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Ackley et al.

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(54) **RFID TAG BATTERY CHARGING METHOD**

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G06K 19/07	(2006.01)
H02J 7/00	(2006.01)
H04B 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H01Q 1/2225*** (2013.01); ***G06K 19/071*** (2013.01); ***G06K 19/0704*** (2013.01); ***G06K 19/0709*** (2013.01); ***H02J 7/007*** (2013.01); ***H02J 7/0068*** (2013.01); ***H04B 5/0062*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2225

USPC 320/107

See application file for complete search history.

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(57) **ABSTRACT**

A trickle-charged RFID device includes a main antenna receiving 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 to collect trickle flows of unused power harvested from wireless interrogator signals received by the RFID device that lack an inquiry for the device. The RFID device further includes a primary storage device, into which the intermediate storage device discharges its collection of trickle flows of unused power when the collection reaches a predetermined threshold level, which recharges power lost from the main storage device. The intermediate storage device can include one or more capacitors including super-capacitors, and the main storage device can include a

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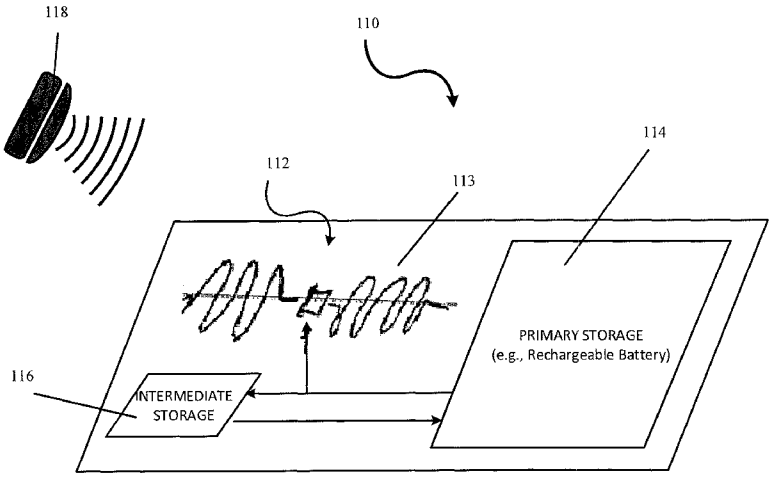

rechargeable battery, such that the effective life of the main storage device is extended from the collected trickle flows.

22 Claims, 7 Drawing Sheets

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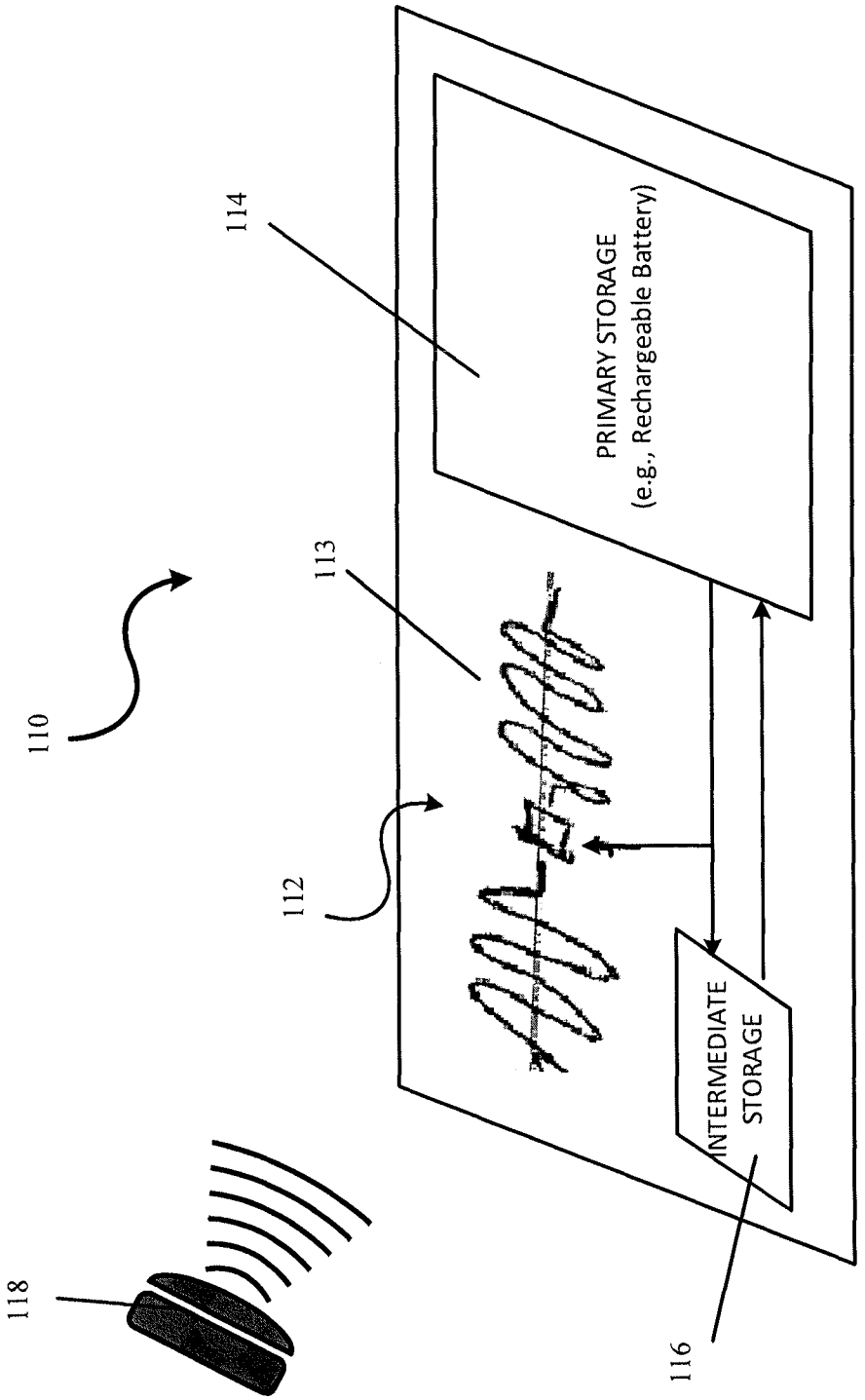
110
112
113
114
116
118
PRIMARY STORAGE
(e.g., Rechargeable Battery)
INTERMEDIATE
STORAGE

FIGURE 1

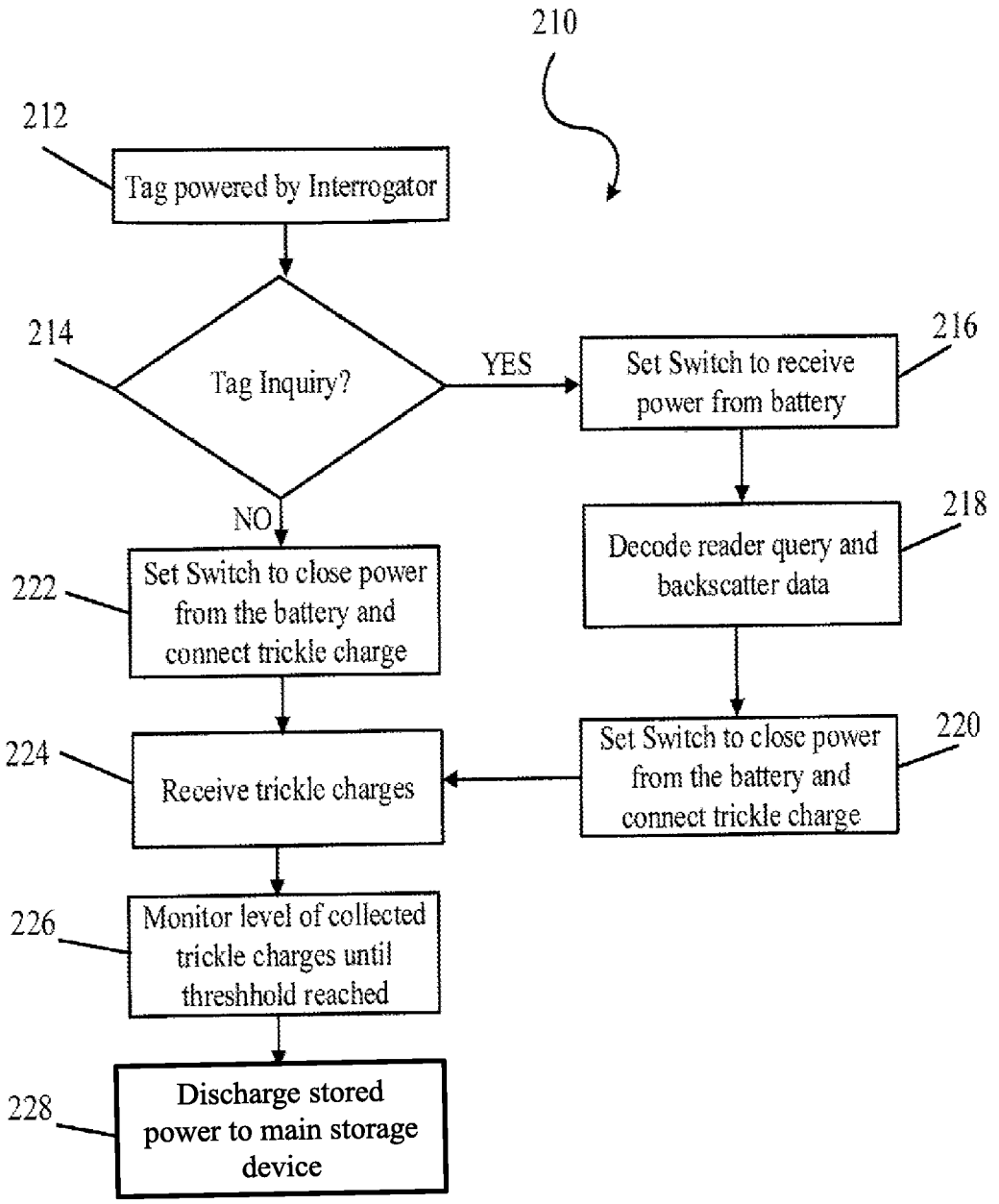
210
212
Tag powered by Interrogator
214
Tag Inquiry?
YES
NO
216
Set Switch to receive power from battery
218
Decode reader query and backscatter data
220
Set Switch to close power from the battery and connect trickle charge
222
Set Switch to close power from the battery and connect trickle charge
224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

FIGURE 2

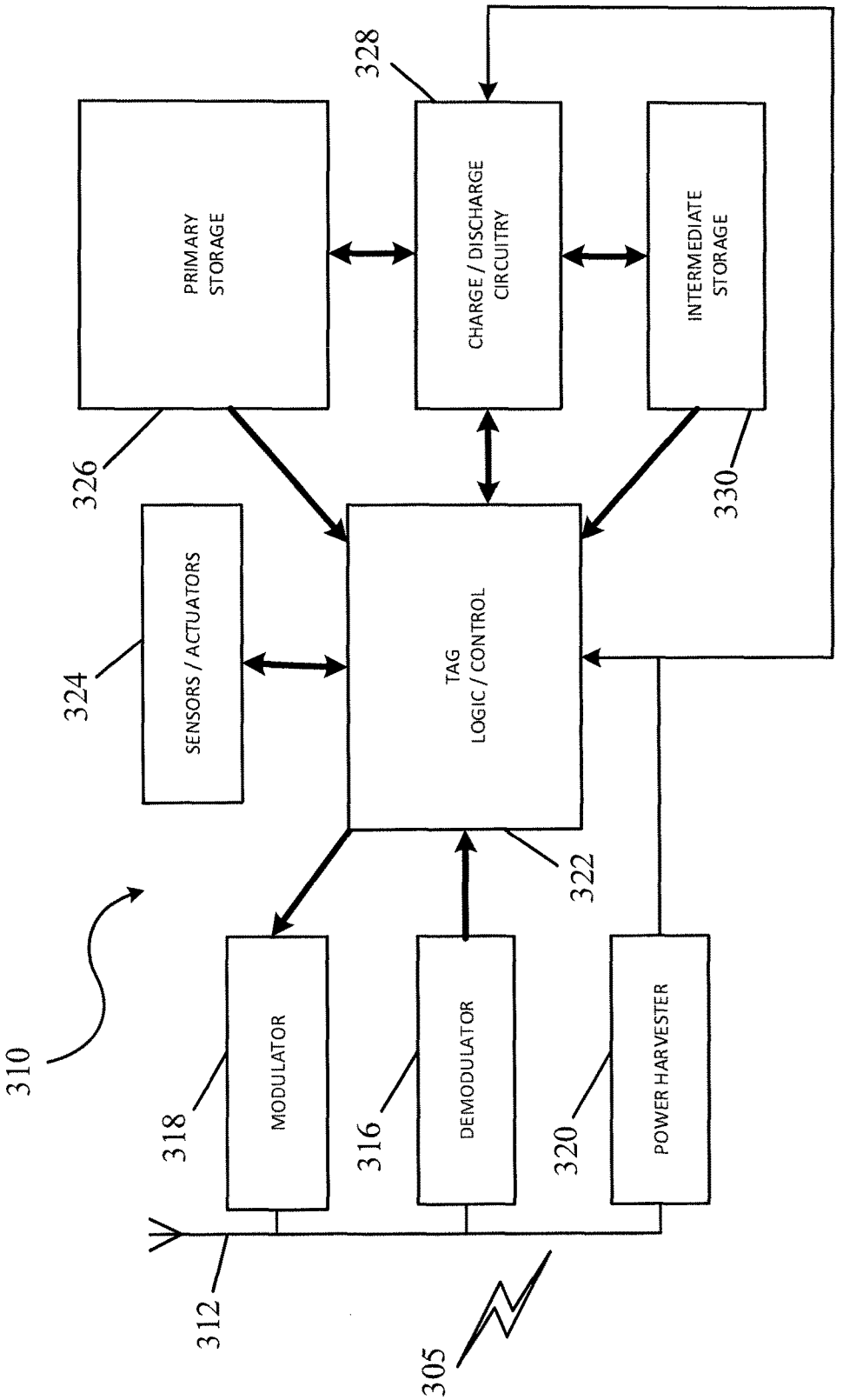
PRIMARY STORAGE
CHARGE / DISCHARGE CIRCUITRY
INTERMEDIATE STORAGE
SENSORS / ACTUATORS
TAG LOGIC / CONTROL
MODULATOR
DEMODULATOR
POWER HARVESTER
310
312
316
318
320
322
324
326
328
330
305

FIGURE 3

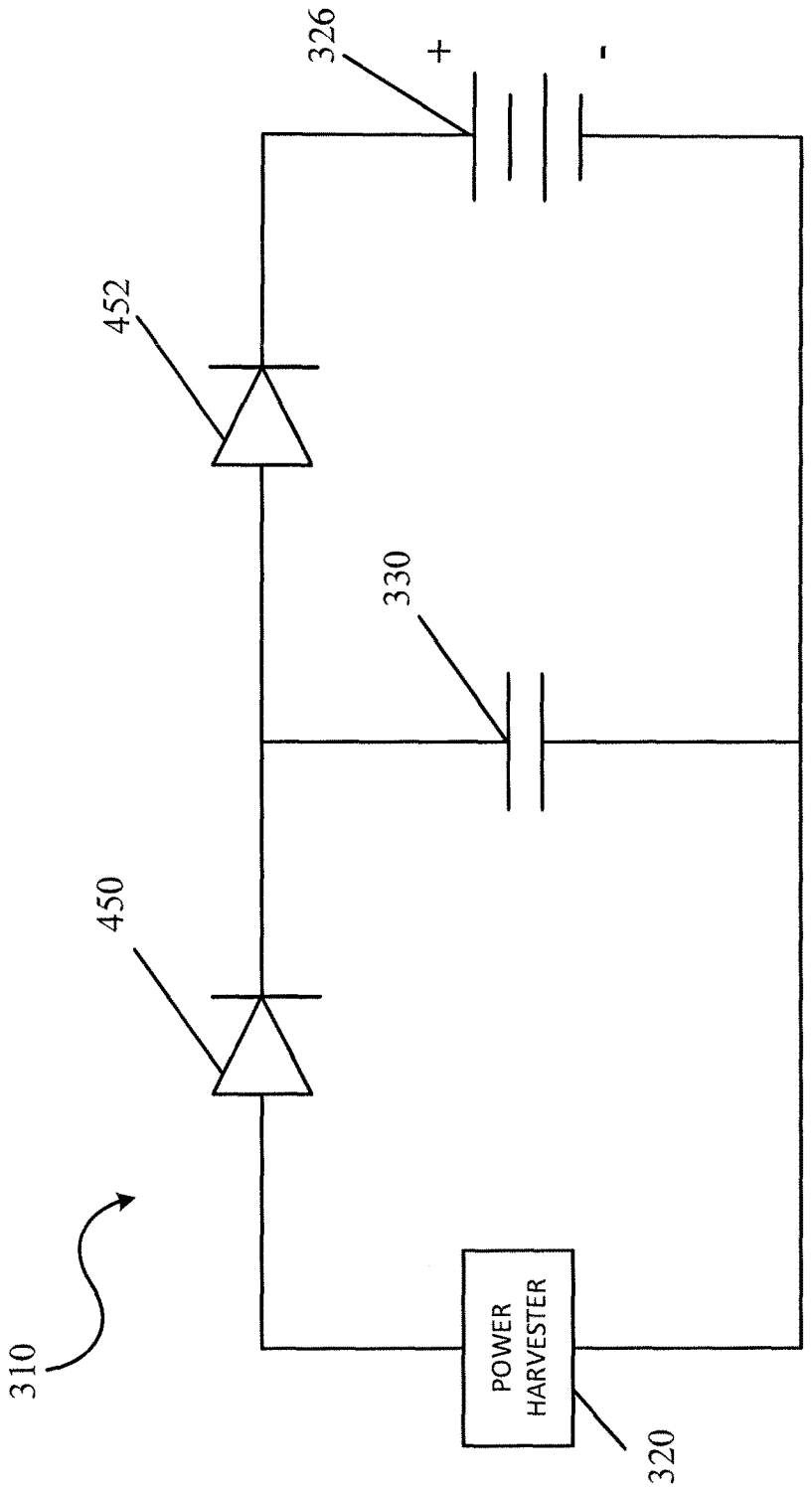

FIGURE 4

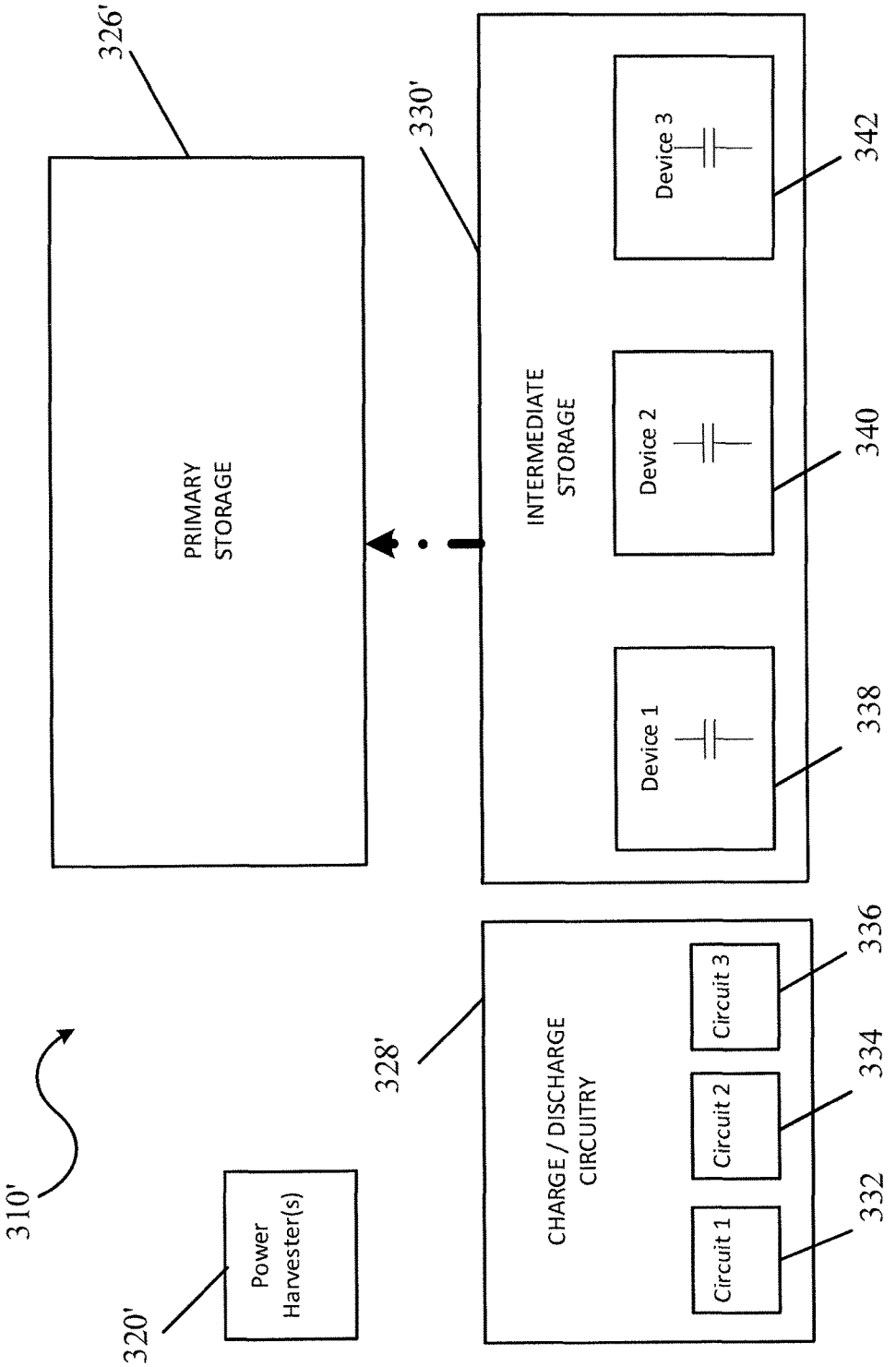
310'
320'
Power Harvester(s)
326'
PRIMARY STORAGE
328'
CHARGE / DISCHARGE CIRCUITRY
Circuit 1
Circuit 2
Circuit 3
332
334
336
330'
INTERMEDIATE STORAGE
Device 1
Device 2
Device 3
338
340
342

FIGURE 5

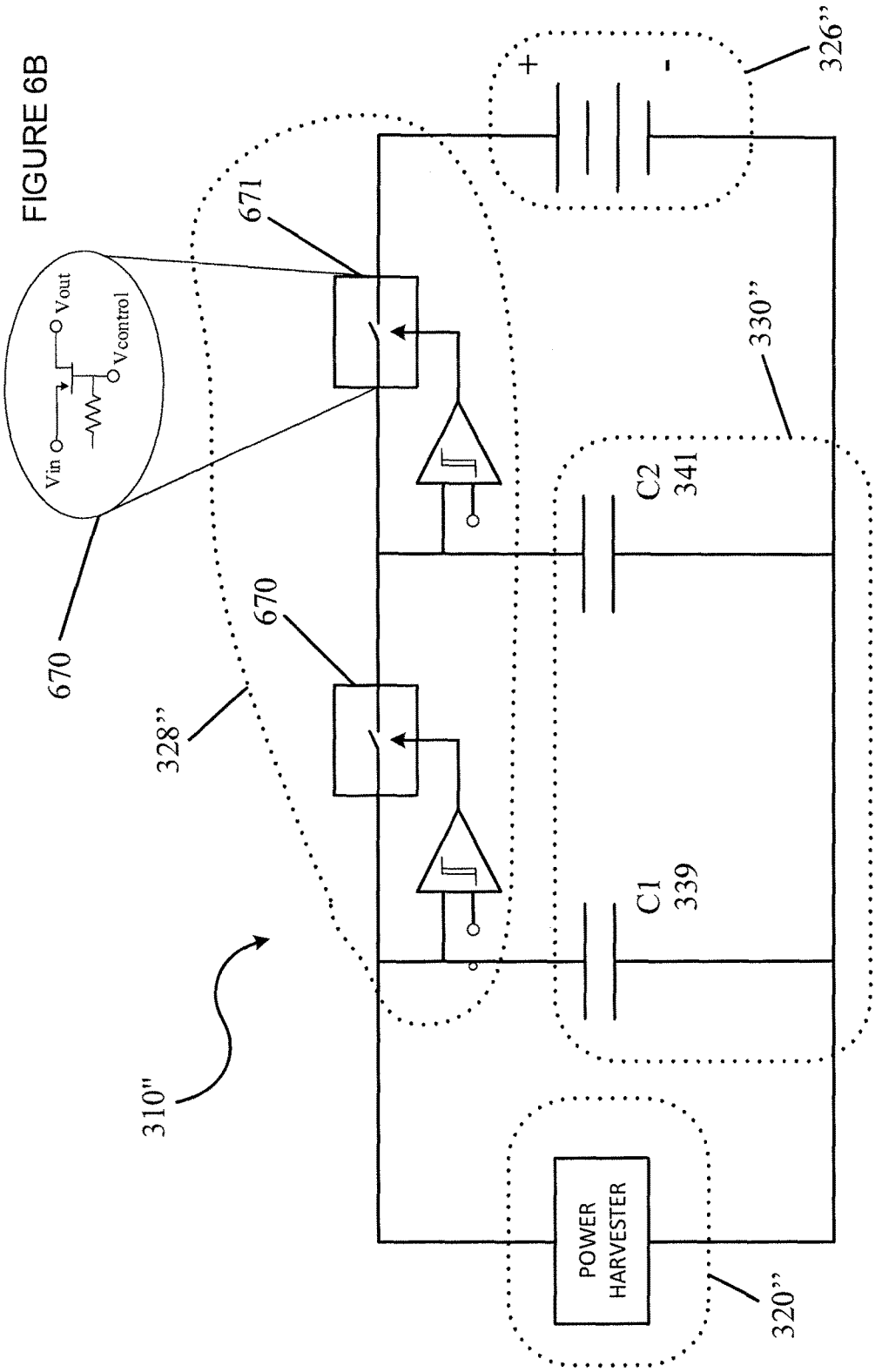
FIGURE 6B
Vin
Vout
Vcontrol
670
671
670
328''
310''
C1
339
C2
341
330''
326''
+
-
POWER
HARVESTER
320''

FIGURE 6A

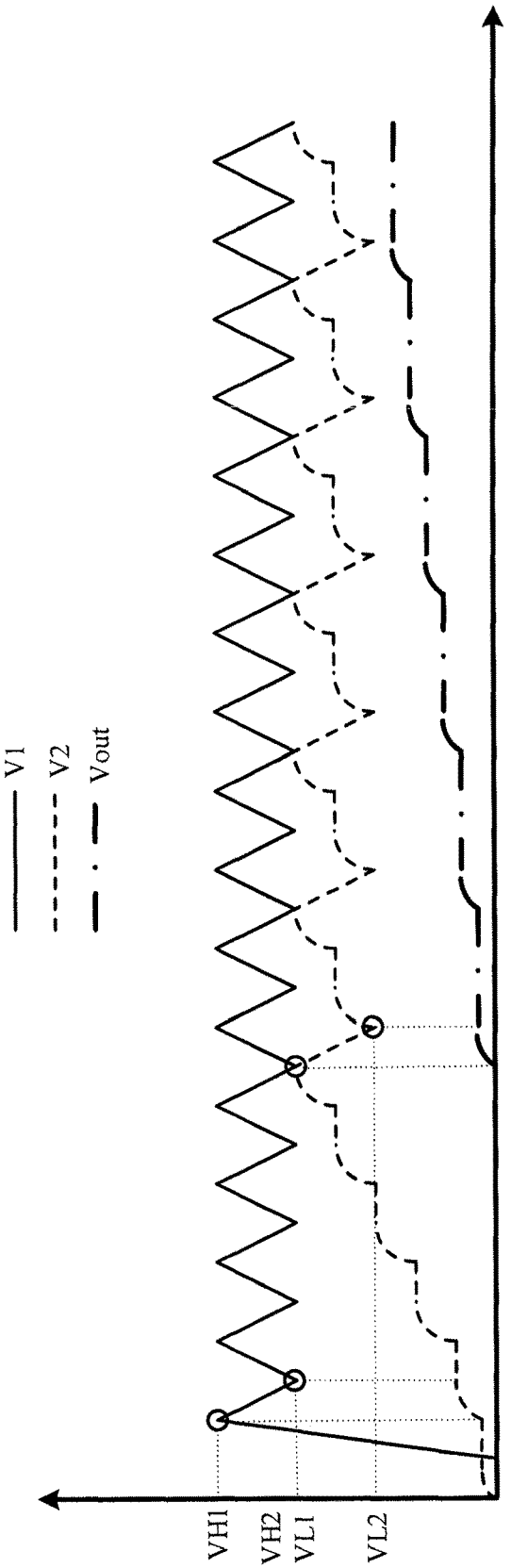

FIGURE 7

RFID TAG BATTERY CHARGING METHOD

BACKGROUND

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.

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.

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.

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

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 can include 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 can collect 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.

The active or semi-passive (battery assisted passive) RFID device can also include 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.

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 can include 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.

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

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.

FIG. **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.

FIG. **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.

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

FIG. **4** shows another arrangement of example components for another RFID device.

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

FIGS. **6**A and **6**B show yet another arrangement of example components for yet another RFID device.

FIG. **7** shows example voltage fluctuations and charge status for the RFID device of FIGS. **6**A and **6**B.

DETAILED DESCRIPTION OF THE DRAWINGS

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 FIG. **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.

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.

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.

Referring now to FIG. **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.

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.

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.

Referring now to FIG. **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.

FIG. **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. 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**.

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 FIG. **6**A.

Referring now to FIG. **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 FIGS. **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.

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'**.

FIGS. **6**A, **6**B and **7** depict components and features of another configuration RFID tag **310"**, 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. **6**A 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 C**1** and C**2**, which can be configurations of one or more super-capacitors. Capacitor C**1** 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. **6**A, Capacitor C**1** **339** and Capacitor C**2** **341** function as Intermediate Storage **330"**.

Charge/Discharge Circuit **328"** further includes one or more Voltage-controlled Switches **670** and **671** (FIG. **6**B), which permit the periodic flow of trickle charges into Intermediate Storage **330"** while preventing it from discharging into Primary Storage **326"** until a pre-determined 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.

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.

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, but also all equivalent ways of practicing or implementing the invention under the claims.

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.

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.

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.

The corresponding structures, materials, acts, and equivalents of all means 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 and spirit 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.

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.

What is claimed is:

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

a first main antenna element configured to receive a first plurality of wireless interrogator signals from one or more RFID readers;

a first power harvester electrically connected with the first main antenna element and configured to obtain power from each of the first plurality of wireless interrogator signals;

an intermediate storage device electrically connected to the first power harvester via a first circuit and configured to collect a plurality of trickle flows of obtained power from the first power harvester for the portion of the first plurality of wireless interrogator signals, the first circuit being configured to divert the plurality of trickle flows to the intermediate storage;

a primary storage device connected with the intermediate storage device via a second circuit, the second circuit configured to drain a collected store of the plurality of trickle flows from the intermediate storage when the collected store reaches a predetermined discharge level;

a control unit configured to direct the plurality of trickle flows obtained from the portion of the first plurality of wireless interrogator signals to the intermediate storage; and

a plurality of switches comprising a first switch and a second switch, wherein the control unit is further configured to close the first switch, upon receipt of the first plurality of wireless interrogator signals lacking a tag inquiry, in order to direct the obtained power to the intermediate storage device until the predetermined discharge level of the collected store has been met in the intermediate storage device, and close the second switch when the predetermined discharge level of the collected store has been reached in order to transfer the power from the intermediate storage device to the primary storage device.

2. The trickle-charged RFID device of claim **1**, wherein the primary storage device comprises a rechargeable battery and the intermediate storage device comprises one or more capacitors.

3. The trickle-charged RFID device of claim **2**, wherein the one or more capacitors comprise one or more supercapacitors.

4. The trickle-charged RFID device of claim **2**, wherein the second circuit comprises one or more diodes configured to drain automatically the collected store of the trickle flows when the predetermined discharge level is met and to provide a recharge burst formed from the collected store to the rechargeable battery.

5. The trickle-charged RFID device of claim **4**, wherein the one or more diodes are further configured to stop the draining of the collected store to the rechargeable battery when a predetermined low level for the collected store is reached.

6. 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 for providing a trickle charge to the intermediate storage and at least a second position connecting the primary storage to a passive antenna element to provide stored power to the passive antenna element while in an active mode.

7. The trickle-charged RFID device of claim **6**, wherein the control unit is further configured to perform actions comprising:

determine if the first plurality of wireless interrogator signals received includes a tag inquiry for the RFID device to enter an active mode;

if yes, then switch the main switch from a first position connecting the intermediate storage to the first power harvester to a second position connecting the main

storage to the passive antenna element while the passive antenna element is in the active mode, and then switch the main switch back to the first position to allow trickle flows of obtained power to charge the intermediate storage; and

if no, then maintain the main circuit in the first position.

8. The trickle-charged RFID device of claim **7**, further comprising a second main antenna connected to a second power harvester, the second power harvester connected to the intermediate storage via a third circuit, the second power harvester being configured to obtain power from each of a plurality of unmodulated wireless signals received at the RFID device.

9. The trickle-charged RFID device of claim **8**, further comprising a third main antenna connected to a third power harvester, the third power harvester connected to the intermediate storage via a fourth circuit, the third power harvester being configured to obtain power from each of a second plurality of modulated, interrogator wireless signals received at the RFID device.

10. The trickle-charged RFID device of claim **1**, further comprising:

a second main antenna element configured to receive a second plurality of wireless interrogator signals; and

a second power harvester electrically connected with the second main antenna element and configured to obtain power from each of the second plurality of wireless 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 second trickle flows of obtained power from the second power harvester, the second circuit being configured to divert the plurality of second trickle flows to the intermediate storage.

11. The trickle-charged RFID device of claim **1**, wherein the plurality of switches are configured to permit a periodic flow of trickle charges into the intermediate storage device while preventing the intermediate storage device from discharging into the primary storage device until the predetermined discharge level of the collected store has been met in the intermediate storage device.

12. The trickle-charged RFID device of claim **11**, wherein the first switch is disposed between the first power harvester and the intermediate storage device, and the second switch that is disposed between the intermediate storage device and the primary storage device.

13. A method for extending a useful life of a main power storage device of a RFID device, the method comprising:

receiving a wireless interrogator signal from a RFID reader;

determining 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 includes the tag inquiry, perform steps comprising:

switching a main switch from a first position connecting an intermediate storage device to a power harvester, to a second position connecting the main storage device for providing stored power out of the main storage device for use while in the active mode;

decoding the received tag inquiry;

backscattering data from the received tag inquiry; and

switching the main switch back to the first position including disconnecting the main storage device from the main circuit and connecting the intermediate storage device to the power harvester; and

providing a plurality of trickle charges obtained from a portion of a first plurality of interrogator signals received that lack a tag inquiry to the intermediate storage device to trickle charge the intermediate storage device; and

if the wireless interrogator signal lacks the tag inquiry, perform steps comprising:

obtaining power from the wireless interrogator signal;

close a first switch, upon receipt of the wireless interrogator signal lacking a tag inquiry, in order to direct the obtained power to the intermediate storage device until a predetermined discharge level of the collected store has been met in the intermediate storage device, thereby diverting a plurality of trickle flows of the obtained power to the intermediate storage;

collecting the plurality of trickle flows; and

close a second switch when the predetermined discharge level of the collected store has been reached in order to transfer the power from the intermediate storage device to the primary storage device, thereby draining the collected plurality of trickle flows from the intermediate storage to the main storage device when the collected store reaches the predetermined discharge level.

14. The method of claim **13**, further comprising:

monitoring a charge level of the intermediate storage device; and

if the charge level of the intermediate storage device reaches a predetermined threshold discharge level, discharging stored power in the intermediate storage device to the main storage device to recharge the main storage device.

15. The method of claim **14**, further comprising:

receiving a second plurality of interrogator wireless signals; and

providing a plurality of trickle charges obtained from the second plurality of interrogator wireless signals to the intermediate storage device to trickle charge the intermediate storage device.

16. The method of claim **15**, wherein:

the second plurality of interrogator wireless signals includes a first type of wireless signals and a second type of wireless signals;

the intermediate storage includes a first type intermediate storage, a second type intermediate storage and an overall intermediate storage;

receiving the second plurality of interrogator wireless signals includes receiving the first type of wireless signals and the second type of wireless signals; and

providing the plurality of trickle charges from the second plurality of interrogator wireless signals to the intermediate storage includes providing the trickle charges from the first type of wireless signals to the first type intermediate storage and providing the trickle charges from the second type of wireless signals to the second type intermediate storage.

17. The method of claim **16**, 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 power 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 power in the second type intermediate storage device to the overall intermediate storage device.

18. The method of claim **17**, further comprising:

monitoring an overall charge level of the overall intermediate storage device;

if the charge level of the overall intermediate storage device reaches an overall predetermined threshold discharge level, discharging stored power in the overall intermediate storage device to the main storage device to recharge the main storage device.

19. The method of claim **18**, wherein monitoring an overall charge level includes dynamically adjusting charge/discharge parameters.

20. A method for extending a useful life of a RFID device comprising a power harvester, a primary energy storage device and an intermediate storage device, the method comprising:

receiving a wireless interrogator signal from a RFID reader into the power harvester, a portion of the wireless interrogator signal lacking a tag inquiry for the RFID device;

connecting the power harvester to the intermediate storage device;

closing a first switch, when the wireless interrogator signal lacks a tag inquiry, in order to direct one or more trickle charges obtained from one or more interrogator signals received at the power harvester to trickle charge the intermediate storage device until a predetermined discharge level has been met in the intermediate storage device, and when the intermediate storage device reaches a predetermined charge level, close a second switch in order to transfer power of the one or more trickle charges from the intermediate storage device to the primary energy storage device.

21. The method of claim **20**, further comprising:

determining if the received 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 yes, perform steps comprising:

switching a main switch from a first position connecting the intermediate storage device to the power harvester, to a second position connecting the primary energy storage device for providing stored power out of the primary energy storage device for use while in the active mode;

decoding the received tag inquiry;

backscattering data from the received tag inquiry; and

switching the main switch back to the first position including disconnecting the primary energy storage device from the main circuit and connecting the intermediate storage device to the power harvester.

22. The method of claim **20**, further comprising:

receiving a second plurality of interrogator wireless signals; and

providing a plurality of trickle charges obtained from the second plurality of interrogator wireless signals to the intermediate storage device to trickle charge the intermediate storage device.

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