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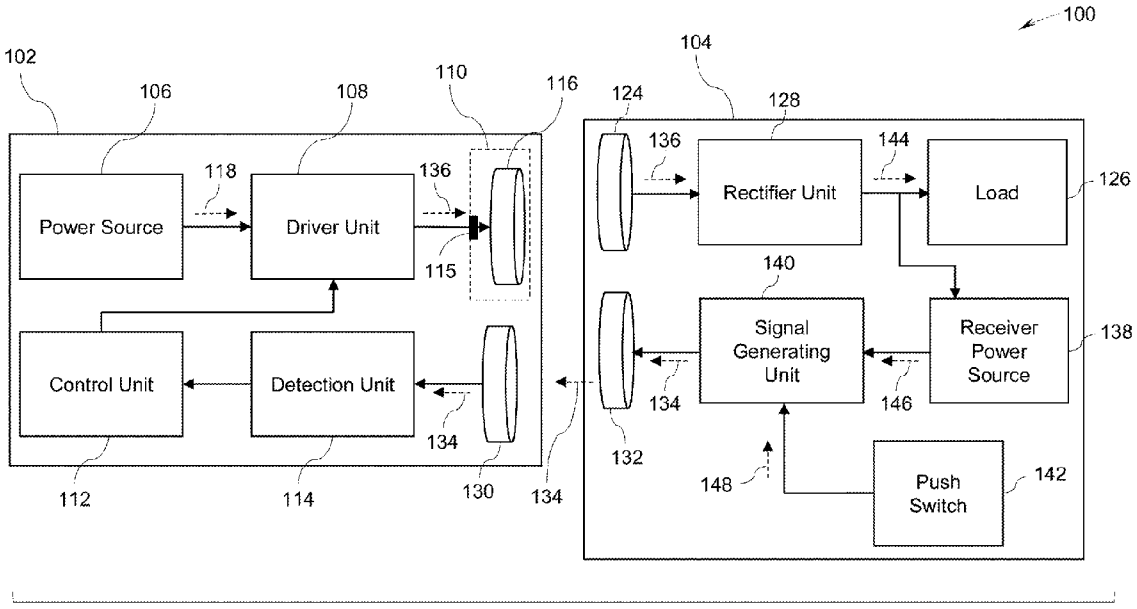


FIG. 1

(57) Abstract: A wireless charging device (102) is disclosed. The wireless charging device (102) includes a transmitter detection coil (130) configured to receive a first alternating current (AC) voltage signal having a characteristic associated with a receiver device (104). Also, the wireless charging device (102) includes a control unit (112) coupled to the transmitter detection coil (130) and configured to detect the receiver device (104) based on the characteristic of the first AC voltage signal. Further, the wireless charging device (102) includes a driver unit (108) coupled to the control unit (112) and configured to convert a direct current (DC) voltage signal of an input power to a second AC voltage signal if the receiver device (104) is detected. In addition, the wireless charging device (102) includes a power transmission coil (116) configured to wirelessly transmit the second AC voltage signal to the receiver device (104).

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A WIRELESS CHARGING DEVICE, A RECEIVER DEVICE, AND AN ASSOCIATED METHOD THEREOF

BACKGROUND

[0001] Embodiments of the present invention relate generally to wireless power systems and more particularly to wireless charging device, a receiver device, and an associated method thereof.

[0002] In general, power transfer systems are used to transfer electric power from a power source to one or more receiver devices, such as for example, mobile devices, biomedical devices, and portable consumer devices. The power transfer systems are contact based power transfer systems or wireless power transfer systems. A contact based power transfer system includes interconnecting wires used to transfer electric power from the power source to receiver devices. Such interconnecting wires may damage or corrode over a period of time. Further, interconnecting wires of a contact based power transfer system contributes to the overall weight of the system. Wireless power transfer systems may be desirable to transfer power from a power source to receiver devices.

[0003] Typically, in a conventional power transfer system, a charging device is used to convert an input electric power received from a power source to a transferrable electric power that is transmitted to charge one or more batteries in a receiver device. However, the charging device may continuously transmit the power even if the receiver device is not present. Such transmission of power results in power loss and affects efficiency of the charging device.

[0004] Therefore, there is a need for an enhanced wireless charging device, a receiver device, and a method for detecting receiver devices.

BRIEF DESCRIPTION

[0005] In accordance with one embodiment of the present invention, a wireless charging device is disclosed. The wireless charging device includes a transmitter detection coil configured to receive a first alternating current (AC) voltage signal having a characteristic associated with a receiver device. Also, the wireless charging device includes a control unit coupled to the transmitter detection coil and configured to detect the receiver device based on the characteristic of the first AC voltage signal. Further, the wireless charging device includes a driver unit coupled to the control unit and configured to convert a direct current (DC) voltage signal of an input power to a second AC voltage signal if the receiver device is detected. In addition, the wireless charging device includes a power transmission

coil coupled to the driver unit and configured to wirelessly transmit the second AC voltage signal to the receiver device.

[0006] In accordance with another embodiment of the present invention, a receiver device is disclosed. The receiver device includes a signal generating unit configured to generate a first alternating current (AC) voltage signal having a characteristic associated with the receiver device. Also, the receiver device includes a receiver detection coil coupled to the signal generating unit and configured to transmit the first AC voltage signal having the characteristic to a wireless charging device. Further, the receiver device includes a power reception coil configured to be magnetically coupled to the wireless charging device and receive input power having a second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device.

[0007] In accordance with another embodiment of the present invention, a method for detecting a receiver device is disclosed. The method includes generating, by a signal generating unit, a first alternating current (AC) voltage signal having a characteristic associated with a receiver device. Also, the method includes transmitting, by a receiver detection coil, the first AC voltage signal having the characteristic to a wireless charging device. Further, the method includes receiving, by a power reception coil, input power having a second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device.

[0008] In accordance with another embodiment of the present invention, a wireless power transfer system is disclosed. The wireless power transfer system includes at least one receiver device including a signal generating unit configured to generate a first alternating current (AC) voltage signal having a characteristic associated with the at least one receiver device. Also, the at least one receiver device includes a receiver detection coil coupled to the signal generating unit and configured to transmit the first AC voltage signal having the characteristic to a wireless charging device. Further, the wireless power transfer system includes the wireless charging device wirelessly coupled to the at least one receiver device and including a transmitter detection coil configured to receive the first alternating current (AC) voltage signal having the characteristic associated with the receiver device. Also, the wireless charging device includes a control unit coupled to the transmitter detection coil and configured to detect the receiver device based on the characteristic of the first AC voltage signal.

DRAWINGS

[0009] These and other features, aspects, and advantages of the present disclosure 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:

[0010] FIG. 1 a block diagram of a wireless power transfer system in accordance with an embodiment of the present invention;

[0011] FIG. 2 is a detailed schematic representation of a wireless power transfer system in accordance with an embodiment of the present invention;

[0012] FIG. 3 is a flow chart illustrating a method for indicating a presence of a receiver device and receiving electric power from a wireless charging device in accordance with embodiments of the present invention; and

[0013] FIG. 4 is a flow chart illustrating a method for detecting a receiver device in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

[0014] As will be described in detail hereinafter, various embodiments of a system and a method for charging one or more receiver devices are disclosed. In particular, embodiments of the system and the method discloses detection of the receiver device prior to transmitting electric power to the receiver device. Additionally, the embodiments of the system and the method discloses detection of one or more foreign objects.

[0015] Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this specification belongs. The terms “first”, “second”, and the like, as used herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The use of terms “including,” “comprising” or “having” and variations thereof herein are meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms “connected” and “coupled” are not restricted to physical or mechanical connections or couplings, and can include electrical connections or couplings, whether direct or indirect. Furthermore, terms “circuit” and “circuitry” and “control unit” may include either a single component or a plurality of components, which are either active and/or passive and are connected or otherwise coupled together to provide the described

function. In addition, the term operationally coupled as used herein includes wired coupling, wireless coupling, electrical coupling, magnetic coupling, radio communication, software based communication, or combinations thereof.

[0016] FIG. 1 is a diagrammatical representation of a wireless power transfer system 100 in accordance with an embodiment of the present invention. The wireless power transfer system 100 includes a wireless charging device 102 and a receiver device 104. The wireless charging device 102 may include a power transmitting device, such as a power bank, a charging pad, or the like. The receiver device 104 may include a mobile device, a biomedical device, a portable consumer device, or the like. For ease of understanding, only one receiver device 104 is depicted in FIG. 1. In other embodiments, the wireless power transfer system 100 may include a plurality of receiver devices that are compatible with one of the wireless frequency standards. In one embodiment, the wireless frequency standards include a Power Matters Alliance (PMA) standard, an Air Fuel Alliance standard, a Qi standard, a Wireless Planning and Coordination (WPC) standard, and the like.

[0017] The wireless charging device 102 is configured to magnetically or wirelessly couple to the receiver device 104 to transmit electrical power to the receiver device 104. In one embodiment, the electric power may be in a range from about 0.1 W to about 3000 W. Further, the receiver device 104 is configured to receive the electric power from the wireless charging device 102 and supply the received electric power to one or more loads, such as batteries in the receiver device 104.

[0018] In a conventional power transfer system, a charging device may continuously transmit power even if a receiver device is not present at a proximate location, resulting in power loss and thereby affecting the efficiency of the charging device.

[0019] The exemplary wireless power transfer system 100 includes detection coils 130, 132 in the wireless charging device 102 and the receiver device 104 respectively. The detections coils 130, 132 aid in detecting the receiver device 104 before transmitting the electric power. The receiver device 104 may be detected at a location within a predetermined distance from the wireless charging device 102. In one embodiment, the predetermined distance may be in a range from about 5 mm to 500 mm. In particular, the detection coil 132 in the receiver device 104 transmits a first AC voltage signal 134 to the wireless charging device 102. The first AC voltage signal 134 is a low voltage signal that is used for detecting the receiver device 104. In one embodiment, the magnitude of the first AC voltage signal 134 is in a range from about 20 V to about 30 V. It may be noted herein that the detection coil 132 in the receiver device 104 may also be alternatively referred as a "receiver detection coil."

[0020] The detection coil 130 in the wireless charging device 102 receives the first AC voltage signal 134. It may be noted that the detection coil 130 in the wireless charging device 102 is alternatively referred to as a "transmitter detection coil." Further, the wireless charging device 102 detects the presence of the receiver device 104 based on one or more characteristics of the received first AC voltage signal 134. In one embodiment, the characteristics of the first AC voltage signal 134 include a frequency and a voltage associated with the receiver device 104. In another embodiment, the characteristic of the first AC voltage signal 134 may be representative of at least one of a frequency and a voltage associated with the receiver device 104. The voltage of the first AC voltage signal may be a peak voltage or a root mean square (RMS) voltage. The aspect of detecting the receiver device 104 is explained in greater detail in the below description.

[0021] The wireless charging device 102 includes a power source 106, a driver unit 108, a transmitting unit 110, a control unit 112, a detection unit 114, and the transmitter detection coil 130. The power source 106 is coupled to the driver unit 108 and used to supply input power having a DC voltage signal 118 to the driver unit 108. In some embodiments, the input power may be in a range from about 0.1W to 3 KW. The magnitude of the DC voltage signal 118 may be in a range from about 20 V to about 500 V. It may be noted that the power source 106 may be positioned within the wireless charging device 102 or external to the wireless charging device 102.

[0022] The driver unit 108 is electrically coupled to the transmitting unit 110 and the control unit 112. Further, the driver unit 108 is configured to convert the DC voltage signal 118 to a second AC voltage signal 136 based on one or more control signals received from the control unit 112. The second AC voltage signal 136 is also referred to as a high power signal that is used for supplying electric power to a load 126, such as one or more batteries in the receiver device 104. In one embodiment, the magnitude of the second AC voltage signal 136 is in a range from about 250 V to about 450 V. The second AC voltage signal 136 is generated when the wireless charging device 102 is operating in a normal mode/a power transmission mode.

[0023] The transmitting unit 110 is configured to transmit the second AC voltage signal 136 received from the driver unit 108. In the exemplary embodiment, the transmitting unit 110 includes a resonant capacitor 115 and a power transmission coil 116 that resonates at a predefined frequency to transmit the second AC voltage signal 136 to the receiver device 104.

[0024] The receiver device 104 includes a power reception coil 124, a rectifier unit 128, the load 126, a receiver power source 138, a signal generating unit 140, the receiver detection coil 132, and a

push switch 142. The power reception coil 124 is configured to receive the second AC voltage signal 136 from the power transmission coil 116 of the wireless charging device 102. The rectifier unit 128 is coupled to the power reception coil 124 and configured to convert the second AC voltage signal 136 to a DC load signal 144 which is further transmitted to the load 126. In one example, this DC load signal 144 may be used for charging the batteries in the receiver power source 138. In one embodiment, the load 126 and the receiver power source 138 may be a combined energy storage module.

[0025] In addition, the signal generating unit 140 is coupled to the receiver power source 138 and configured to receive electric power from the receiver power source 138. The signal generating unit 140 is further configured to generate the first AC voltage signal 134 based on a bias voltage 146 received from the receiver power source 138. In one embodiment, a user may manually switch ON the push switch 142 to send an activation signal 148 to activate the signal generating unit 140. Upon receiving the activation signal 148 from the push switch 142, the signal generating unit 140 generates the first AC voltage signal 134. It may be noted that the push switch 142 may be positioned internal or external to the receiver device 104. Further, the receiver detection coil 132 is coupled to the signal generating unit 140 and used to send the generated first AC voltage signal 134 from the signal generating unit 140 to the wireless charging device 102. It may be noted that although push switch 142 is used, in other embodiments, the signal generating unit 140 may be activated to generate the first AC voltage signal 134 by one or more other methods and/or devices. In one embodiment, the signal generating unit 140 may be activated by moving the receiver device 104 along a desired direction and placing the receiver device 104 on the wireless charging device 102. In another embodiment, the signal generating unit 140 may be activated based on a charge level in the load 126. If the charge level in the load 126 is less than a desired value, the signal generating unit 140 may be activated to generate the first AC voltage signal 134. In yet another embodiment, the signal generating unit 140 may include one or more wireless transceivers that may directly transmit the first AC voltage signal 134 to the detection unit 114 in the wireless charging device 102, using one or more short range communication techniques, such as Bluetooth and near field communication (NFC).

[0026] During operation, the wireless charging device 102 detects the receiver device 104 prior to transmitting the power to the receiver device 104. Particularly, when the receiver device 104 is located within the predetermined distance from the wireless charging device 102, the transmitter detection coil 130 receives the first AC voltage signal 134 from the receiver detection coil 132 of the receiver device

104. Further, the detection unit 114 is coupled to the transmitter detection coil 130 and configured to determine one or more characteristics of the received first AC voltage signal 134.

[0027] Further, the control unit 112 is coupled to the detection unit 114 and configured to detect the receiver device 104 based on the characteristics of the received first AC voltage signal 134. More specifically, if the receiver device 104 is within the predetermined distance from the charging device 102, the characteristics, such as the frequency and the voltage of the first AC voltage signal 134 are within corresponding predefined range. Specifically, the frequency of the first AC voltage signal 134 is within a predefined frequency range and the voltage of the received first AC voltage signal 134 is within a predefined voltage range, if the receiver device 104 is within the predetermined distance from the charging device 102.

[0028] When the receiver device 104 is detected, the control unit 112 drives the driver unit 108 to transmit the second AC voltage signal 136 via the transmitting unit 110 to the detected receiver device 104. If the characteristics, such as the frequency and the voltage of the first AC voltage signal 134 are not within the corresponding range, the control unit 112 determines that the receiver device 104 is not proximate or within the predetermined distance from the charging device 102. As a result, the control unit 112 controls the driver unit to stop the transmission of the second AC voltage signal 136. The aspect of detecting the receiver device 104 is explained in greater detail with reference to FIG. 2.

[0029] In one embodiment, the control unit 112 may also be used to detect one or more foreign objects that are proximate to the wireless charging device 102 based on the frequency and the voltage of the first AC voltage signal 134. More specifically, if a foreign object is proximate to the wireless charging device 102, the frequency and voltage of the first AC voltage signal 134 may be within a different range. The values of the frequency and voltage enables to determine that the object that is proximate to the wireless charging device 102 is a foreign object and not the receiver device 104. Thus, by employing the exemplary wireless charging device 102, the input power may be wirelessly transmitted after detecting the receiver device 104, which in turn reduces power loss in the wireless power transfer system 100 and thereby improve the efficiency of the wireless charging device 102. Further, the exemplary system and method facilitate to reduce electromagnetic interference (EMI) and thereby meet regulatory standards.

[0030] Referring to FIG. 2, a schematic representation of a wireless power transfer system 100 in accordance with the embodiment of FIG. 1. The wireless power transfer system 100 includes the wireless charging device 102 that is configured to be magnetically coupled to the receiver device 104.

[0031] The receiver detection coil 132 in the receiver device 104 is magnetically coupled to the transmitter detection coil 130 of the wireless charging device 102 if the receiver device 104 is located within a predetermined distance from the wireless charging device 102. Further, the signal generating unit 140 is configured to generate the first AC voltage signal 134 based on the DC voltage 146 received from the receiver power source 138 in the receiver device 104. In one embodiment, the DC voltage 146 is used as a bias voltage for the signal generating unit 140 to generate the first AC voltage signal 134. In the illustrated embodiment, the signal generating unit 140 includes a voltage controlled oscillator (VCO) 202, a signal controller 204, and a buffer unit 206. The VCO 202 is electrically coupled to the signal controller 204 and the buffer unit 206. The VCO 202 is pre-tuned or designed to oscillate at a first frequency that is associated with the receiver device 104. Further, the signal controller 204 activates the VCO 202 when the activating signal 148 is received. Upon activating the VCO 202, the VCO 202 receives the bias or DC voltage 146 from the receiver power source 138 and oscillates at the first frequency to convert the received bias or DC voltage 146 to the first AC voltage signal 134 having the first frequency. The buffer unit 206 is used to step-up the power level of the first AC voltage signal 134 before transmitting the first AC voltage signal 134 to the receiver detection coil 132.

[0032] In one embodiment, the user presses the push switch/button 142 that is coupled to the signal generating unit 140, to transmit the activating signal 148 to activate the signal generating unit 140 to generate the first AC voltage signal 134. In one embodiment, the activating signal 148 is transmitted to the signal controller 204 in the signal generating unit 140. It may be noted that although push switch/button 142 is used, in other embodiments, the signal generating unit 140 may be activated by one or more other type of devices.

[0033] Further, the signal generating unit 140 transmits the first AC voltage signal 134 to the wireless charging device 102 via the receiver detection coil 132. In particular, the receiver detection coil 132 is magnetically coupled to the transmitter detection coil 130 to transmit the first AC voltage signal 134 to the transmitter detection coil 130. Further, the detection unit 114 that is coupled to the transmitter detection coil 130, receives the first AC voltage signal 134 from the transmitter detection coil 130. The detection unit 114 determines one or more characteristics of the first AC voltage signal 134. In one embodiment, the characteristics of the first AC voltage signal 134 includes a frequency and a voltage, such as peak voltage and root mean square (RMS) voltage of the first AC voltage signal 134. In one embodiment, the detection unit 114 measures a voltage drop across the transmitter detection coil 130. The voltage drop may be referred to as the voltage of the first AC voltage signal

134. The detection unit 114 includes a frequency counter 208 and a peak detector 210 that are electrically coupled to the transmitter detection coil 130. When the transmitter detection coil 130 receives the first AC voltage signal 134, the frequency counter 208 determines the frequency of the first AC voltage signal 134, while the peak detector 210 determines the voltage of the first AC voltage signal 134. In one embodiment, the peak detector 210 measures the peak voltage of the first AC voltage signal 134.

[0034] Further, the control unit 112 compares the determined characteristics with pre-stored characteristics. More specifically, the control unit 112 may include a look-up table 212 having the pre-stored characteristics of one or more receiver devices. In one embodiment, the characteristics may include frequency and voltage values of the receiver device 104. If the determined characteristics is same or proximate to the pre-stored characteristics, the control unit 112 detects the presence of the receiver device 104. In one embodiment, the control unit 112 may include one or more comparators to compare the characteristics of the first AC voltage signal 134 with the pre-stored characteristics. In one embodiment, the control unit 112 may verify whether at least one of the characteristics is within a predefined range. More specifically, the control unit 112 may determine whether the frequency of the first AC voltage signal 134 is within a predefined frequency range. In another embodiment, the control unit 112 may determine whether the voltage of the first AC voltage signal 134 is within a predefined voltage range.

[0035] Further, the control unit 112 drives the driver unit 108 to transmit electric power to the detected receiver device 104. In particular, the control unit 112 sends one or more control signals to the driver unit 108 to convert the DC voltage signal 118 from the power source 106 to the second AC voltage signal 136. In one embodiment, the control unit 112 may include a pulse width modulator (PWM) to send control signals to the driver unit 108. In one embodiment, the driver unit 108 includes a plurality of electronic switches 214 that are arranged to form a bridge circuit between first terminals 150 and second terminals 152 of the driver unit 108. The switches 214 are activated and deactivated based on the control signals received from the control unit 112 to convert the DC voltage signal 118 to the second AC voltage signal 136. The frequency of the second AC voltage signal 136 is based on a frequency of the control signals transmitted to the driver unit 108. The frequency of the second AC voltage signal 136 is selected based on a frequency standard of the detected receiver device 104. In one embodiment, the first AC voltage signal 134 received from the receiver device 104 may include frequency information related to the frequency standard of the receiver device 104. This frequency

information may be used by the control unit 112 to operate the driver unit 108 at a corresponding frequency for transmitting the second AC voltage signal 136 to the receiver device 104.

[0036] The resonant capacitor 115 and the power transmission coil 116 in the transmitting unit 110 may resonate at a predefined frequency or a resonant frequency to transmit the second AC voltage signal 136 to the power reception coil 124 in the receiver device 104. Further, the power reception coil 124 and a resonant capacitor 125 in the receiver device 104 transmits the received second AC voltage signal 136 to the rectifier unit 128. The rectifier unit 128 converts the second AC voltage signal 136 to the DC load signal 144, which is further transmitted to the load 126. In one embodiment, the rectifier unit 128 includes a plurality of diodes 216 that are arranged to form a bridge circuit. The rectifier unit is configured to convert the second AC voltage signal 136 to the DC load signal 144, which is further transmitted to the load 126. The DC load signal 144 may be used for charging the batteries in the receiver power source 138.

[0037] Referring to FIG. 3, a flow chart illustrating a method 300 for indicating a presence of a receiver device and receiving electric power from a wireless charging device in accordance with certain embodiments of the present invention is depicted. At step 302, a signal generating unit generates a first AC voltage signal having a characteristic associated with a receiver device. In one example, the characteristic includes a frequency and a voltage associated with the receiver device. In one embodiment, the signal generating unit generates the first AC voltage signal when a push switch is manually pressed or switched ON by a user.

[0038] Subsequently, at step 304, the first AC voltage signal is transmitted to a wireless charging device. To that end, a receiver detection coil in the receiver device transmits the first AC voltage signal having the characteristic to a transmitter detection coil in the wireless charging device. In particular, the first AC voltage signal is transmitted to the wireless charging device to indicate the presence of the receiver device to the wireless charging device. In one embodiment, the receiver and transmitter detection coils are used as dedicated coils for communicating signals that aid in detecting the receiver device.

[0039] At step 306, the input power having a second AC voltage signal is received in response to transmitting the first AC voltage signal from the receiver device to the wireless charging device. A power reception coil receives the second AC voltage signal from a power transmission coil of the wireless charging device. In particular, the detection unit determines one or more characteristics from the first AC voltage signal received from the receiver device. The characteristics may include

frequency and voltage values of the first AC voltage signal. Further, the control unit that is coupled to the detection unit, verifies whether the determined characteristics are within their corresponding pre-defined range. For example, the control unit may verify whether the frequency of the first AC voltage signal is within a pre-defined frequency range. Similarly, the control unit may determine whether the voltage of the first AC voltage signal is within a pre-defined voltage range.

[0040] Further, the control unit detects the receiver device, if the characteristics of the first AC voltage signal are within their corresponding pre-defined range. The control unit activates the driver unit to transmit electric power to the receiver device. In one embodiment, the control unit sends one or more control signals to the driver unit to convert the DC voltage signal to the second AC voltage signal. Further, the converted second AC voltage signal is transmitted to the receiver device via the power transmission coil.

[0041] The second AC voltage signal is received by the power reception coil in the receiver device. Further, the rectifier unit coverts this second AC voltage signal to a DC load signal for charging the load, such as one or more batteries in the receiver device.

[0042] FIG. 4 is a flow chart illustrating a method 400 for detecting a receiver device in accordance with embodiments of the present invention. At step 402, a first AC voltage signal having a characteristic associated with the receiver device is received by a transmitter detection coil of a wireless charging device. In one example, the characteristic includes a frequency and a voltage associated with the receiver device. In another example, the characteristic may be representative of a frequency and/or a voltage associated with the receiver device. In particular, the transmitter detection coil is magnetically coupled to a receiver detection coil in the receiver device. Further, the transmitter detection coil receives the first AC voltage signal from the receiver detection coil.

[0043] Subsequently, at step 404, the receiver device is detected by a control unit based on the characteristic of the first AC voltage signal. More specifically, if the receiver device is within the predetermined distance from the wireless charging device, the characteristics, such as the frequency and the voltage of the first AC voltage signal are within corresponding predefined range. Specifically, the frequency of the first AC voltage signal is within a predefined frequency range and the voltage of the received first AC voltage signal is within a predefined voltage range, if the receiver device is within the predetermined distance from the charging device. If the characteristics, such as the frequency and the voltage of the first AC voltage signal are within the corresponding range, the control unit

determines that the receiver device is proximate or within the predetermined distance from the charging device.

[0044] Furthermore, at step 406, a DC voltage signal of an input power is converted to a second AC voltage signal by a driver unit if the receiver device is detected. In particular, if the receiver device is detected, the control unit transmits one or more control signals to the driver unit to convert the DC voltage signal from the power source to the second AC voltage signal.

[0045] In addition, at step 408, the second AC voltage signal is wirelessly transmitted to the receiver device by a power transmission coil. More specifically, a resonant capacitor and the power transmission coil in the transmitting unit may resonate at a predefined frequency or a resonant frequency to transmit the second AC voltage signal to a power reception coil in the receiver device. Further, the power reception coil and a resonant capacitor in the receiver device transmits the received second AC voltage signal to the rectifier unit. The rectifier unit converts the second AC voltage signal to the DC load signal, which is further transmitted to the load.

[0046] In accordance with the exemplary embodiments discussed herein, the exemplary system and method facilitate to detect the receiver device. In particular, the system and method disclosed herein allow charging devices, such as power banks to transmit power only after detecting the receiver device. As a result, power loss is reduced and efficiency of the charging devices is enhanced. Further, the exemplary system and method disclosed herein enable detection of any foreign objects. Further, the exemplary system and method facilitate to reduce electromagnetic interference (EMI) and thereby meet regulatory standards.

[0047] While only certain features of the present disclosure 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 present disclosure.

Claim

1. A wireless charging device (102) comprising:

a transmitter detection coil (130) configured to receive a first alternating current (AC) voltage signal having a characteristic associated with a receiver device (104);

a control unit (112) coupled to the transmitter detection coil (130) and configured to detect the receiver device (104) based on the characteristic of the first AC voltage signal;

a driver unit (108) coupled to the control unit (112) and configured to convert a direct current (DC) voltage signal of an input power to a second AC voltage signal if the receiver device (104) is detected; and

a power transmission coil (116) coupled to the driver unit (108) and configured to wirelessly transmit the second AC voltage signal to the receiver device (104).

2. The wireless charging device (102) of claim 1, further comprising a power source (106) configured to transmit the input power having the DC voltage signal to the driver unit (108).

3. The wireless charging device (102) of claim 1, further comprising a detection unit (114) coupled to the transmitter detection coil (130) and configured to determine the characteristic of the first AC voltage signal, wherein the characteristic of the first AC voltage signal is representative of at least one of a frequency and a voltage associated with the receiver device (104).

4. The wireless charging device (102) of claim 3, wherein the control unit (112) is configured to detect the receiver device (104) if the frequency of the first AC voltage signal is within a predefined frequency range.

5. The wireless charging device (102) of claim 3, wherein the control unit (112) is configured to detect the receiver device (104) if the voltage of the first AC voltage signal is within a predefined voltage range.

6. The wireless charging device (102) of claim 3, wherein the control unit (112) is configured to:

compare the characteristic of the first AC voltage signal with a pre-stored characteristic; and

detect the receiver device (104) if the characteristic of the first AC voltage signal is same or proximate to the pre-stored characteristic.

7. The wireless charging device (102) of claim 1, wherein the control unit (112) is configured to activate the driver unit (108) to transmit the second AC voltage signal after the receiver device (104) is detected.

8. A receiver device (104) comprising:

a signal generating unit (140) configured to generate a first alternating current (AC) voltage signal having a characteristic associated with the receiver device (104);

a receiver detection coil (132) coupled to the signal generating unit (140) and configured to transmit the first AC voltage signal having the characteristic to a wireless charging device (102); and

a power reception coil (124) configured to be magnetically coupled to the wireless charging device (102) and receive input power having a second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device (102).

9. The receiver device (104) of claim 8, further comprising a rectifier unit (128) coupled to the power reception coil (124) and configured to convert the second AC voltage signal to a direct current (DC) load signal to charge at least one load (126).

10. The receiver device (104) of claim 9, further comprising a receiver power source (138) coupled to the signal generating unit (140) and configured to transmit a bias voltage to the signal generating unit (140) to generate the first AC voltage signal, wherein the receiver power source (138) is charged by the DC load signal received from the wireless charging device (102).

11. The receiver device (104) of claim 8, further comprising a push switch (142) coupled to the signal generating unit (140) and configured to activate the signal generating unit (140).

12. The receiver device (104) of claim 8, wherein the characteristic of the first AC voltage signal is representative of at least one of a frequency and a voltage associated with the receiver device (104).

13. A method comprising:

generating, by a signal generating unit (140), a first alternating current (AC) voltage signal having a characteristic associated with a receiver device (104);

transmitting, by a receiver detection coil (132), the first AC voltage signal having the characteristic to a wireless charging device (102); and

receiving, by a power reception coil (124), input power having a second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device (102).

14. The method of claim 13, further comprising converting, by a rectifier unit (128), the second AC voltage signal to a DC load signal to charge at least one load (126).

15. The method of claim 14, further comprising supplying, by a receiver power source (138), a bias voltage to the signal generating unit (140) to generate the first AC voltage signal.

16. A wireless power transfer system comprising:

at least one receiver device (104) comprsing:

a signal generating unit (140) configured to generate a first alternating current (AC) voltage signal having a characteristic associated with the at least one receiver device (104);

a receiver detection coil (132) coupled to the signal generating unit (140) and configured to transmit the first AC voltage signal having the characteristic to a wireless charging device (102);

the wireless charging device (102) wirelessly coupled to the at least one receiver device (104) and comprising:

a transmitter detection coil (130) configured to receive the first alternating current (AC) voltage signal having the characteristic associated with the receiver device (104); and

a control unit (112) coupled to the transmitter detection coil (130) and configured to detect the receiver device (104) based on the characteristic of the first AC voltage signal.

17. The wireless power transfer system of claim 16, wherein the wireless charging device (102) further comprises:

a driver unit (108) coupled to the control unit (112) and configured to convert a direct current (DC) voltage signal of an input power to a second AC voltage signal if the receiver device (104) is detected; and

a power transmission coil (116) coupled to the driver unit (108) and configured to wirelessly transmit the second AC voltage signal to the receiver device (104).

18. The wireless power transfer system of claim 17, wherein the at least one receiver device (104) further comprises:

a power reception coil (124) configured to be magnetically coupled to the wireless charging device (102) and receive input power having the second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device (102); and

a rectifier unit (128) coupled to the power reception coil (124) and configured to convert the second AC voltage signal to a direct current (DC) load signal to charge at least one load (126).

19. The wireless power transfer system of claim 16, wherein the at least one receiver device (104) further comprises a receiver power source (138) coupled to the signal generating unit (140) and configured to transmit a bias voltage to the signal generating unit (140) to generate the first AC voltage signal.

20. The wireless power transfer system of claim 16, wherein the at least one receiver device (104) further comprises a push switch (142) coupled to the signal generating unit (140) and configured to activate the signal generating unit (140).

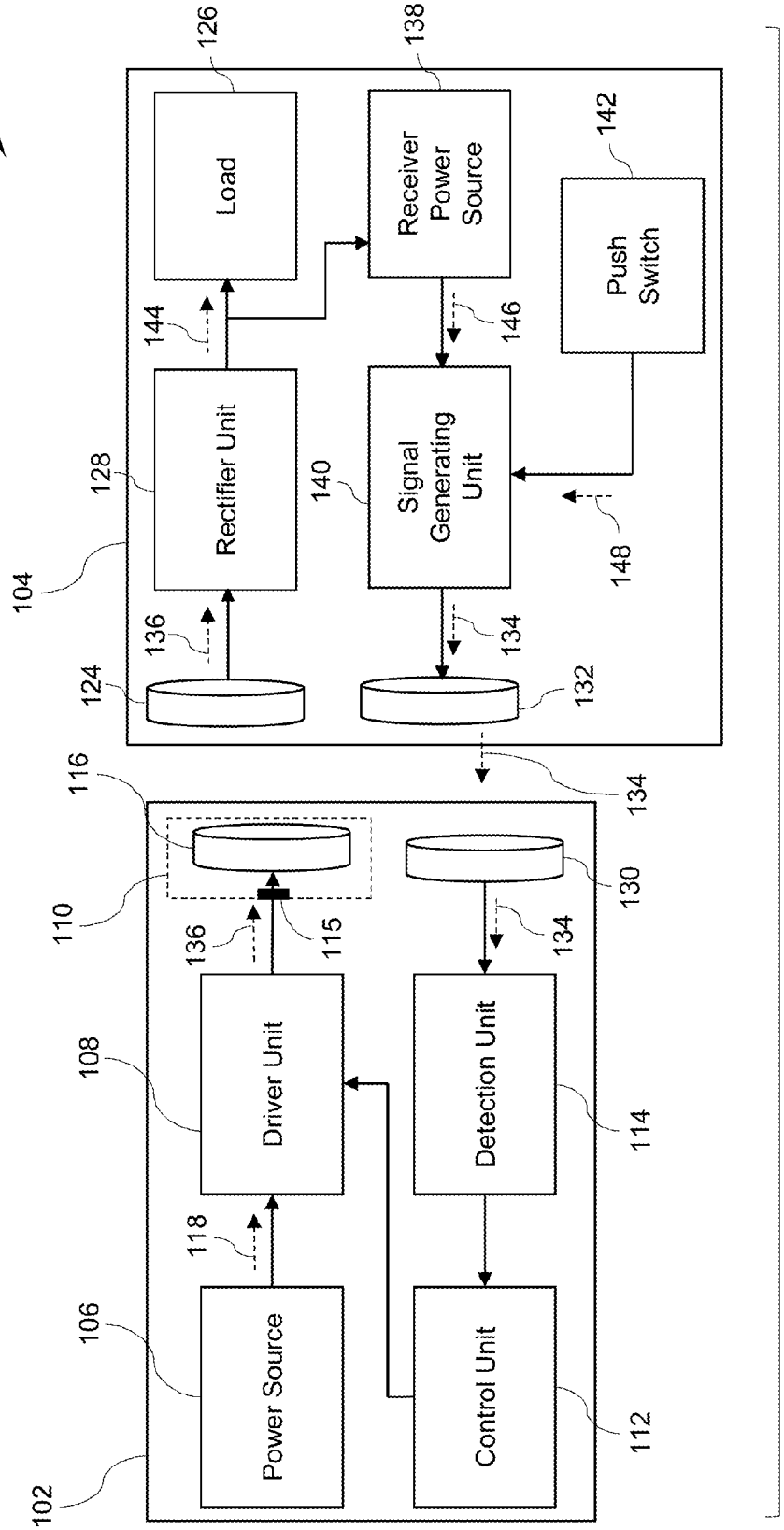

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112
114
116
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124
126
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132
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142
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146
148
Load
Receiver Power Source
Push Switch
Rectifier Unit
Signal Generating Unit
Driver Unit
Detection Unit
Power Source
Control Unit
115

FIG. 1

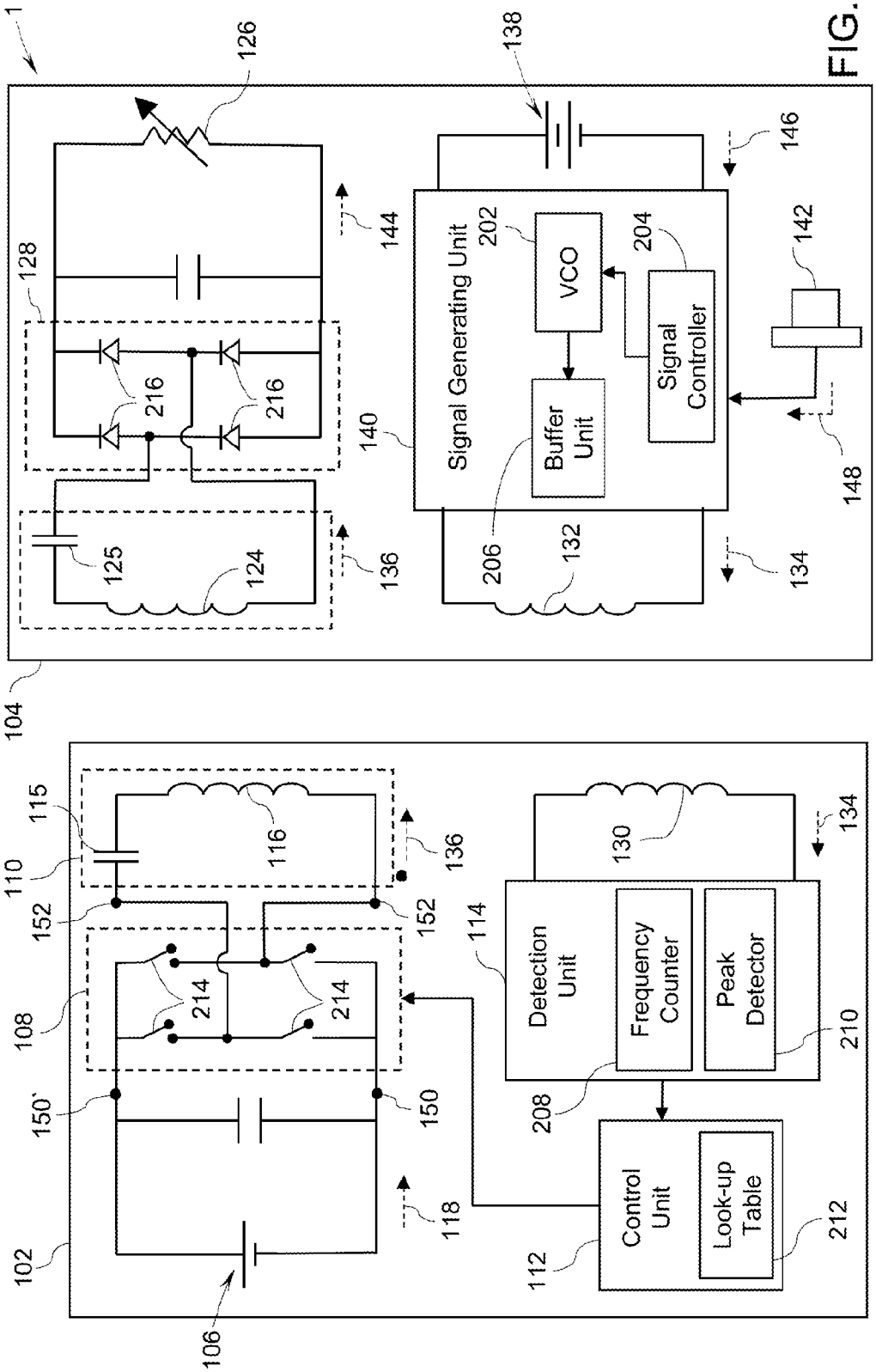

1
126
138
146
144
128
216
216
Signal Generating Unit
202
VCO
204
Signal Controller
142
140
Buffer Unit
148
125
124
136
206
132
134
104
115
116
136
130
134
110
152
152
114
Detection Unit
Frequency Counter
Peak Detector
214
214
108
210
150'
150
208
118
Control Unit
Look-up Table
212
112
102
106

FIG. 2

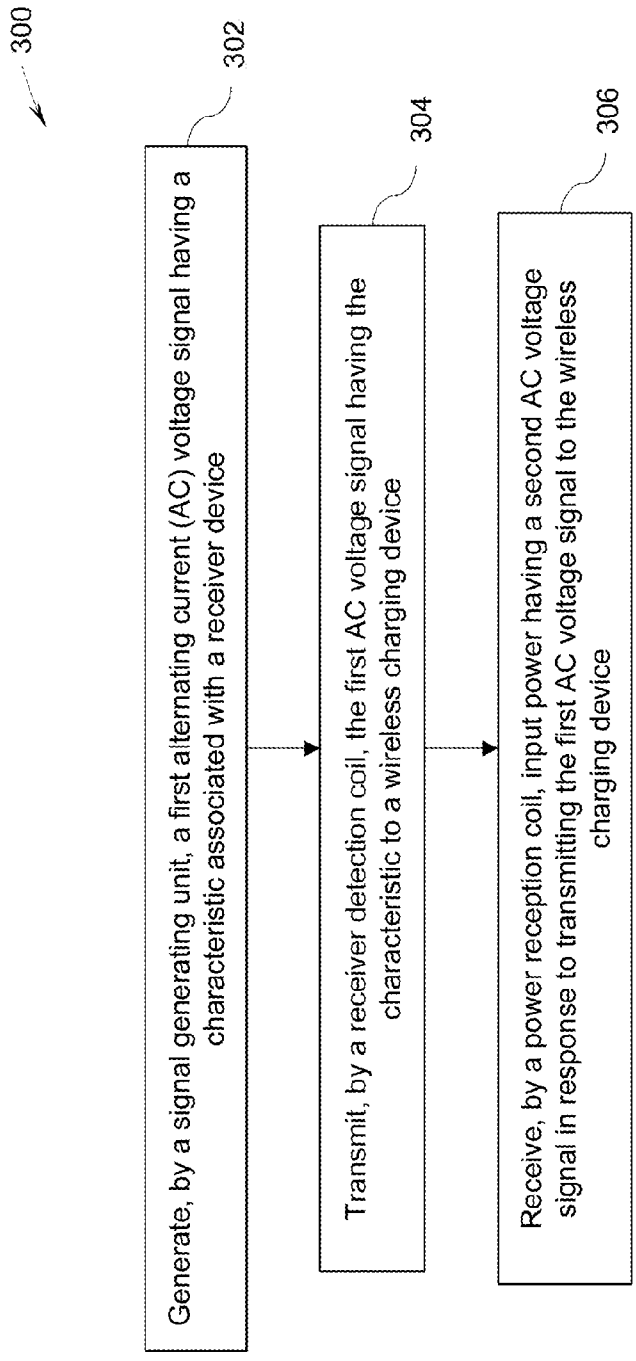

300
302
Generate, by a signal generating unit, a first alternating current (AC) voltage signal having a characteristic associated with a receiver device
304
Transmit, by a receiver detection coil, the first AC voltage signal having the characteristic to a wireless charging device
306
Receive, by a power reception coil, input power having a second AC voltage signal in response to transmitting the first AC voltage signal to the wireless charging device

FIG. 3

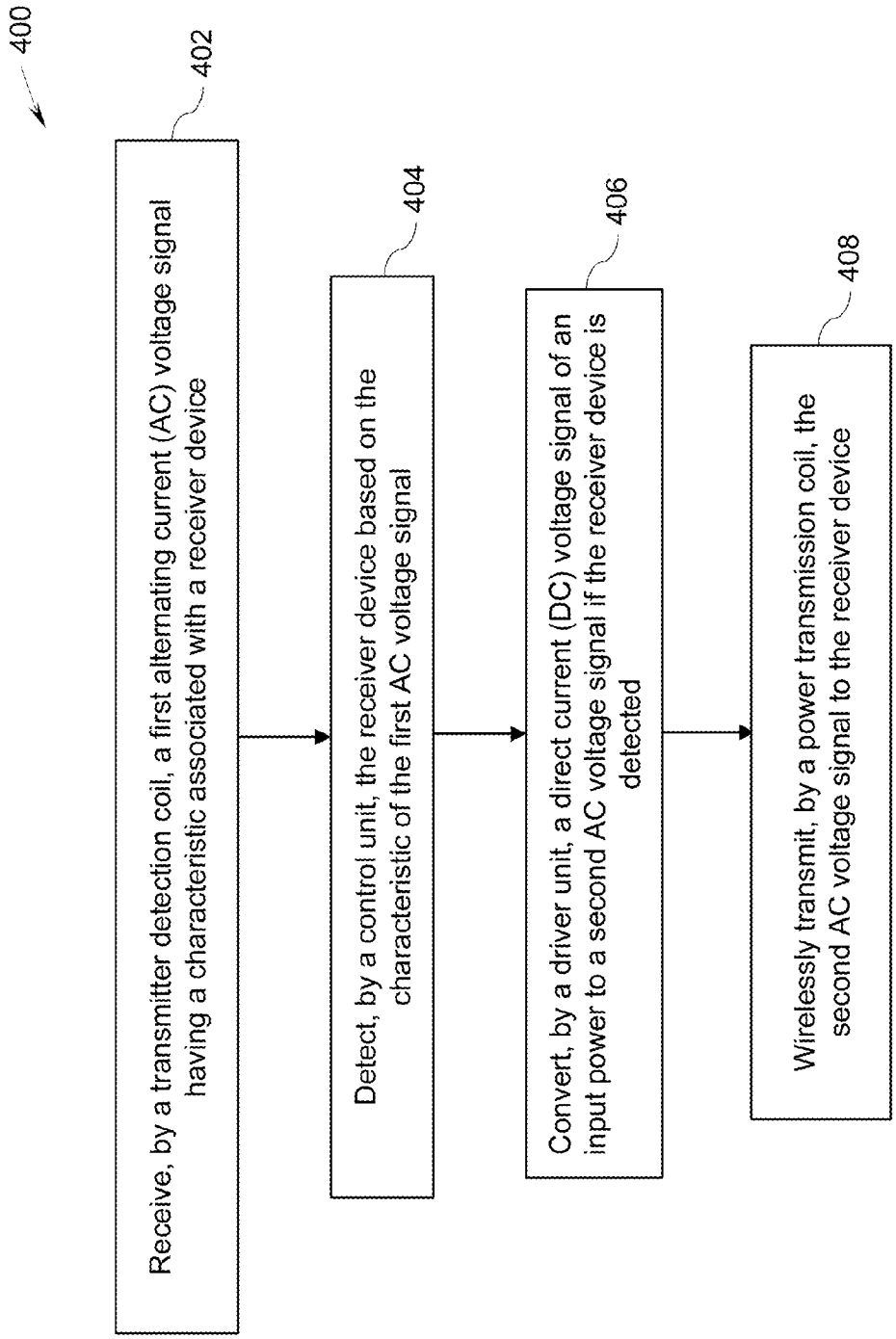

400
402
Receive, by a transmitter detection coil, a first alternating current (AC) voltage signal having a characteristic associated with a receiver device
404
Detect, by a control unit, the receiver device based on the characteristic of the first AC voltage signal
406
Convert, by a driver unit, a direct current (DC) voltage signal of an input power to a second AC voltage signal if the receiver device is detected
408
Wirelessly transmit, by a power transmission coil, the second AC voltage signal to the receiver device

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/030073

A. CLASSIFICATION OF SUBJECT MATTER

H02J 50/90(2016.01)i, H02J 7/02(2006.01)i, H02J 5/00(2006.01)i

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)
H02J 50/90; G01J 1/32; H02J 17/00; H02J 7/00; H02J 7/02; H02J 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: wireless charge, receiver, signal, detection, transmitter, control

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0354069 A1 (HANRIM POSTECH CO., LTD.) 04 December 2014 See paragraphs 13-17, 34-49, 52-56; and figures 1-2.	1-5,7-9,11-14 ,16-18,20
Y		6,10,15,19
Y	KR 10-2011-0132604 A (QUALCOMM INCORPORATED) 08 December 2011 See paragraphs 53, 66; and figures 7, 10.	6,10,15,19
A	US 2012-0306269 A1 (NAM YUN KIM et al.) 06 December 2012 See the whole document.	1-20
A	KR 10-1332163 B1 (SAMSUNG ELECTRO-MECHANICS CO., LTD.) 21 November 2013 See the whole document.	1-20
A	US 2003-0075670 A1 (JUHA TUOMINEN) 24 April 2003 See the whole document.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 August 2018 (08.08.2018)	**08 August 2018 (08.08.2018)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2018/030073

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014-0354069 A1	04/12/2014	CN 104221251 A	17/12/2014
		EP 2797207 A1	29/10/2014
		EP 2797207 A4	16/09/2015
		JP 2015-503323 A	29/01/2015
		JP 6186373 B2	23/08/2017
		KR 10-2014-0107306 A	04/09/2014
		US 9653950 B2	16/05/2017
		WO 2013-095068 A1	27/06/2013
KR 10-2011-0132604 A	08/12/2011	CN 102395983 A	28/03/2012
		CN 102395983 B	13/04/2016
		CN 105844189 A	10/08/2016
		EP 2411940 A2	01/02/2012
		EP 2411940 B1	08/07/2015
		EP 2930648 A2	14/10/2015
		EP 2930648 A3	09/03/2016
		JP 2012-522482 A	20/09/2012
		JP 5743226 B2	01/07/2015
		KR 10-1586524 B1	21/01/2016
		US 2010-0244576 A1	30/09/2010
		US 8803474 B2	12/08/2014
		WO 2010-111541 A2	30/09/2010
		WO 2010-111541 A3	24/03/2011
US 2012-0306269 A1	06/12/2012	EP 2740223 A1	11/06/2014
		EP 2740223 A4	27/05/2015
		KR 10-2012-0134998 A	12/12/2012
		KR 10-2012-0134999 A	12/12/2012
		KR 10-2012-0135076 A	12/12/2012
		KR 10-2012-0135077 A	12/12/2012
		KR 10-2012-0135084 A	12/12/2012
		KR 10-2012-0135085 A	12/12/2012
		KR 10-2012-0135086 A	12/12/2012
		US 2012-0306285 A1	06/12/2012
		US 2012-0306286 A1	06/12/2012
		US 2012-0309306 A1	06/12/2012
		US 2012-0309308 A1	06/12/2012
		US 2016-0164344 A1	09/06/2016
		US 9142997 B2	22/09/2015
		US 9199545 B2	01/12/2015
		US 9350193 B2	24/05/2016
		US 9627930 B2	18/04/2017
		US 9882426 B2	30/01/2018
		WO 2013-022207 A1	14/02/2013
KR 10-1332163 B1	21/11/2013	KR 10-2013-0035725 A	09/04/2013
		US 2013-0082649 A1	04/04/2013
US 2003-0075670 A1	24/04/2003	AU 2002-305229 A1	11/11/2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030073

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 1390196 A2	25/02/2004
		EP 1390196 A4	28/12/2005
		EP 1446857 A1	18/08/2004
		FI 111670 B	29/08/2003
		FI 20012062 A	25/04/2003
		US 2003-0016427 A1	23/01/2003
		US 2006-0139778 A1	29/06/2006
		US 2008-0100935 A1	01/05/2008
		US 6633026 B2	14/10/2003
		US 7319565 B2	15/01/2008
		WO 02-088878 A2	07/11/2002
		WO 02-088878 A3	10/07/2003
		WO 03-036778 A1	01/05/2003