

CHARGER AND RAILWAY VEHICLE

[0001] The present application claims priorities to Chinese Invention Patent Application No. 201811481525.6, titled "CHARGER AND RAILWAY VEHICLE", filed on December 5, 2018 with the Chinese Patent Office, and Chinese Utility Model Patent Application No. 201822038027.6, titled "CHARGER AND RAILWAY VEHICLE", filed on December 5, 2018 with the Chinese Patent Office, both of which are incorporated herein by reference in their entireties.

FIELD

[0002] The present disclosure relates to the technical field of railway vehicles, and in particular to a charger and a railway vehicle.

BACKGROUND

[0003] With the continuous development of railway transportation, railway vehicles such as high-speed trains having a high operation speed are developed.

[0004] In the railway vehicles, a charger is used to convert the three-phase high voltage alternating current power of 380V/50Hz into the direct current power of 110V applicable to a storage battery, a direct current system of 110V and a load connected with the charger. That is, the charger is required to have a function of supplying power to the storage battery, the direct current system of 110V and the connected load requiring the direct current power of 110V in a case that a power supply source is the three-phase high voltage alternating current power of 380V/50Hz, The total power of the charger is (2×30)kW.

[0005] In the conventional technology, the charger is mainly composed of two identical power modules. Each of the power modules charges a group of storage batteries. Outputs of 110V of the two power modules are connected in parallel with each other via a decoupling diode to supply power to the load. The heat dissipating is achieved by forced air cooling. Due to a circuit structure of the charger in the conventional technology, the charger in the conventional technology has disadvantages of a large size, a large total weight and low efficiency, not facilitating lightweight design of the vehicle.

SUMMARY

[0006] In order to solve the above technical problems, a charger and a railway vehicle are provided in the present disclosure, to reduce a total size and a total weight of the charger and improve efficiency of the charger.

[0007] To achieve the above technical object, the following technical solutions are provided according to embodiments of the present disclosure.

[0008] A charger applied to a railway vehicle is provided. The charger includes an input filtering circuit, a power module connected to the input filtering circuit, and an output circuit connected to the power module. The input filtering circuit is configured to filter a received input alternating current voltage and transfer the filtered input alternating current voltage to the power module. The power module includes a first power unit and a second power unit each configured to rectify and reduce the filtered input alternating current voltage to obtain a direct current voltage. The output circuit includes a first output unit and a second output unit each configured to process the direct current voltage to output multiple output voltages. A transistor in the power unit is a silicon carbide transistor.

[0009] Specifically, the power unit includes a pre-charge unit, a rectification unit, a voltage conversion unit, and a filtering unit. The pre-charge unit includes a first output branch and a second output branch. The pre-charge unit is configured to: receive the filtered input alternating current voltage; output a pre-charge current via the first output branch in a case that an output voltage of the pre-charge unit is less than a preset voltage threshold; and output the pre-charge current via the second output branch in a case that the output voltage of the pre-charge unit is not less than the preset voltage threshold. The rectification unit is configured to receive the pre-charge current, rectify the pre-charge current, and perform a first filtering process on the pre-charge current, to obtain a to-be-reduced direct current voltage. The voltage conversion unit is configured to reduce the to-be-reduced direct current voltage, to obtain a to-be-filtered direct current voltage. The filtering unit is configured to perform a second filtering process on the to-be-filtered direct current voltage to obtain the direct current voltage to be transferred to the output circuit.

[0010] Specifically, the first output branch in the pre-charge unit includes: a first switch group including three first switches and a first resistor group including three first resistors.

Each of the first switches and one of the first resistors form one of first pre-charge branches. The second output branch in the pre-charge unit includes a second switch group including three second switches. Each of the second switches forms one of second pre-charge branches. Each of the first pre-charge branches is connected in parallel with one of the second pre-charge branches. The first switch is turned on in the case that the output voltage of the pre-charge unit is less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit is not less than the preset voltage threshold. The second switch is turned on in the case that the output voltage of the pre-charge unit is not less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit is less than the preset voltage threshold.

[0011] Specifically, the rectification unit includes: three rectification branches that are connected in parallel with each other, and a first filtering branch, a second filtering branch and a third filtering branch that are connected in parallel with each of the rectification branches. Each of the rectification branches includes a first diode and a second diode that are connected in series with each other. A cathode of the first diode is connected to an anode of the second diode. The pre-charge current is received at a node connecting the cathode of the first diode and the anode of the second diode. Each of the first diode and the second diode is a silicon carbide Schottky diode. The first filtering branch includes a first capacitor and a second resistor that are connected in series with each other. The second filtering branch includes a second capacitor. The third filtering branch includes a third resistor.

[0012] Specifically, the filtering unit includes a first inductor and a third capacitor. One terminal of the first inductor is connected to a first output terminal of the voltage conversion unit, and the other terminal of the first inductor is connected to one terminal of the third capacitor and serves as a first output terminal of the filtering unit. The other terminal of the third capacitor that is remote from the first inductor is connected to a second output terminal of the voltage conversion unit and serves as a second output terminal of the filtering unit.

[0013] Specifically, the output unit includes a third diode, a first output branch, a second output branch, a third output branch, a fourth output branch and a fifth output branch. An anode of the third diode is connected to the first output terminal of the filtering unit, and a cathode of the third diode is connected to each of the first output branch, the second output branch, the third output branch and the fourth output branch of the output unit. The fifth

output branch of the output unit includes a fifth fuse. One terminal of the fifth fuse is connected to the second output terminal of the filtering unit, and one of the output voltages is outputted from the other terminal of the fifth fuse. The first output branch of the output unit includes a first fuse and a third switch that are sequentially connected in series with each other and is configured to output one of the output voltages. The second output branch of the output unit includes a second fuse and a fourth switch that are sequentially connected in series with each other and is configured to output one of the output voltages. The third output branch of the output unit includes a fourth diode and a third fuse that are sequentially connected in series with each other and is configured to output one of the output voltages. The fourth output branch of the output unit includes a fourth fuse.

[0014] Specifically, a power switch transistor in the voltage conversion unit is a silicon carbide metal-oxide-semiconductor field-effect transistor.

[0015] A railway vehicle is provided. The railway vehicle includes the charger described above.

[0016] It can be seen from the above technical solutions that, a charger and a railway vehicle are provided according to the embodiments of the present disclosure. A transistor in a power unit of the charger is a silicon carbide transistor. The silicon carbide transistor has features of a high switching frequency and a low switching loss, which facilitates reduction of weights of passive devices such as a voltage conversion device and a filtering inductor in the charger, and facilitates improving of operating efficiency of the charger, thereby reducing a total size and a total weight of the charger and improving the efficiency of the charger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In order to more clearly illustrate technical solutions in embodiments of the present disclosure or in the conventional technology, the drawings to be used in the description of the embodiments or the conventional technology are briefly described below. Apparently, the drawings in the following description show only the embodiments of the present disclosure, and other drawings may be obtained by those skilled in the art from the drawings without any creative work.

[0018] Figure 1 is a schematic structural diagram of a charger according to an embodiment

of the present disclosure;

[0019] Figure 2 is a schematic structural diagram of a charger according to another embodiment of the present disclosure;

[0020] Figure 3 is a schematic structural diagram of a charger according to another
5 embodiment of the present disclosure;

[0021] Figure 4 is a schematic structural diagram of a charger according to another embodiment of the present disclosure;

[0022] Figure 5 is a schematic structural diagram showing a specific implementation of the charger according to the embodiments of the present disclosure; and

10 [0023] Figure 6 is a schematic structural diagram showing a specific implementation of the charger according to the embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0024] The technical solutions in the embodiments of the present disclosure are described
15 clearly and completely in conjunction with the drawings in the embodiments of the present disclosure hereinafter. It is apparent that the described embodiments are only some embodiments of the present disclosure, rather than all embodiments. All other embodiments obtained by those skilled in the art based on the embodiments of the present disclosure without any creative work fall within the protection scope of the present disclosure.

20 [0025] A charger applied to a railway vehicle is provided according to an embodiment of the present disclosure. As shown in Figure 1, the charger includes an input filtering circuit 100, a power module connected to the input filtering circuit 100, and an output circuit 300 connected to the power module.

[0026] The input filtering circuit 100 is configured to filter a received input alternating
25 current voltage and transfer the filtered input alternating current voltage to the power module.

[0027] The power module includes a first power unit 210 and a second power unit 220. The power unit is configured to rectify and reduce the filtered input alternating current voltage to obtain a direct current voltage.

[0028] The output circuit 300 includes a first output unit and a second output unit. The

output unit is configured to process the direct current voltage to output multiple output voltages.

[0029] A transistor in the power unit is a silicon carbide transistor.

[0030] In this embodiment, the transistor in the power unit of the charger is a silicon carbide transistor. The silicon carbide transistor has features of a high switching frequency and low switching loss, which facilitates reduction of weights of passive devices such as a voltage conversion device and a filtering inductor in the charger, and facilitates improving of operating efficiency of the charger, thereby reducing a total size and a total weight of the charger and improving the efficiency of the charger.

[0031] Generally, an input alternating current power received by the charger is a three-phase high voltage alternating current power of 380V/50Hz. Reference numerals U, V and W shown in Figure 1 respectively represent a U phase voltage, a V phase voltage and a W phase voltage of the input alternating current power. Each of the multiple output voltages finally outputted by the charger is a direct current voltage of 110V.

[0032] Based on the above embodiment, in an embodiment of the present disclosure, the power unit includes a pre-charge unit 230, a rectification unit 240, a voltage conversion unit 250, and a filtering unit 260, as shown in Figure 2.

[0033] The pre-charge unit 230 includes a first output branch and a second output branch. The pre-charge unit is configured to: receive the filtered input alternating current voltage; output a pre-charge current via the first output branch in a case that an output voltage of the pre-charge unit 230 is less than a preset voltage threshold; and output the pre-charge current via the second output branch in a case that the output voltage of the pre-charge unit 230 is not less than the preset voltage threshold.

[0034] The rectification unit 240 is configured to receive the pre-charge current, rectify the pre-charge current, and perform a first filtering process on the pre-charge current, to obtain a to-be-reduced direct current voltage.

[0035] The voltage conversion unit 250 is configured to reduce the to-be-reduced direct current voltage, to obtain a to-be-filtered direct current voltage.

[0036] The filtering unit 260 is configured to perform a second filtering process on the to-be-filtered direct current voltage to obtain the direct current voltage to be transferred to the

output circuit 300.

[0037] In this embodiment, the pre-charge unit 230 is used to output a small current via the first output branch at the beginning of the operation of the charger, to avoid damage to other components in the charger or a load device in the railway vehicle caused by a current jump. In the case that the output voltage of the pre-charge unit 230 is greater than or equal to the preset voltage threshold, the pre-charge unit 230 outputs a large pre-charge current via the second output branch, to improve the charging efficiency of the charger.

[0038] Specifically, taking the input alternating current power of 380V/50Hz as an example, the preset voltage threshold may be set to be greater than or equal to 200V. For example, the preset voltage threshold may be set as 200V, 250V, 300V and the like, which is not limited herein and depends on actual conditions.

[0039] Based on the above embodiments, in another embodiment of the present disclosure, the pre-charge unit 230 includes the first output branch and the second output branch. The first output branch includes a first switch group and a first resistor group. The first switch group includes three first switches K1. The first resistor group includes three first resistors R1. Each of the first switches K1 and one of the first resistors R1 form one of first pre-charge branches, as show in Figure 3.

[0040] The second output branch includes a second switch group. The second switch group includes three second switches K2. Each of the second switches K2 forms one of second pre-charge branches. Each of the first pre-charge branches is connected in parallel with one of the second pre-charge branches.

[0041] The first switch K1 is turned on in the case that the output voltage of the pre-charge unit 230 is less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit 230 is not less than the preset voltage threshold.

[0042] The second switch K2 is turned on in the case that the output voltage of the pre-charge unit 230 is not less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit 230 is less than the preset voltage threshold.

[0043] In this embodiment, each switch in the first switch group and the second switch group may be turned on or turned off under control of a controller in the railway vehicle. The output voltage of the pre-charge unit 230 may be collected and monitored under the control of

controller in the railway vehicle. In other embodiments of the present disclosure, the above functions may be performed by means of an additional control unit, which is not limited herein.

[0044] Based on the above embodiments, in another embodiment of the present disclosure, the rectification unit 240 includes three rectification branches that are connected in parallel with each other, and a first filtering branch, a second filtering branch and a third filtering branch that are connected in parallel with each of the rectification branches, as show in Figure 4.

[0045] Each of the rectification branches includes a first diode D1 and a second diode D2 that are connected in series. A cathode of the first diode D1 is connected to an anode of the second diode D2. The pre-charge current is received at a node connecting the cathode of the first diode D1 and the anode of the second diode D2. Each of the first diode D1 and the second diode D2 is a silicon carbide Schottky diode.

[0046] The first filtering branch includes a first capacitor C1 and a second resistor R2 that are connected in series with each other.

[0047] The second filtering branch includes a second capacitor C2.

[0048] The third filtering branch includes a third resistor R3.

[0049] The Schottky diode (SBD) has advantages of a low positive voltage drop and a short reverse recovery time. The silicon carbide material is widely applied in the manufacturing of the Schottky diode due to advantages such as a wide forbidden band width and a high saturation electron drift rate. The silicon carbide Schottky diode is widely used as a high frequency and fast switching device due to features such as a high shutdown voltage, a low reverse leakage current and a low switching loss. Each of the first diode D1 and the second diode D2 is implemented by the silicon carbide Schottky diode, improving the overall efficiency of the charger and reducing the overall weight of the filtering capacitor and the filtering inductor.

[0050] Based on the above embodiments, in another embodiment of the present disclosure, the filtering unit 260 includes a first inductor L1 and a third capacitor C3, as show in Figure 5.

[0051] One terminal of the first inductor L1 is connected to a first output terminal of the voltage conversion unit 250. The other terminal of the first inductor L1 is connected to one

terminal of the third capacitor C3 and serves as a first output terminal of the filtering unit 260.

[0052] The other terminal of the third capacitor C3 that is remote from the first inductor L1 is connected to a second output terminal of the voltage conversion unit 250 and serves as a second output terminal of the filtering unit 260.

5 **[0053]** The output unit includes a third diode D3, a first output branch, a second output branch, a third output branch, a fourth output branch and a fifth output branch.

[0054] An anode of the third diode D3 is connected to the first output terminal of the filtering unit 260. A cathode of the third diode D3 is connected to each of the first output branch, the second output branch, the third output branch and the fourth output branch of the
10 output unit.

[0055] The fifth output branch of the output unit includes a fifth fuse F5. One terminal of the fifth fuse F5 is connected to the second output terminal of the filtering unit 260. One of the output voltages is outputted from the other terminal of the fifth fuse F5.

[0056] The first output branch of the output unit includes a first fuse F1 and a third switch
15 K3 that are sequentially connected in series with each other and is configured to output one of the output voltages.

[0057] The second output branch of the output unit includes a second fuse F2 and a fourth switch K4 that are sequentially connected in series with each other and is configured to output one of the output voltages.

20 **[0058]** The third output branch of the output unit includes a fourth diode and a third fuse F3 that are sequentially connected in series with each other and is configured to output one of the output voltages.

[0059] The fourth output branch of the output unit includes a fourth fuse F4.

[0060] In this embodiment, the fifth output branch of the output unit is used to provide an
25 output voltage to a first group of storage batteries. The first output branch, the second output branch, the third output branch and the fourth output branch of the output unit respectively provide output voltages to different loads. The fourth diode is provided in the third output branch of the output unit, to avoid abnormal output of another branch caused by the fact that the third output branch flows back in the case of abnormal output.

[0061] Based on the above embodiments, in a specific implementation, the voltage conversion unit 250 is implemented by a DC/DC power conversion module, and a power switch transistor in the DC/DC power conversion module (i.e., a power switch transistor in the voltage conversion unit 250) is a silicon carbide metal-oxide-semiconductor field-effect transistor (MOSFET). The silicon carbide metal-oxide-semiconductor field-effect transistor has a high switching frequency and a low switching loss, which facilitates reduction of a total weight of a filtering inductor (i.e., the first inductor L1) in the filtering unit 260, and facilitates improving of overall charging efficiency of the charger.

[0062] Reference is made to Figure 6, which is a schematic diagram showing a specific implementation of the charger according to the embodiments of the present disclosure. Figure 6 shows a feasible configuration of the input filtering circuit 100. The input filtering circuit 100 includes a first input branch, a second input branch and a third input branch.

[0063] The first input branch, the second input branch and the third input branch are respectively used to receive three phase voltages (i.e., a U phase voltage, a V phase voltage and a W phase voltage) of the three-phase input alternating current power.

[0064] Each of the first input branch, the second input branch and the third input branch includes a fourth capacitor C4, a second inductor L2, and a sixth fuse F6. The sixth fuse F6 is connected in series with the second inductor L2. One terminal of the fourth capacitor C4 is connected to one terminal of the sixth fuse F6 that is remote from the second inductor L2, to receive one phase voltage of the input alternating current power. The other terminal of the fourth capacitor C4 is grounded or connected to a housing of the charger.

[0065] The sixth fuse F6 functions as a safety device to prevent a large current in the charger. The second inductor L2 together with the fourth capacitor C4 is used to filter the input alternating current voltage.

[0066] Correspondingly, a railway vehicle is further provided according to an embodiment of the present disclosure. The railway vehicle includes the charger according to any one of the above embodiments.

[0067] In summary, a charger and a railway vehicle are provided according to the embodiments of the present disclosure. A transistor in a power unit of the charger is a silicon carbide transistor. The silicon carbide transistor has features of a high switching frequency

and a low switching loss, which facilitates reduction of weights of passive devices such as a voltage conversion device and a filtering inductor in the charger, and facilitates improving of operating efficiency of the charger, thereby reducing a total size and a total weight of the charger and improving the efficiency of the charger.

- 5 **[0068]** Embodiments in this specification are described in a progressive way, each of the embodiments emphasizes differences from other embodiments, and the same or similar parts among the embodiments can be referred to each other.

- 10 **[0069]** Based on the above description of the disclosed embodiments, those skilled in the art can implement or carry out the present disclosure. It is apparent for those skilled in the art to make various modifications to these embodiments. The general principle defined herein may be applied to other embodiments without departing from the spirit or scope of the present disclosure. Therefore, the present disclosure is not limited to the embodiments illustrated herein, but should be defined by the widest scope consistent with the principle and novel features disclosed herein.

CLAIMS

1. A charger applied to a railway vehicle, the charger comprising:

an input filtering circuit;

a power module connected to the input filtering circuit; and

an output circuit connected to the power module, wherein

the input filtering circuit is configured to filter a received input alternating current voltage and transfer the filtered input alternating current voltage to the power module;

the power module comprises a first power unit and a second power unit each configured to rectify and reduce the filtered input alternating current voltage to obtain a direct current voltage;

the output circuit comprises a first output unit and a second output unit each configured to process the direct current voltage to output a plurality of output voltages; and

a transistor in the power unit is a silicon carbide transistor,

wherein the power unit comprises a pre-charge unit comprising a first output branch and a second output branch,

and wherein the pre-charge unit is configured to: receive the filtered input alternating current voltage; output a pre-charge current via the first output branch in a case that an output voltage of the pre-charge unit is less than a preset voltage threshold; and output the pre-charge current via the second output branch in a case that the output voltage of the pre-charge unit is not less than the preset voltage threshold.

2. The charger according to claim 1, wherein the power unit further comprises:

a rectification unit configured to receive the pre-charge current, rectify the pre-charge current, and perform a first filtering process on the pre-charge current, to obtain a to-be-reduced direct current voltage;

a voltage conversion unit configured to reduce the to-be-reduced direct current voltage, to obtain a to-be-filtered direct current voltage; and

a filtering unit configured to perform a second filtering process on the to-be-filtered

direct current voltage to obtain the direct current voltage to be transferred to the output circuit.

3. The charger according to claim 2, wherein

the first output branch in the pre-charge unit comprises: a first switch group comprising three first switches and a first resistor group comprising three first resistors, wherein each of the first switches and one of the first resistors form one of first pre-charge branches,

the second output branch in the pre-charge unit comprises a second switch group comprising three second switches, wherein each of the second switches forms one of second pre-charge branches;

each of the first pre-charge branches is connected in parallel with one of the second pre-charge branches;

the first switch is turned on in the case that the output voltage of the pre-charge unit is less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit is not less than the preset voltage threshold; and

the second switch is turned on in the case that the output voltage of the pre-charge unit is not less than the preset voltage threshold and is turned off in the case that the output voltage of the pre-charge unit is less than the preset voltage threshold.

4. The charger according to claim 2, wherein the rectification unit comprises:

three rectification branches that are connected in parallel with each other, wherein each of the rectification branches comprises a first diode and a second diode that are connected in series with each other, a cathode of the first diode is connected to an anode of the second diode, the pre-charge current is received at a node connecting the cathode of the first diode and the anode of the second diode, and each of the first diode and the second diode is a silicon carbide Schottky diode; and

a first filtering branch, a second filtering branch and a third filtering branch that are connected in parallel with each of the rectification branches, wherein the first filtering branch comprises a first capacitor and a second resistor that are connected in series with each other, the second filtering branch comprises a second capacitor, and the third filtering branch comprises a third resistor.

5. The charger according to claim 2, wherein the filtering unit comprises:

a first inductor; and

a third capacitor, wherein

one terminal of the first inductor is connected to a first output terminal of the voltage conversion unit, and the other terminal of the first inductor is connected to one terminal of the third capacitor and serves as a first output terminal of the filtering unit; and

the other terminal of the third capacitor that is remote from the first inductor is connected to a second output terminal of the voltage conversion unit and serves as a second output terminal of the filtering unit.

6. The charger according to claim 5, wherein the output unit comprises: a third diode, a first output branch, a second output branch, a third output branch, a fourth output branch and a fifth output branch, wherein

an anode of the third diode is connected to the first output terminal of the filtering unit, and a cathode of the third diode is connected to each of the first output branch, the second output branch, the third output branch and the fourth output branch of the output unit;

the fifth output branch of the output unit comprises a fifth fuse, wherein one terminal of the fifth fuse is connected to the second output terminal of the filtering unit, and one of the output voltages is outputted from the other terminal of the fifth fuse;

the first output branch of the output unit comprises a first fuse and a third switch that are sequentially connected in series with each other and is configured to output one of the output voltages;

the second output branch of the output unit comprises a second fuse and a fourth switch that are sequentially connected in series with each other and is configured to output one of the output voltages;

the third output branch of the output unit comprises a fourth diode and a third fuse that are sequentially connected in series with each other and is configured to output one of the output voltages; and

the fourth output branch of the output unit comprises a fourth fuse.

7. The charger according to claim 2, wherein a power switch transistor in the voltage conversion unit is a silicon carbide metal-oxide-semiconductor field-effect transistor.

8. A railway vehicle comprising the charger according to any one of claims 1 to 7.