voltage

(Vrec), and an electric current (ide) to be input into said inverter (6).

7. The direct AC power converter according to claim 3, wherein

said discharge duty that makes said zero voltage duty (dz) minimum is set based on a command value (irec*) of a rectified current (irec) being a sum of an electric current (ib) flowing in said boost chopper (3) and an electric current (idirect) flowing from said first rectifying circuit to said inverter (6), a command value (Vdc*) of said virtual DC link voltage (Vdc), the voltage between both ends (Vc) of said capacitor, said rectified voltage (Vrec), and an electric current (ide) to be input into said inverter (6).

8. The direct AC power converter according to claim 4, wherein

said discharge duty that makes said zero voltage duty (dz) minimum is set based on a command value (irec*) of a rectified current (irec) being a sum of an electric current (ib) flowing in said boost chopper (3) and an electric current (idirect) flowing from said first rectifying circuit to said inverter (6), a command value (Vdc*) of said virtual DC link voltage (Vdc), the voltage between both ends (Vc) of said capacitor, said rectified voltage (Vrec), and an electric current (ide) to be input into said inverter (6).

9. The direct AC power converter according to claim 6, wherein

when said virtual DC link voltage (Vdc) is larger than said rectified voltage (Vrec) and said command value (irec*) of said rectified current (irec) is a predetermined value (dr_max) or more, said rectifying duty (dr) takes said predetermined value, and said discharge duty (de) takes a value obtained by subtracting said predetermined value from 1,

said predetermined value is a value ((Vdc*-Vc)/(Vrec-Vc)) obtained by dividing a value obtained by subtracting said voltage between both ends (Vc) of said capacitor from said command value (Vdc*) of a virtual DC link voltage (Vdc) by a value obtained by subtracting said voltage between both ends (Vc) from said rectified voltage

(Vrec).

10. The direct AC power converter according to claim 7, wherein

when said virtual DC link voltage (Vdc) is larger than said rectified voltage (Vrec) and said command value (irec*) of said rectified current (irec) is a predetermined value (dr_max) or more, said rectifying duty (dr) takes said predetermined value, and said discharge duty (dc) takes a value obtained by subtracting said predetermined value from 1, and

said predetermined value is a value ((Vdc*-Ve)/(Vrec-Ve)) obtained by dividing a value obtained by subtracting said voltage between both ends (Ve) of said capacitor from said command value (Vdc*) of a virtual DC link voltage (Vdc) by a value obtained by subtracting said voltage between both ends (Ve) from said rectified voltage (Vrec).

11. The direct AC power converter according to claim 8, wherein

when said virtual DC link voltage (Vdc) is larger than said rectified voltage (Vrec) and said command value (irec*) of said rectified current (irec) is a predetermined value (dr_max) or more, said rectifying duty (dr) takes said predetermined value, and said discharge duty (dc) takes a value obtained by subtracting said predetermined value from 1, and

said predetermined value is a value ((Vdc*-Ve)/(Vrec-Ve)) obtained by dividing a value obtained by subtracting said voltage between both ends (Ve) of said capacitor from the command value (Vdc*) of a virtual DC link voltage (Vdc) by a value obtained by subtracting said voltage between both ends (Ve) from said rectified voltage (Vrec).

12. The direct AC power converter according to claim 1, further comprising a second rectifying circuit (52) for inputting said rectified voltage (Vrec) into said boost

chopper ~~(3)~~.

13. The direct AC power converter according to claim 2, further comprising a second rectifying circuit ~~(52)~~ for inputting said rectified voltage ~~(Vrec)~~ into said boost chopper ~~(3)~~.

14. The direct AC power converter according to claim 1, wherein said pair of output terminals of said first rectifying circuit is connected to an input side of said boost chopper.

15. The direct AC power converter according to claim 2, wherein said pair of output terminals of said first rectifying circuit is connected to an input side of said boost chopper.

16. The direct AC power converter according to claim 1, wherein said discharge duty ~~(de)~~ is always positive.

17. The direct AC power converter according to claim 2, wherein said discharge duty ~~(de)~~ is always positive.

18. The direct AC power converter according to claim 1, further comprising:

a diode parallel with said switch ~~(41)~~, said diode making a direction of charging said capacitor ~~(34)~~ from said DC link ~~(7)~~ being a forward direction.

19. The direct AC power converter according to claim 2, further comprising:

a diode parallel with said switch ~~(41)~~, said diode making a direction of charging said capacitor ~~(34)~~ from said DC link ~~(7)~~ being a forward direction.