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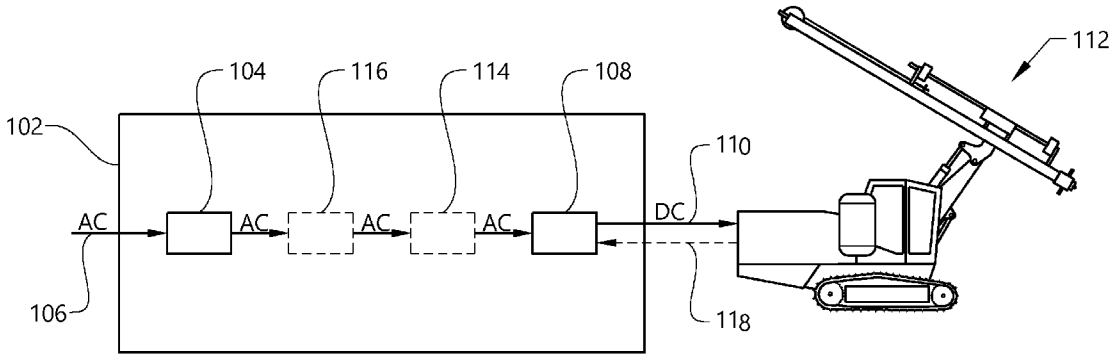

FIG. 1

(57) Abstract: A power supply module (102) for supplying power to at least one mining or construction machine (112), the power supply module (102) comprising: a receiving unit (104) operative for receiving alternating current, AC, power from a power grid or an external power source (106); an alternating current to direct current, AC-DC, converting unit (108) operative for converting the AC power received by the receiving unit (104) to DC power, wherein the power supply module (102) is operative for feeding the DC power to the at least one mining or construction machine (112) via at least one DC transmission line (110), and the power supply module (102) is mobile.

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POWER SUPPLY MODULES AND SYSTEMS FOR MINING OR CONSTRUCTION MACHINES

Technical Field

[0001] The present disclosure relates generally to power supply modules and systems for electric mining or construction machines.

Background

[0002] Electric mining or construction machines become more frequently used in different working environments, e.g., underground mining, surface mining, exploration, etc. Electric mining or construction machines refer to the machines which are powered by electricity, and may include mining, exploration and construction rigs.

[0003] The working environments may be connected to main power grids for power supply during operation. In prior art, each mining or construction machine is equipped with a power system which can convert alternating current to direct current (AC-DC) onboard, so that the incoming AC from the main power grids is converted to DC by the onboard power system. The converted DC is used to charge the battery on the electric mining or construction machine, or used by onboard power consumers, such as electric motors, converters and auxiliary consumers, etc. Therefore the electric mining or construction machines can operate in the working environments on the power supplied by the main power grid.

[0004] However, in prior art the onboard power system may be a heavy and large system which may comprise several components, e.g., filter, rectifier, line converter, transformer, etc. Since the space and weight of the mining or construction machine is limited, there may not be enough space for an onboard power system on the mining or construction machine. Even if there is enough space for an onboard power system on the mining or construction machine, the heavy weight of the power system may bring practical limitations to the mining or construction machine when operating. Furthermore, the heavy onboard power

system may affect the performance and lifetime of the mining or construction machine. The onboard power system may also need a heavy cable to connect the mining or construction machine to the main power grid. The heavy cable may also affect the working performance negatively. Additionally, the onboard power system may increase electromagnetic interference phenomenon, thereby degrading the performance of the mining or construction machine.

[0005] Therefore, there is a need for a power supply solution for the electric mining or construction machines in the working environments, so that a stable and flexible electric power can be supplied to the electric mining or construction machines. The flexibility, weight, volume and performance of the electric mining or construction machine should not be affected negatively.

Summary

[0006] It is an object of the invention to address at least some of the problems and issues outlined above. It is an object of embodiments of the invention to provide a power supply solution for the electric mining or construction machines, so that a stable and flexible electric power can be supplied to the electric mining or construction machines. It is possible to achieve the object and possibly others by providing the power supply modules and systems as defined in the attached claims.

[0007] In a first aspect of the disclosure, there is provided a power supply module for supplying power to at least one mining or construction machine. The power supply module comprising: a receiving unit operative for receiving alternating current, AC, power from a power grid or an external power source; an alternating current to direct current, AC-DC, converting unit operative for converting the AC power received by the receiving unit to DC power. The power supply module is operative for feeding the DC power to the at least one mining or construction machine via at least one DC transmission line, and the power supply module is mobile.

[0008] The disclosure is based on an insight that providing an independent and mobile power supply module for power supply of the mining or construction

machine, so that the mining or construction machine does not need to contain an onboard power system for power supply. The independent mobile power supply module is operative for receiving AC power from a power grid or an external power source and converting it to DC power. The voltage of the AC power from the power grid or external power source can be e.g., 400V. Then the DC power is supplied to a mining or construction machine. Since the power supply module is independent of the mining or construction machine, the mining or construction machine does not need to contain any heavy power system, thus reducing the number of onboard components and required space/weight needed for installation. The power supply module is mobile, so that it can provide power supply to the mining or construction machine in a flexible way. The power supply module can be customized to local requirements (voltage type, frequency, regulations etc.) without having to change the onboard design, layout and function of the electric mining or construction machine. Moreover, components of the power supply module can be protected and installed with less effort than onboard the electric mining or construction machine. This gives the advantage that industrial grade components may be used, for instance with lower IP rating, lower resistance to shock and vibrations, and lower cost compared to onboard rated components.

[0009] In some embodiments, the power supply module is dimensioned to be moved by a vehicle and/or comprises a support structure for movement along the ground.

[00010] The power supply module is mobile by being dimensioned to be moved by a vehicle or by means of a support structure, e.g., wheels or skids. The vehicle can be a motor vehicle or a manual vehicle, e.g., truck, forklift, trolley, etc. By this arrangement, the power supply module can be moved by the vehicle, so as to provide power supply to mining or construction machines in different places.

[00011] In some embodiments, the power supply module further comprises an inductor-capacitor-inductor, LCL, filter operative for reducing high-order harmonics in the received AC power.

[00012] In some embodiments, the power supply module further comprises a transformer, the transformer is operative for transforming the AC power received by the receiving unit to AC power having voltage adapted for the AC-DC converting unit and/or the LCL filter.

[00013] When the voltage of the AC power received by the receiving unit is not adapted for the AC-DC converting unit or the LCL filter, a transformer is arranged after the receiving unit so as to transform the AC power to a voltage which is fit for the following AC-DC converting unit and/or LCL filter. For example, the transformer can transform the voltage of the AC power from the power grid or external power source to 400V. The transformer may also provide galvanic isolation.

[00014] In some embodiments, the AC-DC converting unit comprises a line converter or a rectifier.

[00015] In some embodiments, the AC-DC converting unit is also operative for receiving a control signal for controlling the voltage of the DC power fed to the mining or construction machine, the control signal originating from the mining or construction machine.

[00016] The mining or construction machine may have requirement on the voltage of the DC power fed to it. In order to make sure that the AC-DC converting unit provides DC power with proper voltage, a control signal originated from the mining or construction machine is sent to the AC-DC converting unit so as to control the output voltage of the AC-DC converting unit, so that the voltage of the DC power provided by the AC-DC converting unit is controlled based on the control signal. For example, the DC power output from the AC-DC converting unit can be controlled to be 500-1000V so as to adapt the mining or construction machine.

[00017] In a second aspect of the disclosure, there is provided a system comprising a power supply module according to the first aspect, at least one DC transmission line, and at least one mining or construction machine comprising at

least one onboard energy consumer and/or an energy storage unit, wherein the at least one DC transmission line is operative for transmitting the DC power from the AC-DC converting unit of the power supply module to the at least one mining or construction machine, to supply DC power to the at least one onboard energy consumer and/or the energy storage unit.

[00018] The system is an arrangement of how the power supply module can be utilized by at least one mining or construction machine. The power and supply module receives the AC power from power grid or external power source, converts it to DC power and provides the DC power to the mining or construction machine via at least one DC transmission line. The mining or construction machine may include at least one onboard energy consumer and/or the energy storage unit. The onboard energy consumer is a component of the mining or construction machine which is used to perform work in the working environment, e.g., electric actuators, like electric motors, electric linear actuators or other consumers of electric power used to perform work in the working environment, for example drilling, moving, etc.. The energy storage unit can be a battery. The energy storage unit is optional, that is, the mining or construction machine may include at least one onboard energy consumer with or without the energy storage unit. The DC transmission line can be a cable with a predefined length, e.g., 50-200 meters.

[00019] In some embodiments, the at least one mining or construction machine further comprises an electronic control unit, ECU arranged to communicate with the AC-DC converting unit and arranged to communicate with the at least one onboard energy consumer and/or the energy storage unit, the ECU also being arranged to send a control signal to the AC-DC converting unit for controlling an output DC voltage provided by the AC-DC converting unit, based on the voltage required by the at least one onboard energy consumer and/or the output voltage of the energy storage unit.

[00020] As discussed above, the AC-DC converting unit of the power supply module may receive a control signal originated from the mining or construction machine for controlling output voltage. The control signal is originated from an ECU of the mining or construction machine, and the control signal is based on the

required voltage of the onboard energy consumer, and/or the output voltage of the energy storage unit, if the energy storage unit is available. For example, the control signal can control the voltage of the DC power output from the AC-DC converting unit, so that it is equal to the required voltage of the onboard energy consumer. In another example, the control signal can control the voltage of the DC power output from the AC-DC converting unit, so that it is higher than output voltage of the energy storage unit and can charge the energy storage unit.

[00021] In some embodiments, the at least one mining or construction machine further comprises at least one direct current to direct current, DC-DC, converter operative for receiving the DC power from the DC transmission line, converting the voltage of the DC power to a voltage adapted for supplying the at least one onboard energy consumer and/or energy storage unit, and supplying the converted DC power to the at least one onboard energy consumer and/or the energy storage unit, wherein the ECU is arranged to communicate with the DC-DC converter and arranged to communicate with the at least one onboard energy consumer and/or the energy storage unit, the ECU also being arranged to send a control signal to the DC-DC converter for controlling the converted DC voltage provided by the DC-DC converter.

[00022] The at least one DC-DC converter can be arranged in the mining or construction machine so that the DC-DC converter can convert the voltage of the DC power provided by the DC transmission line into a voltage which fits for the at least one onboard energy consumer and/or the energy storage unit. The ECU is communicatively connected to the DC-DC converter, the at least one onboard energy consumer and/or the energy storage unit. The ECU sends control signal to the DC-DC converter for controlling the output voltage of the DC-DC converter. The output DC power of the DC-DC converter is adapted for the at least one onboard energy consumer and/or the energy storage unit, if the energy storage unit is available. For example, the output voltage of the AC-DC converting unit of the power supply module is 750V. The 750V DC power is transmitted by the DC transmission line and provided to the DC-DC converter of the mining or construction machine. The DC-DC converter converts the 750V DC power to 600-

800V DC power, according to the control signal provided by the ECU. The converted DC power is supplied to the at least one onboard energy consumer and /or the energy storage unit.

[00023] In some embodiments, the at least one mining or construction machine comprises at least one onboard energy consumer and an energy storage unit, wherein the at least one mining or construction machine further comprises a direct current to direct current, DC-DC, converter operative for receiving the DC power from the DC transmission line, converting the voltage of the DC power to a voltage adapted for supplying the energy storage unit, and supplying the converted DC power to the energy storage unit, wherein the ECU is arranged to communicate with the DC-DC converter and arranged to communicate with the energy storage unit, the ECU also being arranged to send a control signal to the DC-DC converter for controlling the converted DC voltage provided by the DC-DC converter, wherein the at least one onboard energy consumer is connected to the at least one DC transmission line.

[00024] In above embodiments, the mining or construction machine comprises both at least one onboard energy consumer and the energy storage unit. The DC-DC converter is dedicated for the energy storage unit, and the ECU is communicatively connected to the DC-DC converter and the energy storage unit. The DC-DC converter may be bidirectional meaning that power can flow in two directions, that is feeding power to other components and receiving power. The at least one onboard energy consumer is directly connected to the DC transmission line and fed by the DC power transmitted by the DC transmission line. For example, the AC-DC converting unit of the power supply module outputs 750V DC power and the 750V DC power is transmitted by the DC transmission line. The at least one onboard energy consumer is fed by the 750V DC power transmitted by the DC transmission line. The DC-DC converter converts the 750V DC power provided by the DC transmission line to 600-800V DC power and feeds the converted DC power to the energy storage unit. The ECU sends control signal to the DC-DC converter to control the output voltage.

[00025] In some embodiment, the AC-DC converting unit of the power supply module is further operative for converting the AC power to DC power at a transmission voltage, the transmission voltage being higher than a voltage adapted for supplying the at least one onboard energy consumer and/or the energy storage unit; wherein the at least one DC transmission line is operative for transmitting the DC power at the transmission voltage; wherein the DC-DC converter of the at least one mining or construction machine is further operative for converting the received DC power at the transmission voltage to DC power at the voltage which is adapted for supplying the at least one onboard energy consumer and/or the energy storage unit.

[00026] High voltage DC power is more suitable for transmission than low voltage DC power because less losses in cable occur when transmitting high volage DC power. Furthermore, high transmission voltage has a more efficient power transfer. It is desired to have higher voltage DC power to be transmitted on the DC transmission line. Therefore, the AC-DC converting unit is further operative for converting AC power to DC power having a transmission voltage. The transmission voltage is higher than the required voltage of the at least one energy consumer and adapted for transmission on the DC transmission line. For example, the transmission voltage can be above 990V. When the DC power with transmission voltage is transmitted to the DC-DC converter of the mining or construction machine, the DC-DC converter converts the DC power with transmission voltage to a lower voltage which is adapted for the at least one onboard energy consumer and/or the energy storage unit. For example, the DC-DC converter can convert the DC power with transmission voltage to 600-800V, which is adapted for the at least one onboard energy consumer and/or the energy storage unit.

[00027] In some embodiments, the energy storage unit is operative for supplying energy to the at least one onboard energy consumer when the at least one mining or construction machine comprises at least one onboard energy consumer and an energy storage unit.

[00028] The energy storage unit can also supply energy to the at least one onboard energy consumer, depending on voltages. For example, when the output voltage of the energy storage unit is higher than the required voltage of the at least one energy consumer, the energy storage unit can supply energy to the at least one onboard energy consumer.

[00029] In some embodiments, the system comprises a plurality of mining or construction machines, each connected to the power supply module via a respective DC transmission line.

[00030] One power supply module can supply power to multiple mining or construction machines, each with a DC transmission line.

Brief Description of Drawings

[00031] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

[00032] Fig. 1 schematically shows a power supply module and a mining or construction machine.

[00033] Fig. 2 schematically shows a mobile arrangement of the power supply module, according to possible embodiments.

[00034] Fig.3-8 schematically show layouts of the systems using power supply modules, according to possible embodiments.

Detailed Description

[00035] Fig. 1 shows a power supply module 102 and a mining or construction machine 112. As discussed in Background, the mining or construction machine 112 may include mining, exploration and construction rigs. The mining or construction machine 112 does not need to contain a power system itself. Instead, a power supply module 102 is connected to the mining or construction machine 112 via a DC transmission line 110, so as to provide DC power to the mining or construction machine.

[00036] In some embodiments, the power supply module 102 for supplying power to at least one mining or construction machine 112 comprises: a receiving unit 104 operative for receiving alternating current, AC, power from a power grid or an external power source 106; an alternating current to direct current, AC-DC, converting unit 108 operative for converting the AC power received by the receiving unit 104 to DC power, wherein the power supply module 102 is operative for feeding the DC power to the at least one mining or construction machine 112 via at least one DC transmission line 110, and the power supply module 102 is mobile.

[00037] An independent and mobile power supply module 102 is provided for power supply of the mining or construction machine 112. The independent mobile power supply module is operative for receiving AC power from a power grid or an external power source 106 and converting it to DC power then supply to the mining or construction machine 112. The external power source may be a power station, a standalone battery source or other external power source which provides power to the power supply module 102. The voltage of the AC power from the power grid or external power source 106 can be e.g., 400V. Since the power supply module 102 is independent of the mining or construction machine 112, the mining or construction machine 112 does not need to contain any heavy power component. Furthermore, the power supply module 102 is mobile, so that it can provide power supply to the mining or construction machine 112 in a flexible way in different places.

[00038] In some embodiments, as shown in fig. 2, the power supply module 102 is dimensioned to be moved by a vehicle 200 and/or comprises a support structure for movement along the ground.

[00039] The power supply module 102 is mobile by being dimensioned to be moved by a vehicle, or by means of a support structure, e.g. wheels or skids. The vehicle can be motor vehicle or manual vehicle, e.g., truck, forklift, trolley, etc. Fig. 2 shows a forklift carrying the power supply module 102. By this arrangement, the power supply module 102 can be carried, dragged, rolled or pushed by the

vehicle, so as to provide power supply to mining or construction machines 112 in different places.

[00040] In some embodiments, referring to fig. 1, the power supply module 102 further comprises an inductor-capacitor-inductor, LCL, filter 114 operative for reducing high-order harmonics in the received AC power.

[00041] In some embodiments, referring to fig. 2, the power supply module 102 further comprises a transformer 116, the transformer 116 is operative for transforming the AC power received by the receiving unit 104 to AC power having voltage adapted for the AC-DC converting unit 108 and/or the LCL filter 114.

[00042] When the voltage of the AC power received by the receiving unit 104 is not adapted for the AC-DC converting unit 108 or the LCL filter 114, a transformer 116 is arranged after the receiving unit 104 so as to transform the AC power to a voltage which is fit for the following AC-DC converting unit 108 and/or LCL filter 114. For example, the transformer 116 can transform the voltage of the AC power from the power grid or external power source, which may be very high, to 400V. The transformer may also provide galvanic isolation.

[00043] In some embodiments, the AC-DC converting unit 108 comprises a line converter or a rectifier. It can also comprise other electric components capable of transferring AC voltage to DC voltage.

[00044] In some embodiments, referring to fig. 1, the AC-DC converting unit 108 is also operative for receiving a control signal 118 for controlling the voltage of the DC power fed to the mining or construction machine 112, the control signal 118 originating from the mining or construction machine 112.

[00045] The mining or construction machine 112 may have requirement on the voltage of the DC power fed to it. In order to make sure that the AC-DC converting unit 108 provides DC power with proper voltage, a control signal 118 originated from the mining or construction machine 112 is sent to the AC-DC converting unit 108 so as to control the output voltage of the AC-DC converting unit 108, so that the voltage of the DC power provided by the AC-DC converting unit 108 is

controlled based on the control signal 118. For example, the DC power output from the AC-DC converting unit 108 can be controlled to be 600-800V so as to adapt the mining or construction machine 112.

[00046] Referring to fig. 3, a system 100 is provided. The system 100 comprises a power supply module 102 according to any one of the above embodiments, at least one DC transmission line 110, and at least one mining or construction machine 112 comprising at least one onboard energy consumer 120 and/or an energy storage unit 122, wherein the at least one DC transmission line 110 is operative for transmitting the DC power from the AC-DC converting unit 108 (shown in fig. 1) of the power supply module 102 to the at least one mining or construction machine 112, to supply DC power to the at least one onboard energy consumer 120 and/or the energy storage unit 122.

[00047] The system 100 is an arrangement of how the power supply module 102 can be utilized by at least one mining or construction machine 112. The power and supply module 102 receives the AC power from power grid or external power source 106, converts it to DC power and provides the DC power to the mining or construction machine 112 via at least one DC transmission line 110. The mining or construction machine 112 may include at least one onboard energy consumer 120 and/or the energy storage unit 122. The onboard energy consumer 120 is a component of the mining or construction machine 120 which is used to perform work in the working environment, e.g., electric actuators, like electric motors, electric linear actuators or other consumers of electric power used to perform work in the working environment, for example drilling, moving, etc. The energy storage unit 122 can be a battery. The energy storage unit 122 is optional, that is, the mining or construction machine 112 may include at least one onboard energy consumer 120 with or without the energy storage unit 122. The DC transmission line 110 can be a cable with a predefined length, e.g., 50-200 meters.

[00048] In some embodiments, as shown in fig. 4, the at least one mining or construction machine 112 further comprises an electronic control unit, ECU 124 arranged to communicate with the AC-DC converting unit 108 and arranged to communicate with the at least one onboard energy consumer 120 and/or the

energy storage unit 122, the ECU 124 also being arranged to send a control signal 118 to the AC-DC converting unit 108 for controlling an output DC voltage provided by the AC-DC converting unit 108, based on the voltage required by the at least one onboard energy consumer 120 and/or the output voltage of the energy storage unit 122.

[00049] As discussed above, the AC-DC converting unit 108 of the power supply module 102 may receive a control signal 118 originated from the mining or construction machine 112 for controlling output voltage. The control signal 118 is originated from an ECU 124 of the mining or construction machine 112, and the control signal 118 is based on the required voltage of the onboard energy consumer 112, and/or the output voltage of the energy storage unit 122, if the energy storage unit 122 is available. For example, the control signal 118 can control the voltage of the DC power output from the AC-DC converting unit 108, so that it is equal to the required voltage of the onboard energy consumer 120. In another example, the control signal 118 can control the voltage of the DC power output from the AC-DC converting unit 108, so that it is higher than output voltage of the energy storage unit 122 and thus can charge the energy storage unit 122.

[00050] In some embodiments, as shown in fig. 5, the at least one mining or construction machine 112 further comprises at least one direct current to direct current, DC-DC, converter 126 operative for receiving the DC power from the DC transmission line 110, converting the voltage of the DC power to a voltage adapted for supplying the at least one onboard energy consumer 120 and/or energy storage unit 122, and supplying the converted DC power to the at least one onboard energy consumer 120 and/or the energy storage unit 122, wherein the ECU 124 is arranged to communicate with the DC-DC converter 126 and arranged to communicate with the at least one onboard energy consumer 120 and/or the energy storage unit 122, the ECU 124 also being arranged to send a control signal 118 to the DC-DC converter 126 for controlling the converted DC voltage provided by the DC-DC converter 126.

[00051] The at least one DC-DC converter 126 can be arranged in the mining or construction machine 122 so that the DC-DC converter 126 can convert the

voltage of the DC power provided by the DC transmission line 110 into a voltage which fits for the at least one onboard energy consumer 120 and/or the energy storage unit 122. The ECU 124 is communicatively connected to the DC-DC converter 126, the at least one onboard energy consumer 120 and/or the energy storage unit 122. The ECU 124 sends control signal 118 to the DC-DC converter 126 for controlling the output voltage of the DC-DC converter 126. The output DC power of the DC-DC converter 126 is adapted for the at least one onboard energy consumer 120 and/or the energy storage unit 122, if the energy storage unit 122 is available. For example, the output voltage of the AC-DC converting unit 108 of the power supply module 102 is 750V. The 750V DC power is transmitted by the DC transmission line 110 and provided to the DC-DC converter 126 of the mining or construction machine 112. The DC-DC converter 126 converts the 750V DC power to 600-800V DC power, according to the control signal 118 provided by the ECU 124. The converted DC power is supplied to the at least one onboard energy consumer 120 and /or the energy storage unit 122.

[00052] In some embodiments, referring to fig. 6, the at least one mining or construction machine 112 comprises at least one onboard energy consumer 120 and an energy storage unit 122, wherein the at least one mining or construction machine 112 further comprises a direct current to direct current, DC-DC, converter 126 operative for receiving the DC power from the DC transmission line 110, converting the voltage of the DC power to a voltage adapted for supplying the energy storage unit 122, and supplying the converted DC power to the energy storage unit 122, wherein the ECU 124 is arranged to communicate with the DC-DC converter 126 and arranged to communicate with the energy storage unit 122, the ECU 124 also being arranged to send a control signal to the DC-DC converter 126 for controlling the converted DC voltage provided by the DC-DC converter 126, wherein the at least one onboard energy consumer 120 is connected to the at least one DC transmission line 110.

[00053] In above embodiments, the mining or construction machine 112 comprises both at least one onboard energy consumer 120 and the energy storage unit 122. The DC-DC converter 126 is dedicated for the energy storage

unit 122, and the ECU 124 is communicatively connected to the DC-DC converter 126 and the energy storage unit 122. The at least one onboard energy consumer 120 is directly connected to the DC transmission line 110 and fed by the DC power transmitted by the DC transmission line 110. For example, the AC-DC converting unit 108 of the power supply module 102 outputs 750V DC power and the 750V DC power is transmitted by the DC transmission line 110. The at least one onboard energy consumer 120 is fed by the 750V DC power transmitted by the DC transmission line 110. The DC-DC converter 126 converts the 750V DC power provided by the DC transmission line 110 to 600-800V DC power and feeds/receives the converted DC power to/from the energy storage unit 122. The ECU 124 sends control signal 118 to the DC-DC converter 126 to control the output voltage.

[00054] In some embodiment, referring to fig. 7, the AC-DC converting unit 108 of the power supply module 102 is further operative for converting the AC power to DC power at a transmission voltage, the transmission voltage being higher than a voltage adapted for supplying the at least one onboard energy consumer 120 and/or the energy storage unit 122; wherein the at least one DC transmission line 110 is operative for transmitting the DC power at the transmission voltage; wherein the DC-DC converter 126 of the at least one mining or construction machine 112 is further operative for converting the received DC power at the transmission voltage to DC power at the voltage which is adapted for supplying the at least one onboard energy consumer 120 and/or the energy storage unit 122.

[00055] High voltage DC power is more suitable for transmission than low voltage DC power because less losses in cable are occurred when transmitting high volage DC power. It is desired to have higher voltage DC power to be transmitted on the DC transmission line 110. Therefore, the AC-DC converting unit 108 is further operative for converting AC power to DC power having a transmission voltage. The transmission voltage is higher than the required voltage of the at least one energy consumer 120 and adapted for transmission on the DC transmission line 110. For example, the transmission voltage can be above 990V. When the DC power with transmission voltage is transmitted to the DC-DC converter 126 of the

mining or construction machine 112, the DC-DC converter 126 converts the DC power with transmission voltage to a lower voltage which is adapted for the at least one onboard energy consumer 120 and/or the energy storage unit 122. For example, the DC-DC converter 126 can convert the DC power with transmission voltage to 600-800V, which is adapted for the at least one onboard energy consumer 120 and/or the energy storage unit 122.

[00056] In some embodiments, the energy storage unit 122 is operative for supplying energy to the at least one onboard energy consumer 120 when the at least one mining or construction machine 112 comprises at least one onboard energy consumer 120 and an energy storage unit 122.

[00057] The energy storage unit 122 can also supply energy to the at least one onboard energy consumer 120, depending on voltages. For example, when the output voltage of the energy storage unit 122 is higher than the required voltage of the at least one energy consumer 120, the energy storage unit 122 can supply energy to the at least one onboard energy consumer 120.

[00058] In some embodiments, referring to fig. 8, the system 100 comprises a plurality of mining or construction machines 112, each connected to the power supply module 102 via a respective DC transmission line 110.

[00059] One power supply module 102 can supply power to multiple mining or construction machines 112, each with a DC transmission line 110.

[00060] Although the description above contains a plurality of specificities, these should not be construed as limiting the scope of the concept described herein but as merely providing illustrations of some exemplifying embodiments of the described concept. It will be appreciated that the scope of the presently described concept fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the presently described concept is accordingly not to be limited. Reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." Further, the term “a number of”, such as in “a number of wireless devices”

signifies one or more devices. All structural and functional equivalents to the elements of the above-described embodiments that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed hereby. Moreover, it is not necessary for an apparatus or method to address each and every problem sought to be solved by the presently described concept, for it to be encompassed hereby. In the exemplary figures, a broken line generally signifies that the feature within the broken line is optional.

CLAIMS

1. A power supply module (102) for supplying power to at least one mining or construction machine (112), the power supply module (102) comprising:

a receiving unit (104) operative for receiving alternating current, AC, power from a power grid or an external power source (106);

an alternating current to direct current, AC-DC, converting unit (108) operative for converting the AC power received by the receiving unit (104) to DC power,

wherein the power supply module (102) is operative for feeding the DC power to the at least one mining or construction machine (112) via at least one DC transmission line (110), and the power supply module (102) is mobile.

2. The power supply module (102) according to claim 1, wherein the power supply module (102) is dimensioned to be moved by a vehicle (200) and/or comprises a support structure for movement along the ground.

3. The power supply module (102) according to claim 1 or 2, the power supply module (102) further comprises an inductor-capacitor-inductor, LCL, filter (114) operative for reducing high-order harmonics in the received AC power.

4. The power supply module (102) according to any one of the preceding claims, the power supply module (102) further comprises a transformer (116), the transformer (116) is operative for transforming the AC power received by the receiving unit (104) to AC power having voltage adapted for the AC-DC converting unit (108) and/or the LCL filter (114).

5. The power supply module (102) according to any one of the preceding claims, wherein the AC-DC converting unit (108) comprises a line converter or a rectifier.

6. The power supply module (102) according to any one of the preceding claims, wherein AC-DC converting unit (108) is also operative for receiving a control signal (118) for controlling the voltage of the DC power fed to the mining or construction machine (112), the control signal (118) originating from the mining or construction machine (112).

7. A system (100) comprising:

a power supply module (102) according to any one of the preceding claims,

at least one DC transmission line (110), and

at least one mining or construction machine (112) comprising at least one onboard energy consumer (120) and/or an energy storage unit (122),

wherein the at least one DC transmission line (110) is operative for transmitting the DC power from the AC-DC converting unit (108) of the power supply module (102) to the at least one mining or construction machine (112), to supply DC power to the at least one onboard energy consumer (120) and/or the energy storage unit (122).

8. The system (100) according to claim 7, wherein the at least one mining or construction machine (112) further comprises an electronic control unit, ECU (124) arranged to communicate with the AC-DC converting unit (108) and arranged to communicate with the at least one onboard energy consumer (120) and/or the energy storage unit (122), the ECU (124) also being arranged to send a control signal (118) to the AC-DC converting unit (108) for controlling an output DC voltage provided by the AC-DC converting unit (108), based on the voltage required by the at least one onboard energy consumer (120) and/or the output voltage of the energy storage unit (122).

9. The system (100) according to claim 8, wherein the at least one mining or construction machine (112) further comprises at least one direct current to direct current, DC-DC, converter (126) operative for receiving the DC power from the DC transmission line (110), converting the voltage of the DC power to a voltage adapted for supplying the at least one onboard energy consumer (120) and/or energy storage unit (122), and supplying the converted DC power to the at least one onboard energy consumer (120) and/or the energy storage unit (122), wherein the ECU (124) is arranged to communicate with the DC-DC converter (126) and arranged to communicate with the at least one onboard energy consumer (120) and/or the energy storage unit (122), the ECU (124) also being arranged to send a control signal (118) to the DC-DC converter (126) for controlling the converted DC voltage provided by the DC-DC converter (126).

10. The system (100) according to claim 8, wherein the at least one mining or construction machine comprises at least one onboard energy consumer (120) and an energy storage unit (122), wherein the at least one mining or construction machine (112) further comprises a direct current to direct current, DC-DC, converter (126) operative for receiving the DC power from the DC transmission line (110), converting the voltage of the DC power to a voltage adapted for supplying the energy storage unit (122), and supplying the converted DC power to the energy storage unit (122), wherein the ECU (124) is arranged to communicate with the DC-DC converter (126) and arranged to communicate with the energy storage unit (122), the ECU (124) also being arranged to send a control signal (118) to the DC-DC converter (126) for controlling the converted DC voltage provided by the DC-DC converter (126), wherein the at least one onboard energy consumer (120) is connected to the at least one DC transmission line (110).

11. The system (100) according to claim 9, wherein the AC-DC converting unit (108) of the power supply module (102) is further operative for converting the AC power to DC power at a transmission voltage, the transmission voltage being higher than a voltage adapted for supplying the at least one onboard energy consumer (120) and/or the energy storage unit (122);

wherein the at least one DC transmission line (110) is operative for transmitting the DC power at the transmission voltage;

wherein the DC-DC converter (126) of the at least one mining or construction machine (112) is further operative for converting the received DC power at the transmission voltage to DC power at the voltage which is adapted for supplying the at least one onboard energy consumer (120) and/or the energy storage unit (122).

12. The system according to any one of the claims 7–11, wherein the energy storage unit (112) is operative for supplying energy to the at least one onboard energy consumer (120) when the at least one mining or construction machine (112) comprises at least one onboard energy consumer (120) and an energy storage unit (122).

13. The system (100) according to any one of claims 7–12 comprising a plurality of mining or construction machines (112), each connected to the power supply module (102) via a respective DC transmission line (110).

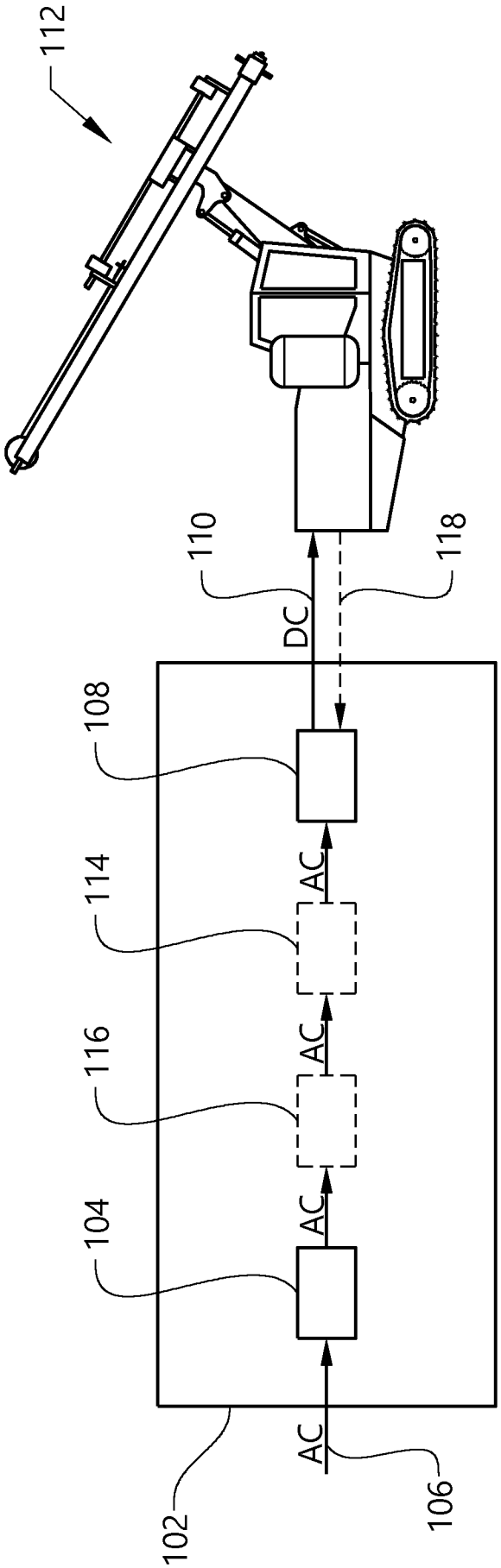
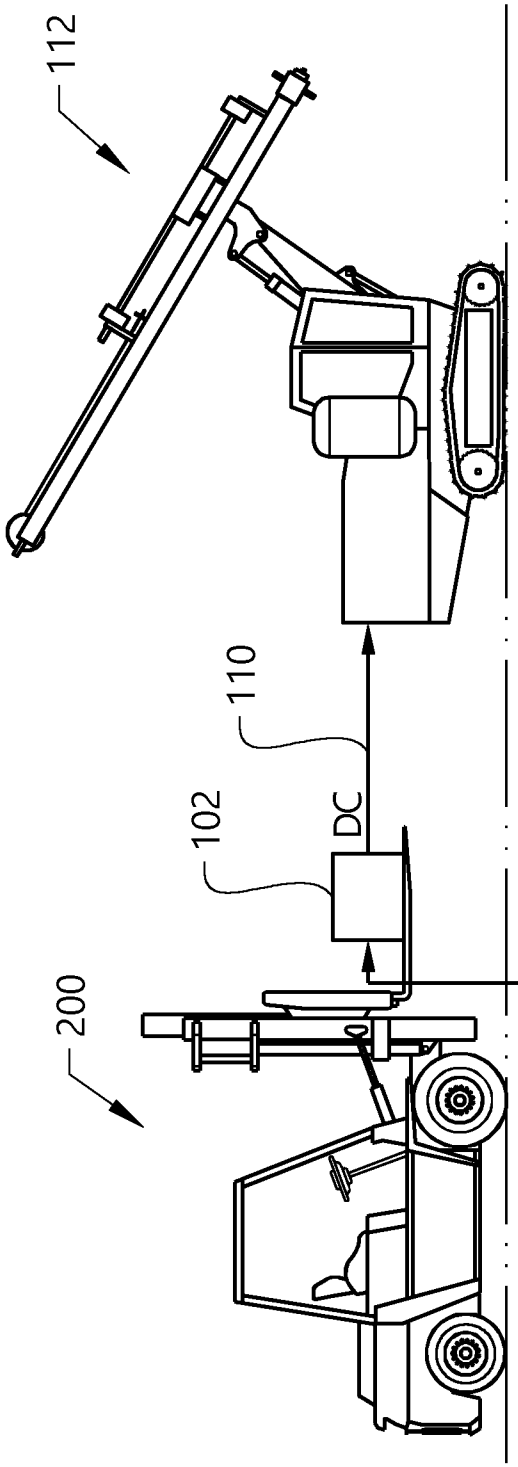

112
110
118
DC
108
114
AC
116
AC
104
AC
AC
102
106

FIG. 1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AC
200
106

FIG. 2

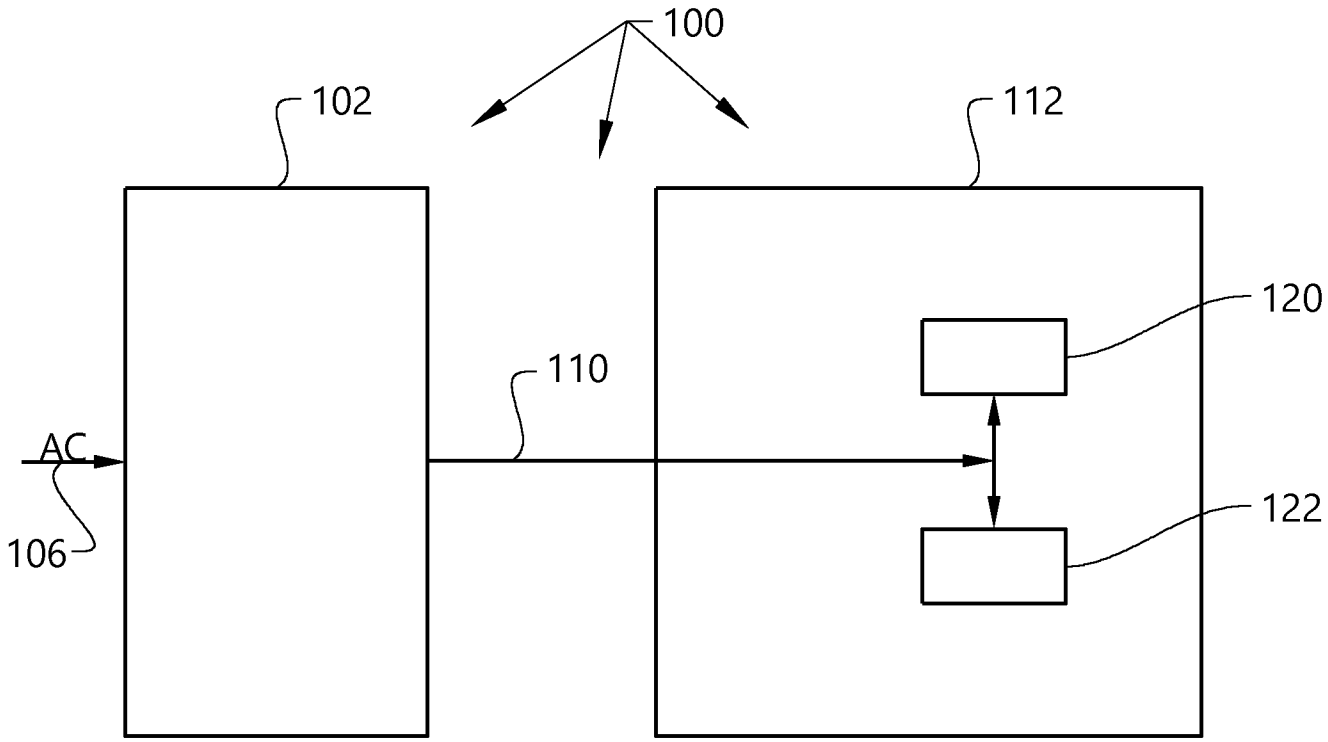
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FIG. 3

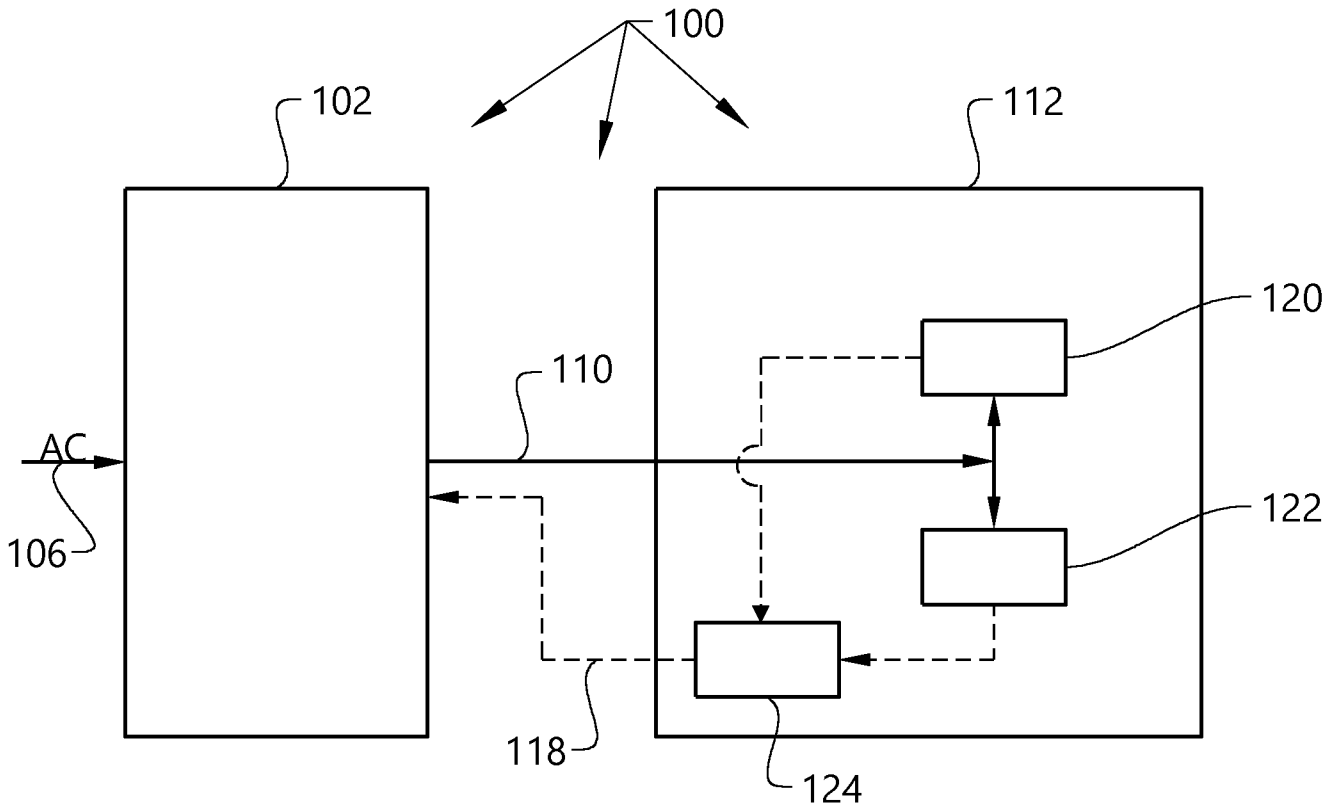
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FIG. 4

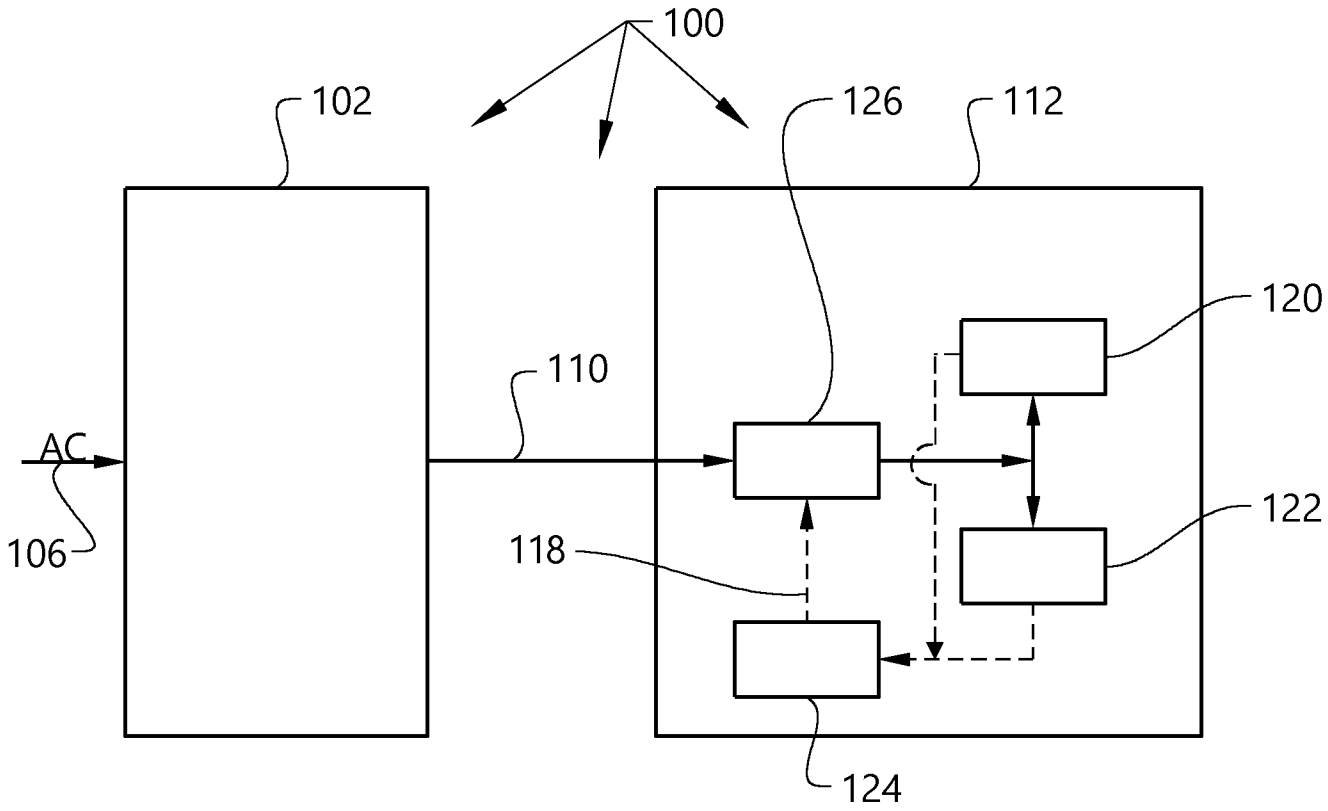
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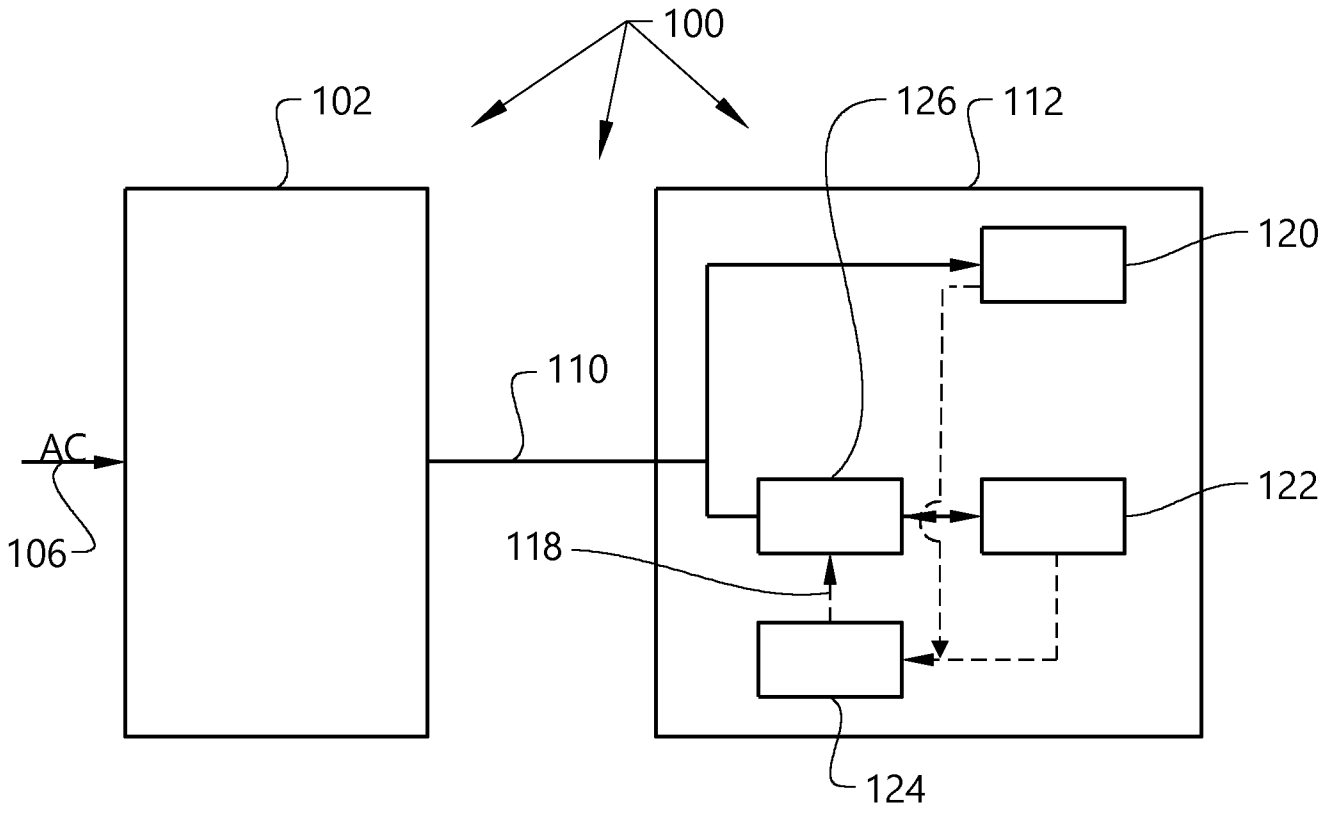
FIG. 5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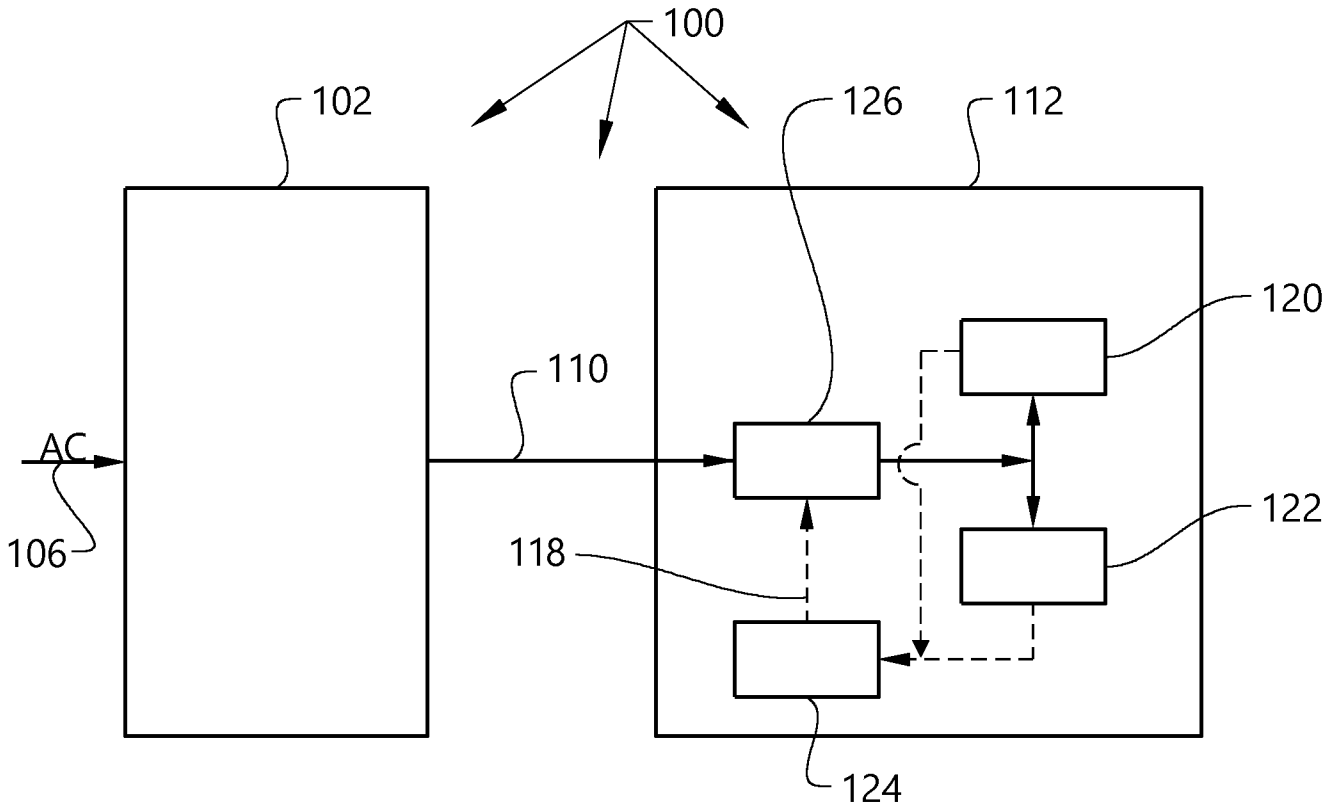
124

FIG. 6


100
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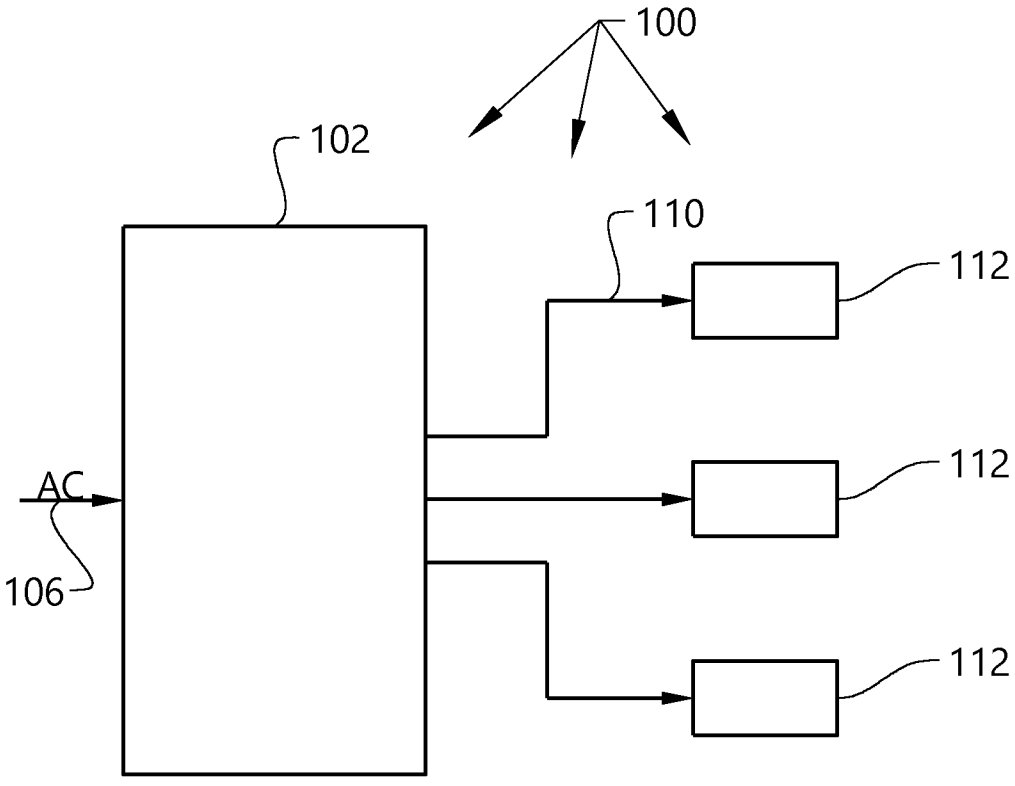
122
124

FIG. 7


100
102
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112
AC
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112

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2023/050716

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60L9/04 B60L53/10 B60L53/35 B60P1/00 B60L50/53
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60L H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2022/219546 A1 (KOUVO MIKKO [SE] ET AL) 14 July 2022 (2022-07-14) paragraphs [0001], [0043], [0055], [0060]; figures 3,4	1-7,9-13
X	US 2009/127048 A1 (ICHIMURA KINYA [US]) 21 May 2009 (2009-05-21) paragraph [0001]; figures 13,17	1-7
X	WO 2023/050426 A1 (HUAWEI TECH CO LTD [CN]) 6 April 2023 (2023-04-06) page 27, lines 21-25; figures 1,2,4,5,6,7,8	1-8,12
A	CN 108 528 263 A (CHONGQING JULU NEW ENERGY CO LTD) 14 September 2018 (2018-09-14) figure 3	3

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 January 2024	28/02/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Varela Fraile, Pablo

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INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2023/050716

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RIVERA SEBASTIAN ET AL: "Electric Vehicle Charging Infrastructure: From Grid to Battery", IEEE INDUSTRIAL ELECTRONICS MAGAZINE, IEEE, US, vol. 15, no. 2, 1 February 2021 (2021-02-01), pages 37-51, XP011862658, ISSN: 1932-4529, DOI: 10.1109/MIE.2020.3039039 [retrieved on 2021-06-24] page 13 -labelled 49- left column, paragraph starting with "Charging stations", 2nd sentence ----- 1	6,8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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