

DESCRIPTION

ANTENNA DEVICE

5 Technical Field

[0001]

The present invention relates to an antenna device of a reader/writer or the like for passive ID tags.

Priority is claimed on Japanese Patent Application No. 2010-218634, filed

10 September 29, 2010, the content of which is incorporated herein by reference.

Background Art

[0002]

For example, antenna devices of reader/writers or the like for passive ID tags

15 include a transmitting antenna (which transmits primary radio waves to an antenna that is different from a receiving antenna) that transmits radio waves to a responder for RF tags or the like that performs exchange of information and a receiving antenna that receives radio waves transmitted from the responder, adjacent to each other, and are configured such that the receiving antenna receives reception radio waves transmitted from the

20 responder while the transmitting antenna transmits radio waves (primary radio waves) to the responder, and the transmitting antenna and the receiving antenna simultaneously perform the transmission and reception of radio waves.

[0003]

On the other hand, in this type of antenna device, if some leaked radio waves

25 leaked from the transmitting antenna are directly or indirectly received by the receiving

antenna, the leaked radio waves become large interference waves, distortion occurs in an antenna pattern, and the receiving characteristics of the receiving antenna deteriorate.

Consequently, there is a possibility that gains or phase characteristics (isolation) cannot be secured. If a sufficient distance is provided between the transmitting antenna and the receiving antenna, the isolation can be secured. However, in many cases, it is actually difficult to space the transmitting antenna and the receiving antenna apart from each other in this way.

[0004]

In the related art, it is suggested and put in practical use that a radio wave shield is provided between the transmitting antenna and the receiving antenna, and the leaked radio waves are cut off between the transmitting antenna and the receiving antenna by this radio wave shield to secure isolation (for example, refer to Patent Document 1 and Patent Document 2).

Prior Art Document

Patent Document

[0005]

[Patent Document 1] Japanese Patent Application, First Publication No, 2008-283391

[Patent Document 2] Japanese Patent Application, First Publication No, 2008-199562

Summary of Invention

Problem to be solved by the Invention

[0006]

However, in the above antenna device of the related art in which a radio wave shield is provided between the transmitting antenna and the receiving antenna, there is a possibility that the leaked radio waves leaked from the transmitting antenna may circumvent the radio wave shield and be received by the receiving antenna.

5 Additionally, since the size of the radio wave shield is set according to the frequency of the radio waves (leaked radio waves) transmitted from the transmitting antenna and the distance between the transmitting antenna and the receiving antenna, the size of the radio wave shield varies for every antenna device in which the frequency of the radio waves transmitted from the transmitting antenna or the distance between the transmitting
10 antenna and the receiving antenna varies is required.

[0007]

An object of the present invention is to provide an antenna device that makes it possible to easily and reliably attenuate leaked radio waves (interference waves) that reach a receiving antenna from a transmitting antenna to secure isolation, even in a case
15 where the frequency of the radio waves (leaked radio waves) transmitted from the transmitting antenna and the distance between the transmitting antenna and the receiving antenna varies.

Solution to Problem

20 [0008]

In order to achieve the above object, the present invention provides the followings means.

[0009]

An antenna device of a first aspect of the present invention includes a receiving
25 antenna that receives radio waves; a transmitting antenna that is provided adjacent to the

receiving antenna and transmits primary radio waves to an antenna that is different from the receiving antenna; and a reflecting member that reflects some leaked radio waves leaked from the transmitting antenna towards the receiving antenna. The reflecting member is arranged such that reflected waves, some of which are the leaked radio waves, are reflected and reach the receiving antenna after being phase-shifted relative to direct waves, which are the leaked radio waves that directly reach the receiving antenna. The antenna device is configured such that interference is caused due to the phase shift between the direct waves and the reflected waves, attenuating the direct waves from the transmitting antenna to the receiving antenna.

10 [0010]

The direct waves and the reflected waves can be made to interfere with each other by reflecting some leaked radio waves by the reflecting member so that they reach the receiving antenna after being phase-shifted relative to the direct waves, which are the leaked radio waves that directly reach the receiving antenna from the transmitting antenna. Thereby, the attenuation effect of the interference waves (leaked radio waves or direct waves) that reach the receiving antenna from the transmitting antenna to deteriorate the receiving characteristics of the receiving antenna can be obtained by arranging the reflecting member such that the phase of the reflected waves is shifted relative to that of the direct waves, without providing a radio wave shield between the transmitting antenna and the receiving antenna as in the antenna device of the related art.

20 [0011]

Additionally, in an antenna device of a second aspect of the present invention, preferably, the transmitting antenna is an antenna that has the directivity of transmitting radio waves toward a predetermined range and has leaked radio waves leaked out of the predetermined range.

[0012]

In a case where the transmitting antenna is an antenna that has the directivity of transmitting radio waves (primary radio waves) toward the predetermined range and has leaked radio waves generated out of the predetermined range, the interference waves that reach the receiving antenna from the transmitting antenna to deteriorate the receiving characteristics of the receiving antenna can be reliably attenuated by providing a reflecting member to make the direct waves, which are the leaked radio waves that directly reach the receiving antenna, and the reflected waves, which are the leaked radio waves that are reflected by the reflecting member, interfere with each other.

[0013]

Moreover, in an antenna device of a third aspect of the present invention, the transmitting antenna may be an antenna that is formed in a rod-like shape, transmits radio waves from an end portion in the direction of an axis to the predetermined range and has leaked radio waves radiated at the center of the axis.

[0014]

In a case where the transmitting antenna is, for example, an antenna, such as a helical antenna, which is formed in the shape of a rod and has leaked radio waves radiated at the center of the axis, the interference waves can be more reliably attenuated by providing the reflecting member to make the direct waves and the reflected waves, which are the leaked radio waves, interfere with each other.

[0015]

Additionally, in an antenna device of a fourth aspect of the present invention, more preferably, the reflecting member is arranged such that a reflected wave having a shortest propagation path among the reflected waves that reach the receiving antenna is phase-shifted relative to a direct wave having a shortest propagation path among the

direct waves by half a wavelength at the position of the receiving antenna.

[0016]

Since the reflecting member is arranged such that the reflected waves, which are the leaked radio waves, are phase-shifted relative to the direct waves by half a

5 wavelength at the position of the receiving antenna, the direct waves and the reflected waves can be made to interfere with each other so as to cancel each other, and the interference waves that reach the receiving antenna from the transmitting antenna to deteriorate the receiving characteristics of the receiving antenna can be eliminated.

Additionally, at this time, in a case where the transmitting antenna is an antenna, such as
10 a helical antenna, the leaked radio waves are radiated at the center of the axis. However, the interference waves that reach the receiving antenna from the transmitting antenna to deteriorate the receiving characteristics of the receiving antenna can be effectively eliminated by arranging the reflecting member such that the reflected wave having the shortest propagation path is phase-shifted relative to the direct wave having the shortest
15 propagation path by half a wavelength.

[0017]

Moreover, in an antenna device of a fifth aspect of the present invention, preferably, the antenna device is configured such that the reflecting member and the transmitting antenna and/or the receiving antenna relatively move according to (i) the
20 distance between the receiving antenna and the transmitting antenna and/or (ii) the frequency of the radio waves transmitted from the transmitting antenna.

[0018]

Even in a case where the frequency of the radio waves transmitted from the transmitting antenna or the distance between the transmitting antenna and the receiving
25 antenna varies, the position of the reflecting member relative to the transmitting antenna

and/or the receiving antenna can be easily set such that the phases of the direct waves and the reflected waves are shifted from each other, according to the frequency of the radio waves transmitted from the transmitting antenna and/or the distance between the transmitting antenna and the receiving antenna.

5

Effects of Invention

[0019]

In the antenna device of the present invention, the attenuation effect of the interference waves that reach the receiving antenna from the transmitting antenna to
10 deteriorate the receiving characteristics of the receiving antenna can be obtained by arranging the reflecting member such that the phase of the reflected waves is shifted relative to that of the direct waves, which are the leaked radio waves, without providing a radio wave shield between the transmitting antenna and the receiving antenna as in the antenna device of the related art.

15

[0020]

Thereby, even in a case where the frequency of the radio waves transmitted from the transmitting antenna or the distance between the transmitting antenna and the receiving antenna varies, isolation can be easily and reliably secured simply by setting the position of the reflecting member relative to the transmitting antenna and/or the
20 receiving antenna such that the phases of the direct waves and the reflected waves are shifted from each other, according to the frequency of the radio waves transmitted from the transmitting antenna and/or the distance between the transmitting antenna and the receiving antenna.

25 Brief Description of Drawings

[0021]

FIG. 1 is a view showing an antenna device according to an embodiment of the present invention.

FIG. 2 is a view showing the antenna device according to the embodiment of the present invention.

FIG. 3 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 4 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 5 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 6 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 7 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 8 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

FIG. 9 is a view showing the experimental results of the isolation characteristics of the antenna device according to the embodiment of the present invention.

Description of Embodiments

[0022]

Hereinafter, an antenna device according to an embodiment of the present invention will be described referring to FIGS. 1 to 9. The present embodiment relates to an antenna device of a reader/writer or the like for passive ID tags.

[0023]

An antenna device A of the present embodiment, as shown in FIGS. 1 and 2, includes a transmitting antenna 1 (transmits primary radio waves to an antenna that is different from a receiving antenna 2) that transmits radio waves to a responder for RF tags or the like that performs exchange of information, and the receiving antenna 2 adjacent to the transmitting antenna 1, that receives radio waves transmitted from the responder. The antenna device A is configured such that the receiving antenna 2 receives reception radio waves transmitted from the responder while the transmitting antenna 1 transmits radio waves (primary radio waves, or transmission radio waves) to the responder, and the transmitting antenna 1 and the receiving antenna 2 simultaneously perform the transmission and reception of the radio waves. Additionally, the antenna device A of the present embodiment is configured to include a reflecting member 3 that transmits radio waves from the transmitting antenna 1 and reflects some leaked radio waves leaked from the transmitting antenna 1 toward the receiving antenna 2.

[0024]

In the present embodiment, the transmitting antenna 1 and the receiving antenna 2 are, for example, helical antennas, and the transmitting antenna 1 and the receiving antenna 2 are provided in parallel at a predetermined interval T1 such that the directions of axis O1 and axis O2 are the same direction. That is, the transmitting antenna 1 of the present embodiment is an antenna that has the directivity of transmitting radio waves toward a predetermined range and has leaked radio waves generated out of the predetermined range. Moreover, the transmitting antenna is an antenna that is formed in the shape of a rod, transmits radio waves from an end portion in the direction of the axis O1 to the predetermined range and has leaked radio waves radiated and generated at the center of the axis O1.

[0025]

Additionally, the reflecting member 3 is, for example, a reflecting mirror, a metal plate, a metal sheet, or the like. The reflecting member 3 is arranged at a predetermined interval T2 from both the transmitting antenna 1 and the receiving antenna 2 such that a reflecting surface 3a is directed to the transmitting antenna 1 and the receiving antenna 2. Moreover, at this time, the reflecting member 3 is disposed such that reflected waves S2, which are reflected by the reflecting member 3 and reach the receiving antenna 2, are phase-shifted relative to direct waves S1, which are leaked radio waves radiated from the transmitting antenna 1 and directly reach the receiving antenna 2, and reach the receiving antenna 2.

[0026]

Additionally, in the present embodiment, the reflecting member 3 is arranged such that the reflected waves S2 that reach the receiving antenna 2 is shifted relative to the direct waves S1 by half a wavelength at the position of the receiving antenna. In addition, the reflecting member 3 is not limited to being formed in a plate shape, and may be constituted by, for example, a mesh structure, a grid structure, or the like as long as the reflecting member can reflect radio waves.

[0027]

In the antenna device A of the present embodiment constituted in this way, the transmitting antenna 1 and the receiving antenna 2 have directivity in the directions of the axes O1 and O2, respectively, and radio waves are transmitted from the transmitting antenna 1 to the responder for RF tags that performs exchange of information.

Additionally, at this time, the transmitting antenna 1 has leaked radio waves generated in a radiation direction with the axis O1 as a center. For this reason, leaked radio waves (direct waves S1 or interference waves) radiated from the transmitting antenna 1 are

received by the receiving antenna 2 adjacent to the transmitting antenna 1 at the predetermined interval T1 therefrom, and the leaked radio waves become large interference waves, distortion occurs in an antenna pattern, and the receiving characteristics of the receiving antenna 2 deteriorate. Consequently, there is a possibility that gains or phase characteristics (isolation) cannot be secured.

[0028]

In contrast, since the antenna device A of the present embodiment includes the reflecting member 3, some of the radio waves radiated from the transmitting antenna 1 are reflected by the reflecting member 3, and the reflected waves S2 reflected on the reflecting member 3 reach the receiving antenna 2. Additionally, at this time, the reflecting member 3 is arranged such that the reflected waves S2 are phase-shifted relative to the direct waves S1 and reach the receiving antenna 2 and the reflected waves S2 are phase-shifted relative to the direct waves S1 by half a wavelength at the position of the receiving antenna. That is, the difference (path difference) between a path T1 of the direct waves S1 that directly reach the receiving antenna 2 from the transmitting antenna 1 and a path (T3+T4) of the reflected waves S2 that reach the reflecting member 3 from the transmitting antenna 1 and reach the receiving antenna 2 from the reflecting member 3 is set such that the phases of the direct waves S1 and the reflected waves S2 that reach the receiving antenna 2 are shifted by half a wavelength.

[0029]

For this reason, the interference between the direct waves S1 and the reflected waves S2 is caused due to the phase shift of the direct waves S1 and the reflected waves S2 that reach the receiving antenna 2 (the direct waves S1 and the reflected waves S2 are mutually cancelled), and the direct waves S1 are attenuated by the reflected waves S2. This attenuates the interference waves without providing a radio wave shield between the

transmitting antenna 1 and the receiving antenna 2 as in the antenna device of the related art.

[0030]

As such, due to the phase shift of the direct waves S1 and the reflected waves S2
5 that reach the receiving antenna 2, the interference between the direct waves S1 and the reflected waves S2 is caused and the interference waves are attenuated. Therefore, even in a case where the frequency of the transmission radio waves or the distance T2 between the transmitting antenna 1 and the receiving antenna 2 vary, isolation is secured simply by setting the position of the reflecting member 3 relative to the transmitting antenna 1
10 and/or the receiving antenna 2 according to the distance T1 between the transmitting antenna 1 and the receiving antenna 2 and/or the frequency of the radio waves radiated from the transmitting antenna 1 such that the reflected waves S2 interfere with the direct waves S1 and these waves are mutually cancelled.

[0031]

15 Also, if the antenna device A is configured such that the reflecting member 3 and the transmitting antenna 1 and/or the receiving antenna 2 can relatively move in advance according to the distance T1 between the transmitting antenna 1 and the receiving antenna 2 and/or the frequency of the radio waves transmitted from the transmitting antenna 1, setting of the relative positions of the transmitting antenna 1, the receiving
20 antenna 2, and the reflecting member 3 can be easily and reliably performed such that the difference between the path T1 of the direct waves S1 and the path (T3+T4) of the reflected waves S2 shifts the phases of the direct waves S1 and the reflected waves S2 by half a wavelength even in a case where the frequency of the radio waves or the distance T1 between the transmitting antenna 1 and the receiving antenna 2 vary. That is, if the
25 relative positions of the transmitting antenna 1, the receiving antenna 2, and the reflecting

member 3 are made variable even in a case where the frequency of the transmission radio waves or the distance T1 between the transmitting antenna 1 and the receiving antenna 2 varies, isolation can be easily and reliably secured.

[0032]

5 Here, a demonstration experiment in which the superiority of the antenna device A of the present embodiment including the reflecting member 3 was confirmed will be described. FIG. 3 is a view showing the results of the demonstration experiment, and showing the isolation characteristics when the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 was gradually
10 changed to 20 mm, 40 mm, 60 mm, 80 mm, and 100 mm. Additionally, in FIG. 3, the horizontal axis represents the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the vertical axis represents isolation characteristics.

[0033]

It was confirmed from FIG. 3 that the gain of about 8 to more than a dozen dB
15 can be obtained if the interval T1 between both the antennas 1 and 2 and the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 have the positional relationship in which the cancelling interference between the direct waves S1 and the reflected waves S2 is caused. That is, it was demonstrated that isolation cannot be secured if the interval T1 between both the antennas 1 and 2 and
20 the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 have the positional relationship in which the difference between the path T1 of the direct waves S1 and the path (T3+T4) of the reflected waves S2 shifts the phases of the direct waves S1 and the reflected waves S2 that have reached the receiving antenna 2 (shifts wavelengths by half a wavelength).

[0034]

On the other hand, FIGS. 4 to 9 show the results when isolation characteristics are confirmed by gradually changing the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 to 6 cm, 10 cm, 20 cm, 30 cm, 40 cm, and 50 cm, and changing the distance T1 between the transmitting antenna 1 and the receiving antenna 2 in the respective cases. Additionally, calculation values together with actual measurement values are shown in FIGS. 4 to 9.

[0035]

Here, a calculation method of the calculation values will be described reference to FIG. 2 showing the positional relationship between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3. First, if the propagation distance of the direct waves S1 is X, the distance between the antennas is T1, and the radius of the transmitting antenna 1 and the receiving antenna 2 is R, the propagation distance X of the direct waves S1 becomes $X = T1 - 2R$. Moreover, if the propagation distance of the reflected waves S2 is Z, and the distance between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 is T2, the transmission distance Z of the reflected waves becomes $Z = 2 \times (((T1/2)^2 + (T2 + R)^2)^{1/2}) - R$.

[0036]

Moreover, the path difference M between the direct waves S1 and the reflected waves S2 becomes $M = Z - X$, and consequently, $C = 2 \times \pi \times M / F$ is established if a relative phase difference C is obtained from the path difference M with the wavelength of the transmission radio waves transmitted from the transmitting antenna 1 being F.

[0037]

Since phase is reversed by 180 degrees when being reflected by the reflecting member 3, the relative phase difference C_Z on the reception side becomes $C_Z = C + \pi(\text{rad})$. Moreover, if the amplitude value of synthetic waves in which the reflected waves S2

have interfered with the direct waves S1 is A, the amplitude value A becomes $A=1+\cos(C_z)$. Additionally, if the logarithmic value of the amplitude value is B, $B=10\times\log(A)$ is established, and if the propagation loss of the direct waves S1 is V, this propagation loss V becomes $V=20\times\log((4\times\pi\times(L-2R))/F)$.

5 [0038]

From the propagation loss V obtained in this way and the directivity P of the receiving antenna 2 in the transverse direction, the calculation value I of the isolation on the reception side is obtained by $I=B+V-P$.

[0039]

10 It was also confirmed from FIGS. 4 to 9 showing the calculation values determined in this way and the actual measurement values that isolation can be secured if the interval T1 between both the antennas 1 and 2 and the interval T2 between the transmitting antenna 1 and the receiving antenna 2, and the reflecting member 3 have the positional relationship in which the difference between the path T1 of the direct waves S1
15 and the path (T3+T4) of the reflected waves S2 shifts the phases of the direct waves S1 and the reflected waves S2 that have reached the receiving antenna 2 (shifts wavelengths by half a wavelength).

[0040]

Accordingly, in the antenna device A of the present embodiment, the direct
20 waves S1 and the reflected waves S2 can be made to interfere with each other by reflecting some leaked radio waves by the reflecting member 3 so as to reach the receiving antenna 2 after being phase-shifted relative to the direct waves S1, which are the leaked radio waves that directly reach the receiving antenna 2 from the transmitting antenna 1. Thereby, the attenuation effect of the interference waves (leaked radio
25 waves) that reach the receiving antenna 2 from the transmitting antenna 1 to deteriorate

the receiving characteristics of the receiving antenna 2 can be obtained by arranging the reflecting member 3 such that the phase of the reflected waves S2 is shifted relative to that of the direct waves S1, without providing a radio wave shield between the transmitting antenna 1 and the receiving antenna 2 as in the antenna device of the related art.

[0041]

Hence, according to the antenna device A of the present embodiment, even in a case where the frequency of the radio waves transmitted from the transmitting antenna 1 or the distance T1 between the transmitting antenna 1 and the receiving antenna 2 varies, isolation can be easily and reliably secured simply by setting the position of the reflecting member 3 relative to the transmitting antenna 1 and/or the receiving antenna 2 such that the phases of the direct waves S1 and the reflected waves S2 are shifted from each other, according to the frequency of the radio waves transmitted from the transmitting antenna 1 and/or the distance T1 between the transmitting antenna 1 and the receiving antenna 2.

[0042]

Additionally, as in the present embodiment, in a case where the transmitting antenna 1 is an antenna that has the directivity of transmitting radio waves toward the predetermined range and has leaked radio waves generated out of the predetermined range and in a case where the transmitting antenna 1 is an antenna, such as a helical antenna, which is formed in the shape of a rod, transmits radio waves from the end portion in the direction of the axis O1 to the predetermined range and has leaked radio waves radiated at the center of the axis O1, the interference waves can be reliably attenuated by providing the reflecting member 3 to make the direct waves S1 and the reflected waves S2, which are the leaked radio waves, interfere with each other.

[0043]

Moreover, since the reflecting member 3 is arranged such that the reflected waves S2, which are the leaked radio waves, are phase-shifted relative to the direct waves S1 by half a wavelength at the position of the receiving antenna, the direct waves S1 and the reflected waves S2 can be made to interfere with each other so as to cancel each other, and the interference waves that reach the receiving antenna 2 from the transmitting antenna 1 to deteriorate the receiving characteristics of the receiving antenna 2 can be eliminated.

[0044]

Additionally, if the reflecting member 3, and the transmitting antenna 1 and/or the receiving antenna 2 are configured so as to move relatively, even in a case where the frequency of the radio waves transmitted from the transmitting antenna 1 or the distance T1 between the transmitting antenna 1 and the receiving antenna 2 varies, the position of the reflecting member 3 relative to the transmitting antenna 1 and/or the receiving antenna 2 can be easily set such that the phases of the reflected waves S2 and the direct waves S1 and are shifted from each other, according to the frequency of the radio waves transmitted from the transmitting antenna 1 and/or the distance T1 between the transmitting antenna 1 and the receiving antenna 2.

[0045]

Such an antenna device A can also be favorably adopted in, for example, electronic toll collection systems, such as ERP (Electronic Road Pricing), which are installed in tollgates on highways or the like. Additionally, it is also possible to favorably adopt, for example, a configuration in which the antenna device A of the present embodiment is provided on a roof portion of a police vehicle so that the exchange of information with responders mounted on other vehicles can be performed, and identification data, such as the contents of license plates of other vehicles, is acquired

while traveling. Moreover, in this case, the roof portion of the vehicle can be used as the reflecting member 3.

[0046]

Although the embodiment of the antenna device according to the present
5 invention has been described above, the present invention is not limited to the above embodiment, and can be appropriately changed without departing from the scope thereof. For example, although description of the present embodiment has been described that the transmitting antenna 1 and the receiving antenna 2 are helical antennas, the transmitting antenna and receiving antenna according to the present invention may not be necessarily
10 limited to the helical antennas.

[0047]

Additionally, in the present embodiment, the difference (path difference)
between the path T1 of the direct waves S1 that directly reach the receiving antenna 2 from the transmitting antenna 1 and the path (T3+T4) of the reflected waves S2 that
15 reach the reflecting member 3 from the transmitting antenna 1 and reach the receiving antenna 2 from the reflecting member 3 is set such that the phases of the direct waves S1 and the reflected waves S2 are shifted by half a wavelength. On the other hand, in the present invention, the path difference may be appropriately adjusted such that the phases of the direct waves S1 and the reflected waves S2 are shifted from each other and the
20 interference effect of the direct waves S1 and the reflected waves S2 is sufficiently obtained. The present invention is not necessarily limited to setting the path difference such that the phases of the direct waves S1 and the reflected waves S2 are phase-shifted by half a wavelength. Particularly, as shown in FIGS. 6 and 8, the interference effect of the direct waves S1 and the reflected waves S2 may be reduced depending on the interval
25 T2 between the reflecting member 3 and the antennas 1 and 2 and the type, shape, or the

like of the antennas 1 and 2 if the path difference is set such that the phases of the direct waves S1 and the reflected waves S2 are phase-shifted by half a wavelength. Even in such a case, by appropriately adjusting the path difference, the interference effect of direct waves S1 and the reflected waves S2 can be enhanced, and the interference waves that deteriorate the receiving characteristics of the receiving antenna 2 can be effectively eliminated.

Industrial Applicability

[0048]

According to the antenna device of the present invention, it is possible to obtain the attenuation effect of the interference waves that reach the receiving antenna from the transmitting antenna to deteriorate the receiving characteristics of the receiving antenna.

Reference Signs List

[0049]

1: TRANSMITTING ANTENNA

2: RECEIVING ANTENNA

3: REFLECTING MEMBER

3a: REFLECTING SURFACE

A: ANTENNA DEVICE

O1: AXIS OF TRANSMITTING ANTENNA

O2: AXIS OF RECEIVING ANTENNA

R: RADIUS OF ANTENNA

S1: DIRECT WAVE

S2: REFLECTED WAVE

CLAIMS

1. An antenna device comprising:

a receiving antenna that receives radio waves;

5 a transmitting antenna that is provided adjacent to the receiving antenna and transmits primary radio waves to an antenna that is different from the receiving antenna; and

a reflecting member that reflects towards the receiving antenna some leaked radio waves leaked from the transmitting antenna, wherein

10 the reflecting member is arranged such that reflected waves, some of which are the leaked radio waves, are reflected and reach the receiving antenna after being phase-shifted relative to direct waves, which are the leaked radio waves that directly reach the receiving antenna, and

the antenna device is configured such that interference is caused due to the phase shift between the direct waves and the reflected waves, attenuating the direct waves from
15 the transmitting antenna to the receiving antenna.

2. The antenna device according to Claim 1, wherein

the transmitting antenna is an antenna that has the directivity of transmitting
20 radio waves toward a predetermined range and has leaked radio waves leaked out of the predetermined range.

3. The antenna device according to Claim 2, wherein

the transmitting antenna is an antenna that is formed in a rod-like shape,
25 transmits radio waves from an end portion in the direction of an axis to the predetermined

range and has leaked radio waves radiated at the center of the axis.

4. The antenna device according to any one of Claims 1 to 3, wherein
the reflecting member is arranged such that a reflected wave having a shortest
5 propagation path among the reflected waves that reach the receiving antenna is
phase-shifted relative to a direct wave having a shortest propagation path among the
direct waves by half wavelength at the position of the receiving antenna.

5. The antenna device according to any one of Claims 1 to 4, wherein
10 the antenna device is configured such that the reflecting member and the
transmitting antenna and/or the receiving antenna relatively move according to (i) the
distance between the receiving antenna and the transmitting antenna and/or (ii) the
frequency of the radio waves transmitted from the transmitting antenna.