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(54) ELECTRONIC DEVICES AND SYSTEMS

(76) Inventors: **Graham Alexander Munro Murdoch**, Wollstonecraft (AU); **Stuart Colin Littlechild**, Stanmore (AU)

Correspondence Address:
Jenkens & Gilchrist, a Professional Corporation
Suite 3200
1445 Ross Avenue
Dallas, TX 75202 (US)

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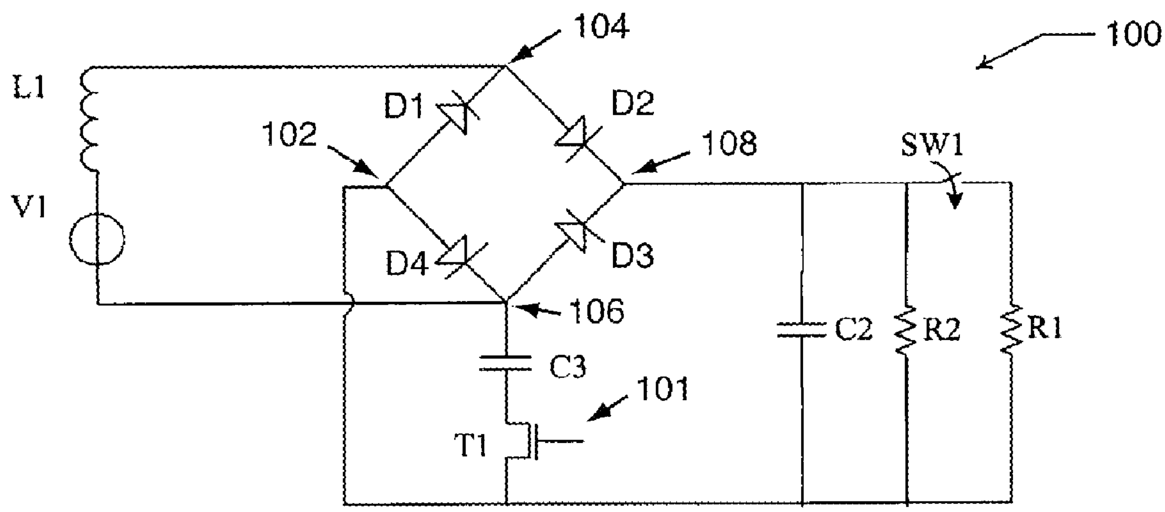
(57) **ABSTRACT**

A device having a switched impedance that can be switched between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier.



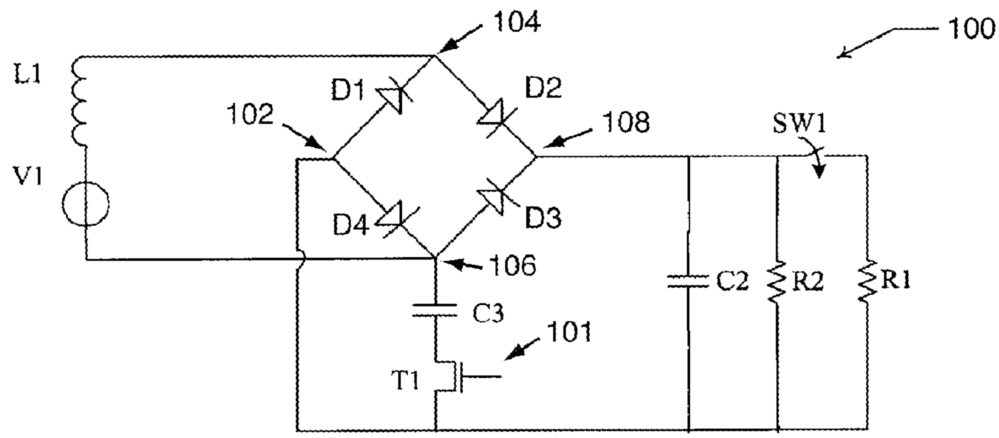


Figure 1

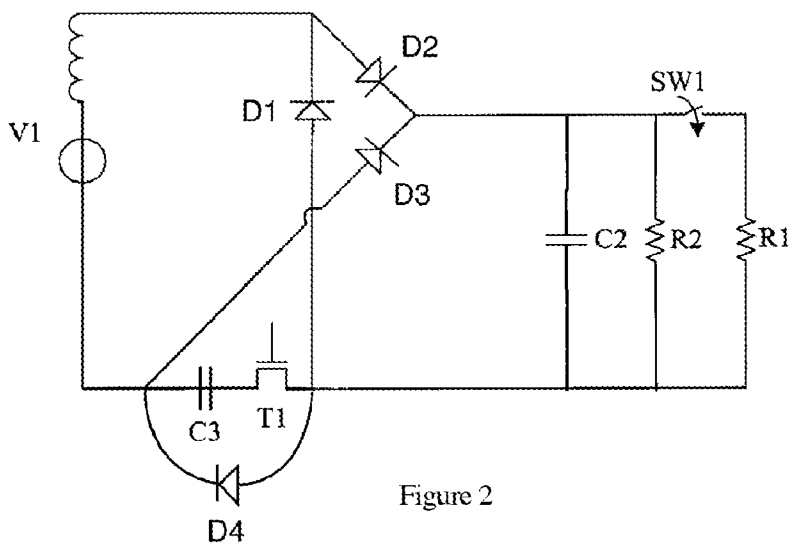


Figure 2

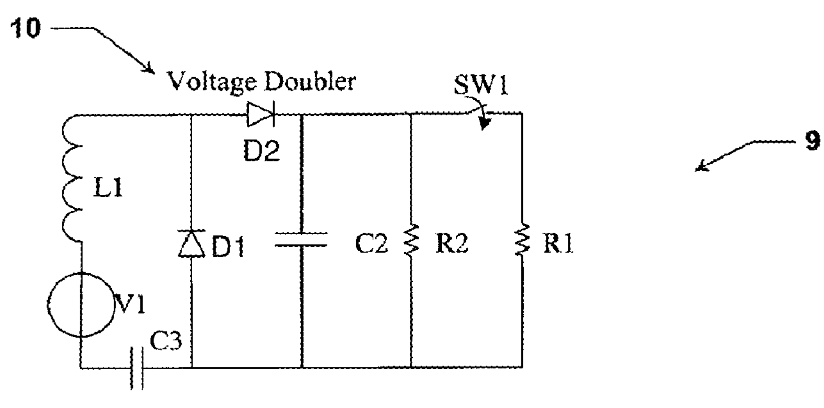


Figure 3

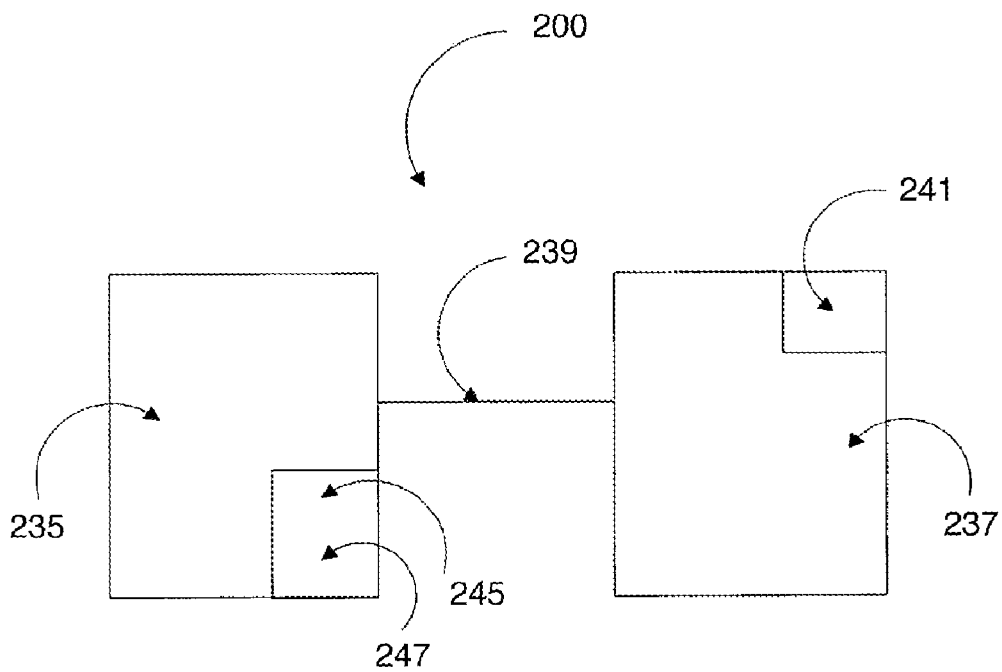


Figure 4

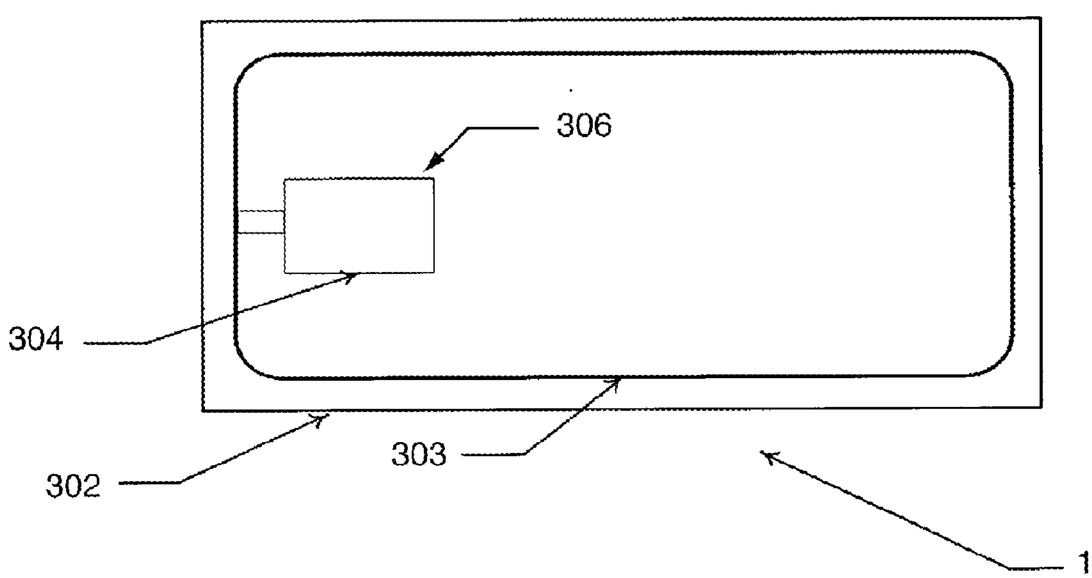


Figure 5

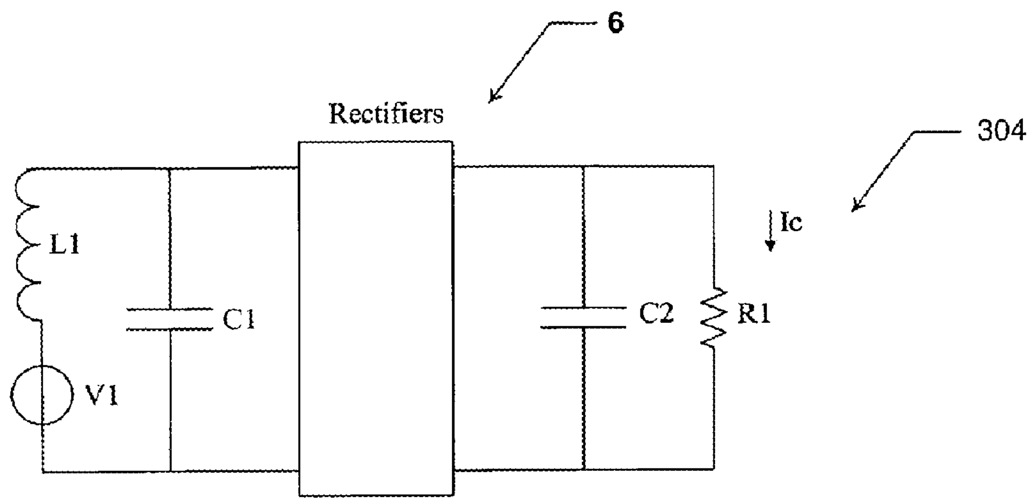


Figure 6

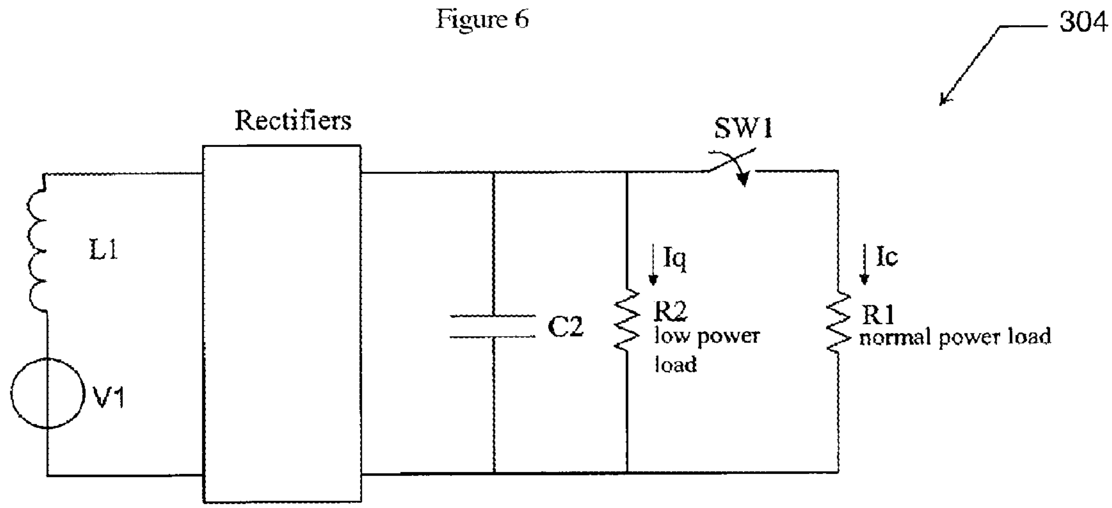


Figure 7

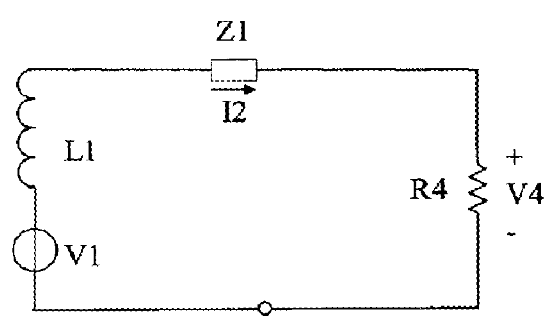


Figure 8

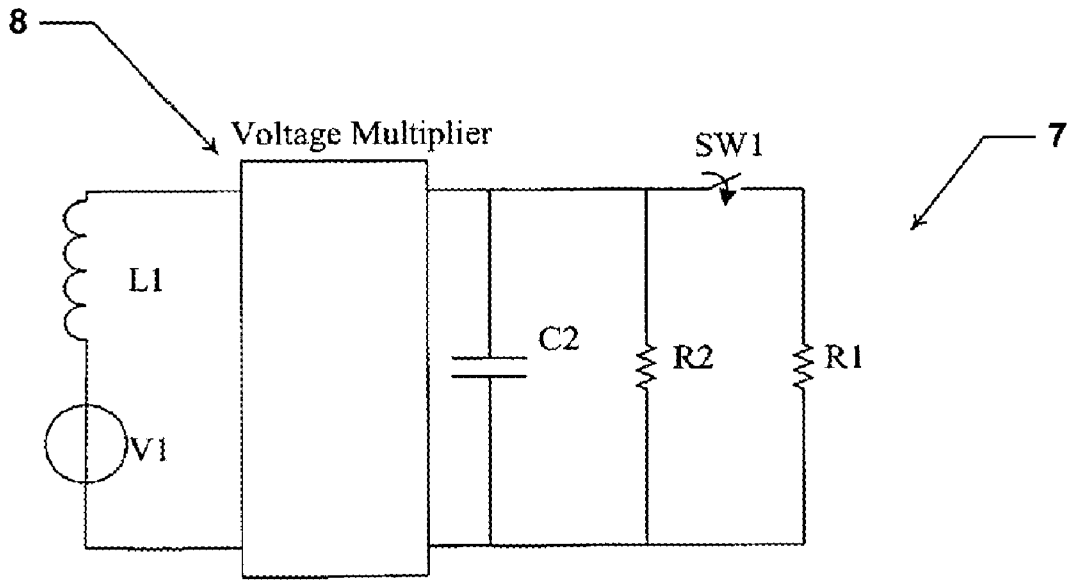


Figure 9

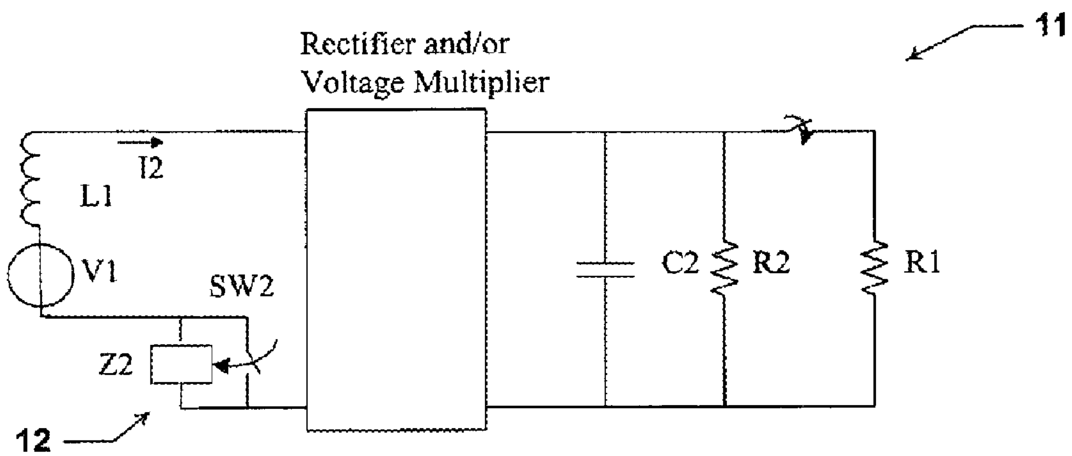


Figure 10

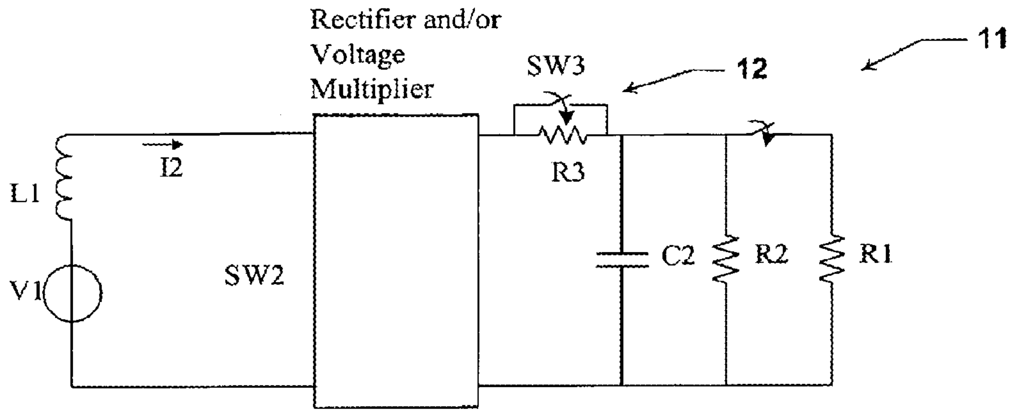


Figure 11

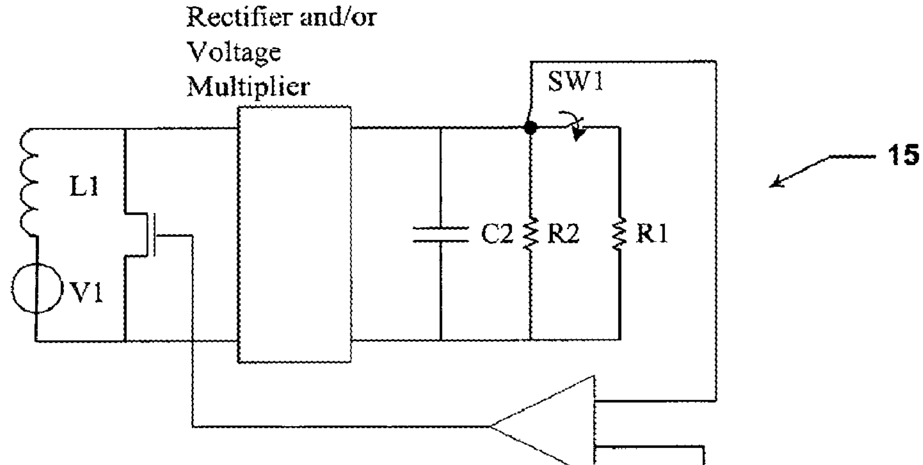


Figure 12

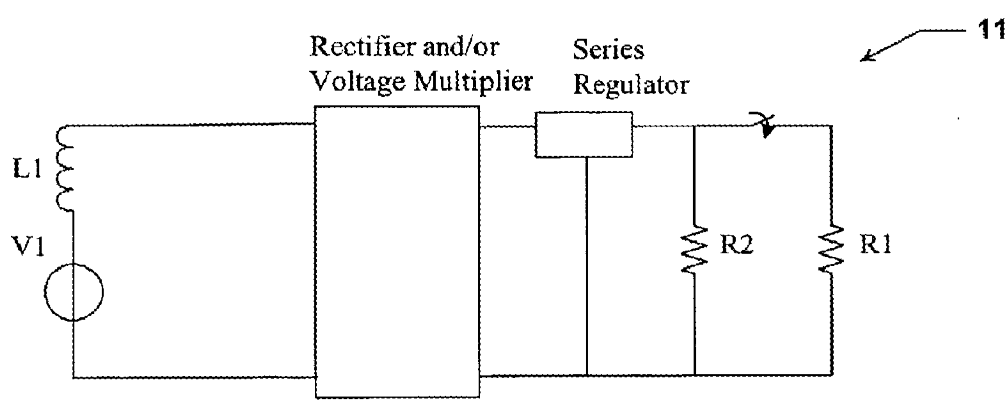


Figure 13

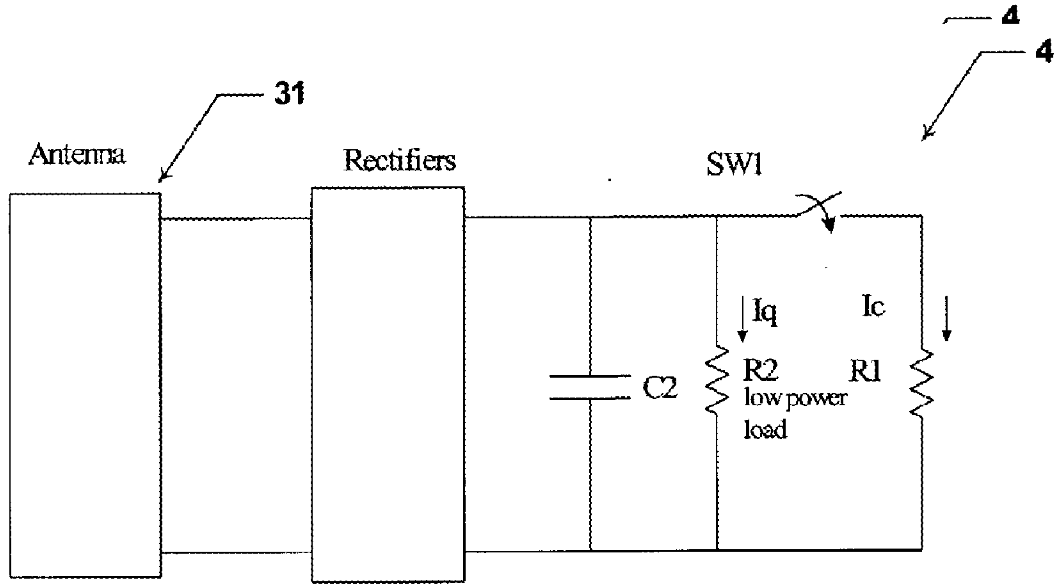


Figure 14

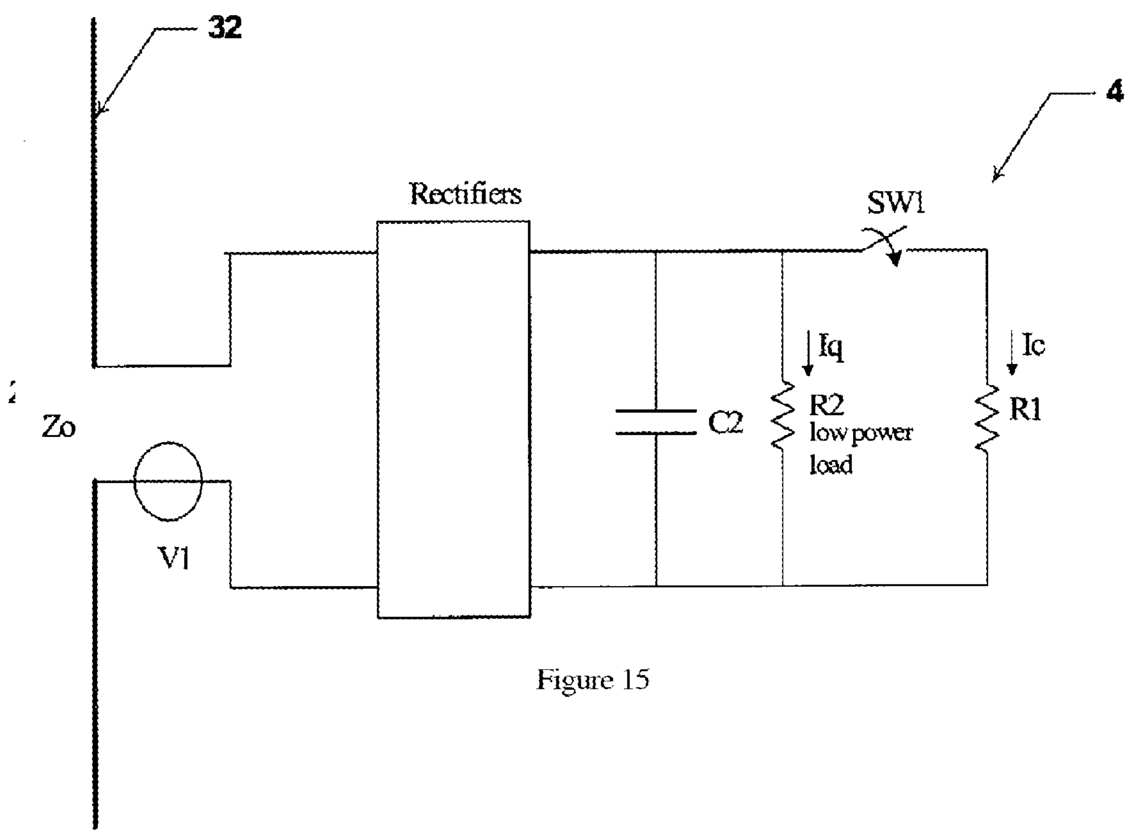


Figure 15

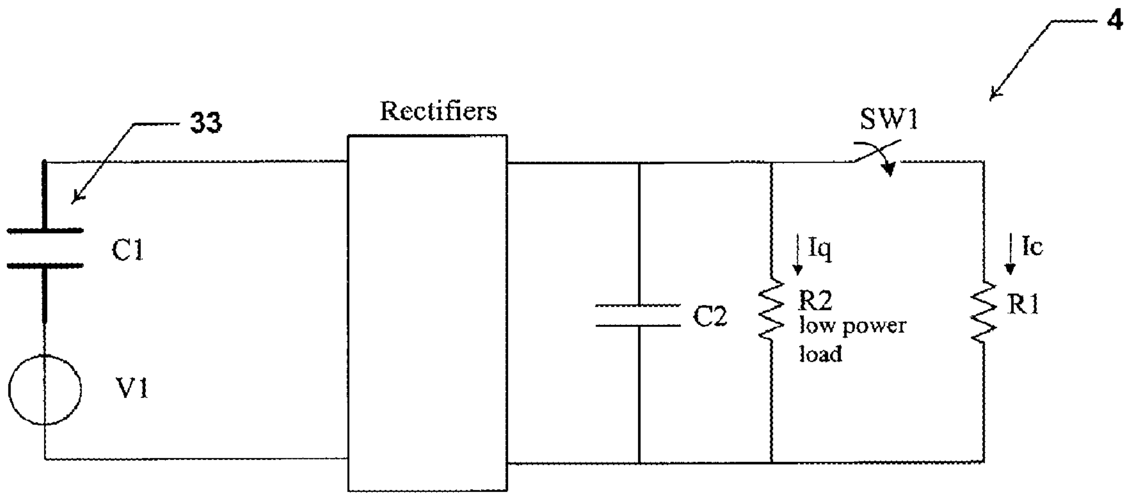


Figure 16

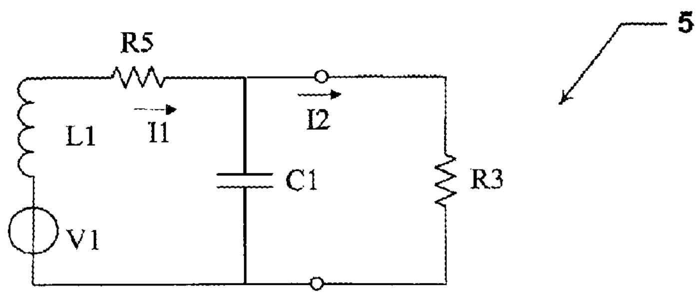


Figure 17

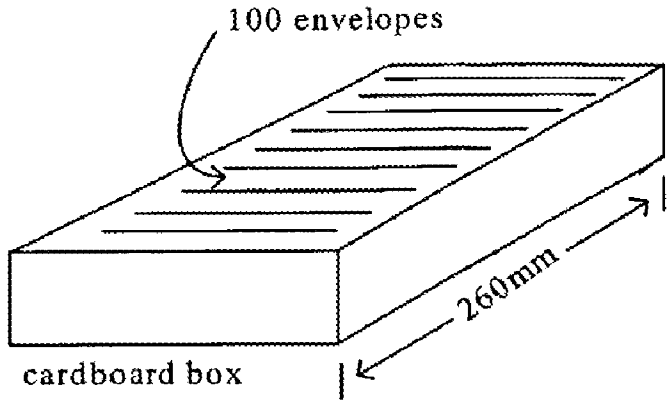


Figure 18

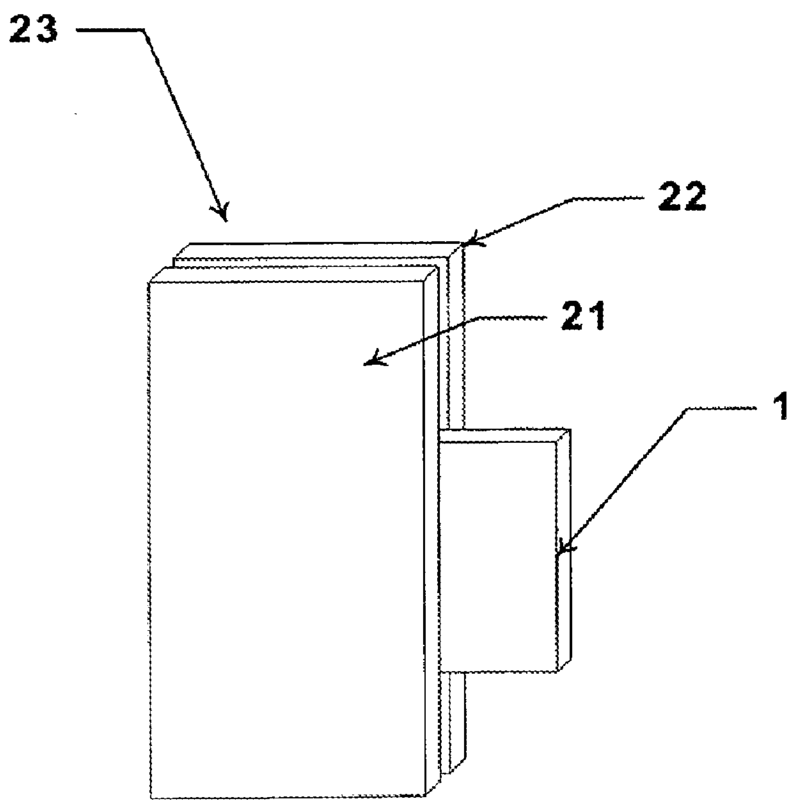


Figure 19

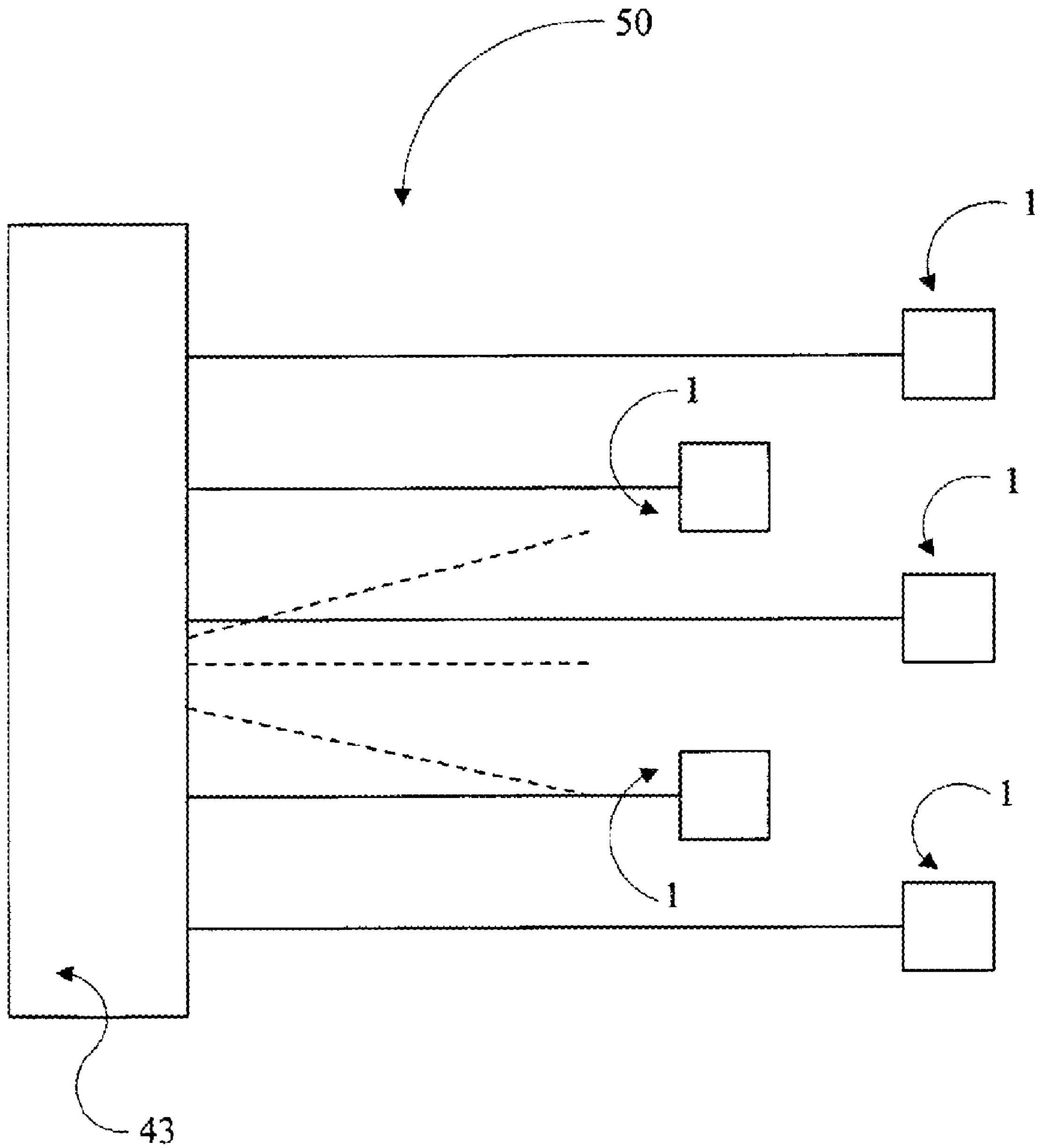


Figure 20

ELECTRONIC DEVICES AND SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application is a continuation of, and incorporates by reference the entire disclosure of, U.S. patent application Ser. No. 10/525,408, which has been accorded a filing date of Apr. 17, 2006. U.S. patent application Ser. No. 10/525,408 is a national-stage filing of PCT/AU2003/001072, filed Aug. 23, 2003.

FIELD OF INVENTION

[0002] In arrangements the invention has been developed primarily as a radio frequency identification ("RFID") tag for a parcel, document or postal handling system and will be described hereinafter with reference to these applications. However, the invention is not limited to those particular fields of use and is also suitable to inventory management, stock control systems, and other applications.

[0003] The present invention provides novel and inventive electronic devices.

BACKGROUND ART

[0004] Passive RFID tags are known, and generally include a resonant tuned antenna coil electrically connected to an integrated circuit (IC). Examples of such RFID tags include: U.S. Pat. No. 5,517,194 (Carroll et al); U.S. Pat. No. 4,546,241 (Walton); U.S. Pat. No. 5,550,536 (Flaxel); and U.S. Pat. No. 5,153,583 (Murdoch).

[0005] Systems that employ RFID typically include an interrogator that generates a magnetic field at the resonant frequency of the tuned antenna coil. When the coil is located within the magnetic field, the two couple and a voltage is generated in the coil. The voltage in the coil is magnified by the coil's Q factor and provides electrical power to the IC. With this power, the IC is thereby able to generate a coded identification signal that is ultimately transmitted to the interrogator.

[0006] Limitations arise because the resonant current that flows in the tuned antenna coil also generates a magnetic field in the region of the coil. That is, if there is an object—such as a second tag with a second coil—disposed near the first coil, the voltage generated by the first coil (and the second coil as well) will be reduced by the partial cancellation—or even complete cancellation—of these respective fields. In turn, this consequential reduction in power will not allow the first tag (and likely the second tag as well) to reliably provide an identification signal to the interrogator.

[0007] In this light, many fields that employ such tags—such as baggage handling services, letter carrying services, inventory management systems, etc.—cannot be processed in "dense" configurations. In other words, such articles must be sufficiently spread apart for the tags—and systems incorporating such tags—to operate reliably. Such "density" limitations thus tend to result in speed and efficiency restrictions.

[0008] In order to address these problems several inventive arrangements have been developed. As mentioned above and whilst these arrangements have been developed with particular regard to radio frequency identification systems that clearly also have advantageous application in a number of other applications.

[0009] The discussion of the prior art within this specification is to assist the addressee understand the invention and is not an admission of the extent of the common general knowledge in the field of the invention.

SUMMARY OF INVENTION

[0010] According to a first aspect of the invention there is provided a device having a switched impedance that can be switched between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier.

[0011] Preferably in the first state the device acts as a voltage doubler and in the second state the device acts as a full wave bridge rectifier. Furthermore the switched impedance preferably comprises a switch in series with a capacitor.

[0012] In preferred embodiment, the full wave bridge rectifier comprises a Wheatstone bridge diode arrangement having a first and a second input and a first and a second output, with the switched impedance being connected between a first input terminal and a first output terminal of the diode arrangement. As such the switched impedance may be connected between a first input terminal and a first output terminal of the rectifier.

[0013] In the ideal the voltage doubler has a voltage gain of two, and transforms the load impedance by a factor of 8. In contrast, the full wave rectifier, in the ideal, has a voltage gain of one, and transforms the load impedance by a factor of 2. Thus, in arrangements, when embodied in the form of a RFID device with an antenna coil, the voltage doubler circuit is arranged to draw a significantly larger current from the antenna coil, and acts as the normal current state rectifier whilst, in contrast, when the full wave rectifier is switched "on" during a low current state significantly less current is drawn.

[0014] Other aspects and preferred aspects are disclosed in the specification and/or defined in the appended claims, forming a part of the description of the invention.

[0015] For example according to a second aspect of the invention there is provided a method of selectively controlling current, the method comprising providing a device operable in one of a first state or a second state, coupling an impedance to the device to enable the switching of the device between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier. The method may include using a receiving means to receive a signal, and selectively controlling the amount of current in the receiving means by switching between the first state and the second state. Further preferred features of the invention will become apparent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0017] **FIG. 1** is a symbolic circuit diagram of a preferred embodiment of the invention;

[0018] **FIG. 2** is a symbolic circuit diagram of the embodiment shown in **FIG. 1**;

[0019] **FIG. 3** is a symbolic circuit diagram of a voltage doubler circuit associated with the embodiment of the invention shown in **FIGS. 1 and 2**;

[0020] **FIG. 4** is a schematic representation of a device according to another preferred embodiment of a related invention;

[0021] **FIG. 5** is a plan view of the embodiment of **FIG. 4**;

[0022] **FIG. 6** is a symbolic circuit diagram in one form illustrating a typical prior art tag;

[0023] **FIG. 7** is a symbolic circuit diagram of an RFID device according to the embodiment shown in **FIG. 4**;

[0024] **FIG. 8** is a circuit model for the device of **FIG. 7**;

[0025] **FIG. 9** is a symbolic circuit diagram of another embodiment of the invention that includes a voltage multiplier;

[0026] **FIG. 10** is a symbolic circuit diagram of a further alternative embodiment of the invention that includes a circuit for changing the current collection efficiency of the antenna;

[0027] **FIG. 11** is a symbolic circuit diagram of a further embodiment of the invention where the circuit for changing the current collection efficiency is on the DC side;

[0028] **FIG. 12** is a symbolic circuit diagram of another embodiment of the invention that includes a circuit for changing the operating voltage;

[0029] **FIG. 13** is a symbolic circuit diagram of a further embodiment of the invention that includes a series voltage regulator circuit;

[0030] **FIG. 14** is an alternative symbolic embodiment of that of **FIG. 7**, where the antenna coil is substituted with a generic interrogation signal-receiving device;

[0031] **FIG. 15** is an alternative symbolic embodiment of that of **FIG. 7**; where the antenna coil is substituted with a dipole antenna;

[0032] **FIG. 16** is an alternative symbolic embodiment of that of **FIG. 7**; where the antenna coil is substituted with a capacitive antenna;

[0033] **FIG. 17** is a circuit model for the prior art circuit of **FIG. 6**;

[0034] **FIG. 18** is a perspective view of a plurality of stacked envelopes, each of which contains a device according to **FIG. 7**;

[0035] **FIG. 19** is a perspective cut-away view of a parcel according to another embodiment; and

[0036] **FIG. 20** is a schematic representation of a system according to a further embodiment.

DETAILED DESCRIPTION

FIGS. **1** to **3**

[0037] It is to be noted at the outset that FIGS. **1** to **3** are "symbolic" or models of a preferred embodiment of the invention.

[0038] Referring to **FIG. 1** there is provided a device **100** having a switched impedance **101** that can be switched between a first state and a second state wherein, in the first state, the device **100** acts as a voltage multiplier and, in the second state, the device **100** acts as a rectifier. In this particular embodiment the voltage multiplier, in the first state of operation, is a voltage doubler and the rectifier, in the second state of operation, is a full wave bridge rectifier.

[0039] In the device **100** there is provided a switched impedance **101** comprising a switch T**1** in series with a capacitor C**3**. The switch T**1** is able to be moved between on and off states so as to switch the device **100** between the first and second states. In the first state the switch T**1** is closed while in the second state the switch T**1** is open.

[0040] With T**1** open no current can flow through capacitor C**3** causing the device **100** to act as a full wave bridge rectifier. The full wave bridge rectifier includes four diodes D**1** to D**4** arranged in a Wheatstone bridge formation. In the formation as shown in **FIG. 1** the tails of D**1** and D**4** extend from a first output terminal **102** of the bridge to respective first and second input terminals **104**, **106**, from which the tails of D**1** and D**4** respectively extend to a second output terminal **108** of the bridge. This formation is known as a Wheatstone bridge.

[0041] With T**1** closed the operation of the device **100** is best understood by recasting **FIG. 1** into the form shown in **FIG. 2**. Taking the effort to recast **FIG. 1** and with subsequent circuit analysis, with switch T**1** closed, there is provided a voltage doubler in which the diodes D**3** and D**4**, effectively, can be thought of being reversed biased so as to conduct no current. Removing D**3** and D**4** from **FIG. 2** consequently results in a voltage doubler arrangement. Moreover, as is know, a voltage doubler of this type, in the ideal, transforms the load impedance by a factor of 8. With switch T**1** open, the full wave bridge rectifier will transform the load impedance by a factor only 2. The advantageous nature of this construction for RFID devices is discussed below.

[0042] The importance of another feature of the device **100** is that with the switched impedance **101** being connected between the input terminal **106** and the output terminal **102** of the bridge, there is provided for the effective reuse of diodes D**1** and D**2** in the second state of operation as a voltage doubler.

FIG. 4

[0043] It will now become apparent that the device **100** includes both a voltage doubler circuit and a full wave rectifier circuit, and finds particular application in RFID devices.

[0044] In the arrangement schematically represented in **FIG. 4** the present invention is embodied as a radio frequency identification device **200**. The device **200** comprises a receiver portion **235**; an integrated circuit **237** with one or more functionalities; a connection **239** between the two; and a state selection means **241** that determines whether the device is in a first state or a second state; and a transmission means **245**—preferably in the form of an antenna **247**. These components are reflected symbolically in the following Figures.

FIG. 5

[**0045**] A radio frequency identification ("RFID") device or tag **1**, is symbolically illustrated in **FIG. 5**. The tag **1** includes a multi-turn coil **303** for receiving an interrogation signal. A transceiver, in the form of an integrated circuit (IC) **304**, is connected to the coil **303** and is responsive to the interrogation signal. In other embodiments, other devices are used as the transceiver; such devices will be readily apparent to those skilled in the art. In this embodiment, coil **303** and the circuit **304** are mounted on a common generally rectangular substrate **302**. The IC includes a memory **306**. The device **100** is included in the tag **1**.

FIG. 6

[**0046**] **FIG. 6** includes a tuning capacitor C**1**. This Figure is discussed below in relation to a specific example.

FIG. 7

[**0047**] As schematically illustrated in FIGS. **7** the circuit **304** toggles between a first state and a second state, wherein the current drawn from the coil **303** by the circuit **304**—in the presence of the interrogation signal—during a first state is greater than the current drawn during a second state. A noted above device **100** is employed within circuit.

FIG. 8

[**0048**] **FIG. 8** illustrates a circuit model for circuit **304**. Particularly:

[**0049**] (a) the voltage V**1** is induced in the antenna coil L**1** by the interrogation field.

[**0050**] (b) Impedance Z**1** represents the series impedance of the antenna coil and any other series—connected impedance.

[**0051**] (c) R**4** symbolically represents the equivalent AC resistance of circuit **304**.

[**0052**] (d) Current I**2** flows from the antenna coil into R**4**.

[**0053**] (e) Voltage V**4** across R**4** symbolically represents the voltage of the antenna terminals of L**1** and circuit **304**, which is rectified and stored on a DC storage capacitor C**2** as shown in **FIG. 3**.

[**0054**] Accordingly, V**4** equals V**1** minus the volt drop in L**1** and Z**1** due to the current I**2** flowing through L**1** and Z**1**. That is:

$$V4=V1-I2.(Z1+jwL1)$$

[**0055**] Where jw is the complex frequency in radians per second. This equation can be rearranged into the following two forms.

$$I2=(V1-V4)/(Z1+jwL1)$$

and

$$I2=V1/(R4+Z1+jwL1)$$

Adjusting I**2**

[**0056**] In light of the above, assuming that the voltage V**1** and the inductance L**1** is fixed, then current I**2** is adjusted by varying either V**4**, R**4** or Z**1**. For instance:

[**0057**] 1. I**2** is varied by changing V**4**. That is, by increasing the output voltage more voltage appears at the coil terminals and less current is drawn from the antenna coil.

[**0058**] 2. I**2** is varied by changing R**4**. That is, by increasing the AC resistance of the circuit **4** less current is drawn from the antenna coil. And,

[**0059**] 3. I**2** is varied by changing Z**1**. That is, by inserting an extra impedance in series with Z**1**, a larger voltage is dropped in the antenna coil impedance and less current is drawn from the antenna coil.

[**0060**] Embodiments incorporating such techniques have in fact already been described in the context of device **100** represented in FIGS. **1** to **3**.

Resonant Tuning

[**0061**] As described with T**1** closed in device **100** there is provided a voltage doubler of the form illustrated in **FIG. 3**. With reference to the embodiment shown in **FIG. 7** this state of operation can be viewed as comprising a voltage multiplier as shown in **FIG. 9**. This is advantageous, since in the absence of resonant tuning, the coil voltage is relatively low because it is not magnified by Q. To compensate, circuit **8** increases the voltage supplied to circuit **7** and allows the circuit to operate with a lower coil voltage; the lower coil voltage also requiring a lower interrogation field.

[**0062**] In other related devices use is made of other types of voltage multipliers, such as triplers or quadruplers. Since the impedance level of the coil used in many preferred embodiments is low—in the order of 200 ohms—it is, therefore, ideally suited to a connection with a voltage multiplier.

Load Impedance

[**0063**] As discussed above the voltage doubler has a voltage gain of two, and transforms the load impedance of the chip by a factor of 8. In contrast, the full wave rectifier has a voltage gain of one, and transforms the load impedance by a factor of 2. Thus, since the voltage doubler circuit draws a significantly larger current from the antenna coil, it acts as the normal current state rectifier. In contrast, the full wave rectifier is switched "on" during the low current state.

[**0064**] In the case of the full wave rectifier, for an AC input voltage of Vac peak (2Vac peak to peak) the DC output voltage Vdc equals Vac. For a DC load resistance Rdc the output power Pout equals Vdcˆ2/Rdc and the input power Pin equals Vacˆ2/2.Rac where Rac is the input impedance. Again, from energy conservation the input power Pin must equal the output power requiring that Vdcˆ2)/Rdc=Vac ˆ2/2.Rac. Substituting Vdc=Vac gives (Vacˆ2)/Rdc=Vac ˆ2/2.Rac and rearranging gives 2.Rac equalling Rdc. Thus the input AC resistance is ½ of the DC load resistance.

[**0065**] The switch T**1** is provided in the form of a MOSFET transistor and as would now be apparent, is used to select either the normal current state or the low current state. (T**1**'s drive is provided by the transceiver.) When transistor

T1 is closed and opened, the circuit respectively acts as a voltage doubler and a full wave rectifier.

[0066] In the present embodiment circuit **304**, has a current cycle during which the circuit randomly selects either the first or the second state for the duration of the cycle. The random selection of state during the cycle by each individual tag reduces the risk of two adjacent radio frequency identification tags simultaneously operating in the first state.

[0067] Moreover, in this embodiment, the selection of the second state by circuit **4** is about 16 times more probable then the selection of the first state. That is, the probability of the circuit **4** drawing a high current—and thereby jeopardizing the performance of an adjacent tag, and itself, by their mutual coupling is 1/16. Accordingly, the tags may operate at a much smaller spatial separation than could be achieved by prior art tags.

[0068] The state selection means is implemented with digital circuits. These circuits are designed to select the current state according to the chosen algorithm or method. There are several methods which can be used to implement the state selection circuits. Logic gates can be used to create a dedicated logic circuit for determining the state selection. A state engine consisting of logic arrays can be designed to implement the state selection function. A microcontroller or processor can execute software instructions that code for the chosen algorithm or method. The preferred embodiment is a logic array controlled by a microcontroller. The microcontroller software executed the slower parts of the chosen algorithm or method while the logic array performs the faster parts of the chosen algorithm or method.

A. Embodiments with an Extra Impedance

[0069] In **FIG. 10**, circuit **11** includes a sub-circuit **12** that provides an extra impedance Z**2** in series with the antenna coil L**1** when circuit **11** is in the low current state. Z**2** can be a resistance, capacitance, inductance or a combination of any, or all, of these. The extra impedance causes a drop in voltage across itself and reduces I**2**. This is advantageous for reducing the current drawn from the antenna during the low current state.

[0070] In other embodiments, such as that shown in **FIG. 11**, circuit I**2** is placed on the DC side of the rectifier and a resistor R**3** is used to reduce I**2**.

B. Embodiments with a Shunt Regulator

[0071] The embodiment shown in **FIG. 12** includes a circuit **15** that utilises a shunt regulator **16** for controlling the operating voltage provided to the integrated circuit. A detailed explanation of the operation of the shunt circuit is given in U.S. Pat. No. 5,045,770.

[0072] In essence, the IC's operating voltage is changed such that the low current state's operating voltage, VA+VB, is higher than the normal current state's operating voltage, VB. When the IC's is at the higher operating voltage, the transceiver portion of the device operates at a lower current—therefore, less current is drawn from the antenna.

[0073] The low current state operating voltage is set as high as is possible given the limitations of the IC technology. In this embodiment, for example, VA+VB=4.2 volts and VB=2.1 volts.

C. Embodiments with a Series Regulator

[0074] The embodiment of **FIG. 13** includes a circuit that utilises a series regulator for controlling the operating voltage. The input voltage to the regulator increases when the circuit toggles into the low current state.

Dimensions

[0075] Returning to **FIG. 5** the substrate **302** is about 80 mm by 50 mm, and includes a plurality of layers that are laminated together to encapsulate the coil **303** and the circuit **304**. In this embodiment, the thickness of the tag **1** is about 0.3 mm. In other embodiments, the dimensions of tag **1** are bigger or smaller. That is, it is generally preferable for the tag to be sized such that it may be unobtrusively incorporated into packaging and other articles.

Devices Used to Transmit the Identification Signal

[0076] In the preferred embodiment, the coil **303** transmits an identification signal generated by the transceiver. In other embodiments, a second separate antenna coil is used to transmit the identification signal.

Devices Used to Receive the Interrogation Signal

[0077] While in this embodiment, the antenna is the coil **303**, other devices may be employed to receive the interrogation signal. Examples of such alternative devices are shown in **FIGS. 14, 15** and **16**. In **FIG. 14**, the interrogation signal is received by a non-specific or generic receiving device **31**. As shown in **FIG. 15** includes a dipole antenna **32** is used for receiving a radiated interrogation signal. In other embodiments (not shown), device **31** is a monopole. In still further embodiments, such as that illustrated in **FIG. 18**, device **31** includes a capacitive antenna **33** for receiving an electric, capacitive, or interrogation signal. Further, it will be understood by the skilled addressee from the teaching herein that the invention is applicable to still other receiving devices, and is not limited by the choice of antenna or the specific form of interrogation signal.

The Typical Operation of Prior Art Tags

[0078] Before further describing the embodiments of the invention, the operation of a typical prior art tag will be examined. A typical tag includes a circuit **6** illustrated schematically in **FIG. 6**. Particularly, the voltage V**1** is induced in antenna coil by the interrogation field, and the antenna coil L**1** is tuned by a tuning capacitor C**1**. Accordingly, L**1** and C**1** form a resonant tuned circuit, which magnifies the voltage V**1** by the loaded Q factor of the antenna coil. The AC voltage generated across the tuned circuit is rectified by a rectifier **6***a*, and the DC output voltage is stored on a storage capacitor C**2**. The DC load of the IC is represented by R**1**.

[0079] **FIG. 17** shows a circuit model for the RFID circuit **5** where corresponding features are denoted by corresponding notations The antenna coil is represented by inductance L**1** and the coil losses by series resistance R**5**. The tuning capacitance and circuit stray capacitance are represented by C**1**, and the losses of the rectifier and IC circuit by R**3**. The resonant currents circulating in the tuned circuit formed by L**1** and C**1** are I**1**; and the output current into R**3** is I**2**.

[0080] The capacitor Q factor (Qc=w.R**3**.C**1**) normally dominates the total resonant Q factor. Typically, Qc has a value of between 10 and 40. Since the ratio of I1/I2=Q, the resonant current I1 is much larger than the output current I2.

[0081] In light of the above, when tags of this type are in close proximity the magnetic field generated by the resonant current couples—through mutual inductance—with proximate tags and, therefore V1 is diminished. In other words, once the tags are in close proximity—that is, within about 50 mm of each other—such "interference" compromises the reliable operation of the tags.

The Removal of the Resonant Capacitor

[0082] In a related aspect it has been appreciated by the inventors that for tags operating in close proximity to each other it is important that these resonant currents are eliminated. Given this, the inventors have found that it is possible to eliminate these resonant currents by disconnecting the resonant capacitor from the antenna coil. However, even with the resonant capacitor removed from prior art devices like that shown in **FIG. 7**, the antenna current drawn by circuit **7** is still too large to allow a plurality of tags to be closely stacked. Specifically, even without a resonant capacitor, if such tags are placed within a few millimetres of each other, the tags will not operate reliably.

Minimising the Current in the Second State

[0083] When the antenna coil current becomes very small or, as in some cases zero, the coil becomes transparent to the interrogation field. In this state the antenna coil has (a) no effect upon the interrogation field and (b) those tags in the low current state do not interfere with the operation of those tags in the normal current state.

[0084] In low current state, tag **1** is not fully functional. That is, the current drawn from the coil is reduced such that only necessary circuit functions are viable. In a preferred embodiment, the current is in order of 30 μA. Ideally, the current is zero; or at least minimised as much as possible.

[0085] In other embodiments, the minimising of current is realised by one or more of a variety of methodologies, including:

[0086] 1. Minimising the required functions to be performed by the circuitry.

[0087] 2. Utilising low power circuitry. Low power circuitry, while widely understood, are much more difficult to design than conventional circuitry. Low power circuits require less current to operate and consequently draw less current. Using low power circuits for those circuits that must remain operational in the low current state reduces the current drawn during the low current state.

[0088] 3. The use of onboard energy storage devices and in particular a capacitive device. On board storage devices can provide the current required to operate the circuits in the low current state. For example, a capacitive device can charge up during the normal current state and use the stored charge during the low current state so as to minimise the current drawn from the antenna. Alternatively, a battery can be used to supply the low current state current.

[0089] More generally, the impedance seen by the antenna coil should be as large as possible. This is particularly so in the low current state. That is, the quantum of the antenna current is proportional to the quantum of the resistive and/or the reactive load as seen by the coil. When the amount of the coil current is too high, coil-to-coil magnetic interference will cause the tags to stop operating reliably.

Operation

[0090] In the **FIG. 7** embodiment—which does not include a resonating capacitor—voltage V**1** is induced in the antenna coil L**1** by the interrogation field. Further, the antenna voltage is rectified and stored on a DC storage capacitor C**2**. The generated current is managed by symbolic switch SW**1**.

A. The Symbolic Switch

[0091] The two states can be symbolically reflected by a switch SW**1** and resistors R**1** and R**2**. Importantly, these are employed to reflect the two states and are not, in fact, part of the invention.

[0092] In other words, switch SW**1** reflects the device's operation in the two different "states". In essence, this is further symbolically implemented by resistors R**1** and R**2**—which are representative of the load provided by circuit **4** in the low current state and the normal current state respectively.

[0093] With the benefit of the teaching herein, it will be appreciated by those skilled in the art that there are many well known methods for disabling circuits and reducing their current consumption—all of which are applicable to achieve the functionality required. For example, there are various hardware and software methods for putting a microprocessor into a "standby" or a "sleep" state. The present invention does however provide a solution whereby the device includes a switched impedance that can be switched between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier.

B. Current Input by the Symbolic Switch

[0094] The change in the current drawn by circuit **304** in the low current and the normal current state corresponds to a change in the antenna coil's current. In the low current state that antenna current is tens of microamperes and in the normal current state the antenna current is hundreds of microamperes. Specifically, typical values are 70 μA in the low current state and 300 μA in the normal current state.

[0095] In **FIG. 7**, the low current state is symbolically represented by switch SW1 being open and the current Iq being drawn through R**2**. In the low current state, the quiescent current Iq is symbolically drawn. The current Iq is very small and is typically a few tens of microamperes. In this embodiment, Iq symbolically represents the current used to: maintain RAM data stored in CMOS memory, operate logic functions, and power analogue circuitry.

[0096] Further, the normal current state is symbolically represented by SW**1** being closed and reflects activation of all of circuit **4**'s functionality. In the normal current state, currents Ic and Iq are drawn. The total current drawn by circuit **304** in the normal current state (Iq+Ic) is typically about 300 μA, although this does vary considerably between embodiments.

Systems Incorporating the Device

[0097] **FIG. 18** illustrates an application of an embodiment of the invention as an inventory system for jewels.

Previously, this process has been achieved manually, and is therefore both time consuming and prone to error.

[0098] In this embodiment, 100 small envelopes are horizontally stacked in a cardboard box; each envelope storing a jewel and a report on the characteristics of the jewel. As is evident from **FIG. 18**, a plurality of RFID tags **1** may be placed within a few millimetres of each other without impacting on the devices' reliability.

[0099] Since each tag **1** is programmed with the contained jewel's characteristics, its uniquely coded identification signal will provide the interrogator with data this is indicative not only of the identity of each tag in the box, but also of the jewel contained within each envelope. Accordingly, the whole box of jewels is accounted for in one automatic process. There is no need to take the envelopes out of the box and separate them to "safe" distances from each other.

[0100] In this way, security is more easily maintained as well. For instance, the interrogator may be placed at a passage (through which the box is placed) between a safety deposit storage area and a customer service area. Preferably, the personnel progressing the box also carries a tag so that their identity may be determined.

The Determination of "State"

[0101] As mentioned earlier, to maximise the reliability of the operation of closely stacked or spaced tags, such as those used in **FIG. 18**, the tags operate in either of two current states. At any one time, a small proportion of the tags are in a normal current state where the tags are responsive to the interrogator, and the remainder of the tags are in a low current state where they are not fully functional. Accordingly, in the **FIG. 18** embodiment, where the tags must operate within a few millimetres of each other, the probability of an individual tag being in the normal state is 1/16.

[0102] Generally speaking, the longer the tags are disposed within the interrogation field, the lower the normal state probability may be. In other embodiments having only a few tags, the probability of the tags being in the normal state can also be decreased. In such instances, the spacing between tags can thereby be further decreased as well.

[0103] The selection of state is made using a predetermined algorithm. An example of a preferred algorithm is a random or a pseudo-random number algorithm.

A. Autonomous Selection

[0104] In a preferred embodiment, the tags randomly select their current state autonomously. That is, the tags randomly choose a current state; receive commands and/or data, and/or transmit replies; and then randomly choose a new current state.

B. Responsiveness to Interrogation Signals

[0105] In alternative embodiments, the interrogation signals are used to direct tags to select a new current state, and the tags randomly choose their current state. These interrogation signals, in some embodiments, take the form of short breaks in the interrogation field. Example of such breaks include a single break and a coded break (where the codes are sequences of breaks directing the tags to perform to various current state selection).

[0106] In further alternative embodiments, other forms of modulation of the interrogation field are used to direct tags in their selection of current state. Examples of such modulations include amplitude, phase, and frequency modulation.

C. Probabilities

[0107] The precise proportion of tags selecting the normal state is not critical, except in so far that the coupling between tags is reduced sufficiently to allow reliable operation. The probabilities or proportion of operating tags should be selected to suit the number and spacing of tags and can be determined by experiment.

[0108] Moreover, the algorithm may be structured so that a tag will be guaranteed to have been in the normal current state at least once every "n" state selections, where "n" is the reciprocal of the probability of selecting the normal state. A simple method of ensuring this is to force the selection of the normal current state if it has not been selected after a fixed number of selections. The value of this fixed number can be selected to suit the number and spacing of tags.

D. Use of Unique Tag Number

[0109] Alternatively, each tag selects a current state dependent upon a fixed number, such as a unique number. In such preferred embodiments, the tag uses a portion of that number to choose a current state. More particularly, in the **FIG. 18** embodiment, each tag's unique number includes a 4-bit mask value. The 4-bit value represents the number of interrogator breaks, or commands, received before the tag enters the normal current state. The field transmitted by the interrogator can be modulated to transmit commands to the tags. Various methods of modulating the field such as pulse, amplitude, frequency and phase are widely used and understood.

[0110] In further embodiments, the mask may be altered each time the tag exits the normal state. In this way, adjacent tags with similar numbers are prevented from moving to the normal current state at the same time.

[0111] Larger and smaller probabilities can be selected by using smaller and longer masks. The mask can also be reduced or increased in length so that probabilities of 1, 1/2, 1/4, 1/8, 1/16, and 1/32 can be selected by employing masks of 0, 1, 2, 3, 4 and 5 bits respectively.

[0112] Another application is illustrated in **FIG. 19**, where tag **1** is shown disposed between two cut-away layers **21** and **22** of a laminated envelope **23**. While tag **1** is shown in the Figure as protruding from between the layers, that is for purposes of illustration only. It will be appreciated that, in use, tag **1** is completely enclosed by the layers. Importantly, since tag **1** is operable, even when in close proximity to a number of like tags, it is possible to reliably interrogate the tags.

Further Applications

[0113] **FIG. 20** depicts a system **50** according to a preferred embodiment of the invention. As shown, an interrogator **43** integrates a plurality of devices **1**.

[0114] For postal envelopes, the user is able to preprogram the tags **1** to include address and content information to facilitate the sorting of the envelope. Moreover, in some embodiments, the tag is pre-programmed with an encrypted message for the intended recipient. For courier envelopes, the courier may pre-program the tag to include data about the intended recipient, the contents of the envelope, the priority of the required delivery, and other data.

[0115] Although the tag **1** is shown sandwiched between two layers of the envelope of **FIG. 19**, in other embodiments it is attached by other means. For example, one embodiment makes use of a plastics pocket formed on the exterior layer of the envelope for selectively receiving the tag. In another embodiment, the tag is simply placed within the envelope with the other contents. Further, attached to parcels, the invention is particularly advantageous because loosely packed parcels will often lie directly adjacent to one another—without any separation. Other alternatives will also be apparent to the skilled addressee in light of the teaching herein.

[0116] In another embodiment of the invention, a tag is disposed within the packaging for a saleable item. Following the placement of the item into the packaging the tag is programmed to include data indicative of the quantity or quality of the contents. This allows ease of distribution and inventory control from the point of packaging to the ultimate point of sale. This embodiment is particularly advantageous when applied to packaging for computer software. However, it is also applicable to other items such as compact disc's, toys, integrated circuits, books, and any other goods that are packed closely together for storage or transportation.

[0117] In more complex embodiments, a number of tags are associated with a single article. In the case of an envelope for courier use, one of the tags contains data readable only by the courier organisation, while another tag includes data only readable by the sender and recipient of the envelope.

The Interrogator

[0118] The interrogator **43** is either a fixed installation device or, in other embodiments, a handheld device. In any event, the interrogator provides an interrogation signal—preferably in the form of a RF field—that is detected by, and selectively responded to, by each tag in its field.

Reusability and Reliability

[0119] The RFID tags of the preferred embodiments provide a re-usable resource, as the tags are re-programmable. Moreover, unlike bar codes, they will not be so easily disabled through physically rough handling.

Other Benefits Associated with the Present System

[0120] Since prior art system, tags are used to identify items such as baggage and are designed to operate at ranges up to 1 metre, the application of such technology is thereby limited to circumstances where tags are well spaced apart. In sharp contrast, the preferred embodiments of the invention are able to be stacked closely and continue to reliably operate.

[0121] A typical application is the identification of RFID tags attached to bundles of letters where the tag data is used to control the automatic sorting of each letter. However, the invention is not limited to this particular field of use. For example, various aspects of the invention are applicable to systems used for identification or inventory management of items such as shoe uppers, shoe soles, diamonds, and jewellery.

[0122] Moreover, in addition to allowing ease of inventory control, the invention facilitates the automated sorting of those articles. This is well illustrated in the context of the jewel handling system and also in the context of mail handling systems—where each piece of mail includes a tag.

[0123] Accordingly, the preferred embodiments may be applied advantageously to various uses such as item identification, stock control, and inventory management. By having the ability to reliably operate in "close" ranges, such as when stacked, the application's tag and system allow these processes to be done in bulk and automatically—without the need for manual intervention. Accordingly, the preferred embodiments of the invention provide many significant advantages over prior art systems.

[0124] It is to be appreciated that the present invention may be provided a radio frequency identification ("RFID") device, the device including: an antenna for receiving an interrogation signal; and a transceiver connected to the antenna and being responsive to the interrogation signal, whereby the transceiver selectively draws current from the antenna.

[0125] The transceiver may toggle between a first state and a second state, wherein the current drawn by the transceiver during the first state is greater than the current drawn during the second state. The transceiver may select the second state more frequently than the first state. More preferably, the probability of selecting the second state is at least twice the probability of selecting the first state.

[0126] In a preferred embodiment, the transceiver has an operating cycle wherein, during that cycle, the transceiver is in either the first or the second state. Preferably, the transceiver selects the first state with a probability of less than ½. More preferably, the probability is less than ¼.

[0127] Even more preferably, the probability is less than or equal to 1/16. Accordingly, the first state is not necessarily selected in each cycle. In signal use, the interrogation signal is generated in a predetermined area by an interrogator. Preferably, the device is maintained within the signal field for more than one cycle. More preferably, the device is maintained within the field for at least the number of cycles equal to the reciprocal of the probability of the first state being selected.

[0128] In a preferred form, the selection of the first state and the second state is based upon a predetermined algorithm. An example of a preferred algorithm is a random or a pseudo-random number.

[0129] Preferably, the antenna and the transceiver are mounted to a common substrate. More preferably, the antenna is a coil and the current generated in the coil is in response to the interrogating signal.

[0130] Preferably, during the first state, the current drawn by the transceiver is to allow its operation. That is, the first state is a normal state, while the second state is a standby state. For example, in the normal state the current supplies the relevant clock circuits, the signal processing circuit, and the like. In this state, the current also allows the transceiver to generate an identification signal.

[0131] More preferably, the transceiver relies upon the current to drive the antenna to transmit the identification signal. In other embodiments, the device includes a separate transmission antenna and the transceiver drives that separate antenna to transmit the identification signal. In both cases, the current drawn from the antenna is the source of power for the generation and transmission of the identification signal.

[0132] The device is preferably passive in that it does not have an onboard power source.

[0133] However, the invention is also applicable to active devices wherein the life of the onboard power source is prolonged.

[0134] The present invention may be provided as a radio frequency identification ("RFID") device, the device including: an antenna for receiving an interrogation signal and being responsive to the signal for supporting an antenna current; a coupling connected to the antenna for toggling the antenna current between a first state and a second state, wherein the antenna current in the first state is greater than the antenna current in the second state; and a transceiver connected to the coupling and drawing an operational current that is derived from the antenna current, whereby the transceiver is selectively responsive to the interrogation signal to generate an identification signal.

[0135] Preferably, during the first state the transceiver is responsive to the interrogation signal to generate the identification signal. More preferably, in the second state the device is responsive to the interrogation signal only for the purpose of toggling the antenna current between the first and second states. That is, the first state is a normal current state, whereas the second state is a low current or standby state.

[0136] Preferably also, the antenna is responsive to the transceiver for transmitting the identification signal. In other embodiments, however, the device includes a separate antenna that is responsive to the transceiver for transmitting the identification signal.

[0137] The present invention may be provided as a system for identifying articles that are collocated with an RFID tag of the first aspect, the system including: an interrogator for providing an interrogating field; a plurality of identification devices mounted to the respective articles, the devices including: respective antennas for being contemporaneously disposed within the field and being responsive to that field for providing antenna currents; respective transceivers that are connected to the antennas for selectively toggling the currents between an operational state and a standby state such that not all the currents are simultaneously in the operational state, whereby the transceivers are responsive to the currents for providing identification signals that include identification data unique to the respective articles; and a receiver for processing the identification signals to extract the identification data and thereby identify the respective articles.

[0138] Preferably, the current drawn by the transceiver during the operational state is greater than the current drawn during the standby state. More preferably, the transceiver selects the standby state more frequently than the operational state. Even more preferable, the probability of selecting the second state is at least twice the probability of selecting the first state.

[0139] In the preferred embodiments, the transceiver has an operating cycle with a start and a finish wherein, during that cycle, the transceiver is in either the first or the second state.

[0140] Preferably also, the transceiver selects the first state with a small probability of less than ½.

[0141] More preferably, the probability is less than ¼. Even more preferably, the probability is less than or equal to 1/16.

[0142] In a preferred form, the selection of state is based upon a predetermined algorithm. An example of a preferred algorithm is a random or a pseudo-random number used to determine the state selection of the transceiver.

[0143] Preferably, the identification signals are transmitted while the respective transceivers are in the first state. More preferably, the transceivers use the respective antennas to transmit the identification signals. In other embodiments, however, the devices include respective second antennas that are used by the transceivers to transmit the identification signals.

[0144] The present invention may be provided as a radio frequency identification("RFID") device including: an antenna that is responsive to an interrogation signal for providing an antenna current; and a transceiver for selecting between a normal state and a standby state wherein, during the normal state, the transceiver is responsive to the interrogation signal for generating an identification signal and, during the standby state, the transceiver is only responsive to the interrogation signal for selecting between the normal and standby states.

[0145] Preferably, in the absence of the interrogation signal the device is inactive. Conversely, in the presence of an interrogation signal, the device is either in the normal state or the standby state. Preferably, the normal state has a short duration and, therefore, the device is predominantly in the standby state in the presence of an interrogating signal. Preferably, during the standby state, the device is only responsive to the interrogation signal for the purpose of selecting between normal and standby states.

[0146] The present invention may provided as a voltage regulator for a radio frequency identification ("RFID") device; the device having: an antenna for receiving an interrogation signal and for transmitting an identification signal and a transceiver for being responsive to the interrogation signal to generate the identification signal. The regulator including: a current coupling for providing a supply voltage to the transceiver, the current coupling, in the first state, drawing a first current from the antenna and, in the second state, drawing a second current from the antenna that is less than the first current.

[0147] The present invention may provided as an identification device for receiving a first signal and transmitting a second signal, the device including: a receiving means for receiving the first signal and employing the first signal to generate a voltage; wherein the receiving means generates a first current from the voltage; an integrated circuit that selectively controls the amount of the first current in the receiving means; a connection between the receiving means and the integrated circuit; a transmission means for generating the second signal; a state selection means for selecting whether the device is in a first state or a second state; wherein-relative to the second state-a relatively larger amount of the first current flows through the receiving means when the device is in the first state; and wherein-relative to the first state-a relatively smaller amount of the first current flows through the receiving means when the device is in the second state.

[0148] The present invention may provided as system for identifying articles, the system including: a signal generator for generating a first signal; a plurality of articles; a plurality of identification devices, each individual device being respectively associated with each individual article; wherein each device includes: a receiving means for receiving the first signal and employing the first signal to generate a voltage; wherein the receiving means generates a first current from the voltage; an integrated circuit that selectively controls the amount of the first current in the receiving means; a connection between the receiving means and the integrated circuit; a transmission means for generating the second signal; a state selection means for selecting whether the device is in a first state or a second state; wherein-relative to the second state-a relatively larger amount of the first current flows through the receiving means when the device is in the first state; and wherein-relative to the first state-a relatively smaller amount of the first current flows through the receiving means when the device is in the second state.

[0149] Although the invention has been described with reference to a number of specific examples, it will be appreciated by those skilled in the art that the invention can be embodied in many other forms.

[0150] While this invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modification(s). This application is intended to cover any variations uses or adaptations of the invention following in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

[0151] As the present invention may be embodied in several forms without departing from the spirit of the essential characteristics of the invention, it should be understood that the above described embodiments are not to limit the present invention unless otherwise specified, but rather should be construed broadly within the spirit and scope of the invention as defined in the appended claims. Various modifications and equivalent arrangements are intended to be included within the spirit and scope of the invention and appended claims. Therefore, the specific embodiments are to be understood to be illustrative of the many ways in which the principles of the present invention may be practiced. In the following claims, means-plus-function clauses are intended to cover structures as performing the defined function and not only structural equivalents, but also equivalent structures. For example, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface to secure wooden parts together, in the environment of fastening wooden parts, a nail and a screw are equivalent structures.

[0152] "Comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof." Thus, unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

1. A device having a switched impedance that can be switched between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier.

2. A device as claimed in claim 1 wherein the device includes receiving means for receiving a signal, the device being configured for selectively controlling the amount of current in the receiving means by switching between the first state and the second state.

3. A device as claimed in claim 2 wherein the current drawn through the receiving means in the first state is greater than the current drawn through the receiving means in the second state.

4. A device as claimed in claim 2 or 3 wherein the receiving means is connected to one or more voltage input terminals of the device.

5. A device as claimed in claim 2 wherein the receiving means comprises a coil in an antenna circuit.

6. A device as claimed in claim 2 wherein the receiving means has a impedance of substantially 200 ohms.

7. A device as claimed in claim 1 wherein a load is connected between one or more output voltage terminals of the rectifier.

8. A device as claimed in claim 7 wherein the load comprises an integrated circuit.

9. A device as claimed in claim 1 wherein the first state is an operational state and the second state is a standby state.

10. A device as claimed in claim 1 wherein the switched impedance comprises a switch in series with a capacitor.

11. A device as claimed in claim 10 wherein the switch of the switched impedance comprises a MOSFET.

12. A device as claimed in claim 1 wherein the switched impedance is connected between a first input terminal and a first output terminal of the rectifier.

13. A device as claimed in claim 1 wherein the device includes a series regulator for controlling an operating voltage by varying resistance when the device is switched between the first and second states.

14. A device as claimed in claim 13 wherein the device includes receiving means in series with the series regulator, the receiving means being configured for receiving a signal.

15. A device as claimed in claim 1 wherein the device includes a load in series with the series regulator.

16. A device as claimed in claim 1 wherein the device includes a shunt regulator to control the operating voltage when the device is switched between the first and second states.

17. A device as claimed in claim 1 wherein the voltage multiplier transforms the load impedance by a factor of 8.

18. A device as claimed in claim 1 wherein the rectifier transforms the load impedance by a factor of 2.

19. A device as claimed in claim 1 wherein the device is configured for controlling current and wherein there is a relatively smaller amount of current, relative to the first state, when the device is in the second state.

20. A device as claimed in claim 19 wherein in the first state the current is hundreds of microamperes and in the second state the current is tens of microamperes.

21. A device as claimed in claim 19 or 20 wherein in the second state the relatively smaller amount of current is less than approximately 50 μA.

22. A device as claimed in claim 19 or 20 wherein in the second state the relatively smaller amount of current is less than approximately 30 μA.

23. A device as claimed in claim 19 wherein in the second state the relatively smaller amount of current is less than approximately 15 μA.

24. A device as claimed in claim 19 or 20 wherein in the second state the relatively smaller amount of current is between approximately 1 μA and approximately 4.99 μA.

25. A device as claimed in claim 19 wherein in the second state the relatively smaller amount of the first current is less than 50% of the relatively larger amount of the first current.

26. A device as claimed in claim 1 wherein the switched impedance is configured to select the second state more frequently than the first state.

27. A device as claimed in claim 1 wherein the switch is used to select the first or second states according to an algorithm.

28. A device as claimed in claim 1 wherein in the second state the device acts as a full wave bridge rectifier.

29. A device as claimed in claim 1 wherein the voltage multiplier provides as increased output voltage.

30. A device as claimed in claim 1 wherein in the first state the device acts as a voltage doubler.

31. A device as claimed in claim 1 wherein the device is utilized in a radio frequency identification device.

32. A device as claimed in claim 1 wherein the radio identification frequency device is passive.

33. A device as claimed in claim 1 wherein in the second state current is used to maintain RAM data stored in CMOS memory, and operate logic functions.

34. A device as claimed in claim 1 including an onboard energy storage device.

35. A method of selectively controlling current, the method comprising: providing a device operable in one of a first state or a second state, coupling an impedance to the device to enable switching of the device between a first state and a second state wherein, in the first state, the device acts as a voltage multiplier and, in the second state, the device acts as a rectifier.

36. A method as claimed in claim 35 wherein the method includes using a receiving means to receive a signal, and selectively controlling the amount of current in the receiving means by switching between the first state and the second state.

37. A method as claimed in claim 36 wherein the current drawn through the receiving means in the first state is greater than the current drawn through the receiving means in the second state.

38. A method as claimed in claim 36 or 37 wherein the receiving means is connected to one or more voltage input terminals of the device.

39. A method as claimed in claim 36 wherein the receiving means comprises a coil in an antenna circuit.

40. A method as claimed in claim 36 wherein the receiving means has a impedance of substantially 200 ohms.

41. A method as claimed in claim 35 wherein a load is connected between one or more output voltage terminals of the rectifier.

42. A method as claimed in claim 41 wherein the load comprises an integrated circuit.

43. A method as claimed in claim 35 wherein the first state is an operational state and the second state is a standby state.

44. A method as claimed in claim 35 wherein the switched impedance comprises a switch in series with a capacitor.

45. A method as claimed in claim 44 wherein the switch of the switched impedance comprises a MOSFET.

46. A method as claimed in claim 35 wherein the switched impedance is connected between a first input terminal and a first output terminal of the rectifier.

47. A method as claimed in claim 35 wherein the device includes a series regulator for controlling an operating voltage by varying resistance when the device is switched between the first and second states.

48. A method as claimed in claim 47 wherein the device includes receiving means in series with the series regulator, the receiving means being configured for receiving a signal.

49. A method as claimed in claim 35 wherein the device includes a load in series with the series regulator.

50. A method as claimed in claim 35 wherein the device includes a shunt regulator to control the operating voltage when the device is switched between the first and second states

51. A method as claimed in claim 35 wherein the voltage multiplier transforms the load impedance by a factor of 8

52. A method as claimed in claim 35 wherein the rectifier transforms the load impedance by a factor of 2.

53. A method as claimed in claim 35 wherein the device is configured for controlling current and wherein there is a relatively smaller amount of current, relative to the first state, when the device is in the second state.

54. A method as claimed in claim 53 wherein in the first state the current is hundreds of microamperes and in the second state the current is tens of microamperes.

55. A method as claimed in claim 53 or 54 wherein in the second state the relatively smaller amount of current is less than approximately 50 μA.

56. A method as claimed in claim 53 or 54 wherein in the second state the relatively smaller amount of current is less than approximately 30 μA.

57. A method as claimed in claim 53 or 54 wherein in the second state the relatively smaller amount of current is less than approximately 15 μA.

58. A method as claimed in claim 53 or 54 wherein in the second state the relatively smaller amount of current is between approximately 1 μA and approximately 4.99 μA.

59. A method as claimed in claim 53 wherein in the second state the relatively smaller amount of the first current is less than 50% of the relatively larger amount of the first current.

60. A method as claimed in claim 35 wherein the switched impedance is configured to select the second state more frequently than the first state.

61. A method as claimed in claim 35 wherein the switch is used to select the first or second states according to an algorithm.

62. A method as claimed in claim 35 wherein in the second state the device acts as a full wave bridge rectifier.

63. A method as claimed in claim 35 wherein the voltage multiplier provides as increased output voltage.

64. A method as claimed in claim 35 wherein the voltage multiplier is a voltage doubler.

65. A method as claimed in claim 35 wherein the device is utilized in a radio frequency identification device.

66. A method as claimed in claim 35 wherein the radio identification frequency device is passive.

67. A method as claimed in claim 35 wherein in the second state current is used to maintain RAM data stored in CMOS memory, and operate logic functions.

68. A method as claimed in claim 35 including an onboard energy storage device.

69. A method as claimed in claim 35 wherein the coupling of the impedance is enabled by a switch.

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