[0064]

The angle-of-arrival identification device 1 according to the first embodiment and the second embodiment is described above as being a device that identifies the angle of arrival on the basis of the phase difference between the "pilot carriers" (the subcarriers on which the phase modulation is not performed) received by the plurality of antenna elements 10. However, other embodiments are not limited to this aspect.

Specifically, the angle-of-arrival identification device 1 according to another embodiment may identify the angle of arrival on the basis of the phase difference of the “data carriers” that are regarded as the “specific subcarriers.” In this case, the angle-of-arrival identification device 1 may identify the phase difference by comparing points (phase change points) at which a phase has been switched due to phase modulation, among the reception signals (the data carriers) received by the plurality of antenna elements 10.

[0065]

In the foregoing, certain embodiments of the present invention have been described, but these embodiments are merely illustrative and are not intended to limit the scope of the invention. These embodiments may be implemented in various other forms, and various omissions, substitutions, and alterations may be made without departing from the gist of the invention. These embodiments and modifications are included in the scope and gist of the invention and are also included in the scope of the invention described in the claims and equivalents thereof.

Industrial Applicability

[0066]

According to the angle-of-arrival identification device, the toll collection system, and the angle-of-arrival identification method described above, the angle of arrival of the frequency-division-multiplexed radio wave can be identified by simple signal processing.

Reference Signs List

[0067]

1 Angle-of-arrival identification device

10 Antenna element

11 High-frequency amplifier

12 Mixer

13 Variable amplifier

CLAIMS

[Claim 1]

An angle-of-arrival identification device that receives a reception signal including a plurality of subcarriers, using a plurality of antenna elements, and identifies an angle of arrival of the reception signal, the angle-of-arrival identification device comprising:

a signal processing unit configured to extract a predefined specific subcarrier from the reception signal received using each of the plurality of antenna elements, and output a signal indicating a phase of the specific subcarrier; and

an angle identification unit configured to identify the angle of arrival based on a phase difference of the specific subcarrier extracted from each of the signal processing units, wherein

the signal processing unit includes

a local transmitter,

a plurality of mixers that multiply regenerative signals from the local transmitter,

a frequency adjustment unit configured to adjust a deviation, from a defined value, of a frequency of the reception signal received using the antenna element, and

a filter unit configured to extract a plurality of the specific subcarriers having different frequencies by performing bandpass filter processing on the reception signal whose frequency has been adjusted,

wherein a first mixer in the plurality of mixers extracts an I-component of the reception signal by multiplying the reception signal by the regenerative signal having the same phase as the reception signal,

a second mixer in the plurality of mixers extracts an Q-component of the reception signal by multiplying the reception signal by the regenerative signal having a phase shifted by 90 degrees from that of the reception signal, and

wherein the signal processing identifies the phase of the specific subcarrier having a highest signal strength among the plurality of specific subcarriers based on the I-component and the Q-component, and outputs a signal indicating the phase of the specific subcarrier.

[Claim 2]

The angle-of-arrival identification device according to claim 1, wherein

the signal processing unit further includes an amplitude adjustment unit configured to adjust, to a predetermined magnitude, an amplitude of the reception signal received using the antenna element.

[Claim 3]

The angle-of-arrival identification device according to claim 1 or 2, wherein

the specific subcarrier is a pilot carrier on which phase modulation for data transmission is not performed.

[Claim 4]

The angle-of-arrival identification device according to claim 3, wherein

the signal processing unit extracts a plurality of the pilot carriers having mutually

different frequencies.

[Claim 5]

A toll collection system comprising:

the angle-of-arrival identification device according to claim 1 or 2.

[Claim 6]

An angle-of-arrival identification method that receives a reception signal including a plurality of subcarriers, using a plurality of antenna elements, and identifies an angle of arrival of the reception signal, the angle-of-arrival identification method comprising:

a signal processing step for extracting a predefined specific subcarrier from the reception signal received using each of the plurality of antenna elements, and outputting a signal indicating a phase of the specific subcarrier; and

an angle identifying step for identifying the angle of arrival based on a phase difference of the specific subcarrier extracted in each of the signal processing steps, wherein

the signal processing step includes

multiplication steps for multiplying regenerative signals from a local transmitter,

a frequency adjustment step for adjusting a deviation, from a defined value, of a frequency of the reception signal received by the antenna element, and

a filtering step for extracting a plurality of the specific subcarriers having different frequencies by performing bandpass filter processing on the reception signal whose frequency has been adjusted,

wherein a first step in the multiplication steps extracts an I-component of the reception signal by multiplying the reception signal by the regenerative signal having the same phase as the reception signal,

a second step in the multiplication steps extracts an Q-component of the reception signal by multiplying the reception signal by the regenerative signal having a phase shifted by 90 degrees from that of the reception signal, and

wherein the signal processing step identifies the phase of the specific subcarrier having a highest signal strength among the plurality of specific subcarriers based on the I-component and the Q-component, and outputs a signal indicating the phase of the specific subcarrier.

[Claim 7]

A computer readable storage medium storing a program that causes a computer of an angle-of-arrival identification device that receives a reception signal including a plurality of subcarriers, using a plurality of antenna elements, and identifies an angle of arrival of the reception signal, to function as:

a signal processing unit configured to extract a predefined specific subcarrier from the reception signal received using each of the plurality of antenna elements, and output a signal indicating a phase of the specific subcarrier; and

an angle identification unit configured to identify the angle of arrival based on a phase difference of the specific subcarrier extracted from each of the signal processing units, wherein

the signal processing unit includes

a local transmitter,

a plurality of mixers that multiply regenerative signals from the local transmitter,

a frequency adjustment unit configured to adjust a deviation, from a defined value, of a frequency of the reception signal received using the antenna element, and

a filter unit configured to extract a plurality of the specific subcarriers having different frequencies by performing bandpass filter processing on the reception signal whose frequency has been adjusted,

wherein a first mixer in the plurality of mixers extracts an I-component of the reception signal by multiplying the reception signal by the regenerative signal having the same phase as the reception signal,

a second mixer in the plurality of mixers extracts an Q-component of the reception signal by multiplying the reception signal by the regenerative signal having a phase shifted by 90 degrees from that of the reception signal, and

wherein the signal processing identifies the phase of the specific subcarrier having a highest signal strength among the plurality of specific subcarriers based on the I-component and the Q-component, and outputs a signal indicating the phase of the specific subcarrier.