

ANTENNA FOR RADIO FREQUENCY IDENTIFICATION SYSTEM

Field of Invention

- 5 The invention relates generally to antennas. In particular, it relates to an antenna for radio frequency identification applications.

Background

- Radio frequency (RF) communication technology is widely used in modern communication systems. One example is a radio frequency identification (RFID) system. In the RFID system, RFID reader antennas are used to transmit and receive RF signals to and from, respectively, RFID tags. Information stored in the RFID tags is usually editable and therefore updateable. The RFID system is therefore commonly used in logistical applications, such as in a warehouse for managing inventory flow.
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Near-field RFID systems normally use loop antennas for transmission and reception of RF signals. However, existing loop antennas have limited RFID coverage for effective communication with the RFID tags due to the orientation of the RFID tags.

- 20 Furthermore, many of the loop antennas have complicated structures that are undesirably difficult and costly to fabricate. High fabrication cost is incurred when a large number of the loop antennas are needed to provide the required RFID coverage.

- 25 There is therefore a need for an antenna for a RFID system for increasing RFID coverage and improving cost efficiency.

Summary

- Embodiments of the invention are disclosed hereinafter for RFID applications that increase RFID coverage and improve cost efficiency.
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In accordance with a first aspect of the invention, there is disclosed an antenna for radio frequency identification applications. The antenna has a radiating element that

comprises a first shaped segment and a second shaped segment. Each of the first and second shaped segments comprises two lobed portions. The radiating element also has a junction from where each of the first and second shaped segments extends. The first shaped segment is spatially displaced from the second shaped segment and is electrically interconnected through the junction. Specifically, one of the two lobed portions of the first shaped segment corresponds with one of the two lobed portions of the second shaped segment for forming a first loop having first current flow therethrough for inducing a first magnetic field, and the other of the two lobed portions of the first shaped segment corresponds with the other of the two lobed portions of the second shaped segment for forming a second loop having a second current flow therethrough for inducing a second magnetic field. Additionally, the first and second current flows in opposite directions and the first loop is disposed spatially adjacent to the second loop for the first and second magnetic fields to generate an interrogation region wherein induced radio frequency is identifiable.

In accordance with a second aspect of the invention, there is disclosed a method for configuring an antenna for radio frequency identification applications. The method includes providing a radiating element formed on at least one side of a substrate, which further comprises the steps of providing a first shaped segment and a second shaped segment. Each of the first and second shaped segments provides two lobed portions. The method also includes providing a junction from where each of the first and second shaped segments extends and spatially displacing the first shaped segment from the second shaped segment. The method further includes interconnecting the first and second shaped segments electrically through the junction. Specifically, one of the two lobed portions of the first shaped segment corresponds with one of the two lobed portions of the second shaped segment for forming a first loop having a first current flow therethrough for inducing a first magnetic field, and the other of the two lobed portions of the first shaped segment corresponds with the other of the two lobed portions of the second shaped segment for forming a second loop having a second current flow therethrough for inducing a second magnetic field. Additionally, the first and second current flows in opposite directions and the first loop is disposed spatially adjacent to the second loop for the first and second magnetic fields to generate an interrogation region wherein induced radio frequency is identifiable.

In accordance with a third aspect of the invention, there is disclosed a system for configuring an antenna for radio frequency identification applications. The system has a host for sending and receiving data. The system also includes a gateway that is coupled to the host for controlling the data sent to and from the host, and an RFID reader that is coupled to the gateway for reading radio frequency signals. The system further contains at least one antenna for transmitting and receiving radio frequency signals, and an antenna multiplexer that is coupled to the gateway and the RFID reader for selecting the at least one antenna for reading data, wherein the antenna comprises a radiating element having a first shaped segment couplable to a second shaped segment via at least one coupling point and forms at least one loop having two opposing lobed portions connectable to an adjacent loop via connectors for generating an interrogation region wherewithin induced radio frequency is identifiable.

Brief Description of Drawings

Embodiments of the invention are described in detail hereinafter with reference to the drawings, in which:

Fig. 1 is a plane view of an antenna according to a first embodiment of the invention;

Fig. 2 illustrates the operational principles of the antenna of Fig. 1;

Fig. 3 is a graph showing the measured returned loss of the antenna of Fig. 1,

Fig. 4 illustrates exemplary geometrical shapes of loops of the antenna of Fig. 1;

Fig. 5 is a schematic diagram showing two shaped segments of the antenna of Fig. 1 formed on the same side of a substrate;

Fig. 6 is a plane view of an impedance matching network connected to one of the loops of the antenna of Fig. 1;

Fig. 7 is a plane view of two radiating elements connected to a common feed;

Figs. 8a and 8b are three-dimensional configurations of the radiating elements of the antenna of Fig. 1;

5 Figs. 9a and 9b are exemplary configurations of the loop of the antenna of Fig. 1;

Fig. 10 is a block diagram of a system for RFID applications; and

Figs. 11 to 13 are exemplary implementations of the antenna of Fig. 1.

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Detailed Description

With reference to the drawings, an antenna for a radio frequency identification (RFID) system according to embodiments of the invention is disclosed for increasing RFID coverage and improving cost efficiency.

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For purposes of brevity and clarity, the description of the invention is limited hereinafter to near-field RFID applications. This however does not preclude various embodiments of the invention from other applications that require similar operating performance as the near-field RFID applications. The operational and functional principles fundamental to the embodiments of the invention are common throughout the various embodiments.

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In the detailed description provided hereinafter and illustrations provided in Figs. 1 to 13 of the drawings, like elements are identified with like reference numerals.

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Embodiments of the invention are described in greater detail hereinafter for an antenna for an RFID system for RFID applications.

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With reference to Fig. 1, an antenna 100 according to a first embodiment of the invention has a radiating element 102 formed along both sides of a substrate 104 for transmitting powering up signals to RFID tags and receiving RFID signals transmitted by the RFID tags. The substrate 104 is preferably planar and has a longitudinal span. Examples of the substrate 104 are printed circuit board (PCB) and non-conductive

material such as foams. A feed 106 is connectable to the radiating element 102 for providing the powering up and RFID signals to and from the radiating element 102 respectively. An impedance matching network 108 is connectable between the radiating element 102 and the feed 106 for matching the impedance between the radiating element 102 and the feed 106.

The following description of the antenna 100 is made with reference to an x-axis, a y-axis and a z-axis. The three axes are perpendicular to each other. The x and y axes extend along the substrate 104 and are coincident therewith. In particular, the x-axis extends centrally along the longitudinal span of the substrate 104.

The radiating element 102 has a first shaped segment 110 formed on one side of the substrate 104. The radiating element 102 is preferably a copper track being laid on the substrate 104. The first shaped segment 110 is preferably continuous and wave shaped. The first shaped segment 110 comprises a plurality of lobed portions 112 alternating about the x-axis.

The lobed portions 112 preferably have a geometrical shape such as a semi-circle or polygon. The lobed portions 112 are preferably arranged substantially longitudinally along the x-axis while each of the lobed portions 112 preferably protrudes away from the x-axis. Each of the lobed portions 112 terminates at two ends that face the x-axis. Each of the lobed portions 112 is preferably connected at a junction 114 where one or both ends of the lobed portions 112 are connected to an adjacent lobed portion 112 through a connector 116.

A second shaped segment 118 of the radiating element 102 is preferably formed on a side of the substrate 104 opposite to the first shaped segment 110. The second shaped segment 118 preferably has lobed portions 112 and connectors 119 that are substantially similar in shape and size as the first shaped segment 110 in order to achieve symmetry between the two segments. Although the second shaped segment 118 is substantially a duplicate of the first shaped segment 110, the second shaped segment 118 is preferably flipped about the x-axis and mirrored with respect to the first shaped segment 110. In this way, both the first and second shaped segments 110,

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118 are positioned longitudinally along the x-axis. In particular, each lobed portion 112 of the first shaped segment 110 substantially directly opposes a corresponding lobed portion 112 of the second shaped segment 118 to consequently define a loop 120.

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Alternatively, the lobed portions 112 of the first and second shaped segments 110, 118 have geometrical shapes such as a rectangle.

Fig. 2 shows the antenna 100 during operation, when an electrical current i flows through the radiating element 102 via the feed 106. The configuration of the loops 120 causes the flow of the electrical current i in any loop 120 to be in one rotational direction and any two adjacent loops 120 to be in opposite rotational directions and thereby causes alternating magnetic flux to be formed along the x-axis. In this way, the electrical currents i that flow in the two adjacent loops 120 are consequently in phase opposition.

The electrical current i energizes the loops 120 and thereby produces a magnetic field 200 that interacts to create an interrogation region 202. The interrogation region 202 is defined by a space immediately surrounding each loop 120 and between two adjacent loops 120 spaced apart by the junction 114 or connectors 116, as well as the volume above and below the substrate 104.

The magnetic field 200 energizes and powers up RFID tags 204 that are provided within the interrogation region 202. The RFID tags 204 subsequently produce RFID signals that contain tag data stored therein. The RFID signals are in turn received by the radiating element 102 and transmitted to an RFID reader via an antenna multiplexer.

The phase opposition of the electrical currents i that flow in two adjacent loops 120 advantageously produces the magnetic field 200 that is substantially uniform in amplitude throughout the interrogation region 202. This configuration of the radiating element 102 and the generation of the uniform magnetic field 200 within the

interrogation region 202 desirably allow the RFID tags 204 to be read substantially independent of the orientation of the tags 204.

The strength of the magnetic field 200 is dependable on the magnitude of the electrical current i , the area of each loop 120 and the displacement between adjacent loops 120.

Fig. 3 is a graph that shows measured returned loss of the antenna 100 at 13.56MHz. The measured results show the antenna 100 having a well-matched impedance matching characteristic at the measured frequency of 13.56MHz.

Fig. 4 shows exemplary geometrical shapes of the loop 120. The dimensions and geometrical shape of each loop 120 are dependent on design requirements. For example, the lobed portions 112 of Fig. 1 have a substantially rectangular shape such that an exemplary dimension of the width d_1 of each lobed portion 112 of the first and second shaped segments 110, 118 is preferably approximately 80 millimeters (mm). At the same time, the lateral displacement d_2 between two adjacent loops 120 is preferably approximately 65mm while the spatial distance d_3 between ends of two opposing lobed portions 120 is preferably approximately 30mm.

In a first alternative embodiment of the invention as shown in Fig. 1, the first and second shaped segments 110, 118 are formed on opposite sides of the substrate 104. The first and second shaped segments 110, 118 are therefore physically separated by the substrate 104 except at a connecting point 119. The connection of the first and second shaped segments 110, 118 is preferably achieved by forming conductive vias at the connecting point 119 so that the two sections 110, 118 are electrically couplable.

In a second alternative embodiment of the invention as shown in Fig. 5, the first and second shaped segments 110, 118 are formed on the same side of the substrate 104 and connected at the connecting point 119. Each connector 116 and any overlapping portions between the first and second shaped segments 110, 118 are preferably physically separated from an adjacent connector 119 or the overlapping portion by a dielectric layer, such as an air gap or bridge.

The impedance matching network 108 is connectable to any part of the radiating element 102 and preferably to an extremity loop 120. As shown in Fig. 6, the impedance matching network 108 is exemplarily connectable to one of the loops 120.

- 5 The first and second shaped segments 110, 118 are also connected at two connecting points 119.

Fig. 7 illustrates two radiating elements 102 connectable to a common feed 106. The two radiating elements 102 can be differently configured and are preferably arranged
10 parallel to each other. This arrangement increases the interrogation region 202 because the number of loops 120 is doubled.

The magnetic field 200 distribution within the interrogation region 202 is controllable by varying the orientation of the loop 120, as shown in Figs. 8a and 8b. For example,
15 some of the loops 120, such as the extremity loops of Fig. 8a, are formed substantially upright along the z-y plane to an adjacent loop 120. The extremity loops 120 are preferably substantially directly opposes each other. In this way, the magnetic field 200 of specific interrogation regions 202 are desirably strengthened and created for satisfying particular design requirements.

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In another example as illustrated in Fig. 8b, parts of the lobed portions 112 belonging to the loop 120 are formed along the z-x plane and are substantially perpendicular to the two extremity loops 120 formed along the z-y plane. This configuration of the loops 212 advantageously allows effective reading of RFID tags 218 that are
25 positioned in a particular plane, such as in a plane substantially parallel or perpendicular to the x-y plane.

As shown in Figs. 9a and 9b, the loop 120 of the antenna 108 may have different sizes and are arranged according to an increasing or decreasing order of the sizes.
30 Additionally, the loop 120 may be constructed from conductive materials in other geometrical forms, such as ellipses, triangles, polygons or annuli.

Fig. 10 shows a block diagram of a system 1000 according to another embodiment of the invention for RFID applications, such as reading and tracking of RFID tags. The system 1000 has a host 1002 that allows a user to send and receive data in relation to the tracking of the RFID tags. The RFID tags are typically attached to articles stored in a housing structure, such a shelf or cupboard. A gateway 1004 is coupled to the host 1002 for controlling the data sent by or to the host 1002, and an RFID reader 1006 is coupled to the gateway 1004 for reading RFID signals. The system 1000 preferably contains more than one antenna 100 for transmitting and receiving radio frequency signals and further contains an antenna multiplexer 1010 that is coupled to both the gateway 1004 and the RFID reader 1006 for switching and selecting when there is more than one antenna 100 for reading RFID signals.

The host 1002, for example a computer or mobile device like a laptop or a personal digital assistant (PDA), is preferably capable of performing wireless communication that supports specifications such as IEEE 802.11 in either ad hoc mode or infrastructure mode. The host 1002 is preferably capable of display information related to tracking of the RFID tags when requested by the user of the system 100. The host 1002 preferably further provides routing capability for supporting multiple users of the antenna system 1000.

The gateway 1004 is capable of performing either wireless or wired communication and preferably provides IEEE 802.11 wireless communication between the host 1002, the RFID reader 1006 and the antenna multiplexer 110. The IEEE 802.11 wireless communication of the gateway 1004 is preferably performed in either ad hoc mode or infrastructure mode. The ad hoc mode is more cost effective and is suitable where wireless communication infrastructure is not available. The infrastructure mode is suitable where high bandwidth communication is required, especially for managing inventory flow.

The RFID reader 1006 preferably supports reading high frequency (HF) RFID signals at 13.56 megahertz (MHz) or at other high frequencies. The RFID reader 1006 provides powering up signals to the antenna 1008 via the antenna multiplexer 1010. The powering up signals are transmitted to the RFID tags for energizing the RFID

tags. Once the RFID tags are energized, RFID signals containing tag data stored in the RFID tags are subsequently transmitted therefrom. The tag data contain information pertaining to the RFID tags. The RFID signals are received by the antenna 100 and are then read by the RFID reader 1006. The RFID reader 1006 thereafter provides the RFID signals to the host 1002 via the gateway 1004 for displaying the tag data stored in the RFID tags.

The antenna multiplexer 1010 is preferably cascadable and has a plurality of output ports for optimizing and accommodating different multi-antenna configuration requirements. The antenna multiplexer 1010 further switches and selects antennas for reading RFID tags as required by the user or users of the antenna system 1000.

The drawings as shown in Figs. 11 to 13 demonstrate exemplary implementations of the antenna 100 for reading RFID tags. The antenna 100 is shown in Fig. 11 to be attached to different locations of a shelf 1100, such as on or underneath a shelf rack 1102 and in between the shelf racks 1102. Fig. 12 shows the antenna 100 being embedded in or attached to an underside of a tabletop 1200. Fig. 13 shows the antenna 100 being attached to a curved surface 1300.

In the foregoing manner, an antenna for an RFID system for RFID applications is disclosed. Although only a number of embodiments of the invention are disclosed, it becomes apparent to one skilled in the art in view of this disclosure that numerous changes and/or modification can be made without departing from the scope and spirit of the invention. For example, the substrate may be formed in various shapes and sizes to satisfy specific design or system requirements.

Claims

1. An antenna formed on at least one side of a substrate for radio frequency
5 identification, the antenna has a radiating element comprising:
a first shaped segment;
a second shaped segment, each of the first and second shaped segments
comprising two lobed portions; and
a junction, the first shaped segment being spatially displaced from the second
10 shaped segment and being electrically interconnected through the junction wherefrom
each of the first and second shaped segments extends,
wherein one of the two lobed portions of the first shaped segment corresponds
with one of the two lobed portions of the second shaped segment for forming a first
loop having a first current flow therethrough for inducing a first magnetic field, and
15 the other of the two lobed portions of the first shaped segment corresponds with the
other of the two lobed portions of the second shaped segment for forming a second
loop having a second current flow therethrough for inducing a second magnetic field,
wherein the first current flow and the second current flow are in rotationally
opposite directions and the first loop is disposed spatially adjacent to the second loop
20 for the first and second magnetic fields to generate an interrogation region
wherewithin induced radio frequency is identifiable.
2. The antenna of claim 1, wherein the ends of corresponding lobed portions are
separated by a gap and oppose each other.
- 25 3. The antenna of claim 1, wherein the junction spatially displaces the first loop
from the second loop.
4. The antenna of claim 1, wherein the first and second shaped segments are
30 formed on opposite sides of the substrate.
5. The antenna of claim 1, wherein the first and second shaped segments form a
single continuous structure.

6. The antenna of claim 1, wherein the first and second shaped segments are one of planar and curved.
- 5 7. The antenna of claim 1, wherein electrical current flowing in the loop and an adjacent loop produces an alternating magnetic flux pattern.
8. The antenna of claim 1, wherein the two lobed portions are one of substantially identical and asymmetrical.
- 10 9. The antenna of claim 1, each of two lobed portions being planar and the plane of the first lobed portions being substantially perpendicular to the plane of the second lobed portions.
- 15 10. The antenna of claim 1, each of two lobed portions of the first and second shaped segments being planar, and the plane of one of the two lobed portions being substantially perpendicular to the plane of the other of the two lobed portions.
- 20 11. The antenna of claim 1, wherein the impedance matching network is connectable to any of the loops.
12. The antenna of claim 1, wherein a multiple of radiating elements are connectable to a common feed.
- 25 13. The antenna of claim 1, wherein the magnetic field in the interrogation region is substantially uniform in amplitude therethroughout.
14. The antenna of claim 1, wherein a feed is couplable to the radiating element.
- 30 15. The antenna of claim 1, wherein an impedance matching network is couplable to the radiating element for matching the impedance between the radiating element and the feed.

16. A method for configuring an antenna for radio frequency identification, the method comprising the steps of:

providing a radiating element formed on at least one side of a substrate;

5 wherein the step of providing the radiating element further comprising the steps of:

providing a first shaped segment;

providing a second shaped segment, each of the first and second shaped segments comprising two lobed portions; and

10 providing a junction, the first shaped segment being spatially displaced from the second shaped segment and being electrically interconnected through the junction wherefrom each of the first and second shaped segments extends,

15 wherein one of the two lobed portions of the first shaped segment corresponds with one of the two lobed portions of the second shaped segment for forming a first loop having a first current flow therethrough for inducing a first magnetic field, and the other of the two lobed portions of the first shaped segment corresponds with the other of the two lobed portions of the second shaped segment for forming a second loop having a second current flow therethrough for inducing a second magnetic field,

20 wherein the first current flow and the second current flow are in rotationally opposite directions and the first loop is disposed spatially adjacent to the second loop for the first and second magnetic fields to generate an interrogation region wherein induced radio frequency is identifiable.

17. The method of claim 16, further comprising the step of providing a feed
25 connectable to the radiating element.

18. The method of claim 16, further comprising the step of providing an impedance matching network connectable to the radiating element and the feed for matching the impedance between the radiating element and the feed.

19. The method of claim 16, wherein the magnetic field in the interrogation region is modifiable by varying the orientation of the loop.
20. The method of claim 16, wherein the connectors are separated by an air gap when the first shaped segment and the second shaped segment are formed on the same side of the substrate.
21. A system for radio frequency identification applications, the system comprising:
- 10 a host for sending and receiving data;
 - a gateway being coupled to the host for controlling the data sent to and from the host;
 - a radio frequency identification reader coupled to the gateway for reading radio frequency signals;
 - 15 at least one antenna for radio frequency identification; and
 - an antenna multiplexer being coupled to the gateway and the radio frequency identification reader for selecting the at least one antenna for reading data,
- wherein the antenna comprises a radiating element having a first shaped segment couplable to a second shaped segment via at least one coupling point and
- 20 forms at least one loop having two opposing lobed portions connectable to an adjacent loop via connectors for generating an interrogation region wherein induced radio frequency is identifiable.