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[Continued on next page]

(54) Title: SYSTEM FOR CONTACTLESS POWER TRANSFER AND A METHOD FOR OPERATING THE SAME

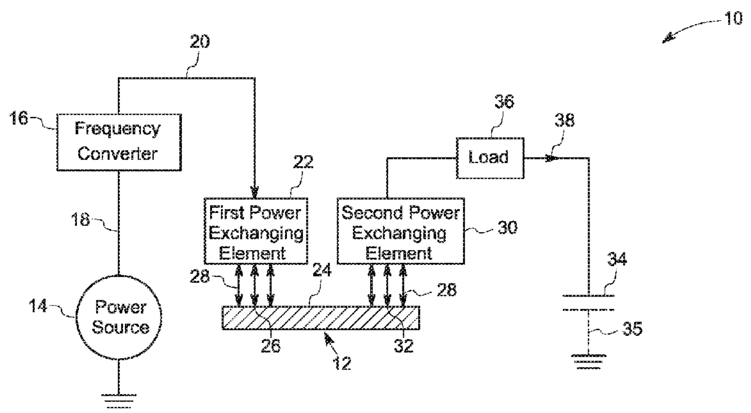

FIG. 1

(57) Abstract: A system 10 for contactless power transfer is disclosed. The system 10 includes a first power exchanging element 22 configured to be operatively coupled to a conductor 12 at a first location 26 of the conductor 12, using an electromagnetic field generated between the first power exchanging element 22 and the conductor 12 at an operating frequency of at least two kilohertz. The system also includes a second power exchanging element 30 configured to be operatively coupled to the conductor 12 at a second location 32 of the conductor 12, using the electromagnetic field generated between the first power exchanging element 22 and the conductor 12 at the operating frequency. The electromagnetic field is used to transmit power from the first power exchanging element 22 to the second power exchanging element 30.

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

— *with information concerning request for restoration of the right of priority in respect of one or more priority claims (Rules 26bis.3 and 48.2(b)(vii))*

SYSTEM FOR CONTACTLESS POWER TRANSFER AND A METHOD FOR OPERATING THE SAME

BACKGROUND

[0001] Embodiments of the present invention relate to a power transfer system and more particularly to a system and method for contactless power transfer.

[0002] Power transfer systems are used to provide electrical power to electrical devices in various applications. In some applications, the devices may be located within a conductive material enclosure and the power transfer systems are required to transmit electrical power to such enclosed devices through the conductive material enclosure.

[0003] In one approach, an intrusive power transfer method is used to provide electrical power. In the intrusive power transfer method, an opening is created in the conductive material enclosure and a physical connection is formed between the device and the power source, using wires. However, such an approach leads to undesirable leakage risks through the opening and compromised structural integrity of the conductive material enclosure.

[0004] In another approach, an induction based power transfer system is used to provide electrical power. The induction based power transfer systems are well known and operate based on the principle of induction. However, such induction based power transfer systems have poor efficiency as the conductive material acts as a shield for a generated magnetic flux.

BRIEF DESCRIPTION

[0005] Briefly, in accordance with one embodiment, a system for contactless power transfer is disclosed. The system includes a first power exchanging element configured to be operatively coupled to a conductor at a first location of the conductor, using an electromagnetic field generated between the first power exchanging element and the conductor at an operating frequency of at least two kilohertz. The system also includes a second power exchanging element configured to be operatively coupled to the conductor at a second location of the conductor, using the electromagnetic field generated between the first power exchanging element and the conductor at the operating frequency. The electromagnetic field is used to transmit power from the first power exchanging element to the second power exchanging element.

[0006] In another embodiment, a system is disclosed. The system includes a conductor and a contactless power transfer system. The contactless power transfer system includes a first power exchanging element configured to be operatively coupled to the conductor at a first location of the conductor, using an electromagnetic field generated between the first power exchanging element and the conductor at an operating frequency of at least two kilohertz. The system also includes a second power exchanging element configured to be operatively coupled to the conductor at a second location of the conductor, using the electromagnetic field generated between the first power exchanging element and the conductor at the operating frequency. The electromagnetic field is used to transmit power from the first power exchanging element to the second power exchanging element. The system further includes a load operatively coupled to the second power exchanging element.

[0007] In yet another embodiment, a method for contactless power transfer is disclosed. The method includes operating a first power exchanging element at an operating frequency of at least two kilohertz. The method also includes operatively coupling the first power exchanging element to a conductor at a first location using an electromagnetic field generated by the first power exchanging coil at the operating frequency. The method further includes operatively coupling a second power exchanging element to the conductor at a second location, using the electromagnetic field. The method also includes transmitting alternating current power from the first power exchanging element to the second power exchanging element via the electromagnetic field for operating a load operatively coupled to the second power exchanging element. The method further includes disposing an alternating current component of the alternating current power, using a charge disposal medium operatively coupled to the load.

DRAWINGS

[0008] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0009] FIG. 1 is a schematic representation of a system for contactless power transfer in accordance with an embodiment of the invention.

[0010] FIG. 2 is a schematic representation of a system for contactless power transfer in accordance with another embodiment of the invention.

[0011] FIG. 3 is a schematic representation of a system for contactless power transfer in accordance with yet another embodiment of the invention.

[0012] FIG. 4 is a schematic representation of a system for contactless power transfer in accordance with another embodiment of the invention.

[0013] FIG. 5 is a schematic representation of a hydrocarbon extraction well including a system for contactless power transfer in accordance with an embodiment of the invention.

[0014] FIG. 6 is a flow chart representing steps involved in a method for contactless power transfer in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0015] Embodiments of the present invention include a system for contactless power transfer. The system includes a first power exchanging element configured to be operatively coupled to a conductor at a first location of the conductor. In other words, the first power exchanging element is configured to be electromagnetically coupled to the conductor. The first power exchanging element is configured to be operatively coupled to the conductor, using an electromagnetic field generated between the first power exchanging element and the conductor at an operating frequency of at least two kilohertz. The system also includes a second power exchanging element configured to be operatively coupled to the conductor at a second location of the conductor, using the electromagnetic field. In other words, the second power exchanging element is configured to be electromagnetically coupled to the conductor. The electromagnetic field is used to transmit power from the first power exchanging element at the first location of the conductor to the second power exchanging element at the second location of the conductor.

[0016] FIG. 1 is a schematic representation of a system 10 for contactless power transfer through a conductor 12 in accordance with an embodiment of the invention. The system 10 includes a power source (PS) 14 operatively coupled to a frequency converter 16. The power source 14 may be an alternating current (AC) power source or a direct current (DC) power source. In one embodiment, the power source 14 provides an AC power 18 to the frequency converter 16. The frequency converter (FC) 16 converts the AC power 18 to a high frequency AC power 20. In one embodiment, the high frequency AC power 20 may include an AC power having an operating frequency of at least two kilohertz. In a specific embodiment, the high frequency AC power 20 may have the operating frequency of at least one megahertz. The conductor 12 may be an electrical conductor. In one embodiment, the conductor

12 may include a metal barrier. In a specific embodiment, the metal barrier may include an iron barrier, an aluminum barrier, or a copper barrier.

[0017] The system 10 also includes a first power exchanging element 22 operatively coupled to the frequency converter 16. The first power exchanging element 22 is configured to be operatively coupled to the first surface 24 of the conductor 12 at a first location 26. The first power exchanging element 22 receives the high frequency AC power 20 and generates an electromagnetic field 28, using the high frequency AC power 20. Furthermore, the system 10 includes a second power exchanging element 30 configured to be operatively coupled to the first surface 24, at a second location 32 of the conductor 12. In one embodiment, the operating frequency of the high frequency AC power 20 is selected based on a plurality of physical parameters of the conductor 12. Such physical parameters may include a type of the conductor 12 and a distance between the two locations 26, 32 of the conductor 12. Furthermore, the operating frequency of the high frequency AC power 20 is selected such that the high frequency AC power 20 generated by the frequency converter 16, enables generation of the electromagnetic field 28 which is used to operatively couple the second power exchanging element 30 to the conductor 12.

[0018] The second power exchanging element 30 is further operatively coupled to a load 36. The high frequency AC power 20 is transmitted from the first power exchanging element 22 disposed at the first location 26 to the second power exchanging element 30 disposed at the second location 32 of the conductor 12. The high frequency AC power 20 received by the second power exchanging element 30, is used to operate the load 36, using a high frequency alternating current component 38 of the high frequency AC power 20. In one embodiment, the load 36 may include a monitoring system. The monitoring system may include, for example, an annulus monitoring system, a wellhead fatigue monitoring system, an engine monitoring system, a turbine monitoring system, or other related monitoring systems. In another embodiment, the load 36 may include a rotatable component. The rotatable component may include, for example, an electrical submersible pump, a downhole separator, or components of a turbine used in different applications such as aviation and energy.

[0019] The system 10 further includes a charge disposal medium 34 operatively coupled to the load 36 of the system 10. In one embodiment, the charge disposal medium 34 may include, for example, an external probe, a metal plate, a wire conductor or an insulated screw. The charge disposal medium 34 is configured to act as a grounding mechanism for a high frequency alternating current component 38 flowing in the system 10. The charge disposal medium 34 forms a parasitic path 35 for the flow of the alternating current component 38.

[0020] Conventionally, induction power transfer systems are operated at very low frequency such as a few kilohertz due to eddy current shielding. Moreover, the conventional capacitive power transfer systems are unable to transfer the alternating current power due to unavailability of a return path for the alternating current component across the conductor. In accordance with the embodiment of the present invention, the charge disposal medium 34 in the system 10 provides a return flow path for flow of the alternating current component 38. The charge disposal medium 34 provides an effective ground for circuit completion by providing a large enough metallic source/sink for discharge such that a half cycle of the high frequency alternating current component cannot change voltage significantly.

[0021] Furthermore, the electromagnetic field 28 generated using the high frequency AC power 20, reduces an overall capacitive impedance of the system 10. Moreover, the electromagnetic field 28 also enables bidirectional exchange of power, data, or a combination thereof sequentially (one after the other) or simultaneously between the first power exchanging element 22 and the second power exchanging element 30. In one embodiment, data may include information obtained by sensors such as pressure sensor, temperature sensor, proximity sensor, strain sensor, and the like.

[0022] FIG. 2 is a schematic representation of a system 40 for contactless power transfer in accordance with another embodiment of the present invention. The system 40 includes the first power exchanging element 22 operatively coupled to the first surface 24, at the first location 26 and the second power exchanging element 30 operatively coupled to the first surface 24, at the second location 32 of the conductor 12. In such an embodiment, a surface 42 of another conductor 13 may be used as the charge disposal medium for enabling the flow back of the alternating current component 38 through the conductor 12. In one embodiment, the surface 42 may be used as the charge disposal medium while operating the system 40 at the operating frequency of above one terahertz. Specifically, the surface 42 of the conductor 13 may be operatively coupled to the load 36. Thereby, the alternating current component 38 is transmitted from the load 36 to the surface 42 of the conductor 13 for providing the return flow path of the alternating current component 38.

[0023] FIG. 3 is a schematic representation of a system 50 for contactless power transfer in accordance with yet another embodiment of the present invention. The system 50 is substantially similar to the system 10 of FIG.1. Specifically, the system 50 includes a first power exchanging coil 52 and a second power exchanging coil 54. In one specific embodiment, the first power exchanging coil 52 and the second power exchanging coil 54 may be a spiral shaped coil. In other embodiments, other types of coils may be used. The electromagnetic coupling of the first and second power exchanging coils 52, 54 to the conductor 12 is influenced by suitable design factors such as dielectric material content having higher permittivity in the first and second power exchanging coils 52, 54, number of coil turns, gap between coil turns, and thickness of each coil turn. In this embodiment, the high frequency AC power 20 is transmitted from the first power exchanging coil 52 to the second power exchanging coil 54, using the generated electromagnetic field 28. The high frequency AC power 20 received by the second power exchanging coil 54 includes a common-mode AC component because of an inherent physical property of the second power exchanging coil 54. Such a common-mode AC component cannot be used to operate the load 36. Therefore, an electronic regulator 56 is operatively coupled between the second power exchanging coil 54 and the load 36. In one embodiment, the electronic regulator 56 may be a half wave rectifier (HWR). The electronic regulator 56 generates a differential current 58 based on the common-mode alternating current component, which is used to operate the load 36. In some embodiments, the second power exchanging coil 54 has an asymmetric configuration. Furthermore, the charge disposal medium 34 enables flow of the differential current 58 from the load 36 to the charge disposal medium 34.

[0024] FIG. 4 is a schematic representation of a system 60 for contactless power transfer in accordance with yet another embodiment of the present invention. The system 60 includes the first power exchanging element 22 operatively coupled to the first surface 24, at the first location 26 and the second power exchanging element 30 operatively coupled to a second surface 64, at a second location 62 of the conductor 12. In such embodiments, the high frequency AC power 20 is transmitted from the first power exchanging element 22 to the second power exchanging element 30 through the conductor 12. Specifically, the high frequency AC power 20 is transmitted from the first surface 24 to the second surface 64 of the conductor 12, using the electromagnetic field 28. The load 36 is coupled to the second power exchanging element 30 and configured to receive the alternating current component 38 from the second power exchanging element 30. The charge disposal medium 34 is operatively coupled to the load 36 for enabling flow of the alternating current component 38 through the conductor 12 to the load 36.

[0025] FIG. 5 is a schematic representation of a hydrocarbon extraction well 72 including the system 10 for contactless power transfer in accordance with an embodiment of the invention. The hydrocarbon extraction well 72 includes a well bore 74, a casing 76 disposed within the well bore 74, and a tubing 78 disposed within the casing 76. The system 10 is configured to transmit high frequency AC power through the casing 76 or the tubing 78. In the illustrated embodiment, the tubing 78 is the conductor and the operation of the system 10 for contactless power transfer is discussed with reference to the tubing 78.

[0026] The system 10 includes the first power exchanging element 22 configured to generate the electromagnetic field 28 based on the high frequency AC power received from the high frequency converter. In the illustrated embodiment, the first power exchanging element 22 is disposed within the well bore 74. The first power exchanging element 22 is operatively coupled to a first surface 80 of the tubing 78, at a first location 82. The first power exchanging element 22 is configured to transmit the high frequency AC power to the tubing 78, using the generated electromagnetic field 28.

[0027] Furthermore, the second power exchanging element 30 is disposed downhole within the well bore 74. Specifically, the second power exchanging element 30 is disposed at the second location 84 on the first surface 80 of the tubing 78. In some embodiments, the first power exchanging element 22 and the second power exchanging element 30 are disposed within an enclosure (not shown) to protect the first power exchanging element 22 and the second power exchanging element 30 from fluids such as oil and gas. In such embodiments, the first power exchanging element 22 and the second power exchanging element 30 are attached to the enclosure. During operation, the second power exchanging element 30 is operatively coupled to the first surface 80, at the second location 84 of the tubing 78 using the electromagnetic field 28 generated between the second power exchanging element 30 and the tubing 78. The high frequency AC power is transmitted from the first location 82 to the second location 84 of the tubing 78 because the first power exchanging element 22 and the second power exchanging element 30 are coupled to the tubing 78. As a result, the high frequency AC power is transmitted from the first power exchanging element 22 to the second power exchanging element 30. The second power exchanging element 30 is operatively coupled to the load 36 disposed downhole in the well bore 74. It may be noted herein that the second location 84 for coupling the second power exchanging element 30 to the tubing 78 is selected in such a way that the efficiency of the power transfer from the power source to the load 36 is maximized. In one embodiment, the load 36 may be a component such an annulus monitoring system, a wellhead fatigue monitoring system, an electrical submersible pump, and/or a downhole separator.

[0028] Furthermore, a charge disposal medium is operatively coupled to the load 36. The charge disposal medium enables the flow of the alternating current component 38. In the illustrated embodiment, a second surface 86 of the tubing 78 is configured to operate as the charge disposal medium.

[0029] In some embodiments, the hydrocarbon extraction well 72 may include the system 60 shown in FIG. 4. In such embodiments, the first power exchanging element 22 may be disposed at the first location 82 on the first surface 80 of the tubing 78 and the second power exchanging element 30 may be disposed at the second location 84 on the second surface 86 of the tubing 78. In such embodiments, the charge disposal medium may include an external probe, a metal plate or an insulated screw.

[0030] In certain other embodiments, the hydrocarbon extraction well 70 may include the system 50 shown in FIG. 3. In such embodiments, the system 50 includes the electronic regulator operatively coupled to the second power exchanging coil 54 and disposed within the well bore 74. The electronic regulator is configured to generate a differential current from a common-mode current component of the high frequency AC power received by the second power exchanging coil 54. The differential current generated by the electronic regulator, is used to operate the load 36 in the hydrocarbon extraction well 70.

[0031] FIG. 6 is a flow chart representing steps involved in a method 90 for contactless power transfer in accordance with an embodiment of the invention. The method 90 includes operating a first power exchanging element at an operating frequency of at least two kilohertz in step 92. In one embodiment, the first power exchanging element is operated at the operating frequency of at least one megahertz. The method 90 also includes operatively coupling the first power exchanging element to a conductor, at a first location, using an electromagnetic field generated by the first power exchanging element in step 94. The method 90 further includes operatively coupling a second power exchanging element to the conductor, at a second location, using the electromagnetic field in step 96. The method 90 also includes transmitting AC power from the first power exchanging element to the second power exchanging element, using the electromagnetic field, for operating a load operatively coupled to the second power exchanging element in step 98. The method 90 further includes disposing an alternating current component of the AC power, using a charge disposal medium operatively coupled to the load in step 100.

[0032] In accordance with the embodiments of the present invention, the electromagnetic field generated at an operating frequency of at least two kilohertz, facilitates to reduce the impedance of the system such that the alternating current component may pass through the conductor. Furthermore, the charge disposal medium enables flow of the alternating current component, thereby permitting the alternating current component to flow through the conductor to the load. Further, undesirable leakage risks are prevented and structural integrity of the conductor is not compromised.

[0033] It is to be understood that a skilled artisan will recognize the interchangeability of various features from different embodiments and that the various features described, as well as other known equivalents for each feature, may be mixed and matched by one of ordinary skill in this art to construct additional systems and techniques in accordance with principles of this specification. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention. However, such induction based power transfer systems have poor efficiency as the conductive material acts as a shield for a generated magnetic flux.

[0034] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS:

1. A contactless power transfer system comprising:

a first power exchanging element configured to be operatively coupled to a conductor, at a first location of the conductor, using an electromagnetic field generated between the first power exchanging element and the conductor, at an operating frequency of at least two kilohertz; and

a second power exchanging element configured to be operatively coupled to the conductor, at a second location of the conductor, using the electromagnetic field generated between the first power exchanging element and the conductor, at the operating frequency,

wherein the electromagnetic field is used to transmit power from the first power exchanging element to the second power exchanging element.

2. The system of claim 1, wherein the operating frequency is at least one megahertz.

3. The system of claim 1, wherein the first power exchanging element and the second power exchanging element are configured to exchange data simultaneously with the power.

4. The system of claim 1, further comprising a charge disposal medium operatively coupled to a load, wherein the second power exchanging element is configured to provide an alternating current component for operating the load and

wherein the charge disposal medium is configured to provide a path for flow of the alternating current component used to operate the load.

5. The system of claim 4, wherein the charge disposal medium comprises a metal plate.

6. The system of claim 1, wherein the first power exchanging element comprises a first power exchanging coil and the second power exchanging element comprises a second power exchanging coil.

7. The system of claim 6, further comprising an electronic regulator operatively coupled to the second power exchanging coil and configured to generate a differential current from a common-mode current received by the second power exchanging coil, wherein the differential current is used to operate a load.

8. The system of claim 7, wherein the electronic regulator comprises a half wave rectifier.

9. The system of claim 1, wherein the first power exchanging element is configured to be operatively coupled to a first surface of the conductor, at the first location and the second power exchanging element is configured to be operatively coupled to the first surface of the conductor, at the second location.

10. The system of claim 9, further comprising the conductor comprising the first surface and a second surface, wherein the second surface is operatively coupled to a load and configured to operate as a charge disposal medium.

11. The system of claim 1, wherein the first power exchanging element is configured to be operatively coupled to a first surface of the conductor, at the first location and the second power exchanging element is configured to be operatively coupled to a second surface of the conductor, at the second location.

12. A system comprising:

a conductor;

a contactless power transfer system comprising:

a first power exchanging element configured to be operatively coupled to the conductor, at a first location of the conductor, using an electromagnetic field generated between the first power exchanging element and the conductor at an operating frequency of at least two kilohertz; and

a second power exchanging element configured to be operatively coupled to the conductor, at a second location of the conductor, using the electromagnetic field generated between the first power exchanging element and the conductor, at the operating frequency, wherein the electromagnetic field is used to transmit power from the first power exchanging element to the second power exchanging element; and

a load operatively coupled to the second power exchanging element.

13. The system of claim 12, wherein the first power exchanging element and the second power exchanging element comprises a first power exchanging coil and a second power exchanging coil respectively.

14. The system of claim 13, wherein the contactless power transfer system further comprises an electronic regulator operatively coupled to the second power exchanging coil and the load, wherein the electronic regulator is configured to generate a differential current from a common-mode current received by the second power exchanging coil, and wherein the differential current is used to operate the load.

15. The system of claim 12, wherein the conductor comprises a casing and a tubing disposed within a well bore of a hydrocarbon extraction well.

16. The system of claim 15, wherein the casing or the tubing comprises a first surface, and wherein the first power exchanging element is configured to be operatively coupled to the first surface of the casing or the tubing, at the first location and the second power exchanging element is configured to be operatively coupled to the first surface of the casing or the tubing, at the second location.

17. The system of claim 16, wherein the casing or the tubing comprises a second surface operatively coupled to the second power exchanging element and configured to operate as a charge disposal medium.

18. The system of claim 15, wherein the casing or the tubing comprises a first surface and a second surface, and wherein the first power exchanging element is configured to be operatively coupled to the first surface of the casing or the tubing, at the first location and the second power exchanging element is configured to be operatively coupled to the second surface of the casing or the tubing, at the second location.

19. The system of claim 12, wherein the load comprises a component of a hydrocarbon extraction well.

20. A method for contactless power transfer comprising:

operating a first power exchanging element at an operating frequency of at least two kilohertz;

operatively coupling the first power exchanging element to a conductor, at a first location, using an electromagnetic field generated by the first power exchanging coil at the operating frequency;

operatively coupling a second power exchanging element to the conductor, at a second location, using the electromagnetic field;

transmitting alternating current power from the first power exchanging element to the second power exchanging element, using the electromagnetic field, for operating a load operatively coupled to the second power exchanging element; and

disposing an alternating current component of the alternating current power, using a charge disposal medium operatively coupled to the load.

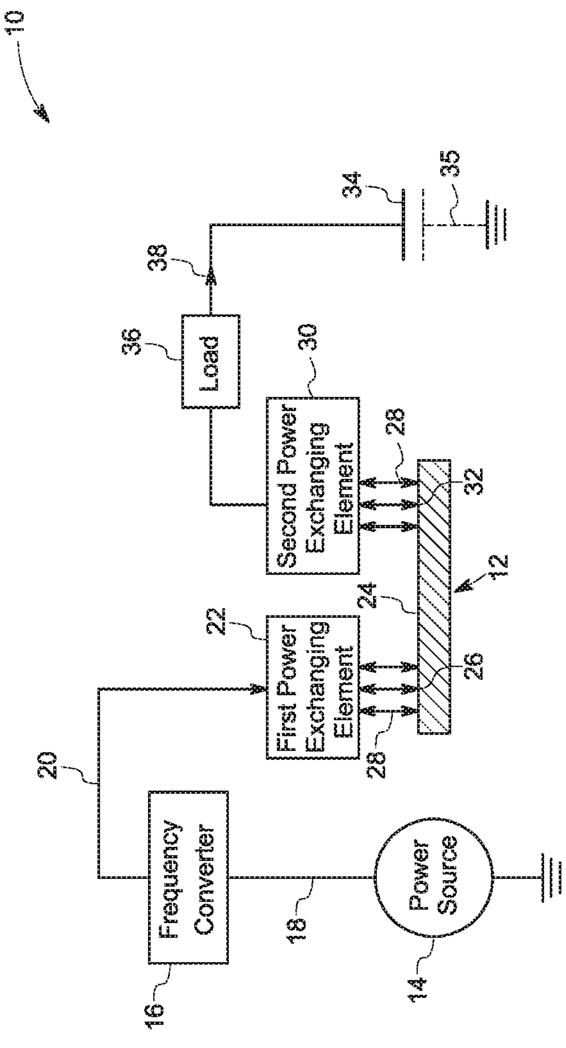

10
Frequency Converter
16
Power Source
14
18
20
First Power Exchanging Element
22
28
26
24
12
Second Power Exchanging Element
30
28
32
Load
36
38
34
35

FIG. 1

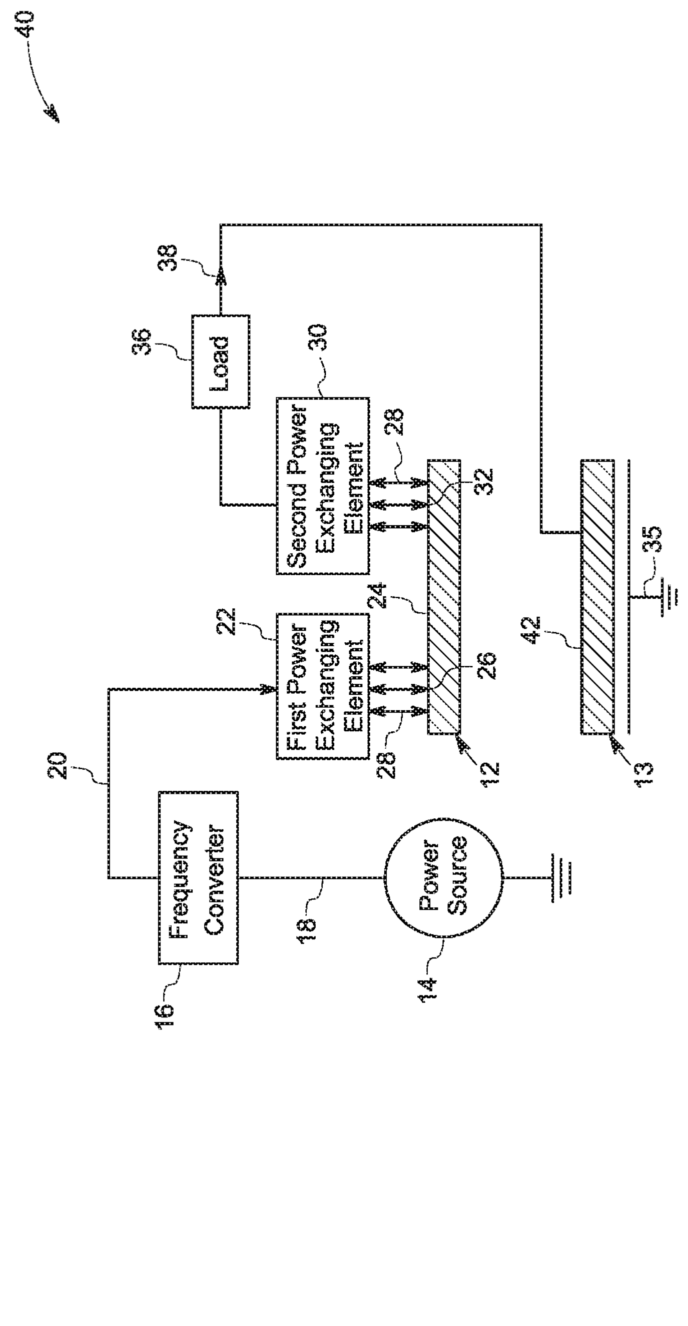
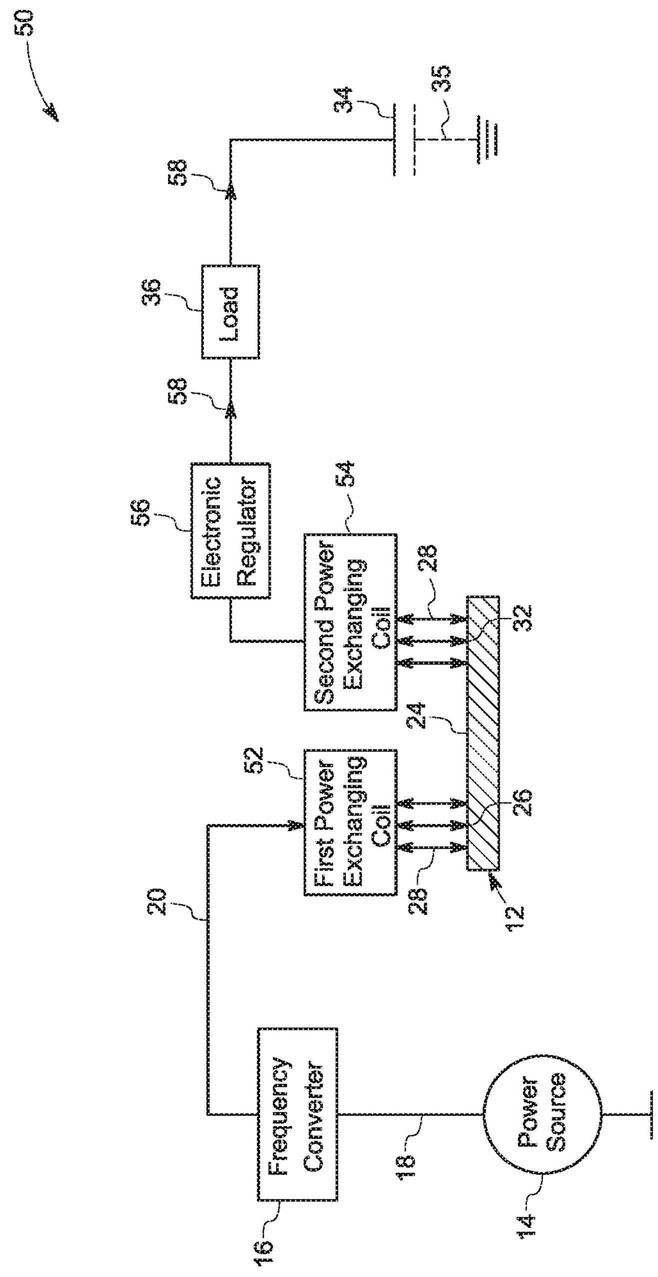

40
38
36
Load
30
Second Power
Exchanging
Element
28
32
22
First Power
Exchanging
Element
24
26
28
12
20
Frequency
Converter
16
18
Power
Source
14
42
35
13

FIG. 2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34
35
58
36
Load
58
56
Electronic Regulator
54
Second Power Exchanging Coil
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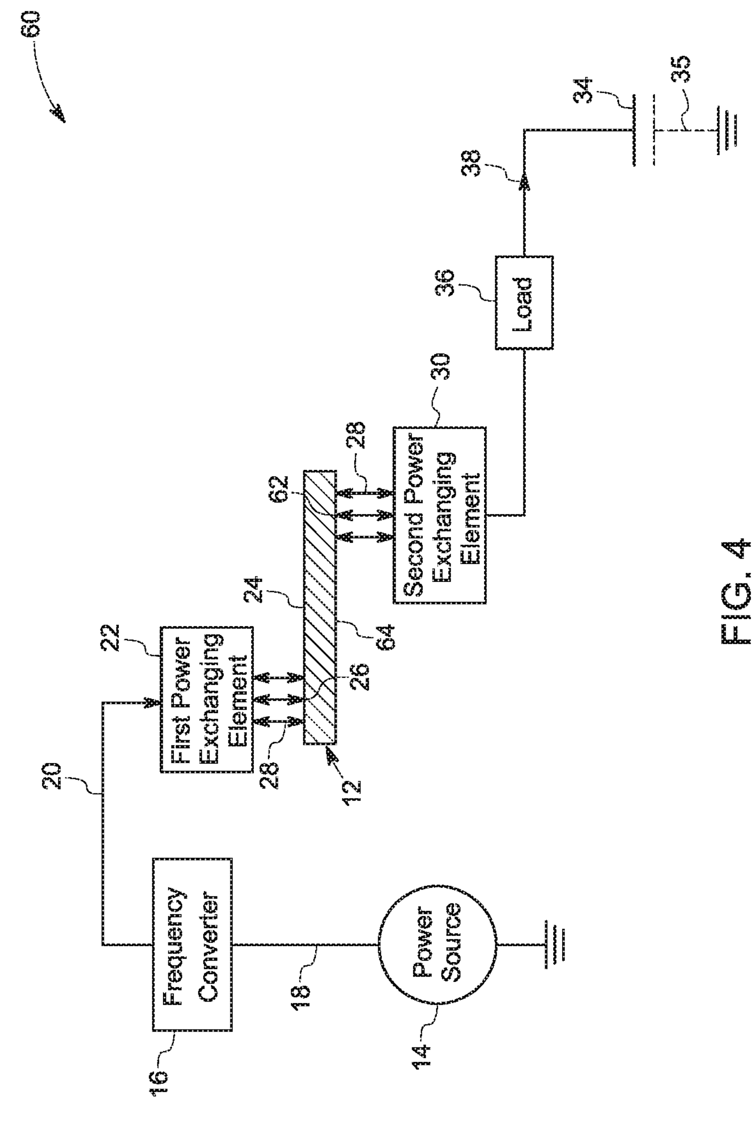
24
52
First Power Exchanging Coil
26
20
28
12
Frequency Converter
Power Source
18
16
14

FIG. 3


60
34
35
38
36
Load
30
28
62
Second Power Exchanging Element
24
64
22
First Power Exchanging Element
26
28
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Frequency Converter
Power Source
18
16
14

FIG. 4

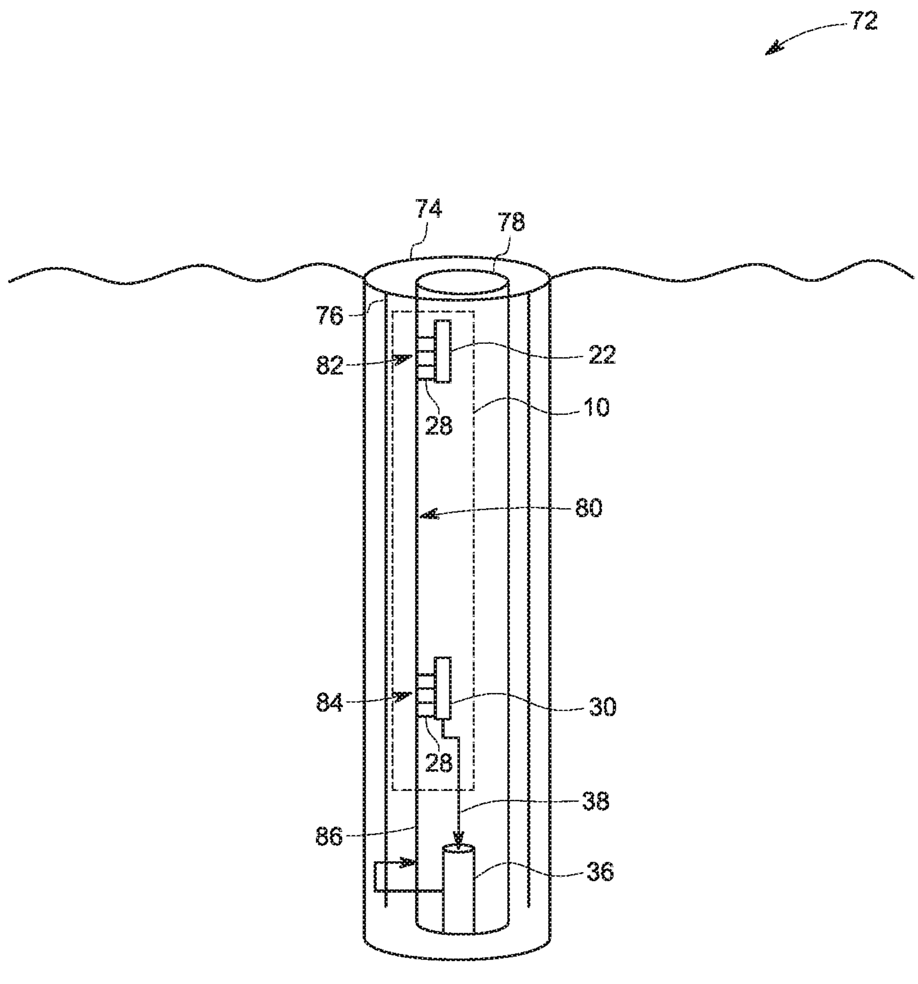

FIG. 5

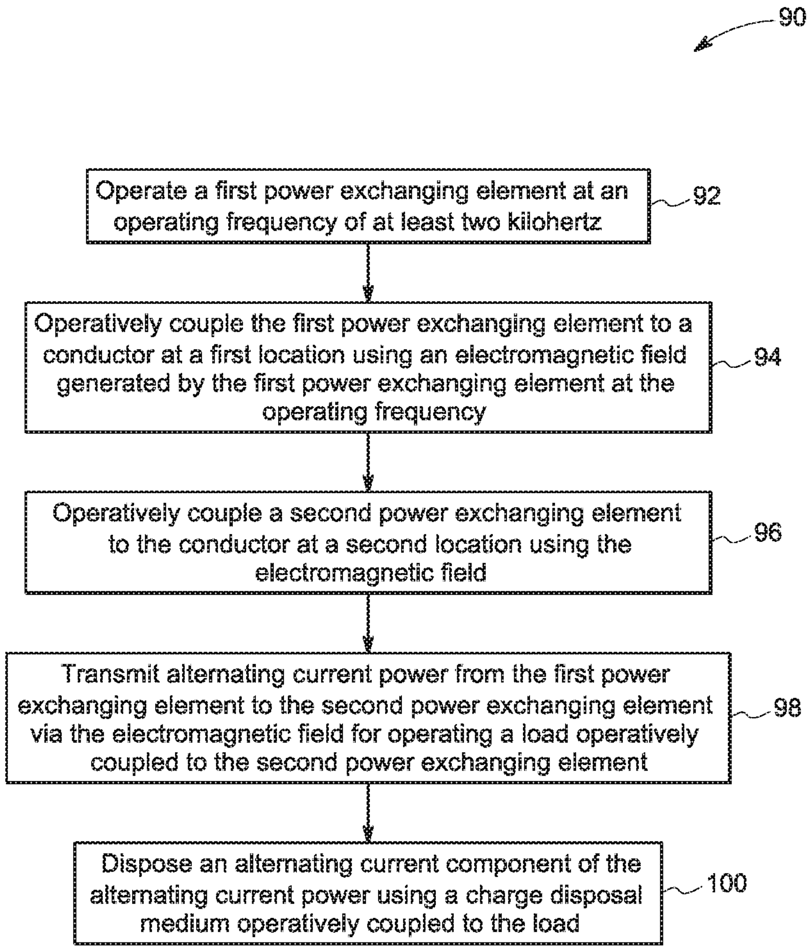
90
Operate a first power exchanging element at an operating frequency of at least two kilohertz
92
Operatively couple the first power exchanging element to a conductor at a first location using an electromagnetic field generated by the first power exchanging element at the operating frequency
94
Operatively couple a second power exchanging element to the conductor at a second location using the electromagnetic field
96
Transmit alternating current power from the first power exchanging element to the second power exchanging element via the electromagnetic field for operating a load operatively coupled to the second power exchanging element
98
Dispose an alternating current component of the alternating current power using a charge disposal medium operatively coupled to the load
100

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/026301

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02J50/05 H02J50/10
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)
E21B 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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2009/115798 A1 (SCHLUMBERGER HOLDINGS; SCHLUMBERGER CA LTD [CA]; PRAD RES & DEV LTD; S) 24 September 2009 (2009-09-24) paragraphs [0036], [0037], [0044]; figure 4b	1-9, 12-14,20 10,11, 15-19
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A	WO 2012/085495 A2 (EXPRO NORTH SEA LTD [GB]; HUDSON STEVEN MARTIN [GB]) 28 June 2012 (2012-06-28) the whole document	1-20

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2017	06/07/2017

Name and mailing address of the ISA/	Authorized officer
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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