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(54) RFID TAG BATTERY CHARGING METHOD

RFID-ETIKETT-BATTERIEAUFLADEVERFAHREN

PROCÉDÉ DE CHARGE DE BATTERIE D'ÉTIQUETTE RFID

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Description

BACKGROUND

[0001] Active RFID tags include fully active (battery operated) RFID tags and semi-passive (battery-assisted passive) RFID tags. Both of these are discussed in general terms herein, and configurations using power storage mechanisms can often include either device. However, either of these devices can be referred to as a power-enhanced RFID tag, in which stored power from the battery or other storage device is used to enhance RFID operations, provide more efficient power usage, increase tag lifespan, and enhance overall the power-related operations for the RFID tag.

[0002] The supplemental power allows active or semi-passive (battery assisted passive) RFID devices be much more effective and versatile compared with purely passive RFID devices. They also have exceptional receive sensitivity when operating in a power-assisted mode versus passive RFID devices. In addition, active or semi-passive (battery assisted passive) RFID devices can perform additional functions under their own power even when not being actively interrogated including collecting sensor data, activating external actuators, and running complex software for cryptography or other purposes. However, active or semi-passive (battery assisted passive) RFID devices are limited in performing their enhanced communications, carrying out supplemental functions and running software due to the limited life of their battery or supplemental power supply.

[0003] The battery life limitation for conventional powered, active or semi-passive (battery assisted passive) RFID devices is inherent due to their reliance on standard, non-rechargeable batteries as their supplemental power source. These devices have a limited life based on the initial charge of their batteries and the rate at which they draw power. Typical RFID applications such as globally monitoring the location of 40-foot ocean-going containers are severely constrained, because it is very difficult to manage and service RFID tags in use prior to depletion of the power supply. Larger capacity batteries including using multiple batteries with RFID devices have been tried, but once these batteries begin to discharge, they deteriorate relatively quickly and reach their lifetime limits quickly; albeit, slightly longer than with regular capacity batteries.

[0004] Patent document number WO2008/010890A2 describes a Radio Frequency Identification (RFID) device which includes a rechargeable solid state battery, control circuitry coupled to the rechargeable solid state battery, and a power source for recharging the rechargeable solid state battery.

[0005] Patent document number US2006/094425A1 describes an energy harvesting circuit which has an active automatic tuning circuit to search for broadcast frequencies in a band of interest and selecting only those broadcast signals received with sufficient RF strength to be used in energy harvesting. The circuit provides power storage devices with a circuit that has a means to select the ambient RF that can maximize or enhance the performance of an RFID circuit by increasing the amount of energy for harvesting. This automatic tuning enables a power storage devices charger circuit to move from location to location without manual tuning of the circuit and increase the effective range of an RFID circuit.

[0006] There has been much discussion and some demonstration of "harvesting" energy from existing RF fields, but generally these fields are very weak and are insufficient to recharge batteries. Further, conventional rechargeable batteries require a significant potential difference in order to reverse the chemical reactions used to store the electrical energy. There have also been attempts to use super-capacitors to store power instead of rechargeable batteries and, thus, avoid the required large potential difference for recharging batteries. However, capacitors and even super-capacitors are much less effective at storing charge for extended periods compared with batteries.

SUMMARY

[0007] The present invention in its various aspects is as set out in the appended claims.

[0008] Various configurations of trickle-charged RFID device and methods for increasing the useful life of a self-powered, active or semi-passive (battery assisted passive) RFID device are provided. A trickle-charged RFID device includes a main antenna to receive wireless interrogator signals from one or more RFID readers, a power harvester connected with the main antenna to obtain power from the wireless interrogator signals, and an intermediate storage device connected to the power harvester. The intermediate storage device collects trickle flows of unused, harvested power that is obtained from wireless interrogator signals lacking an inquiry for the device, such as interrogator signals for other RFID devices.

[0009] The active or semi-passive (battery assisted passive) RFID device also includes a primary storage device, into which the intermediate storage device can discharge its collection of trickle flows from unused power when the collection reaches a predetermined threshold level. The primary storage device can include a rechargeable battery, and the intermediate storage device can include one or more capacitors, such as super-capacitors. The intermediate storage is able to collect unused trickle flows until it reaches predetermined threshold level having high potential versus for the rechargeable battery, such that it can recharge some of the power drained from the main storage device during use of the active or semi-passive (battery assisted passive) RFID device.

[0010] The effective life of the main storage device, such as one or more rechargeable batteries, can be significantly extended based on the high-potential recharge actions of the intermediate storage device provided by

the collected trickle flows. Configurations of the RFID device and related methods for extending their useful life includes collecting trickle charge flows from multiple types of harvested unused power including sources other than interrogator signals, such as unmodulated wireless signals. Multiple types of trickle charge flows obtained from multiple sources can provided an enhanced combined flow into the intermediate storage device, which can significantly improve the recharge rate of the main storage device and, thus, significantly extends its useful life and that of the RFID device.

[0011] Advantages and features of novelty characterizing inventive aspects pertaining to the subject matter described in the application are pointed out with particularity in the appended claims. To gain an improved understanding of advantages and features of novelty, however, reference can be made to the following descriptive matter and accompanying figures that describe and illustrate various configurations and concepts related to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Examples of trickle-charged RFID devices and methods for extending the useful life of self-powered, active or semi-passive (battery assisted passive) RFID devices are illustrated in the figures. The examples and figures are illustrative rather than limiting.

Figure 1 shows a self-powered, trickle-charged, active or semi-passive (battery assisted passive) RFID device having an intermediate storage device that collects trickle flows of unused power and periodically recharges the rechargeable battery based on the trickle flows it collects in accordance with an example configuration.

Figure 2 illustrates a method for extending the useful life of a primary storage device of a self-powered, active or semi-passive (battery assisted passive) RFID device via collecting trickle flows in an intermediate storage device and periodically discharging the collected flows to recharge the primary storage device according to aspects and features described herein.

Figure 3 shows an arrangement of example components for the RFID device of Figure 1.

Figure 4 shows another arrangement of example components for a RFID device not according to the invention.

Figure 5 shows a further arrangement of example components for a further RFID device.

Figures 6A and 6B show an arrangement of example components for a RFID device, according to the present invention.

Figure 7 shows example voltage fluctuations and charge status for the RFID device of Figures 6A and 6B.

DETAILED DESCRIPTION OF THE DRAWINGS

[0013] Described in detail below are example configurations of various trickle-charged RFID devices and methods for increasing the useful life of self-powered, active or semi-passive (battery assisted passive) RFID devices. Some example configurations of trickle-charged, active or semi-passive (battery assisted passive), RFID devices make use of ambient electric fields and inherent means of collecting energy from the fields to provide extended battery life for active or semi-passive (battery assisted passive) and battery-assist RFID tags. Further, example configurations also describe methods of charging a rechargeable battery on an RFID tag that includes a circuit for detecting when the tag is not being actively interrogated, diverting the energy collected on the antenna from the interrogator field to an intermediate storage device (e.g. one or more capacitors), determining when the collected charge is sufficient to induce an increase in battery energy (e.g., recharge), and to discharge the intermediate storage device into the primary storage device, such as a rechargeable battery or arrangement of one or more super-capacitors. Referring now to Figure 1, a self-powered, trickle-charged RFID device 110 is shown that makes use of the inherent strength of interrogator fields in the immediate vicinity of the RFID tags. These tags are generally sitting in a storage yard or on a ship disposed within interrogator fields for a good deal of their lifetimes, or they are located on cars driving within interrogator range, such as cars that drive past toll road sensors, parking garage sensors, etc. These fields are hundreds of times more intense than other fields, such as FM or 802.11. As such, these RFID tags are exposed to significant energy fields on a regular basis, from which they regularly harvest power in preparation for activation, but fail to use if not activated. When the tag is not activated, the harvested power is typically disposed of without being used and is not saved or stored. As shown in Fig. 1, RFID tag 110 includes an antenna 112 and related circuitry that is already impedance matched to collect energy from the field and already configured to use the collected power if activated like conventional active or semi-passive (battery assisted passive) RFID tags. In such tags, once the tag is "turned on" by the field, the energy is not used until the specific tag is interrogated at which point the energy in the battery is used to amplify the return signal.

[0014] However, RFID tag 110 includes an added circuit 113 that diverts unused, excess energy harvested from an interrogator field for use in charging the battery when the tag in idle. The unused, excess energy collected from interrogator field signals provides a low trickle of current that can be captured, stored and used. However, such a trickle of current is not enough to charge a battery directly, especially the large mAh batteries required in some applications, which can be rated at 2000 mAh or greater. As such, RFID tag 110 further includes a means of storing the multiple trickle charges coming from the antenna until the collections is sufficient to cause significant charging of the battery. Such a means is an intermediate storage 116, such as a low-loss capacitor or arrangement of low-loss capacitors. After the capacitor device / intermediate storage 116 builds up charge from a plurality of collected trickle charges to reach a point of significance, a charge/recharge circuit, such as a circuit having one or more diodes, allows a sudden draining of the collected charge into a rechargeable primary/main storage device 114, such as a rechargeable battery or arrangement of one or more long-term super-capacitors.

[0015] Example RFID tag 110 and other example RFID tags discussed herein are generally described along with use in a warehouse / transportation environment. In such a common scenario, RFID tags 110 are placed on movable items that need to be tracked and/or monitored, such as boxes being shipped or vehicles that regularly pass various sensors like parking unit or toll collection sensors. Of course, operations, benefits and features of trickle-charged RFID tags 110 and RFID tags in general could be described under numerous other scenarios and especially those involving movable items, such as tracking assets for a company; monitoring the usage, travel patterns and location of vehicles; maintaining accurate logistics information for military equipment and supplies; tracking natural phenomena like oceanic or atmospheric movements, etc., as well as more complex usages such as establishing ad-hoc network systems.

[0016] Referring now to Figure 2, a method 210 is shown for extending the useful life of a primary storage device of a self-powered, active or semi-passive (battery assisted passive) RFID device via collecting trickle flows in an intermediate storage device and periodically discharging the collected flows to recharge the primary storage device. The method generally includes the step 212 of receiving at an RFID tag an interrogator signal from a RFID reader device, and step 214 of the RFID device determining whether the interrogator signal includes a Tag Inquiry for the particular RFID tag.

[0017] If YES, the interrogator signal does include a Tag Inquiry for the RFID tag, the RFID tag performs the step 216 of Setting a main switch of the RFID tag to receive power from its main storage device, which can be a battery or other storage device, such as a super-capacitor or arrangement of capacitors. The method continues with the RFID tag performing step 218 of Decoding the Tag Inquiry to determine the RFID reader's query and backscattering the data in response to the request. Afterward, the RFID tag performs the step 220 of Setting the main switch to close power from main storage and connect the power harvester to a default position for providing trickle charge flows to the intermediate storage upon receipt of interrogator signals lacking a Tag Inquiry.

[0018] If NO, the interrogator does not include a Tag Inquiry for the RFID tag, the RFID tag performs the step 222 of Maintaining Setting the main switch to close power from main storage and connect the power harvester to a default position for providing trickle charge flows to the intermediate storage upon receipt of interrogator signals lacking a Tag Inquiry. Thereafter, the method includes the step 224 of receiving trickle charges from the power harvester to the intermediate storage for the interrogator signals lacking a Tag Inquiry, and the step 226 of monitoring the level of collected trickle charges stored in intermediate storage until a threshold level is reached. When the threshold level of charge in the intermediate storage has been reached, the method includes step 228 of discharging stored power in the overall intermediate storage device to the main storage device to recharge the main storage device.

[0019] Referring now to Figure 3, in one configuration, the active or semi-passive (battery assisted passive) RFID tag 310, such as RFID tag 110 or similar, includes a Main Antenna 312 and a Main Tag integrated circuit (IC) 322, as well as a Modulator 318, a Demodulator 316 and a Power Harvester 320 that are each connected to IC 322 and Main Antenna 312. In addition, RFID tag 310 includes a main or Primary Storage 326 for providing power when the tag is activated, actuators or Sensors 324 to detect the presence of interrogator signals or other wireless signals, and Charge / Discharge Circuitry 328 to connect Primary Storage 326 to IC 322 when activated and controlling recharging of the storage device, which are each in communication with IC 322. In addition, RFID tag 310 also includes at least one Intermediate Storage device 330, which is in communication with Charge/Discharge Circuitry 328 and is selectively connected with Primary Storage 326 when discharging collected charge into Primary Storage 326 during recharging activities.

[0020] Figure 4 shows components of active or semi-passive (battery assisted passive) RFID tag 310 in an example circuit arrangement that includes Power Harvester 320, which periodically receives trickle flows of unused charge that are received from interrogator signals or other wireless signals that are not used immediately by RFID Tag 310 for activities occurring when in the active state. The RFID tag of Figure 4 does not fall within the scope of the claims. As shown, Power Harvester 320 is further connected with Intermediate Storage 330 and is selectively connected with Primary Storage 326, and also includes one or more diodes 450 and 452.

[0021] Diodes 450 and 452 permit the periodic flow of trickle charges into Intermediate Storage 330 via Diode 450 while preventing Intermediate Storage 330 from discharging into Primary Storage 326 until a pre-determined threshold of collected charge has been met in Intermediate Storage 330 via Diode 452. Once met, Diode 452 allows a portion of collected charge stored in Intermediate Storage 330 to flow into Primary Storage 326 to recharge, at least partially, the primary storage device. Diodes 450 and 452 can have preset, predetermined values that are configured for the particular RFID tag 310 and its intended functionality and desired lifespan. Alternatively, the diodes can be variable and controllable as shown hereafter in Figure 6A.

[0022] Referring now to Figure 5, components of another configuration of a RFID tag is shown as RFID tag 310', which is configured as an active or semi-passive (battery assisted passive) RFID tag that is similar to RFID tag 310 discussed above along with Figures 3 and 4, and which generally includes the same aspects and preferences as RFID tag 310, except as discussed hereafter. As shown, RFID tag 310' includes multiple sub-circuits or circuits 332, 334 and 336 directed to controlling charge and discharge activities for trickle flows received from multiple Power Harvesters 320', which can be configured to harvest power from multiple different interrogator signals or from other sources, such as an unmodulated RF CW from a reader.

[0023] For example, when the tag receives unmodulated RF CW signal from a reader, it can power both the main tag IC and specific switches / circuits related to the unmodulated signal without drawing power from Primary Storage 326'. Excess harvested power from the RF CW signal can be diverted as a trickle flow and be stored in a corresponding Intermediate Storage Sub-device or Device 338, 340 and 342. Similarly, RFID tag 310' can be configured to store trickle flows of charge harvested from other sources, such as different types of interrogator fields, FM wireless signals, WiFi wireless signals, etc. in corresponding Devices 338, 340 and 342. These multiple sub-stores can be stored collectively within Intermediate Storage 330' to enhance its collection rate and the rate at which collected charge can be discharged into Primary Storage 326'.

[0024] Figures 6A, 6B and 7 depict components and features of a configuration RFID tag 310" according to an embodiment of the invention, which is configured as an active or semi-passive (battery assisted passive) RFID tag that is similar to RFID tags 310 and 310' discussed previously, and which generally includes the same aspects and preferences as RFID tags 310 and 310', except as discussed hereafter. As shown, Fig. 6A depicts components forming portions of RFID tag 310" including Charge/Discharge Circuitry 328", Power Harvester 320", Intermediate Storage 330" and Primary Storage 326". Charge/Discharge Circuit 328" includes a connection with Power Harvester 320", which can represent multiple power harvesters, from which it periodically receives trickle flows of unused charge that are received from interrogator signals or other wireless signals and are not used immediately by RFID Tag 310", such as for activities occurring when in the active state. Charge/Discharge Circuit 328" is further connected with Intermediate Storage 330" and is selectively connected with Primary Storage 326". However, Intermediate Storage 330" includes sub-storage devices 339 and 341 in the form of Capacitors C1 and C2, which can be configurations of one or more super-capacitors. Capacitor C1 can be considered part of the Power Harvester/Rf-to-DC Converter 320" and/or part of the Intermediate Storage 330". In the configuration shown in Fig. 6A, Capacitor C1 339 and Capacitor C2 341 function as Intermediate Storage 330".

[0025] Charge / Discharge Circuit 328" further includes one or more Voltage-controlled Switches 670 and 671 (Figure 6B), which permit the periodic flow of trickle charges into Intermediate Storage 330" while preventing it from discharging into Primary Storage 326" until a predetermined threshold of collected charge has been met in Intermediate Storage 330". Voltage-controlled Switches 670 and 671 differ from Diodes 450 and 452 discussed previously, in that their predetermined values can be variable and controllable. Fig. 7 shows example waveforms that illustrate how the respective voltages and charge levels can change over time during the receipt of trickle flows and the eventual discharge/recharge activities.

[0026] It is understood that aspects, features and benefits of the invention described herein are not unique applicable to, nor limited to, RFID networks, systems or devices. Many possibilities for implementing aspects and features of the invention described herein with other types of antenna devices and systems are possible. These and other changes can be made to the invention in light of the above Detailed Description.

[0027] While the above description describes certain examples, and describes the best mode contemplated, no matter how detailed the above appears in text, the invention can be practiced in many ways. Details of the system may vary considerably in its specific implementation, while still being encompassed by the invention disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the invention should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the invention with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the invention to the specific examples disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the invention encompasses not only the disclosed examples.

[0028] While certain aspects of the invention are presented below in certain claim forms, the applicant contemplates the various aspects of the invention in any number of claim forms.

[0029] The flowcharts and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems and methods according to various embodiments. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block might occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems which perform the specified functions or acts, or combinations of special purpose hardware.

[0030] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0031] The corresponding structures, materials, acts, or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to embodiments of the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope of embodiments. The embodiment was chosen and described in order to explain the principles of embodiments and the practical application, and to enable others of ordinary skill in the art to understand embodiments of the invention for various embodiments with various modifications as are suited to the particular use contemplated.

[0032] Although specific embodiments have been illustrated and described herein, those of ordinary skill in the art appreciate that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiments shown and that embodiments have other applications in other environments. This application is intended to cover any adaptations or variations of the present invention. The following claims are in no way intended to limit the scope of embodiments of the invention to the specific embodiments described herein.

Claims

1. A trickle-charged Radio Frequency Identification, RFID, device comprising:

    a first main antenna element (312) configured to receive one or more interrogator signals from one or more RFID readers;
    a first power harvester/RF-to-DC converter (320, 320") electrically connected with the first main antenna element and configured to obtain power from each of the one or more interrogator signals and convert the one or more interrogator signals to DC signals;
    an intermediate storage device (330, 330") electrically connected to the first power harvester /RF-to-DC converter and configured to collect the converted DC signals from the first power harvester/RF-to-DC converter;
    a primary storage device (326, 326") connected with the intermediate storage device via a circuit (328, 328") configured to transfer charge stored in the intermediate storage device when the stored charge reaches a predetermined level;
    said circuit (328, 328") comprising switches (670 and 671) which permit the periodic flow of the DC signals into the intermediate storage device (330, 330") while preventing the intermediate storage device from discharging into the primary storage device (326, 326") until the pre-determined level of collected charge has been met in the intermediate storage device, wherein the switches comprise: 1) a first switch (670) that is disposed between the power harvester/ RF-to-DC converter (320, 320") and the intermediate storage device (330, 330"), and 2) a second switch (671) that is disposed between the intermediate storage device (330, 330") and the primary storage device (326, 326"),
    wherein the circuit is configured to:

        close the first switch (670), upon receipt of the one or more interrogator signals lacking a tag inquiry, in order for the circuit (328) to direct the DC signals to the intermediate storage device until the pre-determined level of collected charge has been met in the intermediate storage device; and
        close the second switch (671) when the predetermined level of collected charge has been reached in order for the circuit (328) to transfer the charge from the intermediate storage device (330, 330") to the primary storage device (326, 326") .

2. The trickle-charged RFID device of Claim 1, wherein the primary storage device comprises a rechargeable battery (326) and the intermediate storage device (330) comprises one or more capacitors (C1, C2).

3. The trickle-charged RFID device of Claim 2, wherein the one or more capacitors comprise one or more super-capacitors.

4. The trickle-charged RFID device of Claim 1, further comprising a main switch configured to switch from a first position connecting the intermediate storage to the first power harvester/RF-to-DC converter for providing a trickle charge to the intermediate storage

and at least a second position connecting the primary storage device to the first main antenna element to provide stored power to the first main antenna element while in an active mode.

5. The trickle-charged RFID device of Claim 4, wherein the control circuit is further configured to:

determine if a first one of the one or more wireless interrogator signals received includes a tag inquiry for the RFID device to enter an active mode;
if the first one of the plurality of wireless interrogator signals received is determined to have included a tag inquiry, then switch the main switch from a first position connecting the intermediate storage to the first power harvester/RF-to-DC converter to a second position connecting the main storage to the first main antenna element while the first main antenna element is in the active mode, and then switch the main switch back to the first position to allow power from the DC signals from the power harvester/RF-to-DC converter to charge the intermediate storage; and
if the first one of the plurality of wireless interrogator signals received is determined to not have included a tag inquiry, then maintain the main circuit in the first position.

6. The trickle-charged RFID device of Claim 5, further comprising a second main antenna connected to a second power harvester, the second power harvester being connected to the intermediate storage via a circuit, the second power harvester being configured to obtain power from each of a plurality of unmodulated wireless signals received at the RFID device.

7. The trickle-charged RFID device of Claim 6, further comprising a third main antenna connected to a third power harvester, the third power harvester being connected to the intermediate storage via a circuit, the third power harvester being configured to obtain power from each of a plurality of modulated, non-interrogator wireless signals received at the RFID device.

8. The trickle-charged RFID device of Claim 1, further comprising:

a second main antenna element configured to receive a plurality of wireless non-interrogator signals; and
a second power harvester electrically connected with the second main antenna element and configured to obtain power from each of the plurality of wireless non-interrogator signals;
wherein the intermediate storage device is electrically connected to the second power harvester via a second circuit and configured to collect a plurality of signals of obtained power from the second power harvester, the second circuit being configured to divert the plurality of signals to the intermediate storage.

9. A method (210) for extending a useful life of a main power storage device of a RFID device, the method comprising:

receiving (212) a wireless interrogator signal from a RFID reader;
determining (214) if the wireless interrogator signal includes a tag inquiry for the RFID device requiring it to enter an active mode in response to the wireless interrogator signal;
if the wireless interrogator signal is determined to include the tag inquiry, perform steps comprising:

switching (216) a main switch from a first position connecting an intermediate storage device (330) to a power harvester/RF-to-DC converter (320), to a second position connecting the main power storage device for providing stored power to a main circuit for use while in the active mode;
decoding (218) the received tag inquiry;
backscattering (218) data from the received tag inquiry; and
switching (220) the main switch back to the first position including disconnecting the main power storage device from the main circuit and connecting the intermediate storage device to the power harvester /RF-to-DC converter;

if the wireless interrogator signal is determined to not include the tag inquiry, perform steps comprising:

converting one or more interrogator signals received to DC signals using the power harvester/ RF-to-DC converter;
providing (224) the DC signals to the intermediate storage device to charge the intermediate storage device by closing a first switch (670) disposed between the power harvester/RF-to-DC converter and the intermediate storage device;
monitoring (226) a level of charge stored in intermediate storage until a predetermined threshold level is reached while the first switch is closed; and
transferring the collected charge from the intermediate storage device to the main

power storage device by closing a second switch (671) disposed between the intermediate storage device to the main power storage device when the predetermined threshold level is reached.

10. The method of Claim 9, further comprising:

receiving a plurality of non-interrogator wireless signals; and
providing DC signals obtained from the plurality of non-interrogator wireless signals to the intermediate storage device to charge the intermediate storage device.

11. The method of Claim 10, wherein:

the plurality of non-interrogator wireless signals includes a first type of non-interrogator wireless signals and a second type of non-interrogator wireless signals;
the intermediate storage includes a first type intermediate storage, a second type intermediate storage and an overall intermediate storage;
receiving a plurality of non-interrogator wireless signals includes receiving a first type of non-interrogator wireless signals and a second type of non-interrogator wireless signals; and
providing a plurality of charges from the plurality of non-interrogator wireless signals to the intermediate storage includes providing the charges from the first type of non-interrogator wireless signals to the first type intermediate storage and providing the charges from the second type of non-interrogator wireless signals to the second type intermediate storage.

12. The method of Claim 11, further comprising:

monitoring a first type charge level of the first type intermediate storage device;
monitoring a second type charge level of the second type intermediate storage device;
if the charge level of the first type intermediate storage device reaches a first type predetermined threshold discharge level, discharging stored charge in the first type intermediate storage device to the overall intermediate storage device; and
if the charge level of the second type intermediate storage device reaches a second type predetermined threshold discharge level, discharging stored charge in the second type intermediate storage device to the overall intermediate storage device.

Patentansprüche

1. Erhaltungsgeladene Funkfrequenzkennung- bzw. RFID-Vorrichtung, umfassend:

ein erstes Hauptantennenelement (312), konfiguriert zum Empfangen eines oder mehrerer Abfragesignale von einem oder mehreren RFID-Lesern;
ein erster Leistungsgewinner/RF-zu-DC-Wandler (320, 320"), elektrisch verbunden mit dem ersten Hauptantennenelement und konfiguriert zum Erlangen von Leistung von jedem des einen oder der mehreren Abfragesignale und Umwandeln des einen oder der mehreren Abfragesignale in DC-Signale;
eine Zwischenspeichervorrichtung (330, 330''), elektrisch verbunden mit dem ersten Leistungsgewinner/RF-zu-DC-Wandler und konfiguriert zum Erfassen der umgewandelten DC-Signale von dem ersten Leistungsgewinner/RF-zu-DC-Wandler;
eine primäre Speichervorrichtung (326, 326''), verbunden mit der Zwischenspeichervorrichtung über einen Schaltkreis (328, 328''), konfiguriert zum Übertragen von in der Zwischenspeichervorrichtung gespeicherter Ladung, wenn die gespeicherte Ladung ein im Voraus bestimmtes Niveau erreicht;
der Schaltkreis (328, 328'') umfassend Schalter (670 und 671), die den periodischen Fluss der DC-Signale in die Zwischenspeichervorrichtung (330, 330'') gestatten, während sie verhindern, dass die Zwischenspeichervorrichtung in die primäre Speichervorrichtung (326, 326'') entlädt, bis das im Voraus bestimmte Niveau von erfasster Ladung in der Zwischenspeichervorrichtung erreicht wurde, wobei die Schalter umfassen:
1) einen ersten Schalter (670), der zwischen dem Leistungsgewinner/RF-zu-DC-Wandler (320, 320'') und der Zwischenspeichervorrichtung (330, 330'') angeordnet ist, und 2) einen zweiten Schalter (671), der zwischen der Zwischenspeichervorrichtung (330, 330'') und der primären Speichervorrichtung (326, 326'') angeordnet ist, wobei der Schaltkreis konfiguriert ist zum:

Schließen des ersten Schalters (670) nach Empfang des einen oder der mehreren Abfragesignale ohne eine Kennzeichnungsanfrage, damit der Schaltkreis (328) die DC-Signale zu der Zwischenspeichervorrichtung leitet, bis das im Voraus bestimmte Niveau erfasster Ladung in der Zwischenspeichervorrichtung erreicht wurde; und
Schließen des zweiten Schalters (671), wenn das im Voraus bestimmte Niveau er-

fasster Ladung erreicht wurde, damit der Schaltkreis (328) die Ladung aus der Zwischenspeichervorrichtung (330, 330'') zu der primären Speichervorrichtung (326, 326'') überträgt.

2. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 1, wobei die primäre Speichervorrichtung eine wiederaufladbare Batterie (326) umfasst und die Zwischenspeichervorrichtung (330) einen oder mehrere Kondensatoren (Cl, C2) umfasst.

3. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 2, wobei der eine oder die mehreren Kondensatoren einen oder mehrere Superkondensatoren umfassen.

4. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 1, ferner umfassend einen Hauptschalter, konfiguriert zum Schalten von einer ersten Position, die den Zwischenspeicher mit dem ersten Leistungsgewinner/RFzu-DC-Wandler zum Bereitstellen, dem Zwischenspeicher, einer Erhaltungsladung verbindet, und mindestens einer zweiten Position, die die primäre Speichervorrichtung mit dem ersten Hauptantennenelement verbindet, um dem ersten Hauptantennenelement gespeicherte Leistung in einem aktiven Modus bereitzustellen.

5. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 4, wobei der Steuerschaltkreis ferner konfiguriert ist zum:

Bestimmen, ob ein erstes eines des einen oder der mehreren empfangenen drahtlosen Abfragesignale eine Kennzeichnungsanfrage für die RFID-Vorrichtung zum Eintreten in einen aktiven Modus enthält;
wenn bestimmt wird, dass das erste eine der Vielzahl von empfangenen drahtlosen Abfragesignalen eine Kennzeichnungsanfrage enthält, dann Schalten des Hauptschalters von einer ersten Position, die den Zwischenspeicher mit dem ersten Leistungsgewinner/RFzu-DC-Wandler verbindet, zu einer zweiten Position, die den Hauptspeicher mit dem ersten Hauptantennenelement verbindet, während das erste Hauptantennenelement in dem aktiven Modus ist, und dann Schalten des Hauptschalters zurück in die erste Position, um zu gestatten, dass Leistung von den DC-Signalen von dem Leistungsgewinner/RF-zu-DC-Wandler den Zwischenspeicher lädt; und
wenn bestimmt wird, dass das erste eine der Vielzahl von empfangenen drahtlosen Abfragesignalen keine Kennzeichnungsanfrage enthält, dann Verbleiben des Hauptschaltkreises in der ersten Position.

6. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 5, ferner umfassend eine zweite Hauptantenne, verbunden mit einem zweiten Leistungsgewinner, wobei der zweite Leistungsgewinner mit dem Zwischenspeicher über einen Schaltkreis verbunden ist, der zweite Leistungsgewinner konfiguriert ist zum Erlangen von Leistung von jedem einer Vielzahl von nicht modulierten drahtlosen Signalen, empfangen an der RFID-Vorrichtung.

7. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 6, ferner umfassend eine dritte Hauptantenne, verbunden mit einem dritten Leistungsgewinner, wobei der dritte Leistungsgewinner mit dem Zwischenspeicher über einen Schaltkreis verbunden ist, der dritte Leistungsgewinner konfiguriert ist zum Erlangen von Leistung von jedem einer Vielzahl von modulierten drahtlosen Nichtabfragesignalen, empfangen an der RFID-Vorrichtung.

8. Erhaltungsgeladene RFID-Vorrichtung nach Anspruch 1, ferner umfassend:

ein zweites Hauptantennenelement, konfiguriert zum Empfangen einer Vielzahl von drahtlosen Nichtabfragesignalen; und
einen zweiten Leistungsgewinner, elektrisch verbunden mit dem zweiten Hauptantennenelement und konfiguriert zum Erlangen von Leistung von jedem der Vielzahl von drahtlosen Nichtabfragesignalen;
wobei die Zwischenspeichervorrichtung mit dem zweiten Leistungsgewinner über einen zweiten Schaltkreis elektrisch verbunden und konfiguriert ist zum Erfassen einer Vielzahl von Signalen erfasster Leistung von dem zweiten Leistungsgewinner, wobei der zweite Schaltkreis konfiguriert ist zum Umleiten der Vielzahl von Signalen zu dem Zwischenspeicher.

9. Verfahren (210) zum Verlängern einer Nutzungsdauer einer Hauptspeichervorrichtung einer RFID-Vorrichtung, das Verfahren umfassend:

Empfangen (212) eines drahtlosen Abfragesignals von einem RFID-Leser;
Bestimmen (214), ob das drahtlose Abfragesignal eine Kennzeichnungsanfrage für die RFID-Vorrichtung enthält, die erfordert, dass sie als Reaktion auf das drahtlose Abfragesignal in einen aktiven Modus eintritt;
wenn bestimmt wird, dass das drahtlose Abfragesignal die Kennzeichnungsanfrage enthält, Durchführen von Schritten, umfassend:

Schalten (216) eines Hauptschalters von einer ersten Position, die eine Zwischenspeichervorrichtung (330) mit einem Leistungs-

gewinner/RF-zu-DC-Wandler (320) verbindet, zu einer zweiten Position, die die Hauptleistungsspeichervorrichtung zum Bereitstellen von gespeicherter Leistung mit einem Hauptschaltkreis verbindet, zur Verwendung in dem aktiven Modus;
Decodieren der empfangenen Kennzeichnungsanfrage;
Rückstreuen (218) von Daten aus der empfangenen Kennzeichnungsanfrage; und
Schalten (220) des Hauptschalters zurück zu der ersten Position, enthaltend Abtrennen der Hauptleistungsspeichervorrichtung von dem Hauptschaltkreis und Verbinden der Zwischenspeichervorrichtung mit dem Leistungsgewinner/RF-zu-DC-Wandler;

wenn bestimmt wird, dass das drahtlose Abfragesignal die Kennzeichnungsanfrage nicht enthält, Durchführen von Schritten, umfassend:

Umwandeln eines oder mehrerer empfangener Abfragesignale in DC-Signale unter Verwendung des Leistungsgewinners/RF-zu-DC-Wandlers;
Bereitstellen (224), der Zwischenspeichervorrichtung, der DC-Signale, um die Zwischenspeichervorrichtung zu laden, durch Schließen eines ersten Schalters (670), angeordnet zwischen dem Leistungsgewinner/RF-zu-DC-Wandler und der Zwischenspeichervorrichtung;
Überwachen (226) eines Niveaus von in dem Zwischenspeicher gespeicherter Ladung, bis ein im Voraus bestimmter Schwellenwert erreicht wird, während der erste Schalter geschlossen ist; und
Übertragen der erfassten Ladung von der Zwischenspeichervorrichtung zu der Hauptleistungsspeichervorrichtung durch Schließen eines zweiten Schalters (671), angeordnet zwischen der Zwischenspeichervorrichtung und der Hauptleistungsspeichervorrichtung, wenn der im Voraus bestimmte Schwellenwert erreicht wird.

10. Verfahren nach Anspruch 9, ferner umfassend:

Empfangen einer Vielzahl von Nichtabfragesignalen; und
Bereitstellen, der Zwischenspeichervorrichtung, von DC-Signalen, erlangt von der Vielzahl von Nichtabfragesignalen, um die Zwischenspeichervorrichtung zu laden.

11. Verfahren nach Anspruch 10, wobei:

die Vielzahl von drahtlosen Nichtabfragesignalen einen ersten Typ von drahtlosen Nichtabfragesignalen und einen zweiten Typ von drahtlosen Nichtabfragesignalen enthält;
der Zwischenspeicher einen Zwischenspeicher eines ersten Typs, einen Zwischenspeicher eines zweiten Typs und einen gesamten Zwischenspeicher enthält;
Empfangen einer Vielzahl von drahtlosen Nichtabfragesignalen enthält, einen ersten Typ von drahtlosen Nichtabfragesignalen und einen zweiten Typ von drahtlosen Nichtabfragesignalen zu empfangen; und
Bereitstellen, dem Zwischenspeicher, einer Vielzahl von Ladungen aus der Vielzahl von Nichtabfragesignalen enthält, die Ladungen aus dem ersten Typ von drahtlosen Nichtabfragesignalen dem Zwischenspeicher des ersten Typs bereitzustellen und die Ladungen aus dem zweiten Typ von drahtlosen Nichtabfragesignalen dem Zwischenspeicher des zweiten Typs bereitzustellen.

12. Verfahren nach Anspruch 11, ferner umfassend:

Überwachen eines Ladungsniveaus eines ersten Typs der Zwischenspeichervorrichtung des ersten Typs;
Überwachen eines Ladungsniveaus eines zweiten Typs der Zwischenspeichervorrichtung des zweiten Typs;
wenn das Ladungsniveau der Zwischenspeichervorrichtung des ersten Typs ein im Voraus bestimmtes Entladungsniveau eines ersten Typs erreicht, Entladen gespeicherter Ladung in der Zwischenspeichervorrichtung des ersten Typs zu der gesamten Speichervorrichtung; und
wenn das Ladungsniveau der Zwischenspeichervorrichtung des zweiten Typs ein im Voraus bestimmtes Entladungsniveau eines zweiten Typs erreicht, Entladen gespeicherter Ladung in der Zwischenspeichervorrichtung des zweiten Typs zu der gesamten Speichervorrichtung.

Revendications

1. Dispositif d'identification radiofréquence, RFID, chargé en régime d'entretien, comprenant :

un premier élément d'antenne principal (312) configuré pour recevoir un ou plusieurs signaux d'interrogation depuis un ou plusieurs lecteurs RFID ;
un premier récupérateur d'énergie/convertisseur RF/C.C. (320, 320") connecté électriquement au premier élément d'antenne principal et configuré pour obtenir une énergie depuis chacun des un ou plusieurs signaux d'interrogation

et convertir les un ou plusieurs signaux d'interrogation en signaux C.C. ;
un dispositif de stockage intermédiaire (330, 330") connecté électriquement au premier récupérateur d'énergie et configuré pour collecter les signaux C.C. convertis depuis le premier récupérateur d'énergie/convertisseur RF/C.C. ;
un dispositif de stockage primaire (326, 326") connecté au dispositif de stockage intermédiaire par l'intermédiaire d'un circuit (328, 328") configuré pour transférer une charge stockée dans le dispositif de stockage intermédiaire quand la charge stockée atteint un niveau prédéterminé ;
ledit circuit (328, 328") comprenant
des commutateurs (670 et 671) qui permettent le flux périodique des signaux C.C. dans le dispositif de stockage intermédiaire (330, 330") tout en empêchant une décharge du dispositif de stockage intermédiaire dans le dispositif de stockage primaire (326, 326") tant que le niveau prédéterminé de charge collectée n'a pas été atteint dans le dispositif de stockage intermédiaire, dans lequel les commutateurs comprennent :
1) un premier commutateur (670) qui est disposé entre le récupérateur d'énergie/convertisseur RF/C.C. (320, 320") et le dispositif de stockage intermédiaire (330, 330"), et 2) un second commutateur (671) qui est disposé entre le dispositif de stockage intermédiaire (330, 330") and le dispositif de stockage primaire (326, 326"),

dans lequel le circuit est configuré pour :

fermer le premier commutateur (670), à la réception des un ou plusieurs signaux d'interrogation sans interrogation d'étiquette, afin que le circuit (328) dirige les signaux C.C. vers le dispositif de stockage intermédiaire jusqu'à ce que le niveau prédéterminé de charge collectée ait été atteint dans le dispositif de stockage intermédiaire ; et
fermer le second commutateur (671) quand le niveau prédéterminé de charge collectée a été atteint pour que le circuit (328) transfère la charge du dispositif de stockage intermédiaire (330, 330") au dispositif de stockage primaire (326, 326").

2. Dispositif RFID chargé en régime d'entretien selon la revendication 1, dans lequel le dispositif de stockage primaire comprend une batterie rechargeable (326) et le dispositif de stockage intermédiaire (330) comprend un ou plusieurs condensateurs (Cl, C2).

3. Dispositif RFID chargé en régime d'entretien selon la revendication 2, dans lequel les un ou plusieurs condensateurs comprennent un ou plusieurs supercondensateurs.

4. Dispositif RFID chargé en régime d'entretien selon la revendication 1, comprenant en outre un commutateur principal configuré pour commuter d'une première position connectant le dispositif de stockage intermédiaire au premier récupérateur d'énergie/convertisseur RF/C.C. pour assurer une charge d'entretien du dispositif de stockage intermédiaire et au moins une seconde position connectant le stockage primaire au premier élément d'antenne principal pour fournir une énergie stockée au premier élément d'antenne principal durant un mode actif.

5. Dispositif RFID chargé en régime d'entretien selon la revendication 4, dans lequel le circuit de commande est configuré en outre pour :

déterminer qu'un premier des un ou plusieurs signaux d'interrogation sans fil reçus comporte ou non une interrogation d'étiquette pour que le dispositif RFID passe dans un mode actif ;
s'il est déterminé que le premier de la pluralité de signaux d'interrogation sans fil reçus comporte une interrogation d'étiquette, commuter alors le commutateur principal d'une première position connectant le dispositif de stockage intermédiaire au premier récupérateur d'énergie/convertisseur RF/C.C. à une seconde position connectant le stockage principal au premier élément d'antenne principal pendant que le premier élément d'antenne principal est dans le mode actif, puis commuter à nouveau le commutateur principal à la première position pour permettre la charge du dispositif de stockage intermédiaire à partir de l'énergie issue des signaux C.C. provenant du récupérateur d'énergie/convertisseur RF/C.C. ; et
s'il est déterminé que le premier de la pluralité de signaux d'interrogation sans fil reçus ne comporte pas d'interrogations d'étiquette, maintenir alors le circuit principal dans la première position.

6. Dispositif RFID chargé en régime d'entretien selon la revendication 5, comprenant en outre une deuxième antenne principale connectée à un deuxième récupérateur d'énergie, le deuxième récupérateur d'énergie étant connecté au dispositif de stockage intermédiaire par l'intermédiaire d'un circuit, le deuxième récupérateur d'énergie étant configuré pour obtenir une énergie depuis chacun d'une pluralité de signaux sans fil non modulés reçus au niveau du dispositif RFID.

7. Dispositif RFID chargé en régime d'entretien selon la revendication 6, comprenant en outre une troisième antenne principale connectée à un troisième récupérateur d'énergie, le troisième récupérateur d'énergie étant connecté au dispositif de stockage intermédiaire par l'intermédiaire d'un circuit, le troisième récupérateur d'énergie étant configuré pour obtenir une énergie depuis chacun d'une pluralité de signaux sans fil non modulés reçue au niveau du dispositif RFID.

8. Dispositif RFID chargé en régime d'entretien selon la revendication 1, comprenant en outre :

un second élément d'antenne principal configuré pour recevoir une pluralité de signaux de non-interrogation sans fil ; et
un deuxième récupérateur d'énergie connecté électriquement au second élément d'antenne principal et configuré pour obtenir une énergie depuis chacun de la pluralité de signaux non d'interrogation sans fil ;
dans lequel le dispositif de stockage intermédiaire est connecté électriquement au deuxième récupérateur d'énergie par l'intermédiaire d'un second circuit et configuré pour collecter une pluralité de signaux d'une énergie obtenue depuis le deuxième récupérateur d'énergie, le second circuit étant configuré pour dévier la pluralité de signaux vers le dispositif de stockage intermédiaire.

9. Procédé (210) de prolongement d'une vie utile d'un dispositif de stockage de énergie principal d'un dispositif RFID, le procédé comprenant :

la réception (212) d'un signal d'interrogation sans fil depuis un lecteur RFID ;
la détermination (214) que le signal d'interrogation sans fil comporte ou non une interrogation d'étiquette pour le dispositif RFID l'obligeant à entrer dans un mode actif en réponse au signal d'interrogation sans fil ;
s'il est déterminé que le signal d'interrogation sans fil comporte l'interrogation d'étiquette, la réalisation d'étapes comprenant :

la commutation (216) d'un commutateur principal d'une première position connectant un dispositif de stockage intermédiaire (330) à un récupérateur d'énergie/convertisseur RF/C.C. (320), à une seconde position connectant le dispositif de stockage de énergie principale pour fournir une énergie stockée à un circuit principal en vue de son utilisation durant le mode actif ;
le décodage (218) de l'interrogation d'étiquette reçue ;
la rétrodiffusion (218) de données à partir de l'interrogation d'étiquette reçue ; et
la commutation à nouveau (220) du commutateur principal à la première position comportant la déconnexion du dispositif de stockage principal du circuit principal et la connexion du dispositif de stockage intermédiaire au récupérateur d'énergie/convertisseur RF/C.C. ;

s'il est déterminé que le signal d'interrogation sans fil ne comporte pas l'interrogation d'étiquette, la réalisation d'étapes comprenant :

la conversion d'un ou de plusieurs signaux d'interrogation reçus en signaux C.C. en utilisant le récupérateur d'énergie/convertisseur RF/C.C. ;
la fourniture (224) des signaux C.C. au dispositif de stockage intermédiaire pour charger le dispositif de stockage intermédiaire en fermant un premier commutateur (670) disposé entre le récupérateur d'énergie/convertisseur RF/C.C. et le dispositif de stockage intermédiaire ;
la surveillance (226) d'un niveau de charge stockée dans un dispositif de stockage intermédiaire jusqu'à ce qu'un niveau seuil prédéterminé soit atteint pendant que le premier commutateur est fermé ; et
le transfert de la charge collectée du dispositif de stockage intermédiaire au dispositif de stockage d'énergie principal en fermant un second commutateur (671) disposé entre le dispositif de stockage intermédiaire et le dispositif de stockage d'énergie principal quand le niveau seuil prédéterminé est atteint.

10. Procédé selon la revendication 9, comprenant en outre :

la réception d'une pluralité de signaux de non-interrogation sans fil ; et
la fourniture de signaux C.C. obtenus depuis la pluralité de signaux de non-interrogation sans fil au dispositif de stockage intermédiaire pour charger le dispositif de stockage intermédiaire.

11. Procédé selon la revendication 10, dans lequel :

la pluralité de signaux de non-interrogation sans fil comporte un premier type de signaux de non-interrogation sans fil et un second type de signaux de non-interrogation sans fil ;
le dispositif de stockage intermédiaire comporte un premier type de dispositif de stockage intermédiaire, un second type de dispositif de stockage intermédiaire et un dispositif de stockage intermédiaire global ;
la réception d'une pluralité de signaux de non-

interrogation sans fil comporte la réception d'un premier type de signaux de non-interrogation sans fil et d'un second type de signaux de non-interrogation sans fil; et

la fourniture d'une pluralité de charges depuis la pluralité de signaux de non-interrogation sans fil au dispositif de stockage intermédiaire comporte la fourniture des charges depuis le premier type de signaux de non-interrogation sans fil au premier type de dispositif de stockage intermédiaire et la fourniture des charges depuis le second type de signaux de non-interrogation sans fil au second type de dispositif de stockage intermédiaire.

12. Procédé selon la revendication 11, comprenant en outre :

la surveillance d'un premier type de niveau de charge du premier type de dispositif de stockage intermédiaire ;

la surveillance d'un second type de niveau de charge du second type de dispositif de stockage intermédiaire ;

si le niveau de charge du premier type de dispositif de stockage intermédiaire atteint un premier type de niveau de décharge limite prédéterminé, la décharge de la charge stockée dans le premier type de dispositif de stockage intermédiaire dans le dispositif de stockage intermédiaire global ; et

si le niveau de charge du second type de dispositif de stockage intermédiaire atteint un second type de niveau de décharge limite prédéterminé, la décharge de la charge stockée dans le second type de dispositif de stockage intermédiaire dans le dispositif de stockage intermédiaire global.

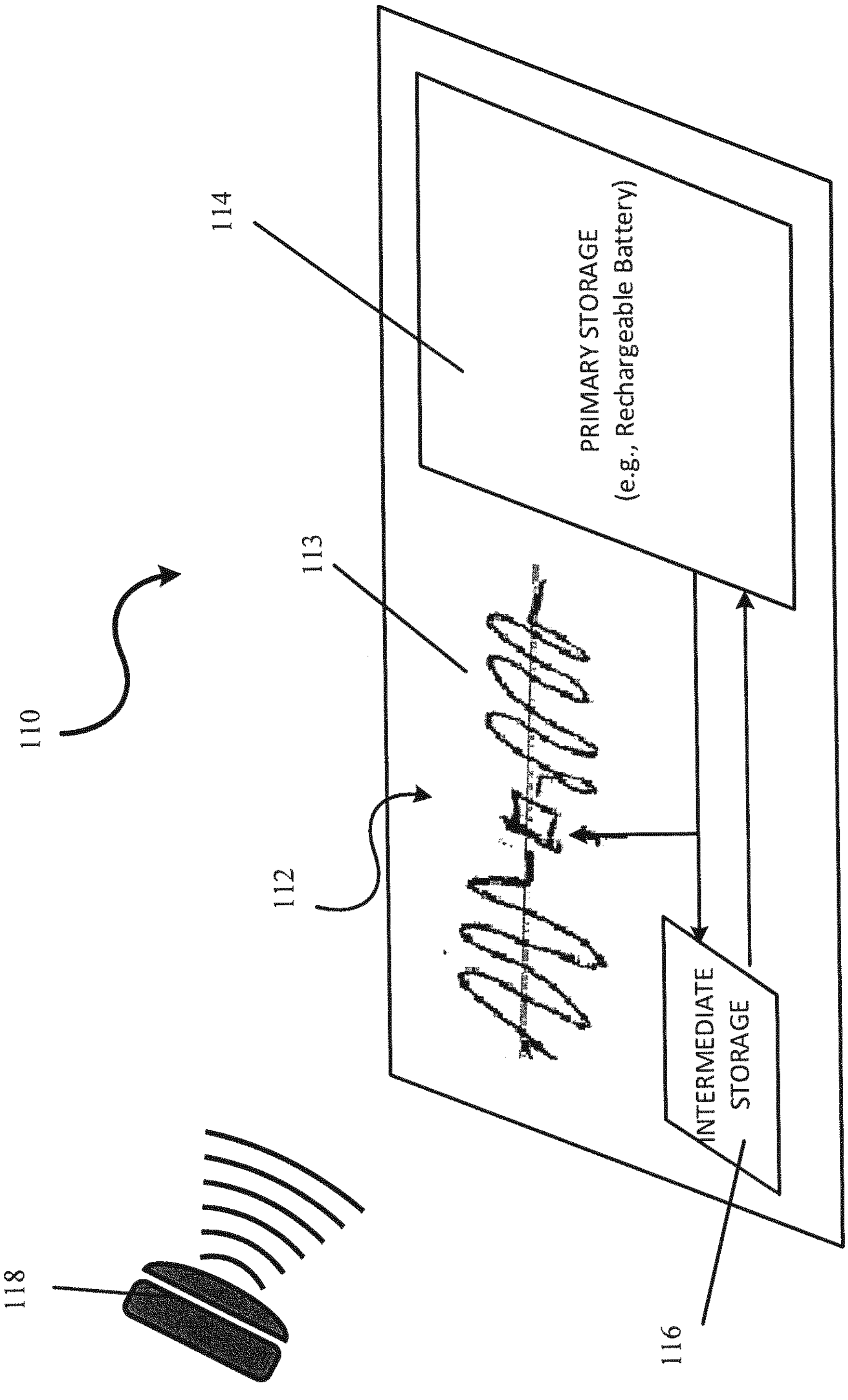
114
PRIMARY STORAGE
(e.g., Rechargeable Battery)
113
110
112
INTERMEDIATE
STORAGE
116
118

FIGURE 1

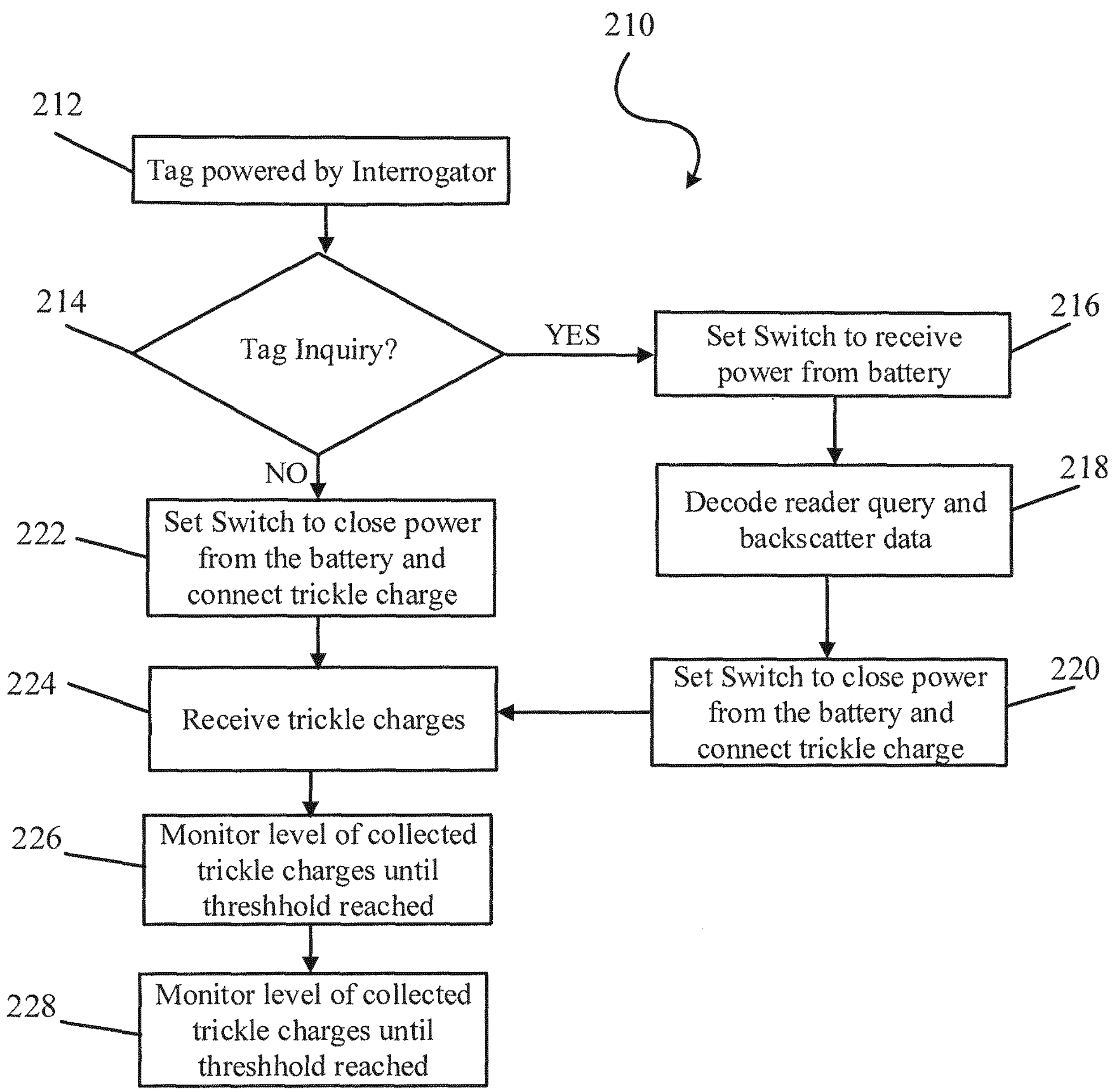
210
212
Tag powered by Interrogator
214
Tag Inquiry?
YES
NO
216
Set Switch to receive power from battery
218
Decode reader query and backscatter data
220
Set Switch to close power from the battery and connect trickle charge
222
Set Switch to close power from the battery and connect trickle charge
224
Receive trickle charges
226
Monitor level of collected trickle charges until threshhold reached
228
Monitor level of collected trickle charges until threshhold reached

FIGURE 2

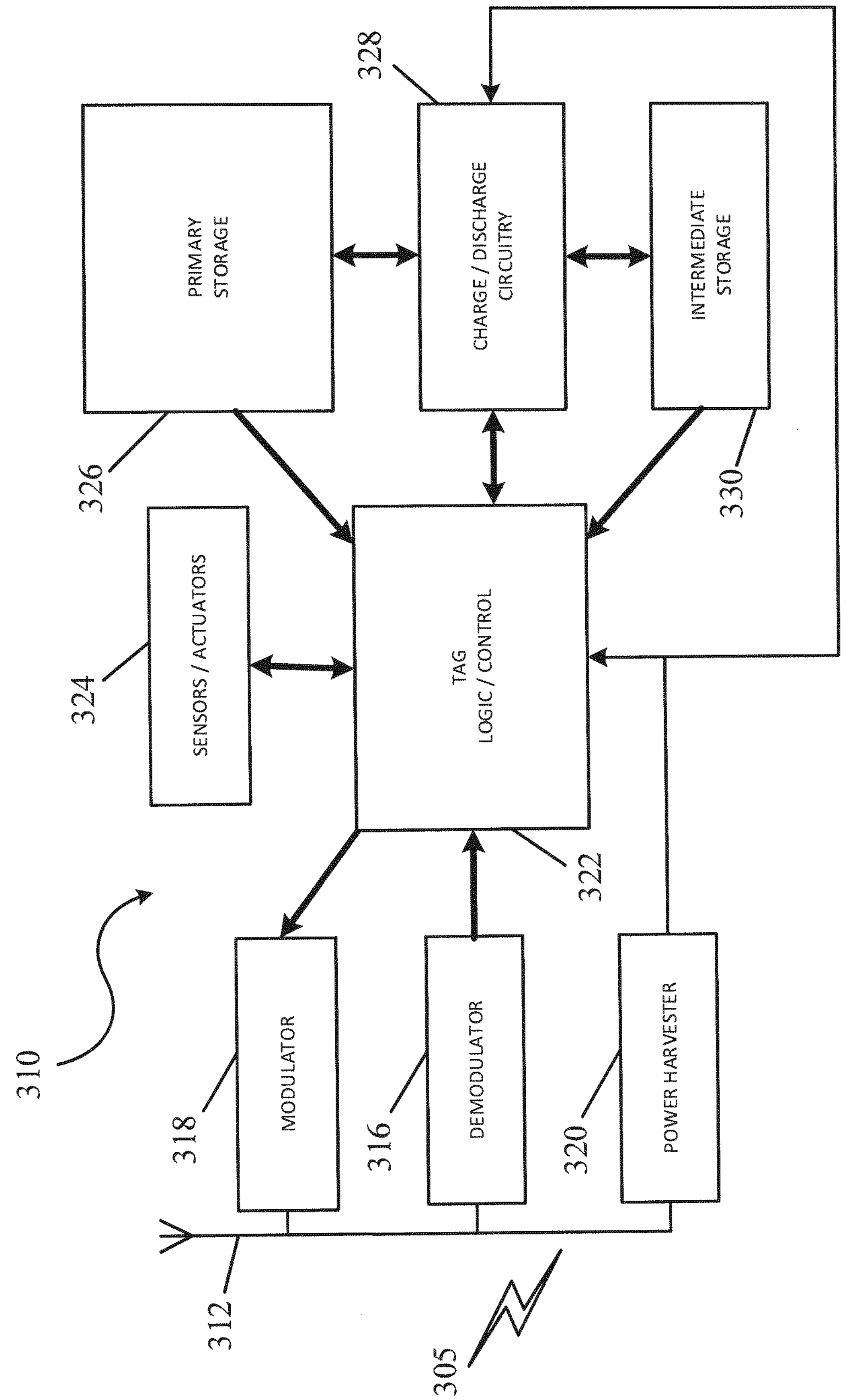
PRIMARY STORAGE
CHARGE / DISCHARGE CIRCUITRY
INTERMEDIATE STORAGE
SENSORS / ACTUATORS
TAG LOGIC / CONTROL
MODULATOR
DEMODULATOR
POWER HARVESTER
305
310
312
316
318
320
322
324
326
328
330

FIGURE 3

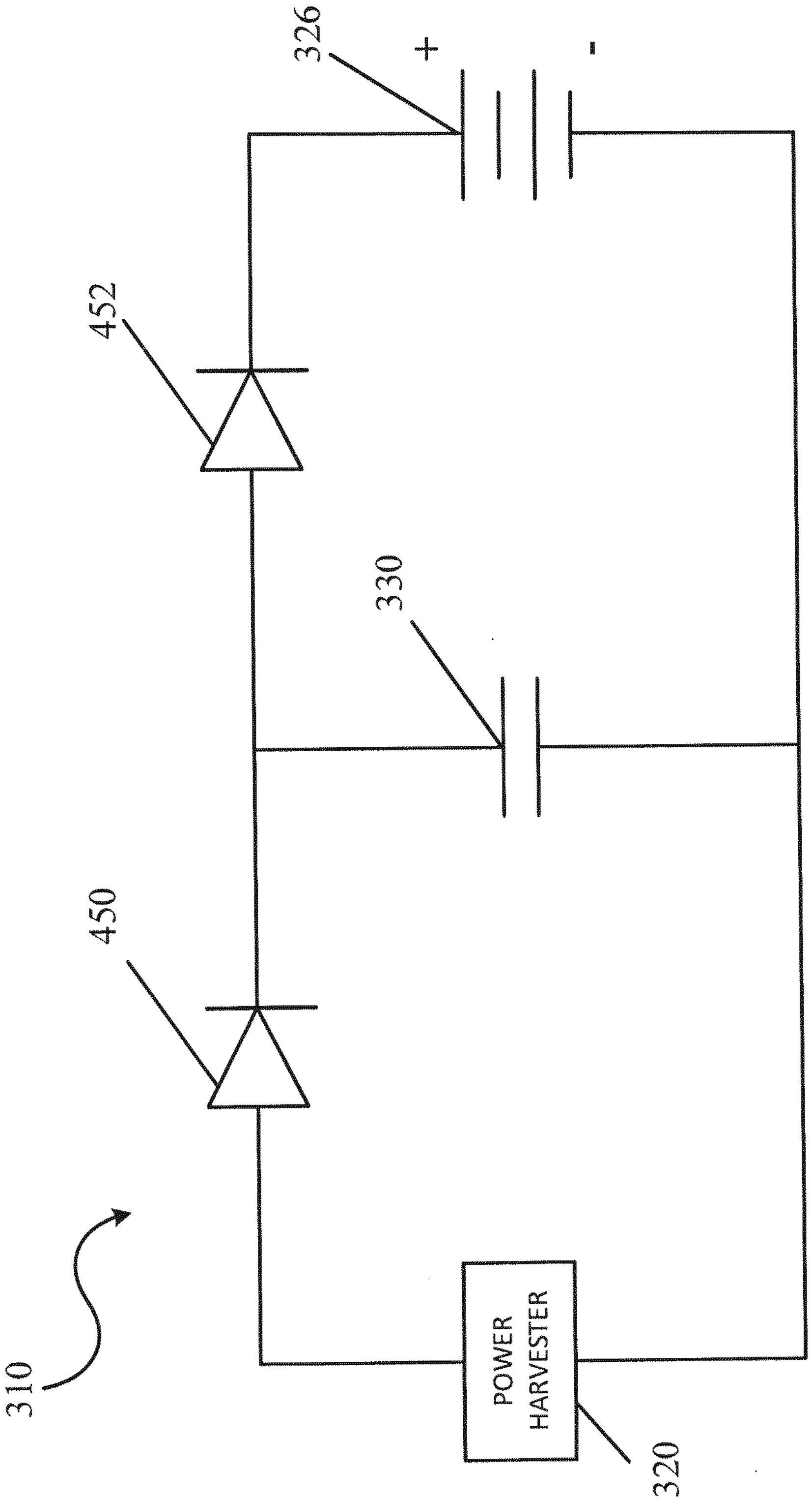

FIGURE 4

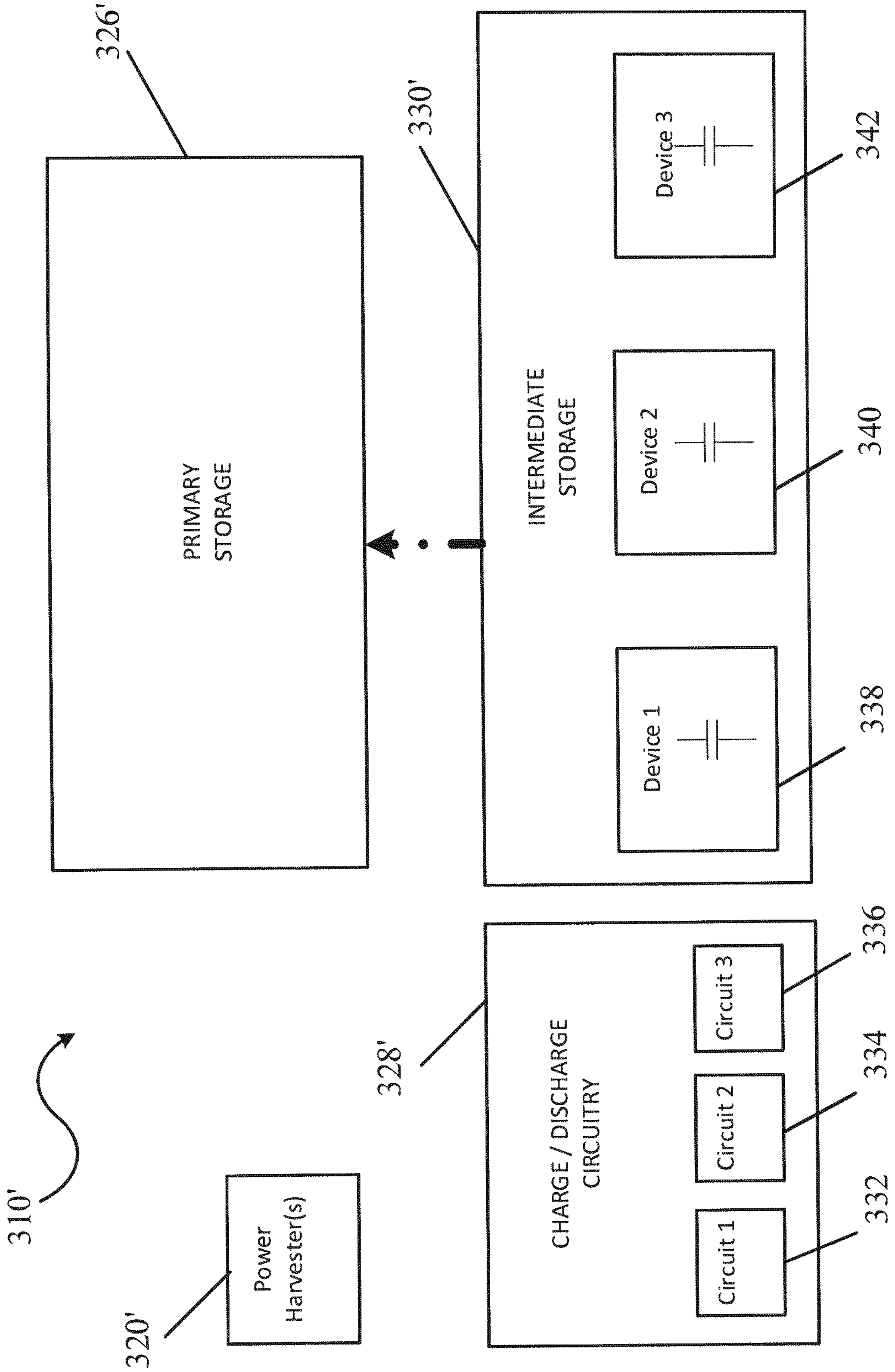
310'
320'
Power Harvester(s)
328'
CHARGE / DISCHARGE CIRCUITRY
Circuit 1
Circuit 2
Circuit 3
332
334
336
326'
PRIMARY STORAGE
330'
INTERMEDIATE STORAGE
Device 1
Device 2
Device 3
338
340
342

FIGURE 5

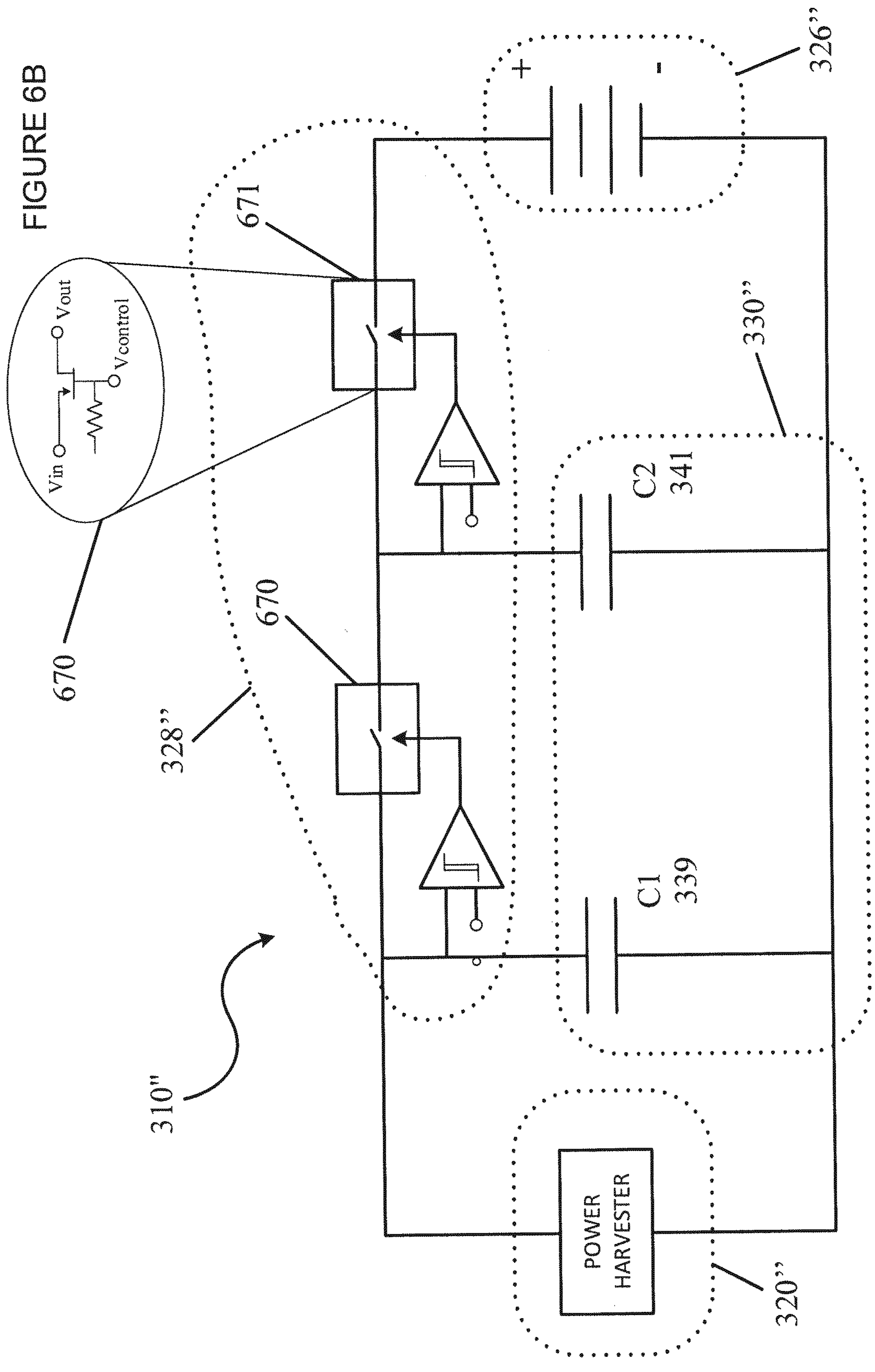

FIGURE 6B

FIGURE 6A

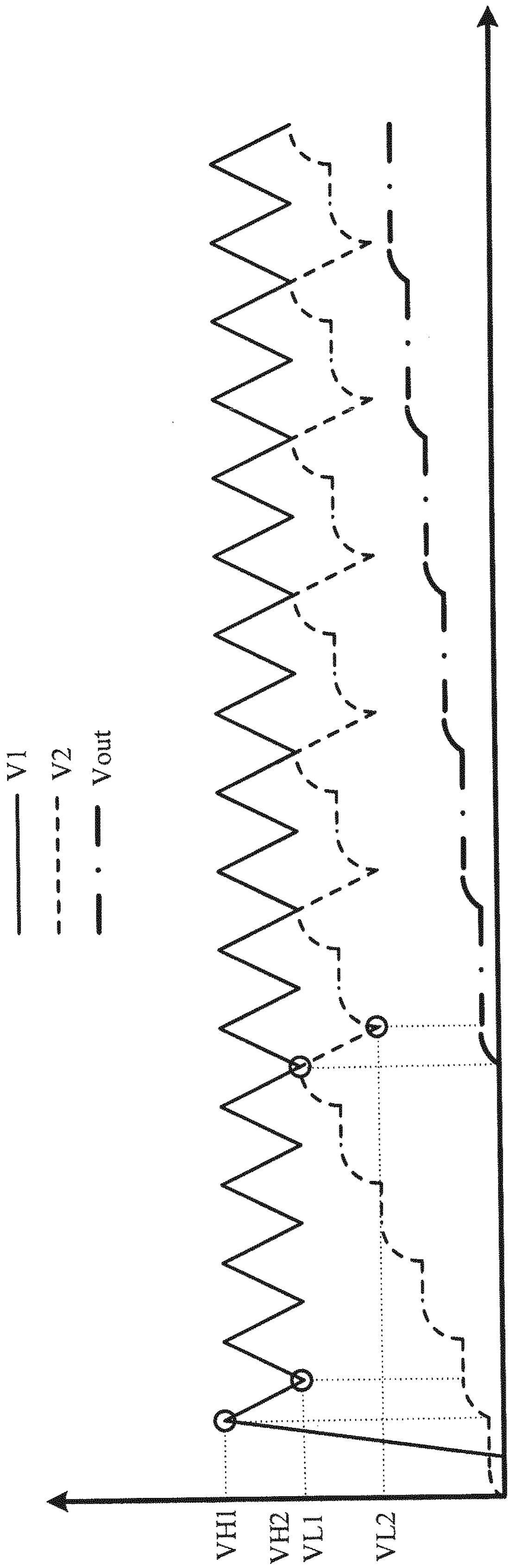

FIGURE 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 2006094425 A1 **[0005]**