DESCRIPTION

TRANSMITTING METHOD, RECEIVING METHOD, TRANSMITTING APPARATUS, AND RECEIVING APPARATUS

TECHNICAL FIELD

[0001]

The present disclosure relates to a transmitting method, a receiving method, a transmitting apparatus, and a receiving apparatus.

BACKGROUND ART

[0002]

The DVB-T2 standard is an example of a digital broadcasting standard in which orthogonal frequency division multiplexing (OFDM) is used (see Non-Patent Literature (NPL) 5).

[0003]

In digital broadcasting according to, for instance, the DVB-T2 standard, a frame in which a plurality of data streams are multiplexed by time division is configured, and data is transmitted on a frame-by-frame basis.

Citation List

Non-Patent Literature

[0004]

NPL 1: R.G. Gallager, "Low-density parity-check codes," IRE Trans. Inform. Theory, IT-8, pp. 21-28, 1962.

NPL 2: "Performance analysis and design optimization of LDPC-coded MIMO OFDM systems" IEEE Trans. Signal Processing., vol. 52, no. 2, pp. 348-361, Feb. 2004.

NPL 3: C. Douillard, and C. Berrou, "Turbo codes with rate -m/(m + 1) constituent

convolutional codes," IEEE Trans. Commun., vol. 53, no. 10, pp. 1630-1638, Oct. 2005.

NPL 4: C. Berrou, "The ten-year-old turbo codes are entering into service," IEEE Communication Magazine, vol. 41, no. 8, pp. 110-116, Aug. 2003.

NPL 5: DVB Document A122, Frame structure, channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2), June 2008.

NPL 6: D.J.C. Mackay, "Good error-correcting codes based on very sparse matrices," IEEE Trans. Inform. Theory, vol. 45, no. 2, pp 399 - 431, March 1999.

NPL 7: S.M. Alamouti, "A simple transmit diversity technique for wireless communications," IEEE J. Select. Areas Commun., vol. 16, no. 8, pp. 1451-1458, Oct 1998.

NPL 8: V. Tarokh, H. Jafrkhani, and A.R. Calderbank, "Space-time block coding for wireless communications: Performance results," IEEE J. Select. Areas Commun., vol. 17, no. 3, no. 3, pp. 451-460, March 1999.

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005]

A transmitting method, a receiving method, a transmitting apparatus, and a receiving apparatus which allow communication using a flexible frame configuration are provided.

SOLUTIONS TO PROBLEM

[0006]

A transmission method according to an aspect of the present disclosure includes: configuring a frame using a plurality of orthogonal frequency-division multiplexing (OFDM) symbols, by allocating a plurality of transmission data to a plurality of areas; and transmitting the frame. Each of the plurality of areas is

identified by at least one time resource among a plurality of time resources and at least one frequency resource among a plurality of frequency resources. The frame includes a first period in which a preamble which includes information on a frame configuration of the frame is transmitted, and a second period in which the plurality of transmission data are transmitted by at least one of time division and frequency division. The second period includes a first area among the plurality of areas, and the first area includes a data symbol generated from first transmission data among the plurality of transmission data, a data symbol generated from second transmission data among the plurality of transmission data and subsequent to the data symbol generated from the first transmission data, and a dummy symbol subsequent to the data symbol generated from the second transmission data.

[0007]

A receiving method according to an aspect of the present disclosure includes receiving a frame, obtaining information, and performing demodulation. When receiving a frame, a frame which includes a first period in which a preamble is transmitted, and a second period in which a plurality of transmission data are transmitted by at least one of time division and frequency division is received. The frame is configured using a plurality of orthogonal frequency-division multiplexing (OFDM) symbols, by allocating the plurality of transmission data to a plurality of areas. Each of the plurality of areas is identified by at least one time resource among a plurality of time resources and at least one frequency resource among a plurality of frequency resources. When obtaining information, information on a frame configuration of the frame is obtained from the preamble. When performing demodulation, at least one of the plurality of transmission data transmitted in the second period is demodulated based on the information on the frame configuration.

[0008]

A transmitting apparatus according to an aspect of the present disclosure

includes: a frame configuring unit configured to configure a frame using a plurality of orthogonal frequency-division multiplexing (OFDM) symbols, by allocating a plurality of transmission data to a plurality of areas; and a transmitter which transmits the frame. Each of the plurality of areas is identified by at least one time resource among a plurality of time resources and at least one frequency resource among a plurality of frequency resources. The frame includes a first period in which a preamble which includes information on a frame configuration of the frame is transmitted, and a second period in which the plurality of transmission data are transmitted by at least one of time division and frequency division. The second period includes a first area among the plurality of areas, and the first area includes a data symbol generated from first transmission data among the plurality of transmission data, a data symbol generated from second transmission data among the plurality of transmission data and subsequent to the data symbol generated from the first transmission data, and a dummy symbol subsequent to the data symbol generated from the second transmission data.

[0009]

A receiving apparatus according to an aspect of the present disclosure includes a receiver, a preamble processor, and a demodulator. The receiver receives a frame which includes a first period in which a preamble is transmitted, and a second period in which a plurality of transmission data are transmitted by at least one of time division and frequency division. The frame is configured using a plurality of orthogonal frequency-division multiplexing (OFDM) symbols, by allocating the plurality of transmission data to a plurality of areas. Each of the plurality of areas is identified by at least one time resource among a plurality of time resources and at least one frequency resource among a plurality of frequency resources. A preamble processor obtains information on a frame configuration of the frame from the preamble. A demodulator demodulates, based on the

information on the frame configuration, at least one of the plurality of transmission data transmitted in the second period.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010]

According to the transmitting apparatus, the receiving apparatus, the transmitting method, and the receiving method according to the present disclosure, communication can be performed using a flexible frame configuration. This yields advantageous effects that high efficiency in data transmission can be achieved in a communications system and furthermore the receiving apparatus can efficiently obtain data.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1 is a view illustrating an example of a configuration of a transmitting apparatus.

FIG. 2 is a view illustrating an example of a frame configuration.

FIG. 3 is a view illustrating an example of a frame configuration.

FIG. 4 is a view illustrating an example of a frame configuration.

FIG. 5 is a view illustrating an example of a frame configuration.

FIG. 6 is a view illustrating an example of a frame configuration.

FIG. 7 is a view illustrating an example of a configuration in a case where a transmitting method using space time block codes is performed.

FIG. 8 is a view illustrating an example of a configuration in a case where the transmitting method using space time block codes is performed.

FIG. 9 is a view illustrating an example of a configuration in a case where a transmitting method using an MIMO method is performed.

FIG. 10 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 11 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 12 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 13 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 14 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 15 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 16 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 17 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

FIG. 18 is a view illustrating an example of a symbol arranging method.

FIG. 19 is a view illustrating an example of the symbol arranging method.

FIG. 20 is a view illustrating an example of the symbol arranging method.

FIG. 21 is a view illustrating an example of the symbol arranging method.

FIG. 22 is a view illustrating an example of the symbol arranging method.

FIG. 23 is a view illustrating an example of a configuration of a receiving apparatus.

FIG. 24 is a view illustrating an example of a frame configuration.

FIG. 25 is a view illustrating an example of a frame configuration.

FIG. 26 is a view illustrating an example of a frame configuration.

FIG. 27 is a view illustrating an example of a frame configuration.

FIG. 28 is a view illustrating an example of a frame configuration.

FIG. 29 is a view illustrating an example of a frame configuration.

FIG. 30 is a view illustrating an example of a frame configuration.

FIG. 31 is a view illustrating an example of a frame configuration.

FIG. 32 is a view illustrating an example of a frame configuration.

FIG. 33 is a view illustrating an example of a frame configuration.

FIG. 34 is a view illustrating an example of a frame configuration.

FIG. 35 is a view illustrating an example of a frame configuration.

FIG. 36 is a view illustrating an example of a frame configuration.

FIG. 37 is a view illustrating an example of a frame configuration.

FIG. 38 is a view illustrating an example of a frame configuration.

FIG. 39 is a view illustrating an example of a symbol arranging method.

FIG. 40 is a view illustrating an example of the symbol arranging method.

FIG. 41 is a view illustrating an insertion example of a pilot symbol to be inserted to a data symbol group.

FIG. 42 is a view illustrating an insertion example of a pilot symbol to be inserted to a data symbol group.

FIG. 43 is a view illustrating an example of the symbol arranging method.

FIG. 44 is a view illustrating an example of the symbol arranging method.

FIG. 45 is a view illustrating an example of area decomposition in a frequency direction and a time direction.

FIG. 46 is a view illustrating an example of the symbol arranging method.

FIG. 47 is a view illustrating an example of area decomposition in the time direction.

FIG. 48 is a view illustrating an example of a frame configuration.

FIG. 49 is a view illustrating an example of a control symbol arranging method.

FIG. 50 is a view illustrating an example of a frame configuration.

FIG. 51 is a view illustrating an example of a frame configuration.

FIG. 52 is a view illustrating an example of a frame configuration.

FIG. 53 is a view illustrating an example of the control symbol arranging method.

FIG. 54 is a view illustrating an example of a frame configuration.

FIG. 55 is a view illustrating an example of the symbol arranging method.

FIG. 56 is a view illustrating an example of the symbol arranging method.

FIG. 57 is a view illustrating an example of a relationship between a transmission station and a terminal.

FIG. 58 is a view illustrating an example of a configuration of a transmitting apparatus.

FIG. 59 is a view illustrating an example of the symbol arranging method.

FIG. 60 is a view illustrating an example of the symbol arranging method.

FIG. 61 is a view illustrating an example of a configuration of a transmitting apparatus.

FIG. 62 is a view illustrating a schematic view of an MIMO system.

FIG. 63 is a view illustrating an example of a frame configuration.

FIG. 64 is a view illustrating an example of inserted dummy symbols (dummy slots).

FIG. 65 is a view illustrating an example of a frame configuration.

FIG. 66 is a view illustrating an example of a frame configuration.

FIG. 67 is a view illustrating an example of a frame configuration.

FIG. 68 is a view illustrating an example of a designator which indicates a frame configuration.

FIG. 69 is a view illustrating an example of a frame configuration.

FIG. 70 is a view illustrating an example of a frame configuration.

FIG. 71 is a view illustrating an example of a designator which indicates a frame configuration.

FIG. 72 is a view illustrating an example of a relation between a base station and terminals.

FIG. 73 is a view illustrating an example of communication between the base station and terminals.

FIG. 74 is a view illustrating an example of a configuration of the base station.

FIG. 75 is a view illustrating an example of a configuration of a terminal.

FIG. 76 is a view illustrating an example of a configuration of a transmitting apparatus included in a base station.

FIG. 77 is a view illustrating examples of data symbol group generators included in a base station.

FIG. 78 is a view illustrating an example of a configuration of a receiving apparatus included in a terminal.

FIG. 79 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 80 is a view illustrating an example of a configuration of time boundaries or frequency boundaries between data symbol groups.

FIG. 81 is a view illustrating an example of a configuration of time boundaries or frequency boundaries between data symbol groups.

FIG. 82 is a view illustrating an example of a configuration of the base station.

FIG. 83 is a view illustrating another example of a configuration of the base station.

FIG. 84 is a view illustrating an example of operation of an interleaver for data symbol group #N.

FIG. 85 is a view illustrating an example of a configuration of an interleaver for data symbol group #N.

FIG. 86 is a view illustrating another example of a configuration of the base station.

FIG. 87 is a view illustrating another example of a configuration of the base station.

FIG. 88 is a view illustrating an example of operation of interleaving of carriers.

FIG. 89 is a view illustrating another example of a configuration of the base station.

FIG. 90 is a view illustrating another example of a configuration of the base station.

FIG. 91 is a view illustrating another example of a frame configuration of a modulated signal.

FIG. 92 is a view illustrating another example of a frame configuration of a modulated signal.

FIG. 93 is a view illustrating another example of a frame configuration of a modulated signal.

FIG. 94 is a view illustrating another example of a frame configuration of a modulated signal.

FIG. 95 is a view illustrating an example of communication between a base station and a plurality of terminals.

FIG. 96 is a view illustrating an example of a configuration of a data symbol group.

FIG. 97 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 98 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 99 is a view illustrating an example of a frame configuration of a

modulated signal.

FIG. 100 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 101 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 102 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 103 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 104 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 105 is a view illustrating an example of a frame configuration of a modulated signal.

FIG. 106 is a view illustrating an example of a configuration of a transmission antenna.

FIG. 107 is a view illustrating an example of a configuration of a receiving antenna.

DESCRIPTION OF EMBODIMENTS

[0012]

(Spatial multiplexing MIMO method)

As a communication method using a multi-antenna, for example, there is a communication method which is referred to as MIMO (Multiple-Input Multiple-Output).

[0013]

In multi-antenna communication which is typically MIMO, data reception quality and/or a data communication rate (per unit time) can be enhanced by modulating transmission data of one or more sequences and simultaneously

transmitting the respective modulated signals from different antennas by using the same frequency (common frequency).

[0014]

FIG. 62 is a view explaining an outline of a spatial multiplexing MIMO method. The MIMO method in FIG. 62 indicates an example of configurations of a transmitting apparatus and a receiving apparatus in a case where a number of transmitting antennas is 2 (TX1 and TX2), a number of receiving antennas (RX1 and RX2) is 2 and a number of transmission modulated signals (transmission streams) is 2.

[0015]

The transmitting apparatus has a signal generator and a wireless processor. The signal generator performs communication channel coding on data, performs MIMO precoding processing, and generates two transmission signals z1(t) and z2(t) which can be transmitted simultaneously by using the same frequency (common frequency). The wireless processor multiplexes individual transmission signals in a frequency direction as necessary, that is, converts the transmission signals into multi-carriers (for example, an OFDM (Orthogonal Frequency Division Multiplexing) method), and also inserts a pilot signal for estimation by a receiving apparatus of a transmission channel distortion, a frequency offset, a phase distortion and the like. However, the pilot signal may estimate other distortions and the like, and the receiving apparatus may also use the pilot signal for signal detection. Note that a mode of using the pilot signal in the receiving apparatus is not limited to this mode. The two transmitting antennas use the two transmitting antennas (TX1 and TX2) to transmit z1(t) and z2(t).

[0016]

The receiving apparatus includes the receiving antennas (RX1 and RX2), a wireless processor, a channel fluctuation estimator and a signal processor. The

receiving antenna (RX1) receives signals transmitted from the two transmitting antennas (TX1 and TX2) of the transmitting apparatus. The channel fluctuation estimator estimates a channel fluctuation value by using a pilot signal, and supplies a channel fluctuation estimation value to the signal processor. The signal processor restores data contained in z1(t) and z2(t) based on channel values estimated as signals received at the two receiving antennas, and obtains the data as one piece of received data. However, the received data may be a hard determination value of "0" or "1" or may be a soft determination value such as log likelihood or a log likelihood ratio.

[0017]

Moreover, various coding methods such as turbo codes (for example, Duo-Binary Turbo codes) and LDPC (Low-Density Parity-Check) codes are used as coding methods (NPLs 1 to 6 and the like).

[0018]

FIRST EXEMPLARY EMBODIMENT

FIG. 1 is an example of a configuration of a transmitting apparatus (of, for example, a broadcast station) in the present exemplary embodiment.

[0019]

Data generator 102 receives an input of transmission data 10801, and control signal 109. Data generator 102 performs error correction coding and mapping which is based on a modulating method, based on information such as information of error correction coding contained in control signal 109 and information of the modulating method contained in control signal 109. Data generator 102 outputs data transmission (quadrature) baseband signal 103.

[0020]

Second preamble generator 105 receives an input of second preamble transmission data 104, and control signal 109. Second preamble generator 105

performs error correction coding and mapping which is based on a modulating method, based on information such as information of error correction of a second preamble contained in control signal 109 and information of the modulating method contained in control signal 109. Second preamble generator 105 outputs second preamble (quadrature) baseband signal 106.

[0021]

Control signal generator 108 receives an input of first preamble transmission data 107, and second preamble transmission data 104. Control signal generator 108 outputs as control signal 109 information of a method for transmitting each symbol. Examples of the method for transmitting each symbol includes a selected transmitting method including an error correction code, a coding rate of the error correction code, a modulating method, a block length, a frame configuration and a transmitting method for regularly switching precoding matrices, a method for inserting a pilot symbol, information or the like of IFFT (Inverse Fast Fourier Transform) (or inverse Fourier transform)/FFT (Fast Fourier Transform) (or Fourier transform), information of a method for reduction a PAPR (Peak to Average Power Ratio) and information of a method for inserting a guard interval.

[0022]

Frame configuring unit 110 receives an input of data transmission (quadrature) baseband signal 103, second preamble (quadrature) baseband signal 106, and control signal 109. Frame configuring unit 110 performs rearrangement in a frequency axis and a time axis based on information of a frame configuration contained in the control signal. Frame configuring unit 110 outputs (quadrature) baseband signal 111_1 of stream 1 and (quadrature) baseband signal 111_2 of stream 2 according to the frame configuration. (Quadrature) baseband signal 111_1 of stream 1 is a signal obtained after mapping, that is, a baseband signal

based on a modulating method to be used, and (quadrature) baseband signal 111_2 of stream 2 is a signal obtained after mapping, that is, a baseband signal based on a modulating method to be used.

[0023]

Signal processor 112 receives an input of baseband signal 111_1 of stream 1, baseband signal 111_2 of stream 2, and control signal 109. Signal processor 112 outputs modulated signal 1 (113_1) obtained after signal processing based on a transmitting method contained in control signal 109 and modulated signal 2 (113_2) obtained after the signal processing based on a transmitting method contained in control signal 109.

[0024]

Note that in the signal processor, for example, an MIMO transmitting method using precoding and phase change (referred to as an MIMO method here), an MISO (Multiple-Input Single-Output) transmitting method using space time block codes (space frequency block codes) (referred to as an MISO method here), and an SISO (Single-Input Single-Output) or an SIMO (Single-Input Multiple-Output) transmitting method for transmitting a modulated signal of one stream from one antenna may be used. However, there is also a case where a modulated signal of one stream is transmitted from a plurality of antennas in the SISO method and the SIMO method. An operation of signal processor 112 will be described in detail below. The MIMO transmitting method may also be an MIMO transmitting method which does not perform phase change.

[0025]

Pilot insertion unit 114_1 receives an input of modulated signal 1 (113_1) obtained after signal processing, and control signal 109. Pilot insertion unit 114_1 inserts a pilot symbol to modulated signal 1 (113_1) obtained after the signal processing, based on information contained in control signal 109 and related to a

method for inserting the pilot symbol. Pilot insertion unit 114_1 outputs modulated signal 115_1 obtained after the pilot symbol insertion.

[0026]

Pilot insertion unit 114_2 receives an input of modulated signal 2 (113_2) obtained after signal processing, and control signal 109. Pilot insertion unit 114_2 inserts a pilot symbol to modulated signal 2 (113_2) obtained after the signal processing, based on information contained in control signal 109 and related to a method for inserting the pilot symbol. Pilot insertion unit 114_2 outputs modulated signal 115_2 obtained after the pilot symbol insertion.

[0027]

IFFT (Inverse Fast Fourier Transform) unit 116_1 receives an input of modulated signal 115_1 obtained after the pilot symbol insertion, and control signal 109. IFFT unit 116_1 performs IFFT based on information of an IFFT method contained in control signal 109. IFFT unit 116_1 outputs signal 117_1 obtained after the IFFT.

[0028]

IFFT unit 116_2 receives an input of modulated signal 115_2 obtained after the pilot symbol insertion, and control signal 109. IFFT unit 116_2 performs IFFT based on information of the IFFT method contained in control signal 109. IFFT unit 116_2 outputs signal 117_2 obtained after the IFFT.

[0029]

PAPR reduction unit 118_1 receives an input of signal 117_1 obtained after the IFFT, and control signal 109. PAPR reduction unit 118_1 performs processing for PAPR reduction on signal 117_1 obtained after the IFFT based on information contained in control signal 109 and related to the PAPR reduction. PAPR reduction unit 118_1 outputs signal 119_1 obtained after the PAPR reduction.

[0030]

PAPR reduction unit 118_2 receives an input of signal 117_2 obtained after the IFFT, and control signal 109. PAPR reduction unit 118_2 performs processing for PAPR reduction on signal 117_2 obtained after the IFFT based on information contained in control signal 109 and related to the PAPR reduction. PAPR reduction unit 118_2 outputs signal 119_2 obtained after the PAPR reduction.

[0031]

Guard interval insertion unit 120_1 receives an input of signal 119_1 obtained after the PAPR reduction, and control signal 109. Guard interval insertion unit 120_1 inserts a guard interval to signal 119_1 obtained after the PAPR reduction, based on information contained in control signal 109 and related to a guard interval insertion method. Guard interval insertion unit 120_1 outputs signal 121_1 obtained after the guard interval insertion.

[0032]

Guard interval insertion unit 120_2 receives an input of signal 119_2 obtained after the PAPR reduction, and control signal 109. Guard interval insertion unit 120_2 inserts a guard interval to signal 119_2 obtained after the PAPR reduction, based on information contained in control signal 109 and related to a guard interval insertion method. Guard interval insertion unit 120_2 outputs signal 121_2 obtained after the guard interval insertion.

[0033]

First preamble insertion unit 122 receives an input of signal 121_1 obtained after the guard interval insertion, signal 121_2 obtained after the guard interval insertion, and first preamble transmission data 107. First preamble insertion unit 122 generates a first preamble signal from first preamble transmission data 107. First preamble insertion unit 122 adds the first preamble to signal 121_1 obtained after the guard interval insertion. First preamble insertion unit 122 adds the first preamble to signal 123_1 obtained after the addition of the first preamble, and

signal 121_2 obtained after the guard interval insertion. First preamble insertion unit 122 outputs signal 123_2 obtained after the addition of the first preamble. Note that the first preamble signal may be added to both of signal 123_1 obtained after the addition of the first preamble and signal 123_2 obtained after addition of the first preamble, and also may be added to any one of signal 123_1 obtained after the addition of the first preamble and signal 123_2 obtained after addition of the first preamble. When the first preamble signal is added to one of signal 123_1 and signal 123_2, the signal to which the first preamble is not added includes a zero signal as a baseband signal in a section in which the signal to which the first preamble is added is added.

[0034]

Wireless processor 124_1 receives an input of signal 123_1 obtained after the addition of the first preamble. Wireless processor 124_1 performs processing such as frequency conversion and amplification on signal 123_1. Wireless processor 124_1 outputs transmission signal 125_1. Then, transmission signal 125_1 is output as a radio wave from antenna 126_1.

[0035]

Wireless processor 124_2 receives an input of signal 123_2 obtained after the addition of the first preamble. Wireless processor 124_2 performs processing such as frequency conversion and amplification on signal 123_2. Wireless processor 124_2 outputs transmission signal 125_2. Then, transmission signal 125_2 is output as a radio wave from antenna 126_2.

[0036]

Note that in the present exemplary embodiment, the MIMO transmitting method using precoding and phase change, the MISO (Multiple-Input Single-Output) transmitting method using space time block codes (or space frequency block codes), and the SISO (Single-Input Single-Output) or the SIMO

(Single-Input Single-Output) transmitting method are used as described above (details will be described below).

[0037]

FIGS. 2 to 6 are examples of frame configurations of a modulated signal to be transmitted by the above-described transmitting apparatus. Characteristics of each frame configuration will be described below.

[0038]

FIG. 2 illustrates an example of a first frame configuration. In FIG. 2, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0039]

FIG. 2 illustrates first preamble 201, second preamble 202, data symbol group #1 203, data symbol group #2 204, and data symbol group #3 205.

[0040]

First, the data symbol groups will be described.

[0041]

A data symbol group may be allocated per video and/or audio stream. For example, symbols for transmitting a first video and/or audio stream are of data symbol group #1 (203), symbols for transmitting a second video and/or audio stream are of data symbol group #2 (204), and symbols for transmitting a third video and/or audio stream are of data symbol group #3 (205). This point is not limited to FIG. 2, and the same also applies to FIGS. 3, 4, 5 and 6. This point is not limited to FIG. 2, and the same also applies to FIGS. 3, 4, 5 and 6.

[0042]

Moreover, for example, PLP (Physical Layer Pipe) in a standard such as DVB-T2 (a second generation digital terrestrial television broadcasting system)

may also be referred to as a data symbol group. That is, in FIG. 2, data symbol group #1 (203) may be referred to as PLP #1, data symbol group #2 (204) may be referred to as PLP #2, and data symbol group #3 (205) may be referred to as PLP #3. This point is not limited to FIG. 2, and the same also applies to FIGS. 3, 4, 5 and 6.

[0043]

First preamble 201 and second preamble 202 include, for example, a symbol for performing frequency synchronization and time synchronization, an example of which is a PSK (Phase Shift Keying) symbol having signal point arrangement in an in-phase I-quadrature Q plane known in the transmitting apparatus and the receiving apparatus, a pilot symbol for estimation by the receiving apparatus of a channel fluctuation, an example of which is a PSK (Phase Shift Keying) symbol having signal point arrangement in an in-phase I-quadrature Q plane known in the transmitting apparatus and the receiving apparatus, a symbol for transmitting transmitting method information of each data symbol group (information for identifying the SISO method, the MISO method and the MIMO method), a symbol for transmitting information related to an error correction code of each data symbol group (for example, a code length and a coding rate), a symbol for transmitting information related to a method for modulating each data symbol (in a case of the MISO method or the MIMO method, since there is a plurality of streams, a plurality of modulating methods is specified), a symbol for transmitting transmitting method information of the first and second preambles, a symbol for transmitting information related to an error correction code of the first and second preambles, a symbol for transmitting information related to a method for modulating the first and second preambles, a symbol for transmitting information related to a method for inserting a pilot symbol, and a symbol for transmitting information related to a method for suppressing a PAPR. This point is not limited to FIG. 2,

and the same also applies to FIGS. 3, 4, 5 and 6.

[0044]

Characteristic points in FIG. 2 are such that a data symbol group is subjected to temporal division and is transmitted.

[0045]

Note that in FIG. 2, a symbol for transmitting a pilot symbol or control information may be inserted to a data symbol group. Moreover, a data symbol group may also be a symbol group based on the MIMO (transmitting) method and the MISO (transmitting) method. As a matter of course, the data symbol group may be a symbol group of the SISO (SIMO) method. In this case, at the same time and the same (common) frequency, a plurality of streams (s1 and s2 described below) is transmitted. In this case, at the same time and the same (common) frequency, a plurality of modulated signals is transmitted from a plurality of (different) antennas. Then, this point is not limited to FIG. 2, and the same also applies to FIGS. 3, 4, 5 and 6.

[0046]

Next, FIG. 3 will be described. FIG. 3 illustrates an example of a second frame configuration. In FIG. 3, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency. Note that the same elements as the elements in FIG. 2 are assigned the same reference numerals in FIG. 3, and operate in the same way as in FIG. 2.

[0047]

Characteristic points in FIG. 3 are such that first preamble 301 and second preamble 302 are inserted (temporarily) between data symbol group #2 (204) and data symbol group #3 (205). That is, when a symbol group formed with a "first

preamble, a second preamble and a data symbol group" is referred to as a group, there are a first group which includes the first preamble, the second preamble, data symbol group #1 and data symbol group #2 and a second group which includes the first preamble, the second preamble and data symbol group #3, and configurations of the data symbol group contained in the first group and of the data symbol group contained in the second group are different.

[0048]

In such a case, for example, a video and/or audio to be transmitted with data symbol group #1 and a video and/or audio to be transmitted with data symbol group #2 are different in coding compressibility of a video and/or audio, but may be the same "video and/or audio." In this way, there is an advantage that the receiving apparatus can obtain a desired "video and/or audio" with high quality by a method as simple as selecting "whether to demodulate data symbol group #1 or demodulate data symbol group #2," and that since a preamble can be made common in this case, control information transmission efficiency can be enhanced.

[0049]

However, contrarily, the video and/or audio to be transmitted with data symbol group #1 and the video and/or audio to be transmitted with data symbol #2 may be different).

[0050]

Moreover, it becomes easy to make the transmitting method for transmitting data symbol group #1 the same as a transmitting method for transmitting data symbol group #2, and to make a transmitting method for transmitting data symbol group #3 different from the transmitting method for transmitting data symbol group #1 (the transmitting method for transmitting data symbol group #2).

[0051]

Although described below, a pilot symbol is inserted to a data symbol group. In this case, a pilot symbol inserting method is different per transmitting method. Note that since a number of modulated signals to be transmitted may be different, there is a possibility that a decrease in transmission efficiency owing to insertion of the pilot symbol can be prevented by gathering a data symbol group per transmitting method.

[0052]

Next, FIG. 4 will be described. FIG. 4 illustrates an example of a third frame configuration. In FIG. 4, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency. Note that elements operating in the same way as in FIG. 2 are assigned the same reference numerals in FIG. 4, and operate in the same way as in FIG. 2.

[0053]

Characteristic points in FIG. 4 are such that data symbol group #1 and data symbol group #2 are subjected to frequency division, and that in addition, "data symbol group #1 (401_1) and data symbol group #2 (402)" and "data symbol group #3 (403)" are subjected to temporal division. That is, data symbol groups are transmitted by using frequency division and temporal division in combination.

[0054]

Next, FIG. 5 will be described. FIG. 5 illustrates an example of a fourth frame configuration. In FIG. 5, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency. Note that elements operating in the same way as in FIGS. 2 and 4 are assigned the same reference numerals in FIG. 5, and operate in the

same way as in FIGS. 2 and 4.

[0055]

Characteristic points in FIG. 5 are such that, as with FIG. 4, data symbol group #1 and data symbol group #2 are subjected to frequency division, and that in addition, "data symbol group #1 (401_1) and data symbol group #2 (402)" and "data symbol group #3 (403)" are subjected to temporal division. That is, data symbol groups are transmitted by using frequency division and temporal division in combination.

[0056]

In addition, characteristic points in FIG. 5 are such that first preamble 301 and second preamble 302 are inserted (temporarily) between "data symbol groups #1 (401_1 and 401_2) and data symbol #2 (402)" and data symbol group #3 (403). That is, when a symbol group formed with a "first preamble, a second preamble and a data symbol group" is referred to as a group, there are a first group which includes the first preamble, the second preamble, data symbol group #1 and data symbol group #2 and a second group which includes the first preamble, the second preamble and data symbol group #3, and configurations of the data symbol group contained in the first group and of the data symbol group contained in the second group are different.

[0057]

In such a case, for example, a video and/or audio to be transmitted with data symbol group #1 and a video and/or audio to be transmitted with data symbol group #2 are different in coding compressibility of a video and/or audio, but may be the same "video and/or audio." In this way, there is an advantage that the receiving apparatus can obtain a desired "video and/or audio" with high quality by a method as simple as selecting "whether to demodulate data symbol group #1 or demodulate data symbol group #2," and that since a preamble can be made

common in this case, control information transmission efficiency can be enhanced.

[0058]

However, contrarily, the video and/or audio to be transmitted with data symbol group #1 and the video and/or audio to be transmitted with data symbol #2 may be different.

[0059]

Moreover, it becomes easy to make the transmitting method for transmitting data symbol group #1 the same as a transmitting method for transmitting data symbol group #2, and to make a transmitting method for transmitting data symbol group #3 different from the transmitting method for transmitting data symbol group #1 (the transmitting method for transmitting data symbol group #2).

[0060]

Although described below, a pilot symbol is inserted to a data symbol group. In this case, a pilot symbol inserting method is different per transmitting method. Note that since a number of modulated signals to be transmitted may be different, there is a possibility that a decrease in transmission efficiency owing to insertion of the pilot symbol can be prevented by gathering a data symbol group per transmitting method.

[0061]

Next, FIG. 6 will be described. FIG. 6 illustrates an example of a fifth frame configuration. In FIG. 6, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency. Note that elements operating in the same way as in FIGS. 2 and 4 are assigned the same reference numerals in FIG. 6, and operate in the same way as in FIGS. 2 and 4.

[0062]

Characteristic points in FIG. 6 are such that, as with FIGS. 4 and 5, data symbol group #1 and data symbol group #2 are subjected to frequency division, and that in addition, "data symbol group #1 (401_1) and data symbol group #2 (402)" and "data symbol group #3 (403)" are subjected to temporal division. That is, data symbol groups are transmitted by using frequency division and temporal division in combination.

[0063]

In addition, characteristic points in FIG. 6 are such that a pilot symbol is inserted (temporarily) between "data symbol groups #1 (401_1 and 401_2) and data symbol #2 (402)" and data symbol group #3 (403).

[0064]

In such a case, for example, a video and/or audio to be transmitted with data symbol group #1 and a video and/or audio to be transmitted with data symbol group #2 are different in coding compressibility of a video and/or audio, but may be the same "video and/or audio." In this way, there is an advantage that the receiving apparatus can obtain a desired "video and/or audio" with high quality by a method as simple as selecting "whether to demodulate data symbol group #1 or demodulate data symbol group #2," and that since a preamble can be made common in this case, control information transmission efficiency can be enhanced.

[0065]

However, contrarily, the video and/or audio to be transmitted with data symbol group #1 and the video and/or audio to be transmitted with data symbol #2 may be different.

[0066]

Moreover, it becomes easy to make the transmitting method for transmitting data symbol group #1 the same as a transmitting method for

transmitting data symbol group #2, and to make a transmitting method for transmitting data symbol group #3 different from the transmitting method for transmitting data symbol group #1 (the transmitting method for transmitting data symbol group #2).

[0067]

Although described below, a pilot symbol is inserted to a data symbol group. In this case, a pilot symbol inserting method is different per transmitting method. Note that since a number of modulated signals to be transmitted may be different, there is a possibility that a decrease in transmission efficiency owing to insertion of the pilot symbol can be prevented by gathering a data symbol group per transmitting method.

[0068]

Note that in the case of the MISO method or the MIMO method, a pilot symbol is inserted to each modulated signal to be transmitted from each transmitting antenna.

[0069]

Then, the insertion of pilot symbol 601 as illustrated in FIG. 6 makes it possible for the receiving apparatus to perform highly precise channel estimation for wave detection and demodulation of each data symbol group. Moreover, when methods for transmitting data symbols are switched, the receiving apparatus needs to adjust a gain of a received signal suitable for the transmitting apparatus. However, it is possible to obtain an advantage that the gain can be adjusted easily by pilot symbol 601.

[0070]

Note that in FIGS. 4, 5 and 6, for example, a video and/or audio to be transmitted with data symbol group #1 and a video and/or audio to be transmitted with data symbol group #2 are different in coding compressibility of a video and/or

audio, but may be the same "video and/or audio." In this way, there is an advantage that the receiving apparatus can obtain a desired "video and/or audio" with high quality by a method as simple as selecting "whether to demodulate data symbol group #1 or demodulate data symbol group #2," and that since a preamble can be made common in this case, control information transmission efficiency can be enhanced. However, contrarily, the video and/or audio to be transmitted with data symbol group #1 and the video and/or audio to be transmitted with data symbol #2 may be different.

[0071]

FIGS. 4, 5 and 6 illustrate the examples where a data symbol group subjected to time division is arranged after a data symbol group subjected to frequency division. However, the arrangement is not limited to this arrangement. The data symbol group subjected to frequency division may be arranged after the data symbol group subjected to time division. In this case, in the example in FIG. 5, the first preamble and the second preamble are inserted between the data symbol group subjected to time division and the data symbol group subjected to frequency division. However, symbols other than the first preamble and the second preamble may be inserted. Then, in the example in FIG. 6, the pilot symbol is inserted between the data symbol group subjected to time division and the data symbol group subjected to frequency division. However, symbols other than the pilot symbol may be inserted.

[0072]

Characteristic points of the present exemplary embodiment will be described.

[0073]

As described above, the frame configurations in FIGS. 2 to 6 have respective advantages. Hence, the transmitting apparatus selects any of the

frame configurations in FIGS. 2 to 6 according to compressibility and a type of data (stream), a transmitting method combining method and a method of service to be provided to a terminal, and transmits symbols such as control information, pilot symbols and data symbols.

[0074]

In order to realize the above, the transmitting apparatus (FIG. 1) may incorporate "information related to a frame configuration" for transmitting information related to a frame configuration to the receiving apparatus (terminal) in the first preamble or the second preamble.

[0075]

For example, in a case where the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 2 when three bits of v0, v1 and v2 are allocated as the "information related to the frame configuration," the transmitting apparatus sets (v0, v1, v2) to (0, 0, 0) and transmits the "information related to the frame configuration."

[0076]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 3, the transmitting apparatus sets (v0, v1, v2) to (0, 0, 1) and transmits the "information related to the frame configuration."

[0077]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 4, the transmitting apparatus sets (v0, v1, v2) to (0, 1, 0) and transmits the "information related to the frame configuration."

[0078]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 5, the transmitting apparatus sets (v0, v1, v2) to (0, 1, 1) and transmits the "information related to the frame configuration."

[0079]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 5, the transmitting apparatus sets (v0, v1, v2) to (1, 0, 0) and transmits the "information related to the frame configuration."

[0080]

Then, the receiving apparatus can learn an outline of a frame configuration of a modulated signal transmitted by the transmitting apparatus, from the "information related to the frame configuration."

[0081]

As described above, the data symbol group is a symbol of any of the SISO (or SIMO) method, the MISO method and the MIMO method. The MISO method and the MIMO method will be described in particular below.

[0082]

The MISO (transmitting) method using space time block codes (space frequency block codes) will be described.

[0083]

A configuration in a case where signal processor 112 in FIG. 1 performs a transmitting method using space time block codes will be described with reference to FIG. 7.

[0084]

Mapper 702 receives an input of data signal (data obtained after error correction coding) 701 and control signal 706. Mapper 702 performs mapping based on information contained in control signal 706 and related to a modulating method. Mapper 702 outputs signal 703 obtained after the mapping. For example, signal 703 obtained after the mapping is arranged in order of s0, s1, s2, s3, ..., s(2i), s(2i + 1), ... (i is an integer equal to or more than 0).

[0085]

MISO (Multiple Input Multiple Output) processor 704 receives an input of signal 703 obtained after the mapping and control signal 706. MISO processor 704 outputs signals 705A and 705B obtained after MISO processing in a case where control signal 706 instructs transmission by the MISO method. For example, signal 705A obtained after the MISO processing is of s0, s1, s2, s3, ..., s(2i), s(2i + 1), ..., and signal 705B obtained after the MISO processing is of -s1*, s0*, -s3*, s2*..., -s(2i + 1)*, s(2i)*, ... Note that "*" means a complex conjugate (for example, s0* is a complex conjugate of s0).

[0086]

In this case, signals 705A and 705B obtained after the MISO processing correspond to modulated signal 1 (113_1) obtained after signal processing in FIG. 1, and modulated signal 2 (113_2) obtained after signal processing, respectively. Note that a method of space time block codes is not limited to the above.

[0087]

Then, modulated signal 1 (113_1) obtained after the signal processing is subjected to predetermined processing, and is transmitted as a radio wave from antenna 126_1. Moreover, modulated signal 2 (113_2) obtained after the signal processing is subjected to predetermined processing, and is transmitted as a radio wave from antenna 126_2.

[0088]

FIG. 8 is a configuration in a case where a transmitting method using space time block codes different from the configuration in FIG. 7 is performed.

[0089]

Mapper 702 receives an input of data signal (data obtained after error correction coding) 701 and control signal 706. Mapper 702 performs mapping based on information contained in control signal 706 and related to a modulating method. Mapper 702 outputs signal 703 obtained after the mapping. For

example, signal 703 obtained after the mapping is arranged in order of s0, s1, s2, s3, ..., s(2i), s(2i + 1), ... (i is an integer equal to or more than 0).

[0090]

MISO (Multiple Input Multiple Output) processor 704 receives an input of signal 703 obtained after the mapping and control signal 706. MISO processor 704 outputs signals 705A and 705B obtained after MISO processing in a case where control signal 706 instructs transmission by the MISO method. For example, signal 705A obtained after the MISO processing is of s0, -s1*, s2, -s3*, ..., s(2i), -s(2i + 1)*, ..., and signal 705B obtained after the MISO processing is of s1, s0*, s3, s2*..., s(2i + 1), s(2i)*, ... Note that "*" means a complex conjugate. For example, s0* is a complex conjugate of s0.

[0091]

In this case, signals 705A and 705B obtained after the MISO processing correspond to modulated signal 1 (113_1) obtained after signal processing in FIG. 1, and modulated signal 2 (113_2) obtained after signal processing, respectively. Note that a method of space time block codes is not limited to the above.

[0092]

Then, modulated signal 1 (113_1) obtained after the signal processing is subjected to predetermined processing, and is transmitted as a radio wave from antenna 126_1. Moreover, modulated signal 2 (113_2) obtained after the signal processing is subjected to predetermined processing, and is transmitted as a radio wave from antenna 126_2.

[0093]

Next, an MIMO method to which precoding, phase change and power change are applied will be described as an example of the MIMO method. However, the method for transmitting a plurality of streams from a plurality of antennas is not limited to this method, and the present exemplary embodiment can

also be carried out by another method.

[0094]

A configuration in a case where signal processor 112 in FIG. 1 performs a transmitting method using the MIMO method will be described with reference to FIGS. 9 to 17.

[0095]

Encoder 1102 in FIG. 9 receives an input of information 1101, and control signal 1112. Encoder 1102 performs encoding based on information of a coding rate and a code length (block length) contained in control signal 1112. Encoder 1102 outputs encoded data 1103.

[0096]

Mapper 1104 receives an input of encoded data 1103, and control signal 1112. Then, it is assumed that control signal 1112 specifies transmission of two streams as a transmitting method. In addition, it is assumed that control signal 1112 specifies modulating method α and modulating method β as modulating methods of the two streams, respectively. Note that modulating method α is a modulating method for modulating x-bit data, and modulating method β is a modulating method for modulating y-bit data. For example, the modulating method is a modulating method for modulating 4-bit data in a case of 16QAM (16 Quadrature Amplitude Modulation), and a modulating method for modulating 6-bit data in a case of 64QAM (64 Quadrature Amplitude Modulation).

[0097]

Then, mapper 1104 modulates the x-bit data of x + y-bit data by modulating method α, generates and outputs baseband signal $s_1(t)$ 1105A, and also modulates the remaining y-bit data by modulating method β, and outputs baseband signal $s_2(t)$ 1105B (note that FIG. 9 illustrates one mapper, but as another configuration, there may separately be a mapper for generating $s_1(t)$ and a mapper for generating $s_2(t)$.

In this case, encoded data 1103 is sorted to the mapper for generating $s_1(t)$ and the mapper for generating $s_2(t)$).

[0098]

Note that $s_1(t)$ and $s_2(t)$ are expressed by complex numbers (however, $s_1(t)$ and $s_2(t)$ may be any of complex numbers and actual numbers), and t represents time. Note that when a transmitting method using multi-carriers such as OFDM (Orthogonal Frequency Division Multiplexing) is used, each of s_1 and s_2 can also be considered as a function of frequency f like $s_1(f)$ and $s_2(f)$ or as a function of time t and frequency f like $s_1(t, f)$ and $s_2(t, f)$.

[0099]

A baseband signal, a precoding matrix, phase change and the like will be described below as a function of time t, but may be considered as a function of frequency f and a function of time t and frequency f.

[0100]

Hence, there is also a case where a baseband signal, a precoding matrix, phase change and the like are described as a function of symbol number i. However, in this case, a baseband signal, a precoding matrix, phase change and the like only need to be considered as a function of time t, a function of frequency f and a function of time t and frequency f. That is, a symbol and a baseband signal may be generated and arranged in a time axis direction, and may be generated and arranged in a frequency axis direction. Moreover, a symbol and a baseband signal may be generated and arranged in the time axis direction and the frequency axis direction.

[0101]

Power changer 1106A (power adjuster 1106A) receives an input of baseband signal $s_1(t)$ 1105A, and control signal 1112. Power changer 1106A sets actual number P_1 based on control signal 1112. Power changer 1106A outputs P_1

× $s_1(t)$ as signal 1107A obtained after power change. Note that P_1 is assumed to be an actual number, but may be a complex number.

[0102]

Similarly, power changer 1106B (power adjuster 1106B) receives an input of baseband signal $s_2(t)$ 1105B, and control signal 512. Power changer 1106B sets actual number P_2. Power changer 1106B outputs $P_2 \times s_2(t)$ as signal 1107B obtained after power change. Note that P_2 is assumed to be an actual number, but may be a complex number.

[0103]

Weighting synthesizer 1108 receives an input of signal 1107A obtained after the power change, signal 1107B obtained after the power change, and control signal 1112. Weighting synthesizer 1108 sets precoding matrix F (or F(i)) based on control signal 1112. Weighting synthesizer 1108 performs the following arithmetic operation, assuming that a slot number (symbol number) is i.

[0104]

[Equation 1]

$$\begin{aligned}\begin{pmatrix} u_1(i) \\ u_2(i) \end{pmatrix} &= F\begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \\ &= \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix}\begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \\ &= \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix}\begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix}\begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}\end{aligned} \quad \cdots (1)$$

[0105]

Here, a(i), b(i), c(i) and d(i) can be expressed by complex numbers (or may be actual numbers), and three or more of a(i), b(i), c(i) and d(i) should not be 0 (zero). Note that a precoding matrix may be a function of i or may not be the function of i. Then, when a precoding matrix is the function of i, the precoding

matrices are switched according to a slot number (symbol number).

[0106]

Then, weighting synthesizer 1108 outputs $u_1(i)$ in equation (1) as signal 1109A obtained after weighting synthesis. Weighting synthesizer 1108 outputs $u_2(i)$ in equation (1) as signal 1109B obtained after the weighting synthesis.

[0107]

Power changer 1110A receives an input of signal 1109A ($u_1(i)$) obtained after the weighting synthesis, and control signal 512. Power changer 1110A sets actual number Q_1 based on control signal 1112. Power changer 1110A outputs $Q_1 \times u_1(t)$ as signal 1111A ($z_1(i)$) obtained after power change (note that Q_1 is assumed to be an actual number, but may be a complex number).

[0108]

Similarly, power changer 1110B receives an input of signal 1109B ($u_2(i)$) obtained after the weighting synthesis, and control signal 1112. Power changer 1110B sets actual number Q_2 based on control signal 512. Power changer 1110B outputs $Q_2 \times u_2(t)$ as signal 1111B ($z_2(i)$) obtained after the power change (note that Q_2 is assumed to be an actual number, but may be a complex number).

[0109]

Hence, the following equation holds.

[0110]

[Equation 2]

$$\begin{aligned}\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \\ &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \\ &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}\end{aligned} \quad \cdots (2)$$

[0111]

Next, a method for transmitting two streams different from the transmitting method in FIG. 9 will be described with reference to FIG. 10. Note that elements operating in the same way as in FIG. 9 are assigned the same reference numerals in FIG. 10.

[0112]

Phase changer 1161 receives an input of signal 1109B obtained after weighting synthesis of $u_2(i)$ in equation (1), and control signal 1112. Phase changer 1161 changes a phase of signal 1109B obtained after the weighting synthesis of $u_2(i)$ in equation (1) based on control signal 1112. Hence, a signal obtained after the phase change of signal 1109B obtained after the weighting synthesis of $u_2(i)$ in equation (1) is expressed by $e^{j\theta(i)} \times u_2(i)$. Phase changer 1161 outputs $e^{j\theta(i)} \times u_2(i)$ as signal 1162 obtained after the phase change (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being the function of i like θ(i).

[0113]

Then, power changers 1110A and 1110B in FIG. 10 each perform power change of an input signal. Hence, output $z_1(i)$ and output $z_2(i)$ of respective power changers 1110A and 1110B in FIG. 10 are expressed by the following equation.

[0114]

[Equation 3]

$$\begin{aligned}\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \\ &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \qquad \cdots (3) \\ &= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}\end{aligned}$$

[0115]

Note that as a method for realizing equation (3), there is FIG. 11 as a configuration different from the configuration in FIG. 10. A difference between FIGS. 10 and 11 is that the power changer and the phase changers are switched in order. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0116]

[Equation 4]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 \times s_1(i) \\ P_2 \times s_2(i) \end{pmatrix} \quad \cdots (4)$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$

[0117]

When value θ(i) of a phase to be changed in equation (3) and equation (4) is set such that, for example, θ(i + 1) - θ(i) is a fixed value, the receiving apparatus is highly likely to obtain good data reception quality in radio wave propagation environment in which a direct wave is dominant. However, how to give value θ(i) of a phase to be changed is not limited to this example.

[0118]

The case where there are some of (or all of) the power changers is described as an example with reference to FIGS. 9 to 11. However, there can also be considered a case where some of the power changers do not exist.

[0119]

For example, when there are neither power changer 1106A (power adjuster 1106A) nor power changer 1106B (power adjuster 1106B) in FIG. 9, $z_1(i)$

and $z_2(i)$ are expressed as follows.

[0120]

[Equation 5]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (5)$$

[0121]

Moreover, when there are neither power changer 1110A (power adjuster 1110A) nor power changer 1110B (power adjuster 1110B) in FIG. 9, $z_1(i)$ and $z_2(i)$ are expressed as follows.

[0122]

[Equation 6]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (6)$$

[0123]

Moreover, when there are neither power changer 1106A (power adjuster 1106A), nor power changer 1106B (power adjuster 1106B), nor power changer 1110A (power adjuster 1110A) nor power changer 1110B (power adjuster 1110B) in FIG. 9, $z_1(i)$ and $z_2(i)$ are expressed as follows.

[0124]

[Equation 7]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (7)$$

[0125]

Moreover, when there are neither power changer 1106A (power adjuster 1106A) nor power changer 1106B (power adjuster 1106B) in FIG. 10 or 11, $z_1(i)$

and $z_2(i)$ are expressed as follows.

[0126]

[Equation 8]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (8)$$

[0127]

Moreover, when there are neither power changer 1110A (power adjuster 1110A) nor power changer 1110B (power adjuster 1110B) in FIG. 10 or 11, $z_1(i)$ and $z_2(i)$ are expressed as follows.

[0128]

[Equation 9]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (9)$$

[0129]

Moreover, when there are neither power changer 1106A (power adjuster 1106A), nor power changer 1106B (power adjuster 1106B), nor power changer 1110A (power adjuster 1110A) nor power changer 1110B (power adjuster 1110B) in FIG. 10 or 11, $z_1(i)$ and $z_2(i)$ are expressed as follows.

[0130]

[Equation 10]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (10)$$

[0131]

Next, a method for transmitting two streams different from the transmitting

methods in FIGS. 9 to 11 will be described with reference to FIG. 12. Note that elements operating in the same way as in FIGS. 9 to 11 are assigned the same reference numerals in FIG. 12, and will not be described.

[0132]

Characteristic points in FIG. 12 are such that phase changer 1151 is inserted.

[0133]

Phase changer 1151 receives an input of baseband signal $s_2(i)$ 1105B, and control signal 1112. Phase changer 1151 changes a phase of baseband signal $s_2(i)$ 1105B based on control signal 1112. In this case, a phase change value is $e^{j\lambda(i)}$ (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being a function of i like λ(i).

[0134]

Then, as considered in the same way as equation (1) to equation (10), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 12 are expressed by the following equation.

[0135]

[Equation 11]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (11)$$

[0136]

Note that as a method for realizing equation (11), there is a configuration of switching power changer 1106B and phase changer 1151 in order as a configuration different from the configuration in FIG. 12. Functions themselves of

changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0137]

[Equation 12]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (12)$$

[0138]

As a matter of course, $z_1(i)$ of equation (11) and $z_1(i)$ of equation (12) are equal, and $z_2(i)$ of equation (11) and $z_2(i)$ of equation (12) are equal.

[0139]

FIG. 13 is another configuration which can realize the same processing as the processing in FIG. 12. Note that elements operating in the same way as in FIGS. 9 to 12 are assigned the same reference numerals in FIG. 13, and will not be described. Then, a difference between FIGS. 12 and 13 is that order in which power changer 1110B and phase changer 1161 are switched in FIG. 12 is order in FIG. 13. Functions themselves of changing power and changing phases are not changed.

[0140]

Then, as considered in the same way as equation (1) to equation (12), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 13 are expressed by the following equation.

[0141]

[Equation 13]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (13)$$

[0142]

Note that as a method for realizing equation (13), there is a configuration of switching power changer 1106B and phase changer 1151 in order as a configuration different from the configuration in FIG. 13. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0143]

[Equation 14]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (14)$$

[0144]

As a matter of course, $z_1(i)$ of equation (11), $z_1(i)$ of equation (12), $z_1(i)$ of equation (13) and $z_1(i)$ of equation (14) are equal, and $z_2(i)$ of equation (11), $z_2(i)$ of equation (12), $z_2(i)$ of equation (13) and $z_2(i)$ of equation (14) are equal.

[0145]

Next, a method for transmitting two streams different from the transmitting methods in FIGS. 9 to 13 will be described with reference to FIG. 14. Note that elements operating in the same way as in FIGS. 9 to 13 are assigned the same reference numerals in FIG. 14, and will not be described.

[0146]

Characteristic points in FIG. 14 are such that phase changer 1181 and phase changer 1151 are inserted.

[0147]

Phase changer 1151 receives an input of baseband signal $s_2(i)$ 1105B, and control signal 1112. Phase changer 1151 changes a phase of baseband signal $s_2(i)$ 1105B based on control signal 1112. In this case, a phase change value is $e^{j\lambda(i)}$ (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being a function of i like λ(i).

[0148]

Moreover, phase changer 1181 receives an input of baseband signal $s_1(i)$ 1105A, and control signal 1112. Phase changer 1181 changes a phase of baseband signal $s_1(i)$ 1105A based on control signal 1112. In this case, a phase change value is $e^{j\delta(i)}$ (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being a function of i like δ(i).

[0149]

Then, as considered in the same way as equation (1) to equation (14), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 14 are expressed by the following equation.

[0150]

[Equation 15]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (15)$$

[0151]

Note that as a method for realizing equation (15), there is a configuration of

switching power changer 1106B and phase changer 1151 in order and of switching power changer 1106A and phase changer 1181 in order as a configuration different from the configuration in FIG. 14. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0152]

[Equation 16]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (16)$$

[0153]

As a matter of course, $z_1(i)$ of equation (15) and $z_1(i)$ of equation (16) are equal, and $z_2(i)$ of equation (15) and $z_2(i)$ of equation (16) are equal.

[0154]

FIG. 15 is another configuration which can realize the same processing as the processing in FIG. 14. Note that elements operating in the same way as in FIGS. 9 to 14 are assigned the same reference numerals in FIG. 15, and will not be described. Then, a difference between FIGS. 14 and 15 is that order in which power changer 1110B and phase changer 1161 are switched in FIG. 14 is order in FIG. 15 (functions themselves of changing power and changing phases are not changed).

[0155]

Then, as considered in the same way as equation (1) to equation (16), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 15 are expressed by the following equation.

[0156]

[Equation 17]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (17)$$

[0157]

Note that as a method for realizing equation (17), there is a configuration of switching power changer 1106B and phase changer 1151 in order and of switching power changer 1106A and phase changer 1181 in order as a configuration different from the configuration in FIG. 15. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0158]

[Equation 18]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} 1 & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \cdots (18)$$

[0159]

As a matter of course, $z_1(i)$ of equation (15), $z_1(i)$ of equation (16), $z_1(i)$ of equation (17) and $z_1(i)$ of equation (18) are equal, and $z_2(i)$ of equation (15), $z_2(i)$ of equation (16), $z_2(i)$ of equation (17) and $z_2(i)$ of equation (18) are equal.

[0160]

Next, a method for transmitting two streams different from the transmitting methods in FIGS. 9 to 15 will be described with reference to FIG. 16. Note that

elements operating in the same way as in FIGS. 9 to 15 are assigned the same reference numerals in FIG. 16, and will not be described.

[0161]

Characteristic points in FIG. 16 are such that phase changer 1181, phase changer 1151, phase changer 1110A and phase changer 1110B are inserted.

[0162]

Phase changer 1151 receives an input of baseband signal $s_2(i)$ 1105B, and control signal 1112. Phase changer 1151 changes a phase of baseband signal $s_2(i)$ 1105B based on control signal 1112. In this case, a phase change value is $e^{j\lambda(i)}$ (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being a function of i like $\lambda(i)$.

[0163]

Moreover, phase changer 1181 receives an input of baseband signal $s_1(i)$ 1105A, and control signal 1112. Phase changer 1181 changes a phase of baseband signal $s_1(i)$ 1105A based on control signal 1112. In this case, a phase change value is $e^{j\delta(i)}$ (j is a unit of an imaginary number). Note that a value of a phase to be changed is a portion characterized by being a function of i like $\delta(i)$.

[0164]

Phase changer 1161 performs phase change on an input signal. A phase change value in this case is $\theta(i)$. Similarly, phase changer 1191 performs phase change on an input signal. A phase change value in this case is $\omega(i)$.

[0165]

Then, as considered in the same way as equation (1) to equation (18), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 16 are expressed by the following equation.

[0166]

[Equation 19]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (19)$$

[0167]

Note that as a method for realizing equation (19), there is a configuration of switching power changer 1106B and phase changer 1151 in order and of switching power changer 1106A and phase changer 1181 in order as a configuration different from the configuration in FIG. 16. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0168]

[Equation 20]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} F \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (20)$$

[0169]

As a matter of course, $z_1(i)$ of equation (19) and $z_1(i)$ of equation (20) are equal, and $z_2(i)$ of equation (19) and $z_2(i)$ of equation (20) are equal.

[0170]

FIG. 17 is another configuration which can realize the same processing as the processing in FIG. 16. Note that elements operating in the same way as in FIGS. 9 to 16 are assigned the same reference numerals in FIG. 17, and will not be described. Then, a difference between FIGS. 16 and 17 is that order in which power changer 1110B and phase changer 1161 are switched in FIG. 14 and order

in which power changer 1110A and phase changer 1191 are switched in FIG. 14 are order in FIG. 17. Functions themselves of changing power and changing phases are not changed.

[0171]

Then, as considered in the same way as equation (1) to equation (20), $z_1(i)$ and $z_2(i)$ which are output signals in FIG. 17 are expressed by the following equation.

[0172]

[Equation 21]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (21)$$

[0173]

Note that as a method for realizing equation (21), there is a configuration of switching power changer 1106B and phase changer 1151 in order and of switching power changer 1106A and phase changer 1181 in order as a configuration different from the configuration in FIG. 17. Functions themselves of changing power and changing phases are not changed. In this case, $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0174]

[Equation 22]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix}$$
$$= \begin{pmatrix} e^{j\omega(i)} & 0 \\ 0 & e^{j\theta(i)} \end{pmatrix} \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} \begin{pmatrix} a(i) & b(i) \\ c(i) & d(i) \end{pmatrix} \begin{pmatrix} e^{j\delta(i)} & 0 \\ 0 & e^{j\lambda(i)} \end{pmatrix} \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (22)$$

[0175]

As a matter of course, $z_1(i)$ of equation (19), $z_1(i)$ of equation (20), $z_1(i)$ of equation (21) and $z_1(i)$ of equation (22) are equal, and $z_2(i)$ of equation (19), $z_2(i)$ of equation (20), $z_2(i)$ of equation (21) and $z_2(i)$ of equation (22) are equal.

[0176]

Matrix F for weighting synthesis (precoding) is described above. However, each exemplary embodiment herein can also be carried out by using precoding matrix F (or F(i)) described below.

[0177]

[Equation 23]

$$F=\begin{pmatrix} \beta\times e^{j0} & \beta\times\alpha\times e^{j0} \\ \beta\times\alpha\times e^{j0} & \beta\times e^{j\pi} \end{pmatrix} \quad \cdots (23)$$

[0178]

or

[0179]

[Equation 24]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} e^{j0} & \alpha\times e^{j0} \\ \alpha\times e^{j0} & e^{j\pi} \end{pmatrix} \quad \cdots (24)$$

[0180]

or

[0181]

[Equation 25]

$$F=\begin{pmatrix} \beta\times e^{j0} & \beta\times\alpha\times e^{j\pi} \\ \beta\times\alpha\times e^{j0} & \beta\times e^{j0} \end{pmatrix} \quad \cdots (25)$$

[0182]

or

[0183]

[Equation 26]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} e^{j0} & \alpha\times e^{j\pi} \\ \alpha\times e^{j0} & e^{j0} \end{pmatrix} \quad \cdots (26)$$

[0184]

or

[0185]

[Equation 27]

$$F=\begin{pmatrix} \beta\times\alpha\times e^{j0} & \beta\times e^{j\pi} \\ \beta\times e^{j0} & \beta\times\alpha\times e^{j0} \end{pmatrix} \quad \cdots (27)$$

[0186]

or

[0187]

[Equation 28]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} \alpha\times e^{j0} & e^{j\pi} \\ e^{j0} & \alpha\times e^{j0} \end{pmatrix} \quad \cdots (28)$$

[0188]

or

[0189]

[Equation 29]

$$F=\begin{pmatrix} \beta\times\alpha\times e^{j0} & \beta\times e^{j0} \\ \beta\times e^{j0} & \beta\times\alpha\times e^{j\pi} \end{pmatrix} \quad \cdots (29)$$

[0190]

or

[0191]

[Equation 30]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix}\alpha\times e^{j0} & e^{j0}\\ e^{j0} & \alpha\times e^{j\pi}\end{pmatrix} \quad \cdots (30)$$

[0192]

Note that in equation (23), equation (24), equation (25), equation (26), equation (27), equation (28), equation (29), and equation (30), α may be an actual number or may be an imaginary number, and β may be an actual number or may be an imaginary number. However, α is not 0 (zero). Then, β is not 0 (zero), either.

Alternatively

[0193]

[Equation 31]

$$F=\begin{pmatrix}\beta\times cos\theta & \beta\times sin\theta\\ \beta\times sin\theta & -\beta\times cos\theta\end{pmatrix} \quad \cdots (31)$$

[0194]

or

[0195]

[Equation 32]

$$F=\begin{pmatrix}cos\theta & sin\theta\\ sin\theta & -cos\theta\end{pmatrix} \quad \cdots (32)$$

[0196]

or

[0197]

[Equation 33]

$$F=\begin{pmatrix}\beta\times\cos\theta & -\beta\times\sin\theta\\ \beta\times\sin\theta & \beta\times\cos\theta\end{pmatrix} \quad \cdots (33)$$

[0198]

or

[0199]

[Equation 34]

$$F=\begin{pmatrix}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{pmatrix} \quad \cdots (34)$$

[0200]

or

[0201]

[Equation 35]

$$F=\begin{pmatrix}\beta\times\sin\theta & -\beta\times\cos\theta\\ \beta\times\cos\theta & \beta\times\sin\theta\end{pmatrix} \quad \cdots (35)$$

[0202]

or

[0203]

[Equation 36]

$$F=\begin{pmatrix}\sin\theta & -\cos\theta\\ \cos\theta & \sin\theta\end{pmatrix} \quad \cdots (36)$$

[0204]

or

[0205]

[Equation 37]

$$F=\begin{pmatrix}\beta\times\sin\theta & \beta\times\cos\theta\\ \beta\times\cos\theta & -\beta\times\sin\theta\end{pmatrix} \quad \cdots (37)$$

[0206]

or

[0207]

[Equation 38]

$$F=\begin{pmatrix} sin\theta & cos\theta \\ cos\theta & -sin\theta \end{pmatrix} \quad \cdots (38)$$

[0208]

Note that in equation (31), equation (33), equation (35) and equation (37), β may be an actual number or may be an imaginary number. However, β is not 0 (zero).

Alternatively

[0209]

[Equation 39]

$$F(i)=\begin{pmatrix} \beta\times e^{j\theta_{11}(i)} & \beta\times\alpha\times e^{j(\theta_{11}(i)+\lambda)} \\ \beta\times\alpha\times e^{j\theta_{21}(i)} & \beta\times e^{j(\theta_{21}(i)+\lambda+\pi)} \end{pmatrix} \quad \cdots (39)$$

[0210]

or

[0211]

[Equation 40]

$$F(i)=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} e^{j\theta_{11}(i)} & \alpha\times e^{j(\theta_{11}(i)+\lambda)} \\ \alpha\times e^{j\theta_{21}(i)} & e^{j(\theta_{21}(i)+\lambda+\pi)} \end{pmatrix} \quad \cdots (40)$$

[0212]

or

[0213]

[Equation 41]

$$F(i)=\begin{pmatrix} \beta\times\alpha\times e^{j\theta_{21}(i)} & \beta\times e^{j(\theta_{21}(i)+\lambda+\pi)} \\ \beta\times e^{j\theta_{11}(i)} & \beta\times\alpha\times e^{j(\theta_{11}(i)+\lambda)} \end{pmatrix} \quad \cdots (41)$$

[0214]

or

[0215]

[Equation 42]

$$F(i)=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} \alpha\times e^{j\theta_{21}(i)} & e^{j(\theta_{21}(i)+\lambda+\pi)} \\ e^{j\theta_{11}(i)} & \alpha\times e^{j(\theta_{11}(i)+\lambda)} \end{pmatrix} \quad \cdots (42)$$

[0216]

or

[0217]

[Equation 43]

$$F(i)=\begin{pmatrix} \beta\times e^{j\theta_{11}} & \beta\times\alpha\times e^{j(\theta_{11}+\lambda(i))} \\ \beta\times\alpha\times e^{j\theta_{21}} & \beta\times e^{j(\theta_{21}+\lambda(i)+\pi)} \end{pmatrix} \quad \cdots (43)$$

[0218]

or

[0219]

[Equation 44]

$$F(i)=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} e^{j\theta_{11}} & \alpha\times e^{j(\theta_{11}+\lambda(i))} \\ \alpha\times e^{j\theta_{21}} & e^{j(\theta_{21}+\lambda(i)+\pi)} \end{pmatrix} \quad \cdots (44)$$

[0220]

or

[0221]

[Equation 45]

$$F(i)=\begin{pmatrix} \beta\times\alpha\times e^{j\theta_{21}} & \beta\times e^{j(\theta_{21}+\lambda(i)+\pi)} \\ \beta\times e^{j\theta_{11}} & \beta\times\alpha\times e^{j(\theta_{11}+\lambda(i))} \end{pmatrix} \quad \cdots (45)$$

[0222]

or

[0223]

[Equation 46]

$$F(i)=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} \alpha\times e^{j\theta_{21}} & e^{j(\theta_{21}+\lambda(i)+\pi)} \\ e^{j\theta_{11}} & \alpha\times e^{j(\theta_{11}+\lambda(i))} \end{pmatrix} \quad \cdots (46)$$

[0224]

or

[0225]

[Equation 47]

$$F=\begin{pmatrix} \beta\times e^{j\theta_{11}} & \beta\times\alpha\times e^{j(\theta_{11}+\lambda)} \\ \beta\times\alpha\times e^{j\theta_{21}} & \beta\times e^{j(\theta_{21}+\lambda+\pi)} \end{pmatrix} \quad \cdots (47)$$

[0226]

or

[0227]

[Equation 48]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix} e^{j\theta_{11}} & \alpha\times e^{j(\theta_{11}+\lambda)} \\ \alpha\times e^{j\theta_{21}} & e^{j(\theta_{21}+\lambda+\pi)} \end{pmatrix} \quad \cdots (48)$$

[0228]

or

[0229]

[Equation 49]

$$F=\begin{pmatrix}\beta\times\alpha\times e^{j\theta_{21}} & \beta\times e^{j(\theta_{21}+\lambda+\pi)}\\ \beta\times e^{j\theta_{11}} & \beta\times\alpha\times e^{j(\theta_{11}+\lambda)}\end{pmatrix}\quad\cdots\ (49)$$

[0230]

or

[0231]

[Equation 50]

$$F=\frac{1}{\sqrt{\alpha^2+1}}\begin{pmatrix}\alpha\times e^{j\theta_{21}} & e^{j(\theta_{21}+\lambda+\pi)}\\ e^{j\theta_{11}} & \alpha\times e^{j(\theta_{11}+\lambda)}\end{pmatrix}\quad\cdots\ (50)$$

[0232]

Here, each of $\theta_{11}(i)$, $\theta_{21}(i)$ and $\lambda(i)$ is a function of i, λ is a fixed value, α may be an actual number or may be an imaginary number, and β may be an actual number or may be an imaginary number. However, α is not 0 (zero). Then, β is not 0 (zero), either. Note that i indicates either time or a frequency or indicates both time and a frequency.

[0233]

Alternatively

[0234]

[Equation 51]

$$F=\begin{pmatrix}\beta & 0\\ 0 & \beta\end{pmatrix}\quad\cdots\ (51)$$

[0235]

or

[0236]

[Equation 52]

$$F=\begin{pmatrix}\beta & 0\\ 0 & -\beta\end{pmatrix} \quad \cdots (52)$$

[0237]

[Equation 53]

$$F=\begin{pmatrix}\beta & 0\\ 0 & \beta\times e^{j\theta(i)}\end{pmatrix} \quad \cdots (53)$$

[0238]

or

[0239]

[Equation 54]

$$F=\begin{pmatrix}\beta & 0\\ 0 & -\beta\times e^{j\theta(i)}\end{pmatrix} \quad \cdots (54)$$

[0240]

or

[0241]

[Equation 55]

$$F=\begin{pmatrix}-\beta & 0\\ 0 & \beta\times e^{j\theta(i)}\end{pmatrix} \quad \cdots (55)$$

[0242]

Here, θ(i) is a function of i, and β may be an actual number or may be an imaginary number. However, β is not 0 (zero), either. Note that i represents either time or a frequency or indicates both time and a frequency.

[0243]

Moreover, each exemplary embodiment herein can also be carried out by

using a precoding matrix other than these matrices.

[0244]

In addition, there may be a method for performing precoding without performing the above-described phase change, to generate a modulated signal and transmit the modulated signal from the transmitting apparatus. In this case, there can be considered an example where $z_1(i)$ and $z_2(i)$ are expressed by the following equation.

[0245]

[Equation 56]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (56)$$

[0246]

[Equation 57]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (57)$$

[0247]

[Equation 58]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = F \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix} \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (58)$$

[0248]

[Equation 59]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = \begin{pmatrix} Q_1 & 0 \\ 0 & Q_2 \end{pmatrix} F \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (59)$$

[0249]

[Equation 60]

$$\begin{pmatrix} z_1(i) \\ z_2(i) \end{pmatrix} = F \begin{pmatrix} s_1(i) \\ s_2(i) \end{pmatrix} \quad \cdots (60)$$

[0250]

Then, $z_1(i)$ obtained in FIGS. 9 to 17, $z_1(i)$ of equation (56), $z_1(i)$ of equation (57), $z_1(i)$ of equation (58), $z_1(i)$ of equation (59) or $z_1(i)$ of equation (60) corresponds to modulated signal 1 (113_1) obtained after signal processing in FIG. 1, and $z_2(i)$ obtained in FIGS. 9 to 17, $z_2(i)$ of equation (56), $z_2(i)$ of equation (57), $z_2(i)$ of equation (58), $z_2(i)$ of equation (59) or $z_2(i)$ of equation (60) corresponds to modulated signal 2 (113_2) in FIG. 1.

[0251]

FIGS. 18 to 22 illustrate examples of a method for arranging $z_1(i)$ and $z_2(i)$ generated in FIGS. 9 to 17.

[0252]

Part (A) of FIG. 18 illustrates a method for arranging $z_1(i)$, and (B) of FIG. 18 illustrates a method for arranging $z_2(i)$. In each of (A) and (B) of FIG. 18, a vertical axis indicates time, and a horizontal axis indicates a frequency.

[0253]

Part (A) of FIG. 18 will be described. First, when $z_1(0)$, $z_1(1)$, $z_1(2)$, $z_1(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated,

$z_1(0)$ is arranged at carrier 0 and time 1,

$z_1(1)$ is arranged at carrier 1 and time 1,

$z_1(2)$ is arranged at carrier 2 and time 1,

...

$z_1(10)$ is arranged at carrier 0 and time 2,

$z_1(11)$ is arranged at carrier 1 and time 2,

$z_1(12)$ is arranged at carrier 2 and time 2, and

....

[0254]

Similarly, when $z_2(0)$, $z_2(1)$, $z_2(2)$, $z_2(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated in (B) of FIG. 18,

$z_2(0)$ is arranged at carrier 0 and time 1,

$z_2(1)$ is arranged at carrier 1 and time 1,

$z_2(2)$ is arranged at carrier 2 and time 1,

...

$z_2(10)$ is arranged at carrier 0 and time 2,

$z_2(11)$ is arranged at carrier 1 and time 2,

$z_2(12)$ is arranged at carrier 2 and time 2, and

....

[0255]

In this case, $z_1(a)$ and $z_2(a)$ in a case of i = a are transmitted from the same frequency and from the same time. Then, FIG. 18 illustrates examples of a case where generated $z_1(i)$ and $z_2(i)$ are preferentially arranged in the frequency axis direction.

[0256]

Part (A) of FIG. 19 illustrates a method for arranging $z_1(i)$, and (B) of FIG. 19 illustrates a method for arranging $z_2(i)$. In each of (A) and (B) of FIG. 19, a vertical axis indicates time, and a horizontal axis indicates a frequency.

[0257]

Part (A) of FIG. 19 will be described. First, when $z_1(0)$, $z_1(1)$, $z_1(2)$, $z_1(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated,

$z_1(0)$ is arranged at carrier 0 and time 1,

$z_1(1)$ is arranged at carrier 1 and time 2,

$z_1(2)$ is arranged at carrier 2 and time 1,

...

$z_1(10)$ is arranged at carrier 2 and time 2,

$z_1(11)$ is arranged at carrier 7 and time 1,

$z_1(12)$ is arranged at carrier 8 and time 2, and

....

[0258]

Similarly, when $z_2(0)$, $z_2(1)$, $z_2(2)$, $z_2(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated in (B) of FIG. 19,

$z_2(0)$ is arranged at carrier 0 and time 1,

$z_2(1)$ is arranged at carrier 1 and time 2,

$z_2(2)$ is arranged at carrier 2 and time 1,

...

$z_2(10)$ is arranged at carrier 2 and time 2,

$z_2(11)$ is arranged at carrier 7 and time 1,

$z_2(12)$ is arranged at carrier 8 and time 2, and

....

[0259]

In this case, $z_1(a)$ and $z_2(a)$ in a case of i = a are transmitted from the same frequency and from the same time. Then, FIG. 19 illustrates examples of a case where generated $z_1(i)$ and $z_2(i)$ are randomly arranged in the frequency axis and time axis directions.

[0260]

Part (A) of FIG. 20 illustrates a method for arranging $z_1(i)$, and (B) of FIG. 20 illustrates a method for arranging $z_2(i)$. In each of (A) and (B) of FIG. 20, a vertical axis indicates time, and a horizontal axis indicates a frequency.

[0261]

Part (A) of FIG. 20 will be described. First, when $z_1(0)$, $z_1(1)$, $z_1(2)$, $z_1(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated,

$z_1(0)$ is arranged at carrier 0 and time 1,

$z_1(1)$ is arranged at carrier 2 and time 1,

$z_1(2)$ is arranged at carrier 4 and time 1,

...

$z_1(10)$ is arranged at carrier 0 and time 2,

$z_1(11)$ is arranged at carrier 2 and time 2,

$z_1(12)$ is arranged at carrier 4 and time 2, and

....

[0262]

Similarly, when $z_2(0)$, $z_2(1)$, $z_2(2)$, $z_2(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated in (B) of FIG. 20,

$z_2(0)$ is arranged at carrier 0 and time 1,

$z_2(1)$ is arranged at carrier 2 and time 1,

$z_2(2)$ is arranged at carrier 4 and time 1,

...

$z_2(10)$ is arranged at carrier 0 and time 2,

$z_2(11)$ is arranged at carrier 2 and time 2,

$z_2(12)$ is arranged at carrier 4 and time 2, and

....

[0263]

In this case, $z_1(a)$ and $z_2(a)$ in a case of i = a are transmitted from the same frequency and from the same time. Then, FIG. 20 illustrates examples of a case where generated $z_1(i)$ and $z_2(i)$ are preferentially arranged in the frequency axis direction.

[0264]

Part (A) of FIG. 21 illustrates a method for arranging $z_1(i)$, and (B) of FIG. 21 illustrates a method for arranging $z_2(i)$. In each of (A) and (B) of FIG. 21, a vertical axis indicates time, and a horizontal axis indicates a frequency.

[0265]

Part (A) of FIG. 21 will be described. First, when $z_1(0)$, $z_1(1)$, $z_1(2)$, $z_1(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated,

$z_1(0)$ is arranged at carrier 0 and time 1,

$z_1(1)$ is arranged at carrier 1 and time 1,

$z_1(2)$ is arranged at carrier 0 and time 2,

...

$z_1(10)$ is arranged at carrier 2 and time 2,

$z_1(11)$ is arranged at carrier 3 and time 2,

$z_1(12)$ is arranged at carrier 2 and time 3, and

....

[0266]

Similarly, when $z_2(0)$, $z_2(1)$, $z_2(2)$, $z_2(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated in (B) of FIG. 21,

$z_2(0)$ is arranged at carrier 0 and time 1,

$z_2(1)$ is arranged at carrier 1 and time 1,

$z_2(2)$ is arranged at carrier 0 and time 2,

...

$z_2(10)$ is arranged at carrier 2 and time 2,

$z_2(11)$ is arranged at carrier 3 and time 2,

$z_2(12)$ is arranged at carrier 2 and time 3, and

....

[0267]

In this case, $z_1(a)$ and $z_2(a)$ in a case of i = a are transmitted from the same

frequency and from the same time. Then, FIG. 21 illustrates examples of a case where generated $z_1(i)$ and $z_2(i)$ are arranged in the time and frequency axis directions.

[0268]

Part (A) of FIG. 22 illustrates a method for arranging $z_1(i)$, and (B) of FIG. 22 illustrates a method for arranging $z_2(i)$. In each of (A) and (B) of FIG. 22, a vertical axis indicates time, and a horizontal axis indicates a frequency.

[0269]

Part (A) of FIG. 22 will be described. First, when $z_1(0)$, $z_1(1)$, $z_1(2)$, $z_1(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated,

$z_1(0)$ is arranged at carrier 0 and time 1,

$z_1(1)$ is arranged at carrier 0 and time 2,

$z_1(2)$ is arranged at carrier 0 and time 3,

...

$z_1(10)$ is arranged at carrier 2 and time 3,

$z_1(11)$ is arranged at carrier 2 and time 4,

$z_1(12)$ is arranged at carrier 3 and time 1, and

....

[0270]

Similarly, when $z_2(0)$, $z_2(1)$, $z_2(2)$, $z_2(3)$, ... corresponding to i = 0, 1, 2, 3, ... are generated in (B) of FIG. 22,

$z_2(0)$ is arranged at carrier 0 and time 1,

$z_2(1)$ is arranged at carrier 0 and time 2,

$z_2(2)$ is arranged at carrier 0 and time 3,

...

$z_2(10)$ is arranged at carrier 2 and time 3,

$z_2(11)$ is arranged at carrier 2 and time 4,

$z_2(12)$ is arranged at carrier 3 and time 1, and

....

[0271]

In this case, $z_1(a)$ and $z_2(a)$ in a case of i = a are transmitted from the same frequency and from the same time. Then, FIG. 22 illustrates examples of a case where generated $z_1(i)$ and $z_2(i)$ are preferentially arranged in the time axis direction.

[0272]

The transmitting apparatus may arrange symbols by any method of the methods in FIGS. 18 to 22 and symbol arranging methods other than the methods in FIGS. 18 to 22. FIGS. 18 to 22 are only examples of symbol arrangement.

[0273]

FIG. 23 is a configuration example of a receiving apparatus (terminal) which receives a modulated signal transmitted by the transmitting apparatus in FIG. 1.

[0274]

In FIG. 23, OFDM method related processor 2303_X receives an input of received signal 2302_X received at antenna 2301_X. OFDM method related processor 2303_X performs reception side signal processing for the OFDM method. OFDM method related processor 2303_X outputs signal 2304_X obtained after the signal processing. Similarly, OFDM method related processor 2303_Y receives an input of received signal 2302_Y received at antenna 2301_Y. OFDM method related processor 2303_Y performs reception side signal processing for the OFDM method. OFDM method related processor 2303_Y outputs signal 2304_Y obtained after the signal processing.

[0275]

First preamble detector/decoder 2311 receives an input of signals 2304_X and 2304_Y obtained after the signal processing. First preamble

detector/decoder 2311 performs signal detection and time-frequency synchronization by detecting a first preamble, and simultaneously obtains control information contained in the first preamble by performing demodulation and error correction decoding and outputs first preamble control information 2312.

[0276]

Second preamble demodulator 2313 receives an input of signals 2304_X and 2304_Y obtained after the signal processing, and first preamble control information 2312. Second preamble demodulator 2313 performs signal processing based on first preamble control information 2312. Second preamble demodulator 2313 performs demodulation (error correction decoding). Second preamble demodulator 2313 outputs second preamble control information 2314.

[0277]

Control information generator 2315 receives an input of first preamble control information 2312, and second preamble control information 2314. Control information generator 2315 bundles control information (related to a receiving operation) and outputs the control information as control signal 2316. Then, control signal 2316 is input to each unit as illustrated in FIG. 23.

[0278]

Modulated signal z_1 channel fluctuation estimator 2305_1 receives an input of signal 2304_X obtained after the signal processing, and control signal 2316. Modulated signal z_1 channel fluctuation estimator 2305_1 estimates a channel fluctuation between an antenna from which the transmitting apparatus has transmitted modulated signal z_1 and receiving antenna 2301_X by using a pilot symbol or the like contained in signal 2304_X obtained after the signal processing, and outputs channel estimation signal 2306_1.

[0279]

Modulated signal z_2 channel fluctuation estimator 2305_2 receives an input

of signal 2304_X obtained after the signal processing, and control signal 2316. Modulated signal z_2 channel fluctuation estimator 2305_2 estimates a channel fluctuation between an antenna from which the transmitting apparatus has transmitted modulated signal z_2 and receiving antenna 2301_X by using a pilot symbol or the like contained in signal 2304_X obtained after the signal processing, and outputs channel estimation signal 2306_2.

[0280]

Modulated signal z_1 channel fluctuation estimator 2307_1 receives an input of signal 2304_Y obtained after the signal processing, and control signal 2316. Modulated signal z_1 channel fluctuation estimator 2307_1 estimates a channel fluctuation between an antenna from which the transmitting apparatus has transmitted modulated signal z_1 and receiving antenna 2301_Y by using a pilot symbol or the like contained in signal 2304_Y obtained after the signal processing, and outputs channel estimation signal 2308_1.

[0281]

Modulated signal z_2 channel fluctuation estimator 2307_2 receives an input of signal 2304_Y obtained after the signal processing, and control signal 2316. Modulated signal z_2 channel fluctuation estimator 2307_2 estimates a channel fluctuation between an antenna from which the transmitting apparatus has transmitted modulated signal z_2 and receiving antenna 2301_Y by using a pilot symbol or the like contained in signal 2304_Y obtained after the signal processing, and outputs channel estimation signal 2308_2.

[0282]

Signal processor 2309 receives an input of signals 2306_1, 2306_2, 2308_1, 2308_2, 2304_X and 2304_Y, and control signal 2316. Signal processor 2309 performs demodulation and decoding processing based on information such as a transmitting method, a modulating method, an error correction coding method,

a coding rate of error correction coding and a block size of an error correction code contained in control signal 2316. Signal processor 2309 outputs received data 2310. In this case, other wave detection (demodulation) and decoding are performed based on the above-described transmitting method.

[0283]

Note that the receiving apparatus extracts a necessary symbol from control signal 2316, and performs demodulation (including signal demultiplexing and signal wave detection) and error correction decoding. Moreover, a configuration of the receiving apparatus is not limited to this configuration.

[0284]

As described above, there is an advantage that flexible video information and flexible broadcast service can be provided to the receiving apparatus (viewer) by enabling the transmitting apparatus to select any frame configuration of the frame configurations in FIGS. 2 to 6. Moreover, there are the advantages as described above in the frame configurations in FIGS. 2 to 6, respectively. Hence, the transmitting apparatus may use a single frame configuration of the frame configurations in FIGS. 2 to 6, and, in this case, it is possible to obtain the effect described above.

[0285]

Moreover, when the transmitting apparatus selects any of the frame configurations in FIGS. 2 to 6, for example, when the transmitting apparatus is installed in a certain area, frame configurations may be switched by setting any of the frame configurations in FIGS. 2 to 6 when the transmitting apparatus is installed and regularly reviewing the setting, or a method for selecting the frame configurations in FIGS. 2 to 6 per frame transmission may be employed. As for a frame configuration selecting method, any selection may be performed.

[0286]

Note that in the frame configurations in FIGS. 2 to 6, another symbol, examples of which include a pilot symbol and a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))), may be inserted to the first preamble. Similarly, a symbol such as a pilot symbol and a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))) may be inserted to a second preamble. Moreover, a preamble is configured with the first preamble and the second preamble. However, the preamble configuration is not limited to this configuration. The preamble may be configured with the first preamble (first preamble group) alone or may be configured with two or more preambles (preamble groups). Note that in regard to the preamble configuration, the same also applies to frame configurations of other exemplary embodiments.

[0287]

Then, the data symbol group is indicated in the frame configurations in FIGS. 2 to 6. However, another symbol, examples of which include a pilot symbol a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))), and a control information symbol, may be inserted. Note that in this regard, the same also applies to frame configurations of other exemplary embodiments.

[0288]

Moreover, another symbol, examples of which include a pilot symbol, a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))), a control information symbol and a data symbol, may be inserted to the pilot symbol in FIG. 6. Note that in this regard, the same also applies to frame configurations of other exemplary embodiments.

[0289]

SECOND EXEMPLARY EMBODIMENT

The first exemplary embodiment describes the case where the transmitting apparatus selects any of the frame configurations in FIGS. 2 to 6 or the case where any of the frames in FIGS. 2 to 6 is used. The present exemplary embodiment will describe an example of the method for configuring the first preamble and the second preamble described in the first exemplary embodiment, in the transmitting apparatus described in the first exemplary embodiment.

[0290]

As described in the first exemplary embodiment, the transmitting apparatus (FIG. 1) may incorporate "information related to a frame configuration" for transmitting information related to a frame configuration to the receiving apparatus (terminal) in the first preamble or the second preamble, to transmit the "information related to the frame configuration."

[0291]

For example, in a case where the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 2 when three bits of v0, v1 and v2 are allocated as the "information related to the frame configuration," the transmitting apparatus sets (v0, v1, v2) to (0, 0, 0) and transmits the "information related to the frame configuration."

[0292]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 3, the transmitting apparatus sets (v0, v1, v2) to (0, 0, 1) and transmits the "information related to the frame configuration."

[0293]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 4, the transmitting apparatus sets (v0, v1, v2) to (0, 1, 0) and transmits the "information related to the frame configuration."

[0294]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 5, the transmitting apparatus sets (v0, v1, v2) to (0, 1, 1) and transmits the "information related to the frame configuration."

[0295]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 5, the transmitting apparatus sets (v0, v1, v2) to (1, 0, 0) and transmits the "information related to the frame configuration."

[0296]

The receiving apparatus can learn an outline of a frame configuration of a modulated signal transmitted by the transmitting apparatus, from the "information related to the frame configuration."

[0297]

Further, the transmitting apparatus (FIG. 1) transmits control information related to a method for transmitting each data symbol group, control information related to a method for modulating each data symbol group (or a set of modulating methods), and control information related to a code length (block length) and a coding rate of an error correction code to be used in each data symbol group, and further transmits information related to a method for configuring a data symbol group in each frame configuration. An example of the method for configuring these pieces of control information will be described below.

[0298]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 2 or 3 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 0, 0) or (0, 0, 1) and transmits (v0, v1, v2). In this case, control information related to a method for transmitting data symbol group #j is a(j, 0) and a(j, 1).

[0299]

In this case, when the method for transmitting data symbol group #(j = K) is of single stream transmission (SISO (SIMO) transmission), the transmitting apparatus sets a(K, 0) = 0 and a(K, 1) = 0 and transmits a(K, 0) and a(K, 1).

[0300]

When the method for transmitting data symbol group #(j = K) is of space time block codes (or space frequency block codes) (MISO transmission), the transmitting apparatus sets a(K, 0) = 1 and a(K, 1) = 0 and transmits a(K, 0) and a(K, 1).

[0301]

When the method for transmitting data symbol group #(j = K) is MIMO method #1, the transmitting apparatus sets a(K, 0) = 0 and a(K, 1) = 1 and transmits a(K, 0) and a(K, 1).

[0302]

When the method for transmitting data symbol group #(j = K) is MIMO method #2, the transmitting apparatus sets a(K, 0) = 1 and a(K, 1) = 1 and transmits a(K, 0) and a(K, 1).

[0303]

Note that MIMO method #1 and MIMO method #2 are different methods and are any method of the above-described MIMO methods. Moreover, here, MIMO method #1 and MIMO method #2 are used. However, the MIMO method which the transmitting apparatus can select may be of one type or may be of two or more types.

[0304]

In FIGS. 2 and 3, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits a(1, 0), a(1, 1), a(2, 0), a(2, 1), a(3, 0) and a(3, 1).

[0305]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 2 or 3 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 0, 0) or (0, 0, 1) and transmits (v0, v1, v2). In this case, control information related to a method for modulating data symbol group j is b(j, 0) and b(j, 1).

[0306]

In this case, a definition described below is made. In a case where the transmitting method is of single stream transmission (SISO (SIMO) transmission), for example, in a case where a(K, 0) = 0 and a(K, 1) = 0 are set in data symbol #(j = K),

when b(K, 0) = 0 and b(K, 1) = 0 hold, the transmitting apparatus sets a data symbol modulating method to QPSK.

[0307]

When b(K, 0) = 1 and b(K, 1) = 0 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM.

[0308]

When b(K, 0) = 0 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 64QAM.

[0309]

When b(K, 0) = 1 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 256QAM.

[0310]

In a case where the transmitting method is of space time block codes (or space frequency block codes) (MISO transmission), or is MIMO method #1 or MIMO method #2, for example, in a case where a(K, 0) = 1 and a(K, 1) = 0, a(K, 0) = 0 and a(K, 1) = 1 or a(K, 0) = 1 and a(K, 1) = 1 are set in data symbol #(j = K),

when b(K, 0) = 0 and b(K, 1) = 0 hold, the transmitting apparatus sets the

data symbol modulating method to QPSK in stream 1 and 16QAM in stream 2.

[0311]

When b(K, 0) = 1 and b(K, 1) = 0 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM in stream 1 and 16QAM in stream 2.

[0312]

When b(K, 0) = 0 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM in stream 1 and 64QAM in stream 2.

[0313]

When b(K, 0) = 1 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 64QAM in stream 1 and 64QAM in stream 2.

[0314]

Note that the modulating method is not limited to the above-described modulating methods. For example, the modulating method may include a modulating method such as an APSK method, non-uniform QAM and non-uniform mapping. The modulating method will be described in detail below.

[0315]

In FIGS. 2 and 3, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits b(1, 0), b(1, 1), b(2, 0), b(2, 1), b(3, 0) and b(3, 1).

[0316]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 2 or 3 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 0, 0) or (0, 0, 1) and transmits (v0, v1, v2). In this case, control information related to a coding method of an error correction code of data symbol group #j is c(j, 0) and c(j, 1).

[0317]

In this case, when an error correction coding method of data symbol group

#(j = K) is of an error correction code of A and a code length of α, the transmitting apparatus sets c(K, 0) = 0 and c(K, 1) = 0 and transmits c(K, 0) and c(K, 1).

[0318]

When an error correction coding method of data symbol group #(j = K) is of the error correction code of A and a code length of β, the transmitting apparatus sets c(K, 0) = 1 and c(K, 1) = 0 and transmits c(K, 0) and c(K, 1).

[0319]

When an error correction coding method of data symbol group #(j = K) is of an error correction code of B and the code length of α, the transmitting apparatus sets c(K, 0) = 0 and c(K, 1) = 1 and transmits c(K, 0) and c(K, 1).

[0320]

When an error correction coding method of data symbol group #(j = K) is of the error correction code of B and the code length of β, the transmitting apparatus sets c(K, 0) = 1 and c(K, 1) = 1 and transmits c(K, 0) and c(K, 1).

[0321]

Note that the setting of the error correction code is not limited to the two settings, and the transmitting apparatus only needs to be able to set one or more types of error correction codes. The setting of the code length is not limited to the two settings, and the transmitting apparatus only needs to be able to set two or more code lengths.

[0322]

In FIGS. 2 and 3, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits c(1, 0), c(1, 1), c(2, 0), c(2, 1), c(3, 0) and c(3, 1).

[0323]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 2 or 3 is assumed, that is, it is assumed that the transmitting

apparatus (FIG. 1) sets (v0, v1, v2) to (0, 0, 0) or (0, 0, 1) and transmits (v0, v1, v2). In this case, control information related to a coding rate of the error correction code of data symbol group #j is d(j, 0) and d(j, 1).

[0324]

In this case, when the coding rate of the error correction code of data symbol group #(j = K) is 1/2, the transmitting apparatus sets d(K, 0) = 0 and d(K, 1) = 0 and transmits d(K, 0) and d(K, 1).

[0325]

When the coding rate of the error correction code of data symbol group #(j = K) is 2/3, the transmitting apparatus sets d(K, 0) = 1 and d(K, 1) = 0 and transmits d(K, 0) and d(K, 1).

[0326]

When the coding rate of the error correction code of data symbol group #(j = K) is 3/4, the transmitting apparatus sets d(K, 0) = 0 and d(K, 1) = 1 and transmits d(K, 0) and d(K, 1).

[0327]

When the coding rate of the error correction code of data symbol group #(j = K) is 4/5, the transmitting apparatus sets d(K, 0) = 1 and d(K, 1) = 1 and transmits d(K, 0) and d(K, 1).

[0328]

Note that the setting of the coding rate of the error correction code is not limited to the four settings, and the transmitting apparatus only needs to be able to set one or more types of coding rates of the error correction code.

[0329]

In FIGS. 2 and 3, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits d(1, 0), d(1, 1), d(2, 0), d(2, 1), d(3, 0) and d(3, 1).

[0330]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 2 or 3 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 0, 0) or (0, 0, 1) and transmits (v0, v1, v2). In this case, information related to a number of symbols in a frame of data symbol group #j is e(j, 0) and e(j, 1).

[0331]

In this case, when the number of symbols in the frame of data symbol group #(j = K) is of 256 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 0 and transmits e(K, 0) and e(K, 1).

[0332]

When the number of symbols in the frame of data symbol group #(j = K) is of 512 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 0 and transmits e(K, 0) and e(K, 1).

[0333]

When the number of symbols in the frame of data symbol group #(j = K) is of 1024 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0334]

When the number of symbols in the frame of data symbol group #(j = K) is of 2048 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0335]

Note that the setting of the number of symbols is not limited to the four settings, and the transmitting apparatus only needs to be able to set one or more types of the number of symbols.

[0336]

In FIGS. 2 and 3, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits e(1, 0), e(1, 1), e(2, 0), e(2, 1), e(3, 0) and e(3, 1).

[0337]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2). In this case, control information related to a method for transmitting data symbol group #j is a(j, 0) and a(j, 1).

[0338]

In this case, when the method for transmitting data symbol group #(j = K) is of single stream transmission (SISO (SIMO) transmission), the transmitting apparatus sets a(K, 0) = 0 and a(K, 1) = 0 and transmits a(K, 0) and a(K, 1).

[0339]

When the method for transmitting data symbol group #(j = K) is of space time block codes (or space frequency block codes) (MISO transmission), the transmitting apparatus sets a(K, 0) = 1 and a(K, 1) = 0 and transmits a(K, 0) and a(K, 1).

[0340]

When the method for transmitting data symbol group #(j = K) is MIMO method #1, the transmitting apparatus sets a(K, 0) = 0 and a(K, 1) = 1 and transmits a(K, 0) and a(K, 1).

[0341]

When the method for transmitting data symbol group #(j = K) is MIMO method #2, the transmitting apparatus sets a(K, 0) = 1 and a(K, 1) = 1 and transmits a(K, 0) and a(K, 1).

[0342]

Note that MIMO method #1 and MIMO method #2 are different methods and are any method of the above-described MIMO methods. Moreover, here, MIMO method #1 and MIMO method #2 are used. However, the MIMO method which the transmitting apparatus can select may be of one type or may be of two or more types.

[0343]

In FIGS. 4, 5 and 6, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits a(1, 0), a(1, 1), a(2, 0), a(2, 1), a(3, 0) and a(3, 1).

[0344]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2). In this case, control information related to a method for modulating data symbol group j is b(j, 0) and b(j, 1).

[0345]

In this case, a definition described below is made. In a case where the transmitting method is of single stream transmission (SISO (SIMO) transmission), for example, in a case where a(K, 0) = 0 and a(K, 1) = 0 are set in data symbol #(j = K),

when b(K, 0) = 0 and b(K, 1) = 0 hold, the transmitting apparatus sets a data symbol modulating method to QPSK.

[0346]

When b(K, 0) = 1 and b(K, 1) = 0 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM.

[0347]

When b(K, 0) = 0 and b(K, 1) = 1 hold, the transmitting apparatus sets the

data symbol modulating method to 64QAM.

[0348]

When b(K, 0) = 1 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 256QAM.

[0349]

In a case where the transmitting method is of space time block codes (or space frequency block codes) (MISO transmission), or is MIMO method #1 or MIMO method #2, for example, in a case where a(K, 0) = 1 and a(K, 1) = 0, a(K, 0) = 0 and a(K, 1) = 1 or a(K, 0) = 1 and a(K, 1) = 1 are set in data symbol #(j = K),

when b(K, 0) = 0 and b(K, 1) = 0 hold, the transmitting apparatus sets the data symbol modulating method to QPSK in stream 1 and 16QAM in stream 2.

[0350]

When b(K, 0) = 1 and b(K, 1) = 0 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM in stream 1 and 16QAM in stream 2.

[0351]

When b(K, 0) = 0 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 16QAM in stream 1 and 64QAM in stream 2.

[0352]

When b(K, 0) = 1 and b(K, 1) = 1 hold, the transmitting apparatus sets the data symbol modulating method to 64QAM in stream 1 and 64QAM in stream 2.

[0353]

Note that the modulating method is not limited to the above-described modulating methods. For example, the modulating method may include a modulating method such as an APSK method, non-uniform QAM and non-uniform mapping. The modulating method will be described in detail below.

[0354]

In FIGS. 4, 5 and 6, since there are data symbol group #1, data symbol

group #2 and data symbol group #3, the transmitting apparatus transmits b(1, 0), b(1, 1), b(2, 0), b(2, 1), b(3, 0) and b(3, 1).

[0355]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2). In this case, control information related to a coding method of an error correction code of data symbol group #j is c(j, 0) and c(j, 1).

[0356]

In this case, when an error correction coding method of data symbol group #(j = K) is of an error correction code of A and a code length of α, the transmitting apparatus sets c(K, 0) = 0 and c(K, 1) = 0 and transmits c(K, 0) and c(K, 1).

[0357]

When an error correction coding method of data symbol group #(j = K) is of the error correction code of A and a code length of β, the transmitting apparatus sets c(K, 0) = 1 and c(K, 1) = 0 and transmits c(K, 0) and c(K, 1).

[0358]

When an error correction coding method of data symbol group #(j = K) is of an error correction code of B and the code length of α, the transmitting apparatus sets c(K, 0) = 0 and c(K, 1) = 1 and transmits c(K, 0) and c(K, 1).

[0359]

When an error correction coding method of data symbol group #(j = K) is of the error correction code of B and a code length of β, the transmitting apparatus sets c(K, 0) = 1 and c(K, 1) = 1 and transmits c(K, 0) and c(K, 1).

[0360]

Note that the setting of the error correction code is not limited to the two settings, and the transmitting apparatus only needs to be able to set one or more

types of error correction codes. The setting of the code length is not limited to the two settings, and the transmitting apparatus only needs to be able to set two or more code lengths.

[0361]

In FIGS. 4, 5 and 6, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits c(1, 0), c(1, 1), c(2, 0), c(2, 1), c(3, 0) and c(3, 1).

[0362]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2). In this case, control information related to a coding rate of the error correction code of data symbol group #j is d(j, 0) and d(j, 1).

[0363]

In this case, when the coding rate of the error correction code of data symbol group #(j = K) is 1/2, the transmitting apparatus sets d(K, 0) = 0 and d(K, 1) = 0 and transmits d(K, 0) and d(K, 1).

[0364]

When the coding rate of the error correction code of data symbol group #(j = K) is 2/3, the transmitting apparatus sets d(K, 0) = 1 and d(K, 1) = 0 and transmits d(K, 0) and d(K, 1).

[0365]

When the coding rate of the error correction code of data symbol group #(j = K) is 3/4, the transmitting apparatus sets d(K, 0) = 0 and d(K, 1) = 1 and transmits d(K, 0) and d(K, 1).

[0366]

When the coding rate of the error correction code of data symbol group #(j

= K) is 4/5, the transmitting apparatus sets d(K, 0) = 1 and d(K, 1) = 1 and transmits d(K, 0) and d(K, 1).

[0367]

Note that the setting of the coding rate of the error correction code is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of coding rates of the error correction code.

[0368]

In FIGS. 4, 5 and 6, since there are data symbol group #1, data symbol group #2 and data symbol group #3, the transmitting apparatus transmits d(1, 0), d(1, 1), d(2, 0), d(2, 1), d(3, 0) and d(3, 1).

[0369]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmit (v0, v1, v2).

[0370]

In this case, when there is a mix of a plurality of data symbol groups in a certain time interval like data symbol group #1 and data symbol group #2 of the frames in FIGS. 4, 5 and 6, this time interval can be set. (A unit time in the time interval in which there is the mix of a plurality of data symbol groups may be referred to as an OFDM symbol.) Information related to this time interval is f(0) and f(1).

[0371]

In this case, when this time interval is of 128 OFDM symbols, the transmitting apparatus sets f(0) = 0 and f(1) = 0 and transmits f(0) and f(1).

[0372]

When this time interval is of 256 OFDM symbols, the transmitting

apparatus sets f(0) = 1 and f(1) = 0 and transmits f(0) and f(1).

[0373]

When this time interval is of 512 OFDM symbols, the transmitting apparatus sets f(0) = 0 and f(1) = 1 and transmits f(0) and f(1).

[0374]

When this time interval is of 1024 OFDM symbols, the transmitting apparatus sets f(0) = 1 and f(1) = 0 and transmits f(0) and f(1).

[0375]

Note that the setting of the time interval is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of the time intervals.

[0376]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2).

[0377]

In this case, when there is no other data symbol group in a certain time interval like data symbol group #3 in FIG. 4, 5 or 6, information related to the number of symbols in a frame of data symbol group #j is e(j, 0) and e(j, 1). However, for example, when there is data symbol group #4 immediately after data symbol group #3, there may be a mix of data symbols of data symbol group #3 and data symbols of data symbol group #4 in a certain time interval at a portion at which data symbol group #3 and data symbol group #4 are adjacent.

[0378]

When the number of symbols in the frame of data symbol group #(j = K) is of 256 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 0 and

transmits e(K, 0) and e(K, 1).

[0379]

When the number of symbols in the frame of data symbol group #(j = K) is of 512 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 0 and transmits e(K, 0) and e(K, 1).

[0380]

When the number of symbols in the frame of data symbol group #(j = K) is of 1024 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0381]

When the number of symbols in the frame of data symbol group #(j = K) is of 2048 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0382]

Note that the setting of the number of symbols is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of the number of symbols.

[0383]

In FIGS. 4, 5 and 6, since data symbol group #3 corresponds to the above, the transmitting apparatus transmits e(3, 0) and e(3, 1).

[0384]

A case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 4, 5, or 6 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (0, 1, 0), (0, 1, 1) or (1, 0, 0) and transmits (v0, v1, v2).

[0385]

In this case, when there is a mix of a plurality of data symbol groups in a

certain time interval like data symbol group #1 and data symbol group #2 of the frames in FIGS. 4, 5 and 6, a number of carriers to be used by each data symbol group can be set.

[0386]

In this case, information related to the number of carriers is g(0) and g(1). For example, a total number of carriers is of 512 carriers.

[0387]

When the number of carriers of a first data symbol group is of 480 carriers and the number of carriers of a second symbol group is of 32 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 0 and g(1) = 0 and transmits g(0) and g(1).

[0388]

When the number of carriers of the first data symbol group is of 448 carriers and the number of carriers of the second symbol group is of 64 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 1 and g(1) = 0 and transmits g(0) and g(1).

[0389]

When the number of carriers of the first data symbol group is of 384 carriers and the number of carriers of the second symbol group is of 128 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 0 and g(1) = 1 and transmits g(0) and g(1).

[0390]

When the number of carriers of the first data symbol group is of 256 carriers and the number of carriers of the second symbol group is of 256 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 1 and g(1) = 1 and transmits g(0) and g(1).

[0391]

Note that the setting of the number of carriers is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of the number of carriers.

[0392]

The case where there is a mix of two data symbol groups is described with reference to FIGS. 4 to 6 as an example of a case where there is a mix of a plurality of data symbol groups in a certain time interval. However, there may be a mix of three or more data symbol groups. This point will be described with reference to FIGS. 24, 25 and 26.

[0393]

FIG. 24 illustrates an example of a frame configuration in a case where there are three data symbol groups in a certain time interval, in contrast to FIG. 4. Elements operating in the same way as in FIG. 4 are assigned the same reference numerals in FIG. 24 and will not be described.

[0394]

FIG. 24 illustrates data symbol group #1 2401, data symbol group #2 2402, and data symbol group #4 2403, and there are data symbol group #1, data symbol group #2 and data symbol group #4 in a certain time interval.

[0395]

FIG. 25 illustrates an example of a frame configuration in a case where there are three data symbol groups in a certain time interval, in contrast to FIG. 5. Elements operating in the same way as in FIG. 5 are assigned the same reference numerals in FIG. 25 and will not be described.

[0396]

FIG. 25 illustrates data symbol group #1 2501, data symbol group #2 2502, and data symbol group #5 2503, and there are data symbol group #1, data symbol group #2 and data symbol group #4 in a certain time interval.

[0397]

FIG. 26 illustrates an example of a frame configuration in a case where there are three data symbol groups in a certain time interval, in contrast to FIG. 6. Elements operating in the same way as in FIG. 6 are assigned the same reference numerals in FIG. 26 and will not be described.

[0398]

FIG. 26 illustrates data symbol group #1 2601, data symbol group #2 2602, and data symbol group #4 2603, and there are data symbol group #1, data symbol group #2 and data symbol group #4 in a certain time interval.

[0399]

The transmitting apparatus in FIG. 1 may be able to select the frame configurations in FIGS. 24 to 26. Moreover, a frame configuration where there are four or more data symbol groups in a certain time interval, in contrast to FIGS. 4 to 6 and 24 to 26 may be employed.

[0400]

FIGS. 24, 25 and 26 illustrate the examples where a data symbol group subjected to time division is arranged after a data symbol group subjected to frequency division. However, the arrangement is not limited to this arrangement. The data symbol group subjected to frequency division may be arranged after the data symbol group subjected to time division. In this case, in the example in FIG. 25, the first preamble and the second preamble are inserted between the data symbol group subjected to time division and the data symbol group subjected to frequency division. However, symbols other than the first preamble and the second preamble may be inserted. Then, in the example in FIG. 26, the pilot symbol is inserted between the data symbol group subjected to time division and the data symbol group subjected to frequency division. However, symbols other than the pilot symbol may be inserted.

[0401]

Note that in a case where the transmitting apparatus (FIG. 1) transmits a modulated signal with the frame configuration in FIG. 24 when the transmitting apparatus incorporates "information related to a frame configuration" for transmitting information related to a frame configuration to the receiving apparatus (terminal) in the first preamble or the second preamble and transmits the "information related to the frame configuration," for example, when three bits of v0, v1 and v2 are allocated as the "information related to the frame configuration," the transmitting apparatus sets (v0, v1, v2) to (1, 0, 1) and transmits the "information related to the frame configuration."

[0402]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 25, the transmitting apparatus sets (v0, v1, v2) to (1, 1, 0) and transmits the "information related to the frame configuration."

[0403]

When the transmitting apparatus transmits a modulated signal with the frame configuration in FIG. 26, the transmitting apparatus sets (v0, v1, v2) to (1, 1, 1) and transmits the "information related to the frame configuration."

[0404]

Note that in FIGS. 24, 25 and 26, a data symbol group may also be a symbol group based on the MIMO (transmitting) method and the MISO (transmitting) method (as a matter of course, the data symbol group may be a symbol group of the SISO (SIMO) method.). In this case, at the same time and the same (common) frequency, a plurality of streams (s1 and s2 described below) is transmitted. In this case, at the same time and the same (common) frequency, a plurality of modulated signals is transmitted from a plurality of (different) antennas.

[0405]

Then, a case where the transmitting apparatus (FIG. 1) selects the frame configuration in FIG. 24, 25, or 26 is assumed, that is, it is assumed that the transmitting apparatus (FIG. 1) sets (v0, v1, v2) to (1, 0, 1), (1, 1, 0) or (1, 1, 1) and transmits (v0, v1, v2).

[0406]

In this case, when there is a mix of a plurality of data symbol groups in a certain time interval like data symbol group #1, data symbol group #2 and data symbol group #4 of the frames in FIGS. 24, 25 and 26, a number of carriers to be used by each data symbol group can be set.

[0407]

In this case, information related to the number of carriers is g(0) and g(1). For example, a total number of carriers is of 512 carriers.

[0408]

When the number of carriers of the first data symbol group is of 448 carriers, the number of carriers of the second symbol group is of 32 carriers and the number of carriers of a third symbol group is of 32 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 0 and g(1) = 0 and transmits g(0) and g(1).

[0409]

When the number of carriers of the first data symbol group is of 384 carriers, the number of carriers of the second symbol group is of 64 carriers and the number of carriers of the third symbol group is of 64 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 1 and g(1) = 0 and transmits g(0) and g(1).

[0410]

When the number of carriers of the first data symbol group is of 256

carriers, the number of carriers of the second symbol group is of 128 carriers and the number of carriers of the third symbol group is of 128 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 0 and g(1) = 1 and transmits g(0) and g(1).

[0411]

When the number of carriers of the first data symbol group is of 480 carriers, the number of carriers of the second symbol group is of 16 carriers and the number of carriers of the third symbol group is of 16 carriers among the two data symbol groups, the transmitting apparatus sets g(0) = 1 and g(1) = 1 and transmits g(0) and g(1).

[0412]

Note that the setting of the number of carriers is not limited to the four settings, and the transmitting apparatus only needs to be able to set one or more types of the number of carriers.

[0413]

Moreover, an effect of improvement in data transmission efficiency can be obtained when in frames in which there is a mix of a "case where there is a mix of a plurality of data symbol groups in a first time interval" and a "case where there is only one data symbol group in a second time interval" as in FIGS. 4, 5, 6, 24, 25 and 26, the transmitting apparatus can separately set a carrier interval (an FFT (Fast Fourier Transform) size or a Fourier transform size) in the "case where there is the mix of a plurality of data symbol groups in the first time interval," and a carrier interval (an FFT (Fast Fourier Transform) size or a Fourier transform size) in the "case where there is only one data symbol group in the second time interval." This is because the carrier interval appropriate in terms of data transmission efficiency in the "case where there is the mix of a plurality of data symbol groups in the first time interval," and the carrier interval appropriate in terms of data

transmission efficiency in the "case where there is only one data symbol group in the second time interval" are different.

[0414]

Hence, control information related to a carrier interval related to the "case where there is the mix of a plurality of data symbol groups in the first time interval" is ha(0) and ha(1).

[0415]

In this case, when the carrier interval is 0.25 kHz, the transmitting apparatus sets ha(0) = 0 and ha(1) = 0, and transmits ha(0) and ha(1).

[0416]

When the carrier interval is 0.5 kHz, the transmitting apparatus sets ha(0) = 1 and ha(1) = 0, and transmits ha(0) and ha(1).

[0417]

When the carrier interval is 1 kHz, the transmitting apparatus sets ha(0) = 0 and ha(1) = 1, and transmits ha(0) and ha(1).

[0418]

When the carrier interval is 2 kHz, the transmitting apparatus sets ha(0) = 1 and ha(1) = 1, and transmits ha(0) and ha(1).

[0419]

Note that the setting of the carrier interval is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of the carrier intervals.

[0420]

Then, control information related to a carrier interval related to the "case where there is only one data symbol group in the second time interval" is hb(0) and hb(1).

[0421]

In this case, when the carrier interval is 0.25 kHz, the transmitting apparatus sets hb(0) = 0 and hb(1) = 0, and transmits hb(0) and hb(1).

[0422]

When the carrier interval is 0.5 kHz, the transmitting apparatus sets hb(0) = 1 and hb(1) = 0, and transmits hb(0) and hb(1).

[0423]

When the carrier interval is 1 kHz, the transmitting apparatus sets hb(0) = 0 and hb(1) = 1, and transmits hb(0) and hb(1).

[0424]

When the carrier interval is 2 kHz, the transmitting apparatus sets hb(0) = 1 and hb(1) = 1, and transmits hb(0) and hb(1).

[0425]

Note that the setting of the carrier interval is not limited to the four settings, and the transmitting apparatus only needs to be able to set two or more types of the carrier intervals.

[0426]

Here, set values of the carrier interval selectable in any of the "case where there is the mix of a plurality of data symbol groups in the first time interval" and the "case where there is only one data symbol group in the second time interval" are made the same such that the set values of the carrier interval in the "case where there is the mix of a plurality of data symbol groups in the first time interval" are 0.25 kHz, 0.5 kHz, 1 kHz and 2 kHz and the set values of the carrier interval in the "case where there is only one data symbol group in the second time interval" are 0.25 kHz, 0.5 kHz, 1 kHz and 2 kHz.. However, a set of set values selectable in the "case where there is the mix of a plurality of data symbol groups in the first time interval" and a set of set values selectable in the "case where there is only one data symbol group in the second time interval" may be different. For example, the set

values of the carrier interval in the "case where there is the mix of a plurality of data symbol groups in the first time interval" may be 0.25 kHz, 0.5 kHz, 1 kHz and 2 kHz, and the set values of the carrier interval in the "case where there is only one data symbol group in the second time interval" may be 0.125 kHz, 0.25 kHz, 0.5 kHz and 1 kHz. Note that the settable values are not limited to this example.

[0427]

Note that there can be considered a method for transmitting control information ha(0) and ha(1) related to the carrier interval related to the "case where there is the mix of a plurality of data symbol groups in the first time interval," and control information hb(0) and hb(1) related to the carrier interval related to the "case where there is only one data symbol group in the second time interval" with any of the first preamble and the second preamble in FIGS. 4, 5, 6, 24, 25 and 26.

[0428]

For example, in FIGS. 4, 6, 24 and 26, there can be considered a method for transmitting control information ha(0) and ha(1) related to the carrier interval related to the "case where there is the mix of a plurality of data symbol groups in the first time interval," and control information hb(0) and hb(1) related to the carrier interval related to the "case where there is only one data symbol group in the second time interval" with first preamble 201 or second preamble 202.

[0429]

In FIGS. 5 and 25, there can be considered a method for transmitting control information ha(0) and ha(1) related to the carrier interval related to the "case where there is the mix of a plurality of data symbol groups in the first time interval" with first preamble 201 or second preamble 202, and transmitting control information hb(0) and hb(1) related to the carrier interval related to the "case where there is only one data symbol group in the second time interval" with first preamble 501 or second preamble 502.

[0430]

Moreover, as another method, in FIGS. 5 and 25, a method for transmitting a plurality of times control information ha(0) and ha(1) related to the carrier interval related to the "case where there is the mix of a plurality of data symbol groups in the first time interval," and control information hb(0) and hb(1) related to the carrier interval related to the "case where there is only one data symbol group in the second time interval," such that ha(0) and ha(1), and hb(0) and hb(1) are transmitted with "first preamble 201 or second preamble 202" and with "first preamble 501 or second preamble 502" may be employed. In this case, for example, the receiving apparatus which is to receive only data of data symbol group #1 and the receiving apparatus which is to receive only data of data symbol group # can learn situations of all frames. Consequently, it is possible to easily and stably operate both of the receiving apparatuses.

[0431]

As a matter of course, the receiving apparatus (for example, FIG. 23) which receives a modulated signal transmitted by the transmitting apparatus in FIG. 1 receives the above-described control information, demodulates and decodes a data symbol group based on this control information and obtains information.

[0432]

As described above, the information described in the present exemplary embodiment is transmitted as control information, and thus it is possible to obtain an effect of enabling improvement in data reception quality and improvement in data transmission efficiency and of enabling an accurate operation of the receiving apparatus.

[0433]

Note that the frame configuration of a modulated signal transmitted by the transmitting apparatus in FIG. 1 is described in the first exemplary embodiment and

the second exemplary embodiment with reference to FIGS. 3, 4, 5 and 6, but arrangement of data symbol group #1 and data symbol group #2 on the frequency axis in FIGS. 4, 5 and 6 is not limited to this arrangement, and for example, data symbol group #1 and data symbol group #2 may be arranged like data symbol group #1 (2701) and data symbol group #2 (2702) in FIGS. 27, 28 and 29. Note that in each of FIGS. 27, 28 and 29, a horizontal axis indicates time, and a vertical axis indicates a frequency.

[0434]

Then, a method for transmitting data symbol groups #1 (401_1 and 401_2) in the frame configuration in FIG. 5 and a method for transmitting data symbol group #2 (402) may be set with first preamble 201 and/or second preamble 202. A method for transmitting data symbol group #3 (403) may be set with first preamble 501 and/or second preamble 502.

[0435]

In this case, either a case where the "method for transmitting data symbol groups #1 (401_1 and 401_2) and the method for transmitting data symbol group #2 (402) are of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 (401_1 and 401_2) and the method for transmitting data symbol group #2 (402) are of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol group #3 (403) is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol group #3 (403) is of SISO transmission (SIMO transmission)" may be selectable.

[0436]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or

MISO transmission" or "SISO transmission (SIMO transmission)," and in the method for transmitting a plurality of data symbol groups present between the "set of the first preamble and the second preamble" and the next "set of the first preamble and the second preamble," there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission).

[0437]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, a fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0438]

However, the present disclosure is not limited to the above.

[0439]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. Note that when there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data

symbol group is as follows.

[0440]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Note that pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0441]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0442]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0443]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0444]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0445]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0446]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0447]

Similarly, in the frame configuration in FIG. 25, a method for transmitting data symbol group #1 (2501), a method for transmitting data symbol group #2 (2502) and a method for transmitting data symbol group #4 (2503) may be set with first preamble 201 and/or second preamble 202, and a method for transmitting data symbol group #3 (403) may be set with first preamble 501 and/or second preamble 502.

[0448]

In this case, either a case where the "method for transmitting data symbol group #1 (2501), the method for transmitting data symbol group #2 (2502) and the method for transmitting data symbol group #4 (2503) are of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol group #1 (2501), the method for transmitting data symbol group #2 (2502) and the method for transmitting data symbol group #4 (2503) are of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol group #3 (403) is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol group #3 (403) is of SISO transmission (SIMO transmission)" may be selectable.

[0449]

That is, a method for transmitting a plurality of data symbol groups present

between a "set of the first preamble and the second preamble" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)," and in the method for transmitting a plurality of data symbol groups present between the "set of the first preamble and the second preamble" and the next "set of the first preamble and the second preamble," there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission).

[0450]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, a fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0451]

However, the present disclosure is not limited to the above.

[0452]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. Note that when there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting

a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0453]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0454]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion

example of a pilot symbol of modulated signal #2 in combination.

[0455]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0456]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0457]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0458]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for

modulated signal #1 may not be referred to as a pilot symbol.

[0459]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0460]

Moreover, in the frame configuration in FIG. 6, a method for transmitting data symbol groups #1 (401_1 and 401_2), a method for transmitting data symbol group #2 (402) and a method for transmitting data symbol group #3 (403) may be set with first preamble 201 and/or second preamble 202.

[0461]

In this case, either a case where the "method for transmitting data symbol groups #1 (401_1 and 401_2) and the method for transmitting data symbol group #2 (402) are of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 (401_1 and 401_2) and the method for transmitting data symbol group #2 (402) are of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol group #3 (403) is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol group #3 (403) is of SISO transmission (SIMO transmission)" may be selectable.

[0462]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a "pilot symbol"

is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". Thus, there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). Then, a method for transmitting a plurality of data symbol groups present between the "pilot symbol" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". Thus, there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). However, FIG. 6 does not illustrate the "set of the first preamble and the second preamble" next to the pilot symbol.

[0463]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0464]

However, the present disclosure is not limited to the above.

[0465]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of

the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0466]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0467]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals

are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0468]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0469]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0470]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0471]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot

symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0472]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0473]

Similarly, a method for transmitting data symbol group #1 (2501) in the frame configuration in FIG. 26, a method for transmitting data symbol group #2 (2502), a method for transmitting data symbol group #4 (2503) and a method for transmitting data symbol group #3 (403) may be set with first preamble 201 and/or second preamble 202.

[0474]

In this case, either a case where the "method for transmitting data symbol group #1 (2501), the method for transmitting data symbol group #2 (2502) and the method for transmitting data symbol group #4 (2503) are of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol group #1 (2501), the method for transmitting data symbol group #2 (2502) and the method for transmitting data symbol group #4 (2503) are of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol group #3 (403) is of MIMO transmission or MISO

transmission" or a case where the "method for transmitting data symbol group #3 (403) is of SISO transmission (SIMO transmission)" may be selectable.

[0475]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a "pilot symbol" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". Thus, there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). Then, a method for transmitting a plurality of data symbol groups present between the "pilot symbol" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). However, FIG. 6 does not illustrate the "set of the first preamble and the second preamble" next to the pilot symbol.

[0476]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0477]

However, the present disclosure is not limited to the above.

[0478]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement of data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0479]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0480]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0481]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0482]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0483]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0484]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0485]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0486]

THIRD EXEMPLARY EMBODIMENT

The first exemplary embodiment and the second exemplary embodiment describe the MIMO transmitting method using precoding and phase change for transmitting a plurality of streams by using a plurality of antennas, and the MISO (Multiple-Input Single-Output) transmitting method using space time block codes or space frequency block codes for transmitting a plurality of streams by using a plurality of antennas. An example of a method for transmitting preambles in a case where it is considered that a transmitting apparatus transmits modulated signals by these transmitting methods will be described. Note that the MIMO

transmitting method may be the MIMO transmitting method which does not perform phase change.

[0487]

The transmitting apparatus in FIG. 1 includes antenna 126_1 and antenna 126_2. In this case, as an antenna configuring method which is highly likely to be easy to demultiplex two modulated signals to be transmitted, there is a method in which

"antenna 126_1 is a horizontal polarizing antenna, and antenna 126_2 is a vertical polarizing antenna,"

or

"antenna 126_1 is a vertical polarizing antenna, and antenna 126_2 is a horizontal polarizing antenna,"

or

"antenna 126_1 is a clockwise rotation round polarization antenna, and antenna 126_2 is a counterclockwise rotation round polarization antenna,"

or

"antenna 126_1 is a counterclockwise rotation round polarization antenna, and antenna 126_2 is a clockwise rotation round polarization antenna."

Such an antenna configuring method will be referred to as a first antenna configuring method.

[0488]

Moreover, an antenna configuring method other than the first antenna configuring method will be referred to as a second antenna configuring method. Hence, examples of the second antenna configuring method include methods in which

"antenna 126_1 is a horizontal polarizing antenna, and antenna 126_2 is a horizontal polarizing antenna,"

and

"antenna 126_1 is a vertical polarizing antenna, and antenna 126_2 is a vertical polarizing antenna,"

"antenna 126_1 is a counterclockwise rotation round polarization antenna, and antenna 126_2 is a counterclockwise rotation round polarization antenna,"

and

"antenna 126_1 is a clockwise rotation round polarization antenna, and antenna 126_2 is a clockwise rotation round polarization antenna."

[0489]

Each transmitting apparatus (FIG. 1) is settable in the first antenna configuring method in which, for example, "antenna 126_1 is the horizontal polarizing antenna, and antenna 126_2 is the vertical polarizing antenna" or "antenna 126_1 is the vertical polarizing antenna, and antenna 126_2 is the horizontal polarizing antenna",

or

the second antenna configuring method in which, for example, "antenna 126_1 is the horizontal polarizing antenna, and antenna 126_2 is the horizontal polarizing antenna" or "antenna 126_1 is the vertical polarizing antenna, and antenna 126_2 is the vertical polarizing antenna". For example, in a broadcast system, any antenna configuring method of the first antenna configuring method and the second antenna configuring method is adopted depending on a place to install the transmitting apparatus (installation area).

[0490]

In such an antenna configuring method, a method for configuring a first preamble and a second preamble in a case of the frame configuring methods, for example, in FIGS. 2 to 6, and 24 to 26 will be described.

[0491]

As with the second exemplary embodiment, the transmitting apparatus transmits control information related to the antenna configuring method by using the first preamble. In this case, the information related to the antenna configuring method is m(0) and m(1).

[0492]

In this case, when in two transmitting antennas of the transmitting apparatus, a first transmitting antenna is a horizontal polarizing antenna and thus transmits a horizontally polarized first modulated signal and a second transmitting antenna is a horizontal polarizing antenna and thus transmits a horizontally polarized second modulated signal), the transmitting apparatus sets m(0) = 0 and m(1) = 0, and transmits m(0) and m(1).

[0493]

When in the two transmitting antennas of the transmitting apparatus, the first transmitting antenna is a vertical polarizing antenna and thus transmits a vertically polarized first modulated signal and the second transmitting antenna is a vertical polarizing antenna and thus transmits a vertically polarized second modulated signal, the transmitting apparatus sets m(0) = 1 and m(1) = 0, and transmits m(0) and m(1).

[0494]

When in the two transmitting antennas of the transmitting apparatus, the first transmitting antenna is a horizontal polarizing antenna and thus transmits a horizontally polarized first modulated signal and the second transmitting antenna is a vertical polarizing antenna and thus transmits a vertically polarized second modulated signal, the transmitting apparatus sets m(0) = 0 and m(1) = 1, and transmits m(0) and m(1).

[0495]

When in the two transmitting antennas of the transmitting apparatus, the

first transmitting antenna is a vertical polarizing antenna and thus transmits a vertically polarized first modulated signal) and the second transmitting antenna is a horizontal polarizing antenna and thus transmits a horizontally polarized second modulated signal), the transmitting apparatus sets m(0) = 1 and m(1) = 1, and transmits m(0) and m(1).

[0496]

Then, the transmitting apparatus transmits m(0) and m(1) with, for example, the first preamble in the frame configuring method in FIGS. 2 to 6 and 24 to 26. Consequently, a receiving apparatus receives the first preamble and demodulates and decodes the first preamble, and thus the receiving apparatus can easily learn what polarized wave is used to transmit a modulated signal (for example, the second preamble and the data symbol group) transmitted by the transmitting apparatus. Consequently, it is possible to accurately set an antenna (including use of a polarized wave) to be used by the receiving apparatus during reception. As a result, it is possible to obtain an effect of making it possible to obtain a high reception gain (high reception field intensity). There is also an advantage that it becomes unnecessary to perform signal processing for reception which has a small effect of obtaining a gain. Consequently, it is possible to obtain an advantage that data reception quality improves.

[0497]

The above describes the point that "there is also an advantage that it becomes unnecessary to perform signal processing for reception which has a small effect of obtaining a gain." Supplemental description will be made on this point.

[0498]

A case where the transmitting apparatus transmits modulated signals only with horizontally polarized waves and the receiving apparatus includes a horizontal polarizing receiving antenna and a vertical polarizing receiving antenna will be

discussed. In this case, the modulated signals transmitted by the transmitting apparatus can be received at the horizontal polarizing receiving antenna of the receiving apparatus. However, the vertical polarizing receiving antenna of the receiving apparatus has very small reception field intensity of the modulated signals transmitted by the transmitting apparatus.

[0499]

Hence, in such a case, when power consumed by the signal processing is considered, it is less necessary to perform an operation of performing signal processing on received signals received at the vertical polarizing receiving antenna of the receiving apparatus and obtaining data.

[0500]

In view of the above, it is necessary for the transmitting apparatus to transmit "control information related to an antenna configuring method," and for the receiving apparatus to perform accurate control.

[0501]

Next, a case where the transmitting apparatus includes two or more horizontal polarizing antennas, yet, it does not necessarily mean that the transmitting apparatus does not include a vertical polarizing antenna, or a case where the transmitting apparatus includes two or more vertical polarizing antennas, yet, it does not necessarily mean that the transmitting apparatus does not include a horizontal polarizing antenna will be described.

[0502]

<Case where transmitting apparatus includes two or more horizontal polarizing antennas>

In this case, when the transmitting apparatus transmits a single stream using the SISO transmitting method or the SIMO transmitting method, the transmitting apparatus transmits modulated signals from one or more horizontal

polarizing antennas. In consideration of this case, when the transmitting apparatus transmits the first preamble including the control information related to the antenna configuring method described above, from one or more horizontal polarizing antennas, the receiving apparatus can receive the first preamble including the control information related to the antenna configuring method with a high gain, and, consequently, can obtain high data reception quality.

[0503]

Then, the receiving apparatus obtains the control information related to the antenna configuring method, and thus the receiving apparatus can learn antenna configuration with which the transmitting apparatus has transmitted the MIMO transmitting method and the MISO transmitting method.

[0504]

<Case where transmitting apparatus includes two or more vertical polarizing antennas>

In this case, when the transmitting apparatus transmits a single stream using the SISO transmitting method or the SIMO transmitting method, the transmitting apparatus transmits modulated signals from one or more vertical polarizing antennas. In consideration of this case, when the transmitting apparatus transmits the first preamble including the control information related to the antenna configuring method described above, from one or more vertical polarizing antennas, the receiving apparatus can receive the first preamble including the control information related to the antenna configuring method with a high gain and, consequently, can obtain high data reception quality.

[0505]

Then, the receiving apparatus obtains the control information related to the antenna configuring method, and thus the receiving apparatus can learn antenna configuration with which the transmitting apparatus has transmitted the MIMO

transmitting method and the MISO transmitting method.

[0506]

Next, a case where the transmitting apparatus includes a horizontal polarizing antenna and a vertical polarizing antenna will be described.

[0507]

In this case, when the transmitting apparatus transmits a single stream using the SISO transmitting method or the SIMO transmitting method, it can be considered that the transmitting apparatus

a first method:

transmits modulated signals from the horizontal polarizing antenna and the vertical polarizing antenna,

a second method:

transmits modulated signals from the horizontal polarizing antenna,

a third method:

transmits modulated signals from the vertical polarizing antenna.

[0508]

In this case, transmission from an antenna used for transmitting the first preamble including the control information related to the antenna configuring method described above is performed by the same method as in a case of transmission from an antenna used for transmitting a single stream using the SISO transmitting method or the SIMO transmitting method.

[0509]

Hence, when modulated signals are transmitted by the first method in transmission of a single stream using the SISO transmitting method or the SIMO transmitting method, the first preamble including the control information related to the antenna configuring method is transmitted from the horizontal polarizing antenna and the vertical polarizing antenna.

[0510]

When modulated signals are transmitted by the second method, the first preamble including the control information related to the antenna configuring method is transmitted from the horizontal polarizing antenna.

[0511]

When modulated signals are transmitted by the third method, the first preamble including the control information related to the antenna configuring method is transmitted from the vertical polarizing antenna.

[0512]

In this way, there is an advantage that the receiving apparatus can receive the first preamble in the same way as in receiving data symbol groups transmitted by the SISO method, that is, it becomes unnecessary to change a signal processing method according to a transmitting method. Note that it is also possible to obtain the above-described advantage.

[0513]

Then, the receiving apparatus obtains the control information related to the antenna configuring method, and thus the receiving apparatus can learn antenna configuration with which the transmitting apparatus has transmitted the MIMO transmitting method and the MISO transmitting method.

[0514]

As described above, the first preamble including the control information related to the antenna configuring method is transmitted, and thus the receiving apparatus can receive the first preamble with a high gain. Consequently, it is possible to obtain an effect of improvement in data symbol group reception quality, and it is possible to obtain an effect of enabling improvement in power efficiency of the receiving apparatus.

[0515]

Note that the case where the control information related to the antenna configuring method is contained in the first preamble is described above as an example, but even when the control information related to the antenna configuring method is not contained in the first preamble, it is possible to obtain the same effect.

[0516]

Then, the antenna used for transmitting the first preamble is highly likely to be determined during installation or maintenance of the transmitting apparatus, and a change in an antenna to be used during an operation can also be made, but such a change is less likely to be frequently made during a practical operation.

[0517]

FOURTH EXEMPLARY EMBODIMENT

The example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is described in the above-described exemplary embodiments. A frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 will be further described in the present exemplary embodiment.

[0518]

FIG. 30 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as in FIG. 2 are assigned the same reference numerals in FIG. 30 and will not be described. In FIG. 30, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0519]

FIG. 30 illustrates data symbol group #1 3001, data symbol group #2 3002

and data symbol group #3 3003. There are data symbol group #1 (3001), data symbol group #2 (3002) and data symbol group #3 (3003) from time t1 to time t2, and, at every time, there is a plurality of data symbol groups.

[0520]

Similarly, FIG. 30 illustrates data symbol group #4 3004, data symbol group #5 3005 and data symbol group #6 3006. There are data symbol group #4 (3004), data symbol group #5 (3005) and data symbol group #6 (3006) from time t2 and time t3, and, at every time, there is a plurality of data symbol groups.

[0521]

Then, FIG. 30 illustrates data symbol group #7 3007, data symbol group #8 3008 and data symbol group #9 3009. There are data symbol group #7 (3007), data symbol group #8 (3008) and data symbol group #9 (3009) from time t3 to time t4, and, at every time, there is a plurality of data symbol groups.

[0522]

In this case, a number of carriers to be used in each data symbol group can be set. The number of symbol groups existing at every time is not limited to three. There only need to be two or more symbol groups.

[0523]

Note that a data symbol group may also be a symbol group based on the MIMO (transmitting) method and the MISO (transmitting) method. As a matter of course, the data symbol group may be a symbol group of the SISO (SIMO) method. In this case, at the same time and the same (common) frequency, a plurality of streams (s1 and s2 described below) is transmitted. In this case, at the same time and the same (common) frequency, a plurality of modulated signals is transmitted from a plurality of (different) antennas. Then, this point is not limited to FIG. 30, and the same also applies to FIGS. 31, 32, 33, 34, 35, 36, 37 and 38.

[0524]

Characteristic points in FIG. 30 are such that frequency division is performed, and that there are two or more time sections in which there is a plurality of data symbol groups. Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections.

[0525]

FIG. 31 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as in FIGS. 2 and 30 are assigned the same reference numerals in FIG. 31 and will not be described. In FIG. 31, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0526]

FIG. 31 illustrates data symbol group #10 3101 and data symbol group #11 3102, and there are data symbol group #10 (3101) and data symbol group #11 (3102) from time t4 to time t5. In this case, temporal division is performed and there is a plurality of data symbol groups.

[0527]

Characteristic points in FIG. 31 are such that frequency division is performed and there are two or more time sections in which there is a plurality of data symbol groups, and that temporal division is performed and there is a plurality of data symbols. Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections, and also of enabling a flexible setting of a data transmission rate by performing temporal division and appropriately defining data sections.

[0528]

FIG. 32 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIGS. 2, 30 and 5 are assigned the same reference numerals in FIG. 32 and will not be described. In FIG. 32, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0529]

FIG. 32 illustrates data symbol group #7 3201 and data symbol group #8 3202, and there are data symbol group #7 (3201) and data symbol group #8 (3202) from time t4 to time t5. In this case, temporal division is performed and there is a plurality of data symbol groups.

[0530]

A difference from FIG. 31 is that first preamble 501 and second preamble 502 are arranged before data symbol group #7 (3201). In this case, control information related to data symbol groups #1 to #6 subjected to frequency division, examples of which include a number of carriers and a time interval which are necessary for each data symbol group, a method for modulating each data symbol group, a method for transmitting each data symbol group and a method of an error correction code to be used in each data symbol group, is transmitted with first preamble 201 and/or second preamble 202 in FIG. 32. Note that the example of control information is described in the second exemplary embodiment. Note that this point will be described additionally.

[0531]

Then, control information related to data symbol groups #7 and #8 subjected to temporal division, examples of which include a number of symbols (or

a time interval) which are necessary for each data symbol group, a method for modulating each data symbol group, a method for transmitting each data symbol group and a method of an error correction code to be used in each data symbol group, is transmitted with first preamble 501 and/or second preamble 502 in FIG. 32. Note that the example of control information is described in the second exemplary embodiment. Note that this point will be described additionally.

[0532]

When the control information is transmitted in this way, it becomes unnecessary to incorporate dedicated control information for the data symbol groups subjected to time division in first preamble 201 and second preamble 202, and also it becomes unnecessary to incorporate dedicated control information for data symbol groups subjected to frequency division in first preamble 501 and second preamble 502, and it is possible to realize data transmission efficiency of control information and simplification of control on control information of the receiving apparatus.

[0533]

Characteristic points in FIG. 32 are such that frequency division is performed and there are two or more time sections in which there is a plurality of data symbol groups, and that temporal division is performed and there is a plurality of data symbols. Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections, and also of enabling a flexible setting of a data transmission rate by performing temporal division and appropriately defining data sections.

[0534]

FIG. 33 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the

same way as in FIGS. 2, 30, 32 and 6 are assigned the same reference numerals in FIG. 33 and will not be described. In FIG. 33, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0535]

FIG. 33 illustrates data symbol group #7 3201 and data symbol group #8 3202, and there are data symbol group #7 (3201) and data symbol group #8 (3202) from time t4 to time t5. In this case, temporal division is performed and there is a plurality of data symbol groups.

[0536]

A difference between FIGS. 30 and 31 is that pilot symbol 601 is arranged before data symbol group #7 (3201). In this case, an advantage in a case of arranging pilot symbol 601 is as described in the first exemplary embodiment.

[0537]

Characteristic points in FIG. 33 are such that frequency division is performed and there are two or more time sections in which there is a plurality of data symbol groups, and that temporal division is performed and there is a plurality of data symbols. Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections, and also of enabling a flexible setting of a data transmission rate by performing temporal division and appropriately defining data sections.

[0538]

FIG. 34 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIG. 2 are assigned the same reference numerals in FIG. 34 and will

not be described. In FIG. 34, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0539]

FIG. 34 illustrates data symbol group #1 3401, data symbol group #2 3402, data symbol group #3 3403, data symbol group #4 3404, data symbol group #5 3405, data symbol group #6 3406, data symbol group #7 3407, and data symbol group #8 3408.

[0540]

In FIG. 34, a data symbol group is arranged on a frame by using a frequency division method. Then, a difference of FIG. 34 from FIGS. 30 to 33 is that there is flexibility in a setting of a time interval between respective data symbol groups.

[0541]

For example, data symbol group #1 has symbols arranged from time t1 to time t2, and has a long time interval as compared to other data symbols. Data symbol groups other than data symbol group #1 also each have a time interval flexibly set.

[0542]

Characteristic points in FIG. 34 are such that frequency division is performed, and that time intervals of data symbol groups are flexibly set. Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections.

[0543]

FIG. 35 is an example of a frame configuration in a modulated signal to be

transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIGS. 2 and 34 are assigned the same reference numerals in FIG. 35 and will not be described. In FIG. 35, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0544]

FIG. 35 illustrates data symbol group #9 3509, data symbol group #10 3510, data symbol group #11 3511 and data symbol group #12 3512. Frequency division is performed, and data symbol group #9, data symbol group #10, data symbol group #11, data symbol group #12 and data symbol group #13 are transmitted between time t2 and time t3. As compared to time t1 and time t2, characteristic points are such that a time interval of data symbol group #9, a time interval of data symbol group #10, and a time interval of data symbol group #11 are equal, and a time interval of data symbol group #12, and a time interval of data symbol group #13 are equal.

[0545]

FIG. 35 illustrates data symbol group #14 3514 and data symbol group #15 3515. Temporal division is performed, and data symbol group #14 and data symbol group #15 are transmitted between time t3 and time t4.

[0546]

Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections and frequency sections.

[0547]

FIG. 36 is an example of a frame configuration in a modulated signal to be

transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIGS. 2, 6, 34 and 35 are assigned the same reference numerals in FIG. 36 and will not be described. In FIG. 36, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0548]

A difference of FIG. 36 from FIG. 35 is that first preamble 501, second preamble 502, first preamble 3601 and second preamble 3602 are arranged. In this case, data symbol groups #1 to #8 and data symbol groups #9 to #13 are subjected to frequency division, and also data symbol groups #14 and #15 are subjected to time division to be arranged.

[0549]

Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections and frequency sections.

[0550]

In this case, control information related to data symbol groups #1 to #8 subjected to frequency division, examples of which include a number of carriers and a time interval which are necessary for each data symbol group, a method for modulating each data symbol group, a method for transmitting each data symbol group and a method of an error correction code to be used in each data symbol group, is transmitted with first preamble 201 and/or second preamble 202 in FIG. 36. Note that the example of control information is described in the second exemplary embodiment. Note that this point will be described additionally.

[0551]

Then, control information related to data symbol groups #9 to #13 subjected to frequency division, examples of which include a number of carriers and a time interval which are necessary for each data symbol group, a method for modulating each data symbol group, a method for transmitting each data symbol group and a method of an error correction code to be used in each data symbol group, is transmitted with first preamble 501 and/or second preamble 502 in FIG. 36. Note that the example of control information is described in the second exemplary embodiment. Note that this point will be described additionally.

[0552]

Moreover, control information related to data symbol groups #14 and #15 subjected to temporal division, examples of which include a number of symbols (or a time interval) which is necessary for each data symbol group, a method for modulating each data symbol group, a method for transmitting each data symbol group and a method of an error correction code to be used in each data symbol group, is transmitted with first preamble 3601 and/or second preamble 3602 in FIG. 36. Note that the example of control information is described in the second exemplary embodiment. Note that this point will be described additionally.

[0553]

When the control information is transmitted in this way, it becomes unnecessary to incorporate dedicated control information for the data symbol groups subjected to time division in first preamble 201, second preamble 202, first preamble 501 and second preamble 502, and also it becomes unnecessary to incorporate dedicated control information for data symbol groups subjected to frequency division in first preamble 3601 and second preamble 3602, and it is possible to realize data transmission efficiency of control information and simplification of control on control information of the receiving apparatus.

[0554]

FIG. 37 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIGS. 2, 6, 34 and 35 are assigned the same reference numerals in FIG. 37 and will not be described. In FIG. 37, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0555]

A difference of FIG. 37 from FIGS. 35 and 36 is that pilot symbols 601 and 3701 are arranged. In this case, data symbol groups #1 to #8 and data symbol groups #9 to #13 are subjected to frequency division, and also data symbol groups #14 and #15 are subjected to time division to be arranged.

[0556]

Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections and frequency sections. Moreover, an effect in a case of inserting a pilot symbol is as described in the first exemplary embodiment.

[0557]

FIG. 38 is an example of a frame configuration in a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as FIGS. 2, 6, 34 and 35 are assigned the same reference numerals in FIG. 38 and will not be described. In FIG. 38, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, since a transmitting method using a multi-carrier method such as an OFDM method is used, there is a plurality of carriers on the vertical axis frequency.

[0558]

A difference of FIG. 38 from FIGS. 35, 36 and 37 is that the "first preamble and the second preamble" or "pilot symbols" 3801 and 3802 are arranged. In this case, data symbol groups #1 to #8 and data symbol groups #9 to #13 are subjected to frequency division, and also data symbol groups #14 and #15 are subjected to time division to be arranged.

[0559]

Consequently, there is an effect of enabling symbol groups of different data reception quality to exist at the same time, and of enabling a flexible setting of a data transmission rate by appropriately defining data sections and frequency sections.

[0560]

Then, as illustrated in FIG. 38, the "first preamble and the second preamble" or "pilot symbols" 3801 and 3802 are inserted and, depending on a situation, the "first preamble and the second preamble" or the "pilot symbols" are switched and used. The above-described switching may be performed based on, for example, the transmitting method.

[0561]

FIGS. 30 to 38 illustrate the examples where a data symbol group subjected to time division is arranged after a data symbol group subjected to frequency division. However, the arrangement is not limited to this arrangement. The data symbol group subjected to frequency division may be arranged after the data symbol group subjected to time division. In this case, in the example in FIGS. 32 and 36, the first preamble and the second preamble are inserted between the data symbol group subjected to time division and the data symbol group subjected to frequency division. However, symbols other than the first preamble and the second preamble may be inserted. Moreover, in the example in FIGS. 33 and 37, the pilot symbol is inserted between the data symbol group subjected to time

division and the data symbol group subjected to frequency division. However, symbols other than the pilot symbol may be inserted.

[0562]

In the present exemplary embodiment, the examples of the frame configuration of the modulated signal to be transmitted by the transmitting apparatus are described with reference to FIGS. 30 to 38. With reference to these figures, the above describes the point that "time division (temporal division) is performed." However, when two data symbol groups are connected, there is a portion subjected to frequency division at a seam portion. This point will be described with reference to FIG. 39.

[0563]

FIG. 39 illustrates symbol 3901 of data symbol group #1 and symbol 3902 of data symbol group #2. As illustrated at time t0 in FIG. 39, the symbol of data symbol group #1 ends with carrier 4. In this case, the symbol of data symbol group #2 is arranged from carrier 5 at time t0. Then, only a portion at time t0 is exceptionally subjected to frequency division. However, there is only the symbol of data symbol group #1 before time t0, and there is only the symbol of data symbol group #2 after time t0. At this point, time division (temporal division) is performed.

[0564]

FIG. 40 illustrates another example. Note that the same reference numerals as those in FIG. 39 are assigned. As illustrated at time t0 in FIG. 40, the symbol of data symbol group #1 ends with carrier 4. Then, as illustrated at time t1, the symbol of data symbol group #1 ends with carrier 5. Then, the symbol of data symbol group #2 is arranged from carrier 5 at time t0, and the symbol of data symbol group #2 is arranged from carrier 6 at time t1. Then, portions at time t0 and time t1 are exceptionally subjected to frequency division. However, there is only the symbol of data symbol group #1 before time t0, and there is only the

symbol of data symbol #2 after time t1. At this point, time division (temporal division) is performed.

[0565]

As illustrated in FIGS. 39 and 40, there is a case where, except for the exceptional portions, there are time at which there is no data symbol other than the symbol of data symbol group #1, but there may be a pilot symbol or the like, and time at which there is no data symbol other than the symbol of data symbol group #2, but there may be a pilot symbol or the like. This case will be referred to as "time division (temporal division) is performed." Hence, an exceptional time existing method is not limited to FIGS. 39 and 40.

[0566]

Moreover, the "time division (temporal division) is performed" is not limited to the present exemplary embodiment, and the same interpretation also applies to the other exemplary embodiments.

[0567]

As described in the first exemplary embodiment, the transmitting apparatus in FIG. 1 may select any frame configuration of the frame configurations described in the first exemplary embodiment to the third exemplary embodiment and the frame configuration described in the present exemplary embodiment, and may transmit a modulated signal. An example of the method for configuring control information of information related to a frame configuration is as described in the first exemplary embodiment.

[0568]

Then, the receiving apparatus (for example, FIG. 23) which receives the modulated signal transmitted by the transmitting apparatus in FIG. 1 receives the control information described in the first exemplary embodiment, the second exemplary embodiment and the like, demodulates and decodes a data symbol

group based on this control information and obtains information. As a result, the information described herein is transmitted as control information, and thus it is possible to obtain an effect of enabling improvement in data reception quality and improvement in data transmission efficiency and of enabling an accurate operation of the receiving apparatus.

[0569]

The method for transmitting data symbol groups #1 to #6 in the frame configuration in FIG. 32 may be set with first preamble 201 and/or second preamble 202. The method for transmitting data symbol groups #7 and #8 may be set with first preamble 501 and/or second preamble 502.

[0570]

In this case, either a case where the "method for transmitting data symbol groups #1 to #6 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 to #6 is of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol groups #7 and #8 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #7 and #8 is of SISO transmission (SIMO transmission)" may be selectable.

[0571]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)," and in the method for transmitting a plurality of data symbol groups present between the "set of the first preamble and the second preamble" and the next "set of the first preamble and the second preamble," there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission

and SISO transmission (SIMO transmission).

[0572]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, a fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0573]

However, the present disclosure is not limited to the above.

[0574]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0575]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol

configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Note that pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0576]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0577]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for

modulated signal #1 are PSK symbols.

[0578]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0579]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0580]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0581]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and

quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0582]

Similarly, the method for transmitting data symbol groups #1 to #8 in the frame configuration in FIG. 36 may be set with first preamble 201 and/or second preamble 202. The method for transmitting data symbol groups #9 to #13 may be set with first preamble 501 and/or second preamble 502. The method for transmitting data symbol groups #14 and #15 may be set with first preamble 3601 and/or second preamble 3602.

[0583]

In this case, either a case where the "method for transmitting data symbol groups #1 to #8 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 to #8 is of SISO transmission (SIMO transmission)" may be selectable., and either a case where the "method for transmitting data symbol groups #9 to #13 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #9 to #13 is of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol groups #14 and #15 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #14 and #15 is of SISO transmission (SIMO transmission)" may be selectable.

[0584]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)," and in the method for transmitting a plurality of data symbol groups present between the "set

of the first preamble and the second preamble" and the next "set of the first preamble and the second preamble," there is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission).

[0585]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0586]

However, the present disclosure is not limited to the above.

[0587]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0588]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Note that pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0589]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0590]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0591]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0592]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0593]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0594]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol

4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0595]

Moreover, the method for transmitting data symbol groups #1 to #8 in the frame configuration in FIG. 33 may be set with first preamble 201 and/or second preamble 202.

[0596]

In this case, either a case where the "method for transmitting data symbol groups #1 to #6 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 to #6 is of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol groups #7 and #8 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #7 and #8 is of SISO transmission (SIMO transmission)" may be selectable.

[0597]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a "pilot symbol" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission SISO transmission (SIMO transmission). Then, a method for transmitting a plurality of data symbol groups present between the "pilot symbol" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of

MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). However, FIG. 33 does not illustrate the "set of the first preamble and the second preamble" next to the pilot symbol.

[0598]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0599]

However, the present disclosure is not limited to the above.

[0600]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0601]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0602]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0603]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0604]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0605]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0606]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0607]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol

4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0608]

Similarly, the method for transmitting data symbol groups #1 to #15 in the frame configuration in FIG. 37 may be set with first preamble 201 and/or second preamble 202.

[0609]

In this case, either a case where the "method for transmitting data symbol groups #1 to #8 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #1 to #8 is of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol groups #9 to #13 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #9 to #13 is of SISO transmission (SIMO transmission)" may be selectable, and either a case where the "method for transmitting data symbol groups #14 and #15 is of MIMO transmission or MISO transmission" or a case where the "method for transmitting data symbol groups #14 and #15 is of SISO transmission (SIMO transmission)" may be selectable.

[0610]

That is, a method for transmitting a plurality of data symbol groups present between a "set of the first preamble and the second preamble" and a "pilot symbol" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and

SISO transmission (SIMO transmission). Then, a method for transmitting a plurality of data symbol groups present between the "pilot symbol" and a next "set of the first preamble and the second preamble" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission). However, FIG. 37 does not illustrate the "set of the first preamble and the second preamble" next to the pilot symbol.

[0611]

Moreover, a method for transmitting a plurality of data symbol groups present between a "pilot symbol" and a "pilot symbol" is of either "MIMO transmission or MISO transmission" or "SISO transmission (SIMO transmission)". There is no mix of MIMO transmission and SISO transmission (SIMO transmission) and there is no mix of MISO transmission and SISO transmission (SIMO transmission).

[0612]

When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, fluctuation of received field intensity increases in the receiving apparatus. For this reason, there is a problem of a quantization error that is likely to occur during AD (Analog-to-Digital) conversion, and consequently of deterioration in data reception quality. However, the above-described way increases a possibility that an effect of suppression of occurrence of such a phenomenon and improvement in data reception quality can be obtained.

[0613]

However, the present disclosure is not limited to the above.

[0614]

Moreover, in association with the above-described switching of the transmitting methods, methods for inserting a pilot symbol to be inserted to a data symbol group are also switched, and there is also an advantage from a viewpoint of improvement in data transmission efficiency. This is because there is no mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method. When there is a mix of the SISO (SIMO) transmitting method and the MIMO (MISO) transmitting method, there is a possibility that frequency of inserting a pilot symbol becomes excessive and that the data transmission efficiency decreases. Note that a configuration of a pilot symbol to be inserted to a data symbol group is as follows.

[0615]

A "pilot symbol to be inserted to a data symbol group during SISO transmission" and a "pilot symbol to be inserted to a data symbol group during MIMO transmission or MISO transmission" are different in a pilot symbol configuring method. This point will be described with reference to the figures. FIG. 41 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during SISO transmission." Note that in FIG. 41, a horizontal axis indicates time, and a vertical axis indicates a frequency. FIG. 41 illustrates symbol 4101 of data symbol group #1, and pilot symbol 4102. In this case, data is transmitted with symbol 4101 of data symbol group #1. Pilot symbol 4102 is a symbol for performing frequency offset estimation, frequency synchronization, time synchronization, signal detection and channel estimation (radio wave propagation environment estimation) in the receiving apparatus. Pilot symbol 4102 is configured with, for example, a PSK (Phase Shift Keying) symbol which is known in the transmitting apparatus and the receiving apparatus. Pilot symbol 4102 is highly likely to need to be a PSK symbol.

[0616]

FIG. 42 illustrates an insertion example of the "pilot symbol to be inserted to the data symbol group during MIMO transmission or MISO transmission." Note that in FIG. 42, a horizontal axis indicates time, and a vertical axis indicates a frequency. "During MIMO transmission or MISO transmission," modulated signals are transmitted from two antennas, respectively. Here, the modulated signals are referred to as modulated signal #1 and modulated signal #2. FIG. 42 illustrates an insertion example of a pilot symbol of modulated signal #1 and an insertion example of a pilot symbol of modulated signal #2 in combination.

[0617]

Example 1)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are PSK symbols.

[0618]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Both of first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are PSK symbols.

[0619]

Then, "first pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1" and "first pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2" are orthogonal (a correlation is zero) at a certain cycle.

[0620]

Example 2)

Case of modulated signal #1:

First pilot symbol 4201 for modulated signal #1 and second pilot symbol 4202 for modulated signal #1 are inserted as illustrated in FIG. 42. First pilot symbol 4201 for modulated signal #1 is a PSK symbol. Second pilot symbol 4202 for modulated signal #1 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, second pilot symbol 4202 for modulated signal #1 may not be referred to as a pilot symbol.

[0621]

Case of modulated signal #2:

First pilot symbol 4201 for modulated signal #2 and second pilot symbol 4202 for modulated signal #2 are inserted as illustrated in FIG. 42. Second pilot symbol 4201 for modulated signal #2 is a PSK symbol. First pilot symbol 4202 for modulated signal #2 is a null symbol (in-phase component I is 0 (zero) and quadrature component Q is 0 (zero)). Hence, first pilot symbol 4202 for modulated signal #2 may not be referred to as a pilot symbol.

[0622]

FIFTH EXEMPLARY EMBODIMENT

The frame of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is described in the fourth exemplary embodiment with reference to FIGS. 30 to 38. In each of FIGS. 30 to 38, the frame is configured in a case where a data symbol group is subjected to frequency division and in a case where a data symbol group is subjected to time division (temporal division). In this case, it is necessary to accurately transmit frequency resources (carriers) and time resources to be used by each data symbol group to a receiving apparatus.

[0623]

In the present exemplary embodiment, an example of a method for

configuring control information related to a frequency (frequency resources) and time (time resources) to be used by each data symbol group in a case of the frame configurations in FIGS. 30 to 38 will be described. Note that the frame configurations in FIGS. 30 to 38 are only examples, and detailed requirements of frame configurations are as described in the fourth exemplary embodiment.

[0624]

<Case where frequency division is performed>

An example of a method for generating control information related to frequency resources and time resources to be used by each data symbol group in a case where frequency division is performed will be described.

[0625]

FIG. 43 illustrates an example in a case where a data symbol group is subjected to frequency division in a frame of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. In FIG. 43, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fourth exemplary embodiment, a data symbol group may be of symbols of any method of an SISO method (SIMO method), an MIMO method and an MISO method.

[0626]

FIG. 43 illustrates symbol 4301 of data symbol group #1. Data symbol group #1 (4301) is transmitted by using carrier 1 to carrier 5 and by using time 1 to time 16. However, a first index of a carrier is assumed to be "carrier 1" but is not limited to "carrier 1," and also a first index of time is assumed to be "time 1" but is not limited to "time 1".

[0627]

FIG. 43 illustrates symbol 4302 of data symbol group #2. Data symbol group #2 (4302) is transmitted by using carrier 6 to carrier 9 and by using time 1 to

time 5.

[0628]

FIG. 43 illustrates symbol 4303 of data symbol group #3. Data symbol group #3 (4303) is transmitted by using carrier 10 to carrier 14 and by using time 1 to time 16.

[0629]

FIG. 43 illustrates symbol 4304 of data symbol group #4. Data symbol group #4 (4304) is transmitted by using carrier 6 to carrier 9 and by using time 6 to time 12.

[0630]

FIG. 43 illustrates symbol 4305 of data symbol group #5. Data symbol group #5 (4305) is transmitted by using carrier 6 to carrier 9 and by using time 13 to time 16.

[0631]

<First Example>

An example of control information related to a frequency and time to be used by each data symbol group in this case will be described.

[0632]

Control information related to a default position of a carrier to be used by data symbol group #j is m(j, 0), m(j, 1), m(j, 2) and m(j, 3),

control information related to a number of carriers to be used by data symbol group #j is n(j, 0), n(j, 1), n(j, 2) and n(j, 3),

control information related to a default position of time to be used by data symbol group #j is o(j, 0), o(j, 1), o(j, 2) and o(j, 3), and

control information related to a number of pieces of time to be used by data symbol group #j is p(j, 0), p(j, 1), p(j, 2) and p(j, 3).

[0633]

In this case, when a default position of a carrier to be used by data symbol group #(j = K) is "carrier 1," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 0, m(K, 2) = 0 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0634]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 2," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 0, m(K, 2) = 0 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0635]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 3," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 1, m(K, 2) = 0 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0636]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 4," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 1, m(K, 2) = 0 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0637]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 5," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 0, m(K, 2) = 1 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0638]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 6," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 0, m(K, 2) = 1 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0639]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 7," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 1, m(K, 2) = 1 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0640]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 8," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 1, m(K, 2) = 1 and m(K, 3) = 0, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0641]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 9," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 0, m(K, 2) = 0 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0642]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 10," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 0, m(K, 2) = 0 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0643]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 11," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 1, m(K, 2) = 0 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0644]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 12," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 1, m(K, 2) = 0 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0645]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 13," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 0, m(K, 2) = 1 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0646]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 14," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 0, m(K, 2)

= 1 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0647]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 15," the transmitting apparatus sets m(K, 0) = 0, m(K, 1) = 1, m(K, 2) = 1 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0648]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 16," the transmitting apparatus sets m(K, 0) = 1, m(K, 1) = 1, m(K, 2) = 1 and m(K, 3) = 1, and transmits m(K, 0), m(K, 1), m(K, 2) and m(K, 3).

[0649]

When a number of carriers to be used by data symbol group #(j = K) is of 1 carrier, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 0, n(K, 2) = 0 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0650]

When the number of carriers to be used by data symbol group #(j = K) is of 2 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 0, n(K, 2) = 0 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0651]

When the number of carriers to be used by data symbol group #(j = K) is of 3 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 1, n(K, 2) = 0 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0652]

When the number of carriers to be used by data symbol group #(j = K) is of 4 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 1, n(K, 2) = 0 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0653]

When the number of carriers to be used by data symbol group #(j = K) is of

5 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 0, n(K, 2) = 1 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0654]

When the number of carriers to be used by data symbol group #(j = K) is of 6 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 0, n(K, 2) = 1 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0655]

When the number of carriers to be used by data symbol group #(j = K) is of 7 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 1, n(K, 2) = 1 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0656]

When the number of carriers to be used by data symbol group #(j = K) is of 8 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 1, n(K, 2) = 1 and n(K, 3) = 0, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0657]

When the number of carriers to be used by data symbol group #(j = K) is of 9 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 0, n(K, 2) = 0 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0658]

When the number of carriers to be used by data symbol group #(j = K) is, of 10 carriers the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 0, n(K, 2) = 0 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0659]

When the number of carriers to be used by data symbol group #(j = K) is, of 11 carriers the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 1, n(K, 2) = 0 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0660]

When the number of carriers to be used by data symbol group #(j = K) is of 12 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 1, n(K, 2) = 0 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0661]

When the number of carriers to be used by data symbol group #(j = K) is of 13 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 0, n(K, 2) = 1 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0662]

When the number of carriers to be used by data symbol group #(j = K) is of 14 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 0, n(K, 2) = 1 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0663]

When the number of carriers to be used by data symbol group #(j = K) is of 15 carriers, the transmitting apparatus sets n(K, 0) = 0, n(K, 1) = 1, n(K, 2) = 1 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0664]

When the number of carriers to be used by data symbol group #(j = K) is of 16 carriers, the transmitting apparatus sets n(K, 0) = 1, n(K, 1) = 1, n(K, 2) = 1 and n(K, 3) = 1, and transmits n(K, 0), n(K, 1), n(K, 2) and n(K, 3).

[0665]

When a default position of time to be used by data symbol group #(j = K) is "time 1," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 0, o(K, 2) = 0 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0666]

When the default position of the time to be used by data symbol group #(j = K) is "time 2," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 0, o(K, 2) = 0 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0667]

When the default position of the time to be used by data symbol group #(j = K) is "time 3," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 1, o(K, 2) = 0 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0668]

When the default position of the time to be used by data symbol group #(j = K) is "time 4," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 1, o(K, 2) = 0 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0669]

When the default position of the time to be used by data symbol group #(j = K) is "time 5," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 0, o(K, 2) = 1 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0670]

When the default position of the time to be used by data symbol group #(j = K) is "time 6," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 0, o(K, 2) = 1 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0671]

When the default position of the time to be used by data symbol group #(j = K) is "time 7," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 1, o(K, 2) = 1 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0672]

When the default position of the time to be used by data symbol group #(j = K) is "time 8," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 1, o(K, 2) = 1 and o(K, 3) = 0, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0673]

When the default position of the time to be used by data symbol group #(j = K) is "time 9," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 0, o(K, 2) = 0

and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0674]

When the default position of the time to be used by data symbol group #(j = K) is "time 10," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 0, o(K, 2) = 0 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0675]

When the default position of the time to be used by data symbol group #(j = K) is "time 11," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 1, o(K, 2) = 0 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0676]

When the default position of the time to be used by data symbol group #(j = K) is "time 12," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 1, o(K, 2) = 0 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0677]

When the default position of the time to be used by data symbol group #(j = K) is "time 13," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 0, o(K, 2) = 1 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0678]

When the default position of the time to be used by data symbol group #(j = K) is "time 14," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 0, o(K, 2) = 1 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0679]

When the default position of the time to be used by data symbol group #(j = K) is "time 15," the transmitting apparatus sets o(K, 0) = 0, o(K, 1) = 1, o(K, 2) = 1 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0680]

When the default position of the time to be used by data symbol group #(j =

K) is "time 16," the transmitting apparatus sets o(K, 0) = 1, o(K, 1) = 1, o(K, 2) = 1 and o(K, 3) = 1, and transmits o(K, 0), o(K, 1), o(K, 2) and o(K, 3).

[0681]

When a number of pieces of time to be used by data symbol group #(j = K) is 1, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 0, p(K, 2) = 0 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0682]

When the number of pieces of time to be used by data symbol group #(j = K) is 2, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 0, p(K, 2) = 0 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0683]

When the number of pieces of time to be used by data symbol group #(j = K) is 3, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 1, p(K, 2) = 0 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0684]

When the number of pieces of time to be used by data symbol group #(j = K) is 4, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 1, p(K, 2) = 0 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0685]

When the number of pieces of time to be used by data symbol group #(j = K) is 5, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 0, p(K, 2) = 1 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0686]

When the number of pieces of time to be used by data symbol group #(j = K) is 6, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 0, p(K, 2) = 1 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0687]

When the number of pieces of time to be used by data symbol group #(j = K) is 7, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 1, p(K, 2) = 1 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0688]

When the number of pieces of time to be used by data symbol group #(j = K) is 8, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 1, p(K, 2) = 1 and p(K, 3) = 0, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0689]

When the number of pieces of time to be used by data symbol group #(j = K) is 9, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 0, p(K, 2) = 0 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0690]

When the number of pieces of time to be used by data symbol group #(j = K) is 10, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 0, p(K, 2) = 0 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0691]

When the number of pieces of time to be used by data symbol group #(j = K) is 11, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 1, p(K, 2) = 0 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0692]

When the number of pieces of time to be used by data symbol group #(j = K) is 12, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 1, p(K, 2) = 0 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0693]

When the number of pieces of time to be used by data symbol group #(j = K) is 13, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 0, p(K, 2) = 1 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0694]

When the number of pieces of time to be used by data symbol group #(j = K) is 14, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 0, p(K, 2) = 1 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0695]

When the number of pieces of time to be used by data symbol group #(j = K) is 15, the transmitting apparatus sets p(K, 0) = 0, p(K, 1) = 1, p(K, 2) = 1 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0696]

When the number of pieces of time to be used by data symbol group #(j = K) is 16, the transmitting apparatus sets p(K, 0) = 1, p(K, 1) = 1, p(K, 2) = 1 and p(K, 3) = 1, and transmits p(K, 0), p(K, 1), p(K, 2) and p(K, 3).

[0697]

Next, data symbol group #3 will be described as an example.

[0698]

Data symbol group #3 (4303) is transmitted by using carrier 10 to carrier 14 and by using time 1 to time 16.

[0699]

As a result, a default position of a carrier is carrier 10. Hence, the transmitting apparatus sets m(3, 0) = 1, m(3, 1) = 0, m(3, 2) = 0 and m(3, 3) = 1, and transmits m(3, 0), m(3, 1), m(3, 2) and m(3, 3).

[0700]

Moreover, a number of carriers to be used is 5. Hence, the transmitting apparatus sets n(3, 0) = 0, n(3, 1) = 0, n(3, 2) = 1 and n(3, 3) = 0, and transmits n(3, 0), n(3, 1), n(3, 2) and n(3, 3).

[0701]

A default position of time is time 1. Hence, the transmitting apparatus sets

o(3, 0) = 0, o(3, 1) = 0, o(3, 2) = 0 and o(3, 3) = 0, and transmits o(3, 0), o(3, 1), o(3, 2) and o(3, 3).

[0702]

Moreover, a number of pieces of time to be used is 16. Hence, the transmitting apparatus sets p(3, 0) = 1, p(3, 1) = 1, p(3, 2) = 1 and p(3, 3) = 1, and transmits p(3, 0), p(3, 1), p(3, 2) and p(3, 3).

[0703]

<Second Example>

FIG. 44 illustrates an example in a case where a data symbol group is subjected to frequency division in a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements common to those in FIG. 43 are assigned the same reference numerals in FIG. 44. Moreover, in FIG. 44, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fourth exemplary embodiment, a data symbol group may be of symbols of any method of an SISO method (SIMO method), an MIMO method and an MISO method.

[0704]

A difference of FIG. 44 from FIG. 43 is that each data symbol group has, for example, a number of carriers of 4 × A (A is an integer equal to or more than 1), that is, the number of carriers to be used by each data symbol group being a multiple of 4 (but, except 0 (zero)), and has a number of pieces of time of 4 × B (B is a natural number equal to or more than 1), that is, the number of pieces of time to be used by each data symbol group being a multiple of 4 (but, except 0 (zero)). However, the number of carriers to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of C (C is an integer equal to or more than 2) except 0 (zero). Moreover, the number of pieces of time to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of

D (D is an integer equal to or more than 2) except 0 (zero).

[0705]

FIG. 44 illustrates symbol 4301 of data symbol group #1. Data symbol group #1 (4301) is transmitted by using carrier 1 to carrier 8, that is, by using 8 (a multiple of 4) carriers and by using time 1 to time 16 (the number of pieces of time is 16, a multiple of 4). However, a first index of a carrier is assumed to be "carrier 1" but is not limited to "carrier 1," and also a first index of time is assumed to be "time 1" but is not limited to "time 1".

[0706]

FIG. 44 illustrates symbol 4302 of data symbol group #2. Data symbol group #2 (4302) is transmitted by using carrier 9 to carrier 12, that is, by using 4 (a multiple of 4) carriers and by using time 1 to time 4 (the number of pieces of time is 4, a multiple of 4).

[0707]

FIG. 44 illustrates symbol 4303 of data symbol group #3. Data symbol group #3 (4303) is transmitted by using carrier 13 to carrier 16, that is, by using 4 (a multiple of 4) carriers and by using time 1 to time 16 (the number of pieces of time is 16, a multiple of 4).

[0708]

FIG. 44 illustrates symbol 4304 of data symbol group #4. Data symbol group #4 (4304) is transmitted by using carrier 9 to carrier 12, that is, by using 4 (a multiple of 4) carriers and by using time 5 to time 12 (the number of pieces of time is 8, a multiple of 4).

[0709]

FIG. 44 illustrates symbol 4305 of data symbol group #5. Data symbol group #5 (4305) is transmitted by using carrier 9 to carrier 12, that is, by using 4 (a multiple of 4) carriers and by using time 13 to time 16 (the number of pieces of time

is 4, a multiple of 4).

[0710]

When each data symbol group is allocated to a frame according to such rules, it is possible to reduce

• a number of bits of the above-described "control information related to the default position of the carrier to be used by data symbol group #j,"

• a number of bits of the above-described "control information related to the number of carriers to be used by data symbol group #j,"

• a number of bits of the above-described "control information related to the default position of the time to be used by data symbol group #j," and

• a number of bits of the above-described "control information related to the number of pieces of time to be used by data symbol group #j," and

it is possible to improve data (information) transmission efficiency.

[0711]

In this case, it is possible to define the control information as follows.

[0712]

The control information related to the default position of the carrier to be used by data symbol group #j is m(j, 0) and m(j, 1),

the control information related to the number of carriers to be used by data symbol group #j is n(j, 0) and n(j, 1),

the control information related to the default position of the time to be used by data symbol group #j is o(j, 0) and o(j, 1), and

the control information related to the number of pieces of time to be used by data symbol group #j is p(j, 0) and p(j, 1).

[0713]

In this case, when a default position of a carrier to be used by data symbol group #(j = K) is "carrier 1," the transmitting apparatus sets m(K, 0) = 0 and m(K, 1)

= 0, and transmits m(K, 0) and m(K, 1).

[0714]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 5," the transmitting apparatus sets m(K, 0) = 1 and m(K, 1) = 0, and transmits m(K, 0) and m(K, 1).

[0715]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 9," the transmitting apparatus sets m(K, 0) = 0 and m(K, 1) = 1, and transmits m(K, 0) and m(K, 1).

[0716]

When the default position of the carrier to be used by data symbol group #(j = K) is "carrier 13," the transmitting apparatus sets m(K, 0) = 1 and m(K, 1) = 1, and transmits m(K, 0) and m(K, 1).

[0717]

When a number of carriers to be used by data symbol group #(j = K) is of 4 carriers, the transmitting apparatus sets n(K, 0) = 0 and n(K, 1) = 0, and transmits n(K, 0) and n(K, 1).

[0718]

When the number of carriers to be used by data symbol group #(j = K) is of 8 carriers, the transmitting apparatus sets n(K, 0) = 1 and n(K, 1) = 0, and transmits n(K, 0) and n(K, 1).

[0719]

When the number of carriers to be used by data symbol group #(j = K) is of 12 carriers, the transmitting apparatus sets n(K, 0) = 0 and n(K, 1) = 1, and transmits n(K, 0) and n(K, 1).

[0720]

When the number of carriers to be used by data symbol group #(j = K) is of

16 carriers, the transmitting apparatus sets n(K, 0) = 1 and n(K, 1) = 1, and transmits n(K, 0) and n(K, 1).

[0721]

When a default position of time to be used by data symbol group #(j = K) is "time 1," the transmitting apparatus sets o(K, 0) = 0 and o(K, 1) = 0, and transmits o(K, 0) and o(K, 1).

[0722]

When the default position of the time to be used by data symbol group #(j = K) is "time 5," the transmitting apparatus sets o(K, 0) = 1 and o(K, 1) = 0, and transmits o(K, 0) and o(K, 1).

[0723]

When the default position of the time to be used by data symbol group #(j = K) is "time 9," the transmitting apparatus sets o(K, 0) = 0 and o(K, 1) = 1, and transmits o(K, 0) and o(K, 1).

[0724]

When the default position of the time to be used by data symbol group #(j = K) is "time 13," the transmitting apparatus sets o(K, 0) = 1 and o(K, 1) = 1, and transmits o(K, 0) and o(K, 1).

[0725]

When a number of pieces of time to be used by data symbol group #(j = K) is 4, the transmitting apparatus sets p(K, 0) = 0 and p(K, 1) = 0, and transmits p(K, 0) and p(K, 1).

[0726]

When the number of pieces of time to be used by data symbol group #(j = K) is 8, the transmitting apparatus sets p(K, 0) = 1 and p(K, 1) = 0, and transmits p(K, 0) and p(K, 1).

[0727]

When the number of pieces of time to be used by data symbol group #(j = K) is 12, the transmitting apparatus sets p(K, 0) = 0 and p(K, 1) = 1, and transmits p(K, 0) and p(K, 1).

[0728]

When the number of pieces of time to be used by data symbol group #(j = K) is 16, the transmitting apparatus sets p(K, 0) = 1 and p(K, 1) = 1, and transmits p(K, 0) and p(K, 1).

[0729]

Next, data symbol group #4 will be described as an example.

[0730]

FIG. 44 illustrates symbol 4304 of data symbol group #4, and data symbol group #4 (4304) is transmitted by using carrier 9 to carrier 12, that is, by using 4 (a multiple of 4) carriers and by using time 5 to time 12 (the number of pieces of time is 8, a multiple of 4).

[0731]

As a result, a default position of a carrier is carrier 9. Hence, the transmitting apparatus sets m(3, 0) = 0 and m(3, 1) =1, and transmits m(3, 0) and m(3, 1).

[0732]

Moreover, a number of carriers to be used is 4. Hence, the transmitting apparatus sets n(3, 0) = 0 and n(3, 1) = 0, and transmits n(3, 0) and n(3, 1).

[0733]

A default position of time is time 5. Hence, the transmitting apparatus sets o(3, 0) = 1 and o(3, 1) = 0, and transmits o(3, 0) and o(3, 1).

[0734]

Moreover, a number of pieces of time to be used is 8. Hence, the transmitting apparatus sets p(3, 0) = 1 and p(3, 1) = 0, and transmits p(3, 0) and p(3,

1).

[0735]

<Third Example>

A control information transmitting method which is different from the control information transmitting method of the second example when a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is a configuration in FIG. 44 will be described.

[0736]

In FIG. 44, each data symbol group has, for example, a number of carriers of 4 × A (A is an integer equal to or more than 1), that is, the number of carriers to be used by each data symbol group being a multiple of 4 (but, except 0 (zero)), and has a number of pieces of time of 4 × B (B is a natural number equal to or more than 1), that is, the number of pieces of time to be used by each data symbol group being a multiple of 4 (but, except 0 (zero)). However, the number of carriers to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of C (C is an integer equal to or more than 2) except 0 (zero). Moreover, the number of pieces of time to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of D (D is an integer equal to or more than 2) except 0 (zero).

[0737]

Hence, area decomposition is performed as illustrated in FIG. 45. In FIG. 45, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, there are carrier 1 to carrier 16, and there are time 1 to time 16 in accordance with FIG. 44. Note that in FIG. 45, each area is configured with an area of 4 × 4 = 16 symbols of 4 carriers in a carrier direction and 4 pieces of time in time direction. In a case of generalization using C and D as described above, each area is configured with an area of C × D symbols of C carriers in the carrier direction and D

pieces of time in the time direction.

[0738]

In FIG. 45, area 4400 configured with carrier 1 to carrier 4 and time 1 to time 4 is referred to as area #0.

[0739]

Area 4401 configured with carrier 5 to carrier 8 and time 1 to time 4 is referred to as area #1.

[0740]

Area 4402 configured with carrier 9 to carrier 12 and time 1 to time 4 is referred to as area #2.

[0741]

Area 4403 configured with carrier 13 to carrier 16 and time 1 to time 4 is referred to as area #3.

[0742]

Area 4404 configured with carrier 1 to carrier 4 and time 5 to time 8 is referred to as area #4.

[0743]

Area 4405 configured with carrier 5 to carrier 8 and time 5 to time 8 is referred to as area #5.

[0744]

Area 4406 configured with carrier 9 to carrier 12 and time 5 to time 8 is referred to as area #6.

[0745]

Area 4407 configured with carrier 13 to carrier 16 and time 5 to time 8 is referred to as area #7.

[0746]

Area 4408 configured with carrier 1 to carrier 4 and time 9 to time 12 is

referred to as area #8.

[0747]

Area 4409 configured with carrier 5 to carrier 8 and time 9 to time 12 is referred to as area #9.

[0748]

Area 4410 configured with carrier 9 to carrier 12 and time 9 to time 12 is referred to as area #10.

[0749]

Area 4411 configured with carrier 13 to carrier 16 and time 9 to time 12 is referred to as area #11.

[0750]

Area 4412 configured with carrier 1 to carrier 4 and time 13 to time 16 is referred to as area #12.

[0751]

Area 4413 configured with carrier 5 to carrier 8 and time 13 to time 16 is referred to as area #13.

[0752]

Area 4414 configured with carrier 9 to carrier 12 and time 13 to time 16 is referred to as area #14.

[0753]

Area 4415 configured with carrier 13 to carrier 16 and time 13 to time 16 is referred to as area #15.

[0754]

In this case, the transmitting apparatus in FIG. 1 transmits control information as in an example described below, in order to transmit information of frequency and time resources being used by each data symbol group to the receiving apparatus.

[0755]

When data symbol group #1 in FIG. 44 is subjected to the area decomposition as illustrated in FIG. 45, data (information) is transmitted by using area #0 (4400), area #1 (4401), area #4 (4404), area #5 (4405), area #8 (4408), area #9 (4409), area #12 (4412) and area #13 (4413). Hence, the transmitting apparatus in FIG. 1 transmits as data symbol group #1 the control information indicating that

"area #0 (4400), area #1 (4401), area #4 (4404), area #5 (4405), area #8 (4408), area #9 (4409), area #12 (4412) and area #13 (4413) are used."

In this case, the control information includes information of the areas (area #0 (4400), area #1 (4401), area #4 (4404), area #5 (4405), area #8 (4408), area #9 (4409), area #12 (4412) and area #13 (4413)).

[0756]

Similarly, the transmitting apparatus in FIG. 1 transmits as data symbol group #2 in FIG. 44 the control information indicating that

"area #2 (4402) is used."

In this case, the control information includes information of the area (area #2 (4402)).

[0757]

The transmitting apparatus in FIG. 1 transmits as data symbol group #3 in FIG. 44 the control information indicating that

"area #3 (4403), area #7 (4407), area #11 (4411) and area #15 (4415) are used."

In this case, the control information includes information of the areas (area #3 (4403), area #7 (4407), area #11 (4411) and area #15 (4415)).

[0758]

The transmitting apparatus in FIG. 1 transmits as data symbol group #4 in FIG. 44 the control information indicating that

"area #6 (4406) and area #10 (4410) are used."

In this case, the control information includes information of the areas (area #6 (4406) and area #10 (4410)).

[0759]

The transmitting apparatus in FIG. 1 transmits as data symbol group #5 in FIG. 44 the control information indicating that

"area #14 (4414) is used."

In this case, the control information includes information of the area (area #14 (4414)).

[0760]

As described above, in <second example> and <third example> there is an advantage that it is possible to transmit a small number of bits of information of time and frequency resources being used.

[0761]

Meanwhile, in <first example> there is an advantage that it is possible to more flexibly allocate time and frequency resources to a data symbol group.

[0762]

<Case where time (temporal) division is performed>

An example of generation of control information related to frequency resources and time resources to be used by each data symbol group in a case where time (temporal) division is performed will be described.

[0763]

<Fourth Example>

Even in a case where time (temporal) division is performed, control information is transmitted in the same way as a case where frequency division is performed. Hence, the above-described <first example> is carried out.

[0764]

<Fifth Example>

Even in a case where time (temporal) division is performed, control information is transmitted in the same way as a case where frequency division is performed. Hence, the above-described <second example> is carried out.

[0765]

<Sixth Example>

Even in a case where time (temporal) division is performed, control information is transmitted in the same way as a case where frequency division is performed. Hence, the above-described <third example> is carried out.

[0766]

<Seventh Example>

e(X, Y) described in the second exemplary embodiment is transmitted as control information. That is, information related to a number of symbols in a frame of data symbol group #j is e(j, 0) and e(j, 1).

[0767]

In this case, for example,

when a number of symbols in a frame of data symbol group #(j = K) is of 256 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 0 and transmits e(K, 0) and e(K, 1).

[0768]

When the number of symbols in the frame of data symbol group #(j = K) is of 512 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 0 and transmits e(K, 0) and e(K, 1).

[0769]

When the number of symbols in the frame of data symbol group #(j = K) is of 1024 symbols, the transmitting apparatus sets e(K, 0) = 0 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0770]

When the number of symbols in the frame of data symbol group #(j = K) is of 2048 symbols, the transmitting apparatus sets e(K, 0) = 1 and e(K, 1) = 1 and transmits e(K, 0) and e(K, 1).

[0771]

Note that the setting of the number of symbols is not limited to the four settings, and the transmitting apparatus only needs to be able to set one or more types of the number of symbols.

[0772]

<Eighth Example>

The transmitting apparatus transmits information of a number of pieces of time to be necessary for each data symbol, to the receiving apparatus, and the receiving apparatus obtains this information and thus can learn frequency and time resources to be used by each data symbol.

[0773]

For example, information related to a number of pieces of time to be used in a frame of data symbol group #j is q(j, 0), q(j, 1), q(j, 2) and q(j, 3).

[0774]

When a number of pieces of time to be used by data symbol group #(j = K) is 1, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 0, q(K, 2) = 0 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0775]

When the number of pieces of time to be used by data symbol group #(j = K) is 2, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 0, q(K, 2) = 0 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0776]

When the number of pieces of time to be used by data symbol group #(j =

K) is 3, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 1, q(K, 2) = 0 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0777]

When the number of pieces of time to be used by data symbol group #(j = K) is 4, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 1, q(K, 2) = 0 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0778]

When the number of pieces of time to be used by data symbol group #(j = K) is 5, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 0, q(K, 2) = 1 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0779]

When the number of pieces of time to be used by data symbol group #(j = K) is 6, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 0, q(K, 2) = 1 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0780]

When the number of pieces of time to be used by data symbol group #(j = K) is 7, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 1, q(K, 2) = 1 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0781]

When the number of pieces of time to be used by data symbol group #(j = K) is 8, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 1, q(K, 2) = 1 and q(K, 3) = 0, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0782]

When the number of pieces of time to be used by data symbol group #(j = K) is 9, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 0, q(K, 2) = 0 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0783]

When the number of pieces of time to be used by data symbol group #(j = K) is 10, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 0, q(K, 2) = 0 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0784]

When the number of pieces of time to be used by data symbol group #(j = K) is 11, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 1, q(K, 2) = 0 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0785]

When the number of pieces of time to be used by data symbol group #(j = K) is 12, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 1, q(K, 2) = 0 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0786]

When the number of pieces of time to be used by data symbol group #(j = K) is 13, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 0, q(K, 2) = 1 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0787]

When the number of pieces of time to be used by data symbol group #(j = K) is 14, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 0, q(K, 2) = 1 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0788]

When the number of pieces of time to be used by data symbol group #(j = K) is 15, the transmitting apparatus sets q(K, 0) = 0, q(K, 1) = 1, q(K, 2) = 1 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0789]

When the number of pieces of time to be used by data symbol group #(j = K) is 16, the transmitting apparatus sets q(K, 0) = 1, q(K, 1) = 1, q(K, 2) = 1 and q(K, 3) = 1, and transmits q(K, 0), q(K, 1), q(K, 2) and q(K, 3).

[0790]

FIG. 46 illustrates an example where a data symbol group is subjected to time (temporal) division in a frame of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. In FIG. 46, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fourth exemplary embodiment, a data symbol group may be of symbols of any method of an SISO method (SIMO method), an MIMO method and an MISO method.

[0791]

In FIG. 46, symbol 4301 is of data symbol group #1, and data symbol group #1 (4301) is transmitted by using carrier 1 to carrier 16 and by using time 1 to time 4. Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for transmitting control information, such carriers are excluded. However, a first index of a carrier is assumed to be "carrier 1" but is not limited to "carrier 1," and also a first index of time is assumed to be "time 1" but is not limited to "time 1".

[0792]

FIG. 46 illustrates symbol 4302, of data symbol group #2, and data symbol group #2 (4302) is transmitted by using carrier 1 to carrier 16 and by using time 5 to time 12. Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for transmitting control information, such carriers are excluded.

[0793]

FIG. 46 illustrates symbol 4303 of data symbol group #3, and data symbol group #3 (4303) is transmitted by using carrier 1 to carrier 16 and by using time 13 to time 16. Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for

transmitting control information, such carriers are excluded.

[0794]

For example, data symbol group #2 is transmitted by using time 5 to time 12, that is, a number of pieces of time is 8. Hence, the transmitting apparatus sets q(2, 0) = 1, q(2, 1) = 1, q(2, 2) = 1, and q(2, 3) = 0, and transmits q(2, 0), q(2, 1), q(2, 2) and q(2, 3).

[0795]

Control information may also be generated for data symbol group #1 and data symbol #3 in the same way, and the transmitting apparatus in FIG. 1 transmits q(1, 0), q(1, 1), q(1, 2) and q(1, 3), and q(2, 0), q(2, 1), q(2, 2) and q(2, 3), and q(3, 0), q(3, 1), q(3, 2) and q(3, 3).

[0796]

The receiving apparatus in FIG. 23 receives q(1, 0), q(1, 1), q(1, 2) and q(1, 3), and q(2, 0), q(2, 1), q(2, 2) and q(2, 3), and q(3, 0), q(3, 1), q(3, 2) and q(3, 3), and learns frequency and time resources being used by data symbol groups. In this case, when it is assumed that the transmitting apparatus and the receiving apparatus share arrangement, for example, such that "data symbol group #1 is temporarily arranged first, and subsequently, data symbol group #2, data symbol group #3, data symbol group #4, data symbol group #5, ..." are arranged, the transmitting apparatus and the receiving apparatus can learn frequency and time resources being used by each data symbol group from learning a number of pieces of time to be used by each data symbol group. It becomes unnecessary for the transmitting apparatus to transmit information of the first time at which each data symbol group is arranged. Consequently, data transmission efficiency improves.

[0797]

<Ninth Example>

Unlike <eighth example>, each data symbol group has, for example, a

number of pieces of time of 4 × B (B is a natural number equal to or more than 1), that is, the number of pieces of time to be used by each data symbol group being a multiple of 4 (but, except 0 (zero)). However, the number of pieces of time to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of D (D is an integer equal to or more than 2) except 0 (zero).

[0798]

FIG. 46 illustrates symbol 4301 of data symbol group #1, and data symbol group #1 (4301) is transmitted by using carrier 1 to carrier 16 and by using time 1 to time 4 (the number of pieces of time is 4, a multiple of 4). Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for transmitting control information, such carriers are excluded. However, a first index of a carrier is assumed to be "carrier 1" but is not limited to "carrier 1," and also a first index of time is assumed to be "time 1" but is not limited to "time 1".

[0799]

FIG. 46 illustrates symbol 4302 of data symbol group #2, and data symbol group #2 (4302) is transmitted by using carrier 1 to carrier 16 and by using time 5 to time 12 (the number of pieces of time is 8, a multiple of 4). Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for transmitting control information, such carriers are excluded.

[0800]

FIG. 46 illustrates symbol 4303 of data symbol group #3, and data symbol group #3 (4303) is transmitted by using carrier 1 to carrier 16 and by using time 13 to time 16 (the number of pieces of time is 8, a multiple of 4). Thus, all carriers which can be allocated as data symbols are used. Note that when there are carriers for arranging a pilot symbol and carriers for transmitting control information,

such carriers are excluded.

[0801]

When each data symbol group is allocated to a frame according to such rules, it is possible to reduce

• a number of bits of the above-described "information related to the number of pieces of time to be used in the frame of data symbol group #j," and

it is possible to improve data (information) transmission efficiency.

[0802]

In this case, it is possible to define the control information as follows.

[0803]

The information related to the number of pieces of time to be used in the frame of data symbol group #j is q(j, 0) and q(j, 1).

[0804]

When a number of pieces of time to be used by data symbol group #(j = K) is 4, the transmitting apparatus sets q(K, 0) = 0 and q(K, 1) = 0, and transmits q(K, 0) and q(K, 1).

[0805]

When the number of pieces of time to be used by data symbol group #(j = K) is 8, the transmitting apparatus sets q(K, 0) = 1 and q(K, 1) = 0, and transmits q(K, 0) and q(K, 1).

[0806]

When the number of pieces of time to be used by data symbol group #(j = K) is 12, the transmitting apparatus sets q(K, 0) = 0 and q(K, 1) = 1, and transmits q(K, 0) and q(K, 1).

[0807]

When the number of pieces of time to be used by data symbol group #(j = K) is 16, the transmitting apparatus sets q(K, 0) = 1 and q(K, 1) = 1, and transmits

q(K, 0) and q(K, 1).

[0808]

For example, data symbol group #2 in FIG. 46 is transmitted by using time 5 to time 12, that is, the number of pieces of time is 8. Hence, the transmitting apparatus sets q(2, 0) = 1 and q(2, 1) = 0, and transmits q(2, 0) and q(2, 1).

[0809]

Control information may also be generated for data symbol group #1 and data symbol #3 in the same way, and the transmitting apparatus in FIG. 1 transmits q(1, 0) and q(1, 1), and q(2, 0) and q(2, 1), and q(3, 0) and q(3, 1).

[0810]

The receiving apparatus in FIG. 23 receives q(1, 0) and q(1, 1), and q(2, 0) and q(2, 1), and q(3, 0) and q(3, 1), and learns frequency and time resources being used by data symbol groups. In this case, when it is assumed that the transmitting apparatus and the receiving apparatus share arrangement, for example, such that "data symbol group #1 is temporarily arranged first, and subsequently, data symbol group #2, data symbol group #3, data symbol group #4, data symbol group #5, ..." are arranged, the transmitting apparatus and the receiving apparatus can learn frequency and time resources being used by each data symbol group from learning the number of pieces of time to be used by each data symbol group. It becomes unnecessary for the transmitting apparatus to transmit information of the first time at which each data symbol group is arranged. Consequently, data transmission efficiency improves.

[0811]

<Tenth Example>

Unlike <eighth example>, each data symbol group has, for example, a number of pieces of time of 4 × B (B is a natural number equal to or more than 1), that is, the number of pieces of time to be used by each data symbol group being a

multiple of 4 (but, except 0 (zero)). Thus, the same as in <ninth example> applies. However, the number of pieces of time to be used by each data symbol group is not limited to a multiple of 4, and may be a multiple of D (D is an integer equal to or more than 2) except 0 (zero).

[0812]

Hence, area decomposition is performed as illustrated in FIG. 47. In FIG. 47, a vertical axis indicates a frequency, and a horizontal axis indicates time. Then, there are carrier 1 to carrier 16, and there are time 1 to time 16 in accordance with FIG. 46. Note that in FIG. 47, each area is configured with an area of 16 × 4 = 64 symbols of 16 carriers in a carrier direction, and 4 pieces of time in a time direction. In a case of generalization using C and D as described above, each area is configured with an area of C × D symbols of C carriers in the carrier direction and D pieces of time in the time direction.

[0813]

In FIG. 47, area 4700 configured with time 1 to time 4 is referred to as area #0.

[0814]

Area 4701 configured with time 5 to time 8 is referred to as area #1.

[0815]

Area 4702 configured with time 9 to time 12 is referred to as area #2.

[0816]

Area 4703 configured with time 13 to time 16 is referred to as area #3.

[0817]

In this case, the transmitting apparatus in FIG. 1 transmits control information as in an example described below, in order to transmit information of frequency and time resources being used by each data symbol group to the receiving apparatus.

[0818]

When data symbol group #1 in FIG. 46 is subjected to the area decomposition as in FIG. 47, data (information) is transmitted by using area #0 (4700). Hence, the transmitting apparatus in FIG. 1 transmits as data symbol group #1 the control information indicating that

"area #0 (4700) is used."

In this case, the control information includes information of the area (area #0 (4700)).

[0819]

Similarly, the transmitting apparatus in FIG. 1 transmits as data symbol group #2 in FIG. 46 the control information indicating that

"area #1 (4701) and area #2 (4702) are used."

In this case, the control information includes information of the areas (area #1 (4701) and area #2 (4702)).

[0820]

The transmitting apparatus in FIG. 1 transmits as data symbol group #3 in FIG. 46 the control information indicating that

"area #3 (4703) is used."

In this case, the control information includes information of the area (area #3 (4703)).

[0821]

The control information during time (temporal) division is described in <fourth example> to <tenth example>. For example, when <fourth example>, <fifth example> and <sixth example> are used, the control information of frequency division and the control information during time (temporal) division can be configured in the same way.

[0822]

Meanwhile, in a case of <seventh example> to <tenth example>, the transmitting apparatus transmits "control information related to use of time and frequency resources during frequency division, and control information related to use of time and frequency resources during time (temporal) division" having different configurations, by using the first preamble and/or the second preamble.

[0823]

Note that for example, in a case of the frame configuration in FIG. 5, first preamble 201 and/or second preamble 202 include control information related to use of time and frequency resources during frequency division, and a configuration may be made such that first preamble 501 and/or second preamble 502 include control information related to use of time and frequency resources during time (temporal) division.

[0824]

Similarly, in a case of the frame configuration in FIGS. 25, 28 and 32, first preamble 201 and/or second preamble 202 include control information related to use of time and frequency resources during frequency division, and a configuration may be made such that first preamble 501 and/or second preamble 502 include control information related to use of time and frequency resources during time (temporal) division.

[0825]

Moreover, in a case of the frame configuration in FIG. 36, first preambles 201 and 501 and/or second preambles 202 and 502 include control information related to use of time and frequency resources during frequency division, and a configuration may be made such that first preamble 3601 and/or second preamble 3602 include control information related to use of time and frequency resources during time (temporal) division.

[0826]

As described above, in <fifth example> <sixth example>, <ninth example> and <tenth example>, there is an advantage that it is possible to transmit a small number of bits of information of time and frequency resources being used.

[0827]

Meanwhile, in <fourth example>, <seventh example> and <eighth example>, there is an advantage that it is possible to more flexibly allocate time and frequency resources to a data symbol group.

[0828]

As in the examples described above, the transmitting apparatus transmits the control information related to use of the time and frequency resources during frequency division and the control information related to use of the time and frequency resources during time (temporal) division, and thus the receiving apparatus can learn a use status of the time and frequency resources of data symbol groups and can accurately demodulate and decode data.

[0829]

SIXTH EXEMPLARY EMBODIMENT

Some examples of a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 are described in the first exemplary embodiment to the fifth exemplary embodiment. A frame configuration different from the frame configurations described in the first exemplary embodiment to the fifth exemplary embodiment will be described in the present exemplary embodiment.

[0830]

FIG. 48 illustrates an example of a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1. Elements operating in the same way as in FIG. 5 are assigned the same reference numerals in FIG. 48. Moreover, in FIG. 48, a vertical axis indicates a frequency, and a

horizontal axis indicates time. Note that as with the first exemplary embodiment to the fifth exemplary embodiment, a data symbol group may be of symbols of any of an SISO method (SIMO method), an MIMO method and an MISO method.

[0831]

A difference of FIG. 48 from FIG. 5 is that first preamble 201 and second preamble 202 in FIG. 5 do not exist. Then, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol groups #1 (401_1 and 401_2) and data symbol group #2 (402) in a frequency direction. Note that the control information symbols include, for example, a symbol for frame synchronization, frequency synchronization and time synchronization, a symbol for notifying of frequency and time resources to be used by each data symbol group described in the fifth exemplary embodiment, information related to a modulating method for generating a data symbol group, and information related to an error correction method for generating a data symbol group, examples of which include information related to a code, information related to a code length, information related to a coding rate, and the like.

[0832]

FIG. 49 illustrates an example of a configuration in a case where the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol groups #1 (401_1 and 401_2) and data symbol group #2 (402) in a frequency direction.

[0833]

In FIG. 49, a vertical axis indicates a frequency, and a horizontal axis indicates time. FIG. 49 illustrates 4901, 4902 and 4903 which are data symbol groups #X. In FIG. 48, X is 1 or 2, and 4904 and 4905 are control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control).

[0834]

As illustrated in FIG. 49, control information symbols (4904 and 4905) are arranged on certain specific carriers (subcarriers or frequency). Note that these specific carriers may include or may not include symbols other than the control information symbols.

[0835]

For example, X = 1 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #1.

[0836]

Similarly, X = 2 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #2.

[0837]

Note that when there are, for example, carrier #1 to carrier #100 in a case where frequency division is performed as in FIG. 48 to arrange control information symbols in frequency and time areas in which a data symbol group is arranged, the control information symbols may be arranged on specific carriers such as carrier #5, carrier #25, carrier #40, carrier #55, carrier #70 and carrier #85, or the control information symbols may be arranged according to arrangement of data symbol groups.

[0838]

Next, an advantage in a case of the frame configuration in FIG. 48 will be described.

[0839]

In a case of the frame configuration in FIG. 5, the receiving apparatus needs to obtain first preamble 201 and second preamble 202, in order to

demodulate and decode data symbol group #1 and data symbol group #2 and to obtain information. For this reason, the receiving apparatus needs to obtain a modulated signal of a frequency band for receiving first preamble 201 and second preamble 202.

[0840]

In such a circumstance, when there is a terminal which needs only data symbol group #2, a frame configuration for enabling demodulation and decoding of data symbol group #2 only with a frequency band occupied by data symbol group #2 is desired in order to enable flexible terminal design, and in a case of the frame configuration in FIG. 48, it is possible to realize this frame configuration.

[0841]

When a frame is configured as in FIG. 48, control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are inserted to data symbol group #2 in the frequency direction as illustrated in FIG. 49. For this reason, the receiving apparatus can demodulate and decode data symbol group #2 by obtaining modulated signals of the frequency band of only data symbol group #2. Hence, flexible terminal design becomes possible.

[0842]

Next, a case where a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is a frame configuration in FIG. 50 will be described. Elements operating in the same way as in FIG. 25 are assigned the same reference numerals in FIG. 50. Moreover, in FIG. 50, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fifth exemplary embodiment, a data symbol group may be of symbols of any of an SISO method (SIMO method), an MIMO method and an MISO method.

[0843]

A difference of FIG. 50 from FIG. 25 is that first preamble 201 and second preamble 202 in FIG. 25 do not exist. Then, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (2501), data symbol group #2 (2502) and data symbol group #4 (2503) in a frequency direction. Note that the control information symbols include, for example, a symbol for frame synchronization, frequency synchronization and time synchronization, a symbol for notifying of frequency and time resources to be used by each data symbol group described in the fifth exemplary embodiment, information related to a modulating method for generating a data symbol group, and information related to an error correction method for generating a data symbol group, examples of which include information related to a code, information related to a code length, information related to a coding rate, and the like.

[0844]

FIG. 49 illustrates an example of a configuration in a case where the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (2501), data symbol group #2 (2502) and data symbol group #4 (2503) in a frequency direction.

[0845]

In FIG. 49, a vertical axis indicates a frequency, and a horizontal axis indicates time. FIG. 49 illustrates 4901, 4902 and 4903 which are data symbol groups #X. For example, in FIG. 50, X is 1, 2 or 4, and 4904 and 4905 are control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control).

[0846]

As illustrated in FIG. 49, control information symbols (4904 and 4905) are

arranged on certain specific carriers (subcarriers or frequency). Note that these specific carriers may include or may not include symbols other than the control information symbols.

[0847]

For example, X = 1 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #1.

[0848]

Similarly, X = 2 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #2.

[0849]

X = 4 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #4.

[0850]

Note that when there are, for example, carrier #1 to carrier #100 in a case where frequency division is performed as in FIG. 50 to arrange control information symbols in frequency and time areas in which a data symbol group is arranged, the control information symbols may be arranged on specific carriers such as carrier #5, carrier #25, carrier #40, carrier #55, carrier #70 and carrier #85, or the control information symbols may be arranged according to arrangement of data symbol groups.

[0851]

Next, an advantage in a case of the frame configuration in FIG. 50 will be described.

[0852]

In a case of the frame configuration in FIG. 25, the receiving apparatus needs to obtain first preamble 201 and second preamble 202, in order to demodulate and decode data symbol group #1, data symbol group #2 and data symbol group #4 and to obtain information. For this reason, the receiving apparatus needs to obtain a modulated signal of a frequency band for receiving first preamble 201 and second preamble 202.

[0853]

In such a circumstance, when there is a terminal which needs only data symbol group #2, a frame configuration for enabling demodulation and decoding of data symbol group #2 only with a frequency band occupied by data symbol group #2 is desired in order to enable flexible terminal design, and in a case of the frame configuration in FIG. 50, it is possible to realize this frame configuration.

[0854]

When a frame is configured as in FIG. 50, control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are inserted to data symbol group #2 in the frequency direction as illustrated in FIG. 49. For this reason, the receiving apparatus can demodulate and decode data symbol group #2 by obtaining modulated signals of the frequency band of only data symbol group #2. Hence, flexible terminal design becomes possible.

[0855]

Next, a case where a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is a frame configuration in FIG. 51 will be described. Elements operating in the same way as in FIG. 28 are assigned the same reference numerals in FIG. 51. Moreover, in FIG. 51, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fifth exemplary embodiment, a data symbol group may be of symbols of any of an SISO method (SIMO method), an

MIMO method and an MISO method.

[0856]

A difference of FIG. 51 from FIG. 28 is that first preamble 201 and second preamble 202 in FIG. 28 do not exist. Then, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (2701) and data symbol group #2 (2702) in a frequency direction. Note that the control information symbols include, for example, a symbol for frame synchronization, frequency synchronization and time synchronization, a symbol for notifying of frequency and time resources to be used by each data symbol group described in the fifth exemplary embodiment, information related to a modulating method for generating a data symbol group, and information related to an error correction method for generating a data symbol group, examples of which include information related to a code, information related to a code length, information related to a coding rate, and the like.

[0857]

FIG. 49 illustrates an example of a configuration in a case where the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (2701) and data symbol group #2 (2702) in a frequency direction.

[0858]

In FIG. 49, a vertical axis indicates a frequency, and a horizontal axis indicates time. FIG. 49 illustrates 4901, 4902 and 4903 which are data symbol groups #X. For example, in FIG. 51, X is 1 or 2, and 4904 and 4905 are control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control).

[0859]

As illustrated in FIG. 49, control information symbols (4904 and 4905) are

arranged on certain specific carriers (subcarriers or frequency). Note that these specific carriers may include or may not include symbols other than the control information symbols.

[0860]

For example, X = 1 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #1.

[0861]

Similarly, X = 2 holds in FIG. 49. Then, as illustrated in FIG. 49, the control information symbols are arranged on certain specific carriers (subcarriers or frequency) of data symbol group #2.

[0862]

Note that when there are, for example, carrier #1 to carrier #100 in a case where frequency division is performed as in FIG. 51 to arrange control information symbols in frequency and time areas in which a data symbol group is arranged, the control information symbols may be arranged on specific carriers such as carrier #5, carrier #25, carrier #40, carrier #55, carrier #70 and carrier #85, or the control information symbols may be arranged according to arrangement of data symbol groups.

[0863]

Next, an advantage in a case of the frame configuration in FIG. 51 will be described.

[0864]

In a case of the frame configuration in FIG. 28, the receiving apparatus needs to obtain first preamble 201 and second preamble 202, in order to demodulate and decode data symbol group #1 and data symbol group #2 and to obtain information. For this reason, the receiving apparatus needs to obtain a

modulated signal of a frequency band for receiving first preamble 201 and second preamble 202.

[0865]

In such a circumstance, when there is a terminal which needs only data symbol group #2, a frame configuration for enabling demodulation and decoding of data symbol group #2 only with a frequency band occupied by data symbol group #2 is desired in order to enable flexible terminal design, and in a case of the frame configuration in FIG. 51, it is possible to realize this frame configuration.

[0866]

When a frame is configured as in FIG. 51, control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are inserted to data symbol group #2 in the frequency direction as illustrated in FIG. 49. For this reason, the receiving apparatus can demodulate and decode data symbol group #2 by obtaining modulated signals of the frequency band of only data symbol group #2. Hence, flexible terminal design becomes possible.

[0867]

Next, a case where a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is a frame configuration in FIG. 52 will be described. Elements operating in the same way as in FIG. 32 are assigned the same reference numerals in FIG. 52. Moreover, in FIG. 52, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fifth exemplary embodiment, a data symbol group may be of symbols of any of an SISO method (SIMO method), an MIMO method and an MISO method.

[0868]

A difference of FIG. 52 from FIG. 32 is that first preamble 201 and second preamble 202 in FIG. 32 do not exist. Then, the control information symbols, an

example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (3001), data symbol group #2 (3002), data symbol group #3 (3003), data symbol group #4 (3004), data symbol group #5 (3005) and data symbol group #6 (3006) in a frequency direction. Note that the control information symbols include, for example, a symbol for frame synchronization, frequency synchronization and time synchronization, a symbol for notifying of frequency and time resources to be used by each data symbol group described in the fifth exemplary embodiment, information related to a modulating method for generating a data symbol group, and information related to an error correction method for generating a data symbol group, examples of which include information related to a code, information related to a code length, information related to a coding rate, and the like.

[0869]

However, the control information symbols are not necessarily arranged on all of data symbol group #1 (3001), data symbol group #2 (3002), data symbol group #3 (3003), data symbol group #4 (3004), data symbol group #5 (3005) and data symbol group #6 (3006) in the frequency direction. This point will be described with reference to FIG. 53.

[0870]

FIG. 53 illustrates an example of arrangement of control information symbols at time t1 to time t3 in FIG. 52. In a case of FIG. 52, data symbol groups 5301, 5302 and 5303 each include any of data symbol group #1 (3001), data symbol group #2 (3002), data symbol group #3 (3003), data symbol group #4 (3004), data symbol group #5 (3005) and data symbol group #6 (3006).

[0871]

FIG. 53 illustrates control information symbols 5304 and 5305, and the control information symbols, an example of which is TMCC (Transmission

Multiplexing Configuration Control), are arranged in a frequency direction. Control information symbol 5304 is arranged on a specific carrier as illustrated in FIG. 53. Moreover, control information symbol 5305 is arranged on a specific carrier (subcarrier or frequency) as illustrated in FIG. 53. Note that this specific carrier may include or may not include symbols other than the control information symbols.

[0872]

When there are, for example, carrier #1 to carrier #100 in a case where frequency division is performed as in FIG. 52 to arrange control information symbols in frequency and time areas in which a data symbol group is arranged, the control information symbols may be arranged on specific carriers such as carrier #5, carrier #25, carrier #40, carrier #55, carrier #70 and carrier #85, or the control information symbols may be arranged according to arrangement of data symbol groups.

[0873]

Next, an advantage in a case of the frame configuration in FIG. 52 will be described.

[0874]

In a case of the frame configuration in FIG. 32, the receiving apparatus needs to obtain first preamble 201 and second preamble 202, in order to demodulate and decode data symbol group #1 (3001), data symbol group #2 (3002), data symbol group #3 (3003), data symbol group #4 (3004), data symbol group #5 (3005) and data symbol group #6 (3006) and to obtain information. For this reason, the receiving apparatus needs to obtain a modulated signal of a frequency band for receiving first preamble 201 and second preamble 202.

[0875]

In such a circumstance, when there is a terminal which needs only data symbol group #2, a frame configuration for enabling demodulation and decoding of

data symbol group #2 only with a frequency band occupied by data symbol group #2 is desired in order to enable flexible terminal design, and in a case of the frame configuration in FIG. 52, it is possible to realize this frame configuration.

[0876]

When a frame is configured as in FIG. 52, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are inserted to a data symbol group in the frequency direction as illustrated in FIG. 53. For this reason, the receiving apparatus can demodulate and decode data symbol group #2 by obtaining modulated signals of the frequency bands around data symbol group #2. Hence, flexible terminal design becomes possible.

[0877]

Next, a case where a frame configuration of a modulated signal to be transmitted by the transmitting apparatus in FIG. 1 is a frame configuration in FIG. 54 will be described. Elements operating in the same way as in FIG. 36 are assigned the same reference numerals in FIG. 54. Moreover, in FIG. 54, a vertical axis indicates a frequency, and a horizontal axis indicates time. Note that as with the first exemplary embodiment to the fifth exemplary embodiment, a data symbol group may be of symbols of any of an SISO method (SIMO method), an MIMO method and an MISO method.

[0878]

A difference of FIG. 54 from FIG. 36 is that first preamble 201 and second preamble 202, and first preamble 501 and second preamble 502 in FIG. 36 do not exist. Then, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on data symbol group #1 (3401), data symbol group #2 (3402), data symbol group #3 (3403), data symbol group #4 (3404), data symbol group #5 (3405), data symbol group #6 (3406), data symbol group #7 (3407), data symbol group #8 (3408), data symbol

group #9 (3509), data symbol group #10 (3510), data symbol group #11 (3511), data symbol group #12 (3512), and data symbol group #13 (3513) in a frequency direction. Note that the control information symbols include, for example, a symbol for frame synchronization, frequency synchronization and time synchronization, a symbol for notifying of frequency and time resources to be used by each data symbol group described in the fifth exemplary embodiment, information related to a modulating method for generating a data symbol group, and information related to an error correction method for generating a data symbol group, examples of which include information related to a code, information related to a code length, information related to a coding rate, and the like.

[0879]

However, control information symbols are not necessarily arranged on all of data symbol group #1 (3401), data symbol group #2 (3402), data symbol group #3 (3403), data symbol group #4 (3404), data symbol group #5 (3405), data symbol group #6 (3406), data symbol group #7 (3407), data symbol group #8 (3408), data symbol group #9 (3509), data symbol group #10 (3510), data symbol group #11 (3511), data symbol group #12 (3512), and data symbol group #13 (3513) in the frequency direction. This point will be described with reference to FIG. 53.

[0880]

FIG. 53 illustrates an example of arrangement of control information symbols at time t1 to time t3 in FIG. 54. In a case of FIG. 54, data symbol groups 5301, 5302 and 5303 each include any of data symbol group #1 (3401), data symbol group #2 (3402), data symbol group #3 (3403), data symbol group #4 (3404), data symbol group #5 (3405), data symbol group #6 (3406), data symbol group #7 (3407), data symbol group #8 (3408), data symbol group #9 (3509), data symbol group #10 (3510), data symbol group #11 (3511), data symbol group #12 (3512), and data symbol group #13 (3513).

[0881]

FIG. 53 illustrates control information symbols 5304 and 5305, and the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged in a frequency direction. Control information symbol 5304 is arranged on a specific carrier as illustrated in FIG. 53. Moreover, control information symbol 5305 is arranged on a specific carrier (subcarrier or frequency) as illustrated in FIG. 53. Note that this specific carrier may include or may not include symbols other than the control information symbols.

[0882]

When there are, for example, carrier #1 to carrier #100 in a case where frequency division is performed as in FIG. 54 to arrange control information symbols in frequency and time areas in which a data symbol group is arranged, the control information symbols may be arranged on specific carriers such as carrier #5, carrier #25, carrier #40, carrier #55, carrier #70 and carrier #85, or the control information symbols may be arranged according to arrangement of data symbol groups.

[0883]

Next, an advantage in a case of the frame configuration in FIG. 54 will be described.

[0884]

In a case of the frame configuration in FIG. 36, the receiving apparatus needs to obtain first preamble 201, second preamble 202, first preamble 501 and second preamble 502, in order to demodulate and decode data symbol group #1 (3401), data symbol group #2 (3402), data symbol group #3 (3403), data symbol group #4 (3404), data symbol group #5 (3405), data symbol group #6 (3406), data symbol group #7 (3407), data symbol group #8 (3408), data symbol group #9 (3509), data symbol group #10 (3510), data symbol group #11 (3511), data symbol

group #12 (3512), and data symbol group #13 (3513) and to obtain information. For this reason, the receiving apparatus needs to obtain a modulated signal of a frequency band for receiving first preamble 201, second preamble 202, first preamble 501 and second preamble 502.

[0885]

In such a circumstance, when there is a terminal which needs only data symbol group #2, a frame configuration for enabling demodulation and decoding of data symbol group #2 only with a frequency band occupied by data symbol group #2 is desired in order to enable flexible terminal design, and in a case of the frame configuration in FIG. 54, it is possible to realize this frame configuration.

[0886]

When a frame is configured as in FIG. 54, the control information symbols, an example of which is TMCC (Transmission Multiplexing Configuration Control), are arranged on a data symbol group in the frequency direction as illustrated in FIG. 53. For this reason, the receiving apparatus can demodulate and decode data symbol group #2 by obtaining modulated signals of the frequency bands around data symbol group #2. Hence, flexible terminal design becomes possible.

[0887]

As in the above-described example, when a data symbol group is arranged by using frequency division, control information symbols are arranged in the frequency direction, and thus it is possible to obtain an effect of enabling flexible terminal design. Note that the control information symbols related to a data symbol group arranged by using time (temporal) division are contained in the first preamble and the second preamble as illustrated in FIG. 48, 50, 51, 52 and 54.

[0888]

Note that control information related to a data symbol group subjected to frequency division may be contained in the first preamble and the second preamble,

or control information related to a data symbol group subjected to time (temporal) division may be contained in control information symbols (4904, 4905, 5304 and 5305) illustrated in FIGS. 49 and 53.

[0889]

SEVENTH EXEMPLARY EMBODIMENT

The case where phase change is performed on a modulated signal is described in the first exemplary embodiment to the sixth exemplary embodiment, in particular, in the first exemplary embodiment. In the present exemplary embodiment, a method for performing phase change on a data symbol group subjected to frequency division will be described in particular.

[0890]

The first exemplary embodiment describes the phase change that is performed on all of baseband signals s1(t) and s1(i) and baseband signals s2(t) and s2(i) or either baseband signals s1(t) and s1(i) or baseband signals s2(t) and s2(i). As features of the present method, phase change is not performed on, for example, pilot symbols (examples of which include a reference symbol, a unique word and a postamble), a first preamble, a second preamble and control information symbols other than symbols for transmitting baseband signal s1(t) and baseband signal s2(t) in a transmission frame.

[0891]

Then, there are the following cases in a method for performing phase change on a data symbol group subjected to frequency division, which includes "performing phase change on all of baseband signals s1(t) and s1(i) and baseband signals s2(t) and s2(i) or either baseband signals s1(t) and s1(i) or baseband signals s2(t) and s2(i)."

[0892]

First Case:

A first case will be described with reference to FIG. 55. In FIG. 55, a vertical axis indicates time, and a horizontal axis indicates a frequency. Part (A) of FIG. 55 illustrates a frame configuration of modulated signals z1(t) and z1(i) in the first exemplary embodiment. Part (B) of FIG. 55 illustrates a frame configuration of modulated signals z2(t) and z2(i) in the first exemplary embodiment. Symbols of modulated signals z1(t) and z1(i) and symbols of modulated signals z2(t) and z2(i) of the same time and the same frequency (the same carrier number) are transmitted from different antennas.

[0893]

In FIG. 55, symbols described as "P" are pilot symbols, and as described above, phase change is not performed on the pilot symbols. In (A) and (B) of FIG. 55, symbols other than the symbols described as "P" are symbols for transmitting data, namely data symbols. Note that in (A) and (B) of FIG. 55, a frame is configured with the data symbols and the pilot symbols, but this configuration is only an example, and as described above, symbols such as control information symbols may be contained. In this case, phase change is not performed on the control information symbols, for example.

[0894]

Part (A) of FIG. 55 illustrates area 5501 on which data symbols belonging to data symbol group #1 are arranged, and area 5502 on which data symbols belonging to data symbol group #2 are arranged. Then, (B) of FIG. 55 illustrates area 5503 on which data symbols belonging to data symbol group #1 are arranged, and area 5504 on which data symbols belonging to data symbol group #2 are arranged. As a result, in the examples in FIG. 55, the data symbol groups are subjected to frequency division and are arranged.

[0895]

In the data symbol groups in FIG. 55, there are 7 cycles of phase change,

and any phase change of 7 types of "phase change $0, phase change $1, phase change $2, phase change $3, phase change $4, phase change $5 and phase change $6" is performed.

[0896]

In symbols of data symbol group #1 in area 5501 in (A) of FIG. 55, there is, for example, a symbol described as "#0 $0." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$0" means performing phase change of "phase change $0."

[0897]

Moreover, there is a symbol described as "#1 $1." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$1" means performing phase change of "phase change $1."

[0898]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0899]

In symbols of data symbol group #2 in area 5502 in (A) of FIG. 55, there is, for example, a symbol described as "%0 $0." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "$0" means performing phase change of "phase change $0."

[0900]

Moreover, there is a symbol described as "%1 $1." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "$1" means performing phase change of "phase change $1."

[0901]

Hence, there are symbols described as "%X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "$Y" means performing phase change of "phase change $Y."

[0902]

In symbols of data symbol group #1 in area 5503 in (B) of FIG. 55, there is, for example, a symbol described as "#0 $0." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$0" means performing phase change of "phase change $0."

[0903]

Moreover, there is a symbol described as "#1 $1." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$1" means performing phase change of "phase change $1."

[0904]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0905]

In symbols of data symbol group #2 in area 5504 in (B) of FIG. 55, there is, for example, a symbol described as "%0 $0." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "$0" means performing phase change of "phase change $0."

[0906]

Moreover, there is a symbol described as "%1 $1." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "$1" means performing phase change of "phase change $1."

[0907]

Hence, there are symbols described as "%X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "$Y" means performing phase change of "phase change $Y."

[0908]

In this case, 7 cycles of phase change are performed in a data symbol of modulated signal z1. For example, "phase change of (2 × 0 × π)/14 radians is performed as phase change $0," "phase change of (2 × 1 × π)/14 radians is performed as phase change $1," "phase change of (2 × 2 × π)/14 radians is performed as phase change $2," "phase change of (2 × 3 × π)/14 radians is performed as phase change $3," "phase change of (2 × 4 × π)/14 radians is performed as phase change $4," "phase change of (2 × 5 × π)/14 radians is performed as phase change $5," and "phase change of (2 × 6 × π)/14 radians is performed as phase change $6" (however, a phase change value is not limited to these values).

[0909]

Then, 7 cycles of phase change are performed in a data symbol of modulated signal z2. For example, "phase change of –(2 × 0 × π)/14 radians is performed as phase change $0," "phase change of –(2 × 1 × π)/14 radians is performed as phase change $1," "phase change of –(2 × 2 × π)/14 radians is performed as phase change $2," "phase change of –(2 × 3 × π)/14 radians is performed as phase change $3," "phase change of –(2 × 4 × π)/14 radians is performed as phase change $4," "phase change of –(2 × 5 × π)/14 radians is performed as phase change $5," and "phase change of –(2 × 6 × π)/14 radians is performed as phase change $6" (however, a phase change value is not limited to these values).

[0910]

Note that as described above, phase change may be performed on modulated signal z1, and may not be performed on modulated signal z2. Moreover, phase change may not be performed on modulated signal z1, and phase change may be performed on modulated signal z2.

[0911]

Features of the first case are such that "7 cycles of phase change are performed in data symbol group #1 together with data symbol group #2." That is, 7 cycles of phase change are performed in data symbols of an entire frame, regardless of a belonging data symbol group.

[0912]

Second Case:

A second case will be described with reference to FIG. 56. In FIG. 56, a vertical axis indicates time, and a horizontal axis indicates a frequency. Part (B) of FIG. 56 illustrates a frame configuration of modulated signals z1(t) and z1(i) in the first exemplary embodiment. Part (B) of FIG. 56 illustrates a frame configuration of modulated signals z2(t) and z2(i) in the first exemplary embodiment. Symbols of modulated signals z1(t) and z1(i) and symbols of modulated signals z2(t) and z2(i) of the same time and the same frequency, namely the same carrier number are transmitted from different antennas.

[0913]

In FIG. 56, symbols described as "P" are pilot symbols, and as described above, phase change is not performed on the pilot symbols. In (A) and (B) of FIG. 56, symbols other than the symbols described as "P" are symbols for transmitting data, namely data symbols. Note that in (A) and (B) of FIG. 56, a frame is configured with the data symbols and the pilot symbols, but this configuration is only an example, and as disclosed above, symbols such as control information

symbols may be contained. In this case, phase change is not performed on the control information symbols, for example.

[0914]

Part (A) of FIG. 56 illustrates area 5501 on which data symbols belonging to data symbol group #1 are arranged, and area 5502 on which data symbols belonging to data symbol group #2 are arranged. Then, (B) of FIG. 56 illustrates area 5503 on which data symbols belonging to data symbol group #1 are arranged, and area 5504 on which data symbols belonging to data symbol group #2 are arranged. As a result, in the example in FIG. 56, the data symbol groups are subjected to frequency division and are arranged.

[0915]

In data symbol group #1 in FIG. 56, there are 7 cycles of phase change, and any phase change of 7 types of "phase change $0, phase change $1, phase change $2, phase change $3, phase change $4, phase change $5 and phase change $6" is performed. Then, in data symbol group #2 in FIG. 56, there are 5 cycles of phase change, and any phase change of 5 types of "phase change ♭0, phase change ♭1, phase change ♭2, phase change ♭3 and phase change ♭4" is performed.

[0916]

In symbols of data symbol group #1 in area 5501 in (A) of FIG. 56, there is, for example, a symbol described as "#0 $0." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$0" means performing phase change of "phase change $0."

[0917]

Moreover, there is a symbol described as "#1 $1." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$1" means performing phase change of "phase change $1."

[0918]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0919]

In symbols of data symbol group #2 in area 5502 in (A) of FIG. 56, there is, for example, a symbol described as "%0 ♭0." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "♭0" means performing phase change of "phase change ♭0."

[0920]

Moreover, there is a symbol described as "%1 ♭1." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "♭1" means performing phase change of "phase change ♭1."

[0921]

Hence, there are symbols described as "%X ♭Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 4). In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "♭Y" means performing phase change of "phase change ♭Y."

[0922]

In symbols of data symbol group #1 in area 5503 in (B) of FIG. 56, there is, for example, a symbol described as "#0 $0." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$0" means performing phase change of "phase change $0."

[0923]

Moreover, there is a symbol described as "#1 $1." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$1" means performing

phase change of "phase change $1."

[0924]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0925]

In symbols of data symbol group #2 in area 5504 in (B) of FIG. 56, there is, for example, a symbol described as "%0 ♭0." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "♭0" means performing phase change of "phase change ♭0."

[0926]

Moreover, there is a symbol described as "%1 ♭1." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "♭1" means performing phase change of "phase change ♭1."

[0927]

Hence, there are symbols described as "%X ♭Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 4). In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "♭Y" means performing phase change of "phase change ♭Y."

[0928]

In this case, 7 cycles of phase change are performed in data symbol group #1 of modulated signal z1. For example, "phase change of (2 × 0 × π)/14 radians is performed as phase change $0," "phase change of (2 × 1 × π)/14 radians is performed as phase change $1," "phase change of (2 × 2 × π)/14 radians is performed as phase change $2," "phase change of (2 × 3 × π)/14 radians is performed as phase change $3," "phase change of (2 × 4 × π)/14 radians is

performed as phase change $4," "phase change of (2 × 5 × π)/14 radians is performed as phase change $5," and "phase change of (2 × 6 × π)/14 radians is performed as phase change $6" (however, a phase change value is not limited to these values).

[0929]

Then, 7 cycles of phase change are performed in data symbol group #1 of modulated signal z2. For example, "phase change of –(2 × 0 × π)/14 radians is performed as phase change $0," "phase change of –(2 × 1 × π)/14 radians is performed as phase change $1," "phase change of –(2 × 2 × π)/14 radians is performed as phase change $2," "phase change of –(2 × 3 × π)/14 radians is performed as phase change $3," "phase change of –(2 × 4 × π)/14 radians is performed as phase change $4," "phase change of –(2 × 5 × π)/14 radians is performed as phase change $5," and "phase change of –(2 × 6 × π)/14 radians is performed as phase change $6". However, a phase change value is not limited to these values.

[0930]

Note that as described above, phase change may be performed in data symbol group #1 of modulated signal z1, and may not be performed in data symbol group #1 of modulated signal z2. Moreover, phase change may not be performed in data symbol group #1 of modulated signal z1, and phase change may be performed in data symbol group #1 of modulated signal z2.

[0931]

Then, 5 cycles of phase change are performed in data symbol group #2 of modulated signal z1. For example, "phase change of (2 × 0 × π)/10 radians is performed as phase change ♭0," "phase change of (2 × 1 × π)/10 radians is performed as phase change ♭1," "phase change of (2 × 2 × π)/10 radians is performed as phase change ♭2," "phase change of (2 × 3 × π)/10 radians is

performed as phase change ♭3," and "phase change of (2 × 4 × π)/10 radians is performed as phase change ♭4". However, a phase change value is not limited to these values.

[0932]

Then, 5 cycles of phase change are performed in data symbol group #2 of modulated signal z2. For example, "phase change of −(2 × 0 × π)/10 radians is performed as phase change ♭0," "phase change of −(2 × 1 × π)/10 radians is performed as phase change ♭1," "phase change of −(2 × 2 × π)/10 radians is performed as phase change ♭2," "phase change of −(2 × 3 × π)/10 radians is performed as phase change ♭3," and "phase change of −(2 × 4 × π)/10 radians is performed as phase change ♭4". However, a phase change value is not limited to these values.

[0933]

Note that as described above, phase change may be performed in data symbol group #2 of modulated signal z1, and may not be performed in data symbol group #2 of modulated signal z2. Moreover, phase change may not be performed in data symbol group #2 of modulated signal z1, and phase change may be performed in data symbol group #2 of modulated signal z2.

[0934]

Features of the second case are such that "7 cycles of phase change are performed in data symbol group #1, and also 5 cycles of phase change are performed in data symbol group #2." That is, unique phase change is performed in each data symbol group. However, the same phase change may be performed in different data symbols.

[0935]

Third Case:

FIG. 57 illustrates a relationship between a transmission station and a

terminal in a case of a third case. Terminal #3 (5703) can receive modulated signal #1 to be transmitted by transmission station #1 (5701), and modulated signal #2 to be transmitted by transmission station #2 (5702). For example, in frequency band A, the same data is transmitted in modulated signal #1 and modulated signal #2. That is, when a baseband signal mapped on a data sequence by a certain modulating method is s1(t, f), transmission station #1 and transmission station #2 both transmit modulated signals based on s1(t, f). Note that t represents time and f represents a frequency.

[0936]

Hence, terminal #3 (5703) receives both of the modulated signal transmitted by transmission station #1 and the modulated signal transmitted by transmission station #2 in frequency band A, and demodulates and decodes data.

[0937]

FIG. 58 is an example of a configuration of transmission station #1 and transmission station #2. A case where transmission station #1 and transmission station #2 both transmit modulated signals based on s1(t, f) as in frequency band A as described above will be discussed.

[0938]

Error correction encoder 5802 receives an input of information 5801 and signal 5813 related to a transmitting method. Error correction encoder 5802 performs error correction coding based on information related to an error correction coding method and contained in signal 5813 related to the transmitting method. Error correction encoder 5802 outputs data 5803.

[0939]

Mapper 5804 receives an input of data 5803 and signal 5813 related to the transmitting method. Mapper 5804 performs mapping based on information related to the modulating method and contained in signal 5813 related to the

transmitting method. Mapper 5804 outputs baseband signal s1(t, f) 5805. Note that data interleaving, that is, data order rearrangement may be performed between error correction encoder 5802 and mapper 5804.

[0940]

Control information symbol generator 5807 receives an input of control information 5806, and information 5813 related to the transmitting method. Control information symbol generator 5807 generates a control information symbol based on information related to the transmitting method and contained in signal 5813 related to the transmitting method. Control information symbol generator 5807 outputs baseband signal 5808 of the control information symbol.

[0941]

Pilot symbol generator 5809 receives an input of signal 5813 related to the transmitting method. Pilot symbol generator 5809 generates a pilot symbol based on signal 5813. Pilot symbol generator 5809 outputs baseband signal 5810 of a pilot symbol.

[0942]

Transmitting method instructing unit 5812 receives an input of transmitting method instruction information 5811. Transmitting method instructing unit 5812 generates and outputs signal 5813 related to the transmitting method.

[0943]

Phase changer 5814 receives an input of baseband signal s1(t, f) 5805, baseband signal 5808 of the control information symbol, baseband signal 5810 of the pilot symbol, and signal 5813 related to the transmitting method. Phase changer 5814 performs phase change based on information of a frame configuration contained in signal 5813 related to the transmitting method, and based on information related to phase change. Phase changer 5814 outputs baseband signal 5815 based on a frame configuration. Note that details will be

described below with reference to FIGS. 59 and 60.

[0944]

Radio unit 5816 receives an input of baseband signal 5815 based on the frame configuration, and signal 5813 related to the transmitting method. Radio unit 5816 performs processing such as interleaving, inverse Fourier transform and frequency conversion based on signal 5813 related to the transmitting method. Radio unit 5816 generates and outputs transmission signal 5817. Transmission signal 5817 is output as a radio wave from antenna 5818.

[0945]

FIG. 59 illustrates an example of a frame configuration of a modulated signal (transmission signal) to be transmitted by the transmission station in FIG. 58. In FIG. 59, a vertical axis indicates time, and a horizontal axis indicates a frequency. In FIG. 59, symbols described as "P" are pilot symbols, and as features of the third case, phase change is performed on the pilot symbols. Moreover, symbols described as "C" are control information symbols, and as features of the third case, phase change is performed on the control information symbols. Note that FIG. 59 is an example in a case where control information symbols are arranged in a time axis direction.

[0946]

In a frame in FIG. 59, there are 7 cycles of phase change, and any phase change of 7 types of "phase change $0, phase change $1, phase change $2, phase change $3, phase change $4, phase change $5 and phase change $6" is performed.

[0947]

In symbols of data symbol group #1 in area 5901 in FIG. 59, there is, for example, a symbol described as "#0 $1." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$1" means performing phase change of "phase

change $1."

[0948]

Moreover, there is a symbol described as "#1 $2." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$2" means performing phase change of "phase change $2."

[0949]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0950]

In symbols of data symbol group #2 in area 5902 in FIG. 59, there is, for example, a symbol described as "%0 $3." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "$3" means performing phase change of "phase change $3."

[0951]

Moreover, there is a symbol described as "%1 $4." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "$4" means performing phase change of "phase change $4."

[0952]

Hence, there are symbols described as "%X $Y". X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6. In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "$Y" means performing phase change of "phase change $Y."

[0953]

Moreover, in FIG. 59, there is a symbol described as "C $0." In this case, "C" means a control information symbol, and "$0" means performing phase change

of "phase change $0."

[0954]

Hence, there are symbols described as "C $Y". Y is an integer equal to or more than 0 and equal to or less than 6. In this case, "C" means a control information symbol, and "$Y" means performing phase change of "phase change $Y."

[0955]

Moreover, in FIG. 59, there are symbols described as "P $0," for example. In this case, "P" means a pilot symbol, and "$0" means performing phase change of "phase change $0."

[0956]

Hence, there are symbols described as "P $Y" (Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "P" means a pilot symbol, and "$Y" means performing phase change of "phase change $Y."

[0957]

In this case, 7 cycles of phase change are performed in a data symbol of a modulated signal. For example, "phase change of $(2 \times 0 \times \pi)/7$ radians is performed as phase change $0," "phase change of $(2 \times 1 \times \pi)/7$ radians is performed as phase change $1," "phase change of $(2 \times 2 \times \pi)/7$ radians is performed as phase change $2," "phase change of $(2 \times 3 \times \pi)/7$ radians is performed as phase change $3," "phase change of $(2 \times 4 \times \pi)/7$ radians is performed as phase change $4," "phase change of $(2 \times 5 \times \pi)/7$ radians is performed as phase change $5," and "phase change of $(2 \times 6 \times \pi)/7$ radians is performed as phase change $6". However, a phase change value is not limited to these values.

[0958]

Note that in modulated signal #1 to be transmitted by transmission station

#1 (5701) and modulated signal #2 to be transmitted by transmission station #2 (5702) in FIG. 57, phase change may be performed on both of modulated signal #1 and modulated signal #2. However, different types of phase change may be performed on modulated signal #1 and modulated signal #2. Note that phase change values may be different, and a cycle of the phase change of modulated signal #1 and a cycle of the phase change of modulated signal #2 may be different. Moreover, phase change may be performed on modulated signal #1, and may not be performed on modulated signal #2. Then, phase change may not be performed on modulated signal #1, and phase change may be performed on modulated signal #2.

[0959]

FIG. 60 illustrates an example of a frame configuration of a modulated signal (transmission signal) to be transmitted by the transmission station in FIG. 58. In FIG. 60, a vertical axis indicates time, and a horizontal axis indicates a frequency. In FIG. 60, symbols described as "P" are pilot symbols, and as features of the third case, phase change is performed on the pilot symbols. Moreover, symbols described as "C" are control information symbols, and as features of the third case, phase change is performed on the control information symbols. Note that FIG. 60 is an example in a case where control information symbols are arranged in a frequency axis direction.

[0960]

In a frame in FIG. 60, there are 7 cycles of phase change, and any phase change of 7 types of "phase change $0, phase change $1, phase change $2, phase change $3, phase change $4, phase change $5 and phase change $6" is performed.

[0961]

In symbols of data symbol group #1 in area 6001 in FIG. 60, there is, for

example, a symbol described as "#0 $0." In this case, "#0" means a "0th symbol" of data symbol group #1. Then, "$0" means performing phase change of "phase change $0."

[0962]

Moreover, there is a symbol described as "#1 $1." In this case, "#1" means a "1st symbol" of data symbol group #1. Then, "$1" means performing phase change of "phase change $1."

[0963]

Hence, there are symbols described as "#X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "#X" means an "Xth symbol" of data symbol group #1. Then, "$Y" means performing phase change of "phase change $Y."

[0964]

In symbols of data symbol group #2 in area 6002 in FIG. 60, there is, for example, a symbol described as "%0 $2." In this case, "%0" means a "0th symbol" of data symbol group #2. Then, "$2" means performing phase change of "phase change $2."

[0965]

Moreover, there is a symbol described as "%1 $3." In this case, "%1" means a "1st symbol" of data symbol group #2. Then, "$3" means performing phase change of "phase change $3."

[0966]

Hence, there are symbols described as "%X $Y" (X is an integer equal to or more than 0, and Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "%X" means an "Xth symbol" of data symbol group #2. Then, "$Y" means performing phase change of "phase change $Y."

[0967]

Moreover, in FIG. 60, there is a symbol described as "C $3," for example. In this case, "C" means a control information symbol, and "$3" means performing phase change of "phase change $3."

[0968]

Hence, there are symbols described as "C $Y" (Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "C" means a control information symbol, and "$Y" means performing phase change of "phase change $Y."

[0969]

Moreover, in FIG. 59, there is a symbol described as "P $3," for example. In this case, "P" means a pilot symbol, and "$3" means performing phase change of "phase change $3."

[0970]

Hence, there are symbols described as "P $Y" (Y is an integer equal to or more than 0 and equal to or less than 6). In this case, "P" means a pilot symbol, and "$Y" means performing phase change of "phase change $Y."

[0971]

In this case, 7 cycles of phase change are performed in a data symbol of a modulated signal. For example, "phase change of $(2 \times 0 \times \pi)/7$ radians is performed as phase change $0," "phase change of $(2 \times 1 \times \pi)/7$ radians is performed as phase change $1," "phase change of $(2 \times 2 \times \pi)/7$ radians is performed as phase change $2," "phase change of $(2 \times 3 \times \pi)/7$ radians is performed as phase change $3," "phase change of $(2 \times 4 \times \pi)/7$ radians is performed as phase change $4," "phase change of $(2 \times 5 \times \pi)/7$ radians is performed as phase change $5," and "phase change of $(2 \times 6 \times \pi)/7$ radians is performed as phase change $6". However, a phase change value is not limited to these values.

[0972]

Note that in modulated signal #1 to be transmitted by transmission station #1 (5701) and modulated signal #2 to be transmitted by transmission station #2 (5702) in FIG. 57, phase change may be performed on both of modulated signal #1 and modulated signal #2. However, different types of phase change may be performed on modulated signal #1 and modulated signal #2. Note that phase change values may be different, and a cycle of the phase change of modulated signal #1 and a cycle of the phase change of modulated signal #2 may be different. Moreover, phase change may be performed on modulated signal #1, and may not be performed on modulated signal #1. Then, phase change may not be performed on modulated signal #1, and phase change may be performed on modulated signal #1.

[0973]

FIGS. 59 and 60 each illustrate the 7 cycles of phase change, as an example. However, a value of the cycle is not limited to this example and may be another value. Moreover, the cycle of phase change may be formed in the frequency axis direction or in the time direction.

[0974]

Moreover, when phase change is performed for each symbol in FIGS. 59 and 60, there may be no cycle of phase change.

[0975]

Note that the configuration of transmission stations #1 and #2 in FIG. 57 is not limited to the configuration in FIG. 58. Another configuration example will be described with reference to FIG. 61.

[0976]

Elements operating in the same way as in FIG. 58 are assigned the same reference numerals in FIG. 61, and will not be described. Features of FIG. 61 are

such that another apparatus transmits data 5803, control information 5806 and transmitting method instruction information 5811, and receiver 6102 in FIG. 61 performs demodulation and decoding to obtain data 5803, control information 5806 and transmitting method instruction information 5811. Hence, receiver 6102 receives a modulated signal transmitted by another apparatus, receives an input of received signal 6101, and demodulates and decodes received signal 6101 to output data 5803, control information 5806, and transmitting method instruction information 5811.

[0977]

Features of the third case are such that "7 cycles of phase change are performed in data symbol group #1 together with data symbol group #2 and symbols other than data symbols." That is, 7 cycles of phase change are performed in symbols of an entire frame. Note that the symbols other than data symbols are control information symbols and pilot symbols in a case of FIGS. 59 and 60, but there may be symbols other than control information symbols and pilot symbols.

[0978]

For example, the transmitting apparatus (transmission station) in FIG. 1 selects and carries out any of the above-described first case, second case and third case. As a matter of course, the transmitting apparatus in FIG. 1 performs the operations described with reference to FIGS. 58 and 61 when the transmitting apparatus selects the third case.

[0979]

As described above, the transmitting apparatus can favorably obtain a diversity effect in each data symbol group by carrying out an appropriate phase change method in each transmitting method. For this reason, the receiving apparatus can obtain an effect of making it possible to obtain good data reception

quality.

[0980]

Note that as a matter of course, the transmitting apparatus (transmission station) may carry out any of the above-described first case, second case and third case alone.

[0981]

EXEMPLARY EMBODIMENT A

FIG. 63 illustrates an example of a frame configuration when the horizontal axis indicates time and the vertical axis indicates frequency, and the same reference numerals are assigned to elements operating in the same way as those in FIGS. 2 and 34.

[0982]

Preambles are transmitted in a period from time t0 to time t1, symbol groups subjected to time division (time division multiplexing (TDM)) are transmitted in a period from time t1 to time t2, and symbol groups subjected to time-frequency division multiplexing (TFDM) are transmitted in a period from time t2 to time t3.

[0983]

In the case of TDM, the number of symbols (or slots) included in each data symbol group #TDX is the number of symbols (or slots) in which data corresponding to an integral multiple of an FEC block (having a block length of an error correction code (a code length of an error correction code)) is fitted.

[0984]

For example, when the block length of an error correction code is 64800 bits and the number of bits for transmitting each symbol of a data symbol group is 4, the number of symbols necessary to transmit 64800 bits that indicate the block length of the error correction code is 16200 symbols. Accordingly, in such a case, the number of symbols of data symbol group #TDX is 16200 × N (N is an integer

greater than or equal to 1). Note that the number of bits for transmitting each symbol is 4 when the single-input single-output (SISO) method and 16QAM are used.

[0985]

In another example, when the block length of an error correction code is 64800 bits and the number of bits for transmitting each symbol of a data symbol group is 6, the number of symbols necessary to transmit 64800 bits that indicate the block length of the error correction code is 10800 symbols. Accordingly, in such a case, the number of symbols of data symbol group #TDX is 10800 × N (N is an integer greater than or equal to 1). Note that when the SISO method and 64QAM are used, the number of bits for transmitting each symbol is 6.

[0986]

In yet another example, when the block length of an error correction code is 64800 bits, and the number of bits for transmitting each slot of a data symbol group is 8, the number of slots necessary to transmit 64800 bits that indicate the block length of the error correction code is 8100. Accordingly, in such a case, the number of slots of data symbol group #TDX is 8100 × N (N is an integer greater than or equal to 1). Note that when the MIMO method is used, the modulation method for stream 1 is 16QAM, and the modulation method for stream 2 is 16QAM, the number of bits for transmitting each slot which includes one symbol of stream 1 and one symbol of stream 2 is 8.

[0987]

Among symbol groups subjected to time division in a period from time t1 to time t2 in FIG. 63, data symbol group #TD1, data symbol group #TD2, data symbol group #TD3, data symbol group #TD4, and data symbol group #TD5 each satisfy that the number of symbols (slots) included in a data symbol group is the number of symbols (slots) in which data corresponding to an integral multiple of an FEC block

(having a block length of an error correction code (a code length of an error correction code)) is fitted, as described above. The symbol groups are arranged in the time axis direction.

[0988]

In FIG. 63, the number of carriers along the frequency axis is 64. Accordingly, carriers from carrier 1 to carrier 64 are present.

[0989]

For example, with regard to data symbol group #TD1, the arrangement of data symbols starts from “time $1, carrier 1”, and subsequently, data symbols are arranged at “time $1, carrier 2”, “time $1, carrier 3”, “time $1, carrier 4”, ..., “time $1, carrier 63”, “time $1, carrier 64”, “time $2, carrier 1”, “time $2, carrier 2”, “time $2, carrier 3”, “time $2, carrier 4”, ..., “time $2, carrier 63”, “time $2, carrier 64”, “time $3, carrier 1”, and so on.

[0990]

With regard to data symbol group #TD3, the arrangement of data symbols starts from “time $6000, carrier 1”, and subsequently data symbols are arranged at “time $6000, carrier 2”, “time $6000, carrier 3”, “time $6000, carrier 4”, ..., “time $6000, carrier 63”, “time $6000, carrier 64”, “time $6001, carrier 1”, “time $6001, carrier 2”, “time $6001, carrier 3”, “time $6001, carrier 4”, ..., “time $6001, carrier 63”, “time $6001, carrier 64”, “time $6002, carrier 1”, and so on, and the arrangement of symbols is completed when a symbol is arranged at “time $7000, carrier 20.”

[0991]

Then, with regard to data symbol group #TD4, the arrangement of data symbols starts from “time $7000, carrier 21.”

[0992]

Furthermore, data symbols in data symbol groups #TD4 and TD#5 are

arranged in accordance with the same rule, and the last symbol of data symbol group #TD5 which is the last data symbol group is arranged at time $10000 at carrier 32.

[0993]

Then, dummy symbols are arranged at carriers from carrier 33 to carrier 64 at time $10000. Accordingly, symbols at carrier 1 to carrier 64 are to be transmitted also at time $10000. Note that each of the dummy symbols has a certain value for in-phase component I and also a certain value for quadrature component Q.

[0994]

For example, in-phase component I of a dummy symbol may be generated using a pseudo-random sequence which includes “0” and “1”, and quadrature component Q of the dummy symbol may be 0. In this case, a pseudo-random sequence is initialized at a position of a first dummy symbol, and in-phase component I may be converted into one of the values +1 and –1, based on in-phase component I = 2 (1/2 – pseudo-random sequence).

[0995]

Alternatively, quadrature component Q of a dummy symbol may be generated using a pseudo-random sequence which includes “0” and “1”, and quadrature component I of the dummy symbol may be 0. In this case, a pseudo-random sequence is initialized at a position of a first dummy symbol, and quadrature component Q may be converted into one of the values +1 and –1, based on quadrature component Q = 2 (1/2 – pseudo-random sequence).

[0996]

Furthermore, an in-phase component of a dummy symbol may be set to a real number other than zero, and a quadrature component of the dummy symbol may be set to a real number other than zero.

[0997]

A method for generating a dummy symbol is not limited to the above. The description with regard to a dummy symbol here is also applicable to dummy symbols later described.

[0998]

According to the above rule, dummy symbols are arranged in a time section (from time t1 to time t2 in FIG. 63) in which time division is performed.

[0999]

The time-frequency division multiplexing (TFDM) method is to be described with reference to FIG. 63.

[1000]

A period from time t2 to time t3 in FIG. 63 shows an example of a frame configuration in which time-frequency division multiplexing is performed.

[1001]

At time $10001, data symbol group #TFD1 (3401) and data symbol #TFD2 (3402) are subjected to frequency division multiplexing, and data symbol group #TFD2 (3402), data symbol group #TFD3 (3403), and data symbol group #TFD6 (3406) are subjected to time division multiplexing at carrier 11. Accordingly, a period from time t2 to time t3 includes a portion on which frequency division is performed and a portion on which time division multiplexing is performed, and thus the method is named “time-frequency division multiplexing”, here.

[1002]

Data symbol group #TFD1 (3401) is present at time $10001 to time $14000, i is greater than or equal to 10001 and less than or equal to 14000, and data symbols are present at carrier 1 to carrier 10 at time i which satisfies the above.

[1003]

Data symbol group #TFD2 (3402) is present at time $10001 to time $11000,

i is greater than or equal to 10001 and less than or equal to 11000, and data symbols are present at carrier 11 to carrier 64 at time i which satisfies the above.

[1004]

Data symbol group #TFD3 (3403) is present at time $11001 to time $13000, i is greater than or equal to 11001 and less than or equal to 13000, and data symbols are present at carrier 11 to carrier 35 at time i which satisfies the above.

[1005]

Data symbol group #TFD4 (3404) is present at time $11001 to time $12000, i is greater than or equal to 11001 and less than or equal to 12000, and data symbols are present at carrier 36 to carrier 64 at time i which satisfies the above.

[1006]

Data symbol group #TFD5 (3405) is present at time $12001 to time $13000, i is greater than or equal to 12001 and less than or equal to 13000, and data symbols are present at carrier 36 to carrier 64 at time i which satisfies the above.

[1007]

Data symbol group #TFD6 (3406) is present at time $13001 to time $14000, i is greater than or equal to 13001 and less than or equal to 14000, and data symbols are present at carrier 11 to carrier 30 at time i which satisfies the above.

[1008]

Data symbol group #TFD7 (3407) is present at time $13001 to time $14000, i is greater than or equal to 13001 and less than or equal to 14000, and data symbol are present at carrier 31 to carrier 50 at time i which satisfies the above.

[1009]

Data symbol group #TFD8 (3408) is present at time $13001 to time $14000, i is greater than or equal to 13001 and less than or equal to 14000, and data symbols are present at carrier 51 to carrier 64 at time i which satisfies the above.

[1010]

The time-frequency division multiplexing method has a feature that the carrier number of an occupied carrier is the same for a data symbol group in all the time sections in which data symbols of the data symbol group are present.

[1011]

The number of symbols (or the number of slots) included in data symbol group #TFDX is U. U is an integer greater than or equal to 1.

[1012]

First, "V (which is an integer greater than or equal to 1) which denotes the number of symbols (or the number of slots) in which data having an integral multiple of a block length of an error correction code (a code length of an error correction code) is fitted" is secured. Note that $U - \alpha + 1 \leq V \leq U$ is to be satisfied (α denotes the number of symbols (or the number of slots) necessary to transmit a block having a block length (a code length) of an error correction code (unit: bits), and is an integer greater than or equal to 1).

[1013]

When $U - V \neq 0$, dummy symbols (or dummy slots) of $U - V$ symbols (or $U - V$ slots) are added. Thus, data symbol group #TFDX includes data symbols that are V symbols (or V slots) and dummy symbols that are $U - V$ symbols (or $U - V$ slots) (each dummy symbol has a certain value for in-phase component I, and also a certain value for quadrature component Q).

[1014]

All the data symbol groups subjected to time-frequency division multiplexing each satisfy that "a data symbol group includes data symbols that are V symbols (or V slots) and dummy symbols that are $U - V$ symbols (or $U - V$ slots)".

[1015]

Specifically, when data symbol groups subjected to time-frequency division

multiplexing needs to have dummy symbols (or dummy slots), dummy symbols (dummy slots) are inserted in data symbol groups separately.

[1016]

FIG. 64 illustrates an example of a state in which dummy symbols (or dummy slots) are inserted in, for example, data symbol group #TFD1 (3401) in FIG. 63.

[1017]

In data symbol group #TFD1 (3401), data symbols are arranged preferentially from a position having a smaller time index. A rule that if data symbols are arranged at all the occupied carriers at a certain time, data symbols are arranged at carriers at a time subsequent to the certain time is adopted.

[1018]

For example, with regard to data symbol group #TFD1 (3401), a data symbol is arranged at carrier 1 at time $10001, and thereafter data symbols are arranged at carrier 2 at time $10001, carrier 3 at time $10001, ..., carrier 9 at time $10001, and carrier 10 at time $10001, as illustrated in FIG. 64. Then, moving on to time $10002, data symbols are arranged at carrier 1 at time $10002, carrier 2 at time $10002, and so on.

[1019]

With regard to data symbol arrangement at time $13995, data symbols are arranged at carrier 1 at time $13995, carrier 2 at time $13995, carrier 3 at time $13995, carrier 4 at time $13995, carrier 5 at time $13995, and carrier 6 at time $13995. This completes arrangement of data symbols.

[1020]

However, there are symbols as data symbol group #TFD1 (3401) at carrier 7, carrier 8, carrier 9, and carrier 10 at time $13995, carrier 1 to carrier 10 at time $13996, carrier 1 to carrier 10 at time $13997, carrier 1 to carrier 10 at time $13998,

carrier 1 to carrier 10 at time $13999, and carrier 1 to carrier 10 at time $14000. Thus, dummy symbols are arranged at carrier 7, carrier 8, carrier 9, and carrier 10 at time $13995, carrier 1 to carrier 10 at time $13996, carrier 1 to carrier 10 at time $13997, carrier 1 to carrier 10 at time $13998, carrier 1 to carrier 10 at time $13999, and carrier 1 to carrier 10 at time $14000.

[1021]

Following the same method as described above, dummy symbols are arranged if necessary also in data symbol group #TFD2 (3402), data symbol group #TFD3 (3403), data symbol group #TFD4 (3404), data symbol group #TFD5 (3405), data symbol group #TFD6 (3406), data symbol group #TFD7 (3407), and data symbol group #TFD8 (3408) in FIG. 63.

[1022]

As described above, dummy symbols are inserted using different methods for a frame subjected to time division multiplexing and a frame subjected to time-frequency division multiplexing, and thus a receiving apparatus can readily sort out data symbols, and demodulate and decode data. Furthermore, an advantageous effect of preventing fall of a data transmission rate due to dummy symbols can be achieved.

[1023]

Note that a frame configuration in which “preambles”, “symbols subjected to time division”, and “symbols subjected to time-frequency division” are arranged in this order along the time axis is described based on the example in FIG. 63, yet the present disclosure is not limited to this. For example, a frame configuration in which “preambles”, “symbols subjected to time-frequency division, and “symbols subjected to time division” are arranged in this order may be adopted, and may also include symbols other than the symbols illustrated in FIG. 63.

[1024]

For example, in FIG. 63, “preambles” may be inserted between “symbols subjected to time division” and “symbols subjected to time-frequency division”, or other symbols may be inserted between “symbols subjected to time division” and “symbols subjected to time-frequency division”.

[1025]

FIG. 65 illustrates an example of a frame configuration in which the horizontal axis indicates time and the vertical axis indicates frequency, and the same reference numerals are assigned to elements operating in the same way as those in FIGS. 2 and 34.

[1026]

Preambles are transmitted in a period from time t0 to time t1, symbol groups subjected to frequency division (frequency division multiplexing (FDM)) are transmitted in a period from time t1 to time t2, and symbol groups subjected to time-frequency division multiplexing (TFDM) are transmitted in a period from time t2 to time t3.

[1027]

In the case of FDM, the number of symbols (or the number of slots) included in each data symbol group #FDX is the number of symbols (or the number of slots) in which data corresponding to an integral multiple of a FEC block (having a block length of an error correction code or a code length of an error correction code) is fitted.

[1028]

For example, when the block length of an error correction code is 64800 bits and the number of bits for transmitting each symbol of a data symbol group is 4, the number of symbols necessary to transmit 64800 bits that indicate the block length of an error correction code is 16200 symbols. Accordingly, in such a case, the number of symbols included in data symbol group #FDX is 16200 × N (N is an

integer greater than or equal to 1). Note that when the single-input single-output (SISO) method and 16QAM are used, the number of bits for transmitting each symbol is 4.

[1029]

In another example, when the block length of an error correction code is 64800 bits and the number of bits for transmitting each symbol of a data symbol group is 6, the number of symbols necessary to transmit 64800 bits that indicate the block length of an error correction code is 10800. Accordingly, in such a case, the number of symbols of data symbol group #FDX is 10800 × N (N is an integer greater than or equal to 1). Note that when the SISO method and 64QAM are used, the number of bits for transmitting each symbol is 6.

[1030]

In yet another example, when the block length of an error correction code is 64800 bits and the number of bits for transmitting each slot of a data symbol group is 8, the number of slots necessary to transmit 64800 bits that indicate the block length of an error correction code is 8100. Thus, in such a case, the number of slots of data symbol group #FDX is 8100 × N (N is an integer greater than or equal to 1). Note that when the MIMO method is used and a modulation method for stream 1 is 16QAM, whereas a modulation method for stream 2 is 16QAM, the number of bits for transmitting each slot which includes one symbol of stream 1 and one symbol of stream 2 is 8.

[1031]

In a period from time t1 to time t2 in FIG. 65, the number of symbols (or the number of slots) in each of data symbol group #FD1, data symbol group #FD2, data symbol group #FD3, and data symbol group #FD4 subjected to frequency division satisfies “the number of symbols (or the number of slots) in which data corresponding to an integral multiple of a FEC block (having a block length of an

error correction code or a code length of an error correction code) is fitted", as described above. Symbol groups are arranged along the frequency axis.

[1032]

In FIG. 65, the number of carriers along the frequency axis is 64. Accordingly, carrier 1 to carrier 64 are present.

[1033]

For example, data symbol group #FD1 includes data symbols at carrier 1 to carrier 15 from time $1 to time $10000.

[1034]

Data symbol group #FD2 includes data symbols at carrier 16 to carrier 29 from time $1 to time $10000, and data symbols at carrier 30 from time $1 to time $6000.

[1035]

Data symbol group #FD3 includes data symbols at carrier 30 from time $6001 to time $10000, data symbols at carrier 31 to carrier 44 from time $1 to time 10000, and data symbols at carrier 45 from time $1 to time $7000.

[1036]

Data symbol group #FD4 includes data symbols at carrier 45 from time $7001 to time $10000, data symbols at carrier 46 to carrier 63 from time $1 to time $10000, and data symbols at carrier 64 from time $1 to time $6000.

[1037]

The last data symbol group among data symbol groups arranged along the frequency axis is data symbol group #4, and the last symbol is at carrier 64 at time $6000.

[1038]

Then, arrangement of dummy symbols starts at time $6001 at carrier 64. Thus, dummy symbols are arranged at carrier 64 from time $6001 to time $10000.

Note that each dummy symbol has a certain value for in-phase component I, and also has a certain value for quadrature component Q.

[1039]

According to the above rule, dummy symbols are arranged in a section subjected to frequency division from time t1 to time t2 in FIG. 65, for example.

[1040]

The above has described that data symbols are allocated preferentially from a position having a smaller frequency index, yet data symbols are preferentially arranged from a position having a smaller time index. This point is to be described.

[1041]

In data symbol group #FD1 (6501), data symbols are preferentially arranged from a position having a smaller time index. A rule that if data symbols are arranged at all the occupied carriers at a certain time, data symbols are arranged at carriers at a time subsequent to the certain time is adopted.

[1042]

For example, in data symbol group #FD1 (6501), as illustrated in FIG. 65, a data symbol is arranged at carrier 1 at time $1, and thereafter data symbols are arranged at carrier 2 at time $1, carrier 3 at time $1, ..., carrier 14 at time $1, and carrier 15 at time $1. Then, moving onto time $2, data symbols are arranged at carrier 1 at time $2, carrier 2 at time $2, carrier 3 at time $2, ..., carrier 14 at time $2, and carrier 15 at time $2.

[1043]

Thereafter, data symbols are arranged also at time $3 in the same manner, and data symbols are arranged up to time $10000 in the same manner.

[1044]

In data symbol group #FD2 (6502), as illustrated in FIG. 65, a data symbol

is arranged at carrier 16 at time $1, and thereafter data symbols are arranged at carrier 17 at time $1, carrier 18 at time $1, …, carrier 29 at time $1, and carrier 30 at time $1. Then, moving onto time $2, data symbols are arranged at carrier 17 at time $2, carrier 18 at time $2, carrier 19 at time $2, …, carrier 29 at time $2, and carrier 30 at time $2. Thereafter, data symbols are arranged also at time $3 in the same manner, and data symbols are arranged up to time $6000 in the same manner.

[1045]

A data symbol is arranged at carrier 16 at time $6001, and thereafter data symbols are arranged at carrier 17 at time $6001, carrier 18 at time $6001, ..., carrier 28 at time $6001, and carrier 29 at time $6001. Then, moving onto time $6002, data symbols are arranged at carrier 17 at time $6002, carrier 18 at time $6002, carrier 19 at time $6002, ..., carrier 28 at time $6002, and carrier 29 at time $6002. Thereafter, data symbols are arranged also at time $6003 in the same manner, and data symbols are arranged up to time $10000 in the same manner.

[1046]

In data symbol group #FD3 (6503), as illustrated in FIG. 65, a data symbol is arranged at carrier 31 at time $1, and thereafter, data symbols are arranged at carrier 32 at time $1, carrier 33 at time $1, ..., carrier 44 at time $1, and carrier 45 at time $1. Moving onto time $2, data symbols are arranged at carrier 31 at time $2, carrier 32 at time $2, carrier 33 at time $2, ..., carrier 44 at time $2, and carrier 45 at time $2. Thereafter, data symbols are arranged also at time $3 in the same manner, and data symbols are arranged up to time $6000 in the same manner.

[1047]

A data symbol is arranged at carrier 30 at time $6001, and thereafter, data symbols are arranged at carrier 31 at time $6001, carrier 32 at time $6001, ..., carrier 44 at time $6001, and carrier 45 at time $6001. Then, moving onto time

$6002, data symbols are arranged at carrier 31 at time $6002, carrier 32 at time $6002, carrier 33 at time $6002, ..., carrier 44 at time $6002, and carrier 45 at time $6002. Data symbols are arranged also at time $6003 in the same manner, and data symbols are arranged up to time $7000 in the same manner.

[1048]

Then, a data symbol is arranged at carrier 30 at time $7001, and thereafter data symbols are arranged at carrier 31 at time $7001, carrier 32 at time $7001, ..., carrier 43 at time $7001, and carrier 44 at time $7001. Then, moving onto time $7002, data symbols are arranged at carrier 30 at time $7002, carrier 31 at time $7002, carrier 32 at time $7002, ..., carrier 43 at time $6002, and carrier 44 at time $6002. Thereafter, data symbols are arranged also at time $7003 in the same manner, and then data symbols are arranged up to time $10000 in the same manner.

[1049]

Data symbols are arranged also for data symbol group #FD4 (6504) in the same manner.

[1050]

Note that the arrangement described here means “a method of arranging generated data symbols in order”, or “a method of rearranging generated data symbols, and arranging the rearranged data symbols in order”.

[1051]

Arranging data symbols in such a manner gives the receiving apparatus an advantage that a less storage capacity is used for storing data symbols. If data symbols are arranged in the frequency direction, it may be difficult to start the next processing until data symbols at time $10000 are received.

[1052]

Data symbol groups #TFDX (3401 to 3408) in FIG. 65 operate in the same

way as those in FIG. 64, and thus description thereof is omitted.

[1053]

As described above, dummy symbols are inserted using different methods for a frame subjected to frequency division multiplexing and a frame subjected to time-frequency division multiplexing, whereby a receiving apparatus can readily sort out data symbols, and demodulate and decode data. Furthermore, an advantageous effect of preventing fall of a data transmission rate due to dummy symbols can be achieved.

[1054]

Note that a frame configuration in which “preambles”, “symbols subjected to frequency division”, and “symbols subjected to time-frequency division” are arranged in the order along the time axis is described based on the example in FIG. 65, yet the present disclosure is not limited to this, and for example, a frame configuration in which “preambles”, “symbols subjected to time-frequency division, and “symbols subjected to frequency division” are arranged in the order may be adopted.

[1055]

The frame configuration may also include symbols other than the symbols illustrated in FIG. 65. As an example, a method of including in the frame configuration “preambles”, “symbols subjected to frequency division, “symbols subjected to time-frequency division”, and “symbols subjected to time division” is described.

[1056]

For example, in FIG. 65, “preambles” may be inserted between “symbols subjected to frequency division” and “symbols subjected to time-frequency division”, and other symbols may be inserted between “symbols subjected to frequency division” and “symbols subjected to time-frequency division”.

[1057]

FIG. 66 illustrates an example of a frame configuration in which the horizontal axis indicates time and the vertical axis indicates frequency, and the same reference numerals are assigned to elements operating in the same way as those in FIG. 2.

[1058]

Symbols 6601 subjected to time division are transmitted in a section from time t1 to t2. Note that an example of a configuration of symbols subjected to time division is as illustrated in FIG. 63, and symbols 6601 subjected to time division include, for example, data symbol group #TD1 (6301), data symbol group #TD2 (6302), data symbol group #TD3 (6303), data symbol group #TD4 (6304), data symbol group #TD5 (6305), and dummy symbols 6306.

[1059]

In a section from time t2 to time t3, symbols 6602 subjected to frequency division are transmitted. Note that an example of a configuration of symbols subjected to frequency division is as illustrated in FIG. 65, and symbols 6602 subjected to frequency division include data symbol group #FD1 (6501), data symbol group #FD2 (6502), data symbol group #FD3 (6503), data symbol group #FD4 (6504), and dummy symbols (6505), for example.

[1060]

In a section from time t3 to time t4, symbols 6603 subjected to time-frequency division are transmitted. Note that an example of a configuration of symbols subjected to time-frequency division is as illustrated in FIGS. 63 and 65, and symbols 6703 subjected to time-frequency division include, for example, data symbol group #TFD1 (3401), data symbol group #TFD2 (3402), data symbol group #TFD3 (3403), data symbol group #TFD4 (3404), data symbol group #TFD5 (3405), data symbol group #TFD6 (3406), data symbol group #TFD7 (3407), and data

symbol group #TFD8 (3408).

[1061]

At this time, a method of inserting dummy symbols to symbols 6601 subjected to time division is the same as the method described above, a method of inserting dummy symbols to symbols 6602 subjected to frequency division is also the same as the method described above, and a method of inserting dummy symbols to symbols 6603 subjected to time-frequency division is also the same as the method described above.

[1062]

As described above, dummy symbols are inserted using different methods for a frame subjected to time division, a frame subjected to frequency division multiplexing, and a frame subjected to time-frequency division multiplexing, whereby a receiving apparatus can readily sort out data symbols, and demodulate and decode data. Furthermore, an advantageous effect of preventing fall of a data transmission rate due to dummy symbols can be achieved.

[1063]

Note that a frame configuration in which “preambles”, “symbols subjected to time division”, “symbols subjected to frequency division”, and “symbols subjected to time-frequency division” are arranged in the order along the time axis is described based on the example in FIG. 66, yet the present disclosure is not limited to this, and for example, “symbols subjected to time division”, “symbols subjected to frequency division”, and “symbols subjected to time-frequency division” may be transmitted in any (temporal) order subsequently to “preambles”. The frame configuration may also include symbols other than the symbols illustrated in FIG. 66.

[1064]

For example, in FIG. 66, “preambles” may be inserted between “symbols

subjected to time division" and "symbols subjected to frequency division", and other symbols may be inserted between "symbols subjected to time division" and "symbols subjected to frequency division". In addition, "preambles" may be inserted between "symbols subjected to frequency division" and "symbols subjected to time-frequency division", and other symbols may be inserted between "symbols subjected to frequency division" and "symbols subjected to time-frequency division".

[1065]

Note that the present disclosure can be achieved even by partially combining and executing the present disclosure.

[1066]

EXEMPLARY EMBODIMENT B

(Frame configuration)

An example of a transmission frame configuration in the present exemplary embodiment is described with reference to FIG. 67. In FIG. 67, the horizontal axis indicates time and the vertical axis indicates frequency. The same reference numerals are assigned to elements operating in the same way as those in FIG. 2. FIG. 67 illustrates an example in which ten multiplex frames from multiplex frame #MF1 (6701) to multiplex frame #MF10 (6710) are included in a transmission frame. The multiplex frames occupy areas that do not overlap each other within a transmission frame. In the example in FIG. 67, multiplex frame #MF1 (6701) occupies an area from carrier 1 to carrier 2000 from time $1 to time $60, multiplex frame #MF2 (6702) occupies an area from carrier 1 to carrier 2000 from time $61 to time $100, multiplex frames #MF3 (6703) occupies an area from carrier 1 to carrier 2000 from time $101 to time $160, multiplex frame #MF4 (6704) occupies an area from carrier 1 to carrier 600 from time $161 to time $360, multiplex frame #MF5 (6705) occupies an area from carrier 601 to carrier 1000 from time $161 to time

$260, multiplex frame #MF6 (6706) occupies an area from carrier 601 to carrier 1000 from time $261 to time $360, multiplex frame #MF7 (6707) occupies an area from carrier 1001 to carrier 1600 from time $161 to time $360, multiplex frame #MF8 (6708) occupies an area from carrier 1601 to carrier 2000 from time $161 to time $400, multiplex frame #MF9 (6709) occupies an area from carrier 1 to carrier 800 from time $361 to time $400, and multiplex frame #MF10 (6710) occupies an area from carrier 801 to carrier 1600 from time $361 to time $400.

[1067]

(Designation of multiplex frame)

A configuration of a multiplex frame is designated as follows, for example. An example of a designator which indicates the configuration of a multiplex frame is illustrated in FIG. 68. The number of multiplex frames is indicated by numMuxFrames. First, numMuxFrames is designated. Next, information on a multiplex frame is designated repeatedly for the count indicated by numMuxFrames. Information on each multiplex frame includes information indicating an area of the multiplex frame, and muxFrameType which is information indicating a type of the multiplex frame. The information indicating an area of the multiplex frame may include, for example, startTime which is a time when the multiplex frame starts, startCarrier which is a carrier at which the multiplex frame starts, endTime which is a time at which the multiplex frame ends, and endCarrier which is a carrier at which the multiplex frame ends. The information on each multiplex frame may include etc which is information on the multiplex frame other than the above.

[1068]

(Type of multiplex frame)

A field labeled with muxFrameType which indicates the type of a multiplex frame is a field for designating the configuration or usage of the multiplex frame, such as time division multiplexing (TDM) and frequency division multiplexing (FDM),

for example. The values of the field labeled with muxFrameType indicating the type of a multiplex frame may include extra values in order that future extension is allowed and a configuration and usage other than TDM or FDM can also be designated.

[1069]

(Designation of last carrier)

A symbol which is not used for data transmission such as a pilot symbol is multiplexed into a transmission frame, and thus the number of carriers which can be used for transmitting data symbols may vary depending on a time. Although FIG. 68 illustrates an example in which carrier 2000 is at the last end, yet for example, even if carrier 2000 is at the last end at time $1, carrier 1998 is at the last end at time $2, and carrier 2003 is at the last end at time $3. Accordingly, a problem arises when an area of a multiplex frame that includes a carrier near the last end is designated.

[1070]

The last end carrier at a time when the number of carriers which can be used to transmit data symbols is the fewest within a multiplex frame which includes a carrier near the last end may be designated in a field labeled with endCarrier of the multiplex frame. In this case, a rectangular multiplex frame may be configured. However, in this case, there are unused carriers at a time when there are many carriers which can be used to transmit data symbols. An unused carrier that is not used to transmit a data symbol is used to transmit a dummy symbol, for example.

[1071]

The last end at a time when the number of carriers which can be used to transmit data symbols is the greatest within a multiplex frame which includes a carrier near the last end may be designated in a field labeled with endCarrier of the multiplex frame. In this case, the number of carriers used to transmit data

symbols varies for each time, according to a carrier at the last end which can be used to transmit a data symbol.

[1072]

A special value that indicates a position of a carrier at the last end which can be used to transmit a data symbol is predetermined for each time, and the special value may be set in a field labeled with endCarrier which indicates a carrier at which a multiplex frame ends. The special value may be the maximum value that can be designated in the field labeled with endCarrier. By setting such a special value in the field labeled with endCarrier which indicates a carrier at which a multiplex frame ends, it is not necessary to identify in advance a carrier at the last end at a time when the number of carriers which can be used to transmit data symbols is the greatest within the multiplex frame.

[1073]

Examples of values designated in the configuration of the multiplex frame illustrated in FIG. 68 are shown below, based on the example illustrated in FIG. 67. The number of multiplex frames is 10, and thus numMuxFrames is 10. Here, with regard to i-th multiplex frame #MFi, a time at which the frame starts is expressed by startTime [i], a carrier at which the frame starts is expressed by startCarrier [i], a time at which the frame ends is expressed by endTime [i], and a type of a multiplex frame is expressed by muxFrameType [i]. In the example of multiplex frame #MF1, startTime [1] is time $1, startCarrier [1] is carrier 1, endTime [1] is time $60, and endCarrier [1] is carrier 2000. In the example of multiplex frame #MF5, startTime [5] is time $161, startCarrier [5] is carrier 601, endTime [5] is time $260, and endCarrier [5] is carrier 1000.

[1074]

FIG. 69 illustrates an example in which a data symbol group is multiplexed into multiplex frame #MF1 (6701) in FIG. 67. The type of multiplex frame #MF1

(6701) is a frame subjected to time division multiplexing (TDM). TDM is designated in muxFrameType [1]. In the example in FIG. 69, three data symbol groups from data symbol group #DS1 (6901) to data symbol group #DS3 (6903) are subjected to TDM. Data symbol group #DS1 (6901), data symbol group #DS2 (6902), data symbol group #DS3 (6903) are sequentially multiplexed into multiplex frame #MF1 (6701), and if there are remaining symbols, a dummy symbol group (6904) is inserted.

[1075]

Information on the arrangement of a data symbol group is designated by, for example, the number of a multiplex frame into which the data symbol group is multiplexed, and an area within the multiplex frame. An area within a multiplex frame is, for example, expressed by a start position and an end position of an area where a data symbol group is multiplexed. When the data symbol groups are multiplexed from the leading end of a multiplex frame without any space, the start positions of areas where the data symbol groups are multiplexed are known, and thus only the end positions of the areas where the data symbol groups are multiplexed may be designated. The start and end positions of areas where data symbol groups are multiplexed may be designated using time positions and carrier positions within a transmission frame, or may be designated using relative time positions and relative carrier positions in a multiplex frame.

[1076]

An example in which three data symbol groups are multiplexed into multiplex frame #MF1 (6701) has been described, yet the number of data symbol groups to be multiplexed into a multiplex frame is not limited to three, and instead no data symbol groups may be multiplexed.

[1077]

As described above, by efficiently multiplexing a plurality of data symbol

groups into one multiplex frame, the number of symbols in a dummy symbol group can be decreased, and transmission efficiency can be improved.

[1078]

FIG. 70 illustrates an example in which data symbol groups are multiplexed into multiplex frame #MF3 (6703) in FIG. 67. The type of multiplex frame #MF3 (6703) is a frame subjected to frequency division multiplexing (FDM). FDM is designated in muxFrameType [3].

[1079]

In the example in FIG. 70, three data symbol groups, namely data symbol group #DS6 (7001) to data symbol group #DS8 (7003) are subjected to frequency division multiplexing. Data symbol group #DS6 (7001), data symbol group #DS7 (7002), and data symbol group #DS8 (7003) are sequentially multiplexed into multiplex frame #MF3 (6703), and if there are remaining symbols, a dummy symbol group (7004) is inserted.

[1080]

Information on the arrangement of a data symbol group is designated by, for example, the number of a multiplex frame into which the data symbol group is multiplexed, and an area within the multiplex frame. An area within a multiplex frame is, for example, expressed by a start position and an end position of an area where a data symbol group is multiplexed. When data symbol groups are multiplexed from the leading end of a multiplex frame without any space, the start positions of areas where the data symbol groups are multiplexed are known, and thus only the end positions of the areas where the data symbol groups are multiplexed may be designated. The start and end positions of areas where data symbol groups are multiplexed may be designated using time positions and carrier positions within a transmission frame, or may be designated using relative time positions and relative carrier positions in a multiplex frame.

[1081]

An example in which three data symbol groups are multiplexed into multiplex frame #MF3 (6703) has been described, yet the number of data symbol groups to be multiplexed into a multiplex frame is not limited to three, and instead no data symbol groups may be multiplexed.

[1082]

As described above, by efficiently multiplexing a plurality of data symbol groups into one multiplex frame, the number of symbols in a dummy symbol group can be decreased, and transmission efficiency can be improved.

[1083]

(Designation of a data symbol group)

Information on a data symbol group is designated as follows, for example. FIG. 71 illustrates an example of a designator with regard to a data symbol group. The number of data symbol groups is indicated by numDataSymbolGroups. First, numDataSymbolGroups is designated. Next, information on a data symbol group is repeatedly designated for a count indicated by numDataSymbolGroups. Information on each data symbol group includes muxFrameIndex indicating the number of a multiplex frame in which a data symbol group is arranged and information indicating an area where a data symbol group is arranged. Information indicating an area in which a data symbol group is arranged includes, for example, endTimeOffset indicating a time at which an area of a data symbol group ends, and endCarrierOffset indicating a carrier in which the area of the data symbol group ends. Information indicating an area in which a data symbol group is arranged may further include, for example, startTimeOffset indicating a time at which an area of a data symbol group starts, and startCarrierOffset indicating a carrier in which the area of the data symbol group starts. Further, startTimeOffset indicating a time at which an area of a data symbol group starts, startCarrierOffset

indicating a carrier at which the area of the data symbol group starts, endTimeOffset indicating a time at which the area of the data symbol group ends, and endCarrierOffset indicating a carrier at which the area of the data symbol group starts may be indicated using time positions and carrier positions within a transmission frame, or may be indicated using relative time positions and relative carrier positions in a multiplex frame. Information on a data symbol group may include etc. indicating information on data symbols other than the above.

[1084]

(Hierarchical structure)

In the present exemplary embodiment, a transmission frame can be flexibly configured by forming a configuration of a multiplex frame and arrangement of data symbol groups into a hierarchy. Furthermore, designation with regard to a configuration of a multiplex frame, and designation with regard to a data symbol group are simplified, thus reducing the amount of information necessary for such designations and improving transmission efficiency.

[1085]

Furthermore, the number of dummy symbols can be reduced and transmission efficiency can be improved, by multiplexing a plurality of data symbol groups into a multiplex frame.

[1086]

(Supplementary Note 1)

The broadcast (or communication) system according to the present disclosure is described according to the above-described exemplary embodiments. However, the present disclosure is not limited to the above-described exemplary embodiments.

[1087]

As a matter of course, the present disclosure may be carried out by

combining a plurality of the exemplary embodiments and other contents described herein.

[1088]

Moreover, each exemplary embodiment and the other contents are only examples. For example, while a "modulating method, an error correction coding method (an error correction code, a code length, a coding rate and the like to be used), control information and the like" are exemplified, it is possible to carry out the present disclosure with the same configuration even when other types of a "modulating method, an error correction coding method (an error correction code, a code length, a coding rate and the like to be used), control information and the like" are applied.

[1089]

As for a modulating method, even when a modulating method other than the modulating methods described herein is used, it is possible to carry out the exemplary embodiments and the other contents described herein. For example, APSK (Amplitude Phase Shift Keying) (such as 16APSK, 64APSK, 128APSK, 256APSK, 1024APSK and 4096APSK), PAM (Pulse Amplitude Modulation) (such as 4PAM, 8PAM, 16PAM, 64PAM, 128PAM, 256PAM, 1024PAM and 4096PAM), PSK (Phase Shift Keying) (such as BPSK, QPSK, 8PSK, 16PSK, 64PSK, 128PSK, 256PSK, 1024PSK and 4096PSK), and QAM (Quadrature Amplitude Modulation) (such as 4QAM, 8QAM, 16QAM, 64QAM, 128QAM, 256QAM, 1024QAM and 4096QAM) may be applied, or in each modulating method, uniform mapping or non-uniform mapping may be performed (any mapping may be performed).

[1090]

Moreover, a method for arranging 16 signal points, 64 signal points or the like on an I-Q plane (a modulating method having 16 signal points, 64 signal points or the like) is not limited to a signal point arranging method of the modulating

methods described herein. Hence, a function of outputting an in-phase component and a quadrature component based on a plurality of bits is a function in a mapper.

[1091]

Moreover, herein, when there is a complex plane, a phase unit such as an argument is a "radian."

[1092]

When the complex plane is used, display in a polar form can be made as display by polar coordinates of a complex number. When point (a, b) on the complex plane is associated with complex number z = a + jb (a and b are both actual numbers, and j is a unit of an imaginary number), and when this point is expressed by [r, θ] in polar coordinates, a = r × cosθ and b = r × sinθ

[1093]

[Equation 61]

$$r = \sqrt{a^2 + b^2} \quad \cdots \quad (61)$$

[1094]

hold, r is an absolute value of z (r = |z|), and θ is an argument. Then, z = a + jb is expressed by $r \times e^{j\theta}$.

[1095]

The present disclosure described herein is applicable to a multi-carrier transmitting method such as the OFDM method, and is also applicable to a single carrier transmitting method. (For example, in a case of a multi-carrier method, symbols are arranged in a frequency axis, but in a case of a single carrier, symbols are arranged only in a time direction.) Moreover, a spread spectrum communication method is also applicable to baseband signals by using spreading codes.

[1096]

Different modulating methods may be used for pieces of data s0, s1, s2 and s3 in the above-described exemplary embodiments, respectively.

[1097]

Herein, a receiving apparatus of a terminal and an antenna may be configured separately. For example, the receiving apparatus includes an interface which receives through a cable an input of a signal received at the antenna or a signal obtained by performing frequency conversion on a signal received at the antenna, and the receiving apparatus performs subsequent processing. Moreover, data and information obtained by the receiving apparatus is subsequently converted into a video or a sound, and a display (monitor) displays the video or a speaker outputs the sound. Further, the data and information obtained by the receiving apparatus may be subjected to signal processing related to a video or a sound (signal processing may not be performed), and may be output from an RCA terminal (a video terminal or an audio terminal), a USB (Universal Serial Bus), a USB 2, a USB 3, an HDMI (registered trademark) (High-Definition Multimedia Interface), an HDMI (registered trademark) 2, a digital terminal or the like of the receiving apparatus. Moreover, the data and information obtained by the receiving apparatus is modulated by using a wireless communication method (Wi-Fi (registered trademark) (IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac, IEEE 802.11ad and the like), WiGiG, Bluetooth (registered trademark) and the like) or a wired communication method (optical communication, power line communication and the like), and these pieces of information may be transmitted to other apparatuses. In this case, a terminal includes a transmitting apparatus for transmitting information. (In this case, the terminal may transmit data including the data and information obtained by the receiving apparatus, or may generate modified data from the data and information

obtained by the receiving apparatus and transmit the modified data).

[1098]

Herein, it can be considered that a communication or broadcast apparatuses such as a broadcast station, a base station, an access point, a terminal and a mobile phone includes the transmitting apparatus. In this case, it can be considered that a communication apparatus such as a television, a radio, a terminal, a personal computer, a mobile phone, an access point and a base station includes the receiving apparatus. Moreover, it can also be considered that each of the transmitting apparatus and the receiving apparatus according to the present disclosure is an apparatus having communication functions and has a form connectable via any interface to an apparatus for executing an application such as a television, a radio, a personal computer and a mobile phone.

[1099]

Moreover, in the present exemplary embodiment, symbols other than data symbols, for example, pilot symbols (preambles, unique words, postambles, reference symbols and the like), and control information symbols may be arranged in frames in any way. Then, these symbols are named a pilot symbol and a control information symbol here, but may be named in any way, and a function itself is important.

[1100]

As a result, for example, a symbol is named a preamble herein, but the name of the symbol is not limited to this name, and the symbol may be named another name such as a control information symbol and a control channel. This symbol is a symbol for transmitting control information such as information of a transmitting method, examples of which include a transmitting method, a modulating method, a coding rate of an error correction code, a code length of an error correction code, a frame configuring method and a Fourier transform method

(size).

[1101]

Moreover, the pilot symbol only needs to be a known symbol modulated by using PSK modulation in a transmitting apparatus and a receiving apparatus or the receiving apparatus may be able to learn a symbol transmitted by the transmitting apparatus by establishing synchronization. The receiving apparatus performs frequency synchronization, time synchronization, channel estimation (of each modulated signal) (estimation of CSI (Channel State Information)), signal detection and the like by using this symbol.

[1102]

Moreover, the control information symbol is a symbol for transmitting information that is used for realizing communication other than data communication (such as application communication) and that needs to be transmitted to a communicating party, examples of the information including a modulating method used for communication, an error correction coding method, a coding rate of the error correction coding method and setting information in an upper layer.

[1103]

In the frame configurations herein, another symbol (for example, a pilot symbol and a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero)))) may be inserted to the first preamble. Similarly, a symbol such as a pilot symbol and a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))) may be inserted to the second preamble. Moreover, a preamble is configured with the first preamble and the second preamble. However, the preamble configuration is not limited to this configuration. The preamble may be configured with the first preamble (first preamble group) alone or may be configured with two or more preambles (preamble groups). Note that in regard to the preamble configuration,

the same also applies to frame configurations of other exemplary embodiments.

[1104]

Moreover, the data symbol group is indicated in the frame configurations herein. However, another symbol, examples of which include a pilot symbol, a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))), and a control information symbol, may be inserted. Note that in this regard, the same also applies to frame configurations of other exemplary embodiments. Then, another symbol, examples of which include a pilot symbol, a null symbol (an in-phase component of the symbol is 0 (zero, and a quadrature component is 0 (zero))), a control information symbol and a data symbol, may be inserted in a pilot symbol.

[1105]

Moreover, some of the frame configurations of modulated signals to be transmitted by the transmitting apparatus are described herein. In this case, the above describes the point that "time division (temporal division) is performed." However, when two data symbol groups are connected, there is a portion subjected to frequency division at a seam portion. This point will be described with reference to FIG. 39.

[1106]

FIG. 39 illustrates symbol 3901 of data symbol group #1 and symbol 3902 of data symbol group #2. As illustrated at time t0 in FIG. 39, the symbol of data symbol group #1 ends with carrier 4. In this case, the symbol of data symbol group #2 is arranged from carrier 5 at time t0. Then, only a portion at time t0 is exceptionally subjected to frequency division. However, there is only the symbol of data symbol group #1 before time t0, and there is only the symbol of data symbol group #2 after time t0. At this point, time division (temporal division) is performed.

[1107]

FIG. 40 illustrates another example. Note that the same reference numerals as those in FIG. 39 are assigned. As illustrated at time t0 in FIG. 40, the symbol of data symbol group #1 ends with carrier 4. Then, as illustrated at time t1, the symbol of data symbol group #1 ends with carrier 5. Then, the symbol of data symbol group #2 is arranged from carrier 5 at time t0, and the symbol of data symbol group #2 is arranged from carrier 6 at time t1. Then, portions at time t0 and time t1 are exceptionally subjected to frequency division. However, there is only the symbol of data symbol group #1 before time t0, and there is only the symbol of data symbol #2 after time t1. At this point, time division (temporal division) is performed.

[1108]

As illustrated in FIGS. 39 and 40, there is a case where, except for the exceptional portions, there are time at which there is no data symbol other than the symbol of data symbol group #1, but there may be a pilot symbol or the like and time at which there is no data symbol other than the symbol of data symbol group #2, but there may be a pilot symbol or the like. This case will be referred to as "time division (temporal division) is performed." Hence, an exceptional time existing method is not limited to FIGS. 39 and 40.

[1109]

Note that the present disclosure is not limited to each exemplary embodiment, and can be carried out with various modifications. For example, the case where the present disclosure is performed as a communication apparatus is described in each exemplary embodiment. However, the present disclosure is not limited to this case, and this communication method can also be used as software.

[1110]

Transmission antennas of transmission stations and base stations, reception antennas of terminals and one antenna described in the drawings may be

configured with a plurality of antennas.

[1111]

Note that a program for executing the above-described communication method may be stored in a ROM (Read Only Memory) in advance to cause a CPU (Central Processing Unit) to operate this program.

[1112]

Moreover, the program for executing the communication method may be stored in a computer-readable storage medium to record the program stored in the recording medium in a RAM (Random Access Memory) of a computer, and to cause the computer to operate according to this program.

[1113]

Then, each configuration of each of the above-described exemplary embodiments and the like may be realized as an LSI (Large Scale Integration) which is typically an integrated circuit having an input terminal and an output terminal. These integrated circuits may be formed as one chip separately, or may be formed as one chip so as to include the entire configuration or part of the configuration of each exemplary embodiment. The LSI is described here, but the integrated circuit may also be referred to as an IC (Integrated Circuit), a system LSI, a super LSI and an ultra LSI depending on a degree of integration. Moreover, a circuit integration technique is not limited to the LSI, and may be realized by a dedicated circuit or a general purpose processor. After manufacturing of the LSI, a programmable FPGA (Field Programmable Gate Array) or a reconfigurable processor which is reconfigurable in connection or settings of circuit cells inside the LSI may be used.

[1114]

Further, when development of a semiconductor technology or another derived technology provides a circuit integration technology which replaces the LSI,

as a matter of course, functional blocks may be integrated by using this technology. There may be biotechnology adaptation or the like as a possibility.

[1115]

The present disclosure is widely applicable to a wireless system which transmits different modulated signals from a plurality of antennas, respectively. Moreover, the present disclosure is also applicable to a case where MIMO transmission is performed in a wired communication system having a plurality of transmission portions (for example, a PLC (Power Line Communication) system, an optical communication system, and a DSL (Digital Subscriber Line) system).

[1116]

Note that the first exemplary embodiment is described by using baseband signals s1(t), s1(i), s2(t), and s2(i). In this case, data to be transmitted with s1(t) and s1(i) and data to be transmitted with s2(t) and s2(i) may be the same.

[1117]

Moreover, s1(t) = s2(t), and s1(i) = s2(i) may hold. In this case, a modulated signal of one stream is transmitted from a plurality of antennas.

[1118]

EXEMPLARY EMBODIMENT C

The present exemplary embodiment describes allocation of data symbol groups to terminals conducted when a base station or an access point (AP), for instance, transmits a modulated signal indicated by a frame configuration based on the time and frequency axes described in this specification such as those illustrated in, for example, FIGS. 2, 3, 4, 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 48, 29, 50, 51, 52, 53, 54, 63, and 65 (but, the frame configuration is not limited to these).

[1119]

FIG. 72 illustrates an example of a relation between a base station (access

point) and terminals. Base station (AP) 7200-00 communicates with terminal #1 (7200-01), terminal #2 (7200-02), ..., and terminal #n (7200-n) (n is a natural number greater than or equal to 2). Note that FIG. 72 illustrates an example of a state in which a base station (AP) communicates with terminals, but the state in which the base station (AP) communicates with terminals is not limited to the state in FIG. 72, and the base station (AP) is assumed to communicate with at least one terminal.

[1120]

FIG. 73 illustrates an example of communication between the base station and terminals in the present exemplary embodiment.

[1121]

<1> First, the terminals each transmit a request for transmitting a data symbol group to a base station (AP).

[1122]

For example, when the base station (AP) and terminals are in a state as illustrated in FIG. 72, terminal #1 (7200-01) transmits a request for transmitting a data symbol group to base station (AP) 7200-00. Similarly, terminal #2 (7200-02) transmits a request for transmitting a data symbol group to base station (AP) 7200-00. Similarly, terminal #n (7200-n) transmits a request for transmitting a data symbol group to base station (AP) 7200-00.

[1123]

<2> The base station receives, from each terminal, a modulated signal which includes a request for a data symbol group. The base station obtains information on the request for a data symbol group from each terminal, and determines allocation of data symbol groups included in a frame of a modulated signal which the base station transmits to the terminals.

[1124]

For example, base station (AP) 7200-00 transmits a modulated signal indicated by the frame configuration in FIG. 54. Base station (AP) 7200-00 has received requests for transmitting data, from terminal #1 (7200-01), terminal #2 (7200-02), terminal #3 (7200-03), terminal #4 (7200-04), terminal #5 (7200-05), terminal #6 (7200-06), terminal #7 (7200-07), and terminal #8 (7200-08).

[1125]

Then, base station (AP) 7200-00 sets data symbol group #1 (3401) in FIG. 54 as a data symbol group for transmitting data to terminal #8 (7200-08). Thus, base station (AP) 7200-00 transmits data (for terminal #8 (7200-08)) to terminal #8 (7200-08), using data symbol group #1 (3401) in FIG. 54.

[1126]

Base station (AP) 7200-00 sets data symbol group #2 (3402) in FIG. 54 as a data symbol group for transmitting data to terminal #7 (7200-07). Thus, base station (AP) 7200-00 transmits data (for terminal #7 (7200-07)) to terminal #7 (7200-07), using data symbol group #2 (3402) in FIG. 54.

[1127]

Base station (AP) 7200-00 sets data symbol group #3 (3403) in FIG. 54 as a data symbol group for transmitting data to terminal #6 (7200-06). Thus, base station (AP) 7200-00 transmits data (for terminal #6 (7200-06)) to terminal #6 (7200-06), using data symbol group #3 (3403) in FIG. 54.

[1128]

Base station (AP) 7200-00 sets data symbol group #4 (3404) in FIG. 54, as a data symbol group for transmitting data to terminal #5 (7200-05). Thus, base station (AP) 7200-00 transmits data (for terminal #5 (7200-05)) to terminal #5 (7200-05), using data symbol group #4 (3404) in FIG. 54.

[1129]

Base station (AP) 7200-00 sets data symbol group #5 (3405) in FIG. 54 as

a data symbol group for transmitting data to terminal #4 (7200-04). Thus, base station (AP) 7200-00 transmits data (for terminal #4 (7200-04)) to terminal #4 (7200-04), using data symbol group #5 (3405) in FIG. 54.

[1130]

Base station (AP) 7200-00 sets data symbol group #6 (3406) in FIG. 54 as a data symbol group for transmitting data to terminal #3 (7200-03). Thus, base station (AP) 7200-00 transmits data (for terminal #3 (7200-03)) to terminal #3 (7200-03), using data symbol group #6 (3406) in FIG. 54.

[1131]

Base station (AP) 7200-00 sets data symbol group #7 (3407) in FIG. 54 as a data symbol group for transmitting data to terminal #2 (7200-02). Thus, base station (AP) 7200-00 transmits data (for terminal #2 (7200-02)) to terminal #2 (7200-02), using data symbol group #7 (3407) in FIG. 54.

[1132]

Base station (AP) 7200-00 sets data symbol group #8 (3408) in FIG. 54 as a data symbol group for transmitting data to terminal #1 (7200-01). Thus, base station (AP) 7200-00 transmits data (for terminal #1 (7200-01)) to terminal #1 (7200-01), using data symbol group #8 (3408) in FIG. 54.

[1133]

Note that a method of allocating data symbol groups to the terminals is not limited to the above method, and data symbol group #1 (3401) may be allocated to a terminal other than terminal #8 (7200-08), for example. In addition, in the above description, the frame configuration of a modulated signal which base station (AP) 7200-00 transmits is the configuration in FIG. 54, but is not limited to this. The frame configuration of a modulated signal which base station (AP) 7200-00 transmits may be the configuration illustrated in, for example, FIG. 2, 3, 4, 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 48, 29, 50, 51, 52, 53, 54, 63, or

65 (or another frame configuration other than these).

[1134]

A frame configuring method is conceivable in which information on a relation between a data symbol group and a terminal (such as, for example, information indicating that “data symbol group #8 (3408) includes data for terminal #1 (7200-01)” is included in first preamble 3601 and/or second preamble 3602 in FIG. 54.

[1135]

Note that a method of transmitting data symbol groups may be any of the SISO method, the MISO method, and the MIMO method, for instance. Note that details are described using examples in this specification. The SISO method is a method with which, for example, one modulated signal is transmitted or one modulated signal is transmitted using a plurality of antennas. Note that modulated signals transmitted from the antennas may be the same or different. The MISO method is, for example, a method in which a space time block code or a time-frequency block code is used. The MIMO method is a method for transmitting, for example, a plurality of modulated signals using a plurality of antennas, for example.

[1136]

The data symbol groups may be used to transmit any type of information including video information, audio information, and text information, or may be used to transmit data for control. In other words, data transmitted using data symbol groups may be any type of data.

[1137]

<3> The terminals each receive a modulated signal transmitted by the base station, extract a data symbol group to be needed, demodulate the data symbol group, and obtain data.

[1138]

For example, when data symbol groups are allocated as described above, terminal #1 (7200-01) receives a modulated signal transmitted by base station (AP) 7200-00, obtains “information on a relation between a data symbol group and a terminal” included in first preamble 3601 and/or second preamble 3602, extracts a data symbol group which includes data for terminal #1 (7200-01), namely data symbol group #8 (3408), and demodulates (and performs error correction decoding on) data symbol group #8 (3408), thus obtaining data.

[1139]

FIG. 74 illustrates an example of a configuration of the base station (AP) in the present exemplary embodiment.

[1140]

Receiver 7400-07 receives an input of received signal 7400-06 which is received by antenna 7400-05. Receiver 7400-07 performs processes such as frequency conversion, signal processing for, for example, OFDM, demapping (demodulation), and error correction decoding, and outputs received data 7400-08.

[1141]

Transmitter 7400-02 receives inputs of, for example, transmission data 7400-01 which includes control information to be transmitted in, for instance, a preamble and received data 7400-08. Transmitter 7400-02 performs, on transmit data 7400-01, processes such as error correction coding, mapping using a modulation method which has been set, signal processing for, for example, OFDM, frequency conversion, and amplification, and generates and outputs modulated signal 7400-03, modulated signal 7400-03 is outputted as a radio wave from antenna 7400-04, and one or more terminals receive modulated signal 7400-03.

[1142]

Note that transmitter 7400-02 receives an input of received data 7400-08.

At this time, received data 7400-08 includes information on requests for transmitting data from terminals. Accordingly, based on the information on requests for transmitting data from terminals, transmitter 7400-02 generates a modulated signal for the frame configuration in FIG. 54, as described above. At this time, transmitter 7400-02 allocates, to terminals, data symbol groups 3401, 3402, 3403, 3404, 3405, 3406, 3407, and 3408 as described above, based on information on requests for transmitting data from terminals. In addition, transmitter 7400-02 generates the first preamble and/or the second preamble in FIG. 54 which include(s) data symbol groups involved in allocation to terminals based on information on requests for transmitting data from terminals, and information related to terminals, such as information indicating, for example, “data symbol group #8 (3408) includes data for terminal #1 (7200-01)”.

[1143]

Note that examples of a configuration of a transmitting apparatus included in the base station (AP) are as illustrated in FIGS. 1, 58, and 76, and the configuration in FIG. 76 is later described.

[1144]

In FIG. 74, the base station (AP) includes single antenna 7400-04 for transmission, but the present disclosure is not limited to a single antenna, and the base station (AP) may include a plurality of antennas for transmission. At this time, transmitter 7400-02 transmits a plurality of modulated signals using the plurality of transmission antennas, and thus generates a plurality of modulated signals.

[1145]

Similarly, in FIG. 74, the base station (AP) includes single antenna 7400-05 for reception, but the present disclosure is not limited to a single antenna, and the base station (AP) may include a plurality of antennas for reception. At this time, a plurality of modulated signals are received using the plurality of antennas, and

receiver 7400-07 performs signal processing on the plurality of modulated signals, thus obtaining received data.

[1146]

FIG. 75 illustrates an example of a configuration of a terminal in the present exemplary embodiment.

[1147]

Receiver 7500-07 receives an input of received signal 7500-06 received via antenna 7500-05, performs processes such as frequency conversion, signal processing for, for example, OFDM, demapping (demodulation), and error correction decoding, and outputs received data 7500-08.

[1148]

Transmitter 7500-02 receives inputs of, for example, transmission data 7500-01 which includes control information transmitted in a preamble, for instance, and received data 7500-08. Transmitter 7500-02 performs, on transmission data 7500-01, error correction coding, mapping using a modulation method which has been set, signal processing for, for example, OFDM, frequency conversion, and amplification, and generates and outputs modulated signal 7500-03. Modulated signal 7500-03 is output as a radio wave from antenna 7500-04, and the base station (AP) receives modulated signal 7500-03.

[1149]

Note that transmitter 7500-02 receives an input of received data 7500-08. At this time, received data 7500-08 may include control information from the base station (AP). At this time, transmitter 7500-02 may set, based on control information from the base station (AP), a transmitting method, a frame configuration, a modulation method, and an error correction coding method, for example, and may generate a modulated signal.

[1150]

Note that an example of a configuration of a receiving apparatus of a terminal is as illustrated in FIGS. 23 and 78, and the configuration in FIG. 78 will be described later. When a modulated signal transmitted by the base station is received, a receiving apparatus of a terminal obtains a first preamble and/or a second preamble, to obtain information on a data symbol group to be demodulated, and subsequently extracts a desired data symbol group, and performs demodulation and error correction decoding on the extracted data symbol group, thus obtaining received data.

[1151]

In FIG. 75, a terminal includes single antenna 7500-04 for transmission, but the present disclosure is not limited to a single antenna, and the terminal may include a plurality of antennas for transmission. At this time, a plurality of modulated signals are transmitted using the plurality of transmission antennas, and transmitter 7500-02 generates a plurality of modulated signals.

[1152]

Similarly, in FIG. 75, a terminal includes single antenna 7500-05 for reception, but the present disclosure is not limited to a single antenna, and the terminal may include a plurality of antennas for reception. At this time, a plurality of modulated signals are received using the plurality of antennas, and receiver 7500-07 performs signal processing on the plurality of modulated signals, thus obtaining received data.

[1153]

FIG. 76 illustrates an example of a configuration of a transmitter included in the base station (AP) in the present exemplary embodiment. Note that in FIG. 76, the same reference numerals are assigned to elements which operate in the same manner as those in FIG. 58.

[1154]

Transmitting method designation information 5811 includes information on allocation of data symbol groups to the terminals. For example, transmitting method designation information 5811 includes information indicating that “data symbol group #1 is for transmitting data to terminal #8”.

[1155]

Transmitting method instructing unit 5812 receives an input of transmitting method designation information 5811, and outputs information 5813 on a transmitting method. For example, information 5813 on a transmitting method includes information on allocation of data symbol groups to terminals, information on a method for transmitting data symbol groups, information on a method for modulating data symbol groups, information on an error correction coding method (code length, coding rate) for data symbol groups, and information on a frame configuration.

[1156]

Data symbol group generator 7600-00 receives inputs of data 5801 and information 5813 on a transmitting method, and generates baseband signals for data symbol groups based on information 5813 on a transmitting method.

[1157]

Frame configuring unit 7600-01 receives inputs of baseband signals 5805 for data symbols, baseband signal 5808 for a control information symbol, baseband signal 5810 for a pilot symbol, and information 5813 on a transmitting method. Frame configuring unit 7600-01 generates and outputs modulated signal 7600-02 according to, for example, the frame configuration in FIG. 54, based on information on the frame configuration included in information 5813 on a transmitting method. Note that as described above, the frame configuration is not limited to the frame configuration in FIG. 54.

[1158]

Radio unit 5861 receives inputs of modulated signal 7600-02 according to a frame configuration, and information on a transmitting method. Radio unit 5816 performs processes such as frequency conversion and amplification on modulated signal 7600-02 according to a frame configuration, and generates and outputs transmission signal 5817. Transmission signal 5817 is output as a radio wave from antenna 5818.

[1159]

FIG. 77 illustrates an example of a configuration of data symbol group generator 7600-00 included in the base station (AP) in FIG. 76.

[1160]

Data symbol group #1 generator 7700-02-1 receives inputs of data #1 (7700-01-1) and information 7700-00 (5813) on transmitting methods. Data symbol group #1 generator 7700-02-1 performs processes such as error correction coding and modulation, based on information on allocation of data symbol groups to terminals, information on methods for transmitting data symbol groups, information on methods for modulating data symbol groups, and information on error correction coding methods (code length, coding rate) for data symbol groups, which are included in information 7700-00 on transmitting methods, and outputs a baseband signal for data symbol group #1 7700-03-1.

[1161]

Data symbol group #2 generator 7700-02-2 receives inputs of data #2 (7700-01-2) and information 7700-00 (5813) on transmitting methods. Data symbol group #2 generator 7700-02-2 performs processes such as error correction coding and modulation, based on information on allocation of data symbol groups to terminals, information on methods for transmitting data symbol groups, information on methods for modulating data symbol groups, and information on error correction coding methods (code length, coding rate) for data symbol groups,

which are included in information 7700-00 on transmitting methods, and outputs a baseband signal for data symbol group #2 7700-03-2.

Similar processing continues.

[1162]

Data symbol group #m generator 7700-02-m receives inputs of data #m (7700-01-m) and information 7700-00 (5813) on transmitting methods. Data symbol group #m generator 7700-02-m performs processes such as error correction coding and modulation, based on information on allocation of data symbol groups to terminals, information on methods for transmitting data symbol groups, information on methods for modulating data symbol groups, and information on error correction coding methods (code length, coding rate) for data symbol groups, which are included in information 7700-00 on transmitting methods, and outputs a baseband signal for data symbol group #m 7700-03-m (note that m is an integer greater than or equal 1 or an integer greater than or equal to 2).

[1163]

FIG. 78 illustrates an example of a configuration of a receiver included in a terminal in the present exemplary embodiment. Note that in FIG. 78, the same reference numerals are assigned to elements which operate in the same manner as those in FIG. 23.

[1164]

OFDM method related processor 2303_X receives an input of received signal 2302_X received by antenna 2301_X. OFDM method related processor 2303_X performs OFDM-related signal processing, and outputs signal 2304_X obtained as a result of the signal processing.

[1165]

First preamble detector/demodulator 2311 receives an input of signal 2304_X obtained as a result of the signal processing. For example, first preamble

detector/demodulator 2311 detects and demodulates the first preamble in FIG. 54, and outputs first preamble control information 2312. Note that this may be applicable to another frame configuration other than the frame configuration in FIG. 54.

[1166]

Second preamble demodulator 2313 receives inputs of signal 2304_X obtained as a result of the signal processing and first preamble control information 2312. For example, second preamble demodulator 2313 demodulates the second preamble in FIG. 54, and outputs second preamble control information 2314.

[1167]

Control signal generator 2315 receives inputs of first preamble control information 2312 and second preamble control information 2314, and outputs control signal 2316. Note that control signal 2316 includes information on allocation of data symbol groups to terminals.

[1168]

Channel fluctuation estimator 7800-01 receives inputs of signal 2304_X obtained as a result of the signal processing and control signal 2316. Signal processor 2309 receives inputs of signal 2304_X obtained as a result of the signal processing and control signal 2316. Based on control signal 2316, channel fluctuation estimator 7800-01 estimates a channel using a preamble and a pilot symbol included in signal 2304_X obtained as a result of the signal processing, and outputs channel estimation signal 7800-02.

[1169]

Signal processor 2309 receives inputs of channel estimation signal 7800-02, signal 2304_X obtained as a result of the signal processing, and control signal 2316. Based on information on allocation of data symbol groups to terminals included in control signal 2316, signal processor 2309 extracts a desired

data symbol group from signal 2304_X obtained as a result of the signal processing, performs processes such as demodulation and error correction decoding on the extracted data symbol group, and outputs received data 2310.

[1170]

As described above, a terminal which is a destination is suitably set for each data symbol group in a modulated signal which the base station (AP) transmits, whereby an advantageous effect of improvement in efficiency of data transmission by the base station (AP) can be obtained.

[1171]

For example, when the base station (AP) transmits a frame as illustrated in FIG. 54 by time division, the above transmitting method is superior in respect of improvement in efficiency of data transmission.

[1172]

Note that as described in other exemplary embodiments, particular symbols (5304, 5305) are arranged at particular carriers as illustrated in FIG. 53 in a period from time t1 to time t3 in the frame configuration in FIG. 54. At this time, the particular symbols (5304, 5305) at the particular carriers may be data symbol groups. For example, the symbols at a particular carrier may be data symbol group #100.

[1173]

EXEMPLARY EMBODIMENT D

The present exemplary embodiment gives a supplementary description with regard to “a method of inserting dummy symbols (or dummy slots) in a data symbol group” described with reference to FIG. 64.

[1174]

FIG. 79 illustrates an example of a frame configuration of a modulated signal which a base station (AP) transmits in the present exemplary embodiment,

and the same reference numerals are assigned to an element which operates in the same manner as in FIG. 2.

[1175]

FIG. 79 illustrates an example of a frame configuration of a modulated signal that the base station (AP) in the present exemplary embodiment transmits, and the vertical axis indicates frequency, whereas the horizontal axis indicates time.

[1176]

In the frame, there are carrier 1 to carrier 64 in the frequency direction, and there are symbols for each carrier.

[1177]

The base station (AP) transmits first preamble 201 and second preamble 202 in a period from time t0 to time t1, as illustrated in FIG. 79.

[1178]

In a period from time t1 time t2, the base station (AP) transmits data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04.

[1179]

In a period from time t2 to time t3, the base station (AP) transmits first preamble 7900-51 and second preamble 7900-52.

[1180]

In a period from time t3 to time t4, the base station (AP) transmits data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09.

[1181]

In a period from time t4 to time t5, the base station (AP) transmits first preamble 7900-53 and second preamble 7900-54.

[1182]

In a period from time t5 to time t6, the base station (AP) transmits data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TD11) 7900-11.

[1183]

In FIG. 79, data symbol group #FD1 (#TFD1) 7900-01 is a data symbol group for which carrier 1 to carrier 15 are used in the frequency axis direction and time $1 to time $10000 are used in the time direction (there are symbols in the carrier direction, and also there are symbols in the time direction).

[1184]

Similarly, data symbol group #FD2 (#TFD2) 7900-02 is a data symbol group for which carrier 16 to carrier 31 are used in the frequency axis direction and time $1 to time $10000 are used in the time direction (there are symbols in the carrier direction, and also there are symbols in the time direction).

[1185]

Data symbol group #FD3 (#TFD3) 7900-03 is a data symbol group for which carrier 32 to carrier 46 are used in the frequency axis direction and time $1 to time $10000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1186]

Data symbol group #FD4 (#TFD4) 7900-04 is a data symbol group for which carrier 47 to carrier 64 are used in the frequency axis direction, and time $1 to time $10000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1187]

As described above, in the frame in FIG. 79, data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are subjected to frequency division multiplexing.

[1188]

In FIG. 79, data symbol group #FD5 (#TFD5) 7900-05 is a data symbol group for which carrier 1 to carrier 15 are used in the frequency axis direction and time ♭1 to time ♭8000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1189]

Similarly, data symbol group #FD6 (#TFD6) 7900-06 is a data symbol group for which carrier 16 to carrier 29 are used in the frequency axis direction and time ♭1 to time ♭8000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1190]

Data symbol group #FD7 (#TFD7) 7900-07 is a data symbol group for which carrier 30 to carrier 38 are used in the frequency axis direction and time ♭1 to time ♭8000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1191]

Data symbol group #FD8 (#TFD8) 7900-08 is a data symbol group for which carrier 39 to carrier 52 are used in the frequency axis direction and time ♭1 to time ♭8000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1192]

Data symbol group #FD9 (#TFD9) 7900-09 is a data symbol group for which carrier 53 to carrier 64 are used in the frequency axis direction and time ♭1 to

time ♭8000 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1193]

Accordingly, in the frame in FIG. 79, data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 are subjected to frequency division multiplexing.

[1194]

In FIG. 79, data symbol group #TD10 (#TFD10) 7900-10 is a data symbol group for which carrier 1 to carrier 64 are used in the frequency axis direction and time *1 to time *50 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1195]

Similarly, data symbol group #TD11 (#TD11) 7900-11 is a data symbol group for which carrier 1 to carrier 64 are used in the frequency axis direction and time *51 to time *81 are used in the time direction. There are symbols in the carrier direction, and also there are symbols in the time direction.

[1196]

Note that FIG. 79 illustrates the case where data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TD11) 7900-11 are subjected to time division multiplexing, yet a configuration may be adopted in which data symbol group #TD11 (#TD11) 7900-11 is not included, for example. In addition, a frame configuration in which the first preamble and the second preamble are included between data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TD11) 7900-11 may be adopted as another example.

[1197]

Note that first preambles 201, 7900-51, and 7900-53 in FIG. 79 may

include symbols other than preamble symbols (or may not include symbols other than preamble symbols). In addition, not all the carriers from carrier 1 to carrier 64 may be used to transmit symbols of the first preamble. For example, a symbol whose in-phase component I is zero and quadrature component Q is zero may be present at a particular carrier.

[1198]

Similarly, second preambles 202, 7900-52, and 7900-54 in FIG. 79 may include a symbol other than preamble symbols, or may not include symbols other than preamble symbols. In addition, not all the carriers from carrier 1 to carrier 64 may be used to transmit symbols of the second preamble. For example, a symbol whose in-phase component I is zero and quadrature component Q is zero may be present at a particular carrier.

[1199]

Data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, data symbol group #FD4 (#TFD4) 7900-04, data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, data symbol group #FD9 (#TFD9) 7900-09, data symbol group #TD10 (#TFD10) 7900-10, and data symbol group #TD11 (#TD11) 7900-11 may include a symbol other than a data symbol or may not include a symbol other than a data symbol. At a particular carrier, there may be a pilot symbol which can be used for channel fluctuation estimation, phase noise estimation, frequency offset estimation, frequency synchronization, and time synchronization, for instance.

[1200]

In FIG. 79, data symbol group #FD1 (#TFD1) 7900-01 and data symbol group #FD (#TFD5) 7900-05 are both transmitted using carrier 1 to carrier 15, and

are symbols arranged at particular carriers and corresponding to symbols 5304 and 5305 arranged at particular carriers in FIG. 53, in a description given with reference to FIGS. 52, 53, and 54 in the sixth exemplary embodiment.

[1201]

Note that a data symbol group and a terminal may be given a relation as described in Exemplary Embodiment C. With regard to this point, as described in detail in Exemplary Embodiment C, for example:

- The base station (AP) transmits data to terminal #1 using data symbol group #FD1 (#TFD1) 7900-01. Accordingly, data symbol group #FD1 (#TFD1) 7900-01 is a data symbol group for transmitting data to terminal #1.

[1202]

- The base station (AP) transmits data to terminal #2 using data symbol group #FD2 (#TFD2) 7900-02. Accordingly, data symbol group #FD2 (#TFD2) 7900-02 is a data symbol group for transmitting data to terminal #2.

[1203]

- The base station (AP) transmits data to terminal #3 using data symbol group #FD3 (#TFD3) 7900-03. Accordingly, data symbol group #FD3 (#TFD3) 7900-03 is a data symbol group for transmitting data to terminal #3.

[1204]

- The base station (AP) transmits data to terminal #4 using data symbol group #FD4 (#TFD4) 7900-04. Accordingly, data symbol group #FD4 (#TFD4) 7900-04 is a data symbol group for transmitting data to terminal #4.

As described above, frequency division multiple access is performed using data symbol groups present in a period from time t1 to time t2. Note that orthogonal frequency division multiple access (OFDMA) is performed when the OFDM method is used.

[1205]

Similarly,

- The base station (AP) transmits data to terminal #A, using data symbol group #FD5 (#TFD5) 7900-05. Accordingly, data symbol group #FD5 (#TFD5) 7900-05 is a data symbol group for transmitting data to terminal #A.

[1206]

- The base station (AP) transmits data to terminal #B using data symbol group #FD6 (#TFD6) 7900-06. Accordingly, data symbol group #FD6 (#TFD6) 7900-06 is a data symbol group for transmitting data to terminal #B.

[1207]

- The base station (AP) transmits data to terminal #C using data symbol group #FD7 (#TFD7) 7900-07. Accordingly, data symbol group #FD7 (#TFD7) 7900-07 is a data symbol group for transmitting data to terminal #C.

[1208]

- The base station (AP) transmits data to terminal #D using data symbol group #FD8 (#TFD8) 7900-08. Accordingly, data symbol group #FD8 (#TFD8) 7900-08 is a data symbol group for transmitting data to terminal #D.

[1209]

- The base station (AP) transmits data to terminal #E using data symbol group #FD9 (#TFD9) 7900-09. Accordingly, data symbol group #FD9 (#TFD9) 7900-09 is a data symbol group for transmitting data to terminal #E.

As described above, frequency division multiple access is performed using data symbol groups present in a period from time t3 to time t4. Note that orthogonal frequency division multiple access (OFDMA) is performed when the OFDM method is used.

[1210]

The base station (AP) transmits data to terminal #α using data symbol group #TD10 (#TFD10) 7900-10. Accordingly, data symbol group #TD10

(#TFD10) 7900-10 is a data symbol group for transmitting data to terminal α.

[1211]

The base station (AP) transmits data to terminal #β using data symbol group #TD11 (#TFD11) 7900-11. Accordingly, data symbol group #TD11 (#TFD11) 7900-11 is a data symbol group for transmitting data to terminal β.

[1212]

Data symbol groups subjected to time division (or time division multiplexing), frequency division (or frequency division multiplexing), and time domain division and frequency domain division (or time domain division multiplexing and frequency domain division multiplexing) in the frames illustrated in, for instance, FIGS. 54 and 79 have been described. Note that the following is applicable to the frames described in the specification, not limited to the frames illustrated in FIGS. 54 and 79.

[1213]

The following describes another example of a configuration of a time boundary or a frequency boundary between data symbol groups.

[1214]

For example, a state as illustrated in FIG. 80 is considered when data symbol groups are divided in the time direction. FIG. 80 is a diagram illustrating an example of division in the time direction.

[1215]

In FIG. 80, the horizontal axis indicates time and the vertical axis indicates frequency (carrier). FIG. 80 illustrates an example in which a first area, a second area, a third area, and a fourth area are obtained as data symbol groups by division in the time direction.

[1216]

As illustrated in FIG. 80, the first area and the second area are present at

time t1. At time t2 and time t3, the second area and the third area are present. The third area and the fourth area do not overlap in the time direction. Cases including such cases are defined as being “divided in the time direction”. For example, time division may be performed such that a plurality of data symbol groups are present at a certain time as illustrated in FIG. 80.

[1217]

Furthermore, an area may have different time widths at different frequencies, as can be seen from the first area to the third area in FIG. 80. Specifically, an area may not be a quadrilateral in a time-frequency plane. Cases including such cases are defined as being “divided in the time direction”.

[1218]

For example, a state as illustrated in FIG. 81 is to be considered when dividing data symbol groups in the frequency direction. FIG. 81 is a diagram illustrating an example of the division in the frequency direction.

[1219]

In FIG. 81, the horizontal axis indicates frequency (carrier), and the vertical axis indicates time. FIG. 81 illustrates an example of a case in which a first area, a second area, a third area, and a fourth area are obtained as data symbol groups by division in the frequency direction.

[1220]

As illustrated in FIG. 81, the first area and the second area are present at carrier c1. Furthermore, the second area and the third area are present at carrier c2 and carrier c3. The third area and the fourth area do not overlap in the frequency direction. The cases including such cases are defined as being “divided in the frequency direction”. For example, frequency division may be performed such that a plurality of data symbol groups are present at a certain frequency (carrier) as illustrated in FIG. 81.

[1221]

Furthermore, an area may have different frequency widths at different times, as can be seen from the first area to the third area in FIG. 81. Specifically, an area may not be a quadrilateral in a time-frequency plane. The cases including such cases are defined as being “divided in the frequency direction”.

[1222]

When data symbol groups are subjected to time domain division and frequency domain division (or time domain division multiplexing and frequency domain division multiplexing), the data symbol groups may be divided in the time direction as illustrated in FIG. 80, and divided in the frequency direction as illustrated in FIG. 81. Specifically, one area of a data symbol group in a time-frequency plane may have different frequency widths at different times, and furthermore may have different time widths at different frequencies.

[1223]

Of course, frequency division may be performed to obtain data symbol groups as shown by data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 in FIG. 79, so that there is no carrier (frequency) at which two or more data symbol groups are present.

[1224]

Furthermore, time division may be performed so as to obtain data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TD11) 7900-11 as illustrated in FIG. 79, so that there is no time (time period) at which two or more data symbol groups are present.

[1225]

FIG. 64 illustrates an example in which dummy symbols (or dummy slots) are inserted in data symbol group #FD1 (#TFD1) 7900-01 in FIG. 79, for example.

An example similar to the following example has already been described with reference to FIGS. 63 and 64.

[1226]

For example, data symbols are preferentially arranged from a smaller time index in data symbol group #FD1 (#TFD1) 7900-01. A rule that if data symbols are arranged at all the occupied carriers at a certain time, data symbols are arranged at carriers at a time subsequent to the certain time is adopted.

[1227]

For example, in data symbol group #TFD1 (3401), as illustrated in FIG. 64, a data symbol is arranged at carrier 1 at time $10001, and thereafter data symbols are arranged at carrier 2 at time $10001, carrier 3 at time $10001, ..., carrier 9 at time $10001, and carrier 10 at time $10001. Then, moving onto time $10002, data symbols are arranged at carrier 1 at time $10002, carrier 2 at time $10002, and so on.

[1228]

At time $13995, data symbols are arranged at carrier 1 at time $13995, carrier 2 at time $13995, carrier 3 at time $13995, carrier 4 at time $13995, carrier 5 at time $13995, and carrier 6 at time $13995. This completes arrangement of data symbols.

[1229]

However, symbols as data symbol group #TFD1 (3401) are present at carrier 7, carrier 8, carrier 9, and carrier 10 at time $13995, carrier 1 to carrier 10 at time $13996, carrier 1 to carrier 10 at time $13997, carrier 1 to carrier 10 at time $13998, carrier 1 to carrier 10 at time $13999, and carrier 1 to carrier 10 at time $14000. Thus, dummy symbols are arranged at carrier 7, carrier 8, carrier 9, and carrier 10 at time $13995, carrier 1 to carrier 10 at time $13996, carrier 1 to carrier 10 at time $13997, carrier 1 to carrier 10 at time $13998, carrier 1 to carrier 10 at

time $13999, and carrier 1 to carrier 10 at time $14000.

[1230]

If necessary, dummy symbols are also arranged in, using the same method as above, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3, (#TFD3) 7900-03, data symbol group #FD4 (#TFD4) 7900-04, data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, data symbol group #FD9 (#TFD9) 7900-09, data symbol group #TD10 (#TFD10) 7900-10, and data symbol group #TD11 (#TFD11) 7900-11 in FIG. 79.

[1231]

As described above, a dummy symbol is inserted in a data symbol group subjected to time division multiplexing, a data symbol group subjected to time division multiplexing, and a data symbol group for which a particular carrier is used, whereby a receiving apparatus readily sorts out data symbols, and demodulates and decodes data, and furthermore an advantageous effect of preventing a fall in the data transmission rate due to dummy symbols can be obtained.

[1232]

Note that in the example in FIG. 79, a frame in which “preambles”, “symbols subjected to frequency division”, “preambles”, “symbols subjected to frequency division”, “preambles”, “symbols subjected to time division”, or in other words, “preambles”, “symbols subjected to frequency division”, “preambles”, “symbols subjected to frequency division”, “preambles”, “symbol groups not subjected to frequency division” are arranged along the time axis in this order has been described, yet the present disclosure is not limited to this. For example, a frame in which “preambles”, “symbols subjected to time division”, “preambles”, and “symbols subjected to frequency division” are arranged in this order along the time axis may be adopted, or a frame in which “preambles”, “symbol groups not

subjected to frequency division", "preambles", and "symbols subjected to frequency division" are arranged in this order along the time axis may be adopted.

[1233]

A method of inserting a dummy symbol group in a data symbol group is not limited to the method illustrated in FIG. 64. The following describes an example of a method of inserting dummy symbols, which is different from the method illustrated in FIG. 64.

[1234]

The number of symbols (or the number of slots) is U in data symbol group #TFD X, data symbol group #FD Y, and data symbol group #TD Z (for example, X, Y, and Z are integers greater than or equal to 1). U is an integer greater than or equal to 1.

[1235]

First, "V (which is an integer greater than or equal to 1) which denotes the number of symbols (or the number of slots) in which data which is an integral multiple of a FEC block (having a block length of an error correction code or a code length of an error correction code) is fitted" is secured. Note that $U - \alpha + 1 \leq V \leq U$ is to be satisfied. α denotes the number of symbols (or the number of slots) necessary to transmit a block having the block length of an error correction code (code length) (unit: bit), and is an integer greater than or equal to 1.

[1236]

When $U - V \neq 0$, dummy symbols (or dummy slots) of $U - V$ symbols (or $U - V$ slots) are added. Thus, data symbol group #TFD X, data symbol group #FD Y, or data symbol group #TD Z includes data symbols of V symbols (or V slots) and dummy symbols of $U - V$ symbols (or $U - V$ slots). Each dummy symbol has a certain value for in-phase component I, and also a certain value for quadrature component Q.

[1237]

Data symbol group #TFD X, data symbol group #FD Y, and data symbol group #TD Z satisfy “including data symbols of V symbols (or V slots) and dummy symbols of U – V symbols (or U – V slots).

[1238]

Specifically, when data symbol group #TFD X, data symbol group #FD Y, and data symbol group #TD Z need to have dummy symbols (or dummy slots), dummy symbols (dummy slots) are inserted in each data symbol group.

[1239]

An example of a configuration of the base station (AP) which utilizes a dummy symbol insertion method is described.

[1240]

The configuration of the base station (AP) is the configuration in FIG. 1 in which data generator 102 and frame configuring unit 110 are replaced with those in FIG. 82. The following describes FIG. 82.

[1241]

The same reference numerals are assigned to elements in FIG. 82 which operate in the same manner as those in FIG. 1.

[1242]

Error correction encoder 8200-02-1 for data symbol group #1 receives inputs of data 8200-01-1 for data symbol group #1 (for terminal #1, for example) and control signals 8200-00 and 109. Based on information on an error correction coding method included in control signals 8200-00 and 109 such as, for example, information on an error correction code, the code length of an error correction code, and the coding rate of an error correction code, error correction encoder 8200-02-1 performs error correction coding on data 8200-01-1 for data symbol group #1, and outputs data 8200-03-1 for data symbol group #1 obtained as a result of error

correction coding.

[1243]

Similarly, error correction encoder 8200-02-2 for data symbol group #2 receives inputs of data 8200-01-2 for data symbol group #2 (for terminal #2, for example) and control signals 8200-00 and 109. Based on information on an error correction coding method included in control signals 8200-00 and 109 such as, for example, information on an error correction code, the code length of an error correction code, and the coding rate of an error correction code, error correction encoder 8200-02-2 performs error correction coding on data 8200-01-2 for data symbol group #2, and outputs data 8200-03-2 for data symbol group #2 obtained as a result of error correction coding.

Similar processing continues.

[1244]

Error correction encoder 8200-02-N for data symbol group #N (N is an integer greater than or equal to 1) receives inputs of data 8200-01-N for data symbol group #N (for terminal #N, for example) and control signals 8200-00 and 109. Based on information on an error correction coding method included in control signals 8200-00 and 109 such as, for example, information on an error correction code, the code length of an error correction code, and the coding rate of an error correction code, error correction encoder 8200-02-N performs error correction coding on data 8200-01-N for data symbol group #N, and outputs data 8200-03-N for data symbol group #N obtained as a result of error correction coding.

[1245]

Interleaver 8200-04-1 for data symbol group 1 receives inputs of data 8200-03-1 for data symbol group #1 obtained as a result of error correction coding and control signals 8200-00 and 109. Based on information on an rearrangement method included in control signals 8200-00 and 109, interleaver 8200-04-1

rearranges data 8200-03-1 for data symbol group #1 obtained as a result of error correction coding, and outputs rearranged data 8200-05-1 for data symbol group #1.

[1246]

Similarly, interleaver 8200-04-2 for data symbol group #2 receives inputs of data 8200-03-2 for data symbol group #2 obtained as a result of error correction coding and control signals 8200-00 and 109. Based on information on the rearrangement method included in control signals 8200-00 and 109, interleaver 8200-04-2 rearranges data 8200-03-2 for data symbol group #2 obtained as a result of error correction coding, and outputs rearranged data 8200-05-2 for data symbol group #2.

Similar processing continues.

[1247]

Interleaver 8200-04-N for data symbol group #N receives inputs of data 8200-3-N for data symbol group #N obtained as a result of error correction coding and control signals 8200-00 and 109. Based on information on a rearrangement method included in control signals 8200-00 and 109, interleaver 8200-04-N rearranges data 8200-03-N for data symbol group #N obtained as a result of error correction coding, and outputs rearranged data 8200-05-N for data symbol group #N.

[1248]

Mapper 8200-06-1 for data symbol group #1 receives inputs of rearranged data 8200-05-1 for data symbol group #1 and control signals 8200-00 and 109. Based on information on a modulation method included in control signals 8200-00 and 109, mapper 8200-06-1 maps rearranged data 8200-05-1 for data symbol group #1, and outputs signal 8200-07-1 for data symbol group #1 obtained as a result of mapping the data.

[1249]

Similarly, mapper 8200-06-2 for data symbol group #2 receives inputs of rearranged data 8200-05-2 for data symbol group #2 and control signals 8200-00 and 109. Based on information on a modulation method included in control signals 8200-00 and 109, mapper 8200-06-2 maps rearranged data 8200-05-2 for data symbol group #2, and outputs signal 8200-07-2 for data symbol group #2 obtained as a result of mapping the data.

Similar processing continues.

[1250]

Mapper 8200-06-N for data symbol group #N receives inputs of rearranged data 8200-05-N for data symbol group #N and control signals 8200-00 and 109. Based on information on a modulation method included in control signals 8200-00 and 109, mapper 8200-06-N maps rearranged data 8200-05-N for data symbol group #N, and outputs signal 8200-07-N for data symbol group #1 obtained as a result of mapping the data.

[1251]

Frame configuring unit 110 receives inputs of signal 8200-07-1 for data symbol group #1 obtained as a result of mapping the data, signal 8200-07-2 for data symbol group #2 obtained as a result of mapping the data, ..., and signal 8200-07-N for data symbol group #N obtained as a result of mapping the data, (quadrature) baseband signal 106 for the second preamble, and control signals 8200-00 and 109. Based on information on a frame configuration included in control signals 8200-00 and 109, examples of which are the frame configurations illustrated in, for instance, FIGS. 54 and 79, frame configuring unit 110 outputs (quadrature) baseband signal 8201_1 for stream 1 according to the frame configuration and/or (quadrature) baseband signal 8201_2 for stream 2 according to the frame configuration. Note that the frame configurations are not limited to

those illustrated in FIGS. 54 and 79.

[1252]

For example, when control signals 8200-00 and 109 designate MIMO transmission and MISO transmission, frame configuring unit 110 outputs (quadrature) baseband signal 8201_1 for stream 1 according to a frame configuration, and (quadrature) baseband signal 8201_2 for stream 2 according to a frame configuration.

[1253]

When control signals 8200-00 and 109 designate SISO transmission, frame configuring unit 110 outputs, for example, (quadrature) baseband signal 8201_1 for stream 1 according to a frame configuration.

[1254]

Note that the subsequent processing is as illustrated with reference to FIG. 1. In addition, the configurations illustrated in FIGS. 1 and 82 are examples of a configuration of a device, and the present disclosure is not limited to the configurations.

[1255]

A description of another example of a configuration of the base station (AP) is given.

[1256]

Another configuration of the base station (AP) is a configuration illustrated in FIG. 76, in which data symbol group generator 7600-00 and frame configuring unit 7600-01 are replaced with those in FIG. 83.

[1257]

The same reference numerals are assigned to elements in FIG. 83 which operate in the same manner as in FIGS. 58, 76, and 82, and description of such elements is omitted.

[1258]

Frame configuring unit 7600-01 receives inputs of signal 8200-07-1 for data symbol group #1 obtained as a result of mapping data, signal 8200-07-2 for data symbol group #2 obtained as a result of mapping data, ..., signal 8200-07-N for data symbol group #N obtained as a result of mapping data, baseband signal 5808 for a control symbol, baseband signal 5810 for a pilot symbol, and control signals 8200-00 and 5831. Based on information on a frame configuration included in control signals 8200-00 and 5831, examples of which are the frame configurations illustrated in, for instance, FIGS. 54 and 79, frame configuring unit 7600-01 outputs modulated signal 7600-02 according to the frame configuration. Note that the frame configurations are not limited to those illustrated in FIGS. 54 and 79.

[1259]

Note that the subsequent processes are as described with reference to FIG. 76. The configurations illustrated in FIGS. 76 and 83 show examples of an apparatus, but the present disclosure is not limited to the configurations.

[1260]

Examples of operation of interleaver 8200-04-1 for data symbol group #1, interleaver 8200-04-2 for data symbol group #2, ..., and interleaver 8200-04-N for data symbol group #N in FIGS. 82 and 83, for instance are described with reference to FIG. 84.

[1261]

The number of symbols (or the number of slots) in data symbol group #TFD X, data symbol group #FD Y, data symbol group #TD Z (for example, X, Y, and Z are integers greater than or equal to 1) is U. U is an integer greater than or equal to 1. The number of bits for transmitting each symbol (or each slot) is C. C is an integer greater than or equal to 1.

[1262]

"V (which is an integer greater than or equal to 1) which denotes the number of symbols (or the number of slots) in which data which is an integral multiple of a FEC block (having a block length of an error correction code or a code length of an error correction code) is fitted" is secured. Note that $U - \alpha + 1 \leq V \leq U$ is to be satisfied (α denotes the number of symbols (or the number of slots) necessary to transmit a block having the block length of an error correction code (code length) (unit: bit), and is an integer greater than or equal to 1).

[1263]

When $U - V \neq 0$, dummy symbols (or dummy slots) of $U - V$ symbols (or $U - V$ slots) are added. Thus, data symbol group #TFD X, data symbol group #FD Y, or data symbol group #TD Z includes data symbols of V symbols (or V slots) and dummy symbols of $U - V$ symbols (or $U - V$ slots). Each dummy symbol has a certain value for in-phase component I, and also a certain value for quadrature component Q.

[1264]

Data symbol group #TFD X, data symbol group #FD Y, and data symbol group #TD Z satisfy "including data symbols of V symbols (or V slots) and dummy symbols of $U - V$ symbols (or $U - V$ slots).

[1265]

Thus, when $U - V \neq 0$, the number of bits of "data for data symbols (which is an integral multiple of a FEC block (having a block length of an error correction code) or (having a code length of an error correction code) is $C \times V = A \times C \times \alpha$ bits (A is an integer greater than or equal to 1), and the number of bits of data for dummy symbols is $C \times (U - V)$.

[1266]

FIG. 84 illustrates when $U - V \neq 0$, examples of operation of interleaver

8200-04-1 for data symbol group #1, interleaver 8200-04-2 for data symbol group #2, ..., and interleaver 8200-04-N for data symbol group #N in, for example, FIGS. 82 and 83 with respect to “data for data symbols” having $C \times V = A \times C \times \alpha$ bits (A is an integer greater than or equal to 1) and “data for dummy symbols” having $C \times (U - V)$ bits.

[1267]

Part (a) of FIG. 84 illustrates an example of a configuration of data before being rearranged. For example, data is arranged in the order of data for data symbols and data for dummy symbols. Note that the arrangement of data before being rearranged is not limited to (a) in FIG. 84.

[1268]

Part (b) of FIG. 84 illustrates data obtained by rearranging the sequence of data illustrated in (a) of FIG. 84. Specifically, (b) of FIG. 84 illustrates data obtained by rearranging data of $C \times U$ bits. A method of rearranging data may be performed according to any rule.

[1269]

Mapper 8200-06-1 for data symbol group #1, mapper 8200-06-2 for data symbol group #2, ..., and mapper 8200-06-N for data symbol group #N illustrated in, for instance, FIGS. 82 and 83 map rearranged data illustrated in (b) of FIG. 84.

[1270]

Note that a method of rearranging data used by interleaver 8200-04-1 for data symbol group #1, a method of rearranging data used by interleaver 8200-04-2 for data symbol group #2, ..., and a method of rearranging data used by interleaver 8200-04-N for data symbol group #N may be the same as or different from one another.

[1271]

As described above, when “data for data symbols” and “data for dummy

symbols” are rearranged, arrangement of data symbols and dummy symbols of a data symbol group is not limited to the arrangement as illustrated in FIG. 64. For example, dummy symbols may be arranged at any position within a data symbol group along time and frequency axes. In addition, there may be a case where symbols or slots include “data” and “dummy data”.

[1272]

Interleaver 8200-05-1 for data symbol group #1, interleaver 8200-05-2 for data symbol group #2, ..., and interleaver 8200-05-N for data symbol group #N may switch between rearrangement methods for each frame. One or more (interleavers) of interleaver 8200-05-1 for data symbol group #1, interleaver 8200-05-2 for data symbol group #2, ..., and interleaver 8200-05-N for data symbol group #N may not rearrange data. For example, a configuration may be adopted in which data symbol group #FD1 (#TFD1) 7900-01 and data symbol group #FD5 (#TFD5) 7900-05 arranged at particular carriers in FIG. 79 are not rearranged. This yields an advantageous effect that a receiving apparatus can obtain data of a data symbol group at a particular carrier with less delay.

[1273]

FIG. 85 illustrates an example of a configuration of interleaver 8200-05-1 for data symbol group #1, interleaver 8200-05-2 for data symbol group #2, ..., and interleaver 8200-05-N for data symbol group #N. Note that the same reference numerals are assigned to elements which operate in the same manner as those in FIGS. 82 and 83.

[1274]

Dummy data generator 8500-01 receives an input of control signal 8200-00. Dummy data generator 8500-01 generates dummy data, based on information on dummy data included in control signal 8200-00, an example of which is the number of bits used to create dummy data, and outputs dummy data 8500-02.

[1275]

Interleaver 8500-04 receives inputs of data 8500-03 obtained as a result of error correction coding (corresponding to data 8200-03-1 for data symbol group #1 obtained as a result of error correction coding, data 8200-03-2 for data symbol group #2 obtained as a result of error correction coding, ..., and data 8200-03-N for data symbol group #N obtained as a result of error correction coding in FIGS. 82 and 83, for instance), dummy data 8500-02, and control signal 8200-00. Based on information on an interleaving method included in control signal 8200-00, interleaver 8500-04 rearranges data 8500-03 obtained as a result of error correction coding and dummy data 8500-02, and outputs rearranged data 8500-05 (corresponding to rearranged data 8200-05-1 for data symbol group #1, rearranged data 8200-05-2 for data symbol group #2, ..., and rearranged data 8200-05-N for data symbol group #N in FIGS. 82 and 83, for instance).

[1276]

Note that, for example, a method of configuring data (or dummy data) of a dummy symbol using data known to a transmitting apparatus and a receiving apparatus is conceivable.

[1277]

For example, the first preamble and/or the second preamble in a frame as illustrated in FIGS. 54 and 79 may include information such as “information relevant to a carrier and time which each data symbol group uses”, “information relevant to the number of bits (or the number of symbols) of dummy data (or dummy symbols) to be inserted in each data symbol group”, “information on a method of transmitting each data symbol group”, “information relevant to a method of modulating (or a set of methods of modulating) each data symbol group”, “information relevant to an interleaving method used by each data symbol group”, and “information relevant to an error correction code used by each data symbol group”. Accordingly, the

receiving apparatus can demodulate data symbols of each data symbol group. Note that the frame configurations are not limited to those illustrated in FIGS. 54 and 79, for instance.

[1278]

As described above, data for data symbols is arranged discretely in symbols present along the time and frequency axes by rearranging data for data symbols and dummy data, whereby time and frequency diversity gains can be obtained, so that an advantageous effect of improving quality of data received by the receiving apparatus can be obtained.

[1279]

Another example of a configuration of a base station (AP) to which a dummy symbol insertion method is applied.

[1280]

The configuration of a base station (AP) is a configuration in FIG. 1 in which data generator 102 and frame configuring unit 110 are replaced with those in FIG. 86. The following describes FIG. 86.

[1281]

The same reference numerals are assigned to elements in FIG. 86 which operates in the same manner as those in FIGS. 1 and 82, and description of such elements is omitted.

[1282]

Carrier interleaver 8600-01-1 for data symbol group #1 receives inputs of signal 8200-07-1 for data symbol group #1 obtained as a result of mapping data, and control signal 8200-00. Carrier interleaver 8600-01-1 interleaves a carrier for signal 8200-07-1 for data symbol group #1 obtained as a result of mapping data, based on information on a carrier interleaving method included in control signal 8200-00, and outputs signal 8600-02-1 for data symbol group #1 for which the

carrier has been interleaved. Note that interleaving of carriers is described later.

[1283]

Similarly, carrier interleaver 8600-01-2 for data symbol group #2 receives inputs of signal 8200-07-2 for data symbol group #2 obtained as a result of mapping data, and control signal 8200-00. Carrier interleaver 8600-01-2 interleaves a carrier for signal 8200-07-2 for data symbol group #2 obtained as a result of mapping data, based on information on a carrier interleaving method included in control signal 8200-00, and outputs signal 8600-02-2 for data symbol group #2 for which the carrier has been interleaved. Note that interleaving of carriers is described later.

Similar processing continues.

[1284]

Carrier interleaver 8600-01-N for data symbol group #N receives inputs of signal 8200-07-N for data symbol group #N obtained as a result of mapping data, and control signal 8200-00. Carrier interleaver 8600-01-N interleaves a carrier for signal 8200-07-N for data symbol group #N obtained as a result of mapping data, based on information on a carrier interleaving method included in control signal 8200-00, and outputs signal 8600-02-N for data symbol group #N for which the carrier has been interleaved. Note that interleaving of carriers is described later.

[1285]

Note that processing on portions other than this is as described with reference to FIGS. 1 and 82, and thus description thereof is omitted. In addition, the configurations illustrated in FIGS. 1 and 86 are examples of a configuration of an apparatus, and thus the present disclosure is not limited to the configurations.

[1286]

An example of another configuration of the base station (AP) is described.

[1287]

Another configuration of a base station (AP) is a configuration in FIG. 76 in which data symbol group generator 7600-00 and frame configuring unit 7600-01 are replaced with those in FIG. 87.

[1288]

The same reference numerals are assigned to elements in FIG. 87 which operate in the same manner as those in FIGS. 58, 76, 82, and 86, and description of such elements is omitted (thus, description of FIG. 87 is omitted).

[1289]

Note that FIGS. 76 and 87 illustrate examples of a configuration of an apparatus, and the present disclosure is not limited to such configurations.

[1290]

The following describes, with reference to FIG. 88, an example of operation of interleaving of carriers by carrier interleaver 8600-01-1 for data symbol group #1, carrier interleaver 8600-01-2 for data symbol group #2, ..., and carrier interleaver 8600-01-N for data symbol group #N in FIGS. 86 and 87.

[1291]

Part (a) in FIG. 88 illustrates an example of a symbol configuration of a data symbol group before interleaving of carriers, where the horizontal axis indicates time, and the vertical axis indicates frequency (carrier). As illustrated in (a) of FIG. 88, symbols at carrier $1 are named a first symbol column, symbols at carrier $2 are named a second symbol column, symbols at carrier $3 are named a third symbol column, symbols at carrier $4 are named a fourth symbol column, symbols at carrier $5 are named a fifth symbol column, symbols at carrier $6 are named a sixth symbol column, and symbols at carrier $7 are named a seventh symbol column. Thus, a data symbol group includes the first symbol column to the seventh symbol column.

[1292]

Part (b) of FIG. 88 illustrates an example of a symbol configuration of a data symbol group after interleaving of carriers.

[1293]

As illustrated in (a) and (b) of FIG. 88, the first symbol column arranged at carrier $1 before interleaving of carriers is arranged at carrier $4 after interleaving of carriers.

[1294]

The second symbol column arranged at carrier $2 before interleaving of carriers is arranged at carrier $6 after interleaving of carriers.

[1295]

The third symbol column arranged at carrier $3 before interleaving of carriers is arranged at carrier $5 after interleaving of carriers.

[1296]

The fourth symbol column arranged at carrier $4 before interleaving of carriers is arranged at carrier $2 after interleaving of carriers.

[1297]

The fifth symbol column arranged at carrier $5 before interleaving of carriers is arranged at carrier $7 after interleaving of carriers.

[1298]

The sixth symbol column arranged at carrier $6 before interleaving of carriers is arranged at carrier $1 after interleaving of carriers.

[1299]

The seventh symbol column arranged at carrier $7 before interleaving of carriers is arranged at carrier $3 after interleaving of carriers.

[1300]

As shown by the above example, carrier interleaver 8600-01-1 for data symbol group #1, carrier interleaver 8600-01-2 for data symbol group #2, ..., and

carrier interleaver 8600-01-N for data symbol group #N change the carrier positions of symbol columns. Note that interleaving of carriers in FIG. 88 is a mere example, and a carrier interleaving method is not limited to this.

[1301]

As described above, data symbols are arranged so as to increase temporal and frequency diversity gains by interleaving of carriers, and thus an advantageous effect of improving quality of data received by the receiving apparatus can be obtained.

[1302]

As a configuration of a base station (AP) which operates in the same manner as the base station (AP) having a configuration in FIG. 1 in which data generator 102 and frame configuring unit 110 are replaced with the elements in FIG. 86, a configuration in FIG. 1 in which data generator 102 and frame configuring unit 110 are replaced with the elements in FIG. 89 may be adopted.

[1303]

The same reference numerals are assigned to elements in FIG. 89 which operate in the same manner as those in FIGS. 1 and 82, and description of such elements is omitted.

[1304]

Carrier interleaver 8900-01-1 receives inputs of (quadrature) baseband signal 8201_1 for stream 1, and control signal 8200-00. Carrier interleaver 8900-01-1 interleaves carriers (see FIG. 88) based on information on interleaving of carriers included in control signal 8200-00, and outputs baseband signal 8900-02-1 obtained as a result of interleaving of carriers.

[1305]

Similarly, carrier interleaver 8900-01-2 receives inputs of (quadrature) baseband signal 8201_2 for stream 2 and control signal 8200-00. Carrier

interleaver 8900-01-2 interleaves carriers (see FIG. 88) based on information on interleaving of carriers included in control signal 8200-00, and outputs baseband signal 8900-02-2 obtained as a result of interleaving of carriers.

[1306]

Accordingly, signal processor 112 in FIG. 1 receives an input of baseband signal 8900-02-1 obtained as a result of interleaving of carriers, instead of (quadrature) baseband signal111_1 for stream 1, and receives an input of baseband signal 8900-02-2 obtained as a result of interleaving of carriers, instead of (quadrature) baseband signal111_2 for stream 2.

[1307]

In FIG. 76, as a configuration of a base station (AP) which operates in the same manner as the base station (AP) having a configuration in FIG. 76 in which data symbol group generator 7600-00 and frame configuring unit 7600-01 are replaced with the elements in FIG. 87, a configuration in FIG. 76 in which data symbol group generator 7600-00 and frame configuring unit 7600-01 are replaced with the elements in FIG. 90 may be adopted.

[1308]

The same reference numerals are assigned to elements in FIG. 90 which operate in the same manner as those in FIGS. 58, 76, and 82, and description of such elements is omitted.

[1309]

Carrier interleaver 9000-01 receives inputs of modulated signal 7600-02 and control signal 8200-00, interleaves carriers (see FIG. 88) based on information on interleaving of carriers included in control signal 8200-00, and outputs baseband signal 9000-02 obtained as a result of interleaving of carriers.

[1310]

Accordingly, radio unit 5816 in FIG. 76 receives an input of baseband

signal 9000-02 obtained as a result of interleaving of carriers, instead of modulated signal 7600-02.

[1311]

The above completes description of a method of inserting some dummy symbols or dummy data to a data symbol group. Dummy symbols or dummy data are inserted in such a manner, whereby a receiving apparatus readily sorts out data symbols, and demodulates and decodes the data symbols, and furthermore, an advantageous effect of preventing a fall in the data transmission rate due to dummy symbols or dummy data can be obtained. An advantage that one or more data symbol groups can be efficiently transmitted, or in other words, a transmission speed can be set for each data symbol group can be obtained.

[1312]

(Supplementary Note 2)

The second exemplary embodiment has described separately setting a carrier (subcarrier) interval when data symbol groups are subjected to frequency division multiplexing, and a carrier (subcarrier) interval when data symbol groups are subjected to time division multiplexing or not subjected to frequency division multiplexing. Of course, this is applicable to Exemplary embodiments C and D.

[1313]

For example, in FIG. 79, a carrier (subcarrier) interval for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-2, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted and a carrier (subcarrier) interval for a time period in which data symbol group #TD10 (#TFD10) 7900-10 is transmitted may be the same or may be different. Note that FIG. 79 illustrates an example of a frame configuration when carrier (subcarrier) intervals are “the same”.

[1314]

Note that FIG. 91 illustrates an example of a frame configuration when carrier (subcarrier) intervals are “different”. Note that a channel interval for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-2, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted and a channel interval for a time period in which data symbol group #TD10 (#TFD10) 7900-10 is transmitted is the same. Note that an occupied frequency band for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-2, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted and an occupied frequency band for a time period in which data symbol group #TD10 (#TFD10) 7900-10 is transmitted may be the same or may be different. In FIG. 91, the number of carriers (subcarriers) present in a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-2, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted is 64, whereas the number of carriers (subcarriers) present in a time period in which data symbol group #TD10 (#TFD10) 7900-10 is transmitted is 256.

[1315]

Similarly, in FIG. 79, a carrier (subcarrier) interval for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-2, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted, and a carrier (subcarrier) interval for a time period in which the first preamble (or the second preamble) is transmitted may be the same or may be different. Note that FIG. 79 illustrates an example of a frame configuration when carrier (subcarrier) intervals are “the same”.

[1316]

Note that FIG. 91 illustrates an example of a frame configuration when

carrier (subcarrier) intervals are “different”. However, a channel interval for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted, and a channel interval for a time period in which the first preamble (or the second preamble) is transmitted are the same. Note that an occupied frequency band for a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted, and an occupied frequency band for a time period in which the first preamble (or the second preamble) is transmitted may be the same or may be different. In FIG. 91, the number of carriers (subcarriers) present in a time period in which data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 are transmitted is 64, whereas the number of carriers (subcarriers) present in a time period in which the first preamble (or the second preamble) is transmitted is 256.

[1317]

In FIG. 79, a carrier (subcarrier) interval for a time period in which the first preamble is transmitted, and a carrier (subcarrier) interval for a time period in which the second preamble is transmitted may be different.

[1318]

Note that FIG. 92 illustrates an example when carrier (subcarrier) intervals are “different”. Note that a channel interval for a time period in which the first preamble is transmitted and a channel interval for a time period in which the second preamble is transmitted are the same. However, an occupied frequency band for a time period in which the first preamble is transmitted, and an occupied frequency band for a time period in which the second preamble is transmitted may

be the same or may be different. In FIG. 92, the number of carriers (subcarriers) present in a time period in which the first preamble is transmitted is 64, whereas the number of carriers (subcarriers) present in a time period in which the second preamble is transmitted is 256.

[1319]

In FIG. 79, a carrier (subcarrier) interval for a time period in which the first preamble is transmitted and a carrier (subcarrier) interval for a time period in which data symbol group #TFD10 (#TFD10) 7900-10 is transmitted may be different.

[1320]

Note that FIG. 93 illustrates an example when carrier (subcarrier) intervals are “different”. Note that a channel interval for a time period in which the first preamble is transmitted and a channel interval for a time period in which data symbol group #TFD10 (#TFD10) 7900-10 is transmitted are the same. Note that an occupied frequency band for a time period in which the first preamble is transmitted, and an occupied frequency band for a time period in which data symbol group #TFD10 (#TFD10) 7900-10 is transmitted may be the same or may be different. In FIG. 93, the number of carriers (subcarriers) present in a time period in which the first preamble is transmitted is 64, whereas the number of carriers (subcarriers) present in a time period in which data symbol group #TFD10 (#TFD10) 7900-10 is transmitted is 256.

[1321]

Note that the above description of the supplementary note has been given using the frame configuration illustrated in FIG. 79 as an example, yet an applicable frame configuration is not limited to this. An exemplary embodiment to be combined with the second exemplary embodiment is not limited to Exemplary Embodiment C and Exemplary Embodiment D. When the second exemplary embodiment is combined with Exemplary Embodiment C or with Exemplary

Embodiment D, the above description of the supplementary note is applied to the combination, and furthermore, terminals are allocated to data symbols, and dummy symbols (or dummy data) are added to the data symbols.

[1322]

In this specification, conceivable examples of data included in a data symbol group include a data packet, a packet of information on an image, a packet of audio information, a packet of information on a video or a still image, a data stream, an image stream, an audio stream, and a stream of a video or a still image. The type or a configuration of data included in a data symbol group is not limited to these.

[1323]

For example, the case where a base station (or an access point (AP), for instance) transmits a modulated signal indicated by frame configurations based on the time and frequency axes described in this specification such as those illustrated in, for example, FIGS. 2, 3, 4, 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 48, 29, 50, 51, 52, 53, 54, 63, 65, and 79 has been described, nevertheless an exemplary embodiment in which different terminals transmit data symbol groups in a frame configuration based on the time and frequency axes described in this specification is possible. The following describes this point. The frame configuration is not limited to those illustrated in the above drawings.

[1324]

For example, the following configuration may be adopted.

[1325]

For example, the case where a base station (or an access point (AP), for instance) transmits a modulated signal indicated by frame configurations based on the time and frequency axes described in this specification such as those illustrated in, for example, FIGS. 2, 3, 4, 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36,

37, 38, 48, 29, 50, 51, 52, 53, 54, 63, 65, and 79 has been described, nevertheless an exemplary embodiment in which different terminals transmit data symbol groups in a frame configuration based on the time and frequency axes described in this specification is possible. The following describes this point. The frame configuration is not limited to those illustrated in the above drawings.

[1326]

A modulated signal transmitting method used by a plurality of terminals based on the frame configuration in FIG. 94 is to be described.

[1327]

In FIG. 94, data symbol group #FD1 (#TFD1) 7900-01 is transmitted by terminal #1.

[1328]

Data symbol group #FD2 (#TFD2) 7900-02 is transmitted by terminal #2. Data symbol group #FD3 (#TFD3) 7900-03 is transmitted by terminal #3. Data symbol group #FD4 (#TFD4) 7900-04 is transmitted by terminal #4. Data symbol group #FD5 (#TFD5) 7900-05 is transmitted by terminal #5. Data symbol group #FD6 (#TFD6) 7900-06 is transmitted by terminal #6. Data symbol group #FD7 (#TFD7) 7900-07 is transmitted by terminal #7. Data symbol group #FD8 (#TFD8) 7900-08 is transmitted by terminal #8. Data symbol group #FD9 (#TFD9) 7900-09 is transmitted by terminal #9. Data symbol group #TD10 (#TFD10) 7900-10 is transmitted by terminal #10. Data symbol group #TD11 (#TFD11) 7900-11 is transmitted by terminal #11.

[1329]

FIG. 95 illustrates a state of communication between a base station (AP) and terminal #1, terminal #2, terminal #3, terminal #4, terminal #5, terminal #6, terminal #7, terminal #8, terminal #9, terminal #10, and terminal #11. Part (a) of FIG. 95 illustrates a state in which the base station (AP) transmits a modulated

signal, (b) of FIG. 95 illustrates a state in which terminal #1, terminal #2, terminal #3, and terminal #4 transmit a modulated signal, (c) of FIG. 95 illustrates a state in which terminal #5, terminal #6, terminal #7, terminal #8, and terminal #9 transmit a modulated signal, (d) of FIG. 95 illustrates a state in which terminal #10 transmits a modulated signal, and (e) of FIG. 95 illustrates a state in which terminal #11 transmits a modulated signal.

[1330]

As illustrated in FIG. 95, the base station (AP) performs “symbol transmission” 9500-01. For example, control information and data symbols are transmitted by “symbol transmission” 9500-01. At this time, the control information includes information on a terminal which is to transmit a modulated signal in a period from time t1 to time t2 in FIG. 122 (and information on frequency allocation or carrier allocation to the terminal).

[1331]

As illustrated in FIG. 95, terminal #1, terminal #2, terminal #3, and terminal #4 receive “symbol” 9500-01 transmitted by the base station (AP), and perform “symbol transmission” 9500-02.

[1332]

At this time, terminal #1 transmits data symbol group #FD1 (#TFD1) 7900-01 as illustrated in FIG. 94, terminal #2 transmits data symbol group #FD2 (#TFD2) 7900-02 as illustrated in FIG. 94, terminal #3 transmits data symbol group #FD3 (#TFD3) 7900-03 as illustrated in FIG. 94, and terminal #4 transmits data symbol group #FD4 (#TFD4) 7900-04 as illustrated in FIG. 94.

[1333]

Next, as illustrated in FIG. 95, the base station (AP) performs “symbol transmission” 9500-03. For example, control information and data symbols are transmitted by “symbol transmission” 9500-03. At this time, the control

information includes information on a terminal which is to transmit a modulated signal in a period from time t3 to time t4 in FIG. 94 (and information on frequency allocation or carrier allocation to the terminal).

[1334]

As illustrated in FIG. 95, terminal #5, terminal #6, terminal #7, terminal #8, and terminal #9 receive “symbol” 9500-03 transmitted by the base station (AP), and perform “symbol transmission” 9500-04.

[1335]

At this time, terminal #5 transmits data symbol group #FD5 (#TFD5) 7900-05 as illustrated in FIG. 94, terminal #6 transmits data symbol group #FD6 (#TFD6) 7900-06 as illustrated in FIG. 94, terminal #7 transmits data symbol group #FD7 (#TFD7) 7900-07 as illustrated in FIG. 94, terminal #8 transmits data symbol group #FD8 (#TFD8) 7900-08 as illustrated in FIG. 94, and terminal #9 transmits data symbol group #FD9 (#TFD9) 7900-09 as illustrated in FIG. 94.

[1336]

As illustrated in FIG. 95, the base station (AP) performs “symbol transmission” 9500-05. For example, control information and data symbols are transmitted by “symbol transmission” 9500-05. At this time, the control information includes information on a terminal which is to transmit a modulated signal in a period from time t5 to time t6 in FIG. 94 (and information on time allocation to the terminal).

[1337]

As illustrated in FIG. 95, terminal #10 and terminal #11 receive “symbol” 9500-05 transmitted by the base station (AP), and terminal #10 and terminal #11 perform “symbol transmission” 9500-06 and “symbol transmission” 9500-07, respectively.

[1338]

At this time, terminal #10 transmits data symbol group #TD10 (#TFD10) 7900-10 as illustrated in FIG. 94, and terminal #11 transmits data symbol group #TD11 (#TFD11) 7900-11 as illustrated in FIG. 94.

[1339]

FIG. 96 illustrates an example of a configuration of data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2, (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, data symbol group #FD4 (#TFD4) 7900-04, data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, data symbol group #FD9 (#TFD9) 7900-09, data symbol group #TD10 (#TFD10) 7900-10, and data symbol group #TD11 (#TFD11) 7900-11 when terminal #1, terminal #2, terminal #3, terminal #4, terminal #5, terminal #6, terminal #7, terminal #8, terminal #9, terminal #10, and terminal #11 transmit data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, data symbol group #FD4 (#TFD4) 7900-04, data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, data symbol group #FD9 (#TFD9) 7900-09, data symbol group #TD10 (#TFD10) 7900-10, and data symbol group #TD11 (#TFD11) 7900-11, respectively. Note that in FIG. 96, the horizontal axis indicates time and the vertical axis indicates frequency (carrier).

[1340]

As illustrated in FIG. 96, each data symbol group includes third preamble 9600-01, fourth preamble 9600-02, and data symbols 9600-03, for example.

[1341]

For example, third preamble 9600-01 includes a PSK symbol (known to a transmitting apparatus and a receiving apparatus) for signal detection, time

synchronization, and frequency synchronization, and fourth preamble 9600-02 includes an automatic gain control (AGC) symbol for the receiving apparatus to perform AGC, a pilot symbol (reference symbol) for the receiving apparatus to perform channel estimation, terminal information for the base station (AP) to identify a terminal, and a control information symbol for transmitting information on a method of modulating data symbols 9600-03 and an error correction code for data symbols 9600-03, for instance.

[1342]

Data symbols 9600-03 include data to be transmitted by a terminal to the base station (AP).

[1343]

Note that the arrangement of third preamble 9600-01, fourth preamble 9600-02, and the data symbols along the time and frequency axes is not limited to the arrangement in FIG. 96, and for example, the third preamble and the fourth preamble may be arranged at particular carriers.

[1344]

The frame configurations described in this specification based on the time and frequency axes such as those illustrated in, for example, FIGS. 2, 3, 4, 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 48, 29, 50, 51, 52, 53, 54, 63, 65, and 79 may each be a frame configuration in which a transmitting method is the SISO (or SIMO) method, a frame configuration in which a transmitting method is the MISO method, or a frame configuration in which a transmitting method is the MIMO method. Note that this applies to all the frames of all the exemplary embodiments. The frame configurations are not limited to those illustrated in the above drawings.

[1345]

Furthermore, in this specification, a description has been given using the

OFDM method as an example, yet a portion of the specification in which the OFDM method is performed can be achieved in the same manner even if a transmitting method in which multi-carrier is used is adopted.

[1346]

EXEMPLARY EMBODIMENT E

The present exemplary embodiment describes a specific example in the case where a base station (AP) transmits a modulated signal indicated by a frame configuration in FIG. 79, as described in Exemplary embodiments C and D.

[1347]

Exemplary Embodiment D has described an example in which dummy symbols (dummy slots or dummy data) are inserted to data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 present in a period from time t1 to time t2 in FIG. 79, whereas the present exemplary embodiment describes an example in which dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1348]

FIG. 97 illustrates an example of a configuration of data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 present in a period from time t1 to time t2 in FIG. 79, when dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1349]

At least one of data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 present in a period from time t1 to time t2 in FIG. 79 includes empty symbols (empty slots) 9700-02 as illustrated in FIG. 97.

FIG. 97 illustrates an example of a configuration of a data symbol group in a period from time t1 to time t2 when the horizontal axis indicates time and the vertical axis indicates frequency (carrier). In FIG. 97, 9700-01 denotes data symbols, and the base station (AP) transmits data using the symbols.

[1350]

9700-02 in FIG. 97 denotes empty symbols (or empty slots), and the base station (AP) does not transmit data using the symbols. Thus, symbols are not present in empty symbols (empty slots) 9700-02, that is, a modulated signal is not present in a time section and a frequency section which empty symbols (empty slots) 9700-02 occupy.

[1351]

FIG. 98 illustrates an example in which when the base station (AP) transmits a modulated signal using the frame configuration in FIG. 79, when one of data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 present in a period from time t1 to time t2 includes “empty symbols (empty slots)” 9700-02 is generated as illustrated in FIG. 97, the base station (AP) transmits another data symbol group using “empty symbols (empty slots)” 9700-02.

[1352]

In FIG. 98, the vertical axis indicates frequency (carrier), and the horizontal axis indicates time. The same reference numeral is assigned to a data symbol which operates in the same manner as that in FIG. 97, and description of such a data symbol is omitted. The base station (AP) transmits another data symbol using “empty symbols (empty slots)” 9700-02 in FIG. 97.

[1353]

In FIG. 98, 9800-01 is a preamble and 9800-02 is data symbol group #A,

and preamble 9800-01 and data symbol group #A (9800-02) are, for example, symbols (symbol groups) for transmitting data to new terminal #A.

[1354]

For example, preamble 9800-01 includes symbols for terminal #A to perform signal detection, time synchronization, frequency synchronization, and channel estimation, and also includes control information symbols used for generating data symbol group #A such as information on an error correction coding method, information on a modulated signal, and information on a transmitting method, and terminal #A can demodulate and decode data symbol group #A by obtaining the control information.

[1355]

Exemplary Embodiment D has described an example in which dummy symbols (dummy slots or dummy data) are inserted to data symbol group #FD5, (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 79, nevertheless the present exemplary embodiment describes an example in which dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1356]

FIG. 99 illustrates an example of a configuration of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 79, when dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1357]

At least one of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 79 includes empty symbols (empty slots) 9900-02 as illustrated in FIG. 99.

[1358]

FIG. 99 illustrates an example of a configuration of a data symbol group in a period from time t1 to time t2 when the horizontal axis indicates time and the vertical axis indicates frequency (carrier). In FIG. 99, 9900-01 denotes data symbols, and the base station (AP) transmits data using the symbols.

[1359]

9900-02 in FIG. 99 denotes empty symbols (or empty slots), and the base station (AP) does not transmit data using the empty symbols. Thus, symbols are not present in empty symbols (empty slots) 9900-02, that is, a modulated signal is not present in a time section and a frequency section which empty symbols (empty slots) 9900-02 occupy.

[1360]

FIG. 100 illustrates an example in which when the base station (AP) transmits a modulated signal using the frame configuration in FIG. 79, when one of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 includes “empty symbols (empty slots)” 9900-02 as illustrated in FIG. 99, the base station (AP) transmits another data symbol group using “empty symbols (empty slots)” 9900-02.

[1361]

In FIG. 100, the vertical axis indicates frequency (carrier), and the

horizontal axis indicates time. The same reference numeral is assigned to a data symbol which operates in the same manner as that in FIG. 99, and description of such a data symbol is omitted. The base station (AP) transmits other data symbols using “empty symbols (empty slots)” 9900-02 in FIG. 99.

[1362]

In FIG. 100, 10000-01 denotes a preamble, 10000-02 denotes data symbol group #B, and preamble 10000-01 and data symbol group #B (10000-02) are, for example, symbols (symbol groups) for transmitting data to new terminal #B.

[1363]

For example, preamble 10000-01 includes symbols for terminal #B to perform signal detection, time synchronization, frequency synchronization, and channel estimation, and also includes control information symbols used for generating data symbol group #B such as information on an error correction coding method, information on a modulated signal, and information on a transmitting method, and terminal #B can demodulate and decode data symbol group #B by obtaining the control information.

[1364]

The first preambles and the second preambles are present, and data symbol groups are subjected to frequency division in a period from time t1 to time t2 and a period from time t3 to time t4 as illustrated in FIG. 79. Then if the base station (AP) transmits data symbols, the data symbol groups subjected to frequency division are to include “empty symbols (empty slots)”.

[1365]

As described with reference to FIGS. 98 and 100, the base station (AP) transmits data symbol groups using “empty symbols (empty slots)”, whereby an advantageous effect of improvement in data transmission efficiency can be obtained in a system which includes the base station (AP) and a terminal. At this

time, although preambles are transmitted in FIGS. 98 and 100, adding the empty symbols produces an advantageous effect that a (new) terminal can recognize that a data symbol group is present. In addition, the base station (AP) transmits a preamble and a data symbol group as illustrated in FIGS. 98 and 100, whereby interference of data symbols can be prevented, that is, a plurality of data symbols are prevented from being present at the same time and at the same frequency, for instance.

[1366]

Note that the application to data symbol groups subjected to time division (or the case in which data symbol groups are arranged such that there is no time at which two or more data symbol groups are present) in FIG. 79 is described.

[1367]

Exemplary Embodiment D has described an example in which dummy symbols (dummy slots or dummy data) are inserted to data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #11 (#TFD11) 7900-11 in FIG. 79, whereas the present exemplary embodiment describes an example in which dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1368]

Data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TFD11) 7900-11 in FIG. 79 include empty symbols (empty slots) 10100-02, as illustrated in FIG. 101. FIG. 101 illustrates an example of a configuration of data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TFD11) 7900-11 when the horizontal axis indicates time and the vertical axis indicates frequency (carrier). In FIG. 101, 10100-01 denotes data symbols, and the base station (AP) transmits data using the data symbols.

[1369]

10100-02 in FIG. 101 denotes empty symbols (or empty slots), and the base station (AP) does not transmit data using the empty symbols. Thus, symbols are not present in empty symbols (empty slots) 10100-02, that is, a modulated signal is not present in a time section and a frequency section which empty symbols (empty slots) 10100-02 occupy.

[1370]

The distinguishing point in FIG. 101 is that an empty symbol (empty slot) is not present over a plurality of time sections. For example, data symbol group #TD10 (#TFD10) 7900-10 in FIG. 79 is brought into a state as illustrated in FIG. 101. At this time, empty symbols (empty slots) 10100-02 are present only at time "*50", as illustrated in FIG. 101.

[1371]

Even if a new data symbol group is transmitted in a state illustrated in FIG. 101, it is difficult to greatly improve data transmission efficiency. In addition, it is also difficult to transmit a preamble and a data symbol group at different times.

[1372]

Accordingly, when data symbol groups are subjected to time division (or data symbol groups are arranged such that there is no time at which two or more data symbol groups are present), a configuration in which new "preamble and data symbol group" are transmitted is to be applied. Note that a configuration in which new "preamble and data symbol group" are transmitted may be applied.

[1373]

As described above, by newly transmitting (a preamble and) a data symbol group, using an "empty symbol (empty slot)" in a data symbol group, an advantageous effect of improvement in data transmission efficiency can be obtained in a system which includes a base station (AP) and a terminal.

[1374]

The following describes another example in the case where the base station (AP) transmits a modulated signal indicated by a frame configuration in FIG. 79, as described in Exemplary Embodiments C and D.

[1375]

FIG. 102 illustrates an example of another configuration of a frame which a base station (AP) transmits and is different from the configuration in FIG. 79. The same reference numerals are assigned to elements which operate in the same manner as those in FIGS. 2 and 79, and description of such elements is omitted.

[1376]

A difference of the configuration illustrated in FIG. 102 from that in FIG. 79 is that a third preamble is inserted in the frame, between time t2 and time t3.

[1377]

Exemplary Embodiment D has described an example in which dummy symbols (dummy slots or dummy data) are inserted to data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 102, whereas the present exemplary embodiment describes an example in which dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1378]

FIG. 99 illustrates an example of a configuration of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 102, when dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1379]

At least one of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 in FIG. 102 includes empty symbols (empty slots) 9900-02 as illustrated in FIG. 99.

[1380]

FIG. 99 illustrates an example of a configuration of a data symbol group in a period from time t3 to time t4 when the horizontal axis indicates time and the vertical axis indicates a frequency (carrier). In FIG. 99, 9900-01 denotes data symbols, and the base station (AP) transmits data using the data symbols.

[1381]

9900-02 in FIG. 99 denotes empty symbols (or empty slots), and the base station (AP) does not transmit data using the empty symbols. Thus, symbols are not present in empty symbols (empty slots) 9900-02, that is, a modulated signal is not present in a time section and a frequency section which empty symbols (empty slots) 9900-02 occupy.

[1382]

FIG. 103 illustrates an example in which when the base station (AP) transmits a modulated signal using the frame configuration in FIG. 102 and when one of data symbol group #FD5 (#TFD5) 7900-05, data symbol group #FD6 (#TFD6) 7900-06, data symbol group #FD7 (#TFD7) 7900-07, data symbol group #FD8 (#TFD8) 7900-08, and data symbol group #FD9 (#TFD9) 7900-09 present in a period from time t3 to time t4 includes “empty symbols (empty slots)” 9900-02, as illustrated in FIG. 99, the base station (AP) transmits another data symbol group using “empty symbols (empty slots)” 9900-02.

[1383]

In FIG. 103, the vertical axis indicates frequency (carrier) and the horizontal axis indicates time, and the same reference numeral is assigned to a data symbol which operates in the same manner as that in FIG. 99, and description of such a data symbol is omitted. The base station (AP) transmits other data symbols using "empty symbols (empty slots)" 9900-02 in FIG. 99.

[1384]

In FIG. 103, 10300-01 denotes data symbol group #A, and data symbol group #B (10300-01) includes symbols (is a symbol group) for, for example, transmitting data to new terminal #B.

[1385]

For example, third preamble 10200-01 in FIG. 102 includes symbols for terminal #B to perform signal detection, time synchronization, frequency synchronization, and channel estimation, and control information symbols used for generating data symbol group #B such as information on an error correction coding method, information on a modulated signal, information on a transmitting method, and a time position and a frequency position at which data symbol group #B is present. Thus, terminal #B can demodulate and decode data symbol group #B by obtaining the control information.

[1386]

Note that in FIG. 102, the third preamble is inserted between time t2 and time t3, yet the third preamble may be inserted between time t0 and time t1. At this time, for example, at least one of data symbol group #FD1 (#TFD1) 7900-01, data symbol group #FD2 (#TFD2) 7900-02, data symbol group #FD3 (#TFD3) 7900-03, and data symbol group #FD4 (#TFD4) 7900-04 present in a period from time t1 to time t2 in FIG. 102 includes empty symbols (empty slots) 9900-02 as illustrated in FIG. 99, and data symbol group #B may be transmitted using empty symbols (empty slots) 9900-02, as illustrated in FIG. 103.

[1387]

The application to data symbol groups subjected to time division (or the case in which data symbol groups are arranged such that there is no time at which two or more data symbol groups are present) in FIG. 102 is described.

[1388]

Exemplary Embodiment D has described an example in which dummy symbols (dummy slots or dummy data) are inserted to data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TFD11) 7900-11 in FIG. 102, whereas the present exemplary embodiment describes an example in which dummy symbols (dummy slots or dummy data) are not inserted to the data symbol groups.

[1389]

Data symbol group #TD10 (#TFD10) 7900-10 and data symbol group #TD11 (#TFD11) 7900-11 in FIG. 102 include empty symbols (empty slots) 10100-02 as illustrated in FIG. 101. FIG. 101 illustrates an example of a configuration of data symbol group #10 (#TFD10) 7900-10 and data symbol group #TD11 (#TFD11) 7900-11 when the horizontal axis indicates time and the vertical axis indicates frequency (carrier). In FIG. 101, 10100-01 denotes data symbols, and the base station (AP) transmits data using the data symbols.

[1390]

10100-02 in FIG. 101 denotes empty symbols (or empty slots), and the base station (AP) does not transmit data using the empty symbols. Thus, symbols are not present in empty symbols (empty slots) 10100-02, that is, a modulated signal is not present in a time section and a frequency section which empty symbols (empty slots) 10100-02 occupy.

[1391]

The distinguishing point in FIG. 101 is that an empty symbol (empty slot) is

not present over a plurality of time sections. For example, data symbol group #TD10 (#TFD10) 7900-10 in FIG. 79 is brought into a state as illustrated in FIG. 101. At this time, as illustrated in FIG. 101, empty symbols (empty slots) 10100-02 are present only at time "*50."

[1392]

If a new data symbol group is transmitted in the state in FIG. 101, data transmission efficiency improves although the improvement is not to be greatly made. For example, if the usage does not involve high-speed data transmission, empty symbols (empty slots) 10100-02 can be effectively used for data transmission.

[1393]

At this time, third preamble 10400-01 is inserted between time t4 and time t5, as illustrated in FIG. 104 (note that in FIG. 104, the horizontal axis indicates time and the vertical axis indicates frequency, and the same reference numerals are assigned to elements which operate in the same manner as those in FIG. 79, and description of such elements is omitted). As illustrated in FIG. 105, data symbol group #C (10500-01) is transmitted using empty symbols (empty slots) 10100-02 illustrated in FIG. 101 (note that in FIG. 105, the horizontal axis indicates time and the vertical axis indicates frequency, and the same reference numeral is assigned to an element which operates in the same manner as that in FIG. 101, and description of such an element is omitted).

[1394]

In FIG. 105, data symbol group #C (10500-01) includes symbols (is a symbol group) for, for example, transmitting data to new terminal #C.

[1395]

For example, third preamble 10400-01 in FIG. 104 includes symbols for terminal #C to perform signal detection, time synchronization, frequency

synchronization, and channel estimation, and control information symbols used for generating data symbol group #C such as information on an error correction coding method, information on a modulated signal, information on a transmitting method, and a time position and a frequency position at which data symbol group #C is present. Thus, terminal #C can demodulate and decode data symbol group #C by obtaining the control information.

[1396]

Note that a frame configuration as illustrated in FIG. 105 in which data symbol group #C (10500-01) is not transmitted may be adopted.

[1397]

As described above, by newly transmitting a data symbol group using “empty symbols (empty slots)” in a data symbol group, an advantageous effect of improvement in data transmission efficiency can be obtained in a system which includes a base station (AP) and a terminal.

[1398]

Note that transmitting methods in FIGS. 100 and 102 are methods of transmitting a (new) data symbol group and a preamble, yet the base station (AP) may transmit a data symbol group and a preamble using either of the transmitting methods. Depending on the communication condition, the base station (AP) may switch between the transmitting methods in FIGS. 100 and 102, and may transmit a data symbol group and a preamble. Note that the base station (AP) may determine whether to switch between the transmitting methods in FIGS. 100 and 102, or the base station (AP) may switch between the transmitting methods according to a designation from a terminal communicating with the base station (AP).

[1399]

(Supplementary Note 3)

Exemplary embodiments C and D, for instance, have described a method in which the base station (AP) inserts a dummy symbol to a data symbol group, and Exemplary Embodiment C has described a method in which the base station (AP) arranges an empty symbol (empty slot) in a data symbol group. At this time, for each frame, the base station (AP) may switch between a method of inserting a dummy symbol to a data symbol group and a method of arranging an empty symbol (empty slot) in a data symbol group, and use the switched method.

[1400]

This specification has described the case of setting a “carrier interval” as an example of setting “the FFT size or the Fourier transform size”, yet the present disclosure is not limited to this, and “the number of subcarriers used for an OFDM modulated signal” may be set by setting “the FFT size or the Fourier transform size”.

[1401]

For example, changing “the FFT size or the Fourier transform size” means changing “the number of subcarriers used for an OFDM modulated signal”.

[1402]

Various frame configurations have been described in this specification. The base station (AP) transmits a modulated signal having a frame configuration described in this specification, using a multi-carrier method such as an OFDM method. At this time, when a terminal communicating with the base station (AP) transmits a modulated signal, the modulated signal transmitted by the terminal may be based on a single carrier method (the base station (AP) can simultaneously transmit data symbol groups to a plurality of terminals using the OFDM method, and a terminal can reduce power consumption by using a single carrier method).

[1403]

A time division duplex (TDD) method in which a terminal transmits a

modulation signal, using a portion of a frequency band used for a modulated signal transmitted by the base station (AP) may be applied.

[1404]

This specification describes operation and configurations of a base station (AP) and a terminal. For example, FIG. 74 illustrates an example of a configuration of the base station (AP), and FIG. 75 illustrates a configuration of a terminal. The number of transmission antennas is one and the number of receiving antennas is one in FIG. 74, yet as described in this specification, the MIMO transmitting method and/or the MISO method may be applied as a transmitting method, and thus the number of transmission antennas is not limited to one and may be two or more, and furthermore, the number of receiving antennas is not limited to one, and may be two or more. Similarly, the number of transmission antennas is one and the number of receiving antennas is one in FIG. 75, yet as described in this specification, the MIMO transmitting method and/or the MISO method may be applied as a transmitting method, and thus the number of transmission antennas is not limited to one and may be two or more, and furthermore, the number of receiving antennas is not limited to one and may be two or more.

[1405]

FIGS. 74 and 75 illustrate transmission antenna 7400-04, receiving antenna 7400-05, transmission antenna 7500-04, and receiving antenna 7500-05, yet transmission antennas 7400-04 and 7500-04 may each include a plurality of antennas, and receiving antennas 7400-05 and 7500-05 may each include a plurality of antennas. The following gives supplementary description with regard to these points.

[1406]

FIG. 106 illustrates an example of a configuration of transmission antennas

7400-04 and 7500-04, for example.

[1407]

Divider 10600-02 receives an input of transmission signal 10600-01. Divider 10600-02 divides transmission signal 10600-01, and outputs transmission signals 10600-03_1, 10600-03_2, 10600-03_3, and 10600-03_4.

[1408]

Multiplier 10600-04_1 receives inputs of transmission signal 10600-03_1 and control signal 10600-00. Based on information on a multiplication coefficient included in control signal 10600-00, multiplier 10600-04_1 multiplies transmission signal 10600-03_1 by the multiplication coefficient, and outputs signal 10600-05_1 obtained as a result of the multiplication, and signal 10600-05_1 obtained as a result of the multiplication is output from antenna 10600-06_1 as a radio wave.

[1409]

When transmission signal 10600-03_1 is denoted by T × 1(t) (t: time) and the multiplication coefficient is denoted by W1, signal 10600-05_1 obtained as a result of the multiplication can be represented by T × 1(t) × W1. W1 can be defined by a complex number, and thus may be a real number.

[1410]

Multiplier 10600-04_2 receives inputs of transmission signal 10600-03_2 and control signal 10600-00. Based on information on a multiplication coefficient included in control signal 10600-00, multiplier 10600-04_2 multiplies transmission signal 10600-03_2 by the multiplication coefficient, and outputs signal 10600-05_2 as a result of the multiplication, and signal 10600-05_2 obtained as a result of the multiplication is output from antenna 10600-06_2 as a radio wave.

[1411]

When transmission signal 10600-03_2 is denoted by T × 2(t) (t: time) and the multiplication coefficient is denoted by W2, signal 10600-05_2 obtained as a

result of the multiplication can be represented by T × 2(t) × W2. W2 can be defined by a complex number, and thus may be a real number.

[1412]

Multiplier 10600-04_3 receives inputs of transmission signal 10600-03_3 and control signal 10600-00. Based on information on a multiplication coefficient included in control signal 10600-00, multiplier 10600-04_3 multiplies transmission signal 10600-03_3 by the multiplication coefficient, and outputs signal 10600-05_3 obtained as a result of the multiplication, and signal 10600-05_3 obtained as a result of the multiplication is output from antenna 10600-06_3 as a radio wave.

[1413]

When transmission signal 10600-03_3 is denoted by T × 3(t) (t: time) and the multiplication coefficient is denoted by W3, signal 10600-05_3 obtained as a result of the multiplication can be represented by T × 3(t) × W3. W3 can be defined by a complex number, and thus may be a real number.

[1414]

Multiplier 10600-04_4 receives inputs of transmission signal 10600-03_4 and control signal 10600-00. Based on information on a multiplication coefficient included in control signal 10600-00, multiplier 10600-04_4 multiplies transmission signal 10600-03_4 by the multiplication coefficient, and outputs signal 10600-05_4 obtained as a result of the multiplication, and signal 10600-05_4 as a result of the multiplication is output from antenna 10600-06_4 as a radio wave.

[1415]

When transmission signal 10600-03_4 is denoted by T × 4(t) (t: time) and the multiplication coefficient is denoted by W4, signal 10600-05_4 obtained as a result of the multiplication can be expressed by T × 4(t) × W4. W4 can be defined by a complex number, and thus may be a real number.

[1416]

Note that the following may be satisfied, “the absolute value of W1, the absolute value of W2, the absolute value of W3, and the absolute value of W4 are the same”. In this case, this corresponds to a state in which a phase has been changed. Of course, the absolute value of W1, the absolute value of W2, the absolute value of W3, and the absolute value of W4 may not be the same.

[1417]

FIG. 106 illustrates an example in which each antenna includes four antennas (and four multipliers), yet the number of antennas is not limited to 4, and may include two or more antennas.

[1418]

FIG. 107 illustrates an example of a configuration of receiving antennas 7400-05 and 7500-05, for example.

[1419]

Multiplier 10700-03_1 receives inputs of received signal 10700-02_1 received by antenna 10700-01_1 and control signal 10700-00. Based on information on a multiplication coefficient included in control signal 10700-00, multiplier 10700-03_1 multiplies received signal 10700-02_1 by the multiplication coefficient, and outputs signal 10700-04_1 obtained as a result of the multiplication.

[1420]

When received signal 10700-02_1 is denoted by R × 1(t) (t: time) and the multiplication coefficient is denoted by D1, signal 10700-04_1 obtained as a result of the multiplication can be expressed by R × 1(t) × D1. D1 can be defined by a complex number, and thus may be a real number.

[1421]

Multiplier 10700-03_2 receives inputs of received signal 10700-02_2 received by antenna 10700-01_2 and control signal 10700-00. Based on information on a multiplication coefficient included in control signal 10700-00,

multiplier 10700-03_2 multiplies received signal 10700-02_2 by the multiplication coefficient, and outputs signal 10700-04_2 obtained as a result of the multiplication.

[1422]

When received signal 10700-02_2 is denoted by R × 2(t) (t: time) and the multiplication coefficient is denoted by D2, signal 10700-04_2 as a result of the multiplication can be expressed by R × 2(t) × D2. D2 can be defined by a complex number, and thus may be a real number.

[1423]

Multiplier 10700-03_3 receives inputs of received signal 10700-02_3 received by antenna 10700-01_3 and control signal 10700-00. Based on information on a multiplication coefficient included in control signal 10700-00, multiplier 10700-03_3 multiplies received signal 10700-02_3 by the multiplication coefficient, and outputs signal 10700-04_3 obtained as a result of the multiplication.

[1424]

When received signal 10700-02_3 is denoted by R × 3(t) (t: time) and the multiplication coefficient is denoted by D3, signal 10700-04_3 obtained as a result of the multiplication can be expressed by R × 3(t) × D3. D3 can be defined by a complex number, and thus may be a real number.

[1425]

Multiplier 10700-03_4 receives inputs of received signal 10700-02_4 received by antenna 10700-01_4 and control signal 10700-00. Based on information on a multiplication coefficient included in control signal 10700-00, multiplier 10700-03_4 multiplies received signal 10700-02_4 by the multiplication coefficient, and outputs signal 10700-04_4 obtained as a result of the multiplication.

[1426]

When received signal 10700-02_4 is denoted by R × 4(t) (t: time) and the multiplication coefficient is denoted by D4, signal 10700-04_4 obtained as a result

of the multiplication can be expressed by R × 4(t) × D4. D4 can be defined by a complex number, and thus may be a real number.

[1427]

Combiner 10700-05 combines signals 10700-04_1, 10700-04_2, 10700-04_3, and 10700-04_4 all obtained as a result of the multiplication, and outputs combined signal 10700-06. Note that combined signal 10700-06 can be expressed by R × 1(t) × D1 + R × 2(t) × D2 + R × 3(t) × D3 + R × 4(t) × D4.

[1428]

FIG. 107 illustrates an example in which each antenna includes four antennas (and four multipliers), yet the number of antennas is not limited to four, and may include two or more antennas.

INDUSTRIAL APPLICABILITY

[1429]

The present disclosure is widely applicable to a wireless system which transmits different modulated signals from a plurality of antennas, respectively. Moreover, the present disclosure is also applicable to a case where MIMO transmission is performed in a wired communication system having a plurality of transmission portions (for example, a PLC (Power Line Communication) system, an optical communication system, and a DSL (Digital Subscriber Line) system).

REFERENCE MARKS IN THE DRAWINGS

[1430]

102 data generator

105 second preamble generator

108 control signal generator

110 frame configuring unit

112 signal processor

114 pilot insertion unit

116	IFFT unit
118	PAPR reduction unit
120	guard interval insertion unit
122	first preamble insertion unit
124	wireless processor
126	antenna

CLAIMS

1. A transmitting method comprising:

generating a preamble, a first subframe, and a second subframe such that the first subframe is provided between the preamble and the second subframe in a time direction, the preamble carrying control information, the first subframe being generated by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources, the second subframe being generated by mapping third modulated signals of a third PLP onto time-frequency resources;

inserting pilot signals into the preamble, the first subframe, and the second subframe;

performing Inverse Fast Fourier Transform (IFFT) processing on the preamble, the first subframe, and the second subframe to generate an orthogonal frequency-division multiplexing (OFDM) signal after the pilot signals are inserted; and

transmitting the OFDM signal, wherein

the time-frequency resources in the first subframe include first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers, the first resources being adjacent to the second resources in the time direction,

the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,

the first sequence is mapped onto the first resources within a first range in the frequency direction, from a first starting position,

the second sequence is mapped onto the second resources within the first range,

the second modulated signals include a third sequence of second modulated signals and a fourth sequence of second modulated signals following the third sequence,

the third sequence is mapped onto the first resources within a second range in the frequency direction, from a second starting position,

the fourth sequence is mapped onto the second resources within the second range,

a sequence of the third modulated signals is mapped onto the time-frequency resources in the second subframe from a third starting position, and

the control information includes the first starting position, the second starting position, and the third starting position.

2. The transmitting method according to claim 1, wherein

the first starting position is a position of a resource among the first resources corresponding to a lowest frequency in the first range, and

the second starting position is a position of a resource among the first resources corresponding to a lowest frequency in the second range.

3. The transmitting method according to claim 1, wherein the second subframe is generated by mapping the third modulated signals of the third PLP and fourth modulated signals of a fourth PLP onto the time-frequency resources such that the third PLP and the fourth PLP are multiplexed in the second subframe.

4. A receiving method comprising:

receiving an orthogonal frequency-division multiplexing (OFDM) signal; and

demodulating the received OFDM signal to obtain data of at least one of a first Physical Layer Pipe (PLP), a second PLP, or a third PLP, wherein

the OFDM signal is generated by: inserting pilot signals into a preamble, a first subframe, and a second subframe such that the first subframe is provided between the preamble and the second subframe in a time direction; and then performing Inverse Fast Fourier Transform (IFFT) processing on the preamble, the first subframe, and the second subframe,

the preamble carries control information,

the first subframe is generated by mapping first modulated signals of the first PLP and second modulated signals of the second PLP onto time-frequency resources, the second subframe is generated by mapping third modulated signals of the third PLP onto time-frequency resources,

the time-frequency resources in the first subframe include first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers, the first resources being adjacent to the second resources in the time direction,

the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,

the first sequence is mapped onto the first resources within a first range in the frequency direction, from a first starting position,

the second sequence is mapped onto the second resources within the first range,

the second modulated signals include a third sequence of second modulated signals and a fourth sequence of second modulated signals following

the third sequence,

the third sequence is mapped onto the first resources within a second range in the frequency direction, from a second starting position,

the fourth sequence is mapped onto the second resources within the second range,

a sequence of the third modulated signals is mapped onto the time-frequency resources from a third starting position, and

the control information includes the first starting position, the second starting position, and the third starting position.

5. The receiving method according to claim 4, wherein

the first starting position is a position of a resource among the first resources corresponding to a lowest frequency in the first range, and

the second starting position is a position of a resource among the first resources corresponding to a lowest frequency in the second range.

6. The receiving method according to claim 4, wherein the second subframe is generated by mapping the third modulated signals of the third PLP and fourth modulated signals of a fourth PLP onto the time-frequency resources such that the third PLP and the fourth PLP are multiplexed in the second subframe.