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US 2011298283 A1, US 2009302687 A1, WO 2007060189 A1, JP 2007151218 A,
MacLeod N. et al.: "Connection of renewable energy sources through grid constraint points using HVDC power transmission systems", Transmission and Distribution Conference and Exposition, 2010 IEEE PES, IEEE, Piscataway, NJ, USA 19.4.2010,
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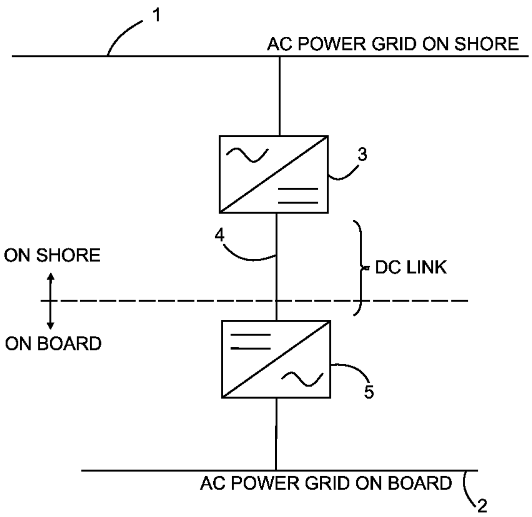
(57) Tiivistelmä - Sammandrag

The invention relates to a power supply connection between shore and a ship comprising a rectifier (3) on shore. The rectifier is connectable to an AC power grid (1) on shore. The connection further comprises an inverter (5) on the ship, and a DC link (4) between the rectifier and the inverter. The inverter (5) is connectable to an AC power grid (2) on board.

Keksintö koskee maan ja aluksen välistä voimansiirtoyhteyttä, joka käsittää tasasuuntaajan (3) maissa. Tasasuuntaaja on yhdistettävissä maissa olevaan ACvoimaverkkoon (1). Yhteys käsittää lisäksi vaihtosuuntaajan (5) aluksessa ja DC-linkin (4) tasasuuntaajan ja vaihtosuuntaajan välissä. Vaihtosuuntaaja (5) on yhdistettävissä aluksessa olevaan AC-voimaverkkoon (2).



Power connection between shore and ship

Field of technology

The invention relates to a power connection between shore and a ship. The power connection is capable of transmitting electric power. More specifically the invention relates to a power connection between a port and a ship.

Prior art

When a ship is at a berth it usually use it’s auxiliary generator or generators to produce necessary electricity used on the ship, or it is connected to a power grid on shore. The use of own generator/s produces exhaust gases and noise that are not desirable. The use of the power grid may not be possible, because the on-board AC power grid use different frequency and voltage level/levels that the AC power grid on shore. For example, 50 Hz are used in Europe, and 60 Hz are used in North America. The connection between the power grid on shore and the power grid on board corresponds usually only at the permanent berth of the ship, i.e. at the same position at the same quay where the ship is moored usually.

It is known that an AC power grid on shore is connected to a ship via a frequency converter, a transformer and several wires. The wires are in connection with the transformer and the ship. In this way the frequency and voltage of the grid on shore is converted to the frequency and voltage of an AC power grid on board. Many connections wires may be required and faults on the ship’s grid can transfer to the power grid on shore.

WO 2007060189 shows another known solution to connect the AC power grid on shore to the ship’s AC power network. In this solution a converter is installed on board. The converter is connected to the AC power grid on shore through an AC cable. The range of the converter may not be enough for voltage levels used in different ports. This situation may occur especially when the ship sails all over the world. Further, the AC power network at the port may have relatively high transmission losses.

US 20110298283 shows yet another known solution where the connection has a rectifier, a DC distribution network, and also inverters and transformers at each berth of a quay. The DC distribution network makes power distribution at the port more efficiently. DC distribution voltage can be higher than AC distribution level, which decreases transmission losses. The rectifier is positioned far away from the berths, so valuable space at the quay is saved for other activities like unloading and loading of goods. However, the inverter and the transformer are still installed at each berth near the sea taking space at the quay that is a central place of different activities.

Further, a berthing time is relatively long when using AC power supply from shore to the ship. This is due to synchronization and rotation check between the power grids on shore and on aboard. In addition, it is also 2/3 possibility to mix the phases when connecting them.

Short description of invention

The objective of the invention is to reduce problems mentioned above. Further, the invention provides a solution that is not so vulnerable for environmental conditions. The aims are achieved in a way described in an independent claim. Dependent claims relate to different embodiments of the invention.

According to the invention the power supply connection between shore and a ship comprises a rectifier on shore. The rectifier is connectable to an AC power grid on shore. The connection further comprises an inverter on the ship, and a DC link between the rectifier and the inverter. The inverter is connectable to an AC power grid on board.

List of figures

In the following, the invention is described in more detail by reference to the figures of the enclosed drawings, where

Figure 1 illustrates an example of a power connection between shore and a ship according to the invention,

Figure 2	illustrates another example of a power connection according to the invention,
Figure 3	illustrates yet another example of a power connection according to the invention,
Figure 4	illustrates further an example of a power connection according to the invention and
Figure 5	illustrates a method according to the invention in a form of a diagram.

Description of the invention

Figure 1 illustrates a simplified example of an embodiment of the invention. An AC power grid 1 exists on shore, which can be utilized to supply electric power to a moored ship. The ship has also an AC power grid 2. Because the on-board power grid has usually different voltage and frequency than in the grid on shore a connection arrangement between these two different grids is needed. In the invention, there is a rectifier 3 on shore and an inverter 5 on the ship. There is a DC link 4 between the rectifier and the inverter. The rectifier 3 is connectable to the AC power grid 1 on shore. The inverter 5 is connectable to the AC power grid 2 on board.

The rectifier 3 can be situated at a suitable place in a port in order that it is not required to install it at a berth of a quay. So, the space at the berth is saved. The DC link 4 can be constructed in many ways. For example, the DC link can be a cable or cables from the rectifier 3 to each berth where there is a cable connector for connecting the cable to another cable that is connectable to the inverter 5 on the ship. A simple structure of the DC link is that it is one cable connected to the rectifier and the inverter. This structure is suitable for a small quay, having for example only one or two berths.

The DC link can be made for a high voltage DC connection, but lower DC voltage can also be used. DC connection can use higher voltage than AC connection with a similar cable. For example, cost-effective low voltage cables can provide 1500 V DC link, but only 1000 V AC link with the same cables. This means that transmission losses are minor in the DC link. It is also possible to use wires with smaller diameters. The DC link can be a two-wire connection. The DC link can also be one wire connection in which case the sea provides another line. It is also possible to use multiple wire in which case diameters of the wires can be smaller.

The connection of the rectifier 3, DC link 4 and the inverter 5 is suitable to handle mismatches of voltages and frequencies in a very large range between the power grid 1 on shore and the on-board power grid 2. The establishing and maintenance of the connection is easy to provide because only the rectifier is at the port. So, the personnel of the port can match the rectifier's AC side to be suitable with the available power network. Similarly the personnel of the ship can match the inverter's AC side to match with the on-board power grid.

Since the inverter is on the ship (and inside the ship), and not at the berth, it is not so vulnerable to environmental conditions. The wind and moisture on shore next to the sea can be very harsh, which means that the inverters at the berths must be maintained very carefully and frequently. In addition, temperature changes outdoor strains the inverter. Thus the life period of the inverter is longer when placed on the ship. The rectifier of inventive connection can be situated on a more sheltered place at the port.

Further, the power grid of the ship is not required to synchronize with the grid on shore when using the inventive connection. So the phase check between the ship and shore is not needed as well. Therefore time is not spent to synchronization, and the phases are not mixed. The reliability of the connection is very good because the on-shore power grid and the on-board power grid are isolated, i.e. they are in connection via the DC link. The protection arrangement (circuit breakers etc.) is easy to provide. Faults on ship systems are not transferred to on shore systems. In addition, it is possible that the power is supplied from the ship to the port and vice versa.

Figure 2 shows another example of the invention. In this embodiment the DC link comprises a DC distribution network 4A at the port and cable connectors 4B on each berth. The DC distribution network is connected 4C to the rectifier 3. The

DC distribution network is convenient in ports having several berths (and maybe several quays). The electric power distribution losses are minor at the port when utilizing the DC distribution network. Further the DC network enables an electro-magnetic field free environment. In addition, the DC link can comprise at least one cable 4D between the connector and the ship. Instead of using the cable, another connection can be used if possible, for example a connection bar, if the structures of the berth and the ship allows this. It may also be possible that the connection further comprises a transformer 9 on an AC side of the inverter 5.

Fig. 3 shows an example, where the DC link further comprises a switchgear 6 on the ship for connecting the DC link to a DC grid 7 on the ship. This switchgear can be used for changing the power feed to separate parts of the ship's power network. Some ships have an internal DC grid because they have one or several big DC loads. If the DC voltages are the same on shore and on board, it is efficient that the switch connects the DC link to the ship's DC grid. Alternatively the DC link can be directly connected to the DC grid on the ship having a connector for the DC link as illustrated in Fig. 4. On this kind of ships there is usually a DC/AC connection 8 between the ship's DC and AC grids for transmitting power between the grids. As showed in Fig. 4 the connection 8 may have an inverter 10.

Fig. 5 illustrates a method for connecting power supply between shore and a ship. Power of the shore's power supply is rectified 51 to DC power on shore. In addition a connection is provided 52 to transmit the DC power between shore and the ship, and the DC power transmitted is inverted 53 to AC power on the ship. The already mentioned embodiments show different ways how the method can be realized in practice.

The embodiments described above are simplified illustrations. Real solutions comprise also, for example, circuit breakers and other devices. These devices are however familiar to a skilled person, so he has no difficulties of making an inventive embodiment when utilizing this description.

It is evident from the examples presented above that an embodiment of the invention can be created using a variety of different solutions. It is also evident

20125544 PRH 23 -05- 2012

that the invention is not limited to the examples mentioned in this text but can be implemented in many other different embodiments within the scope of the inventive idea.

Claims

1. A power supply connection between shore and a ship, the connection comprising a rectifier (3) on shore, which rectifier is connectable to an AC power grid (1) on shore, **characterized** in that the connection further comprises an inverter (5) on the ship, and a DC link (4) between the rectifier (3) and the inverter (5), which inverter is connectable to an AC power grid (2) on board.

2. A power supply connection according to claim 1, **characterized** in that the DC link comprises a DC distribution network (4A) on a port and cable connectors (4B) on each berth.

3. A power supply connection according to claim 2, **characterized** in that the DC link further comprises at least one cable (4D) between the connector (4B) and the ship.

4. A power supply connection according to claim 3, **characterized** in that the DC link further comprises a switchgear (6) on the ship for connecting the DC link to a DC grid (7) on the ship.

5. A power supply connection according to claim 1, 2, 3 or 4, **characterized** in that the connection further comprises a transformer (9) on an AC side of the inverter.

6. A method for connecting power supply between shore and a ship, in which method power of the shore's power supply is rectified (51) to DC power on shore, **characterized** in that in addition a connection is provided (52) to transmit the DC power between shore and the ship, and the DC power transmitted is inverted (53) to AC power on the ship.

Patenttivaatimukset

1. Maan ja aluksen välinen voimansiirtoyhteys, yhteyden käsittäessä tasasuuntaajan (3) maissa, joka tasasuuntaaja on yhdistettävissä maissa olevaan AC-voimaverkkoon (1), tunnettu siitä, että yhteys käsittää lisäksi vaihtosuuntaajan (5) aluksessa sekä DC-linkin (4) tasasuuntaajan (3) ja vaihtosuuntaajan (5) välissä, joka vaihtosuuntaaja on yhdistettävissä aluksessa olevaan AC-voimaverkkoon (2).

2. Patenttivaatimuksen 1 mukainen voimansiirtoyhteys, tunnettu siitä, että DC-linkki käsittää DC-jakeluverkon (4A) satamassa ja kaapeliliittimet (4B) kussakin laituripaikassa.

3. Patenttivaatimuksen 2 mukainen voimansiirtoyhteys, tunnettu siitä, että DC-linkki lisäksi käsittää ainakin yhden kaapelin (4D) liittimen (4B) ja aluksen välissä.

4. Patenttivaatimuksen 3 mukainen voimansiirtoyhteys, tunnettu siitä, että DC-linkki lisäksi käsittää kytkinlaitteen (6) aluksessa DC-linkin kytkemiseksi aluksessa olevaan DC-verkkoon (7).

5. Patenttivaatimuksen 1, 2, 3 tai 4 mukainen voimansiirtoyhteys, tunnettu siitä, että yhteys lisäksi käsittää muuntimen (9) vaihtosuuntaajan AC-puolella.

6. Menetelmä maan ja aluksen välisen voimansiirron yhdistämiseksi, jossa menetelmässä tasasuunnataan (51) maissa olevan voimansiirron voima DC-voimaksi maissa, tunnettu siitä, että järjestetään käyttöön (52) yhteys DC-voiman siirtämiseksi maan ja aluksen välillä, ja vaihtosuunnataan (53) siirretty DC-voima AC-voimaksi aluksessa.

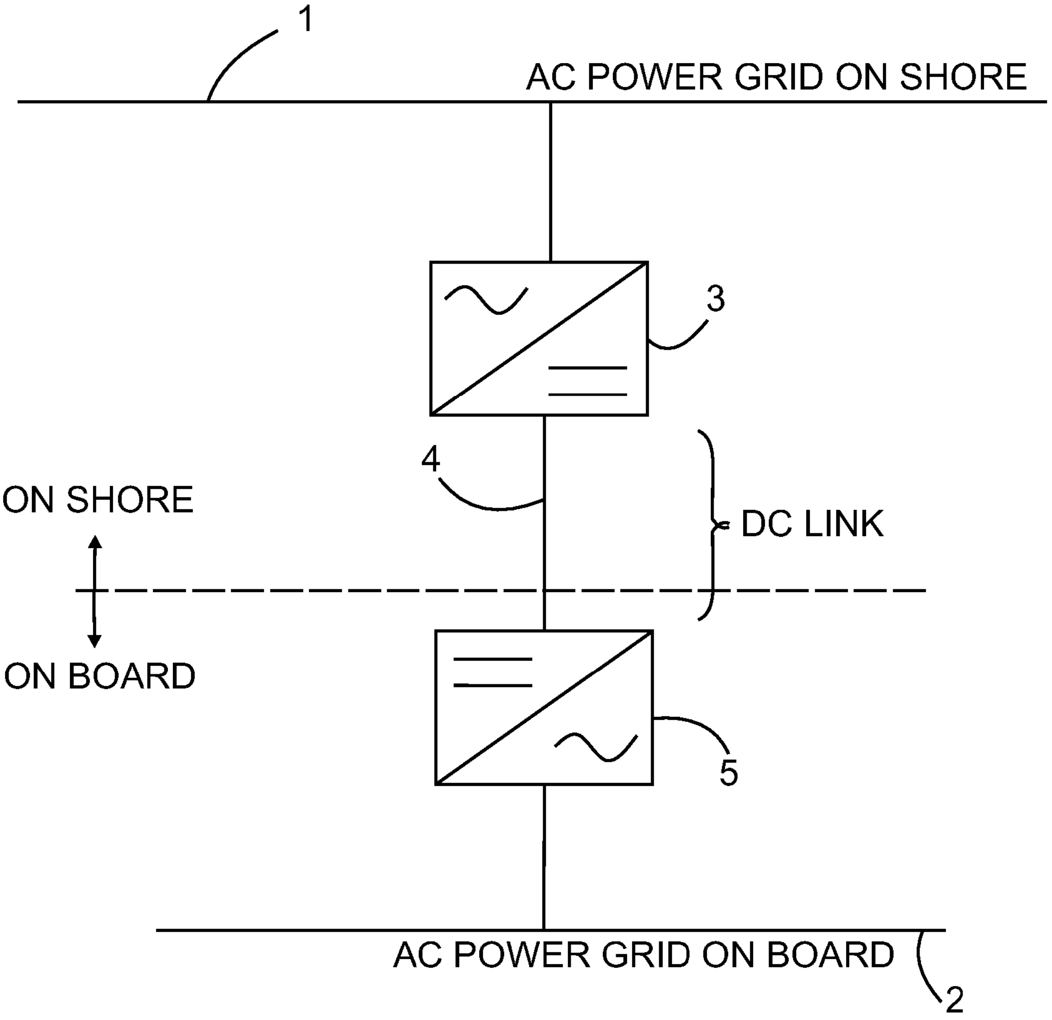


FIG. 1

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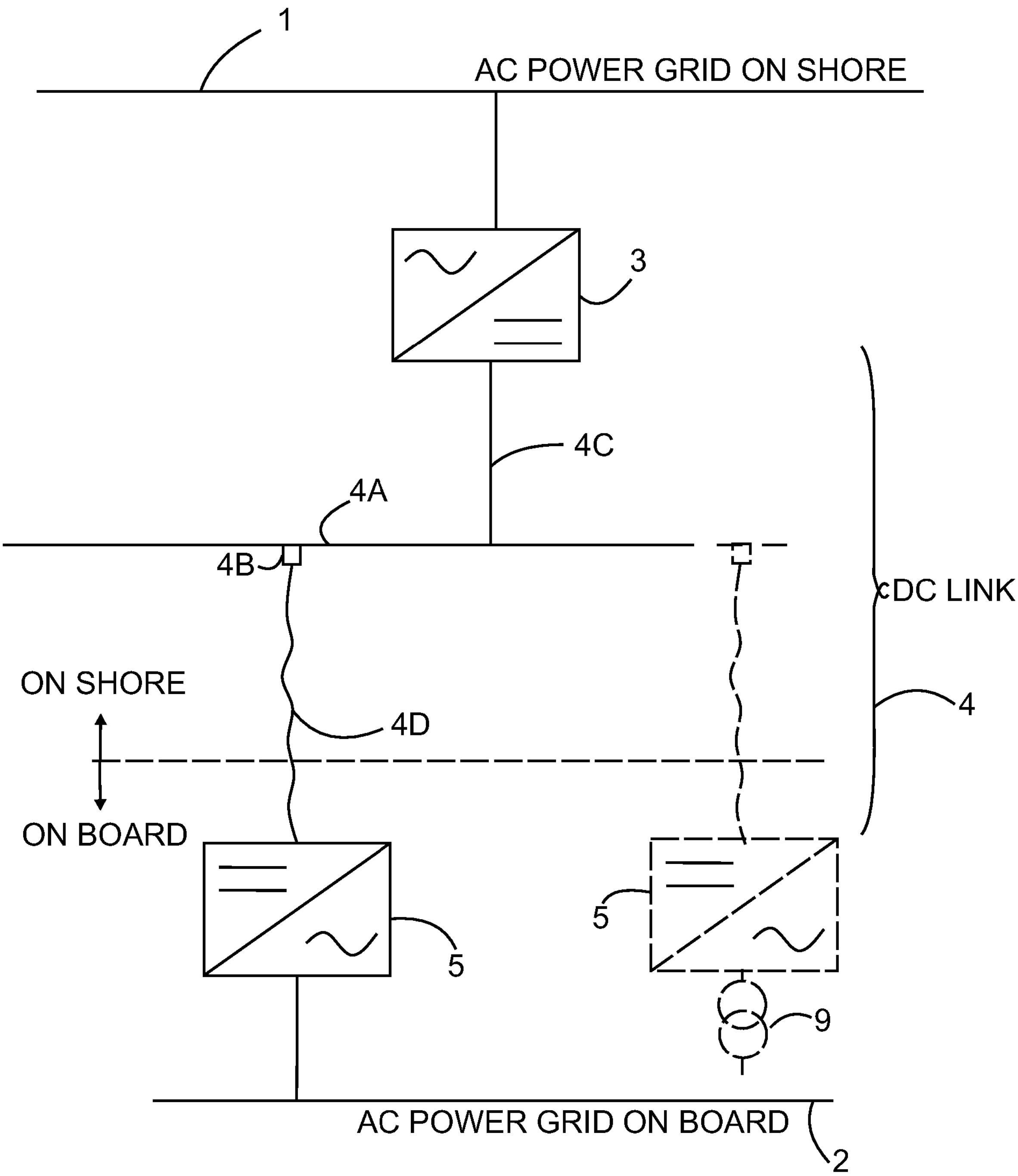
1
AC POWER GRID ON SHORE
3
4C
4A
4B
DC LINK
4
ON SHORE
4D
ON BOARD
5
5
9
AC POWER GRID ON BOARD
2

FIG. 2

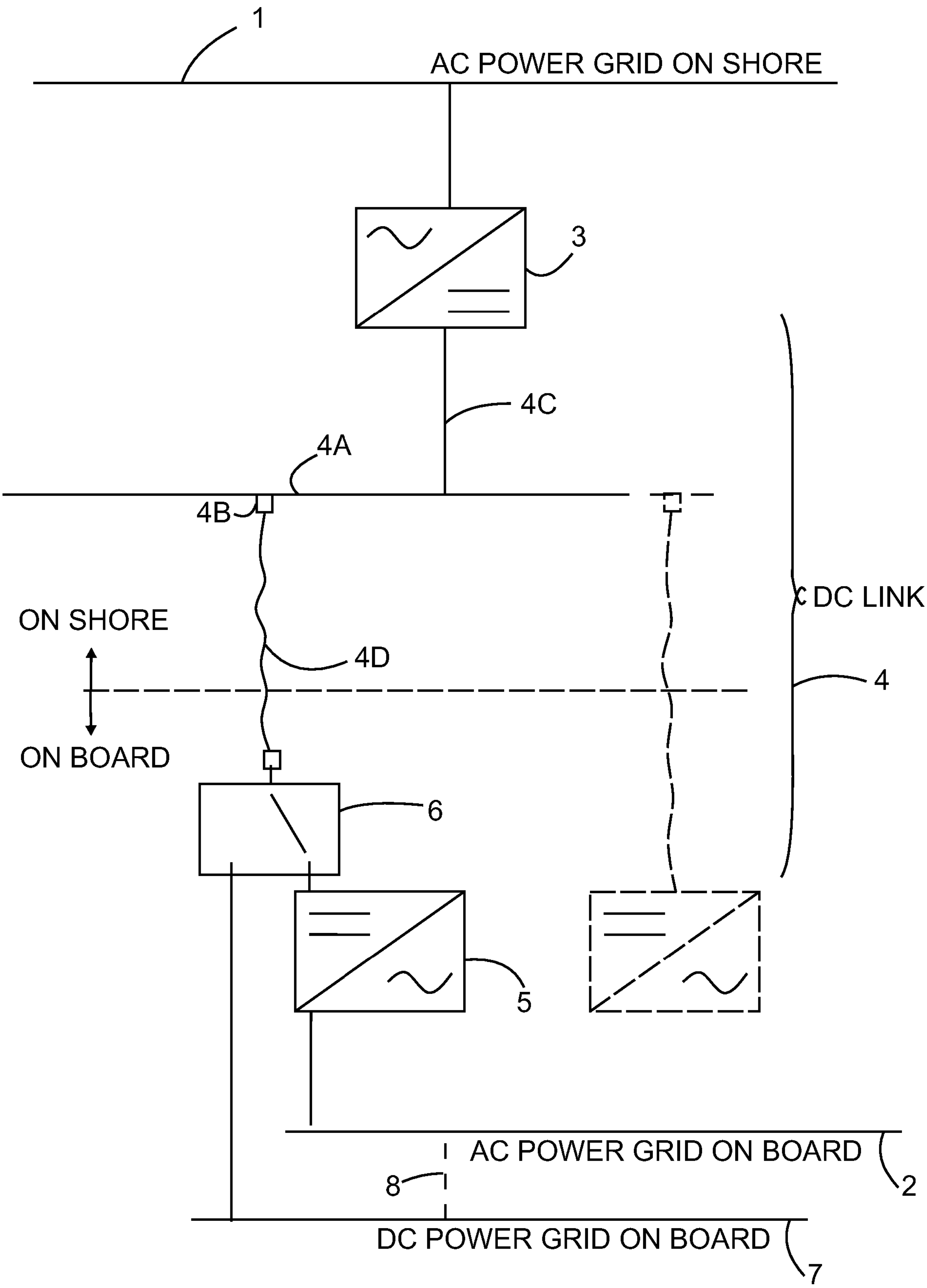

FIG. 3

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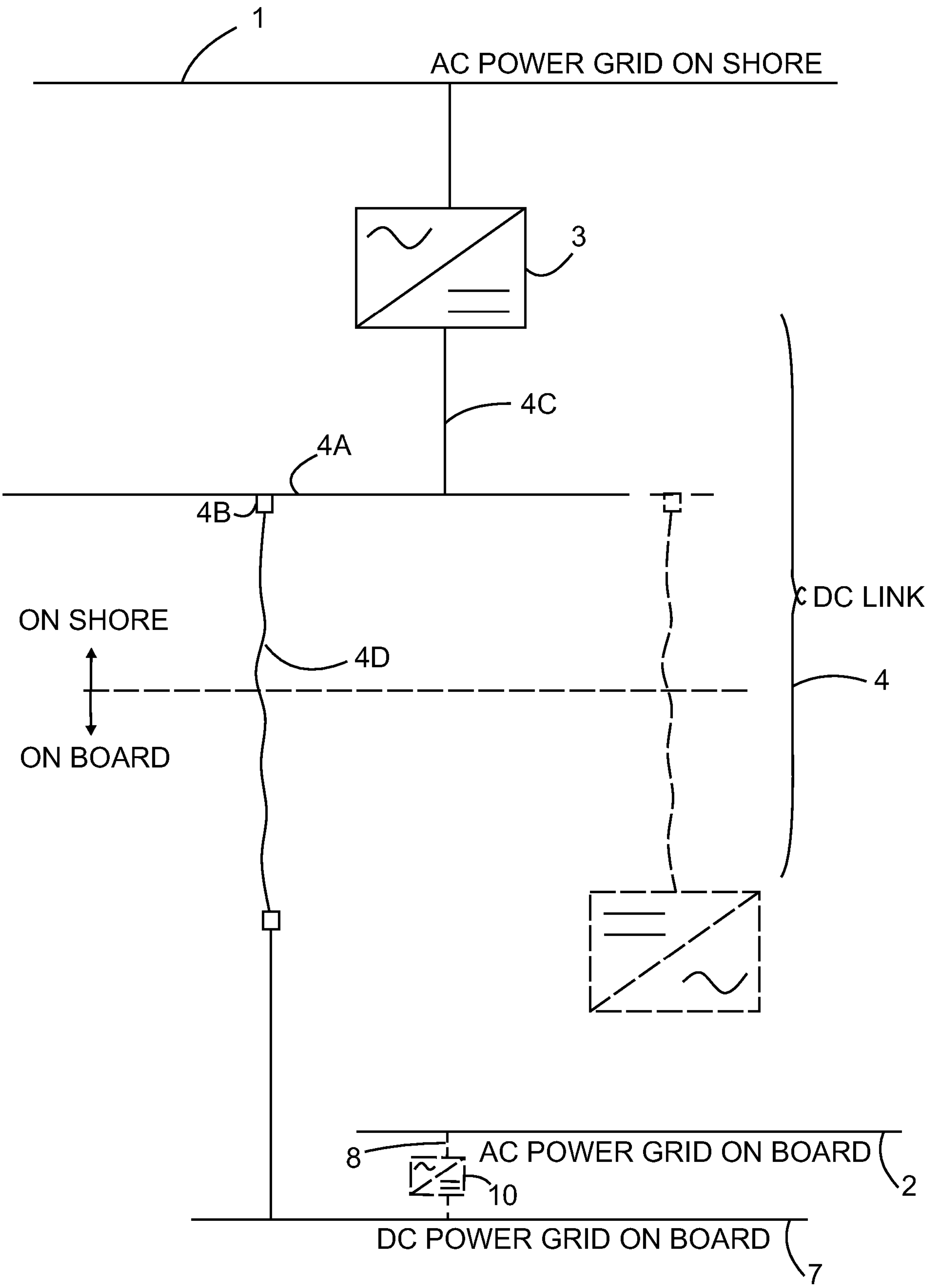

FIG. 4

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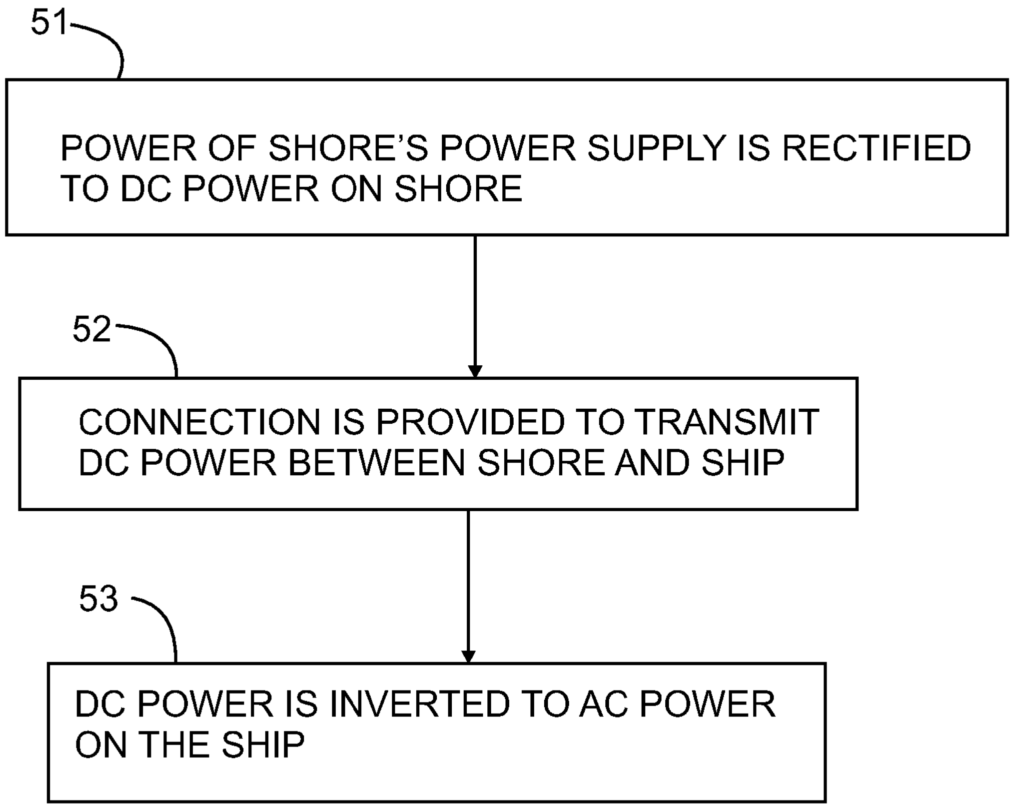
51
POWER OF SHORE’S POWER SUPPLY IS RECTIFIED TO DC POWER ON SHORE
52
CONNECTION IS PROVIDED TO TRANSMIT DC POWER BETWEEN SHORE AND SHIP
53
DC POWER IS INVERTED TO AC POWER ON THE SHIP

FIG. 5