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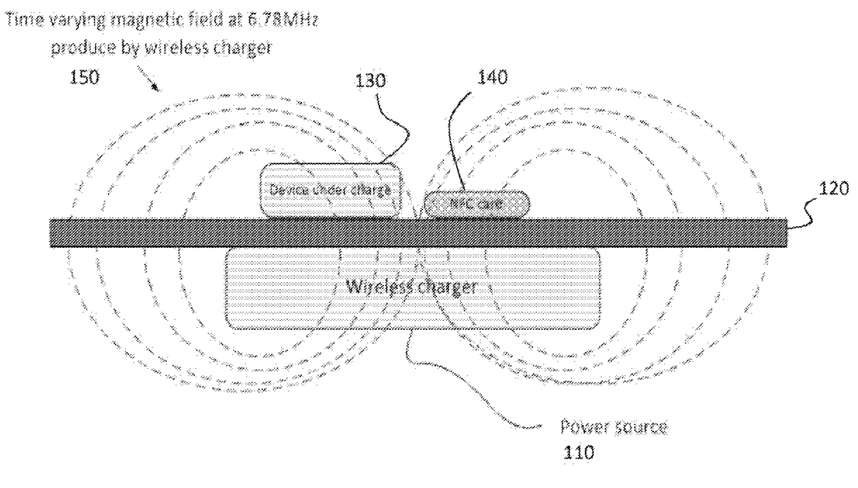

Fig. 1

(57) Abstract: The disclosure relates to a method, apparatus and system to wirelessly charge a device. In one embodiment, the disclosure relates to a wireless charging station having a detector to identify presence of a device at or near the charging station that would otherwise be damaged by the magnetic field of the wireless charging station. The detector detects a response signal emitted from the device under charge and determines whether to generate the desired magnetic field to charge the device or to cease the magnetic field to preserve the device from potential damage caused by the magnetic field.

WO 2016/175919 A1

SYSTEM AND METHOD FOR SAFE WIRELESS CHARGING STATION

RELATED APPLICATIONS

The present application claims the benefit of U.S. Patent Application No. 14/865,434, filed on September 25, 2015, entitled "SYSTEM AND METHOD FOR SAFE WIRELESS CHARGING STATION" and U.S. Provisional Application No. 62/154,058, filed April 28, 2015, and titled "SYSTEM AND METHOD FOR SAFE WIRELESS CHARGING STATION", the contents of which are expressly incorporated herein in their entirety.

BACKGROUND

The disclosure relates to safe and improved wireless charging stations. Specifically, the disclosed embodiments provides improved charging stations for detecting devices at or near a wireless charging station that may be damaged by the magnetic field of the wireless charging station.

DESCRIPTION OF RELATED ART

Wireless charging or inductive charging uses a magnetic field to transfer energy between two devices. Wireless charging can be implemented at a charging station. Energy is sent from one device to another device through an inductive coupling. The inductive coupling is used to charge batteries or run the receiving device. The Alliance for Wireless Power (A4WP) was formed to create industry standard to deliver power through non-radiative, near field, magnetic resonance from the Power Transmitting Unit (PTU) to a Power Receiving Unit (PRU).

The A4WP defines five categories of PRU parameterized by the maximum power delivered out of the PRU resonator. Category 1 is directed to lower power applications (e.g., Bluetooth headsets). Category 2 is directed to devices with power output of about 3.5 W and Category 3 devices have an output of about 6.5 W. Categories 4 and 5 are directed to higher-power applications (e.g., tablets, netbooks and laptops).

PTUs of A4WP use an induction coil to generate a magnetic field from within a charging base station, and a second induction coil in the PRU (i.e., portable device) takes power from the magnetic field and converts the power back into electrical current to charge the battery. In this manner, the two proximal induction coils form an electrical transformer. Greater distances between sender and receiver coils can be achieved when the inductive charging system uses magnetic resonance coupling. Magnetic resonance coupling is the near field wireless transmission of electrical energy between two coils that are tuned to resonate at the same frequency.

Wireless charging is particularly important for fast wireless charging of devices including smartphones, tablets and laptops. There is a need for improved wireless charging systems to extend the active charging area and to improve coupling and charging uniformity while avoiding disruption of nearby devices that may be damaged by the generated magnetic field.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other embodiments of the disclosure will be discussed with reference to the following exemplary and non-limiting illustrations, in which like elements are numbered similarly, and where:

Fig. 1 is a schematic overview showing a A4WP charger, device under charge and an NFC card;

Fig. 2 is the top view of an NFC device on A4WP charger network;

Fig. 3 shows two exemplary transfer functions of the network of Fig. 2;

Fig. 4 is an exemplary flow diagram according to one embodiment of the disclosure;

Fig. 5 illustrates a measured polling signal with 6.78 MHz carrier and the response from an exemplary NFC device; and

Fig. 6 illustrates an exemplary device according to one embodiment of the disclosure.

DETAILED DESCRIPTION

Certain embodiments may be used in conjunction with various devices and systems, for example, a mobile phone, a smartphone, a laptop computer, a sensor device, a Bluetooth (BT) device, an UltrabookTM, a notebook computer, a tablet computer, a handheld device, a Personal Digital Assistant (PDA) device, a handheld PDA device, an on board device, an off-board device, a hybrid device, a vehicular device, a non-vehicular device, a mobile or portable device, a consumer device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless Access Point (AP), a wired or wireless router, a wired or wireless modem, a video device, an audio device, an audio-video (AV) device, a wired or wireless network, a wireless area network, a Wireless Video Area Network (WVAN), a Local Area Network (LAN), a Wireless LAN (WLAN), a Personal Area Network (PAN), a Wireless PAN (WPAN), and the like.

Some embodiments may be used in conjunction with devices and/or networks operating in accordance with existing Institute of Electrical and Electronics Engineers (IEEE) standards (IEEE 802.11-2012, IEEE Standard for Information technology-Telecommunications and information exchange between systems Local and metropolitan area networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, March 29, 2012; IEEE 802.11 task group ac (TGac) ("IEEE 802.11-09/0308r12 – TGac Channel Model Addendum Document"); IEEE 802.11 task group ad (TGad) (IEEE 802.11ad-2012, IEEE Standard for Information Technology and brought to market under the WiGig brand – Telecommunications and Information Exchange Between Systems – Local and

Metropolitan Area Networks – Specific Requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications – Amendment 3: Enhancements for Very High Throughput in the 60GHz Band, 28 December, 2012)) and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing Wireless Fidelity (Wi-Fi) Alliance (WFA) Peer-to-Peer (P2P) specifications (Wi-Fi P2P technical specification, version 1.2, 2012) and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing cellular specifications and/or protocols, e.g., 3rd Generation Partnership Project (3GPP), 3GPP Long Term Evolution (LTE), and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing Wireless HDTM specifications and/or future versions and/or derivatives thereof, units and/or devices which are part of the above networks, and the like.

Some embodiments may be implemented in conjunction with the BT and/or Bluetooth low energy (BLE) standard. As briefly discussed, BT and BLE are wireless technology standard for exchanging data over short distances using short-wavelength UHF radio waves in the industrial, scientific and medical (ISM) radio bands (i.e., bands from 2400–2483.5 MHz). BT connects fixed and mobile devices by building personal area networks (PANs). Bluetooth uses frequency-hopping spread spectrum. The transmitted data are divided into packets and each packet is transmitted on one of the 79 designated BT channels. Each channel has a bandwidth of 1 MHz. A recently developed BT implementation, Bluetooth 4.0, uses 2 MHz spacing which allows for 40 channels.

Some embodiments may be used in conjunction with one way and/or two-way radio communication systems, a BT device, a BLE device, cellular radio-telephone communication systems, a mobile phone, a cellular telephone, a wireless telephone, a Personal Communication Systems (PCS) device, a PDA device which incorporates a wireless communication device, a mobile or portable Global Positioning System (GPS) device, a device which incorporates a GPS receiver or transceiver or chip, a device which incorporates an RFID element or chip, a Multiple Input Multiple Output (MIMO) transceiver or device, a Single Input Multiple Output (SIMO) transceiver or device, a Multiple Input Single Output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, Digital Video Broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device, e.g., a Smartphone, a Wireless Application Protocol (WAP) device, or the like. Some demonstrative embodiments may be used in conjunction with a WLAN. Other embodiments may be used in conjunction with any other suitable wireless communication network, for example, a wireless area network, a "piconet", a WPAN, a WVAN and the like.

Electromagnetic induction based Wireless charging and Near Field Communication (NFC) are two technologies that are based on inductive coupling between two coils. Wireless charging based on A4WP is using 6.78MHz industrial, scientific or medical (ISM) frequency band to deliver power between wireless charger and device, while NFC (and some other RFID technologies) is using 13.56 MHz ISM frequency band to deliver power and data between devices.

Conventional A4WP standard uses lost-power calculation to determine if a rogue or foreign object or device is at or near the magnetic charging field. The conventional methods conduct the lost-power calculation in the following manner. A wireless power charger knows the output power of its PTU coil. A PRU under charge communicates back to the PTU charger as to how much power it has received during a given period. If the received power is smaller than the transmit power, then some of the power has been lost. If the lost power is large enough (e.g., larger than a pre-defined threshold), then the charger will conclude that a rogue object is positioned at or near the charging pad. When a rogue object is detected, the power transfer will cease and the wireless charging system will revert to its latching fault (off) state.

Conventional lost-power algorithms are not be able to detect small NFC devices (or RFID) such as NFC sticker. This is due to the fact that such devices are designed to effectively capture magnetic field. Such devices heat up and are damaged with low amounts of power which is well below the lost-power detection threshold of conventional wireless chargers. Consequently, NFC and RFID devices may be damaged by the A4WP wireless charging magnetic fields.

To overcome these and other shortcomings of the conventional wireless charging systems, certain embodiment of the disclosure provide a wireless charging system capable of detecting presence of sensitive devices (e.g., NFC-compatible devices and RFID). In one embodiment, the disclosed embodiments provide a detection algorithm that detects presence of a device prone to damage by the A4WP wireless charging field at or near a wireless charging station.

In an exemplary implementation, the A4WP wireless charging station uses 6.78MHz frequency as the carrier frequency to carry out NFC interrogation and modulates the charging signal to perform NFC card detection while charging the device under charge (DUC). In another embodiment, the disclosed algorithm may be executed prior to the A4WP charger entering the power transfer state. In still another embodiment, the wireless charger may perform the search algorithm even during the power transfer state. In a further embodiment, when presence of a sensitive device is detected, the charger may end power transfer process, decrease maximum magnetic field and/or inform the user to remove the sensitive device from the wireless charging field.

The disclosed embodiments are particularly advantageous because a wireless charger may readily detect presence or entry of a sensitive device (e.g., NFC or RFID) into the wireless charger's magnetic field. The wireless charger may then decide whether to enter into wireless power transfer or not. The disclosed embodiments are particularly suitable for small devices whose presence may be undetectable to the conventional lost-power calculation techniques.

Fig. 1 is a schematic overview showing a A4WP charger, a DUC and an NFC card. Fig. 1 illustrates wireless charger 120 connected to power source 110 and emitting time varying magnetic field 150. The magnetic field is emitted at 6.78MHz which is used by DUC 130 to convert magnetic field 150 into power used to charge the device battery (not shown). NFC card 140 is also located on charger 120. NFC card 140 may be damaged by magnetic field 150 which produces voltage and current in the NFC coil (not shown) due to inductive coupling which is fundamental to NFC technology.

Fig. 2 shows an NFC device on A4WP charger (top view). In Fig. 2, V_{in} – identified as 205 – is the voltage on the A4WP charger coil 210. V_{out} – identified as 220 – is the voltage on the NFC Application-Specific Integrated Circuit (ASIC) 250. The combination of A4WP coil 210, A4WP matching network (not shown), NFC coil 240, NFC matching network 230 and the location of NFC coil 240 on the A4WP coil 210 will define the voltage transfer function between V_{in} and V_{out}.

Fig. 3 shows two exemplary transfer functions relating to Fig. 2 network. Curve 310 presents a suitable matching network that filters the 6.78MHz frequency with excellent rejection. Curve 320 illustrates poor frequency rejection at the 6.78MHz frequency. When the NFC device is placed on the A4WP charger and input voltage (V_{in}) is high, then output voltage may be high as well (see red curve 320). Here, the NFC device either dumps the excess voltage/power onto a fixed resistor on the chip (thereby generating significant heat), or the NFC ASIC inside the device may be damaged due to high voltage.

In one embodiment, the disclosure provides an algorithm to detect if an NFC device is located at or near the charging field. Another embodiment uses the A4WP charging hardware and 6.78 MHz frequency signal to detect presence of a sensitive NFC card and/or other devices. The disclosed principles may be implemented without the need to add dedicated NFC transceiver to the wireless charging mat.

Fig. 4 is an exemplary flow diagram for implementing an embodiment of the disclosure. Specifically, Fig. 4 demonstrates a method to detect presence of an NFC device in the charging field. At step 402, a wireless charger polls the charging environment by sending periodic A4WP short beacons. In one implementation, the charger may send a specific NFC poll followed by a periodic beacon. The beacon may be a sort or a long beacon. In one embodiment of the disclosure, wireless charging may occur immediately upon detecting a mobile device in the charging field. Steps 402 may be implemented simultaneously while the wireless charging is underway.

Referring again to step 402, the wireless charger may send one or more periodic short A4WP beacons followed by one or more periodic NFC polls. The NFC polls may be the so-called NFC-like polls and may be followed by one or more periodic beacons. The beacons may be short or long beacons. As stated, the NFC-like polls can be at a frequency of about 6.78MHz and may be modulated on top of the 6.78MHz A4WP charging signal.

In certain embodiments, the wireless charger may only send one or more periodic short A4WP beacons or one or more periodic NFC polls followed by periodic beacon(s). In still another embodiment, the wireless charger may transmit one or more periodic NFC polls followed by one or more periodic beacons. The order of A4WP and NFC-like (or NFC) signals may be changed to accommodate the desired application without departing from the disclosed principles.

As stated, the NFC poll produced by the charger may be an NFC-like polling signal performed with a 6.78MHz carrier and not a 13.56MHz one as required by NFC specification. The NFC-like poll enables using the A4WP charger's existing hardware and will not require dedicated NFC transceiver or 13.56MHz clock to be embedded into the A4WP charger. In certain embodiments, an NFC polling signal may be generated at 13.56 MHz by using appropriate signaling circuitry.

For the NFC device/tag has high voltage transfer function at about 6.78MHz (for example, curve 320 of Fig. 3), then the device may risk damage. Here, the NFC device receives the NFC-like poll signal produced by the wireless charger and responds with load modulation that can be detected by the wireless charger. Since the frequency is 6.78 MHz (not 13.56 MHz), the NFC device responds in load modulation signals similar to NFC data, but in half frequency. The charger may include built-in capability to detect load modulation signaling at 6.78MHz. By using the 6.78 MHz frequency as the carrier for the NFC tag detection, the disclosed embodiment differentiates a well implemented NFC device having selective input matching from a poorly implemented device prone to damage by the 6.78 MHz charging field. NFC devices that are not prone to heating or damage by the charging field may not be detected by this scheme and thereby not cause false alarm.

At step 404, the wireless charger detects a response signal. In one embodiment of the disclosure, the device on which process of Fig. 4 is implemented includes NFC circuitry. If the detected response signal is only an NFC signal, as shown by arrow 405, then the user is informed to remove the NFC device from the wireless charging environment as step 416. The user may, for example, hear a ringtone or some other indication to remove NFC device from the charger. If the device is not removed, the wireless charger my not engage its magnetic field.

If the detected response signal is an impedance change as shown by arrow 406, the wireless charger may send one or more NFC poll(s) followed by a beacon as shown at step 407. The beacon may be a short or a long beacon. In one embodiment, the power beacon may not contain data and be longer than conventional power beacons. If no response is received from the external device, the process returns to step 404.

If the detected response signal indicates detection of an NFC device and presence of BLE Advertisement as shown by arrow 410, then an A4WP registration step takes place as shown at step 412. The NFC device and the BLE device may be one device or they may comprise two or more devices. At the registration step 412, determination may be made as to whether the device has built-in NFC capability as shown at step 414. If the device does not include a built-in NFC (here, the PTU understands that the NFC device is separate from the phone and not embedded in the phone), then the user is advised to remove the NFC device from the charger at step 416. Similar mechanisms as above may be used to notify the user.

Thereafter, the process reverts back to the intermittent polling step(s) of step 402. If there is a built-in NFC device, then the device may communicate its maximum power and charging requirements to the PTU as shown in step 424. If there a built-in NFC device is not present, then the PTU will determine that another NFC device is locate on the charger and it will revert back to step 402 as provided above.

If the response to the inquiry of step 414 indicates that the DUC does include a built-in NFC, at step 424 various information including maximum magnetic field parameters are exchanged between the DUC and the wireless charger. At step 416, the wireless charger is configured to produce the desired maximum magnetic field and at step 422, the A4WP power transfer between the wireless charger and the DUC commences.

Referring back to the inquiry step 404, if the detected response signal indicates presence of a BLE device only, as shown in arrow 418, the A4WP devices is registered at step 420 and charging of the DUC begins at step 422. Step 420 may be implemented similar to that of step 412. Further, information on a previously registered DUC may be retrieved (for example, as part of step 420) for a known device and its charging requirements. The information may be locally stored or stored at a remote server and retrieved when needed.

In certain embodiments of the disclosure, one or more of the steps shown with reference to Fig. 4 may be implemented in a processor. The processor may represent an actual processor or a virtual processor. The processor may have one or more modules (actual or virtual) to implement each step. In one embodiment, a non-transitory computer-readable storage device may be used to store or execute instructions to direct one or more processors of a wireless charging station to implement one or more steps discussed herein. The storage device may reside on hardware (e.g., solid-state memory), software (e.g., virtual memory) or a combination of hardware and software (e.g., firmware). When executed, the instructions may dynamically configure a magnetic field to accommodate external device. The dynamic configuration may increase the generated magnetic field for optimal charging of the mobile device or cease charging to avoid damage to a proximal external device.

Fig. 5 illustrates a measured polling signal with 6.78 MHz carrier and the response from an exemplary NFC device. Specifically, Fig. 5 shows a picture of the measured signal of NFC-like polling using a carrier at 6.78 MHz instead of 13.56 MHz and its corresponding feedback. The feedback is from load modulation created by an NFC tag. The left side of Fig. 5 shows part of the NFC-like polling sequence. The right side of Fig. 5 shows the load modulation answer from the NFC device (or NFC tag). The left hand side shows the charging signal as a pure sine wave with a carrier signal modulated thereon to produce NFC-like polling at 6.78 MHz frequency.

The data represented in Fig. 5 were carried out with NFC tags based on all major NFC standards (i.e., ISO 14443, ISO 18092 and ISO 15693) and all tags can provide proper response to polling signal modulated onto 6.78 MHz. The response signal may also be decoded by an NFC reader operating at 6.78 Mhz. In one embodiment, the data rate of the signal may be half of NFC, and the bit duration may be twice as compared to NFC (due to working with carrier of 6.78MHz).

In addition to the exemplary flow diagram shown in Fig. 4, during power transfer state, the NFC-like polling sequence may be modulated to the 6.78 MHz charging signal. In one embodiment, the signal may be periodically repeat the polling sequence for all types of NFC tags/device. Given the fast modulation of NFC polling signal, the wireless charging receiver is not likely to experience any impact to the wireless charging user experience and performance. While from detecting NFC tag perspective, continuous polling allows the early detection of potentially problematic NFC devices entering active charging field and getting damaged.

Fig. 6 illustrates an exemplary device or apparatus according to one embodiment of the disclosure. Fig. 6 shows PTU 610 having controller 620, wireless charging coil 630, detector 640 and circuitry 650. While not shown, controller 620, coil 630 and detector 640 may communicate with each other. PTU 610 may define any wireless charging device configured to operation within the A4WP specification and requirements. PTU 610 may define a A4WP charger.

Circuitry 650 may optionally be included to communicate with controller 620 and to produce NFC-like polling modulation according to the disclosed embodiments using the charging signal at 6.78MHz as carrier frequency. In an alternative embodiment, the function of circuitry 650 may be implemented by coil 630. Coil 630 may convert the modulated signals to magnetic field used to charge the PRU. The generated magnetic field (not shown) may also be modulated and it may include the NFC-like polling signals as described above. Other desired frequencies may be provided by controller 620, optionally directly, to coil 630 without departing from the disclosed embodiments.

Detector 640 may define a separate unit or may be optionally combined with coil 630. Detector 640 may comprise integrated circuitry and mechanism required to detect feedback from load modulation by an external device (e.g., an RFID tag, NFC device, BT/BLE device or device under charge). In an optional embodiment, an NFC reader (not shown) may be included in PTU 610. The NFC reader (not shown) may be integrated with detector 640 or may be configured as a separate unit. Other sensors and/or detectors (not shown) may also be included to detect other unique signals without departing from the disclosed principles.

In one embodiment, controller 620 may cause coil 630 (either directly or through circuitry 650) to transmit periodic short A4WP beacons to identify a nearby DUC. In another embodiment, controller 620 may cause coil 630 (either directly or through circuitry 650) to send periodic NFC-like poll(s) followed by periodic long beacon(s). A device which may be an NFC device may receive the NFC-like poll signal from coil 630 and respond with load modulation signaling that can be detected by detector 640. Detector 640 may comprise circuitry to detect load modulation signaling at the transmitted NFC-like signal (e.g., 6.78 MHz). Detector 640 may use the 6.78 MHz as the carrier to differentiate between a damage prone device from an otherwise magnetically chargeable device.

Upon detecting presence of a sensitive device at or near PTU 610, detector 640 may alert controller 620. Controller 620 may then direct coil 630 to dynamically disengage from generating a magnetic field. In an exemplary embodiment, controller 620 may cause external displays to communicate a message to the user that charging may not be commenced due to presence of a sensitive device. In another embodiment, controller 620 may sound an alarm to alert the user. Controller 620 may also determine the duration and frequency of beacon signaling such that sensitive external devices may be detected without excessive interruption of the wireless charging operation.

Alternatively, Detector 640 may dynamically signal Controller 620 that a sensitive device is not present. Controller 620 may then determine the desired charging configuration for the DUC by exchanging magnetic field parameters with the DUC. Controller 620 may direct coil 630 to generate the maximum magnetic field to charge the DUC. Controller 620 may intermittently cause coil 630 and detector 640 to detect presence of sensitive devices at or near PTU 610.

The following non-limiting examples are provided to further illustrates the disclosed principles. Example 1 is directed to a wireless charging station, comprising: a transmitter to transmit one or more periodic A4WP beacons; a detector to detect a response from an external device in response to the one or more A4WP beacons and to identify the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and a controller including processing circuitry to dynamically configure a magnetic field for the identified external device.

Example 2 is directed to the wireless charging station of example 1, wherein the transmitter transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

Example 3 is directed to the wireless charging station of any foregoing example , wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

Example 4 is directed to the wireless charging station of any foregoing example, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

Example 5 is directed to the wireless charging station of any foregoing example, further comprising an A4WP charger coil in communication with the controller to generate and adaptively control the magnetic field.

Example 6 is directed to the wireless charging station of any foregoing example, wherein the detector detects a BLE and NFC response and one of instruct removal of the external device or exchange magnetic parameters with the external device.

Example 7 is directed to the wireless charging station of any foregoing example, wherein the detector detects a BLE signal and the controller configures the A4WP charger for power transfer.

Example 8 is directed to an apparatus comprising a detector and a circuitry, the detector configured to detect presence of a proximal electronic device at or near a magnetic field from a modulated signal received from the external device, the modulated signal including one or more of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change in magnetic field or a combination thereof.

Example 9 is directed to the apparatus of any foregoing example, wherein the circuitry is configured to dynamically initiate, continue or cease the magnetic field when the proximal electronic device is detected.

Example 10 is directed to the apparatus of any foregoing example, wherein the circuitry transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

Example 11 is directed to the apparatus of any foregoing example, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

Example 12 is directed to the apparatus of any foregoing example, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

Example 13 is directed to the apparatus of any foregoing example, further comprising an A4WP charger coil in communication with the controller to generate and adaptively control the magnetic field.

Example 14 is directed to the apparatus of any foregoing example, wherein the detector detects a BLE signal and directs the A4WP charger coil for power transfer to the proximal electronic device.

Example 15 is directed to a method to detect presence of an external device proximal to a wireless charging station, the method comprising: transmitting one or more periodic A4WP beacons; detecting a response to the one or more periodic A4WP beacons from an external device and identifying the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and dynamically configuring a magnetic field to accommodate external device.

Example 16 is directed to the method of any foregoing example, further comprising, transmitting one or more periodic A4WP beacons and one or more periodic NFC-like polls.

Example 17 is directed to the method of any foregoing example, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz and are followed by a long beacon.

Example 18 is directed to the method of any foregoing example, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

Example 19 is directed to the method of any foregoing example, generating the magnetic field by engaging an A4WP charger coil.

Example 20 is directed to the method of any foregoing example, further comprising detecting a BLE and NFC response from the external device and exchanging magnetic parameters with the external device.

Example 21 is directed to the method of any foregoing example, wherein the detector detects a BLE signal and the controller configures the A4WP charger for power transfer.

Example 22 is directed to a non-transitory computer-readable storage device comprising a set of instructions to direct one or more processors associated with a wireless charging station to: transmit one or more periodic A4WP beacons; detect a response to the one or more periodic A4WP beacons from an external device and identify the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and dynamically configure a magnetic field to accommodate external device.

Example 23 is directed to the non-transitory computer-readable storage device of any foregoing example, wherein the transmitter transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

Example 24 is directed to the non-transitory computer-readable storage device of any foregoing example, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

Example 25 is directed to the non-transitory computer-readable storage device of any foregoing example, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

Example 26 is directed to a method to detect presence of an Near Field Communication (NFC)/RFID device proximal to a wireless charging station, the method comprising: transmitting NFC-like polls having a carrier frequency of about 6.78MHz; detecting a response to the NFC-like polls, the response comprising by an NFC load modulation, and dynamically configuring a magnetic field generated by the charging station to accommodate the NFC/RFID device.

Example 27 is directed to the method of any foregoing example, further comprising transmitting NFC-like polls at the carrier frequency of about 6.78 MHz while charging the NFC/RFID device with the 6.78 MHz signal.

Various embodiments of the invention may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; a flash memory, etc.

While the principles of the disclosure have been illustrated in relation to the exemplary embodiments shown herein, the principles of the disclosure are not limited thereto and include any modification, variation or permutation thereof.

What is claimed is:

1. A wireless charging station, comprising:

a transmitter to transmit one or more periodic A4WP beacons;

a detector to detect a response from an external device in response to the one or more A4WP beacons and to identify the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and

a controller including processing circuitry to dynamically configure a magnetic field for the identified external device.

2. The wireless charging station of claim 1, wherein the transmitter transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

3. The wireless charging station of claim 2, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

4. The wireless charging station of claim 3, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

5. The wireless charging station of claim 1, further comprising an A4WP charger coil in communication with the controller to generate and adaptively control the magnetic field.

6. The wireless charging station of claim 1, wherein the detector detects a BLE and NFC response and one of instruct removal of the external device or exchange magnetic parameters with the external device.

7. The wireless charging station of claim 5, wherein the detector detects a BLE signal and the controller configures the A4WP charger for power transfer.

8. An apparatus comprising a detector and a circuitry, the detector configured to detect presence of a proximal electronic device at or near a magnetic field from a modulated signal received from the external device, the modulated signal including one or more of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change in magnetic field or a combination thereof.

9. The apparatus of claim 8, wherein the circuitry is configured to dynamically initiate, continue or cease the magnetic field when the proximal electronic device is detected.

10. The apparatus of claim 8, wherein the circuitry transmits one or more periodic

A4WP beacons and one or more periodic NFC-like polls.

11. The apparatus of claim 10, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

12. The apparatus of claim 11, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

13. The apparatus of claim 9, further comprising an A4WP charger coil in communication with the controller to generate and adaptively control the magnetic field.

14. The apparatus of claim 13, wherein the detector detects a BLE signal and directs the A4WP charger coil for power transfer to the proximal electronic device.

15. A method to detect presence of an external device proximal to a wireless charging station, the method comprising:

transmitting one or more periodic A4WP beacons;

detecting a response to the one or more periodic A4WP beacons from an external device and identifying the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and

dynamically configuring a magnetic field to accommodate external device.

16. The method of claim 15, further comprising, transmitting one or more periodic A4WP beacons and one or more periodic NFC-like polls.

17. The method of claim 16, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz and are followed by a long beacon.

18. The method of claim 17, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

19. The method of claim 15, generating the magnetic field by engaging an A4WP charger coil.

20. The method of claim 15, further comprising detecting a BLE and NFC response from the external device and exchanging magnetic parameters with the external device.

21. The method of claim 15, wherein the detector detects a BLE signal and the controller configures the A4WP charger for power transfer.

22. A non-transitory computer-readable storage device comprising a set of instructions to direct one or more processors associated with a wireless charging station to:

transmit one or more periodic A4WP beacons;

detect a response to the one or more periodic A4WP beacons from an external device and identify the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and

dynamically configure a magnetic field to accommodate external device.

23. The non-transitory computer-readable storage device of claim 22, wherein the transmitter transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

24. The non-transitory computer-readable storage device of claim 23, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

25. The non-transitory computer-readable storage device of claim 24, wherein the NFC load modulated is a modulation of the one or more NFC-like polls by the external device.

26. A method to detect presence of an Near Field Communication (NFC)/RFID device proximal to a wireless charging station, the method comprising:

transmitting NFC-like polls having a carrier frequency of about 6.78MHz;

detecting a response to the NFC-like polls, the response comprising by an NFC load modulation, and

dynamically configuring a magnetic field generated by the charging station to accommodate the NFC/RFID device.

27. The method of claim 26, further comprising transmitting NFC-like polls at the carrier frequency of about 6.78 MHz while charging a device with the 6.78 MHz NFC-like polling signal.

28. A non-transitory computer-readable storage device comprising a set of instructions to direct one or more processors associated with a wireless charging station to implement the steps or processes of any of the preceding claims.

29. A wireless charging station, comprising:

a means for transmitting one or more periodic A4WP beacons;

a means for detecting a response from an external device in response to the one or more A4WP beacons and to identify the response as one of a Bluetooth Low Energy (BLE) advertisement, a Near Field Communication (NFC) load modulation, an impedance change or a combination thereof; and

a means for controlling g including processing circuitry to dynamically configure a magnetic field for the identified external device.

30. The wireless charging station of claim 29, wherein the means for transmitting transmits one or more periodic A4WP beacons and one or more periodic NFC-like polls.

31. The wireless charging station of claim 30, wherein the one or more NFC-like polls have a frequency of about 6.78 MHz.

32. The wireless charging station of claim 31, wherein load modulated is a modulation of the one or more NFC-like polls by the external device.

33. The wireless charging station of claim 29, further comprising an A4WP charger coil in communication with the means for controlling to generate and adaptively control the magnetic field.

34. The wireless charging station of claim 29, wherein the means for detecting detects a BLE and NFC response and one of instruct removal of the external device or exchange magnetic parameters with the external device.

35. The wireless charging station of claim 33, wherein the means for detecting detects a BLE signal and the means for controlling configures the A4WP charger for power transfer.

36. A method to detect presence of an Near Field Communication (NFC)/RFID device proximal to a wireless charging station, the method comprising:

transmitting NFC-like polls having a carrier frequency of about 6.78MHz;

detecting a response to the NFC-like polls, the response comprising by an NFC load modulation, and

dynamically configuring a magnetic field generated by the charging station to accommodate the NFC/RFID device.

37. The method of claim 36, further comprising transmitting NFC-like polls at the carrier frequency of about 6.78 MHz while charging a device with the 6.78 MHz NFC-like polling signal.

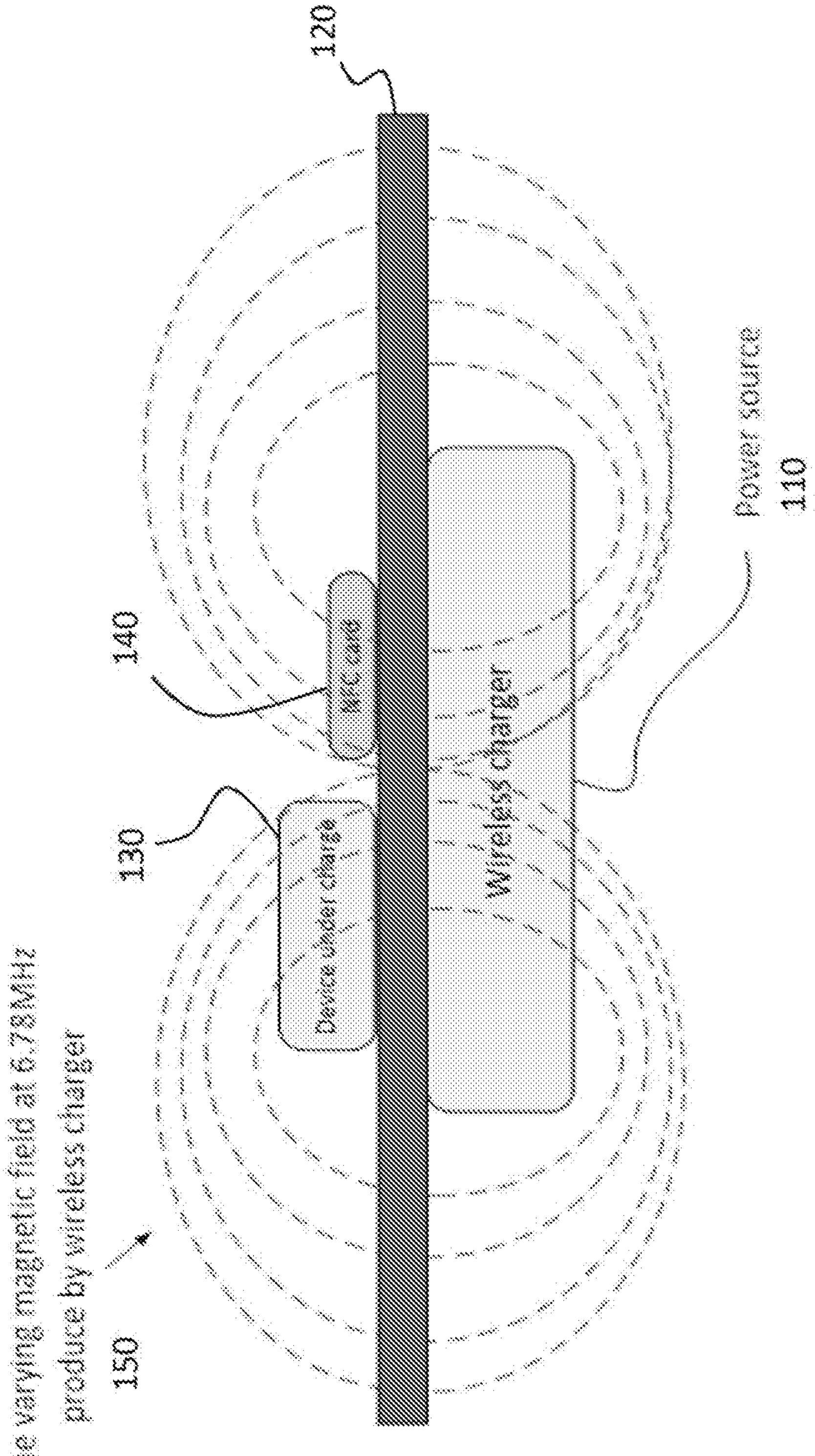
Time varying magnetic field at 6.78MHz
produce by wireless charger
150
130
Device under charge
140
NFC card
120
Wireless charger
Power source
110

Fig. 1

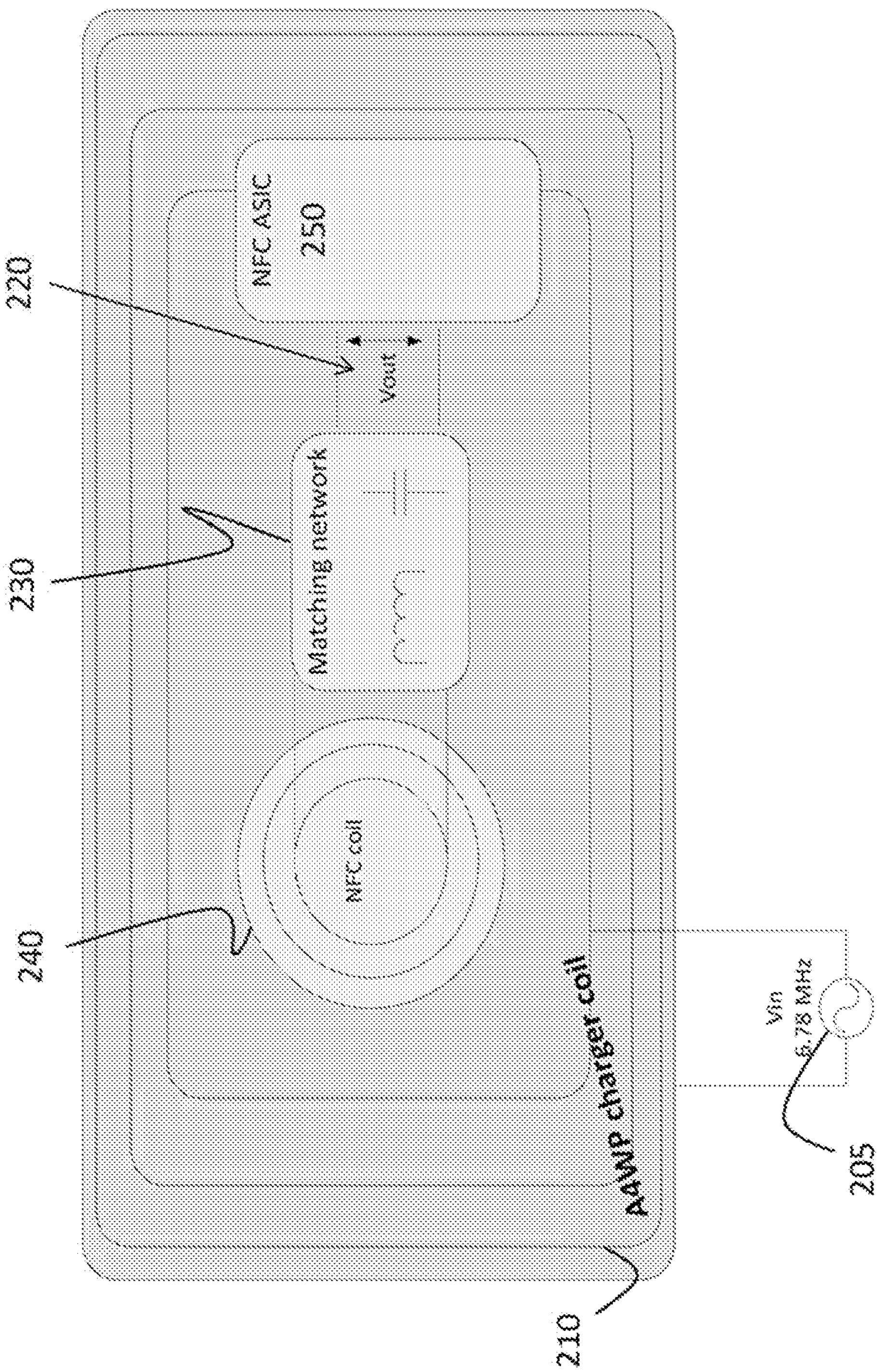
220
NFC ASIC
250
Vout
230
Matching network
240
NFC coil
A4WP charger coil
Vin
6.78 MHz
205
210

Fig. 2

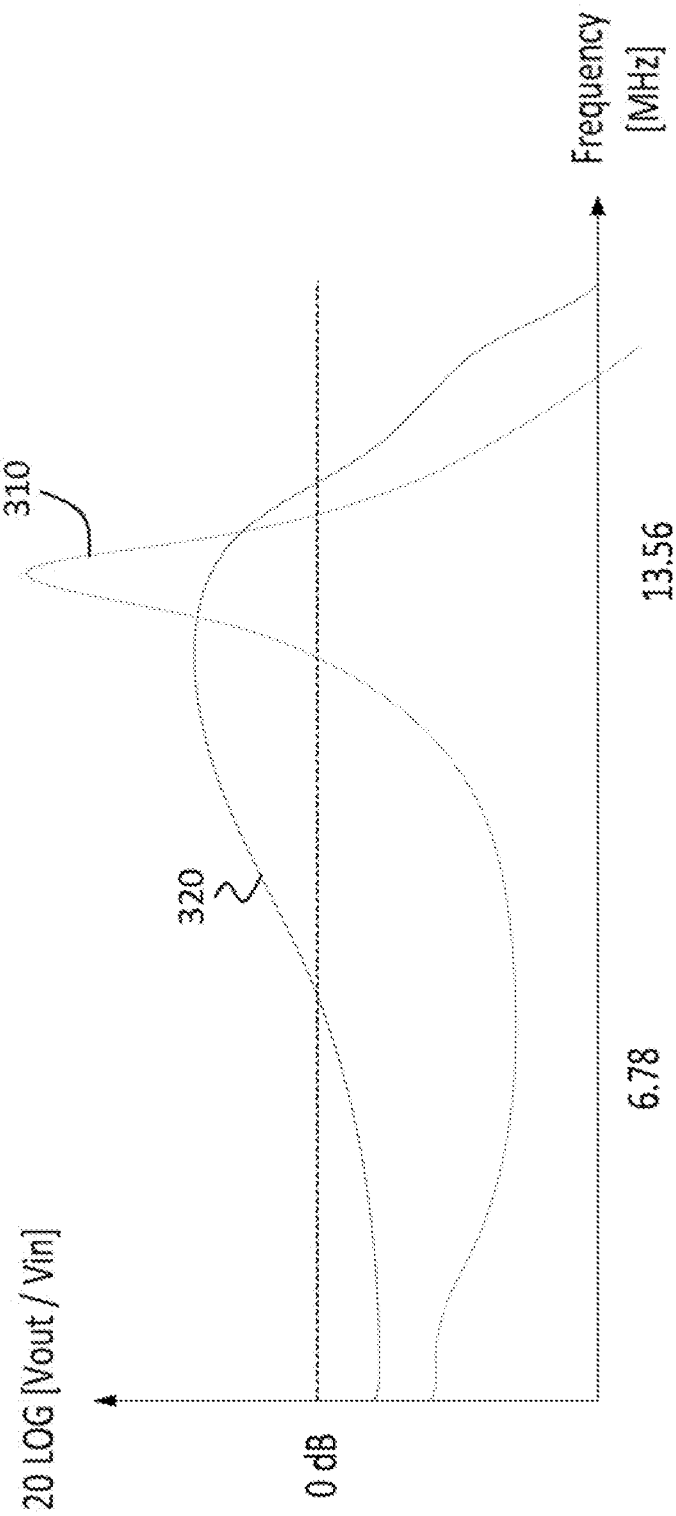

Fig. 3

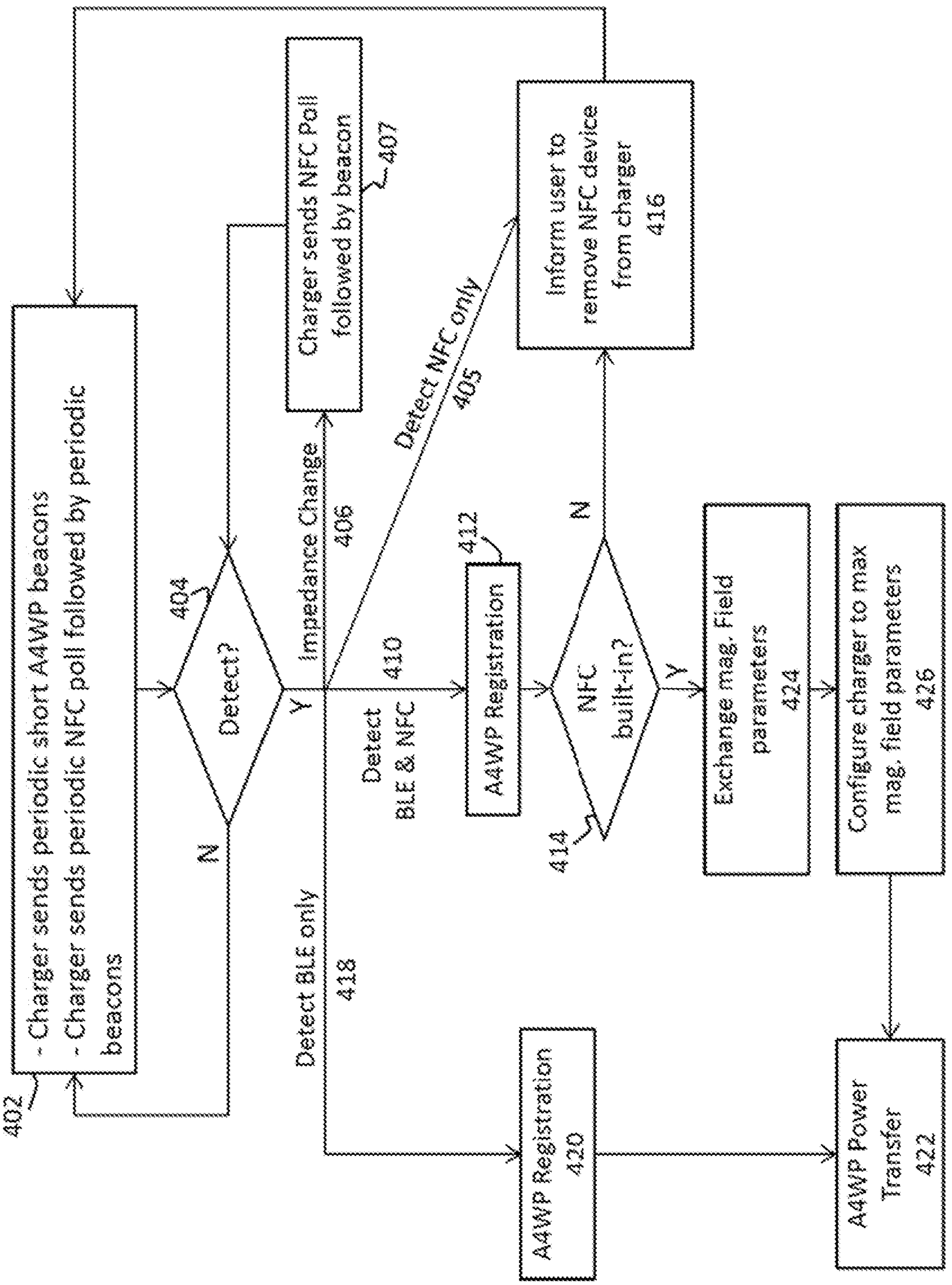
- Charger sends periodic short A4WP beacons
- Charger sends periodic NFC poll followed by periodic beacons
402
Detect?
404
N
Y
Impedance Change
406
Charger sends NFC Poll followed by beacon
407
Detect NFC only
405
Inform user to remove NFC device from charger
416
Detect BLE & NFC
410
A4WP Registration
412
NFC built-in?
414
N
Y
Exchange mag. Field parameters
424
Configure charger to max mag. field parameters
426
Detect BLE only
418
A4WP Registration
420
A4WP Power Transfer
422

Fig. 4

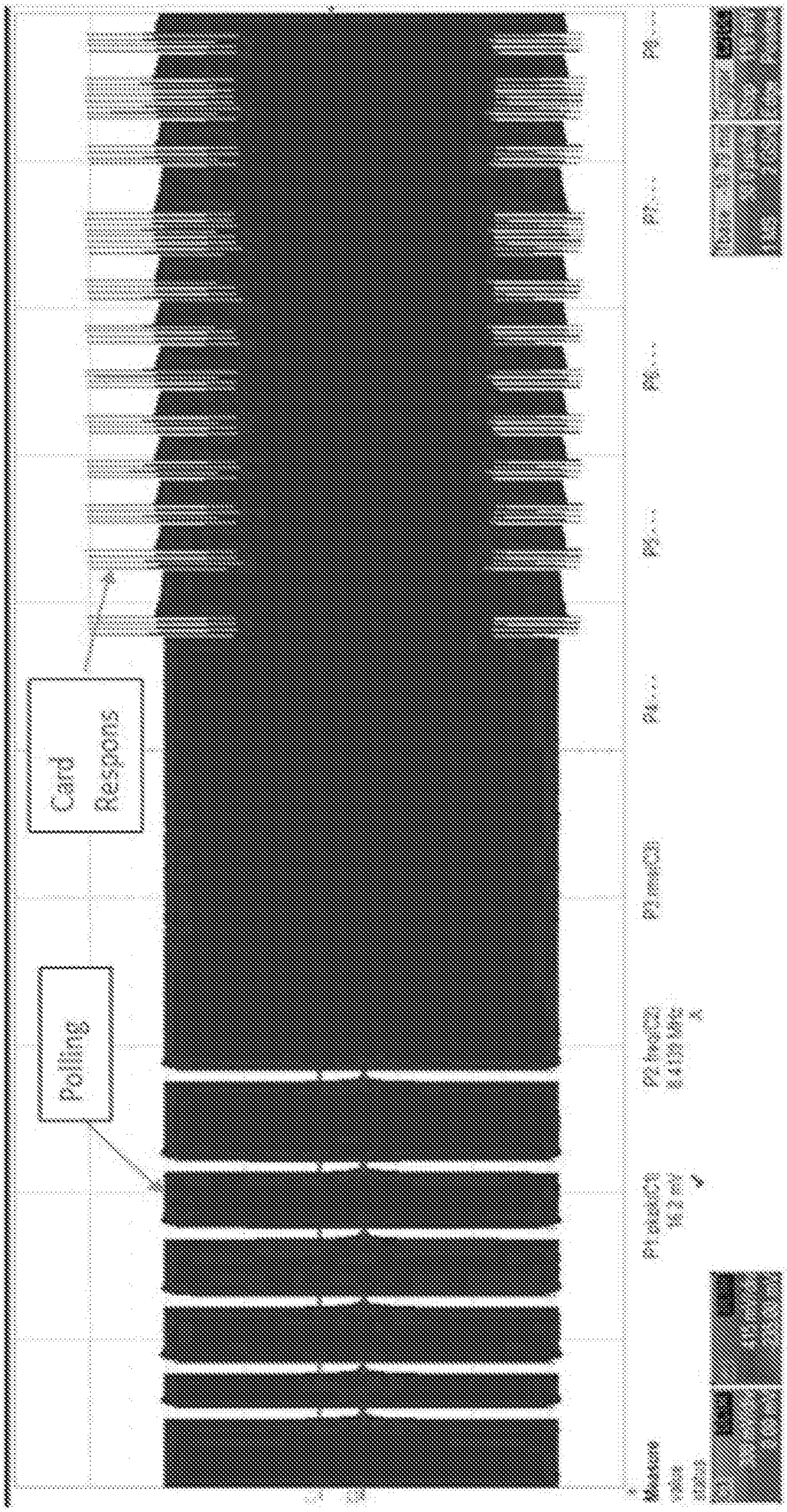

Fig. 5

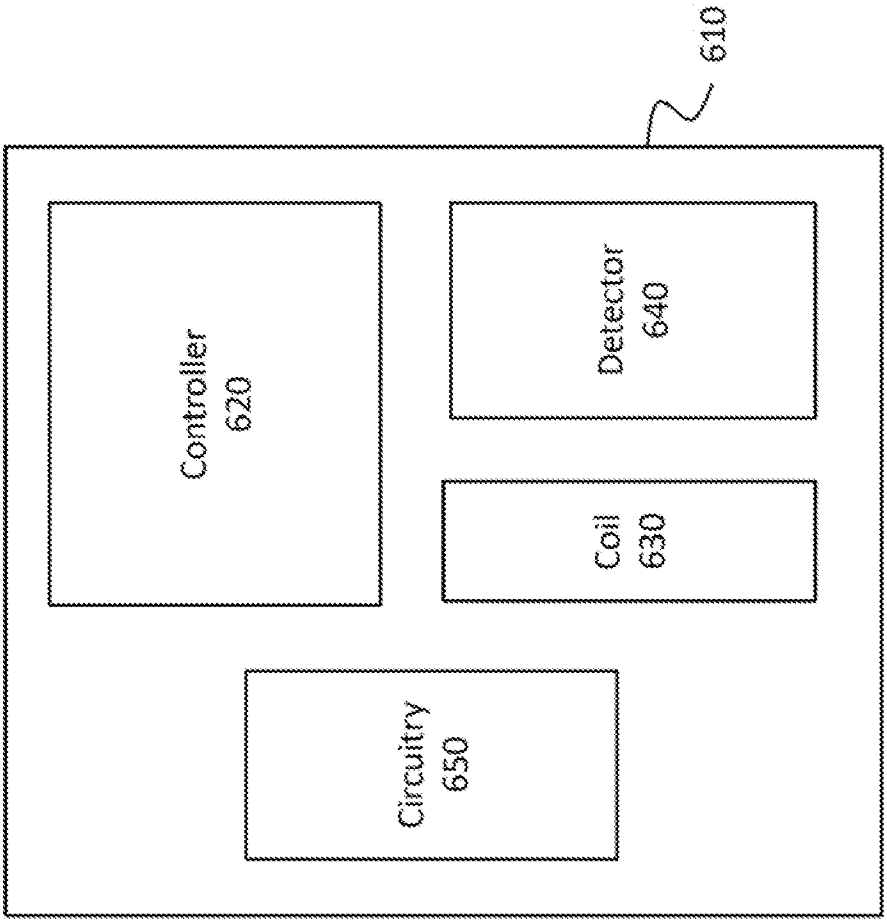

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/020883

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/00(2006.01)i, H02J 50/90(2016.01)i, H02J 50/80(2016.01)i, H04B 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 7/00; H04B 5/00; H01F 38/14; H02J 17/00; H02J 7/02; H02J 50/90; H02J 50/80

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 charging, station, A4WP, beacon, detector, BLE, NFC, load, modulation, frequency

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0094116 A1 (JOHN WALLEY et al.) 03 April 2014 See paragraphs 33-147, claims 1-20 and figures 2-11.	8,10
Y		1-7,9,11-25,28-35
A		26-27,36-37
X	US 2012-0248891 A1 (WILLIAM ANTHONY DRENNEN) 04 October 2012 See paragraphs 29-77, claims 1-20 and figures 4-13.	26-27,36-37
Y		1-7,9,11-25,28-35
A	US 2011-0148349 A1 (SE HAN KIM et al.) 23 June 2011 See paragraphs 75-134 and figures 6-13.	1-37
A	US 2014-0191568 A1 (MOJO MOBILITY, INC.) 10 July 2014 See paragraphs 93-168 and figures 6-17.	1-37
A	US 2011-0127843 A1 (JEYHAN KARAOGUZ et al.) 02 June 2011 See paragraphs 80-167 and figures 7-36.	1-37

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
07 June 2016 (07.06.2016)

Date of mailing of the international search report
07 June 2016 (07.06.2016)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/020883

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