

DESCRIPTION**WIRELESS TAG, COMMUNICATION TERMINAL, AND COMMUNICATION
SYSTEM****Field**

5 [0001] The present invention relates to a wireless tag,
a communication terminal, and a communication system.

Background

[0002] Individual identification is performed by a
wireless tag such as an RFID tag. The wireless tag
10 includes an IC chip and an antenna. Identification data of
an individual is recorded in the IC chip of the wireless
tag. A communication device referred to as "reader-writer"
communicates identification data with the wireless tag. An
example of techniques related to an antenna device is
15 disclosed in Patent Literature 1.

Citation List**Patent Literature**

[0003] Patent Literature 1: Japanese Laid-open Patent
Publication No. 2002-280829

20 **Summary**

Technical Problem

[0004] Depending on a positional relationship between a
communication device that transmits a radio wave and an
antenna of a wireless tag, there is a possibility that the
25 radio wave cannot be received sufficiently by the antenna
of the wireless tag. Not only in the case of the wireless
tag, but also in a case where a communication terminal
including an antenna and the communication device
communicate with each other, depending on the positional
30 relationship therebetween, there is a possibility that the
radio wave cannot be received sufficiently by the antenna
of the communication terminal.

[0005] An object of the present invention is to provide

a wireless tag and a communication terminal that can suppress reduction of receiving sensitivity. Another object of the present invention is to provide a communication system that can perform smooth communication of information.

Solution to Problem

[0006] According to a first embodiment of the present invention, there is provided a wireless tag comprising: an IC chip; a first dipole antenna that is connected to a first connection part of the IC chip and receives a radio wave; and a second dipole antenna that is connected to a second connection part of the IC chip, is provided to intersect with the first dipole antenna, and receives the radio wave simultaneously with the first dipole antenna, wherein the IC chip combines, based on the radio wave, first received power that is generated by the first dipole antenna and second received power that is generated by the second dipole antenna.

[0007] According to a second embodiment of the present invention, there is provided a communication system comprising: the wireless tag according to the first embodiment; and a communication device that communicates with the wireless tag in a contactless manner.

[0008] According to a third embodiment of the present invention, there is provided a communication terminal comprising: an IC chip; a first dipole antenna that is connected to a first connection part of the IC chip and receives a radio wave; and a second dipole antenna that is connected to a second connection part of the IC chip, is provided to intersect with the first dipole antenna, and receives the radio wave simultaneously with the first dipole antenna, wherein the IC chip combines, based on the radio wave, first received power that is generated by the

first dipole antenna and second received power that is generated by the second dipole antenna.

[0009] According to a fourth embodiment of the present invention, there is provided a communication system comprising: the communication terminal according to the third embodiment; and a communication device that communicates with the communication terminal in a contactless manner.

Advantageous Effects of Invention

10 [0010] According to the wireless tag and the communication terminal of the present invention, reduction of receiving sensitivity can be suppressed. According to the communication system of the present invention, smooth communication of information can be performed.

Brief Description of Drawings

15 [0011] FIG. 1 is a schematic diagram illustrating an example of a communication system according to a first embodiment.

FIG. 2 is a functional block diagram illustrating an example of the communication system according to the first embodiment.

FIG. 3 is a perspective view illustrating an example of a wireless tag according to the first embodiment.

FIG. 4 is a plan view illustrating an example of the wireless tag according to the first embodiment.

FIG. 5 is a diagram schematically illustrating an example of a radio wave transmitted from an antenna of a communication device according to the first embodiment.

FIG. 6 is a diagram schematically illustrating an example of a radio wave transmitted from the antenna of the communication device according to the first embodiment.

FIG. 7 is a diagram schematically illustrating a relation between a radio wave of a certain polarization

plane and received power that is output from an antenna of a wireless tag upon reception of the radio wave.

FIG. 8 is a diagram schematically illustrating an example of combined received power of first received power and second received power, when the antenna has received
5 the radio wave illustrated in FIG. 7.

FIG. 9 is a diagram schematically illustrating a relationship between a radio wave of a certain polarization plane and received power that is output from an antenna of
10 a wireless tag upon reception of the radio wave.

FIG. 10 is a diagram schematically illustrating an example of combined received power of first received power and second received power, when the antenna has received the radio wave illustrated in FIG. 9.

FIG. 11 is a diagram schematically illustrating an
15 example of the combined received power of the first received power and the second received power, when the antenna has received the radio wave illustrated in FIG. 9.

FIG. 12 is a diagram schematically illustrating a
20 relationship between a radio wave of a certain polarization plane and received power that is output from an antenna of a wireless tag upon reception of the radio wave.

FIG. 13 is a diagram schematically illustrating an example of combined received power of first received power and second received power, when the antenna has received
25 the radio wave illustrated in FIG. 12.

FIG. 14 is a diagram schematically illustrating an example of the combined received power of the first received power and the second received power, when the
30 antenna has received the radio wave illustrated in FIG. 12.

FIG. 15 is a diagram schematically illustrating a relationship between a radio wave of a certain polarization plane and received power that is output from an antenna of

a wireless tag upon reception of the radio wave.

FIG. 16 is a diagram schematically illustrating an example of combined received power of first received power and second received power, when the antenna has received
5 the radio wave illustrated in FIG. 15.

FIG. 17 is a diagram illustrating an example of received power of an antenna according to a comparative example.

FIG. 18 is a cross-sectional view illustrating an
10 example of a wireless tag according to a second embodiment.

FIG. 19 is a plan view illustrating an example of a wireless tag according to a third embodiment.

FIG. 20 is a plan view illustrating an example of a wireless tag according to a fourth embodiment.

15 FIG. 21 is a perspective view illustrating an example of a wireless tag according to a fifth embodiment.

FIG. 22 is a cross-sectional view illustrating an example of an antenna of a communication device according to a sixth embodiment.

20 FIG. 23 is a plan view illustrating an example of the antenna of the communication device according to the sixth embodiment.

FIG. 24 is a cross-sectional view illustrating an example of an antenna of a communication device according
25 to a seventh embodiment.

FIG. 25 is a cross-sectional view illustrating an example of an antenna of a communication device according to an eighth embodiment.

FIG. 26 is a plan view illustrating an example of an
30 antenna of a communication device according to a ninth embodiment.

FIG. 27 is a diagram illustrating an example of a communication system according to a tenth embodiment.

FIG. 28 is a diagram illustrating an example of a communication terminal according to an eleventh embodiment.

Description of Embodiments

[0012] Exemplary embodiments of the present invention
5 will be explained below with reference to the drawings;
however, the present invention is not limited thereto.
Constituent elements in the respective embodiments
described below can be combined with each other as
appropriate. Further, there is a case where some of these
10 constituent elements are not used. In addition, the
constituent elements in the following embodiments include
those that can be replaced and easily conceived by persons
skilled in the art, or that are substantially equivalent.
[0013] <First embodiment>

15 A first embodiment is described. FIG. 1 is a
schematic diagram illustrating an example of a
communication system 1 according to the present embodiment.
FIG. 2 is a functional block diagram illustrating an
example of the communication system 1 according to the
20 present embodiment. As illustrated in FIGS. 1 and 2, the
communication system 1 includes a wireless tag 3 provided
on goods 2 and a communication device 4 that communicates
with the wireless tag 3 in a contactless manner. The type
of the goods 2 includes products and devices.

25 [0014] In the present embodiment, the type of the
communication system 1 includes an RFID (radio frequency
identification) system. The type of the wireless tag 3
includes an RFID tag. In the present embodiment, the
wireless tag 3 is an IC tag including an IC chip 5. The
30 wireless tag 3 stores therein identification data. The
type of the communication device 4 includes a reader-writer
device that can communicate with the wireless tag 3. The
communication device 4 can acquire the identification data

of the wireless tag 3 via contactless communication (radio communication). The communication device 4 can record the identification data in the wireless tag 3 via contactless communication. The communication device 4 can update the
5 identification data of the wireless tag 3 via contactless communication.

[0015] The communication device 4 includes a controller 6, a communicator 7, an antenna 8, and a storage 9. The controller 6 includes a CPU (Central Processing Unit) and
10 controls operations of the communication device 4. The communicator 7 includes a transmitter that transmits data and a receiver that receives data. The antenna 8 is connected to the communicator 7. The antenna 8 performs transmission and reception of a radio wave. The storage 9
15 includes a storage medium such as a ROM (Read Only Memory) or a RAM (Random Access Memory). The storage 9 holds the identification data of the wireless tag 3.

[0016] The wireless tag 3 includes an antenna 10 and the IC chip 5 to which the antenna 10 is connected. The IC
20 chip 5 includes a controller 13 that processes data and a storage 14 that stores therein the identification data. The controller 13 processes received power P output from the antenna 10. The IC chip 5 can be referred to as "communication element 5" or as "transmission/reception
25 element 5".

[0017] In the present embodiment, the antenna 10 includes a first dipole antenna 11 and a second dipole antenna 12 that is provided to intersect with the first dipole antenna 11. The antenna 10 is a so-called "cross
30 dipole antenna".

[0018] Each of the first dipole antenna 11 and the second dipole antenna 12 is connected to the IC chip 5. The controller 13 processes first received power P1 output

from the first dipole antenna 11 and second received power P2 output from the second dipole antenna 12.

[0019] The storage 14 holds the identification data for distinguishing the wireless tag 3 of its own from other
5 wireless tags 3. The communication device 4 communicates with the wireless tag 3 to read the identification data stored in the storage 14 of the wireless tag 3, to write the identification data in the storage 14, and to rewrite the identification data in the storage 14. The
10 communication device 4 reads the identification data of the wireless tag 3 to identify the goods 2 to which the wireless tag 3 is attached.

[0020] An example of operations of the communication system 1 is described. When data is transmitted from the
15 communication device 4 to the wireless tag 3, a radio wave is emitted from the antenna 8 of the communication device 4. The wireless tag 3 receives the radio wave emitted from the antenna 8 by the antenna 10. Upon reception of the radio wave, the antenna 10 generates the received power P. The
20 wireless tag 3 is activated by the received power P generated by the antenna 10, and the controller 13 and the storage 14 are operated. The controller 13 performs necessary processes such as processing of the identification data.

[0021] When data is transmitted from the wireless tag 3
25 to the communication device 4, a radio wave is emitted from the antenna 10 of the wireless tag 3. The communication device 4 receives the radio wave emitted from the antenna 10 by the antenna 8. The controller 7 extracts data from
30 the radio wave received by the antenna 8.

[0022] Next, an example of the wireless tag 3 according to the present embodiment is described. In the following descriptions, an XYZ orthogonal coordinate system is set,

and positional relations among respective elements are described while referring to the XYZ orthogonal coordinate system. One direction in a predetermined plane is designated as an X-axis direction, a direction orthogonal to the X-axis direction in the predetermined plane is
5 designated as a Y-axis direction, and a direction orthogonal to each of the X-axis direction and the Y-axis direction is designated as a Z-axis direction. Rotating (tilting) directions around the X-axis, the Y-axis, and the
10 Z-axis are respectively designated as a θX direction, a θY direction, and a θZ direction.

[0023] FIG. 3 is a perspective view schematically illustrating an example of the wireless tag 3 according to the present embodiment. FIG. 4 is a plan view
15 schematically illustrating an example of the wireless tag 3 according to the present embodiment. As illustrated in FIGS. 3 and 4, the wireless tag 3 includes a base material 15, the IC chip 5 provided on the base material 15, the first dipole antenna 11 that is connected to a first
20 connection part 16 of the IC chip 5, and the second dipole antenna 12 that is provided to intersect with the first dipole antenna 11 and is connected to a second connection part 17 of the IC chip 5.

[0024] The base material 15 is a sheet-like member (a
25 flexible material) having flexibility. The base material 15 is formed of an insulating material. The base material 15 can be a sheet-like member made of synthetic resin such as polyethylene terephthalate (PET), or can be a sheet-like member made of paper. The based material 15 can be made of
30 glass.

[0025] Each of the first connection part 16 and the second connection part 17 includes a power feeding terminal. Each of the first connection part 16 and the second

connection part 17 is a metallic part (conductive part). The first connection part 16 can be referred to as "first port 16". The second connection part 17 can be referred to as "second port 17".

5 [0026] The first dipole antenna 11 and the second dipole antenna 12 receive a radio wave transmitted from the communication device 4. The first dipole antenna 11 and the second dipole antenna 12 simultaneously receive the radio wave transmitted from the communication device 4.

10 [0027] Each of the first dipole antenna 11 and the second dipole antenna 12 is formed of a conductive material. Each of the first dipole antenna 11 and the second dipole antenna 12 can be formed of metal such as aluminum or copper.

15 [0028] The first dipole antenna 11 and the first connection part 16 are in contact with each other. The first dipole antenna 11 and the first connection part 16 are fixed to each other. The second dipole antenna 12 and the second connection part 17 are in contact with each other. The second dipole antenna 12 and the second connection part 17 are fixed to each other.

[0029] In the present embodiment, two first connection parts 16 are provided. The first dipole antenna 11 includes an antenna element 11A that is connected to one of the first connection parts 16, and an antenna element 11B that is connected to the other of the first connection parts 16. Each of the antenna element 11A and the antenna element 11B has a linear shape. The antenna element 11A and the antenna element 11B are provided in parallel to the X-axis. The antenna element 11A and the antenna element 11B are provided on a virtual line that is in parallel to the X-axis and passes the IC chip 5.

30 [0030] In the present embodiment, two second connection

parts 17 are provided. The second dipole antenna 12 includes an antenna element 12A that is connected to one of the second connection parts 17, and an antenna element 12B that is connected to the other of the second connection parts 17. Each of the antenna element 12A and the antenna element 12B has a linear shape. The antenna element 12A and the antenna element 12B are provided in parallel to the Y-axis. The antenna element 12A and the antenna element 12B are provided on a virtual line that is in parallel to the Y-axis and passes the IC chip 5.

[0031] One end part of the antenna element 11A (an end part on a -X side) and the first connection part 16 are connected to each other. The other end part of the antenna element 11B (an end part on a +X side) and the first connection part 16 are connected to each other. One end part of the antenna element 12A (an end part on a -Y side) and the second connection part 17 are connected to each other. The other end part of the antenna element 12B (an end part on a +Y side) and the second connection part 17 are connected to each other.

[0032] Each of the antenna element 11A, the antenna element 11B, the antenna element 12A, and the antenna element 12B is connected to the IC chip 5 so as to extend in an emitting direction from the IC chip 5.

[0033] In the present embodiment, a size (length) L1 of the antenna element 11A and a size (length) L1 of the antenna element 11B, both of which are directed in the X-axis direction, are equal. A size (length) L2 of the antenna element 12A and a size (length) L2 of the antenna element 12B, both of which are directed in the Y-axis direction, are equal. The lengths L1 of the antenna element 11A and the antenna element 11B and the lengths L2 of the antenna element 12A and the antenna element 12B are

equal.

[0034] A size (width) $W1$ of the antenna element 11A and a size (width) $W1$ of the antenna element 11B, both of which are directed in the Y-axis direction, are equal. A size
5 (width) $W2$ of the antenna element 12A and a size (width) $W2$ of the antenna element 12B, both of which are directed in the X-direction, are equal. The widths $W1$ of the antenna element 11A and the antenna element 11B and the sizes
10 (widths) $W2$ of the antenna element 12A and the antenna element 12B are equal.

[0035] That is, in the present embodiment, structures (outlines) of the antenna element 11A, the antenna element 11B, the antenna element 12A, and the antenna element 12B are substantially the same.

15 [0036] In the present embodiment, the first dipole antenna 11 and the second dipole antenna 12 are provided to be orthogonal to each other. In the XY plane that is in parallel to a top surface of the base material 15, an angle θ formed by the first dipole antenna 11 and the second
20 dipole antenna 12 is substantially 90 degrees.

[0037] FIG. 5 is a diagram schematically illustrating an example of a radio wave transmitted from the antenna 8 of the communication device 4. In FIG. 5, the radio wave moves in the Z-axis direction. The radio wave includes an
25 electric field and a magnetic field. In FIG. 5, the electric-field vector (the polarization direction) of the radio wave is in parallel to the X-axis. That is, a polarization plane of the radio wave illustrated in FIG. 5 is in parallel to the XZ plane. In the following
30 descriptions, the radio wave illustrated in FIG. 5 is referred to as "radio wave in the first linear polarization state".

[0038] FIG. 6 is a diagram schematically illustrating an

example of a radio wave transmitted from the antenna 8 of the communication device 4. In FIG. 6, the radio wave moves in the Z-axis direction. The radio wave includes an electric field and a magnetic field. In FIG. 6, the electric-field vector (the polarization direction) of the radio wave is in parallel to the Y-axis. That is, a polarization plane of the radio wave illustrated in FIG. 6 is in parallel to the YZ plane. In the following descriptions, the radio wave illustrated in FIG. 6 is referred to as "radio wave in the second linear polarization state".

[0039] The electric-field vector (the polarization plane) of the radio wave in the first linear polarization state and the electric-field vector (the polarization plane) of the radio wave in the second linear polarization state are orthogonal to each other.

[0040] As illustrated in FIG. 5, when a positional relationship between the communication device 4 and the wireless tag 3 is set such that the longitudinal direction of the first dipole antenna 11 and the electric-field vector of the radio wave in the first linear polarization state are in parallel to each other, the first dipole antenna 11 can receive the radio wave in the first linear polarization state with high sensitivity. In other words, when the longitudinal direction of the first dipole antenna 11 and the electric-field vector of the radio wave match each other, the first received power P1 output from the first dipole antenna 11 is maximized.

[0041] As illustrated in FIG. 6, when a positional relation between the communication device 4 and the wireless tag 3 is set such that the longitudinal direction of the second dipole antenna 12 and the electric-field vector of the radio wave in the second linear polarization

state are in parallel to each other, the second dipole antenna 12 can receive the radio wave in the second linear polarization state with high sensitivity. In other words, when the longitudinal direction of the second dipole antenna 12 and the electric-field vector of the radio wave match each other, the second received power P2 output from the second dipole antenna 12 is maximized.

[0042] As described above, in the present embodiment, the antenna 10 can receive both the radio wave in the first linear polarization state and the radio wave in the second linear polarization state with high sensitivity by using the first dipole antenna 11 and the second dipole antenna 12.

[0043] Next, an example of operations of the communication system 1 according to the present embodiment is described. In the present embodiment, the first dipole antenna 11 and the second dipole antenna 12 simultaneously receive the same radio wave transmitted from the communication device 4. The IC chip 5 of the wireless tag 3 combines the first received power P1 that is generated by the first dipole antenna 11 based on the received radio wave and the second received power P2 that is generated by the second dipole antenna 12 based on the received radio wave.

[0044] Upon reception of the radio wave, the first dipole antenna 11 generates the first received power P1. The first dipole antenna 11 outputs the first received power P1 based on a radio-wave component Dx of the received radio wave, which is directed in the longitudinal direction (the X-axis direction) of the first dipole antenna 11. The first received power P1 is a value corresponding to the radio-wave component Dx of the radio wave received by the first dipole antenna 11, which is directed in the

longitudinal direction (the X-axis direction) of the first dipole antenna 11. The radio-wave component D_x is a concept including the amplitude and intensity of the radio wave directed in the X-axis direction.

5 [0045] Upon reception of the radio wave, the second dipole antenna 12 generates the second received power P_2 . The second dipole antenna 12 outputs the second received power P_2 based on a radio-wave component D_y of the received radio wave, which is directed in the longitudinal direction
10 (the Y-axis direction) of the second dipole antenna 12. The second received power P_2 is a value corresponding to the radio-wave component D_y of the radio wave received by the second dipole antenna 12, which is directed in the longitudinal direction (the Y-axis direction) of the second
15 dipole antenna 12. The radio-wave component D_y is a concept including the amplitude and intensity of the radio wave directed in the X-axis direction.

[0046] In the present embodiment, the controller 13 of the IC chip 5 combines the first received power P_1 that is
20 generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12, and outputs combined received power P_m . The controller 13 performs a computation for combining the first received power P_1 and the second received power P_2 ,
25 and generates the combined received power P_m . For example, the controller 13 combines the first received power P_1 and the second received power P_2 , and outputs the combined power as the combined received power P_m . That is, the controller 13 calculates a combined value between a first
30 component of the first received power P_1 directed in the longitudinal direction (the X-axis direction) of the first dipole antenna 11 and a second component of the second received power P_2 directed in the longitudinal direction

(the Y-axis direction) of the second dipole antenna 12, and outputs the combined value as the combined received power P_m . In the following descriptions, it is assumed that the first received power P_1 is in parallel to the X-axis and the second received power P_2 is in parallel to the Y-axis.

[0047] FIG. 7 is a diagram schematically illustrating a relation between a radio wave of a certain polarization plane and the received power P that is output from the antenna 10 upon reception of the radio wave. FIG. 7

illustrates an example in which the longitudinal direction of the first dipole antenna 11 and the polarization plane of the radio wave match each other. As illustrated in FIG. 7, when the longitudinal direction of the first dipole antenna 11 and the polarization plane of the radio wave match each other, the first received power P_1 that is output from the first dipole antenna 11 is maximized. On the other hand, the second received power P_2 that is output from the second dipole antenna 12 is minimized.

[0048] FIG. 8 is a diagram schematically illustrating an example of the combined received power P_m in which the first received power P_1 and the second received power P_2 are combined, when the antenna 10 has received the radio wave illustrated in FIG. 7. The controller 13 of the IC chip 5 combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12, and outputs the combined received power P_m . In the examples illustrated in FIGS. 7 and 8, the second received power P_2 is substantially zero. The combined received power P_m is substantially equal to the first received power P_1 .

[0049] FIG. 9 is a diagram schematically illustrating a relation between a radio wave of a certain polarization

plane and the received power P that is output from the antenna 10 upon reception of the radio wave. FIG. 9 illustrates an example in which the polarization plane of the radio wave is tilted with respect to the longitudinal direction of the first dipole antenna 11. As illustrated in FIG. 9, when the polarization plane of the radio wave is tilted with respect to the longitudinal direction of the first dipole antenna 11, the first received power P_1 is output from the first dipole antenna 11, and the second received power P_2 is output from the second dipole antenna 12.

[0050] FIG. 10 is a diagram schematically illustrating an example of the combined received power P_m in which the first received power P_1 and the second received power P_2 are combined, when the antenna 10 has received the radio wave illustrated in FIG. 9. The controller 13 of the IC chip 5 combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12, and outputs the combined received power P_m . In the examples illustrated in FIGS. 9 and 10, the first received power P_1 is larger than the second received power P_2 . The combined received power P_m has a value based on the first received power P_1 and the second received power P_2 .

[0051] In FIG. 10, the first received power P_1 and the second received power P_2 are composited in a scalar manner; however, as illustrated in FIG. 11, when the first received power P_1 and the second received power P_2 have a phase difference, they can be composited in a vector manner. That is, as illustrated in FIG. 11, it is also possible that a composite vector of a vector of the first received power P_1 and a vector of the second received power P_2 is

obtained to output the composite vector as the combined received power P_m . That is, it is possible that an absolute value of a composite vector of a first vector component of the first received power P_1 directed in the longitudinal direction (the X-axis direction) of the first dipole antenna 11 and a second vector component of the second received power P_2 directed in the longitudinal direction (the Y-axis direction) of the second dipole antenna 12 is obtained to output the absolute value of the composite vector as the combined received power P_m .

[0052] FIG. 12 is a diagram schematically illustrating a relationship between a radio wave of a certain polarization plane and the received power P that is output from the antenna 10 upon reception of the radio wave. FIG. 12 illustrates an example in which the polarization plane of the radio wave is tilted with respect to the longitudinal direction of the second dipole antenna 12. As illustrated in FIG. 12, when the polarization plane of the radio wave is tilted with respect to the longitudinal direction of the second dipole antenna 12, the first received power P_1 is output from the second dipole antenna 11, and the second received power P_2 is output from the second dipole antenna 12.

[0053] FIG. 13 is a diagram schematically illustrating an example of the combined received power P_m in which the first received power P_1 and the second received power P_2 are combined, when the antenna 10 has received the radio wave illustrated in FIG. 12. The controller 13 of the IC chip 5 combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12, and outputs the combined received power P_m . In the examples illustrated in FIGS. 12 and 13, the second

received power P_2 is larger than the first received power P_1 . The combined received power P_m has a value based on the first received power P_1 and the second received power P_2 .

5 [0054] In FIG. 13, the first received power P_1 and the second received power P_2 are composited in a scalar manner; however, as illustrated in FIG. 14, when the first received power P_1 and the second received power P_2 have a phase difference, they can be composited in a vector manner.

10 [0055] FIG. 15 is a diagram schematically illustrating a relationship between a radio wave of a certain polarization plane and the received power P that is output from the antenna 10 upon reception of the radio wave. FIG. 15 illustrates an example in which the longitudinal direction of the second dipole antenna 12 and the polarization plane of the radio wave match each other. As illustrated in FIG. 15, when the longitudinal direction of the second dipole antenna 12 and the polarization plane of the radio wave match each other, the second received power P_2 output from the second dipole antenna 12 is maximized. On the other hand, the first received power P_1 that is output from the first dipole antenna 11 is minimized.

[0056] FIG. 16 is a diagram schematically illustrating an example of the combined received power P_m in which the first received power P_1 and the second received power P_2 are combined, when the antenna 10 has received the radio wave illustrated in FIG. 15. The controller 13 of the IC chip 5 combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12, and outputs the combined received power P_m . In the examples illustrated in FIGS. 15 and 16, the first received power P_1 is substantially zero. The combined

received power P_m is substantially equal to the second received power P_2 .

[0057] The controller 13 performs necessary processes such as processing of identification data based on the combined received power P_m . For example, the controller 13 stores the identification data in the storage 14 based on the combined received power P_m . It is possible that the controller 13 updates data in the storage 14 based on the combined received power P_m .

10 [0058] As described above, according to the present embodiment, it is configured that the IC chip 5 combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12 to generate the combined received power P_m . Therefore, reduction of the reception sensitivity of the wireless tag 3 can be suppressed. In the present embodiment, because the antenna (cross dipole antenna) 10 including the first dipole antenna 11 and the second dipole antenna 12 that intersects with the first dipole antenna 11 receives a radio wave transmitted from the communication device 4, even when the polarization state of the radio wave changes or only one of the radio wave in the first linear polarization state and the radio wave in the second linear polarization state is transmitted, a combined received power P_m of a desired value can be obtained. Therefore, reduction of the reception sensitivity of the wireless tag 3 can be suppressed.

[0059] FIG. 17 is a diagram illustrating a comparative example. As illustrated in FIG. 17, in a case where an antenna 10J includes only a dipole antenna that is long in the X-axis direction, when a radio wave having a polarization plane tilted with respect to the longitudinal

direction of the antenna 10J is transmitted to the antenna 10J, the value of received power PJ that is generated by the antenna 10J becomes small. Similarly, in a case where the antenna 10J includes only a dipole antenna that is long in the Y-axis direction, even when a radio wave having a polarization plane tilted with respect to the longitudinal direction of the antenna 10J is transmitted to the antenna 10J, the value of the received power PJ that is generated by the antenna 10J becomes small.

10 [0060] Furthermore, in a case where the antenna 10J includes only a dipole antenna that is long in the X-axis direction, when a radio wave in the second linear polarization state is transmitted to the antenna 10J, the value of the received power PJ that is generated by the antenna 10J becomes small. Similarly, in a case where the antenna 10J includes only a dipole antenna that is long in the Y-axis direction, when a radio wave in the first linear polarization state is transmitted to the antenna 10J, the value of the received power PJ that is generated by the antenna 10J becomes small. As a result, the reception sensitivity of the antenna 10J is reduced.

[0061] According to the present embodiment, the antenna 10 includes both the first dipole antenna 11 and the second dipole antenna 12. Therefore, regardless of the polarization state of the radio wave to be transmitted, the radio wave can be received with high sensitivity.

[0062] Further, because the first dipole antenna 11 and the second dipole antenna 12 are provided to be orthogonal to each other, regardless of the polarization state of the radio wave to be transmitted, the antenna 10 can receive the radio wave with high sensitivity.

[0063] <Second embodiment>

A second embodiment is described. In the following

descriptions, constituent parts identical or equivalent to those described in the above embodiment are denoted with the same reference signs and descriptions thereof will be omitted.

5 [0064] FIG. 18 is a cross-sectional view illustrating an example of a wireless tag 3B according to the present embodiment. The wireless tag 3B includes a base material 15, an IC chip 5 provided on the base material 15, and a first dipole antenna 11 and a second dipole antenna 12 that
10 are connected to the IC chip 5.

[0065] In the present embodiment, the wireless tag 3B includes a dielectric body 18 that is provided to be in contact with both the first dipole antenna 11 and the second dipole antenna 12. The type of the dielectric body
15 18 includes an insulator such as glass. In the present embodiment, the dielectric body 18 has a plate shape. The IC chip 5, the first dipole antenna 11, and the second dipole antenna 12 are provided between the base material 15 and the dielectric body 18.

20 [0066] When the dielectric body 18 is not provided, the length of the first dipole antenna 11 is $L1$, and the length of the second dipole antenna 12 is $L2$. When the dielectric body 18 having a dielectric constant ϵ_r is provided, the length of the first dipole antenna 11 becomes $L1/(\epsilon_r)^{1/2}$,
25 and the length of the second dipole antenna 12 becomes $L2/(\epsilon_r)^{1/2}$. That is, by providing the dielectric body 18, the lengths of the first dipole antenna 11 and the second dipole antenna 12 can be reduced.

[0067] As described above, according to the present
30 embodiment, because the dielectric body 18 is provided, the sizes of the first dipole antenna 11 and the second dipole antenna 12 can be reduced. Accordingly, downsizing of the

wireless tag 3B can be achieved.

[0068] <Third embodiment>

A third embodiment is described. In the following descriptions, constituent parts identical or equivalent to those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0069] FIG. 19 is a cross-sectional view illustrating an example of a wireless tag 3C according to the present embodiment. The wireless tag 3C includes a base material 15, an IC chip 5C provided on the base material 15, a first dipole antenna 11 that is connected to a first connection part 16C of the IC chip 5C, and a second dipole antenna 12 that is connected to a second connection part 17C of the IC chip 5C.

[0070] The first dipole antenna 11 and the second dipole antenna 12 are provided to intersect with each other. In the present embodiment, the first dipole antenna 11 and the second dipole antenna 12 are not orthogonal to each other.

[0071] As described above, the first dipole antenna 11 and the second dipole antenna 12 do not need to be orthogonal to each other. As the IC chip 5C combines the first received power P_1 that is generated by the first dipole antenna 11 and the second received power P_2 that is generated by the second dipole antenna 12 to generate the combined received power P_m , reduction of the reception sensitivity of the wireless tag 3C is suppressed.

[0072] <Fourth embodiment>

A fourth embodiment is described. In the following descriptions, constituent parts identical or equivalent to those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0073] FIG. 20 is a cross-sectional view illustrating an example of a wireless tag 3D according to the present embodiment. The wireless tag 3D includes a base material 15, an IC chip 5D provided on the base material 15, a first dipole antenna 11D that is connected to a first connection part 16D of the IC chip 5D, and a second dipole antenna 12D that is connected to a second connection part 17D of the IC chip 5D.

[0074] In the present embodiment, each of the first dipole antenna 11D and the second dipole antenna 12D has a meander shape. That is, each of the first dipole antenna 11D and the second dipole antenna 12D is a so-called "meander line antenna".

[0075] The first dipole antenna 11D is provided along a central axis G1. Some parts of the first dipole antenna 11D are provided on one side of the central axis G1 and also some parts of the first dipole antenna 11D are provided on the other side of the central axis G1. The second dipole antenna 12D is provided along a central axis G2. Some parts of the second dipole antenna 12D are provided on one side of the central axis G2 and also some parts of the second dipole antenna 12D are provided on the other side of the central axis G2.

[0076] In the present embodiment, the central axis G1 and the central axis G2 are orthogonal to each other. Note that the central axis G1 and the central axis G2 do not need to be orthogonal to each other. It suffices that the central axis G1 and the central axis G2 intersect with each other, and the angle formed by the central axis G1 and the central axis G2 can be an angle smaller than 90 degrees.

[0077] <Fifth embodiment>

A fifth embodiment is described. In the following descriptions, constituent parts identical or equivalent to

those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0078] FIG. 21 is a cross-sectional view illustrating an example of a wireless tag 3E according to the present embodiment. The wireless tag 3E includes an IC chip 5E, a first dipole antenna 11E that is connected to a first connection part 16E of the IC chip 5E, a second dipole antenna 12E that is connected to a second connection part 17E of the IC chip 5E, and a third dipole antenna 13E that is connected to a third connection part 18E of the IC chip 5E.

[0079] Each of an antenna element of the first dipole antenna 11E, an antenna element of the second dipole antenna 12E, and an antenna element of the third dipole antenna 13E is connected to the IC chip 5E so as to extend from the IC chip 5E in a radiation direction.

[0080] The first dipole antenna 11E and the second dipole antenna 12E are orthogonal to each other. The second dipole antenna 12E and the third dipole antenna 13E are orthogonal to each other. The third dipole antenna 13E and the first dipole antenna 11E are orthogonal to each other. The longitudinal direction of the first dipole antenna 11E is in parallel to the X-axis. The longitudinal direction of the second dipole antenna 12E is in parallel to the Y-axis. The longitudinal direction of the third dipole antenna 13E is in parallel to the Z-axis.

[0081] The IC chip 5E combines the first received power P_1 that is generated by the first dipole antenna 11E, the second received power P_2 that is generated by the second dipole antenna 12E, and the third received power P_3 that is generated by the third dipole antenna 13E to generate the combined received power P_m .

[0082] As described above, a set of three dipole

antennas (11E, 12E, and 13E) can be connected to the IC chip 5E. The IC chip 5E combines the first received power P1 that is generated by the first dipole antenna 11E, the second received power P2 that is generated by the second dipole antenna 12E, and the third received power P3 that is generated by the third dipole antenna 13E to generate the combined received power Pm, thereby suppressing reduction of the reception sensitivity of the wireless tag 3E.

[0083] <Sixth embodiment>

10 A sixth embodiment is described. In the following descriptions, constituent parts identical or equivalent to those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

15 [0084] FIG. 22 is a cross-sectional view illustrating an example of an antenna 8F of the communication device 4 according to the present embodiment. FIG. 23 is a plan view illustrating an example of the antenna 8F of the communication device 4 according to the present embodiment.

20 [0085] In the present embodiment, the antenna 8F is a patch antenna that transmits a radio wave of a circular polarized wave. As illustrated in FIGS. 22 and 23, the patch antenna (microstrip antenna) 8F includes a radiator 21 that radiates a radio wave, a dielectric body 22 that is provided to be in contact with the radiator 21, a base plate 23 that supports the dielectric body 22, and a power feeder 24 that is provided to be in contact with the radiator 21.

25 [0086] The radiator 21 is a conductive plate-shaped member. The radiator 21 is made of metal such as copper. The dielectric body 22 is an insulating member such as a plastic plate. The base plate 23 is a conductive plate-shaped member. The base plate 23 is made of metal such as

copper. The type of the power feeder 24 includes a coaxial cable, for example. The power feeder 24 is provided so as not to be in contact with the base plate 23. As power is supplied via the power feeder 24 to the radiator 21, a
5 radio wave is radiated from a top surface (a radiation surface) 21S of the radiator 21.

[0087] The base plate 23 is provided with a gap with respect to the radiator 21. The dielectric body 22 is provided between the radiator 21 and the base plate 23.

10 The dielectric body 22 is provided to be in contact with each of the radiator 21 and the base plate 23, which are conductive members.

[0088] As illustrated in FIG. 23, in a plane that is in parallel to the top surface of the base plate 23, the
15 outline of the radiator 21 is hexagonal. In the present embodiment, the radiator 21 is manufactured by providing notches 21K on some parts of a square plate. Because the outline of the radiator 21 is hexagonal, resonant frequency of the radiator 21 directed in the X-axis direction and
20 resonant frequency of the radiator 21 directed in the Y-axis direction are different from each other. Accordingly, a radio wave of a circular polarized wave is radiated from the top surface (the radiation surface) 21S of the radiator 21.

25 [0089] As described above, according to the present embodiment, because a radio wave of a circular polarized wave is transmitted from the antenna 8F, even if a wireless tag (such as the wireless tag 3) faces an arbitrary direction, the wireless tag can receive the radio wave
30 transmitted from the antenna 8F with high sensitivity.

[0090] <Seventh embodiment>

A seventh embodiment is described. In the following descriptions, constituent parts identical or equivalent to

those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0091] FIG. 24 is a cross-sectional view illustrating an
5 example of an antenna 8G of the communication device 4 according to the present embodiment. The antenna 8G is a patch antenna. The present embodiment is a modification of the sixth embodiment described above.

[0092] The antenna 8G includes a radiator 21 that
10 radiates a radio wave, a dielectric body 22 that is provided to be in contact with the radiator 21, a base plate 23 that supports the dielectric body 22, and a power feeder 24 that is provided to be in contact with the radiator 21. In the present embodiment, the antenna 8G
15 includes a dielectric body 25 that is provided to be in contact with the top surface 21S of the radiator 21. The dielectric body 22 is provided to be in contact with a rear surface of the radiator 21. The radiator 21 is provided between the dielectric body 22 and the dielectric body 25.
20 The type of the dielectric body 25 includes an insulator such as glass. In the present embodiment, the dielectric body 25 has a plate shape.

[0093] As described above, according to the present embodiment, as the dielectric body 25 is provided, the size
25 of the radiator 21 can be reduced. Accordingly, downsizing of the antenna 8G can be achieved.

[0094] <Eighth embodiment>

An eighth embodiment is described. In the following descriptions, constituent parts identical or equivalent to
30 those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0095] FIG. 25 is a cross-sectional view illustrating an

example of an antenna 8H of the communication device 4 according to the present embodiment. The antenna 8H is a patch antenna and includes a radiator 21, a base plate 23 that is provided to face the radiator 21 with a gap therebetween, and a power feeder 24 that is provided to be in contact with the radiator 21. In the present embodiment, air is filled in the gap between the radiator 21 and the base plate 23. In the present embodiment, the antenna 8H is an air-gap patch antenna.

10 [0096] As described above, the gap between the radiator 21 and the base plate 23 can be filled with air. Accordingly, a dielectric body (the dielectric body 22) becomes unnecessary, and thus cost reduction of the communication device 4 can be achieved.

15 [0097] <Ninth embodiment>

A ninth embodiment is described. In the following descriptions, constituent parts identical or equivalent to those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

20 [0098] FIG. 26 is a plan view illustrating an example of an antenna 8I of the communication device 4 according to the present embodiment. The antenna 8I is a patch antenna and includes a base plate 23 and a plurality of radiators 21 that are provided on the base plate 23. The plurality of the radiators 21 are provided in an arrayed form. According to the present embodiment, because the plurality of radiators 21 are provided on 11 base plates 23, cost reduction in manufacturing of the antenna 8I can be achieved.

30

[0099] <Tenth embodiment>

A tenth embodiment is described. In the following descriptions, constituent parts identical or equivalent to

those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0100] In the present embodiment, an application example of the communication system 1 described in the above
5 embodiments is described. FIG. 27 is a diagram illustrating an application example of the communication system 1 according to the present embodiment. FIG. 27 illustrates an example in which the communication system 1
10 is used in an electronic toll collection system (ETC system).

[0101] A wireless tag 3 is mounted on a vehicle 200. The wireless tag 3 is provided in an in-vehicle device of an ETC system. The in-vehicle device functions as a
15 communication terminal mounted on the vehicle 200. The wireless tag includes identification data for distinguishing a plurality of vehicles 200.

[0102] A communication device 4 is provided at an ETC gate. The communication device 4 communicates with the
20 wireless tag 3 mounted on the vehicle 200 and identifies the vehicle 200 that passes the ETC gate. In the present embodiment, because the reception sensitivity of the wireless tag 3 is high, the communication device 4 can smoothly communicate with the wireless tag 3 in a state
25 where the wireless tag 3 is mounted on the vehicle 200 on moving.

[0103] The wireless tag 3 can be attached on a windshield of the vehicle 200. By providing the first dipole antenna 11 and the second dipole antenna 12 of the
30 wireless tag 3 to be in contact with the windshield of the vehicle 200, the windshield functions as a dielectric body. That is, the windshield of the vehicle 200 can be used as the dielectric body (the dielectric body 18) described

above with reference to FIG. 18. As the IC chip 5, the first dipole antenna 11, and the second dipole antenna 12 are provided between the base material 15 and the windshield (the dielectric body), the sizes of the first dipole antenna 11 and the second dipole antenna 12 can be reduced. Accordingly, downsizing of the wireless tag 3 can be achieved.

[0104] <Eleventh embodiment>

An eleventh embodiment is described. In the following descriptions, constituent parts identical or equivalent to those described in the above embodiments are denoted with the same reference signs and descriptions thereof will be omitted.

[0105] FIG. 28 is a diagram illustrating an example of a communication terminal 30 according to the present embodiment. The type of the communication terminal 30 includes a portable terminal such as a smartphone (a portable telephone). The communication terminal 30 includes an IC chip 5, a first dipole antenna 11 that is connected to a first connection part 16 of the IC chip 5 and receives a radio wave, and a second dipole antenna 12 that is connected to a second connection part 17 of the IC chip 5, is provided to intersect with the first dipole antenna 11, and receives the radio wave simultaneously with the first dipole antenna 11, as described in the above embodiments. The IC chip 5 combines, based on the radio wave, a first received power P1 that is generated by the first dipole antenna 11 and a second received power P2 that is generated by the second dipole antenna 12.

[0106] The communication terminal 30 can communicate in a contactless manner with the communication device 4 that is described in the above embodiments. For example, the communication device 4 may be provided in an automatic

ticket checker, or may be provided in an automatic vending machine. The communication device 4 communicates with the communication terminal 30 in a contactless manner, thereby the communication device 4 can identify the communication terminal 30 and can perform charging.

Reference Signs List

	[0107]	1	communication system
		2	goods
		3	wireless tag
10		4	communication device
		5	IC chip
		6	controller
		7	communicator
		8	antenna
15		9	storage
		10	antenna
		11	first dipole antenna
		11A	antenna element
		11B	antenna element
20		12	second dipole antenna
		12A	antenna element
		12B	antenna element
		13	controller
		14	storage
25		15	base material
		16	first connection part
		17	second connection part
		18	dielectric body
		21	radiator
30		21K	notch
		21S	top surface
		22	dielectric body
		23	base plate

	24	power feeder
	25	dielectric body
	30	communication terminal
	200	vehicle
5	Dx	radio-wave component
	Dy	radio-wave component
	L1	length
	L2	length
	P1	first received power
10	P2	second received power
	Pm	combined received power
	W1	width
	W2	width

CLAIMS

1. A wireless tag comprising:
 - an IC chip; and
 - an antenna including
 - a first dipole antenna that is connected to a first connection part of the IC chip and receives a radio wave, and
 - a second dipole antenna that is connected to a second connection part of the IC chip, is provided to be orthogonal to the first dipole antenna, and receives the radio wave simultaneously with the first dipole antenna, wherein
 - the antenna is configured to receive the radio wave in a first linear polarization state and the radio wave in a second linear polarization state wherein a polarization plane of the radio wave in the second linear polarization state is orthogonal to a polarization plane of the radio wave in the first linear polarization state,
 - the first dipole antenna is configured to output a first received power based on a first radio-wave component of the received radio wave, which is directed in a longitudinal direction of the first dipole antenna,
 - the second dipole antenna is configured to output a second received power based on a second radio-wave component of the received radio wave, which is directed in a longitudinal direction of the second dipole antenna, and
 - the IC chip is configured to calculate a combined value between a first component of the first received power directed in the longitudinal direction of the first dipole antenna and a second component of the second received power directed in the longitudinal direction of the second dipole antenna, and outputs the combined value as a combined received power.
2. The wireless tag according to claim 1, comprising a dielectric body that is provided to be in contact with each of the first dipole antenna and the second dipole antenna.
3. A communication system comprising:
 - the wireless tag according to claim 1 or 2; and
 - a communication device that communicates with the wireless tag in a contactless manner.
4. The communication system according to claim 3, wherein the communication device includes a patch antenna that transmits a radio wave of a circular

polarized wave.

5. The communication system according to claim 4, comprising a dielectric body that is provided to be in contact with a conductive part of the patch antenna.

6. The communication system according to claim 4 or 5, wherein the patch antenna includes

a radiator that radiates a radio wave, and

a conductive base plate that is provided with a gap with respect to the radiator.

7. A communication terminal comprising:

an IC chip;

an antenna including

a first dipole antenna that is connected to a first connection part of the IC chip and receives a radio wave, and

a second dipole antenna that is connected to a second connection part of the IC chip, is provided to be orthogonal to the first dipole antenna, and receives the radio wave simultaneously with the first dipole antenna, wherein

the antenna is configured to receive the radio wave in a first linear polarization state and the radio wave in a second linear polarization state wherein a polarization plane of the radio wave in the second linear polarization state is orthogonal to a polarization plane of the radio wave in the first linear polarization state,

the first dipole antenna is configured to output a first received power based on a first radio-wave component of the received radio wave, which is directed in a longitudinal direction of the first dipole antenna,

the second dipole antenna is configured to output a second received power based on a second radio-wave component of the received radio wave, which is directed in a longitudinal direction of the second dipole antenna, and

the IC chip is configured to calculate a combined value between a first component of the first received power directed in the longitudinal direction of the first dipole antenna and a second component of the second received power directed in the longitudinal direction of the second dipole antenna, and outputs the combined value as a combined received power.

8. A communication system comprising:

the communication terminal according to claim 7; and

a communication device that communicates with the communication terminal in a contactless manner.