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Jasmin Thairintr

Signature of Jasmin Thairintr

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(71) Applicant 000004329
JVC
3-12 Moriya-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken

(72) Inventor Koro Mori
c/o JVC
3-12 Moriya-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken

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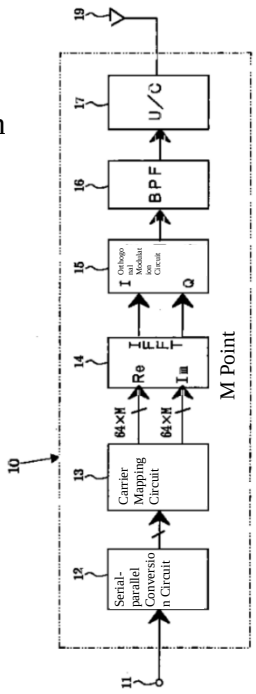
(54) [Title of Invention] GENERATION METHOD FOR MULTI-CARRIER SIGNAL, DECODING METHOD FOR MULTI-CARRIER SIGNAL, MULTI-CARRIER SIGNAL GENERATION DEVICE, AND MULTI-CARRIER SIGNAL DECODING DEVICE

(57) [Abstract]
[Problem] To realize a high-speed, large-capacity communication system that can flexibly respond to a wide range of transmission speeds, with high channel utilization and frequency utilization efficiency.
[Resolution Means] A multi-carrier signal generation device and a decoding device thereof, provided with a communication band composed of multiple unit communication bands using a predetermined number N of subcarriers having an IFFT 14 capable of simultaneously generating at least twice the number of subcarriers as N, and the subcarrier signals generated by that IFFT provided to the multiple unit communication bands are simultaneously orthogonally modulated by a common orthogonal modulation circuit 15 to obtain a transmission signal, and reception of the transmitted signal is configured to be demodulated commonly by an FFT 25, enabling simple configuration and high-speed, large-capacity data transmission.



[Scope of Patent Claims]

[Claim 1]A generation method for a multi-carrier signal comprising, in a communication band in which are arranged two or more unit communication bands for performing communication using a predetermined number N (where N is a natural number) of subcarriers, performing IFFT operations of a degree greater than or equal to twice N, and simultaneously generating the subcarrier signals provided to the two or more unit communication bands.

[Claim 2]The generation method for a multi-carrier signal according to claim 1, wherein a guard band is set between adjacent unit communication bands, and a subcarrier signal is generated in which a subcarrier signal in synchronization with the subcarrier signal is inserted into the set guard band.

[Claim 3]The generation method for a multi-carrier signal according to claim 1, wherein a guard band is set between adjacent unit communication bands, and a subcarrier signal that is in synchronization with the subcarrier signal is inserted into the set guard band, while generation excludes the subcarrier signals at the non-adjacent ends of the adjacent unit communication bands.

[Claim 4]A decoding method for a multi-carrier signal that, in a communication band in which are arranged multiple unit communication bands for performing communication using a predetermined number N (where N is a natural number) of subcarriers, simultaneously decodes the subcarrier signals supplied to multiple unit communication bands simultaneously supplied with synchronized symbol periods, comprising at least: a first step of performing FFT operations on the supplied subcarrier signals with a degree of at least twice N, and a second step of obtaining a decoded signal related to the subcarrier signals supplied simultaneously from the operation results obtained through FFT operations in the first step.

[Claim 5]A multi-carrier signal generation device, wherein, in a communication band in which are arranged two or more unit communication bands for performing communication using a predetermined number N (where N is a natural number) of sub carriers, IFFT operations of a degree greater than or equal to twice N are performed, and the subcarrier signals supplied to the two or more unit communication bands are simultaneously generated.

[Claim 6]A multi-carrier signal decoding device comprising a decoding method for a multi-carrier signal that, in a communication band in which are arranged multiple unit communication bands for performing communication using a predetermined number N (where N is a natural number) of sub carriers, decodes signals of the multiple unit communication bands supplied simultaneously, comprising FFT means for performing FFT operations on the subcarrier signals supplied to the multiple unit communication bands with a degree of at least twice N to obtain calculation results, and carrier demapping means for obtaining a decoded signal related to the signals of the multiple unit communication bands supplied simultaneously based on the operation results obtained by the FFT means.

[Detailed Description of Invention]

[0001]

[Technical Field of Invention]The present invention relates to a generation method for a multi-carrier signal for multimedia communication that can flexibly operate communication bandwidth to accommodate a wide range of transmission speeds, and has favorable channel utilization, as well as a decoding method for a multi-carrier signal, a multi-carrier signal generation device, and a multi-carrier signal decoding device.

[0002]

[Conventional Art]Conventionally, multi-carrier signal transmission technologies such as OFDM (Orthogonal Frequency Division Multiplexing) have been used and put into practical use as technologies to realize high-speed wireless LANs (local area network) and high-speed wireless access systems.

[0003]The practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four

channels spaced 20 MHz apart, and communication is conducted through each channel. FIG. 11 illustrates the channel arrangement used in the wireless access system.

[0004]In the figure, each channel has a unit communication bandwidth of 20 MHz, enabling transmission of 20 Mbps or more, and the transmission method used is OFDM, which is strong against multipath interference caused by reflected waves from buildings, walls, and the like and has high frequency utilization efficiency.

[0005]FIG. 12 illustrates an arrangement of subcarrier frequencies for one channel in the 5 GHz band wireless access system. For subcarriers in the figure, the spacing between each carrier is set to 312.5 kHz, and when the center frequency is carrier #0, there are 53 carriers from #−26 to #+26, among which carrier #0 (DC: direct current) is not used as the carrier level is set to 0, and four carriers #−21, #−7, #7, and #21 are used as pilot carriers, so an information signal is allocated to the remaining 48 carriers as data to be transmitted.

[0006]FIG. 13 illustrates a configuration of a wireless access system generation device that performs such signal transmission. In the figure, supplied serial data is converted to parallel data by a serial-parallel conversion circuit 12, and the converted parallel data is assigned to each carrier constituting OFDM by a carrier mapping circuit 13a, and the signal with data assigned is supplied to a 64-point IFFT (Inverse Fast Fourier Transform; inverse fast Fourier transform) circuit 14a.

[0007]In the IFFT circuit 14a, inverse Fourier transformation is performed based on the 64 real part data and imaginary part data supplied from the carrier mapping circuit 13a, and the supplied frequency domain data is converted into a time domain signal, and the converted real part and imaginary part signals are supplied to an orthogonal modulation circuit 15.

[0008]The conversion from frequency domain to time domain signal generally uses IFFT operations. FIG. 14 illustrates a state of signals supplied to terminals of the 64-point IFFT element used in this example of the 5 GHz band wireless access system.

[0009]In the figure, the terminals illustrated on the left indicate a state of input of a complex signal supplied when generating an OFDM signal using the IFFT element. That is, since carrier 0 (DC: direct current) that constitutes the OFDM signal is not used here, the level of the input signal is set to 0.

[0010]Also, the signal levels of inputs 27 to 37, which correspond to the frequencies at both ends of the transmission frequency band, are set to 0, suppressing the frequency spectrum components at the boundaries of adjacent frequency channels, thereby forming a guard band.

[0011]In this way, an OFDM signal having a spectrum based on the subcarrier frequency arrangement illustrated as #−26 to #−1 and #1 to #26, as illustrated in FIG. 12, is generated as a transmission signal.

[0012]Among the transmission signals, the subcarriers other than the pilot signals that transmit the information signal are modulated based on the complex signal sequence supplied to the IFFT using BPSK (bi-phase shift keying), QPSK (quadrature phase shift keying), 16QAM (16 level Quadrature Amplitude Modulation), ... or the like, and when the sampling clock frequency of the IFFT is 20 MHz, the modulated signal is generated as an OFDM signal with a subcarrier frequency interval of 312.5 kHz as the output of an IQ modulation circuit after the IFFT processing.

[0013]Note that here, the modulation by

BPSK, QPSK, 16QAM, or the like differs in the way the number of bits is allocated for each subcarrier during digital modulation in the carrier mapping circuit 13a of the generation device illustrated in FIG. 13, and for BPSK, 1 bit is allocated for one subcarrier wave, for QPSK, 2 bits are allocated, and for 16QAM, 4 bits are allocated to generate the modulated wave.

[0014]The subcarriers generated in this way are supplied to the orthogonal modulation circuit 15, where the supplied IQ (In-phase Quadrature) signal components are orthogonally modulated as signals in the intermediate frequency band, and the OFDM signal obtained through orthogonal modulation is limited to the required frequency band signal to be transmitted by the BPF 16, and the band-limited intermediate frequency signal is frequency-converted (U/C: up convert) to a signal in the frequency band of 5 GHz by a frequency conversion circuit 17, and the signal generated by frequency conversion is radiated from an antenna 19 into a spatial transmission path.

[0015]Next, the reception of the OFDM signal radiated into the spatial transmission path in this manner will be described. FIG. 15 illustrates a configuration of the OFDM decoding device and describes its operation.

[0016]In the figure, the signal radiated into the spatial transmission path is received by an antenna 21, and the received signal is down-converted (D/C) by a frequency conversion circuit 22, and the intermediate frequency band signal obtained by down-conversion has the frequency band signal necessary for demodulation selected and extracted by a BPF 23, and the extracted signal is supplied to an orthogonal demodulation circuit 24.

[0017]In the orthogonal demodulation circuit 24, the supplied signal is IQ demodulated to obtain the I and Q component signals, and the obtained signal is converted into a digital signal by an A/D converter that is not illustrated, and the converted I and Q signals are supplied to a 64-point FFT circuit 25a.

[0018]In the FFT circuit 25a, the supplied I and Q signals are converted from the time domain to the frequency domain, and demodulated output signals corresponding to the digital modulation such as BPSK, QPSK, 16QAM, and the like, applied to each subcarrier signal constituting the OFDM are obtained.

[0019]The demodulated output signals of each subcarrier obtained in the FFT circuit 25a are supplied to a carrier demapping circuit 26a, where the digitally modulated signals are decoded for each subcarrier.

[0020]The parallel data for each carrier obtained through decoding is supplied to a parallel-serial conversion circuit 27 and converted into serial data, and the converted serial data is supplied as a decoded output signal from an information signal output terminal 29 of the OFDM signal decoding device 20a.

[0021]Thus, the OFDM signal radiated from the OFDM signal generation device 10a into the spatial transmission path is received and decoded by the OFDM signal decoding device 20a, and the operation for decoding is performed based on the demodulated output of the FFT 25a that operates in synchronization with the IFFT 14a. That is, synchronization of the FFT 25a is performed based on the pilot signal illustrated in FIG. 12, and synchronization processing such as clock signal synchronization of the FFT circuit of the decoding device 20a or the like and symbol synchronization related to the window time synchronization of the FFT circuit and the like is carried out, enabling demodulation and decoding operations of the

supplied OFDM signal by the digital demodulation and decoding circuit.

[0022]Moreover, such signal synchronization is performed not only for the synchronization between the generation device and the decoding device but also for the synchronization between the information signal to be transmitted and the generation device. It is preferable that the transfer rate of the information signal supplied to the generation device is the same as the transfer rate at which the generation device transmits, but usually, the transfer rates of both are different values.

[0023]In particular, in recent years, in addition to video and audio information, various types of information referred to as multimedia information, such as character codes, still image information, graphics information, and musical instrument control information, have begun to be transmitted.

[0024]Due to the diverse content in multimedia communication that transmits such multimedia information, there is a significant difference in the transfer speeds of data treated as information, but the OFDM signal generation device and decoding device must perform the generation and decoding operations of the OFDM signal without disrupting synchronization even for information signals with large differences in data rates.

[0025]As a method of transmission for content with different transmission speeds that has been conventionally used, there are TDM (time division multiplex system) or TDMA (time division multiple access) methods.

[0026]In these transmission methods, a method is used to allocate the number of assigned slots according to a communication partner that requires speed, and by changing the modulation method of the assigned slots to BPSK, QPSK, 16QAM, and 64QAM, or the like, the rate of the information signal transmitted depending on the transmission parameters changes, such as obtaining a larger transmission rate in a method of multi-valued digital modulation despite the transmission distance becoming shorter.

[0027]In general wireless transmission systems, it is common to determine the number of transmission channels required for a given frequency bandwidth and assign the number of channels to be used according to the information to be transmitted to operate the transmission of content information.

[0028]

[Problem to Be Solved by Invention]Incidentally, with society having entered the information age, the demand for multimedia communication that transmits various contents such as images and sounds will continue to increase, and further, the high definition of video signals and the high quality of audio signals will progress, leading to the need for faster and larger capacity communication channels for higher quality information signal transmission.

[0029]In the acceleration of the communication channel, it is necessary to allocate a wide frequency bandwidth for each transmission channel, but when the bandwidth per channel is increased, the number of channels that can be operated within the allocated frequency bandwidth for the entire communication system decreases, and the like, making it impossible to significantly increase both the number of channels and the transmission speed per channel.

[0030]Furthermore, multimedia communication requires the establishment of wireless transmission and reception systems that can efficiently transmit content information even for content with diverse

transmission rates.

[0031]Furthermore, to achieve high transmission speeds, it is necessary to increase the modulation method to a higher order, but since high C/N is required for the transmission of multi-valued modulated signals, the maximum reachable distance becomes smaller.

[0032]Thus, to achieve higher transmission speeds within a limited bandwidth, it is important to eliminate waste in the use of the given frequency band and to effectively expand the practically usable bandwidth.

[0033]Therefore, for example, there is a method to flexibly operate by switching the bandwidth according to the communication speed, but to change the bandwidth, multiple filters for passband must be prepared and switched, which complicates the device.

[0034]Additionally, there is a method to perform communication by mixing wide bandwidth channels and narrow channels, but depending on the channel usage situation, there may be vacancies in the bandwidth, and it is also difficult to repurpose narrow vacant channels for wideband signal transmission channels, and the like, resulting in low bandwidth utilization efficiency in these cases as well.

[0035]Moreover, there is a method to distribute data to multiple channels only when communication at high transmission speeds is necessary, but while this allows for high transmission speeds, it still requires multiple individual modulation and demodulation devices and filters as transmission and reception means, leading to complexity and higher costs of the devices.

[0036]The present invention has been made in view of the above points, aiming to enable high-speed, large-capacity transmission, flexibly and efficiently respond to a wide range of transmission speeds, and realize a transmission system with high channel utilization and frequency utilization efficiency through a generation method of multi-carrier signals, a decoding method of multi-carrier signals, and a configuration of devices for them.

[0037]

[Means for Solving Problem]The present invention consists of the following means 1) to 6) to solve the above problems. That is,

[0038]1) A generation method for a multi-carrier signal characterized by, in a communication band in which are arranged two or more unit communication bands for performing communication using a predetermined number N (where N is a natural number) of subcarriers, performing IFFT operations of a degree greater than or equal to twice N, and simultaneously generating the subcarrier signals provided to the two or more unit communication bands.

[0039]2) The generation method for a multi-carrier signal according to 1), characterized by a guard band being set between adjacent unit communication bands, and a subcarrier signal being generated in which a subcarrier signal in synchronization with the subcarrier signal is inserted into the set guard band.

[0040]3) The generation method for a multi-carrier signal according to 1), characterized by a guard band being set between adjacent unit communication bands, and a subcarrier signal that is in synchronization with the subcarrier signal being inserted into the set guard band, while generation excludes the subcarrier signals at the non-adjacent ends of the adjacent unit communication bands.

[0041]4) A decoding method for a multi-carrier signal characterized by, in a communication band in which are arranged multiple unit communication bands for performing communication using a predetermined number N (where N is a

natural number) of subcarriers, simultaneously decoding the subcarrier signals supplied to multiple unit communication bands simultaneously supplied with synchronized symbol periods, and being provided with at least: a first step (25) of performing FFT operations on the supplied subcarrier signals with a degree of at least twice N, and a second step (26) of obtaining a decoded signal related to the subcarrier signals supplied simultaneously from the operation results obtained through FFT operations in the first step.

[0042]5) A multi-carrier signal generation device, characterized by, in a communication band in which are arranged two or more unit communication bands for performing communication using a predetermined number N (where N is a natural number) of sub carriers, performing IFFT operations of a degree greater than or equal to twice N, and simultaneously generating the subcarrier signals supplied to the two or more unit communication bands.

[0043]6) A multi-carrier signal decoding device characterized by a decoding method for a multi-carrier signal that, in a communication band in which are arranged multiple unit communication bands for performing communication using a predetermined number N (where N is a natural number) of sub carriers, decodes signals of the multiple unit communication bands supplied simultaneously, and being provided with FFT means (25) for performing FFT operations on the subcarrier signals supplied to the multiple unit communication bands with a degree of at least twice N to obtain calculation results, and carrier demapping means (26) for obtaining a decoded signal related to the signals of the multiple unit communication bands supplied simultaneously based on the operation results obtained by the FFT means.

[0044]

[Embodiments of Invention]Below, suitable examples of a generation method of a multi-carrier signal, a decoding method of a multi-carrier signal, a multi-carrier signal generation device, and a multi-carrier signal decoding device of the present invention will be described. FIG. 1 illustrates a configuration of the multi-carrier signal generation device, and FIG. 2 illustrates a configuration of the multi-carrier signal decoding device, describing the operation of these devices.

[0045]A multi-carrier signal generation device 10 illustrated in FIG. 1 is composed of an information signal input terminal 11, a serial-parallel conversion circuit 12, a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17. The transmission signal from this generation device is supplied to an antenna 19 and radiated into the spatial transmission path from that antenna.

[0046]The transmission signal supplied to the spatial transmission path is received by an antenna 21 and supplied to the multi-carrier signal decoding device for decoding operation, but the multi-carrier signal decoding device 20 is composed of a downconverter (D/C) 22, a BPF 23, an orthogonal demodulation circuit 24, an FFT (Fast Fourier Transform; fast Fourier transform) 25, a carrier demapping circuit 26, a parallel-serial conversion circuit 27, and an information signal output terminal 29.

[0047]Next, the operation of the multi-carrier signal generation device 10 and the multi-carrier signal decoding device 20, which are configured as described, will be discussed. First, the serial format information signal related to the content to be transmitted is

supplied to the serial-parallel conversion circuit 12 via the information signal input terminal 11.

[0048]In the serial-parallel conversion circuit 12, the serial format information signal is converted into a parallel format signal divided into multiple blocks, and the converted signal is then supplied to the carrier mapping circuit 13.

[0049]In the carrier mapping circuit 13, the digital modulation method for the subcarriers of the multiple blocks constituting the multi-carrier signal is selected based on whether it is BPSK, QPSK, 16QAM, 64QAM, or the like, and the corresponding voltage values for each signal point defined in the two-dimensional plane defined by the real axis (I) and the imaginary axis (Q) are selected and supplied.

[0050]That is, the voltage values defined for each signal point corresponding to the parallel format signals for each subcarrier in the serial-parallel conversion circuit 12 are generated and supplied to the IFFT circuit 14.

[0051]In this way, the IFFT circuit 14 performs an inverse Fourier transform on the frequency domain information related to the signal point positions for each subcarrier supplied for multiple computation blocks, obtaining time domain information in each IFFT circuit block, and the obtained I (In-phase) signal and Q (Quadrature) signal are supplied to the orthogonal modulation circuit 15.

[0052]In the orthogonal modulation circuit 15, an intermediate frequency signal is supplied, a digital modulated multi-carrier signal is obtained as a signal with positive and negative frequencies relative to that intermediate frequency, and the obtained signal is supplied to the BPF 16, where the necessary frequency components for transmission are passed through and obtained.

[0053]The signal that has passed through the BPF 16 is supplied to the upconverter 17, where the multi-carrier signal in the intermediate frequency band is converted into a transmission frequency signal supplied to the spatial transmission path, amplified in power, and supplied to the antenna 19, from which the supplied multi-carrier signal is radiated into the spatial transmission path.

[0054]Thus, the content information is modulated as a multi-carrier signal of multiple blocks and radiated into the spatial transmission path, and the radiated signal is received by the multi-carrier signal decoding device, where the content information is decoded.

[0055]That is, the multi-carrier signal of multiple blocks supplied to the spatial transmission path is received by the antenna 21, and the received signal is supplied to the downconverter (D/C) 22, where it is converted into an intermediate frequency signal.

[0056]The signal converted to the intermediate frequency is supplied to the BPF 23, where only the signals necessary for reception pass through, and the passed signal is supplied to the orthogonal demodulation circuit 24, where orthogonal demodulation is performed to obtain the I and Q signals of multiple blocks, and the obtained signals are supplied to the FFT 25.

[0057]In the FFT 25, the supplied I and Q signals, which are time domain signals of multiple supplied blocks, undergo a time-frequency transformation to obtain demodulated signals related to each multi-carrier signal, which are signals in the frequency domain, and the obtained demodulated signals are supplied to the carrier demapping circuit 26.

[0058]In the carrier demapping circuit 26, the demodulated signal points on the I and Q

plane for each subcarrier are obtained, and the digital data values of the positions of the modulation signal points close to the positions of these demodulated signal points are supplied as decoded data.

[0059]In this way, the data supplied in multiple parallel signal formats obtained by decoding the multi-carrier signal composed of multiple transmitted subcarriers is supplied to the serial-parallel conversion circuit 27, where it is converted into a serial signal format, and the converted data is supplied to the information signal output terminal 29.

[0060]Thus, the multi-carrier signal composed of subcarrier signals of multiple blocks is simultaneously demodulated in the FFT 25, the demodulated signals of multiple blocks obtained through demodulation are simultaneously decoded in the carrier mapping circuit 26, and the decoded signals of multiple blocks obtained through decoding are converted into a serial data format signal in the parallel-serial conversion circuit 27, and the signal obtained through decoding is supplied to the information signal output terminal 29.

[0061]As described above, the multi-carrier signal generation device 10 and the multi-carrier signal decoding device 20 are configured to be able to execute generation and decoding processes for multi-carrier signals by generating multi-carrier signals for simultaneous transmission using multiple communication bands, transmitting those signals, and receiving the transmitted multi-carrier signals of multiple communication bands collectively.

[0062]Here, the generation and decoding of the multi-carrier signal of multiple bands configured in this way will be described in detail. First, the number of unit communication bands (hereinafter referred to as bandwidth) for transmitting OFDM signals is set to M=4, and the operation when all four consecutive bandwidths are empty channels and used to transmit multi-carrier signals will be described.

[0063]The data rate handled by the multi-carrier signal generation device that generates the transmission signal for transmitting using all four bandwidths can achieve four times the data rate compared to a generation device that generates a transmission signal for only one bandwidth.

[0064]That is, when the subcarrier modulation method for each of the four bandwidths is the same, an input signal at four times the rate is supplied to the serial-parallel conversion circuit 12, from which a signal with four times the number of parallel data is supplied to the carrier mapping circuit 13, where data allocation corresponding to the subcarriers of the four communication bandwidths is made, and the signal with the data allocation is supplied to the IFFT 14.

[0065]In that IFFT 14, an IFFT operation circuit with four times the number of points compared to the IFFT operation that generates the transmission signal for one communication bandwidth is used for IFFT signal processing.

[0066]FIG. 3 illustrates the conversion from the frequency domain to the time domain of a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems. In the figure, the numbers illustrated on the left side of the IFFT operation element indicated by a rectangle represent the input side terminals, and the right side represents the output side terminals, with input terminal numbers 0 to 255 indicating the input terminal numbers in the frequency domain.

[0067]For input terminals 6 to 58, signals for digital modulation for subcarriers with channel 3 numbers from -26 to +26 are

supplied, and similarly, for input terminals 70 to 122, 134 to 186, and 198 to 250, signals for digital modulation for subcarriers of channels 4, 1, and 2 are supplied, while other terminals are supplied with a voltage of 0 (Null) to set the output signal of the subcarriers to 0.

[0068]As a result of supplying such signals and performing IFFT operations, time domain output signals are obtained at output terminals 0 to 255, but for signals obtained in this way, signals for a frequency domain for Bi+2 are supplied to input terminals 6 to 58, those for Bi+3 to 70 to 122, those for Bi to 134 to 186, and those for Bi+1 to 198 to 250, and these supplied frequency domain signals are converted into time domain signals, resulting in output signals obtained at the terminals illustrated on the right side of the figure in time order.

[0069]Next, the frequency distribution of the signal obtained by supplying the output signal obtained in this way to the orthogonal modulation circuit 15 will be described. FIG. 4 illustrates the frequency band and the positions of the subcarrier frequencies within that band.

[0070]In the figure, the horizontal axis represents frequency, and the vertical axis represents the level of the signal spectrum. That is, the frequency bands are in the order of Bi, Bi+1, Bi+2, and Bi+3 from the left side, and to the left of each frequency band, carriers from the negative 26th to the positive 26th carrier exist.

[0071]In this way, the modulation signals for the four bands from Bi to Bi+3 are generated simultaneously by the aforementioned IFFT illustrated in FIG. 3. Note that the sampling clock frequency for operating the IFFT at this time needs to perform calculations at a higher speed compared to the IFFT that generates the modulation signal for one bandwidth, and the circuit section that generates the output signal in the final time domain (domain) will operate the output circuit at four times the frequency clock, sequentially reading the signals from the IFFT output terminal side.

[0072]Thus, the operation for obtaining the modulation signals of four consecutive bandwidths with one IFFT has been described, and next, the operation when three of the four bandwidths are secured as vacant channels and communication is performed using those three bandwidths will be described.

[0073]FIG. 5 illustrates an example of communicating using the bandwidth of empty channels excluding the bandwidth in communication. In the figure, the horizontal axis is the frequency axis, and the frequency band that is already being communicated is indicated as a) and the bandwidth for communication using vacant channels is indicated as b) on this frequency axis.

[0074]That is, among the communication bandwidths B1 to B8, B3 indicated as a) is already used by user A, and B6 and B7 are already used by user B, while user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4, B5, and B8 bandwidths.

[0075]Here, since three consecutive bandwidths are not available, in conventional cases, communication was to be held until three consecutive bandwidths became available, but in the generation and decoding device illustrated in this example, it is possible to generate multi-carrier signals for communication using B1, B2, and B4 as illustrated in b), even though they are not consecutive.

[0076]In generation of such multi-carrier signals using non-consecutive bandwidths, the output signals of the bandwidths Bi to Bi+3 corresponding to B1 to B4 are generated using the IFFT elements illustrated

in FIG. 3, and the output signal of the Bi+2 channel has the signal level supplied to 3#-26 to 3#26 set to 0, thereby setting the carrier level of that bandwidth to 0.

[0077]In this way, a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal generation device as illustrated in FIG. 1.

[0078]Thus, the bit rate of the information signal that can be transmitted by the multi-carrier signal using three bandwidths as the communication bandwidth can achieve three times the rate of transmitting one bandwidth.

[0079]Therefore, when the multi-carrier signal modulation method of the multi-carrier signal generation device 10 is the same, the transmission rate of the information signal supplied to the input terminal 11 is set to three times the rate when using one bandwidth, and the parallel output signal of the serial-parallel conversion circuit 12 is supplied to the carrier mapping circuit 13 as parallel data with three times the amount of data per symbol time.

[0080]In the carrier mapping circuit 13, data allocation is performed for digital modulation for each subcarrier of the three communication bandwidths, and no data allocation is made for the subcarrier of bandwidth B3, which is not used because user A is using it.

[0081]In this way, by setting the input signal level of the subcarriers for bandwidth B3 to 0 at the terminal in the IFFT 14, the time-domain signal obtained from the IFFT 14 will be generated as a multi-carrier transmission signal that has the spectrum of subcarrier signals only in the three bandwidths of B1, B2, and B4, as illustrated in FIG. 5b).

[0082]The multi-carrier signal supplied from the multi-carrier signal generation device 10 to the spatial transmission path via the antenna 19 is received and decoded by the multi-carrier signal decoding device 20, and the receiving operation of the multi-carrier signal decoding device 20 will be described next.

[0083]The FFT 25 in the multi-carrier signal decoding device 20 has an input terminal for 256 time-domains corresponding to the IFFT illustrated in FIG. 3, or has a serial signal input terminal for sequentially inputting 256 time-domain signals, and 256 point FFT operations are performed to generate output signals of the 256 frequency domains by performing FFT operations on the signals supplied to the terminal.

[0084]A decoding device that receives a normal single-channel OFDM signal may be realized using a 64-point FFT, but the multi-carrier signal decoding device 20 having this 256-point FFT may simultaneously demodulate the multi-carrier signals of four channels supplied as signals of the same symbol period and simultaneously decode the demodulated data.

[0085]Then, it may receive signals from any channel among the four consecutive channels, and for example, it may also receive the signal illustrated as b) in FIG. 5.

[0086]FIG. 6 illustrates the frequency spectrum of the received signal when receiving that signal. In the figure, the horizontal axis represents the frequency axis, and the vertical axis illustrates the spectrum of the received signal.

[0087]Among the received signal spectrum, the three bandwidths B1, B2, and B4 illustrate the spectrum obtained by receiving the received signals that are in a synchronized state at the same symbol time, while B3 is illustrated as a round-shaped signal indicating that it is a signal that is not in a synchronized state.

[0088]That is, the decoding of a signal with

such a spectrum distribution is performed as follows: the signal obtained from the antenna 21 is supplied to the downconverter 22 and converted to an intermediate frequency, the converted signal is supplied to the BPF 23, where the signal components of the frequency bandwidth necessary for demodulation are frequency-selected, and the resulting signals for the four communication bandwidths are A/D converted by an A/D converter that is not illustrated and then supplied to the FFT 25.

[0089]Then, in the FFT 25, the four bandwidth signals B1 to B4 are converted from time-domain signals to frequency-domain signals, and the data of user C in the three bandwidths B1, B2, and B4, which are in a synchronized relationship in a symbol time or the like, is decoded, while the data of user A in bandwidth B3 is communicating asynchronously with user C, so that asynchronous B3 signal is computed and supplied by FFT 25 as an unnecessary noise signal component.

[0090]Therefore, for signals supplied from FFT 25 to the carrier demapping circuit 26, signals corresponding to the three bandwidths B1, B2, and B4 that user C is using for communication is selected, and the received data that has been mapped and transmitted to subcarriers is supplied to the carrier demapping circuit 26.

[0091]In the carrier demapping circuit 26, the digital data from the supplied data is decoded in a manner corresponding to the carrier mapping, and the decoded data gained is supplied to the parallel-serial conversion circuit 27, where the parallel data obtained for each subcarrier is converted to serial data by a method corresponding to the multi-carrier signal generation device and supplied to the information signal output terminal 29.

[0092]In this way, the signal transmitted using multiple bandwidths is received simultaneously, and the decoded signal is obtained, but the channel allocation information related to the allocation of the multiple bandwidths used at that time may be transmitted, for example, by the channel information at the beginning of the transmission signal, thereby transmitting the multiple channel information assigned there to the decoding device.

[0093]For this channel assignment information, a method may be used in which multiple channel allocation information is also transmitted along with information regarding the transmission parameters of the data frame, such as a preamble signal for acquiring synchronization signals to be transmitted prior to transmitting the modulated subcarriers, the modulation method related to the multi-level modulation of the transmitted data, the coding rate, and the like.

[0094]Furthermore, that information may be transmitted over all communication bandwidths used, or a specific frequency bandwidth may be designated as a transmission parameter transmission bandwidth, for example, the bandwidth positioned at the lowest frequency, and the transmission parameters may be included and transmitted in that bandwidth.

[0095]The above describes a case where information signals are transmitted using multiple bandwidths, but the transmission channel changes the transmission characteristics of the bandwidth according to the usage status of that bandwidth or adjacent bandwidths, and a method is adopted to change the modulation order of the digital modulation or the coding rate of the digital modulation according to the bandwidth, then transmit.

[0096]Even in such cases, as long as the

symbol periods are the same, that is, when the window periods of the IFFT 14 and the FFT 25 are the same, it is possible to generate and decode information signals even when different transmission rates are set for each band.

[0097]The setting of the communication parameters changes according to the digital modulation type of the transmitted subcarriers, such as BPSK (bi-phase shift keying), QPSK (quadrature phase shift keying), and 16QAM (16-level Quadrature Amplitude Modulation).

[0098]Moreover, in cases where means are adopted for transmitting with added error correction codes such as convolutional codes or Reed-Solomon codes for error correction of the transmitted data (Forward Error Correction; FEC), the transmission rate of the information signal also changes.

[0099]Then, in cases where such FEC circuits are used, the FEC circuit is inserted in front of the serial-parallel conversion circuit illustrated in FIG. 1 on the generation side, and the FEC circuit is inserted after the parallel-serial conversion circuit 27 illustrated in FIG. 2 on the decoding side, allowing for correction of erroneous data that occurs during data transmission.

[0100]Next, an example of transmission parameters when using multi-level modulation and FEC circuits will be described. A first parameter example is when the FEC coding rate R = 3/4, each subcarrier is modulated with QPSK, and multimedia content is transmitted at a speed of 72 Mbps using four frequency bands.

[0101]In this case, the number of subcarriers used for data transmission in one band is 48 waves, the symbol period length is 4 μs, and when the digital modulation of the carrier is QPSK, 2 bits may be transmitted per carrier wave during the symbol period, and since the coding rate R is 3/4, the total transmission speed when assuming transmission using all four bands is calculated as 2 bits × 48 waves × 1 / (4×10^{-6} seconds) × (3/4) × 4 = 72 Mbps.

[0102]A second parameter example is the parameters when transmitting the 72 Mbps information signal using three of the four bands, the digital modulation of the subcarriers is 16QAM, which allows for 4 bits per carrier, and when a coding rate R is set to 1/2 to enhance correction capability, the total transmission speed for the three bands is 4 bits × 48 waves × 1 / (4×10^{-6} seconds) × (1/2) × 3 = 72 Mbps.

[0103]In the second parameter example, since the modulation is changed from QPSK to 16QAM compared to the first parameter example, the required C/N (carrier to noise ratio) is expected to increase, and the error rate is expected to increase, therefore, by reducing the coding rate from 3/4 to 1/2, the correction capability for erroneous signals is enhanced, reducing the increase in data bit errors, allowing for the transmission of 72 Mbps with three bands as with four bands.

[0104]Furthermore, when using those three bands, the positions of each band may be consecutive three bands, or as illustrated in b) of FIG. 5, they may be three bands in which bands between the three bands are being used by another user.

[0105]The above has illustrated parameter examples for transmitting an information signal of 72 Mbps using three or four bands, and next, an example for transmitting an information signal of 96 Mbps will be described.

[0106]A third parameter example is when the signal of the multimedia content of 96 Mbps is transmitted using four bands, with the FEC coding rate R = 1/2, and each subcarrier is digitally modulated with 16QAM.

[0107]In this case, when transmitting using

four bands, the transmission rate is calculated as 4 bits × 48 waves × 1 / (4×10^{-6} seconds) × (1/2) × 4 = 96 Mbps.

[0108]A fourth parameter example is when transmitting the information signal of 96 Mbps using three bands available for transmission among the four bands, where the digital modulation of the carrier is 16QAM and the coding rate R is set to 3/4, resulting in a transmission speed of 4 bits × 48 waves × 1 / (4×10^{-6} seconds) × (3/4) × 3 = 108 Mbps.

[0109]In this fourth example, since the coding rate is increased from 1/2 to 3/4, the correction capability decreases, and the maximum transmission distance becomes smaller, therefore, data of the difference of 12 Mbps between 108 Mbps and 96 Mbps is transmitted by adding error correction signals such as Reed-Solomon to improve transmission quality degradation.

[0110]A fifth parameter example is when using three available bands for the 96 Mbps signal, where the digital modulation of the carrier is 16QAM and the coding rate R is set to 2/3, resulting in a transmission speed of 4 bits × 48 waves × 1 / (4×10^{-6} seconds) × (2/3) × 3 = 96 Mbps.

[0111]In this fifth example, the coding rate has been changed from 1/2 to 2/3 compared to the third example, but it is possible to transmit content data of 96 Mbps using three bands.

[0112]The above has illustrated five parameter examples for transmitting digital data using multi-carrier signals using three or four bands. Moreover, the subcarriers transmitted in those bands are not arranged continuously even when transmitted in adjacent bands, and guard bands are provided between those bands.

[0113]The guard band is designed to transmit by inserting 53 carriers into a band where 64 carriers can be placed, which is done by assigning null data when generating subcarriers using IFFT.

[0114]FIG. 7 illustrates a terminal diagram of an IFFT element used to describe a 64-point IFFT for communication in a conventional single band. The 64-point IFFT in the figure is designed so that the input values at input terminals 27 to 37 are set to zero, preventing the generation of components for subcarriers #−32 to #−27 and #+27 to #+31, thereby reducing the spectrum components at both ends of the band.

[0115]This is also true for the IFFT illustrated in FIG. 3, where, for example, the subcarrier signals for transmission in band Bi+2 are supplied to terminals 6 to 58, and null signals are provided to terminals 0 to 5 and 59 to 63, and in accordance with the subcarrier arrangement following the conventional communication method that prevents signal interference between adjacent bands.

[0116]By establishing such guard band areas, communication may be conducted with reduced interference between adjacent bands, which is necessary for multiple users to independently use one band for communication.

[0117]However, as illustrated in the previous example, when communicating using multiple bands, when those bands that exist continuously, there is no need to provide such guard bands. This is because the OFDM signals of multiple bands generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another.

[0118]Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for

the omission of guard bands.

[0119]Therefore, communication of multi-carrier signals using multiple consecutive bands does not require suppression of the signal components in the guard band areas between the consecutive bands, allowing for the arrangement of subcarrier signals that are in synchronization.

[0120]FIG. 8 illustrates a state where subcarriers are arranged consecutively in bands that are used continuously. In the figure, the horizontal axis represents the frequency axis, and the vertical axis illustrates the spectrum of the multi-carrier signal.

[0121]The signal spectrum illustrated in c) is for transmitting signals using three bands B1, B2, and B4, where consecutive multi-carrier signals are arranged between the adjacent bands B1 and B2.

[0122]In d), consecutive multi-carrier signals are arranged between the consecutive bands B3 and B4, and in e), since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3.

[0123]By continuously arranging multi-carrier signals in this way, it is possible to increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate.

[0124]In the case of the IFFT illustrated in FIG. 3, the input values at input terminals 187 to 197 are set to zero, but in the case of c), because subcarrier signals inserted between bands B1 and B2 are generated, data allocation may be made for 10 subcarriers at 10 input terminals excluding input terminal 192 among input terminals 187 to 197.

[0125]The increase in transmission rate due to the increase in subcarriers in that case allows for the addition of 10 subcarriers in the guard band area to 144 carriers (48 waves × 3 bands), resulting in an increase rate of about 7%.

[0126]Furthermore, when three continuous bands B1, B2, and B3 are available as in e), data may be allocated to 10 subcarriers each between B1 and B2 and between B2 and B3, totaling 20 subcarriers, resulting in an increase in transmission rate of about 14%.

[0127]Moreover, when communication is conducted using four consecutive bands, data allocation may be made to a total of 30 subcarriers, resulting in an increase in transmission rate of about 16% (30/192).

[0128]FIG. 9 illustrates the carrier arrangement when adding such subcarriers. In the figure, f) illustrates an arrangement of subcarriers having conventional guard bands, while g) illustrates a case where subcarriers are arranged consecutively in consecutive bands.

[0129]Thus, the increase in subcarriers obtained in this way may be used to transmit additional information, such as adding error correction codes as additional information, thereby increasing the number of modulation levels in digital modulation or increasing the coding rate to a large value, which may ultimately increase the transmission rate by correcting the resulting error signals.

[0130]Then, the subcarrier signal used additionally for the increase of the transmission rate, when decoded in a multi-carrier signal decoder that does not have the function to decode subcarriers within the guard band, may have a slight increase in data error rate, but since the information signals transmitted within the normal bandwidth may still be decoded, there are no significant drawbacks such as a substantial loss of transmitted information.

[0131]In this way, the area of the guard band may be effectively utilized, and next, other utilization methods will be described. FIG. 10 illustrates a method of utilizing the guard

band to narrow the transmission bandwidth. In the figure, f) illustrates the spectrum when transmitting data using two bands B1 and B2, which are the same as f) in FIG. 9, and h) illustrates the spectrum when subcarriers are arranged in the guard band between those bands.

[0132]That is, the spectrum illustrated in h) increases the number of data carriers by allocating subcarrier data to the guard band between the consecutive bands B1 and B2, but the number of allocations for the subcarriers on both sides of the increased bandwidth is reduced accordingly.

[0133]By doing so, the subcarriers on the left side of band B1 and the right side of B2 are reduced, thereby suppressing the spread of the spectrum in each band and further reducing interference to adjacent channels.

[0134]This may particularly reduce the impact of interference on adjacent stations when weak electric field communication is being conducted near this generation device, so when determining whether to assign and communicate with an adjacent channel while an adjacent station is communicating, when using the multi-carrier signal generation device in which interference to the adjacent station may be set low in advance, the adjacent channel is set and assigned as a vacant channel, and communication may begin.

[0135]That is, in order for the multi-carrier signal generation device and the decoding device to set the communication channels, they perform a search for vacant channels using means such as carrier sensing, which is not illustrated, for the communication channels where transmission is permitted, making it easier to set the communication channels at that time.

[0136]As described above, an example of assigning multiple communication channels using an IFFT that may generate OFDM signals for four bands has been illustrated, but this method may be expanded, for example, by using a 512-point IFFT that is 8 times the order of 64 to generate multi-carrier signals for eight bands, or by using a 1024-point IFFT that is 16 times the order to generate multi-carrier signals for sixteen bands.

[0137]In these cases, it is necessary to increase the computation speed of the IFFT as the multiplier increases, but in that case, it becomes easier to set the used channels so that communication may be conducted using any three vacant channels among the, for example, sixteen channels.

[0138]Then, the reception of multiple OFDM signals transmitted in distant bands as done in this way may be performed by a decoding device using an FFT of 8 times or 16 times the order or the like, as with the generation device.

[0139]As detailed above, according to the embodiment illustrated here, these are a multi-carrier signal generation device and a decoding device that perform the generation and decoding processes of signals transmitted to a communication bandwidth corresponding to multiple times the unit communication bandwidth, enabling multimedia communication that can accommodate transmission speeds from medium-speed communication using a single unit communication band to high-speed communication using multiple unit communication bandwidths.

[0140]Furthermore, in an environment where a large number of individual users (transmitting stations) coexist and are used under rules such as individual carrier sensing without a base station or without a control station, even if the unit communication bands acting as vacant channels are not consecutive,

high-speed communication may be conducted using multiple unit communication bands, and even when the vacant channel unit communication bands are not consecutive, communication using those vacant channels can be performed, thus increasing the channel utilization rate.

[0141]Moreover, when communicating using multiple consecutive unit communication bands, the method of utilizing a guard band between those unit communication bands for communication increases frequency utilization efficiency and can further enhance the transmission speed of the information signals.

[0142]Additionally, when communicating using multiple consecutive unit communication bands, it is also possible to conduct communication that reduces interference to adjacent channels by utilizing the guard band between those unit communication bands and reducing the multi-carrier signals on both the low and high sides of the consecutive unit communication bands, thereby suppressing the spread of the spectrum.

[0143]Furthermore, the generation device and decoding device can be configured with only one system of IFFT or FFT and filter corresponding to a number of points that is multiple times the unit communication bandwidth, enabling the transmission or reception of signals for multiple unit communication bands.

[0144]Thus, in a wireless transmission system where the communication bandwidth consists of N unit communication bands (N is a positive integer) of a predetermined bandwidth, a multi-carrier signal generation device can be realized having transmission means for M consecutive unit communication bandwidths (M is a positive integer less than or equal to N) enables high-speed transmission using multiple (≤M) unit communication bands capable of transmission detected by means such as carrier sensing among the multiple (M) unit communication bands, generating carriers by allocating data only to subcarriers corresponding to the unit communication bands capable of transmission, and ensuring that carriers are not generated for unit communication bands that should refrain from transmission as detected by means such as carrier sensing.

[0145]In addition, in the multi-carrier signal decoding device that receives the signals generated and transmitted by the generation device, a multi-carrier signal decoding device is configured having receiving means for M consecutive unit communication bandwidths (≤N), and among the decoded data obtained by demodulating from the multi-carrier signal of the M unit communication bands, the received data is extracted from the decoded data corresponding to the unit communication bands used by the generation device, thus enabling the decoding of the transmitted information signals.

[0146]At this time, the generation device transmits information about which combination of unit communication bands is being used for transmission by a predetermined unit communication band, notifying the decoding device at the beginning of the transmission signal, and the decoding device performs decoding of the signals obtained from all necessary receiving channels.

[0147]Through these means, high-speed transmission becomes possible, and a multi-carrier signal generation device and decoding device that can accommodate a wide range of transmission speeds from low to high using one type of generation device and decoding device that processes M unit communication

bandwidths collectively can be configured.

[0148]When communicating using multiple unit communication bands, those unit communication bands can communicate even when they are not consecutive, thus improving channel utilization efficiency.

[0149]Even when there are adjacent vacant channels capable of transmission, by allocating data to the multi-carrier signal located in the guard band between the normal unit communication bands, it is possible to achieve a higher transmission speed without interfering with adjacent stations.

[0150]

[Effect of Invention]According to the invention described in claim 1, it is possible to simultaneously generate subcarrier signals transmitted in different unit communication bands, thereby simplifying the signal processing for multi-carrier signal generation and flexibly accommodating a wide range of transmission speeds, providing a method for generating multi-carrier signals for transmitting high-speed, large-capacity information signals with high channel utilization and frequency utilization efficiency.

[0151]Furthermore, according to the invention described in claim 2, particularly by inserting subcarrier signals into the guard band part of adjacent unit communication bands to transmit information signals, in addition to the effects of claim 1, it is possible to provide a method for generating multi-carrier signals that increase the transmission bit rate.

[0152]Furthermore, according to the invention described in claim 3, particularly by inserting subcarrier signals into the guard band part of adjacent unit communication bands to transmit information signals while ensuring that subcarrier signals are not transmitted at the opposite end of the adjacent side of the unit communication band, in addition to the effects of claim 1, it is possible to provide a method for generating multi-carrier signals that reduces interference with other adjacent transmission signals.

[0153]According to the invention described in claim 4, it is possible to simultaneously decode subcarrier signals transmitted by different unit communication bands, thereby simplifying the signal processing for multi-carrier signal receiving and flexibly accommodating a wide range of transmission speeds, and to provide a method for decoding multi-carrier signals for receiving high-speed, large-capacity information signals with high channel utilization and frequency utilization efficiency.

[0154]According to the invention described in claim 5, it is possible to simultaneously generate subcarrier signals transmitted in different unit communication bands, thereby simplifying the signal processing for multi-carrier signal generation and flexibly accommodating a wide range of transmission speeds, and to provide a configuration of a multi-carrier signal generation device for transmitting high-speed, large-capacity information signals with high channel utilization and frequency utilization efficiency.

[0155]According to the invention described in claim 6, it is possible to simultaneously decode subcarrier signals transmitted by different unit communication bands, thereby simplifying the signal processing for multi-carrier signal receiving and flexibly accommodating a wide range of transmission speeds, and to provide a configuration of a multi-carrier signal decoding device for receiving high-speed, large-capacity information signals with high channel utilization and frequency utilization efficiency.

[Brief Description of Drawings]

[FIG. 1]A schematic block diagram of a multi-carrier signal generation device according to an embodiment of the present invention.

[FIG. 2]A schematic block diagram of a multi-carrier signal decoding device according to an embodiment of the present invention.

[FIG. 3]A 256-point IFFT processor performing 64-point IFFT operations in four systems according to an embodiment of the present invention.

[FIG. 4]A diagram illustrating the communication bandwidth and the position of the arranged subcarrier frequencies according to an embodiment of the present invention.

[FIG. 5]A diagram illustrating the state of communication performed using a vacant channel bandwidth according to an embodiment of the present invention.

[FIG. 6]A diagram illustrating a received signal frequency spectrum when communicating using multiple bandwidths according to an embodiment of the present invention.

[FIG. 7]A diagram illustrating the relationship between the terminals and signals of the 64-point IFFT used when communicating in a single bandwidth.

[FIG. 8]A diagram illustrating an arrangement of consecutive subcarriers in consecutive bandwidths according to an embodiment of the present invention.[FIG. 9]A diagram for describing a consecutive arrangement of subcarriers according to an embodiment of the present invention.

[FIG. 10]A diagram illustrating an arrangement of subcarriers arranged consecutively, reducing the bandwidth according to an embodiment of the present invention.

[FIG. 11]A diagram illustrating a channel arrangement used in conventional wireless access systems.

[FIG. 12]A diagram illustrating an arrangement of subcarrier frequencies for one channel in a conventional 5 GHz band wireless access system.

[FIG. 13]A diagram illustrating a configuration of a conventional wireless access system generation device.

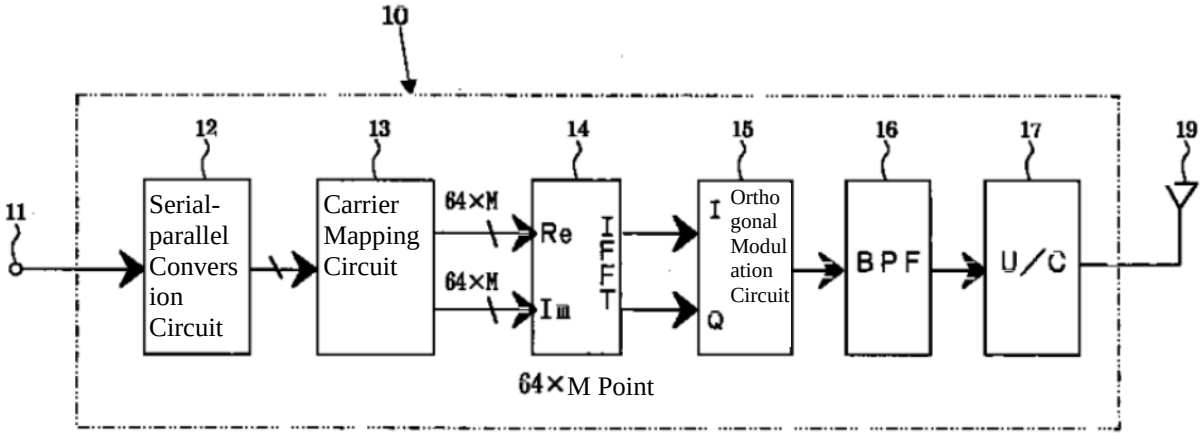
[FIG. 14]A diagram illustrating the relationship between the 64-point IFFT terminal and the supplied signal in a conventional wireless access system.

[FIG. 15]A diagram illustrating a configuration of a conventional OFDM signal decoding device.

[Description of Reference Numerals]

10, 10a Multi-carrier signal generation device
11 Information signal input terminal
12 Serial-parallel conversion circuit
13, 13a Carrier mapping circuit
14, 14a IFFT circuit
15 Orthogonal modulation circuit
16 BPF
17 Upconverter
19 Antenna
20, 20a Multi-carrier signal decoding device
22 Downconverter
23 BPF
24 Orthogonal demodulation circuit
25, 25a FFT
26, 26a Carrier demapping circuit
27 Parallel-serial conversion circuit
29 Information signal output terminal

[FIG. 1]


10
11
12
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14
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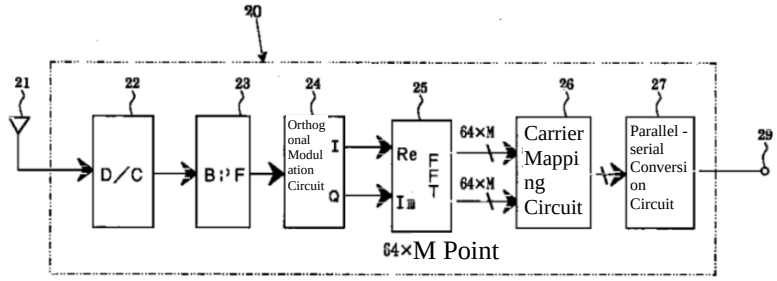
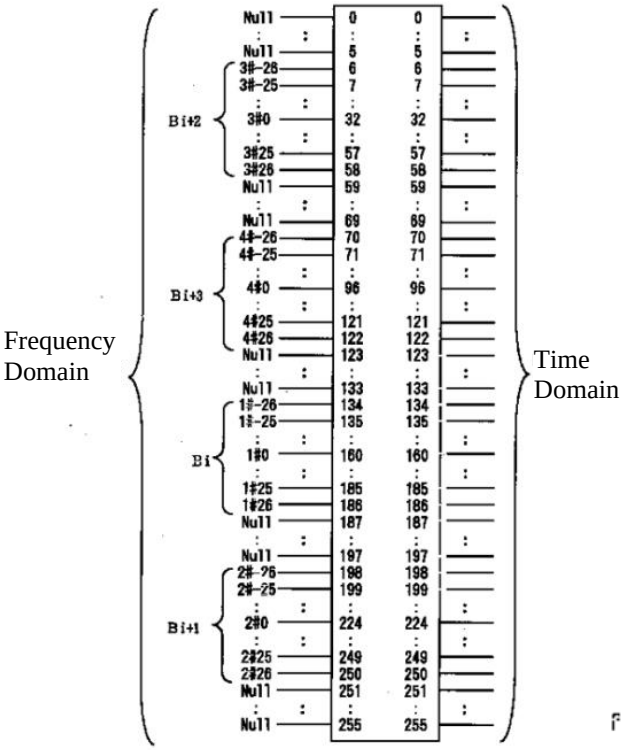
16
17
19
Serial-parallel Conversion Circuit
Carrier Mapping Circuit
64×M
64×M
Re
Im
IFFT
I
Q
Orthogonal Modulation Circuit
BPF
U/C
64×M Point

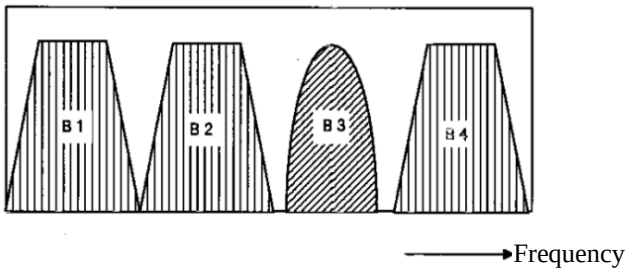
[FIG. 2]



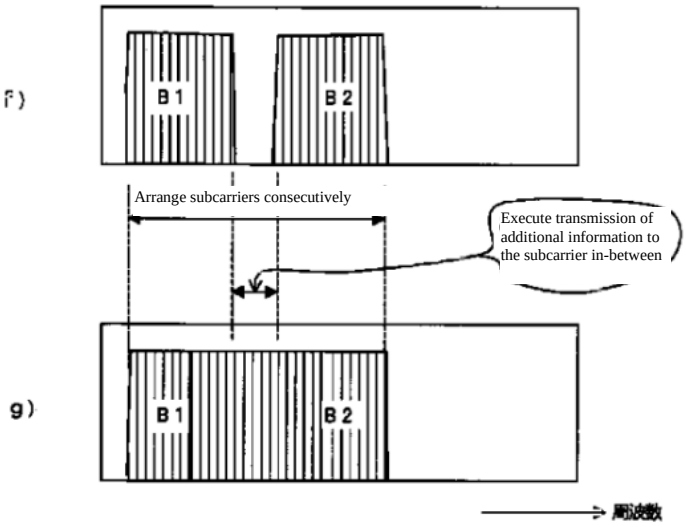
[FIG. 3]



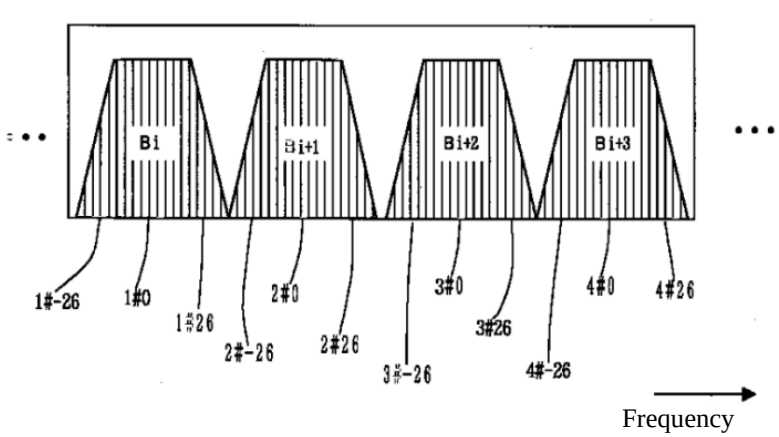
[FIG. 6]



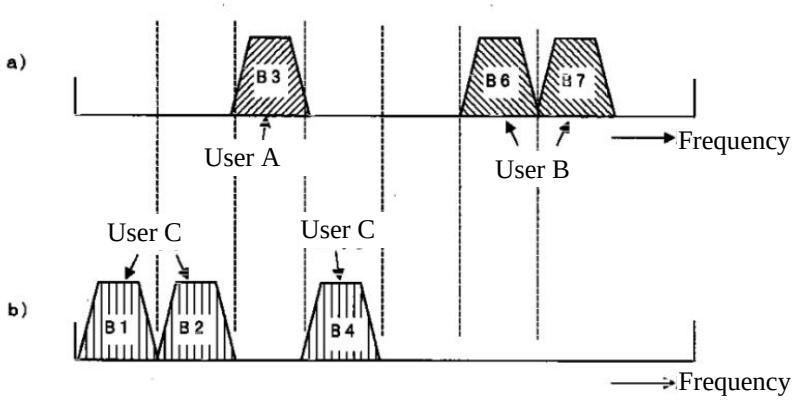
[FIG. 9]



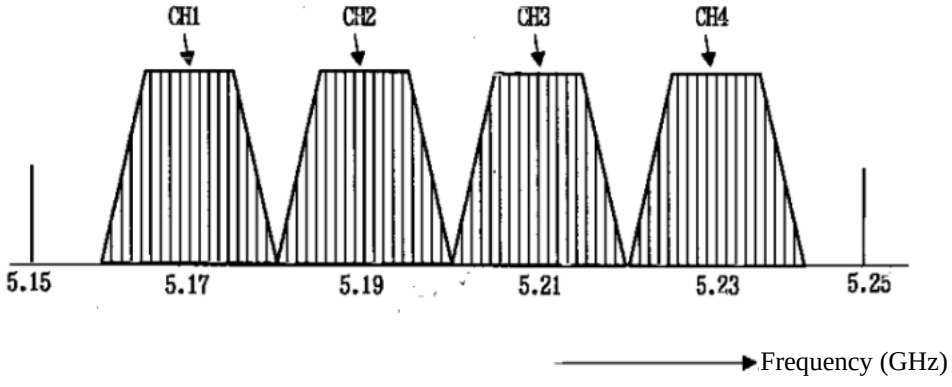
[FIG. 4]



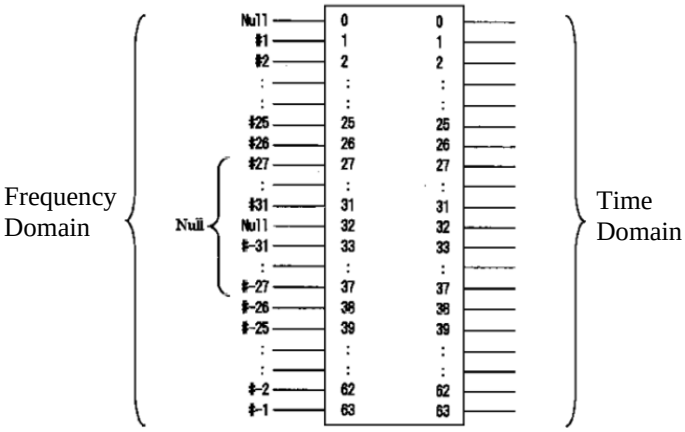
[FIG. 5]



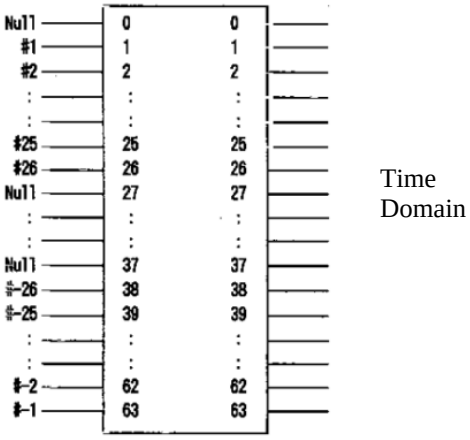
[FIG. 11]



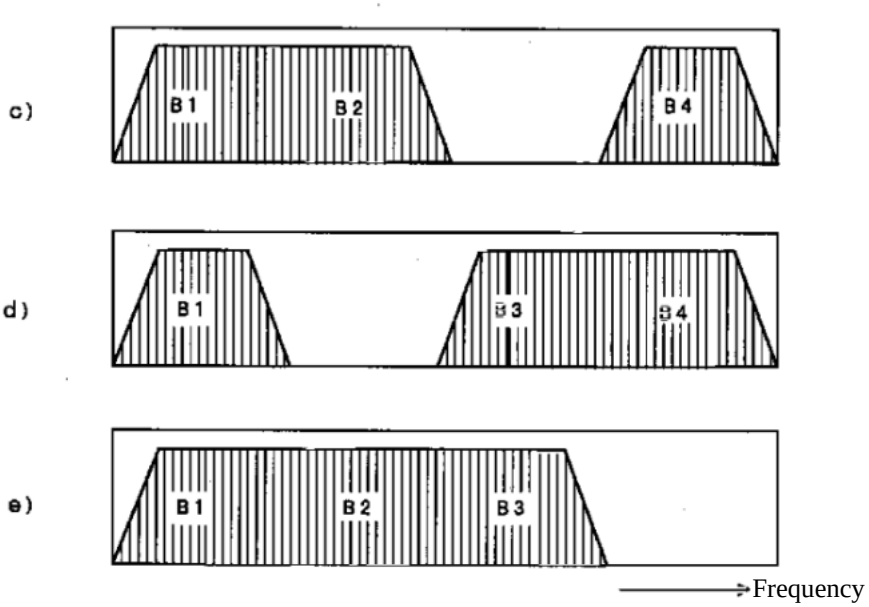
[FIG. 7]



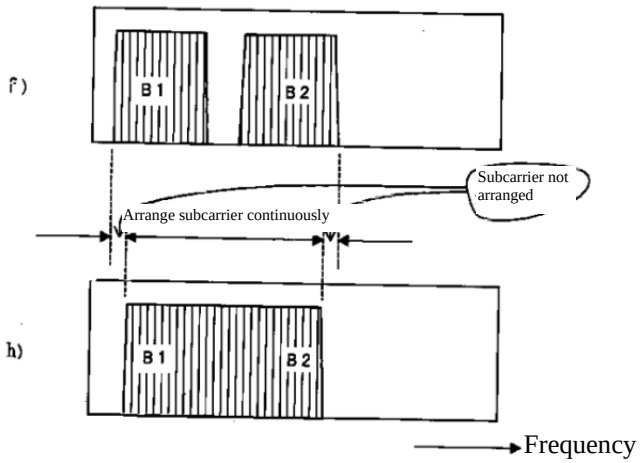
[FIG. 14]



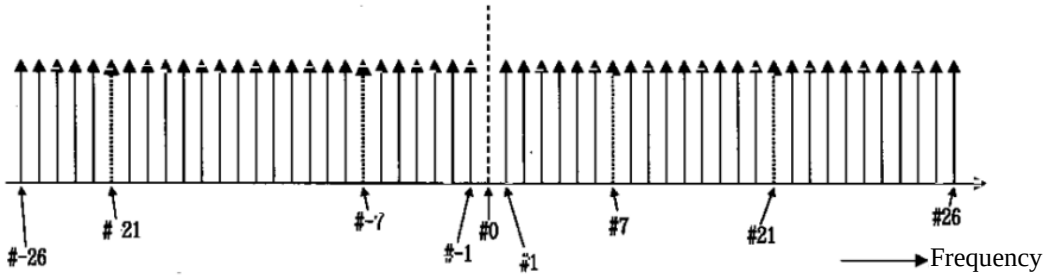
[FIG. 8]



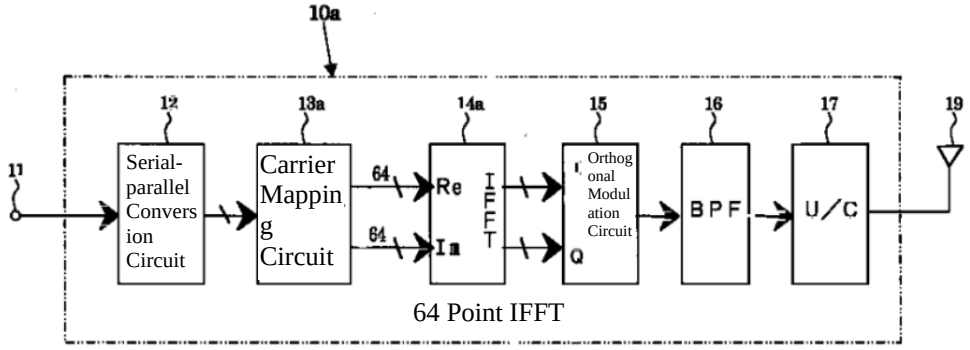
[FIG. 10]



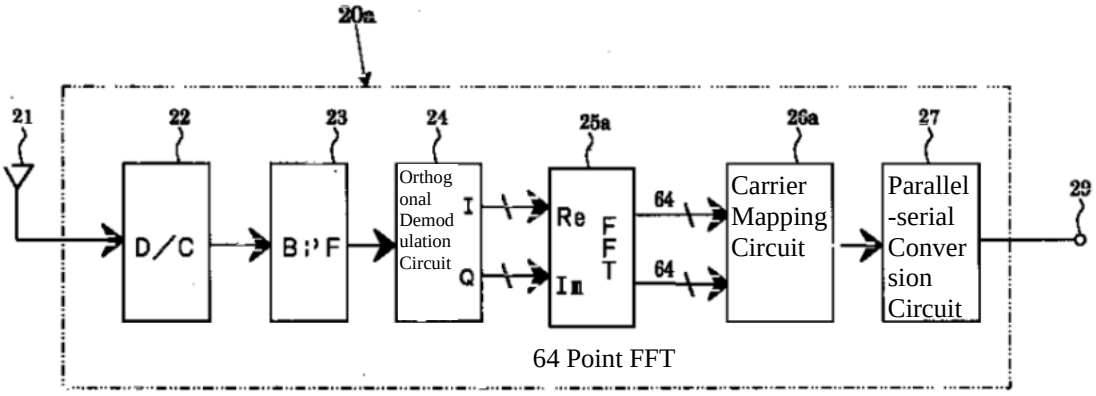
[FIG. 12]



[FIG. 13]



[FIG. 15]


20a
21
22
23
24
25a
26a
27
29
D/C
B.P.F
Orthogonal Demodulation Circuit
I
Q
Re
Im
FFT
64
64
Carrier Mapping Circuit
Parallel-serial Conversion Circuit
64 Point FFT