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CA 2929266 A1 2016/07/14

(21) 2 929 266

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2016/05/09

(41) Mise à la disp. pub./Open to Public Insp.: 2016/07/14

(51) Cl.Int./Int.Cl. *E05B 47/00* (2006.01), *G08B 21/24* (2006.01), *H01Q 9/04* (2006.01), *H02J 1/00* (2006.01)

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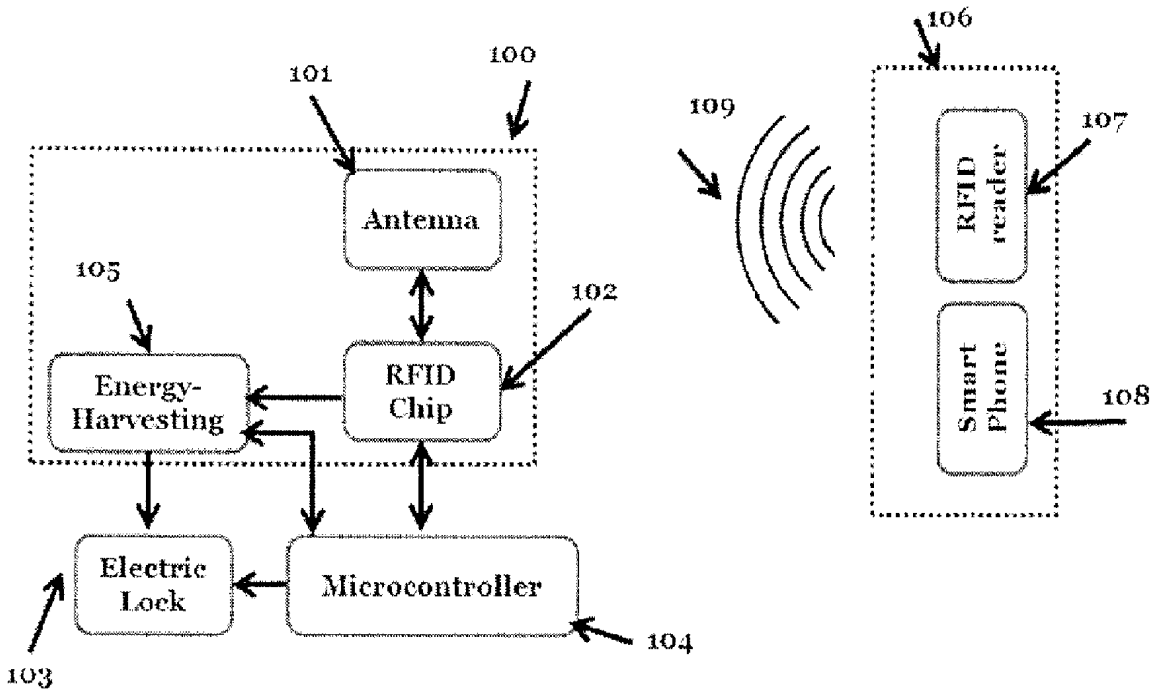
(54) Titre : DISPOSITIF DE VERROUILLAGE ELECTRONIQUE RFID INTELLIGENT SANS FIL
(54) Title: BATTERYLESS SMART RFID ELECTRONIC LOCK SYSTEM



(57) Abrégé/Abstract:
In this invention, a batteryless Radio Frequency Identification (RFID) electronic lock system is disclosed. The developed batteryless RFID electronic lock system consists of a smart RFID tag, an electronic circuit with a microcontroller, an electric (or electromagnetic) lock, and a RFID reader (a conventional RFID reader or a smart phone). The developed batteryless RFID electronic lock system does not embed the RFID reader within the frame of the electric (electromagnetic) lock. It comprises a smart RFID tag and an electronic circuit to the frame of the electric (electromagnetic) lock. The RFID reader (or smart phone) is used to operate the developed batteryless electronic lock system by transmitting electromagnetic waves. When it receives a signal from the RFID reader (or from a smart phone), the smart RFID tag produces an energy harvesting that is used to power the electronic circuit of the batteryless RFID electronic lock. That is, the developed electronic lock system is batteryless as no battery is needed to power the electronic circuit. The developed batteryless electronic lock system can be used in several applications including, but not limited to, buildings entrance, electronic furniture locking systems, luggage (bags, purses, suitcases, wallets, briefcases, handbags, billfolds, portfolios, valises, and grips) locks, security locks, and electronic gates.

Batteryless Smart RFID Electronic Lock System

ABSTRACT

In this invention, a batteryless Radio Frequency Identification (RFID) electronic lock system is disclosed. The developed batteryless RFID electronic lock system consists of a smart RFID tag, an electronic circuit with a microcontroller, an electric (or electromagnetic) lock, and a RFID reader (a conventional RFID reader or a smart phone). The developed batteryless RFID electronic lock system does not embed the RFID reader within the frame of the electric (electromagnetic) lock. It comprises a smart RFID tag and an electronic circuit to the frame of the electric (electromagnetic) lock. The RFID reader (or smart phone) is used to operate the developed batteryless electronic lock system by transmitting electromagnetic waves. When it receives a signal from the RFID reader (or from a smart phone), the smart RFID tag produces an energy harvesting that is used to power the electronic circuit of the batteryless RFID electronic lock. That is, the developed electronic lock system is batteryless as no battery is needed to power the electronic circuit. The developed batteryless electronic lock system can be used in several applications including, but not limited to, buildings entrance, electronic furniture locking systems, luggage (bags, purses, suitcases, wallets, briefcases, handbags, billfolds, portfolios, valises, and grips) locks, security locks, and electronic gates.

FIELD OF THE DISCLOSURE

The developed system is related to electronic lock systems, more particularly to batteryless smart RFID electronic lock systems.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of the developed RFID batteryless electronic lock system. In this disclosed figure, the developed batteryless RFID electronic lock system consists of a smart RFID tag, an electronic circuit with a very low power microcontroller, electric (or electromagnetic) latch system, and a RFID reader (traditional RFID reader or smart phone). In addition, Fig. 1 also shows the energy harvesting generated by the smart RFID tag when it receives electromagnetic waves (RF signals) from the RFID reader. This energy harvesting is used to operate the developed batteryless RFID electronic lock system.

Fig. 2 represents the schematic view of the developed battery-less RFID electronic lock system where the electronic circuit with the microcontroller is integrated with the smart RFID tag.

In Fig. 3, a new circuit, charge pump, is included to boost the energy harvesting generated by the smart RFID tag. As a result, the energy harvesting can operate an electric (or electromagnetic) latch that requires a large amount of energy in some applications.

To improve the energy harvesting even further, an additional circuit is added in Fig. 4. The advantage of the new circuit is to perform another charge pump circuit (voltage doubler circuit) as a Tripler.

In some applications that need large memory (e.g., when high level of security is required), the developed system is able to record the information about the authenticated users who locked (or unlocked) the electronic lock system. The information recorded may include the identity of the users who used their authentication to lock (or unlock) the electronic lock system, and the date and time of their access to the electronic lock system. Thus, additional memory is included in Fig. 5.

In some application, when the developed batteryless RFID electronic lock system is incorporated with a big electric (or electromagnetic) latch, an energy supply (e.g., a battery) is included as shown in Fig. 6.

In Fig. 7, other electronic devices (e.g., sensors) are integrated in the disclosed batteryless RFID electronic lock system.

BACKGROUND OF THE INVENTION

RFID-based technology has recently gained more interest and become one of the fastest growing wireless technologies. It has rapidly spread over a wide range of industrial and commercial applications. Because of its low-cost and relatively easy deployment, RFID-based technology plays an important role in various industries and business processes. RFID applications can be operated at several frequency bands such as low frequency (LF) band (125 KHz to 135 KHz), high frequency (HF) band (13.56 MHz), ultra high frequency (UHF) band (860 MHz to 960 MHz), and microwave frequency (MW) band (2.4 GHz to 2.4835 GHz). A typical RFID system consists of a tag (transponder) and a reader (interrogator). The tag is usually composed of a microchip attached to an antenna mounted on a substrate. In most of RFID systems, the reader sends electromagnetic waves and the RFID tag receives and respond to these waves. There are different kinds of RFID tags; active, semi-active, and passive RFID tags. Active and semi-active RFID tags require power sources to operate their microchips. On the other hand, passive RFID tags do not require power sources as they use the field created by the reader to draw the power needed to operate their microchips circuits. Thus, passive RFID tags are inexpensive as they do not contain any source supplying power to their microchips circuits. In addition, it achieves superior performance in terms of life time compared to active and semi-active RFID tags.

RFID systems are widely implemented in many industries that rely on access control system. The RFID electronic lock systems exist in market today use passive RFID tags with RFID readers. The RFID reader is embedded with the frame of the electronic lock, whereas the RFID tag is not. That is, the RFID tag is not incorporated with the frame of the electronic lock. The RFID reader attached to the electronic lock has to be always active. That is, the RFID has to be powered all the time in order to transmit electromagnetic waves. To receive and respond to these waves, the RFID tag has to get closer to the RFID reader. If the password saved on the RFID tag is similar to the password saved on the RFID reader, the RFID tag will open the lock.

The RFID electronic lock systems exist in market today are inefficient because of four reasons. The first reason is that the RFID reader is incorporated with the frame of the electric lock. That is, if the customer has ten doors, for example, the customer will need ten electronic locks with ten RFID readers attached to them. This would be uneconomical because the RFID readers are very expensive. The second reason is that incorporating the RFID reader with the frame of the electric lock will increase the size of the electronic lock. That is, the size of the electronic lock may not be suitable for the customer's needs. The third reason is that the RFID reader has to be active all the time which means a large consumption of power. The fourth reason is that the RFID electronic locks available today usually require one or two voltage sources in order to be able to perform their task effectively. In case that the RFID electronic lock requires low power to operate, one voltage source may be enough to operate both the electronic circuit and the electric lock. On the other hand, in case that the RFID electronic lock requires high power to operate, two voltage sources will be needed. One of them is a low voltage source to operate the electronic circuit. The second one is a high voltage source to operate the electric lock. An example of the locks that require high voltage sources is those who are used in buildings

entrances. Hence, the high cost, large size, and large consumption of power of the RFID electronic lock systems available in market today limit the widespread use of this technology in electronic lock system applications.

Consequently, a new RFID electronic lock system that handles all deficiencies the exist RFID electronic lock systems have needs to be developed.

SUMMARY OF THE INVENTION

In this invention, a new batteryless RFID electronic lock system with low cost, flexible size, and low power consumption is developed. The developed electronic lock system uses smart RFID tags to operate electric (or electromagnetic) locks. The developed electronic lock system consists of a smart RFID tag, an electronic circuit with a microcontroller, an electric (or electromagnetic) lock, and a RFID reader (a conventional RFID reader or a smart phone). Unlike the traditional RFID electronic lock systems exist in market today, the developed batteryless RFID electronic lock system does not include the RFID reader in the frame of the electric (electromagnetic) lock. The developed batteryless RFID lock system comprises a smart RFID tag and an electronic circuit to the frame of the electric (electromagnetic) lock. The RFID reader (conventional RFID reader or smart phone) is used to operate the developed batteryless electronic lock system by transmitting electromagnetic waves. When it receives a signal from the RFID reader (or from a smart phone), the smart RFID tag produces an energy harvesting that is used to power the electronic circuit of the batteryless RFID electronic lock. Hence, the developed batteryless electronic lock system uses the energy harvesting from the smart RFID tag to power the electronic circuit used to operate the electric (or electromagnetic) lock. That is, the developed electronic lock system is batteryless as no battery is needed to power the electronic circuit. Using a batteryless mechanism in the developed electronic lock system means that the cost of the electronic lock system will be reduced. It also means that the electronic lock system will last longer as no battery needs to be replaced in the electronic circuit.

In the developed batteryless RFID electronic lock, the RFID reader does not have to be powered all the time. It is only activated when needed. Because the RFID reader is not embedded with the frame of the developed batteryless RFID electronic lock, the size of the developed lock can be shaped based on the customer needs. In addition, the cost of the developed batteryless RFID electronic lock will be reduced. For example, if the customer has ten doors, the customer will need ten batteryless RFID electronic locks with ten smart RFID tags. The customer in this case only needs one RFID reader (a conventional RFID reader or smart phone) to operate these ten batteryless RFID electronic locks. On the other hand, in case of using traditional RFID electronic locks, the customer will need ten RFID readers (one RFID reader embedded with each RFID electronic lock of each door). Because the smart RFID tags are much cheaper than RFID readers, the cost of the developed batteryless RFID electronic lock will be much lower than the cost of the traditional RFID electronic locks for this example.

The developed batteryless electronic lock system is very secure and can be operated only by the authenticated people. This is because of two reasons. The first reason is that the smart RFID tag used in the developed batteryless electronic lock system can be protected by a password. That is, only the authenticated people can get the access to the smart RFID tag memory. The second reason is that the developed batteryless electronic lock system uses a microcontroller in its electronic circuit. This microcontroller compares the data (or password) received from the RFID reader (a smart phone or any other conventional RFID reader) with the data (or password) saved on its memory. If the received data (or password) is similar to what is stored on its memory, the microcontroller takes the action to lock (unlock) the electronic lock

system. Therefore, only the authenticated people can lock (unlock) the developed batteryless electronic lock system.

The developed batteryless electronic lock system has also the ability to be programmed so that the authentication to lock (or unlock) the developed electronic lock system can be given to more than one person. It also has the ability to be programmed so that the time and the identity of the authenticated people who lately used their authentication to lock (or unlock) the electronic system are saved. This makes the developed batteryless electronic lock system become more practical and can be used in several different aspects. Moreover, the developed batteryless electronic lock system has the ability to program its smart RFID tag so that the information about the owner of the property which the electronic lock is attached to can be obtained. That is, in case the property which the developed batteryless electronic lock is attached to is lost, it would be very easy to know the owner of that property by using any NFC reader (such as a smart phone or any other conventional RFID reader). By just reading the smart RFID tag of the developed batteryless electronic lock by any NFC reader, the owner's information of the property (such as the name, address, phone number, email, or any other information saved by the owner on the memory of the smart RFID tag of the developed batteryless electronic lock) can be easily obtained. The developed batteryless electronic lock system can be used in several applications including, but not limited to, buildings entrance, electronic furniture locking systems, luggage (bags, purses, suitcases, wallets, briefcases, handbags, billfolds, portfolios, valises, and grips) locks, security locks, vehicle smart locks, and electronic gates.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the developed batteryless RFID electronic lock are shown here. In this invention, a batteryless RFID electronic lock is developed. The developed batteryless RFID electronic lock system consists of a smart RFID tag, an electronic circuit with a microcontroller, an electric (or electromagnetic) lock, and a RFID reader (a conventional RFID reader or a smart phone). The developed batteryless RFID electronic lock system does not embed the RFID reader within the frame of the electric (electromagnetic) lock. It comprises a smart RFID tag and an electronic circuit to the frame of the electric (electromagnetic) lock. The developed lock has low cost, flexible size, and low power consumption. Hence, it can be implemented in several applications including, but not limited to, buildings entrance, electronic furniture locking systems, luggage (bags, purses, suitcases, wallets, briefcases, handbags, billfolds, portfolios, valises, and grips) locks, security locks, and electronic gates.

The operation method of the developed lock can be summarized as follows:
The developed batteryless RFID electronic lock embeds the smart RFID tag with the frame of the electric (or electromagnetic) lock. The user taps their RFID reader (a traditional RFID reader or a smart phone) to lock (or unlock) the developed batteryless RFID electronic lock. When the smart RFID tag receives a signal from the RFID reader (or a smart phone), it generates an energy harvesting which is used by the developed lock to operate its electronic circuit. After receiving the data (password) from the RFID reader (or the smart phone) through the smart RFID tag, the microcontroller attached to the electronic circuit compares this date (password) to the date (password) stored in its memory. If the received data (or password) is similar to what is stored on its memory, the microcontroller takes the action to lock (unlock) the electronic lock system. Therefore, only the authenticated people can lock (unlock) the developed electronic lock system.

Fig. 1 to 7 show the embodiments of the developed batteryless RFID electronic lock. In Fig 1, the developed batteryless RFID electronic lock system consists of a smart RFID tag **100**, an electronic circuit with a microcontroller **104**, an electric (or electromagnetic) lock **103**, and a RFID reader **106** (a conventional RFID reader or a smart phone). The smart RFID tag consists of an antenna **101** and a RFID chip (IC) **102**, and it produces an energy harvesting **105** when the tag receives an electromagnetic waves (Radio Frequency signals) **109** from the RFID reader **106**. The smart RFID tag **100** may be passive, active, or semi-active. The antenna **101** of the smart RFID tag **100** may be wire antenna, patch antenna, loop antenna or any other type of antennas. Different types of antennas can be used including inductive coupling antenna in case of operating in Near Field Communication, and Far Field Antennas in case of operating in Ultra High Frequency bands. The RFID reader **106** used by the user to lock or (unlock) the developed lock can be a conventional (traditional) RFID reader or a smart phone. The electronic circuit **104** consists of a microcontroller and may include some other electronic components such as resistors, capacitance, transistors, diodes, etc. The electronic circuit **104** can be either embedded with the smart RFID tag **100** in one component or installed as a separate component.

In Fig. 2, the electronic circuit **104** of the developed batteryless RFID electronic lock is embedded with the smart RFID tag **100**.

In Fig. 3, a charge pump circuit **110** is included to boost the energy harvesting **105** generated by the smart RFID tag **100**. Hence, the energy harvesting **105** can operate an electric (or electromagnetic) latch that requires a large amount of energy in some applications.

In Fig. 4, an additional circuit **111** is added so that the energy harvesting **105** generated by the smart RFID tag **100** is more increased.
In Fig. 5, an additional memory **112** is added to the developed lock system so that the system can be implemented when more information about the authentication users is needed to be recorded. The information to be saved may include the identity of the users who used their authentication to lock (or unlock) the electronic lock system, and the date and time of their access to the electronic lock system.

In Fig. 6, an energy supply source **113** is included to power the big electric (electromagnetic) latches that require high voltage sources.

In Fig. 7, other electronic devices (e.g. sensors) **114** are included to the developed RFID electronic lock system.

The applications and descriptions shown in this invention are just illustrating examples of the invention. Thus, these examples do not limit the scope of this invention.

We claim:

The developed batteryless RFID electronic lock system consists of a smart RFID tag, an electronic circuit with a microcontroller, an electric (or electromagnetic) lock, and a RFID reader (a conventional RFID reader or a smart phone).

1- The developed batteryless RFID electronic lock operates at all RFID frequency bands (i.e. LF, HF, UHF, and MW bands).
2- The developed batteryless RFID electronic lock may have several shapes and sizes.
3- The integrated circuits of the invention shown in previous sections are just examples and do not present the absolute orientation of the invention (i.e. the orientation of the components of the integrated circuits may be changed). Thus, the integrated circuit of the invention may be developed differently from the presented examples.
4- The electronic circuit of the developed electronic lock may also be powered by a low voltage source (battery) instead of using the energy harvesting produced by the RFID tag.
5- Several smart RFID tags can be utilized in this invention such as (passive, active, and semi-active RFID tags). In case of using active or semi-active RFID tags, energy harvesting may not be used.
6- The RFID tag may use different types of antennas; including inductive coupling antenna in case of operating in Near Field Communication, and Far Field Antennas in case of operating in Ultra High Frequency bands.
7- The antenna of the RFID tag may be wire antenna, patch antenna, loop antenna or any other type of antennas.
8- Any type of multi-port antenna (or two antenna) can be used in this invention to provide extra energy harvesting; one antenna operates the RFID tag and the second one to provide extra energy harvesting.
9- The reader used in this invention can be a conventional (traditional) RFID reader or a smart phone. A miniaturized RFID reader can be especially designed for this invention. The reader is always carried by the user and is not embedded with the developed electronic lock.
10- A smart phone application is used in this invention so that the user can function the developed electronic lock (i.e. lock, unlock, send password, update password, save the user's information on the smart RFID tag, etc.).
11- The RFID reader (or the smart phone application) can be programmed so that if the luggage that uses the developed lock is out of a predefined distance from the RFID reader, the RFID reader makes an alarm sound (signal, text message, or phone call) that reminds the owner about their luggage. This can be implemented in case of using Far Field Communication, FFC.
12- Other electronic devices such as sensors and GPS can be added to the smart RFID tag.
13- A backup key may be used in this invention.
14- Light or sound indicators can be attached to the developed batteryless electronic lock to indicate the status of the lock.
15- The applications shown in previous sections are just illustrating examples. Thus, these examples do not limit the scope of this invention.

16- The developed batteryless electronic lock is very secure and can be operated by one or several authenticated people.
17- The smart RFID tag used in this invention can save the developed lock owner's information (name, address, email, phone, etc.). This information can be used to identify the owner, in case the owner lost their property which the developed lock is attached to.
18- The charge pump circuit presented in the invention is just an illustration example of the operation of boosting the energy harvesting. Different electronic circuits or ICs may be employed to enhance (boost) the energy harvesting.
19- I2C communication protocol is used in this invention. However, different Universal Serial Communication Interface protocols (e.g. SPI, UART, etc.) may be implemented.
20- A voltage regulator may be added to the invention to regulate the energy harvesting.
21- A SRAM buffer can be used in this invention to speed the data transfer (Pass-through mode) between the I2C and RF interfaces.
22- This invention is suitable to modern applications that require low cost and more secure electronic lock systems.

DRAWINGS SHEETS

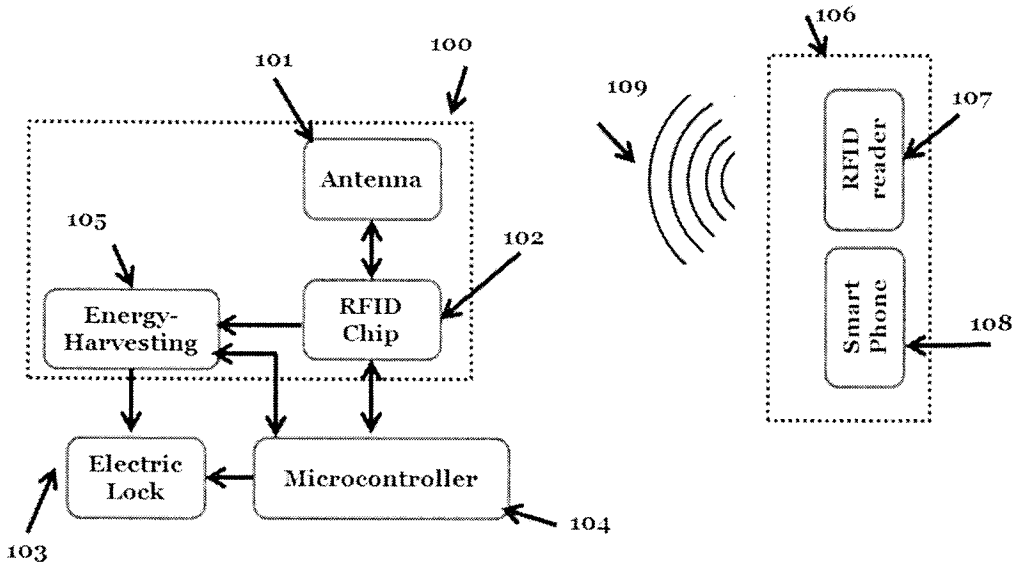
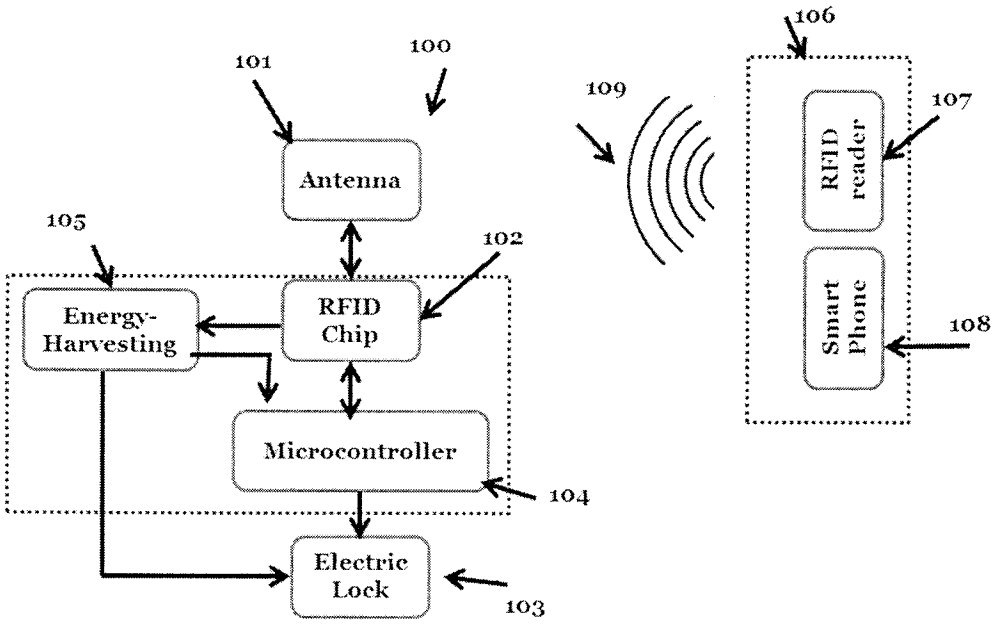


Fig. 1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101
100
109
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RFID Chip
Smart Phone
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Microcontroller
104
Electric Lock
103

Fig. 2

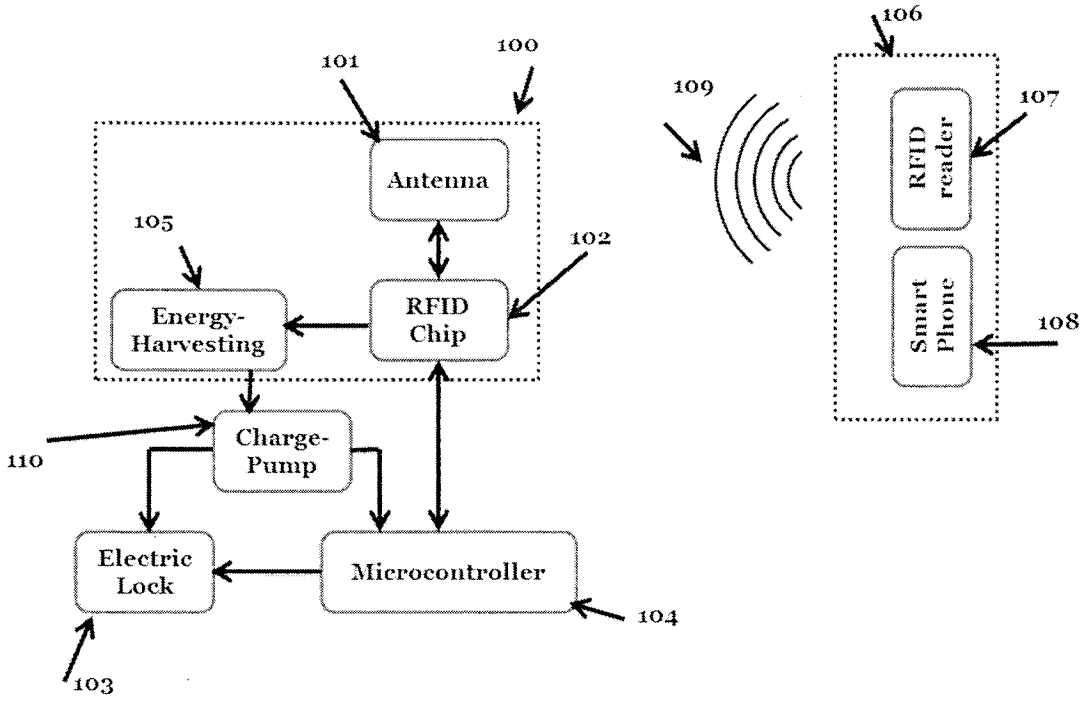
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Fig. 3

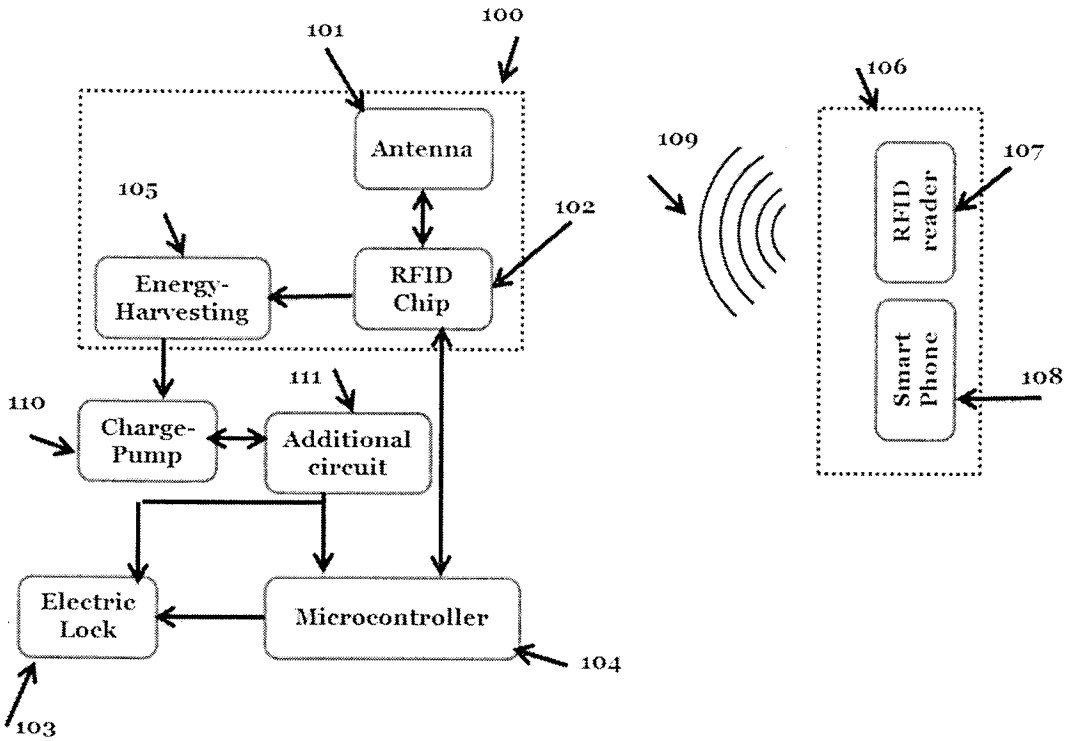
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Fig. 4

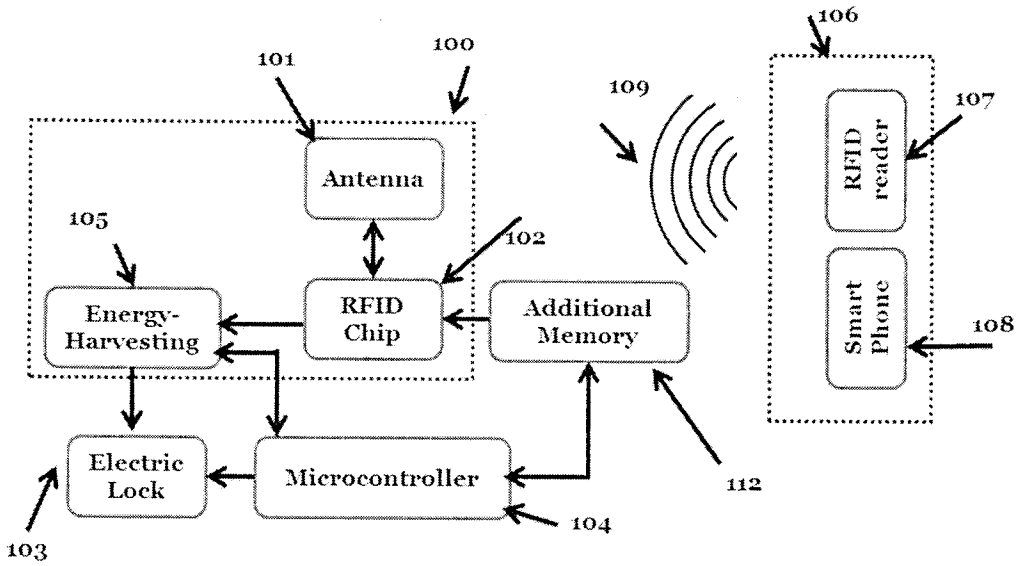
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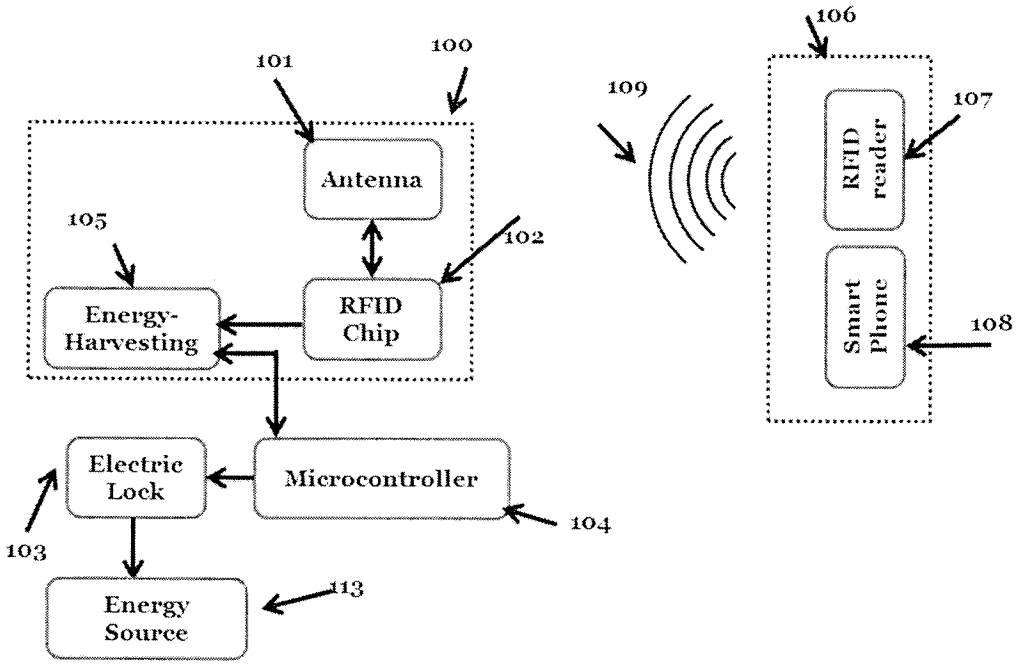
Fig. 5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Electric Lock
Microcontroller
103
104
Energy Source
113

Fig. 6

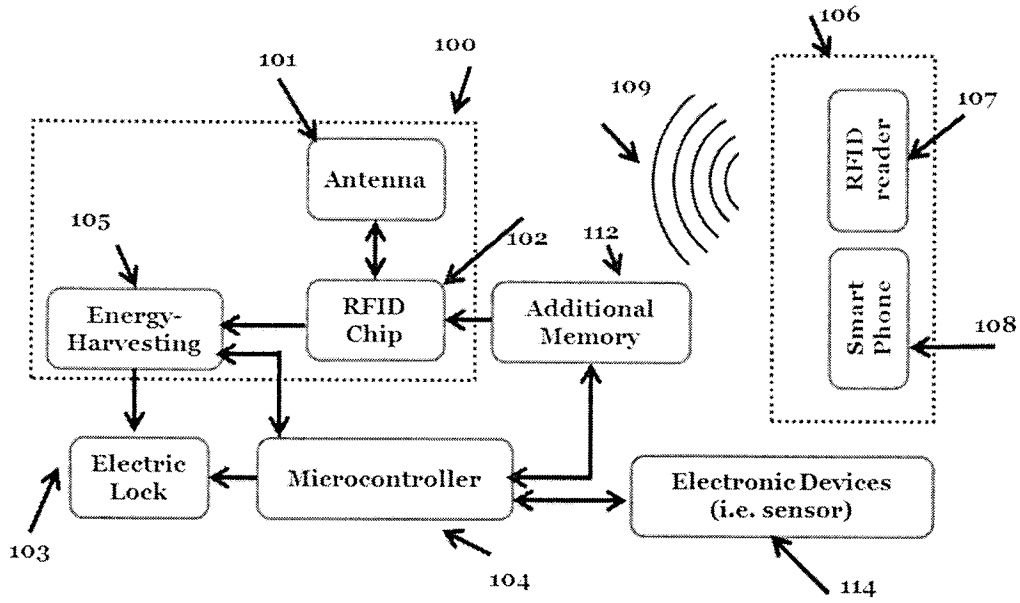
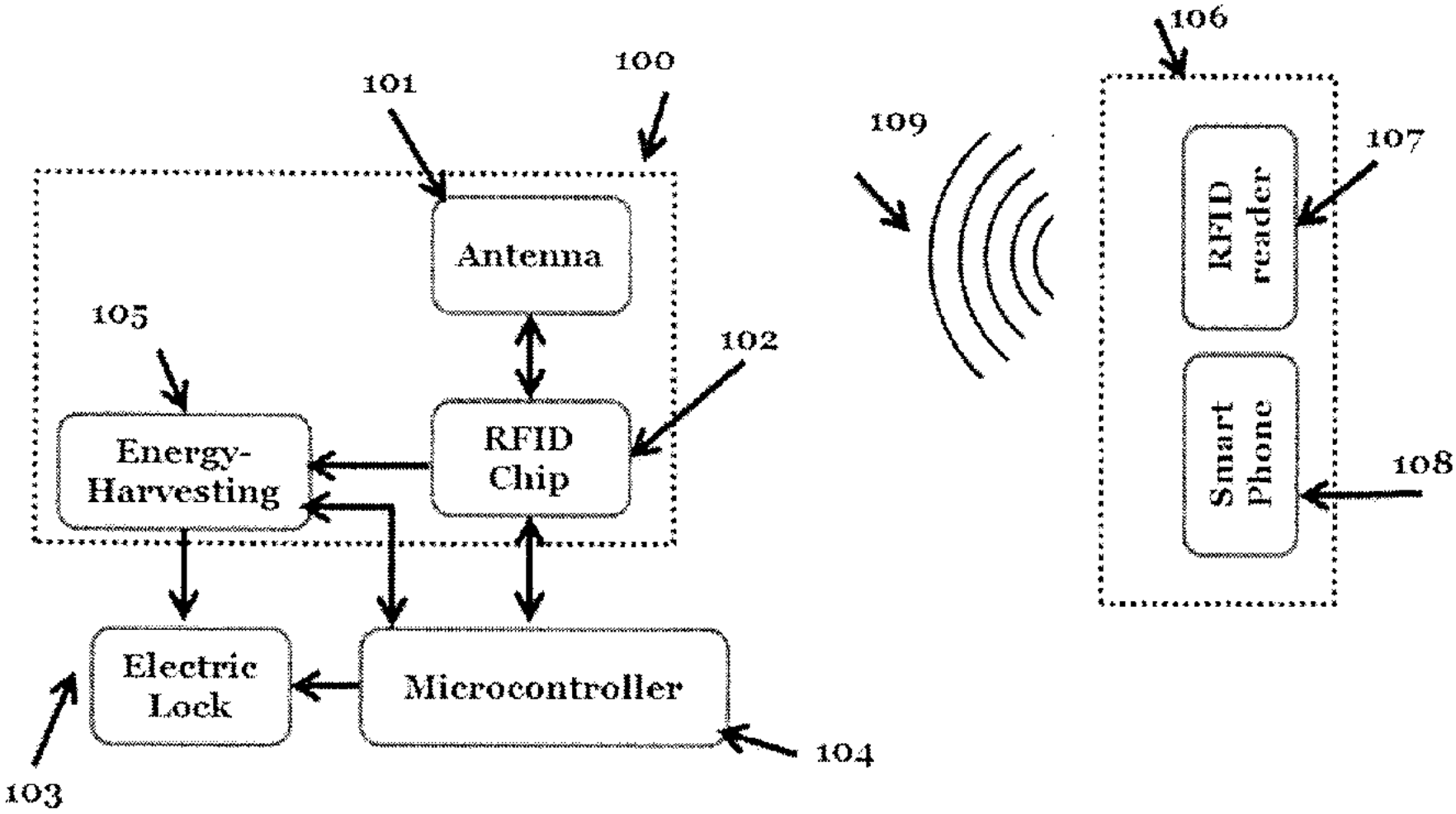

106
101
100
109
107
RFID reader
Antenna
105
102
112
Energy-Harvesting
RFID Chip
Additional Memory
Smart Phone
108
Electric Lock
Microcontroller
Electronic Devices (i.e. sensor)
103
104
114

Fig. 7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