

**JP2006197520A WIRELESS COMMUNICATION SYSTEM, WIRELESS COMMUNICATION
DEVICE AND WIRELESS COMMUNICATION METHOD**

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Wireless communication system, wireless communication apparatus, and wireless communication method

The present invention relates to a radio communication apparatus, and more particularly to a propagation path estimation technique in an OFDM / FDMA (OFDMA) cellular system.

In recent years, with an increase in communication capacity, there are an increasing number of users who demand high-speed data transmission in a wireless communication system. A multi-carrier transmission system represented by OFDM (Orthogonal Frequency Division Multiplexing) attracts attention as one of communication systems capable of realizing high-speed and large-capacity data transmission. OFDM is a method used in IEEE802.11a, which is a 5 GHz band wireless system, and digital terrestrial broadcasting, and communicates by arranging several tens to thousands of carriers at the minimum frequency interval where theoretically no interference occurs. It is a method. Normally, this carrier is called a subcarrier in OFDM, and communication is performed by digitally modulating each subcarrier such as PSK and QAM. Further, it is known that strong resistance to frequency selective fading can be obtained by combining OFDM and an error correction method. FIG. 7 is a diagram illustrating a configuration example of a data packet in IEEE802.11a. As shown in FIG. 7, the data packet used in IEEE802.11a has preambles A and B and a data signal. Preamble A is used for OFDM symbol synchronization and frequency synchronization, and preamble B is used for antenna identification and propagation path estimation. These two preambles are both predetermined signals and are known signals on the receiving side.

Next, the configuration of the OFDM modulation / demodulation circuit is shown in FIGS. 8 and 9, respectively. However, the number of subcarriers used is N. FIG. 8 is a functional block diagram showing a simplified configuration example of the OFDM modulation circuit. In FIG. 8, a code 1000 is an error correction code unit, a code 1001 is a serial / parallel conversion unit (S / P conversion unit), a code 1002 is a mapping unit, and a code 1003 is an IDFT (Inverse Discrete Fourier Transform: Inverse Discrete Fourier Transform) section, reference numeral 1004 is parallel / serial (P / S conversion section), reference numeral 1005 is a preamble A generation section, reference numeral 1006 is a preamble B generation section, and reference numeral 1007 is a multiplex. 1008 is a guard interval insertion unit, 1009 is a digital / analog conversion unit (D / A conversion unit), 1010 is a radio transmission unit, and 1011 is an antenna.

Information data transmitted from the OFDM modulation circuit is subjected to error correction coding in an error correction coding section 1000. Next, the S / P conversion unit 1001 performs serial / parallel conversion for the data necessary for the modulation of each carrier, and the mapping unit 1002 modulates each carrier. Thereafter, IDFT is performed in the IDFT unit 1003. FIG. 8 shows an example in which IDFT is used for OFDM modulation. However, in general circuits, the number of points is $2n$, and an inverse fast Fourier transform (IFFT) is often used, and N waves are used. When generating an OFDM signal, a value of $2n$ closest to N is generally used as the number of IFFT points.

After IDFT, the P / S conversion unit 1004 converts the data into serial data, and the multiplex unit 1007 time-multiplexes the preamble A and the preamble B, resulting in the packet configuration shown in FIG. Then, the guard interval inserting unit 1008 inserts a guard interval. The guard interval is inserted to reduce intersymbol interference when receiving an OFDM signal. Further, the data is converted into an analog signal by the D / A converter 1009, and then converted into a frequency to be transmitted by the wireless transmitter 1010, and then the packet is transmitted from the antenna 1011.

FIG. 9 is a simplified block diagram of an OFDM demodulation circuit. In the receiver, basically, an operation reverse to the transmission process is performed. In FIG. 9, reference numeral 1020 denotes an antenna, reference numeral 1021 denotes a wireless reception unit, reference numeral 1022 denotes an A / D (analog / digital) conversion unit, reference numeral 1023 denotes a synchronization unit, and reference numeral 1024

denotes a GI removal unit. Reference numeral 1025 denotes an S / P converter, reference numeral 1026 denotes a DFT (Discrete Fourier Transform) part, reference numeral 1027 denotes a changeover switch, reference numeral 1028 denotes a preamble multiplier, and reference numeral 1029 , 1030 is a multiplication unit, 1031 is a demapping unit, 1032 is a P / S conversion unit, and 1033 is an error correction decoding unit. However, as described above, in general, the demodulation circuit often uses an FFT instead of a DFT.

The radio wave received by the antenna unit 1020 is frequency-converted to a frequency band in which the radio reception unit 1021 can perform A / D conversion. The data converted into the digital signal by the A / D conversion unit 1022 is subjected to OFDM symbol synchronization using the preamble A in the synchronization unit 1023, and the guard interval is removed in the GI removal unit 1024. Thereafter, the S / P conversion unit 1025 performs parallel conversion. After DFT in DFT section 1026, changeover switch 1027 sends reception preamble B after DFT to preamble multiplication section 1028, and the reception data signal after DFT is sent to multiplication section 1029. Preamble multiplication section 1028 multiplies the complex conjugate of received preamble B and preamble B used on the transmission side (multiplication in the frequency domain) to estimate the propagation path.

Here, propagation path estimation and propagation path compensation using a preamble (preamble B), which is a known signal, will be briefly described using mathematical expressions. First, it is assumed that the preamble used on the transmission side is $p(f)$ and the information signal is $s(f)$. Here, these are expressed as signals in the frequency domain. In addition, when the fluctuation received in the propagation path after the preamble or information signal is transmitted is $c(f)$, the reception preamble $p'(f)$ and the reception information signal $s'(f)$ are respectively expressed by the following equations. The Here, $c(f)$ is a complex function that gives different amplitude fluctuation and phase rotation for each subcarrier.

$$p'(f) = c(f) \times p(f) \quad (1) \quad s'(f) = c(f) \times s(f) \quad (2)$$

However, for simplicity, thermal noise in the receiver is not considered here. As described above, first, the preamble multiplier 1028 takes a complex conjugate of $p'(f)$ and multiplies these received signals with the preamble $p(f)$ used on the transmission side. This is expressed in equation (3).

The output (Equation (3)) of this preamble multiplication unit 1028 is sent to the multiplication unit 1029 and the multiplication unit 1030, where multiplication with the received data signal and the received preamble is performed. The output of the multiplier 1029 is shown in Equation (4), and the output of the multiplier 1030 is shown in Equation (5).

As shown in the equation (4), by multiplying the reception information signal by the output of the preamble multiplier 1028, the influence of the phase rotation due to the propagation path fluctuation $c(f)$ is compensated, and the phase equal to the transmission signal $s(f)$. Is obtained.

The outputs of the multiplication unit 1029 and the multiplication unit 1030 (the above equations (4) and (5)) obtained as described above are input to the demapping unit 1031 and after propagation path compensation shown in the equation (5) The demapping of the information signal is performed for each subcarrier with reference to the preamble. Thereafter, necessary data is serialized by P / S conversion section 1032, error correction is performed by error correction decoding section 1033, and transmission data is decoded.

Further, there is a technique described in Non-Patent Document 1 as one of the methods aimed at increasing the speed and quality of OFDM. Normally, different information bits are assigned to each OFDM subcarrier, but Non-Patent Document 1 uses a method of assigning the same information bits to all subcarriers. In this way, in order to maintain a high transmission rate while assigning the same information bits to all subcarriers, Non-Patent Document 1 sets a different phase rotation amount for each information bit, and sets the set phase rotation as a subcarrier. Thus, different information bits can be assigned to the same subcarrier for transmission. Here, FIG. 10 shows a part of the transmitter configuration shown in Non-Patent Document 1. As shown in FIG. 10, in the transmission device in Non-Patent Document 1, information bits mapped by mapping section 1050 (note that BPSK modulation is targeted in Non-Patent Document 1) This is copied and input to the subcarrier modulation / phase rotation unit 1052 (here, the number of subcarriers is N). In this subcarrier modulation / phase rotation section 1052, as shown in FIG. 10, information bits are assigned to all subcarriers, and phase rotation set for each information bit is given to each subcarrier. At this time, the phase rotation given to the first

subcarrier of the k th information bit is 0, and the phase rotation given to the n th subcarrier is $(n-1) \Delta\theta_k$, which is continuous between adjacent subcarriers. Phase rotation to give.

In Non-Patent Document 1, all the subcarriers to which phase rotation has been applied in this way are added, and the output of the subcarrier modulation unit / phase rotation unit of all information bits is added in adder 1053. The receiving apparatus multiplies the complex conjugate of the phase rotation given by the transmitting apparatus to compensate for the phase rotation and restore the information data. In Non-Patent Document 1, a system using the above configuration is called a CI (Carrier Interferometry) / OFDM system. By using such a configuration, reception characteristics are improved compared to normal OFDM and a high transmission rate can be secured. It is shown.

The propagation path estimation method and propagation path compensation method described above provide good characteristics when systems using the same frequency band are not located nearby, that is, when no interference signal is observed. However, when a system using the same frequency band is located nearby or when a one-cell repetitive cellular system using the same frequency band is realized in all cells, the propagation path is influenced by the influence of interference coming from adjacent systems or adjacent cells. The accuracy of estimation is significantly degraded, and correct propagation path compensation cannot be performed. In order to deal with such a problem, the CI / OFDM signal described above is used in the preamble B shown in FIG. 7, and a different phase rotation amount is set for each adjacent system or cell, thereby causing interference. A method for estimating a propagation path with reduced signal influence is effective.

[D. A. Wiegandt, Z. Wu, C. R. Nassar, "High-throughput, high-performance OFDM via pseudo-orthogonal carrier interferometry spreading codes", IEEE Transactions on Communications, vol. 51, no. 7, Jul. 2003, pp. 1123-1134.]

As described above, by applying the CI / OFDM technique to channel estimation, it is possible to perform channel estimation with high accuracy even in a situation where interference from an adjacent system or cell arrives. However, when using OFDM / FDMA (OFDMA) cellular system, which is expected to realize high-speed transmission rates with excellent frequency utilization efficiency, the channel estimation method using CI / OFDM technology is used. Since terminals with different numbers of receivable subchannels (one access unit on the frequency axis composed of multiple subcarriers) are mixed, different processing must be performed for each terminal with a different number of receivable subchannels. There is a problem that processing becomes complicated. Specifically, the phase rotation amount in the CI / OFDM signal needs to be set to a different value depending on the number of subchannels that can be received by the terminal, which causes a problem in that the processing on the base station side becomes complicated.

The present invention is characterized by providing a technique that simplifies processing when a propagation path estimation method using CI / OFDM technology is used for an OFDM / FDMA (OFDMA) cellular system.

The present invention adds a subcarrier to which phase rotation has been added, and further adds the output of a modulation unit that performs subcarrier modulation of all information bits and a phase rotation unit that performs phase rotation to perform channel estimation. It is characterized by simplifying the processing in OFDM technology. In addition, even if the number of subchannels to be received changes on the receiving side, propagation path estimation of a necessary band is efficiently performed.

That is, according to one aspect of the present invention, in a communication system using the OFDMA system, a subcarrier modulated to the same phase and the same amplitude is proportional to the frequency and becomes $2n\pi$ (n is an integer) within the subchannel band. A transmitter that transmits an OFDM signal to which phase rotation is applied, and one or more subchannels of the OFDM signal, receives a phase rotation opposite to the phase rotation, demodulates the OFDM signal, and performs channel estimation. There is provided a wireless communication system including a receiving device.

According to another aspect of the present invention, in a communication system using the OFDMA system, a phase that is proportional to the frequency and becomes $2n\pi$ (n is an integer) in the subchannel band with respect to subcarriers modulated to the same phase and amplitude. A transmitter for transmitting an OFDM signal multiplied by a predetermined code and receiving one or more subchannels of the OFDM signal, giving a phase rotation opposite to the phase rotation, and the code. There is provided a communication system comprising: a receiving device that multiplies the complex conjugate of the received signal and demodulates an

OFDM signal to estimate a propagation path. The OFDM signal is preferably composed of one or more subchannels including subchannels that use only some of the subcarriers in the subchannel band.

According to another aspect of the present invention, in a communication system using the OFDMA scheme, a means for assigning a sequence having the same phase and the same amplitude to a subcarrier, and a subcarrier assigned a sequence having the same phase and the same amplitude. And a phase shift means for providing a phase rotation proportional to the frequency and giving a phase rotation of $2n\pi$ (n is an integer) within the subchannel band.

Further, a receiving device that receives a signal transmitted from the transmitting device, the first Fourier transform unit that collectively Fourier-transforms the received signal composed of one or more subchannels, and after the Fourier transform Phase shift means for giving a phase rotation opposite to the phase rotation given on the transmission side for the subcarrier, an inverse Fourier transform means for performing an inverse Fourier transform on the subcarrier after the phase shift, There is provided a receiving apparatus that includes a time axis filtering unit that applies a time window to a signal and a second Fourier transform unit that performs Fourier transform on the signal after time axis filtering, and performs propagation path estimation.

Further, in a communication system using the OFDMA system, a subchannel band proportional to a frequency is proportional to a means for assigning a sequence having the same phase and the same amplitude to a subcarrier, and a subcarrier assigned a sequence having the same phase and the same amplitude. The transmission apparatus includes a phase shift means for applying a phase rotation of $2n\pi$ (where n is an integer), and a spreading unit that multiplies each subcarrier by a predetermined code.

In addition, a receiving device that receives a signal transmitted from the transmitting device, the first Fourier transform unit that collectively performs Fourier transform on the received signal composed of one or more subchannels, Phase shift means for giving a phase rotation opposite to the phase rotation given to the transmission side for the subcarrier, a despreading unit for multiplying each subcarrier by a predetermined code, and a phase carrier for the phase shifted subcarrier. Inverse Fourier transform means for performing Fourier transform, time filtering means for applying a time window to the signal after inverse Fourier transform, and second Fourier transform means for Fourier transforming the signal after time filtering, What is provided is a receiving device.

In the communication device according to the present invention, for a subcarrier modulated to the same phase and the same amplitude on the transmission side, a signal with a phase rotation that is proportional to the frequency and $2n\pi$ (n is an integer) in the subchannel band is transmitted. Or, for subcarriers modulated to the same phase and amplitude, a phase rotation that is proportional to the frequency and becomes $2n\pi$ (n is an integer) within the subchannel band, and transmits an OFDM signal multiplied by a predetermined code Thus, transmission can be performed in the same process without depending on the number of subchannels to be received.

The reception side also performs Fourier transform on the received signal in accordance with the number of subchannels to be received, and a phase shift that gives the phase rotation opposite to the phase rotation given on the transmission side to the subcarrier after the Fourier transform, and transmission When a code is sometimes multiplied, by performing a process of multiplying each subcarrier by a predetermined code, it is possible to efficiently perform propagation path estimation of a necessary band even if the number of received subchannels changes.

In this specification, the OFDMA system is an OFDM / FDMA (hereinafter referred to as OFDMA) technique that performs FDMA in units of one or more subcarriers in order to increase the number of multiplexed channels in an OFDM system, and will be described in detail later. Also, all the subcarriers to which phase rotation has been applied are added, and the output of the subcarrier modulation unit / phase rotation unit of all information bits is added and transmitted. On the receiving side, the phase rotation given by the transmitter is transmitted. A system that uses a configuration that compensates for phase rotation and restores information data by multiplying by complex conjugate is called a CI (Carrier Interferometry) / OFDM system. Hereinafter, a method for estimating a propagation path using a CI signal will be described. The CI signal can be generated by aligning the phase of each subcarrier of the OFDM signal. As an example, when $1 + j0$ is input to each subcarrier and inverse discrete Fourier transform (hereinafter referred to as "IDFT") is performed, an impulse is output at a

position of $t = 0$ in the time waveform. When this waveform is transmitted and the received waveform that has passed through the fading environment is subjected to discrete Fourier transform (hereinafter referred to as “DFT”), a frequency response can be obtained.

In the CI waveform obtained by the above processing, PAPR (Peak to Average Power Ratio) is large, and the amplifier is burdened. Therefore, by multiplying each subcarrier by a specific random number, the impulse transmission waveform can be spread in time. When receiving, a normal frequency response can be obtained by multiplying each subcarrier after DFT by the random number used for spreading. By performing IDFT on this frequency response, an unsread impulse response can be obtained.

This outline will be described with reference to FIG. FIG. 2 (A) shows a transmitted propagation path estimation waveform. The orthogonal arrows shown by dotted lines represent the real axis component and the imaginary axis component, and the bold arrow running diagonally represents the frequency axis. Also, the thick arrows in the lower diagram of FIG. 2A represent the modulation data a_k (real axis) and b_k (imaginary axis) of each frequency.

When an ideal reception without any influence of a propagation path such as fading is made, FIG. 2A becomes an input to the spreading code multiplication unit (only f_0 is extracted and shown in the following diagram).

In the code multiplier, the complex conjugate signal of the random number for spreading is multiplied, so that the signals have the same amplitude on the real axis shown in FIG. When this is IDFT, the impulse signal can be seen only at $t = 0$ as shown in FIG. Actually, if there is fading, the output of the code multiplier is rotated in phase due to the influence of fading, and the amplitude also varies. This waveform is shown in FIG. When the waveform shown in FIG. 2D is similarly subjected to IDFT processing, a waveform as shown in FIG. Since the difference between FIG. 2B and FIG. 2D is the propagation path response, the impulse response of FIG. 2C becomes FIG. 2E. Here, consider a case where a plurality of transmitters simultaneously use this propagation path estimation signal. In this case, the impulse responses of the terminals obtained are overlapped, and the impulse response for each terminal cannot be obtained. In order to solve this problem, the position of the impulse can be changed.

Since the relationship of the time shift of Fourier transform is, it can be seen that the position of the impulse on the time axis changes by changing the phase of each subcarrier. This will be described with reference to FIG. Here, the diffusion is excluded for easy understanding. FIG. 3A is a diagram illustrating a state in which the phase of each subcarrier is rotated. When IDFT is performed in this state, as shown in FIG. 3B, an impulse (solid arrow) is generated at the position of $t = 1$. FIG. 3C is a graph showing the phase rotation amount of each subcarrier when performing 16-point IDFT for easy understanding. When the rotation is 2π (rad) as a whole, the position of the impulse is shifted by one sample, and the impulse is generated at the position of $t = 1$ (see FIG. 3D).

Hereinafter, the OFDMA wireless communication technique according to the present embodiment will be described with reference to the drawings using the above principle. First, the form of the 1st form of this invention is demonstrated. In the OFDM system, in order to increase the number of multiplexed channels, there is an OFDM / FDMA (hereinafter referred to as OFDMA) technology that performs FDMA in units of one or a plurality of subcarriers. A unit for performing FDMA is called a subchannel. An example of the outline of OFDMA is shown in FIG. Here, a case where 512 subcarriers are divided into 8 subchannels of 64 subcarriers is shown.

As shown in FIG. 4 (A), in the OFDMA system according to the present embodiment, it is conceivable that there are several types of subchannels used at the same time depending on the complexity of the terminal. At this time, for example, when a device that receives only one subchannel intends to implement the technique according to the present embodiment, the processing for estimating the propagation path may be complicated. This will be described with reference to FIG. FIG. 4B is a diagram illustrating an example in which the phase of each subcarrier is adjusted so that the phase is rotated by 2π in all subcarriers on the transmission side. In this state, when the received signal is extracted by extracting only one subchannel at the position (1) shown in FIG. 4B, the change in phase is 0 to $1 / 4\pi$, and only one subchannel at the position (2). Since the phase of the subcarrier changes depending on where the subchannel is extracted, from $1 / 4\pi$ to $1 / 2\pi$, the processing becomes complicated. Also, as for the random numbers used for spreading, only a part of the sequence is used when only one subchannel is received, and it is necessary to switch the random numbers used at the position of the received subchannel. On the other hand, this embodiment provides a means that does not complicate the

processing of a device that receives only one subchannel, and that a device that receives a plurality of subchannels can also receive normally.

The second graph in FIG. 4B is a diagram illustrating an example of phase control performed on the transmission side. In the example shown here, the phase starts from $1/2\pi$ (rad) within one subcarrier and rotates by 2π (rad). This is controlled so that the same phase rotation is performed in all subchannels. This phase rotation amount may be a positive integer multiple (including 0) of 2π within one subchannel. An example of 4π rotation in one subchannel is shown in the third graph in FIG.

The random number ρ used for spreading uses the following sequence.

$$\rho(k + N_{scn}) = \rho'(k)$$

Here, N_{scn} is the number of subcarriers per subchannel, and ρ is a sequence in which the sequence of ρ' is repeated for the subchannel. Various sequences can be used for ρ' , but as an example, pseudo-random numbers using M sequences, orthogonal sequences such as Walsh codes, and the like are conceivable. This outline is shown in the graph in the fourth row of FIG. By using a code of such a sequence, it is possible to demodulate data without changing the code when any subchannel is received.

As described above, the receiving process is not complicated in a device that receives only one subchannel by controlling the phase and spreading of each subcarrier on the transmitting side, and the device that receives a plurality of subchannels can also operate normally. A transmission waveform that can be received can be created. However, a problem occurs in a device that receives a plurality of subchannels. Since the position of the impulse changes depending on the number of subchannels to be received, an accurate frequency response cannot be obtained by the same processing.

This outline will be described with reference to FIG. In this example, when only one subchannel is received, the impulse position is at the position of $t = 1$ as indicated by the white arrow, and when two subchannels are received, the impulse is at the position of $t = 2$.

When receiving a plurality of subchannels, it is necessary to have a configuration capable of performing this correction. FIG. 1 is a block diagram of a transmitter and a receiver for realizing such a technique. It is assumed that the transmission side and the reception side are completely synchronized.

FIG. 1 is a block diagram illustrating a configuration example of an OFDMA communication apparatus according to the present embodiment, in which FIG. 1A is a transmission side block and FIG. 1B is a reception side block. As shown in FIG. 1A, reference numeral 101 denotes a serial-parallel converter that parallelizes an input signal for processing each subcarrier, and reference numeral 102 denotes a phase that adjusts the phase of data of each subcarrier. Reference numeral 103 denotes a shift block for spreading the data of each subcarrier. Reference numeral 104 denotes an IDFT block for performing inverse discrete Fourier transform processing for reading the data of each subcarrier and converting it into a time axis waveform.

As shown in FIG. 1 (b), reference numeral 701 is a DFT block that performs DFT to separate the received signal into components for each subcarrier, and reference numeral 702 returns the spreading process performed on the transmission side. 703 is a phase shift block for adjusting and aligning the phase of each subcarrier, 704 is an IDFT block for converting the signal after phase adjustment of each subcarrier into an impulse, Reference numeral 705 denotes a time axis filter that removes unnecessary signals from the impulse waveform, and reference numeral 706 denotes a DFT block that DFTs the shaped impulse waveform to obtain a frequency response. In the figure, N_{sch} represents the number of subchannels received, and N_{scn} represents the number of subcarriers per subchannel.

First, the operation of the transmission side block will be described. A serial-parallel converter 101 is used to distribute a $1 + j0$ signal for each subcarrier. Thereafter, the phase shift block 102 sets the phase of each carrier to a desired value. The phase-adjusted signal is diffused with a predetermined random number ρ in the diffusion block 103, converted into a time axis signal in the IDFT block 104, and a signal for propagation path estimation is generated. This random number ρ is a sequence satisfying $\rho(k + N_{scn}) = \rho'(k)$ shown above, and is a sequence in which ρ' is repeated. In the communication apparatus according to the present embodiment, processing is performed in the order of phase shift and spreading, but the same signal is generated even if this order is switched.

Next, the operation on the receiving side is shown. The received signal is separated into signals for each subcarrier by the DFT block 701. Thereafter, in the despreading block 702, despreading is performed by multiplying the complex conjugate of the random number ρ used on the transmission side, and the signal before spreading is taken out. This random number ρ is a sequence satisfying $\rho(k + N_{scn}) = \rho'(k)$, and is a sequence obtained by repeating ρ' . Next, the phase of the despread signal is corrected by the phase shift block 703 so that the phase of each subcarrier is corrected. At this time, correction of $-\Delta\theta_{sc} \times (1 \text{ to } N_{sch} \times N_{scn})$ is performed in order to correct the phase of the subcarrier according to the number of subchannels to be received. $\Delta\theta_{sc}$ is a phase difference with the adjacent subcarrier, and $\Delta\theta_{sc} \times N_{scn}$ is a value equal to the amount of phase rotation per subchannel set at the time of transmission. Next, the phase corrected signal is IDFTed by the IDFT block 704 to obtain an impulse waveform. Since this impulse waveform includes signals other than the signal generated from the target propagation path estimation signal, unnecessary signals are deleted by applying a time window by the time axis filter 705. The frequency response after removing the unnecessary signal can be obtained by performing DFT on the signal after removing the unnecessary signal in the DFT block 706.

By performing the above processing in each block, propagation path estimation can be normally performed even if a plurality of subchannels are received in an environment including a device that receives only one subchannel.

Next, a communication device according to a second embodiment of the present invention will be described with reference to the drawings. In the first embodiment, it is assumed that the arrangement of subcarriers is continuous between subchannels.

The communication technique according to the present invention can be implemented even if the subcarriers are not necessarily continuous. Hereinafter, an embodiment in which a guard band and a carrier hole are provided for each subchannel will be described.

FIG. 6A is a diagram showing an outline of an arrangement example of subcarriers used in the radio communication technique according to the present embodiment. As shown in FIG. 6 (a), the same subcarrier spacing as that of the wireless communication technique according to the first embodiment of the present invention is used, and the subchannel bandwidth is similarly set to two subcarriers on both sides of the subchannel. It is assumed that there is a carrier hole in the center of the guard band of the minute and the subchannel.

Even in such a case, the band including the guard band may be handled as a subchannel so that the phase changes uniformly within the band. In other words, phase control is performed ignoring carriers that are not used as guard bands or carrier holes. FIG. 6B is a diagram showing an outline of such processing. As shown in FIG. 6B, similarly to the case of the first embodiment, control is performed so that an integer multiple phase of 2π rotates in one subchannel.

In this way, by controlling the phase of each subcarrier, the time during which an impulse is generated can be controlled even if the number of received subchannels changes, as in the wireless communication technique according to the first embodiment. It becomes possible.

Note that the configuration of the device used may be the same as that of the device according to the first embodiment. However, it suffices that transmission / reception of unused subcarriers is not performed.

As described above, according to the radio communication technique according to the present embodiment, even when subcarriers are not continuous, propagation path estimation can be normally performed even if a plurality of subchannels are received.

The present invention can be used for an OFDMA communication apparatus.

It is a block diagram which shows the structural example of the OFDMA communication apparatus by this Embodiment, Fig.1 (a) is a transmission side block, FIG.1 (b) is a receiving side block. In this Embodiment, it is a figure which shows the relationship between a frequency response and an impulse response. FIG. 3A is a diagram showing how the position of the impulse changes on the time axis by changing the phase of each subcarrier, and FIG. 3A shows how the phase of each subcarrier is rotated, and FIG. FIG. 3B is a graph showing a state in which an impulse (solid arrow) is generated at the position of $t = 1$, and FIG. 3C is a graph showing

the phase rotation amount of each subcarrier when performing 16-point IDFT. FIG. 3D is a diagram showing a state in which the impulse position is shifted by one sample and the impulse is generated at the position of $t = 1$ when rotated as a whole by 2π (rad). FIG. 4A is a diagram showing an example of the outline of OFDMA, and FIG. 4B is a diagram showing a state in which there are several types of subchannels used simultaneously according to the complexity of the terminal. is there. It is a figure which shows the problem in the apparatus which receives multiple subchannels. FIG. 6A is a diagram showing an outline of an arrangement example of subcarriers used in the radio communication technique according to the present embodiment. FIG. 6B is a diagram showing an outline of the processing. It is a figure which shows the structural example of the data packet in IEEE802.11a. It is a functional block diagram showing a simplified configuration example of an OFDM modulation circuit. FIG. 3 is a simplified block diagram of an OFDM demodulation circuit. 2 is a diagram showing a part of a transmitter configuration shown in Non-Patent Document 1.

Explanation of symbols

101...Serial-parallel converter, 102 ... phase shift block, 103 ... spread block for spreading data of each subcarrier, 104 ... IDFT block, 701 ... DFT block, 702 ... despread block, 703 ... phase shift block, 704 ... IDFT Block, 705 ... time axis filter, 706 ... DFT block.