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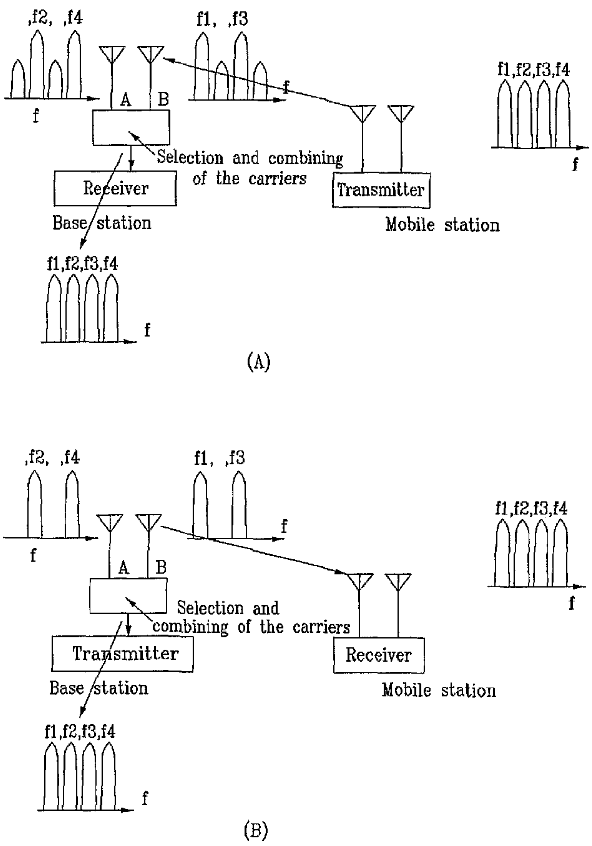
(54) Title: MULTICARRIER CDMA TRANSMITTING DEVICE AND METHOD USING FREQUENCY HOPPING METHOD



(57) Abstract: A multi-carrier CDMA transfer device using frequency hopping uses frequency hopping in the multi-cell environment to be applied to MC-CDMA models (FH-MC/CDMA TDD) that are strong against multi-path fading. A transmitter of the transfer device frequency-hops input data and spreads carriers per block by using codes in the frequency domain, and a receiver despreads received signals to frequency-hop the signals and restore original data. Optionally, an array antenna having a plurality of antenna elements is applied to the transmitter and the receiver, and weights are adaptively applied depending on the channel quality when transmitting and receiving signals through the antenna elements. Therefore, frequency diversity is obtainable and inter-cell interference and inter-code interference is optimized in the MC-CDMA method. Also, changes of frequency hopping reduce temporal variations of channels and prevent a high SN ratio.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MULTICARRIER CDMA TRANSMITTING DEVICE AND METHOD USING FREQUENCY HOPPING METHOD

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a radio communication method for high data rates. More specifically, the present invention relates to a multi-carrier CDMA transfer device and method for applying frequency hopping to the multi-carrier CDMA (MC-CDMA) to optimize inter-cell and inter-code interference reduction and obtain frequency diversity in a radio communication environment.

(b) Description of the Related Art

The current radio communication system uses the IMT 2000 standard which realizes data rates of 144kbps in the mobile environment and 2Mbps in the stationary environment.

However, a higher-rate radio system is required so as to realize multimedia communication such as e-mail, high-rate Internet access, transmission of high-precision moving pictures, and downloads of huge volumes of files in the mobile environment. Recently, 3.5^{th} and 4^{th} generation radio communication studies have been progressing, which aim at the data rates of 5Mbps at a maximum in the mobile condition and several tens of Mbps in the stationary condition.

In order to realize high-rate and high-quality information transmission in the radio communication environment, transmission methods with strong characteristics against deterioration of communication quality and high frequency allowance are needed, which include Orthogonal Frequency Division Multiplex (OFDM) and the Multi-Carrier-Code Division Multiple Access (MC-CDMA) systems.

The OFDM scheme for applying a plurality of orthogonal carriers to the CDMA scheme to thus realize multiplexing is classified as the OFDM Time Division Multiple Access (OFDM-TDMA) for allowing a plurality of users to use different time slots as shown in FIG. 1(a), and the OFDM Frequency Division Multiple Access (OFDM-FDMA) for allowing different users to use predetermined carriers as shown in FIG. 1(b).

The MC-CDMA, categorized as one of the W(Wide)-CDMA schemes, loads user information on different carriers and provides the same to the frequency domain so that a plurality of users may perform communication through code multiplexing as shown in FIG. 1C.

However, the above-described OFDM scheme is weak in interference generated by other cells in the multi-cell environment, and hence, the bit error rate (BER) and communication capacity are problematically worsened because of the interference, and the above-noted MC-CDMA scheme is strong against interference provided by other cells but inter-code interference is increased to worsen system performance when the number of users in a cell is increased, and the same is weak in the peak to average power ratio (PAPR) and the shadowing effect is generated because of obstacles such as buildings.

SUMMARY OF THE INVENTION

It is an advantage of the present invention to provide an MC-CDMA transfer device and method for applying a frequency hopping method to the MC-CDMA to obtain frequency diversity and optimizing inter-cell interference and inter-code interference to improve data rates and communication performance.

In one aspect of the present invention, a transmitting device for the multi-carrier CDMA based on frequency hopping, comprises: a serial to parallel converter for converting input data into parallel data; a frequency hopper for using a predetermined frequency hopping pattern to frequency-hop the parallel data; a spreader for copying the data output by the frequency hopper by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks; and an IFFT unit for performing inverse fast Fourier transform (IFFT) on the spread data and transmitting the executed data through a transmit antenna.

The frequency hopper determines the predetermined frequency hopping pattern so as to use different frequencies to the parallel data input by the serial to parallel converter with respect to time.

In another aspect of the present invention, a receiving device for the multi-carrier CDMA based on frequency hopping, comprises: an FFT unit for performing fast Fourier transform (FFT) on signals received through a receive antenna, and outputting data; a despreader for despreading the data with different spread codes; a combiner for dividing the data despread by the despreader into a predetermined number of blocks, combining data of the respective blocks, and outputting the combined data; a frequency dehopper for frequency-dehopping the data output by the combiner by using a predetermined frequency dehopping pattern; and a parallel to serial converter for converting the data output by the frequency dehopper into serial data, and outputting the serial data.

The frequency dehopper determines the predetermined frequency dehopping pattern so as to use different frequencies for the parallel data output by the combiner with respect to time.

The predetermined frequency dehopping pattern is established to be opposite to the frequency hopping pattern of the corresponding transmitting device.

In still another aspect of the present invention, a transmitting device for the multi-carrier CDMA based on frequency hopping comprises: an array antenna having a plurality of antenna elements; a frequency hopper for frequency-hopping input data by using a predetermined frequency hopping pattern; a spreader for copying the data output by the frequency hopper by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks; N adaptive transmission controllers for applying weights to the respective data spread by the spreader, performing IFFT on the weighted data, and outputting the executed data to a corresponding antenna element wherein N corresponds to the number of antenna elements of the array antenna; and a weight controller for controlling the weight of the adaptive transmission controller according to a channel quality.

In still yet another aspect of the present invention, a receiving device for the multi-carrier CDMA based on frequency hopping comprises: an array antenna having a plurality of antenna elements; N adaptive receiving controllers for performing FFT on the signals output by the array antenna, applying corresponding weights to the executed signals, and outputting weighted signals wherein N corresponds to the number of antenna elements of the array antenna; a weight controller for controlling the weight of the adaptive receiving controller according to a channel quality; a despreader for despreading the data output by the adaptive receiving controller with different spread codes; a combiner for dividing the data despread by the despreader into a predetermined number of blocks, combining the data of the respective blocks, and outputting data; and a frequency dehopper for frequency-dehopping the data output by the combiner by using a predetermined frequency dehopping pattern, and outputting executed data.

The spreader spreads the data output by the frequency hopper by using carriers with less correlation in the frequency domain.

The despreader despreads the FFT-performed data by using carriers with less correlation in the frequency domain.

In still further another aspect of the present invention, a transfer device comprises: an array antenna having a plurality of antenna elements; a transmitter for applying a weight to the respective transmitting transmission and transmitting the weighted transmission data through the array antenna according to the multi-carrier CDMA method based on frequency hopping, the weight allowing adaptive control; and a receiver for receiving the data through the array antenna and respectively applying a weight to the received data according to the multi-carrier CDMA method based on the frequency hopping, the weight allowing adaptive control.

The weights determined to be applicable to the receiver are used for the weights applicable to the transmitter.

In still further another aspect of the present invention, a transmission method for the multi-carrier CDMA based on frequency hopping comprises: converting input data into parallel data; frequency-hopping the converted parallel data by using a predetermined frequency hopping pattern; copying the frequency-hopped data by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks; and performing IFFT on the spread data and transmitting the executed data through a transmit antenna.

In still further another aspect of the present invention, a receiving method for the multi-carrier CDMA based on frequency hopping comprises: performing FFT on the signal received through a receive antenna, and outputting FFT-performed data; despreading the FFT-performed data with different spread codes, dividing the despread data into a predetermined number of blocks, combining the data, and outputting combined data; frequency-dehopping the combined and output data by using a predetermined frequency dehopping pattern; and converting the frequency-dehopped data into serial data, and outputting the serial data.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows conventional OFDM and MC-CDMA systems wherein (a) is an OFDM-TDMA method, (b) is an OFDM-FDMA, and (c) is an MC-CDMA method;

FIG. 2 shows a diagram for an MC-CDMA model using the frequency hopping method according to an exemplary embodiment of the present invention;

FIG. 3 shows a conceptual diagram for an MC-CDMA model using the frequency hopping method according to an exemplary embodiment of the present invention;

FIG. 4 shows a block diagram for an MC-CDMA transmitting device using the frequency hopping method according to an exemplary embodiment of the present invention;

FIG. 5 shows a block diagram for an MC-CDMA receiving device using the frequency hopping method according to an exemplary embodiment of the present invention;

FIG. 6 shows exemplified frequency hopping by a transmitting device shown in FIG. 4 wherein (a) indicates the case of t=0, and (b) indicates the case of $t=T_{FH}$;

FIG. 7 shows an exemplified spread pattern applicable to the transmitting device shown in FIG. 4;

FIG. 8 shows an exemplified despread pattern applicable to the receiving device shown in FIG. 5;

FIG. 9 shows another exemplified spread pattern applicable to the transmitting device shown in FIG. 4;

FIG. 10 shows another exemplified despread pattern applicable to the receiving device shown in FIG. 5;

FIG. 11 shows a configuration diagram of packets used by the MC-CDMA transfer device using the frequency hopping method according to an exemplary embodiment of the present invention, wherein (a) indicates the case when preambles are provided, and (b) indicates the case when preambles and post-ambles are provided;

FIG. 12 shows a concept of transmission diversity wherein (a) indicates an uplink case and (b) indicates a downlink case; and

FIG. 13 shows a configuration diagram of a base station of the MC-CDMA transfer device using the frequency hopping method according to a second exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following detailed description, only the preferred embodiment of the invention has been shown and described, simply by way of illustration of the best mode contemplated by the inventor(s) of carrying out the invention. As will be realized, the invention is capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive. To clarify the present invention, parts which are not described in the specification are omitted, and parts for which same descriptions are provided have the same reference numerals.

An MC-CDMA transfer device and method using the frequency hopping method according to exemplary embodiments of the present invention will be described with reference to drawings.

As shown in FIG. 2, the frequency hopping is used in the MC-CDMA model (including FH-MC/CDMA TDD) which is resistant against multi-path fading in the multi-cell environment to thereby obtain multi-carrier-based frequency diversity and optimize inter-cell and inter-code interference reduction.

FIG. 3 shows a conceptual diagram for the MC-CDMA using the frequency hopping method according to an exemplary embodiment of the present invention.

As shown, the merits of MC-CDMA which is resistant against interference caused by multi-cells are used. In detail, codes are multiplexed, and block-based carriers are spread to a broadband by the frequency hopping method, which may be the optimal method for multiplexing the cells depending on the carriers in a like manner of the OFDMA. In the embodiment, the carriers are spread for each block of multi-carriers, and hence, the inter-cell interference from the multi-cells is minimized.

FIG. 4 shows a block diagram for an MC-CDMA transmitting device using the frequency hopping method according to an exemplary embodiment of the present invention.

As shown, the MC-CDMA transmitting device includes a data generator 101, an encoder/interleaver 103, a mapper 105, a pilot inserter 107, a serial to parallel converter 109, a frequency hopper 111, n copiers 113-1 to 113-n, a spreader 115, an IFFT (Inverse Fast Fourier Transform) unit 117, a parallel to serial converter 119, and a guard interval inserter 121.

The data generator 101 generates data to be transmitted according to the MC-CDMA method using the frequency hopping method.

The encoder/interleaver 103 encodes and interleaves transmission data generated by the data generator 101, and outputs result data.

The mapper 105 converts the data output by the encoder/interleaver 103 into signals which follow a predetermined modulation method (e.g., a 4-ary QPSK), and outputs the signals.

The pilot inserter 107 multiplexes the data output by the mapper 105 and inserts a pilot into the multiplexed data.

The serial to parallel converter 109 converts the serial data output by the pilot inserter 107 into a predetermined number (e.g., n) of parallel data, and outputs the parallel data.

The frequency hopper 111 performs frequency hopping on the n parallel data output by the serial to parallel converter 109, and outputs result data.

The copiers 113-1 to 113-n copy each of the n data output by the frequency hopper 111 by as many as the number of spread factors (SF), and output result data.

The spreader 115 uses different spread codes for the respective data output by the copiers 113-1 to 113-n to spread the data with respect to the frequency axis, and outputs spread results.

The IFFT unit 117 performs IFFT on the data spread and output by the spreader 115, and outputs result data.

The parallel to serial converter 119 converts the parallel data output by the IFFT unit 117 into serial data, and outputs the serial data.

The guard interval inserter 121 inserts a guard interval to the data output by the parallel to serial converter 119, and outputs result data to the transmit antenna 123.

An operation of the transmitting device shown in FIG. 4 will be described.

A transmission data sequence generated by the data generator 101 is encoded and interleaved by the encoder/interleaver 103, and converted into signals of a predetermined modulation method by the mapper 105.

A pilot is inserted into the transmission data sequence which is mapped to be signals of the predetermined modulation method by the pilot inserter 107, and the transmission data sequence is then converted into n parallel data by the serial to parallel converter 109.

The n parallel data are frequency-hopped by the frequency hopper 111. In this instance, it is established in the frequency hopping process that frequency-hopped information for the respective parallel data, that is, a frequency hopping pattern is given according to a well-known frequency hopping method.

The n frequency-hopped parallel data are respectively copied by as many as the number of spread factors by the n copiers 113-1 to 113-n, and are then spread with respect to the frequency axis by the spreader 115 using different spread codes.

The spread parallel data are IFFT-performed by the IFFT unit 117, and are converted into serial data by the parallel to serial converter 119, and a guard interval is inserted into the serial data by the guard interval inserter 121, and the serial data are transmitted as multi-carrier signals with n carriers to the receiver through the transmit antenna 123.

FIG. 5 shows a block diagram for an MC-CDMA receiving device using the frequency hopping method according to an exemplary embodiment of the present invention.

As shown, the MC-CDMA receiving device includes a guard interval eliminator(-GI) 203, a serial to parallel converter 205, an FFT unit 207, a despreader 209, a channel estimator 211, n combiners 213-1 to 213-n , a frequency dehopper 215, a parallel to serial converter 217, and a decoder/de-interleaver 219.

The guard interval eliminator 203 eliminates the guard interval from the signal received through the receive antenna 201, and outputs a result signal.

The serial to parallel converter 205 converts the serial data output by the guard interval eliminator 203 into parallel data, and outputs the parallel data.

The FFT unit 207 performs FFT on the parallel data output by the serial to parallel converter 205, and outputs executed data.

The despreader 209 despreads the data output by the FFT unit 207 by using corresponding spread codes.

The channel estimator 211 uses the data despread by the despreader 209 to output a channel estimate.

The n combiners 213-1 to 213-n modify the data despread by the despreader 209 with the channel estimate provided by the channel estimator 211, combine the modified data by as many as the number of spread factors, and output n parallel data.

The frequency dehopper 215 dehops the parallel data output by the combiners 213-1 to 213-n according to a predefined frequency dehopping pattern, and outputs dehopped data. In this instance, the frequency dehopping pattern is established to be opposite to the frequency hopping pattern used by the frequency hopper 111 installed in the transmitting device.

The parallel to serial converter 217 converts the parallel data output by the frequency dehopper 215 into serial data, and outputs the serial data.

The decoder/de-interleaver 219 decodes/de-interleaves the data output by the parallel to serial converter 217, and outputs restored data.

An operation of the receiving device shown in FIG. 5 will be described.

The guard interval is eliminated from the signals received through the receive antenna 201 by the guard interval eliminator 203, the signals without the guard interval are converted into parallel data by the serial to parallel converter 205, and FFT is performed on the parallel data by the FFT unit 207.

The FFT-performed data are despread by the despreader 209 by using the corresponding spread codes.

Channel variation values of the respective subcarriers are estimated by the channel estimator 211, and the estimated channel variation values are compensated and combined by the n combiners 213-1 to 213-n to output n parallel data.

The n despread parallel data are frequency-dehopped by the frequency dehopper 215 by using the predefined frequency dehopping pattern.

The frequency dehopped data are converted into serial data by the parallel to serial converter 217, and the serial data are than decoded and de-interleaved by the decoder/de-interleaver 219 to thus obtain final restored data.

Methods for combining the carriers by the n combiners 213-1 to 213-n include the equal gain combining (EGC) method and the maximal ratio combining (MRC) method.

Also, when the codes are multiplexed, inter-code interference is generated, and an equalizer is used in this case to reduce the inter-code interference. The equalizer uses the minimum mean-square error (MMSE) method and the maximum likelihood detection (MLD) method and uses correlation of codes to eliminate the interference component and thereby efficiently process the interference.

As described above, the frequency hopping method is used to spread and despread the multi-carriers and accordingly has a strong characteristic against the interference signal. That is, much of within-cell interference and inter-cell interference is solved.

Further, the MC-CDMA transfer device using the frequency hopping method is an orthogonal variable spread factor (OVSF) system, and increases code spread factors in the multi-cell environment with much interference to thus reduce an influence of the interference. In addition, the modulation method can be adaptively varied according to the channel condition. In particular, as the carrier to noise Interference ratio (CINR) becomes lowered, the spread factor of codes is increased and a low data-rate modulation method is used. For example, for a high data rate transmission, the spreader 115 uses a low spread factor and the mapper 105 uses a high data-rate modulation method including 16QAM or 64QAM in the case of a good CINR environment, and the spreader 115 uses a high spread factor and the mapper 105 uses a low data-rate modulation method (including the BPSK and QPSK) to reduce the influence of the interference in the case of a bad CINR environment.

FIG. 6 shows exemplified frequency hopping by a transmitting device shown in FIG. 4 wherein (a) indicates the case of t=0, and (b) indicates the case of $t=T_{FH}$.

As shown, the transmitting device uses a predefined frequency hopping pattern so as to frequency-hop the parallel signals input to the frequency hopper 111 by using frequencies which are different with respect to time.

Referring to (a) of FIG. 6, in the case in which the time t is given to be 0, when the serial data signals of 1, 2, 3, 4, 5, 6, 7, and 8 are sequentially input to the serial to parallel converter 109 in the transmitting device, the data of 1, 2, 3, 4, 5, 6, 7, and 8 are output to be parallel data by the serial to parallel converter 109, and the parallel data are converted and output by the frequency hopper 111 according to a predetermined frequency hopping pattern when the time t is given to be 0. For example, the parallel data in the order of 1, 2, 3, 4, 5, 6, 7, and 8 are frequency-hopped to be the parallel data in the order of 8, 3, 6, 1, 7, 2, 4, and 5 according to the frequency hopping pattern with respect to time t=0, and the executed parallel data are output to the n copiers 113-1 to 113-n.

In the case of time t=0, when the parallel data in the order of 8, 3, 6, 1, 7, 2, 4, and 5 respectively output by the n combiners 213-1 to 213-n in the receiving device are input to the frequency dehopper 215, the frequency dehopper 215 uses a frequency dehopping pattern with respect to time t=0 to frequency-dehop the input parallel data to be parallel data in the order of 1, 2, 3, 4, 5, 6, 7, and 8 and output the executed data to the parallel to serial converter 217. The parallel to serial converter 217 receives the parallel data of 1, 2, 3, 4, 5, 6, 7, and 8 output by the frequency dehopper 215, converts the same into serial data in the order of 1, 2, 3, 4, 5, 6, 7, and 8. In this instance, the frequency dehopping pattern is opposite to the frequency hopping pattern.

A case in which the time is given to be $t=T_{TH}$ other than the case of time of t=0 will be described with reference to (b) in FIG. 6.

In the transmitting device, when the serial data signals of 1, 2, 3, 4, 5, 6, 7, and 8 are sequentially input to the serial to parallel converter 109, the data of 1, 2, 3, 4, 5, 6, 7, and 8 are output to be parallel data by the serial to parallel converter 109, and the parallel data are converted and output by the frequency hopper 111 according to a predetermined frequency hopping pattern used when the time is given as $t=T_{TH}$. For example, the parallel data in the order of 1, 2, 3, 4, 5, 6, 7, and 8 are frequency-hopped to be parallel data in the order of 3, 4, 5, 7, 1, 6, 8, and 2 according to a frequency hopping pattern with respect to time $t=T_{TH}$, and the executed parallel data are output to the n copiers 113-1 to 113-n.

In the case in which the time is given to be $t=T_{TH}$, when the parallel data in the order of 3, 4, 5, 7, 1, 6, 8, and 2 output by the n combiners 213-1 to 213-n in the receiving device are input to the frequency dehopper 215, the frequency dehopper 215 uses a frequency dehopping pattern with respect to the time $t=T_{TH}$ to frequency-dehop the parallel data into in the order of 1, 2, 3, 4, 5, 6, 7, and 8 and outputs the executed parallel data to the parallel to serial converter 217. The parallel to serial converter 217 receives the parallel data from the frequency dehopper 215, converts the same into serial data, and outputs the serial data in the order of 1, 2, 3, 4, 5, 6, 7, and 8. In this instance, the frequency dehopping pattern is opposite to the frequency hopping pattern.

As described with reference to (a) and (b) of FIG. 6, the frequency hopper 111 of the transmitting device frequency-hops the input parallel signals according to a predetermined hopping pattern which is determined to use different frequencies with respect to time. In a like manner, the frequency dehopper 215 of the receiving device can frequency-dehop the input parallel signals according to a predetermined dehopping pattern which is determined to use different frequencies with respect to time. In this instance, the frequency dehopping pattern is opposite to the frequency hopping pattern which is used at the same time with the frequency dehopping pattern.

In the above-noted embodiment, eight serial and parallel data are used, and without being restricted to this, it will be easily understood by a person skilled in the art that data other than eight data can also be applied.

The above-described embodiment uses the total subcarriers, and it is also possible to control the number of serial to parallel conversion and configure subcarriers which transmit no data.

FIG. 7 shows an exemplified spread pattern applicable to the transmitting device shown in FIG. 4.

As shown in FIG. 7, the spreader 115 includes a plurality of multipliers 115-11 to 115-1SF, 115-21 to 115-2SF, ..., 115-n1 to 115-nSF for multiplying the parallel signals output by the n copiers 13-1 to 113-n by different spread codes $C_{1,1}$ to $C_{1,SF}$, $C_{2,1}$ to $C_{2,SF}$, and $C_{n,1}$ to $C_{n,SF}$. In this instance, the number of multipliers is given to be n×SF, and SF represent the number of spread factors.

When the n copiers 113-1 to 113-n of the transmitting device copy the parallel data frequency-hopped and output by the frequency hopper 111 by as many as the number of spread factors and output copied data, the multipliers 115-11 to 115-1SF, 115-21 to 115-2SF, ..., 115-n1 to 115-nSF of the spreader 115 multiply the copied parallel data by the spread codes $C_{1,1}$ to $C_{1,SF}$, $C_{2,1}$ to $C_{2,SF}$, and $C_{n,1}$ to $C_{n,SF}$, and output multiplied data to the IFFT unit 117 thereby performing spreading on the frequency domain.

FIG. 8 shows an exemplified despread pattern applicable to the receiving device shown in FIG. 5.

As shown, the despreader 209 includes a plurality of multipliers 209-11 to 209-1SF, 209-21 to 209-2SF, ..., 209-n1 to 209-nSF for multiplying the parallel signals output by the FFT unit 207 by different spread codes, that is, spread codes spread code $C_{1,1}$ to $C_{1,SF}$, $C_{2,1}$ to $C_{2,SF}$, $C_{n,1}$ to $C_{n,SF}$ used by the spreader 115. In this instance, the number of multipliers is given to be n×SF.

When the FFT 207 of the receiving device performs FFT on the data converted and output by the serial to parallel converter 205 and outputs executed data, the multipliers 209-11 to 209-1SF, 209-21 to 209-2SF, ..., 209-n1 to 209-nSF of the despreader 209 multiply the executed data by the spread codes $C_{1,1}$ to $C_{1,SF}$, $C_{2,1}$ to $C_{2,SF}$, $C_{n,1}$ to $C_{n,SF}$ corresponding to the parallel data output by the FFT unit 207, combine the multiplied data into groups of blocks by as many as the number of spread factors, and output the combined data to the n combiners 213-1 to 213-n to thus perform despreading on the frequency domain.

FIG. 9 shows another exemplified spread pattern applicable to the transmitting device shown in FIG. 4.

As shown in FIG. 9, the spreader 115' includes a plurality of multipliers 115-11' to 115-1SF', 115-21' to 115-2SF', ..., 115-n1' to 115-nSF' for multiplying the parallel signals output by the n copiers 113-1, 113-2, ..., 113-n by different spread codes $C_{1,1}$ to $C_{n,1}$, $C_{1,2}$ to $C_{n,2}$, $C_{1,SF}$ to $C_{n,SF}$. In this instance, the number of multipliers is given to be n×SF.

The spreader 115' is different from the spreader 115 described with reference to FIG. 7 in that the spreader 115' uses carriers with less correlation to spread the respective data on the frequency domain. That is, the spreader 115 in FIG. 7 spreads the SF-numbered parallel signals output by the copier 113-1 by using the same block-based spread codes $C_{1,1}$ to $C_{1,SF}$ with high correlation, and the spreader 115' selects a single output signal from each of the n copiers 113-1 to 113-n to generate a single group of blocks, and uses the same block-based spread code with high correlation to the corresponding block to perform spreading, and as a result, the spread codes $C_{1,1}$ to $C_{n,1}$ with less correlation are used to the SF parallel signals output by the same copier (e.g., 113-1) to thus perform spreading.

FIG. 10 shows another exemplified despread pattern applicable to the receiving device shown in FIG. 5.

As shown in FIG. 10, the despreader 209' includes a plurality of multipliers 209-11' to 209-1SF', 209-21' to 209-2SF', ..., 209-n1' to 209-nSF' for multiplying the parallel signals output by the FFT unit 207 by different spread codes $C_{1,1}$ to $C_{n,1}$, $C_{1,2}$ to $C_{n,2}$, $C_{1,SF}$ to $C_{n,SF}$ used by the spreader 115' shown in FIG. 9. In this instance, the number of multipliers is given to be n×SF.

The spreader 209' is different from the spreader 209 described with reference to FIG. 8 in that the spreader 209' uses carriers with less correlation to spread the respective data on the frequency domain. That is, the spreader 209 in FIG. 8 receives the block-based data spread and transmitted by the spreader 115 and despreads the same by using the same block-based spread codes $C_{1,1}$ to $C_{1,SF}$ with high correlation, and the spreader 209' receives block-based data spread and transmitted by the spreader 115' from the FFT unit 207, uses the same block-based spread codes $C_{1,1}$ to $C_{n,1}$, $C_{1,2}$ to $C_{n,2}$, $C_{1,SF}$ to $C_{n,SF}$ with less correlation to the corresponding block to perform spreading, and hence, the spread codes with less correlation are used to the same block-based data to thus perform spreading.

The combination of multi-carrier signals by using adjacent carriers deteriorates the frequency effect since the adjacent carriers have much correlation in the multi-carrier system. Therefore, as described with reference to FIGs. 9 and 10, the deterioration of frequency effect is reduced and great frequency diversity is obtained by combining the subcarrier signals with less correlation and spreading and despreading the combined subcarrier signals.

FIG. 11 shows a configuration diagram of packets used by the MC-CDMA transfer device using the frequency hopping method according to an exemplary embodiment of the present invention, wherein (a) indicates the case when preambles are provided, and (b) indicates the case when preambles and post-ambles are provided.

As shown, the cases of (a) and (b) indicate performance of frequency hopping by three times.

Referring to (a) of FIG. 11, the number of preambles and mid-ambles (PrA) are controllable according to the number of performing the frequency hopping, and accordingly, channels are estimated by using the preambles and mid-ambles (PrA).

Referring to (b) of FIG. 11, the number of preambles (PrA) and post-ambles (PoA) are controllable according to the number of performing the frequency hopping, and when the channels are estimated by using the preambles (PrA) before the data and the post-amble (PoA) after the data, the channels are efficiently estimated compared to the case of estimating the channels by using the preambles (PrA) as shown in (a).

FIG. 12 shows a concept of transmission diversity wherein (a) indicates an uplink case and (b) indicates a downlink case.

The uplink and downlink have a characteristic of high correlation in the case of using the time division duplex (TDD). By using this advantage, received states of the uplink are measured to select antennas with good received states as shown in (a) of FIG. 12, and the states of the downlink channel are measured to select antennas with good states and transmit carriers as shown in (b) of FIG. 12.

Accordingly, better communication services are realized by using the carriers with a high received power and transmitting the data.

FIG. 13 shows a configuration diagram of a base station of the MC-CDMA transfer device using the frequency hopping method according to a second exemplary embodiment of the present invention.

As shown, the base station includes array antennas 300-1 to 300-m with a plurality of elements, guard interval inserters and eliminators 400-1 to 400-m coupled to the array antennas 300-1 to 300-m, a receiving device 500 having input terminals coupled to the guard interval inserters and eliminators 400-1 to 400-m, and a transmitting device 600 having output terminals coupled to the guard interval inserters and eliminators 400-1 to 400-m.

The guard interval inserters and eliminators 400-1 to 400-m insert guard intervals into the signals output by the transmitting device 600, and output the signals through the array antennas 300-1 to 300-m, and eliminate the guard intervals from the signals received through the array antennas 300-1 to 300-m and output the signals to the receiving device 500.

Since the receiving device 500 is similar to the receiving device described with reference to FIG. 5, the components performing the same functions have the same reference numerals, and the components which are different from those of the receiving device shown in FIG. 5 will now be described.

Compared to the receiving device shown in FIG. 5, the receiving device 500 includes adaptive control blocks 501-1 to 501-m for adaptively controlling weights of the parallel signals output by the FFT unit 207 between the FFT unit 207 for performing FFT on the signals without guard intervals and the despreader 209 for despreading the signals output by the FFT unit 207.

The adaptive control blocks 501-1 to 501-m include a plurality of multipliers 503-1 to 503-l for multiplying the respective signals output by the FFT unit 207 by weights and outputting multiplied signals; a plurality of adders 505-1 to 505-l for adding the signals output by the multipliers corresponding to the respective adaptive control blocks and outputting added signals to the despreader 209; a subtracter 507 for calculating differences between the signals output by the adders and a predefined reference signal, and outputting calculated signals; and a weight controller 509 for controlling weights of the respective multipliers 503-1 to 503-l according to difference signals output by the subtracter 507.

Since the transmitting device 600 is similar to the transmitting device described with reference to FIG. 4, the components performing the same functions have the same reference numerals, and the components which are different from those of the transmitting device shown in FIG. 4 will now be described.

Compared to the transmitting device shown in FIG. 4, the transmitting device 600 includes adaptive control blocks 601-1 to 601-m for adaptively controlling weights of the parallel signals output by the spreader 115 between the spreader 115 and the IFFT unit 117 for performing IFFT on the signals spread and output by the spreader 115.

The adaptive control blocks 601-1 to 601-m include a plurality of multipliers 603-1 to 603-l for multiplying the respective signals output by the spreader 115 by weights and outputting multiplied signals. In this instance, the weight controller 509 of the receiving device 500 controls the weights input to the multipliers 603-1 to 603-l. That is, the weights for adaptively controlling the multipliers 503-1 to 503-l are applied in a like manner to the multipliers 603-1 to 603-l of the transmitting device 600 according to the respective array antennas 300-1 to 300-m of the receiving device 500.

In the above-described MC-CDMA transfer device using the frequency hopping method, and in particular, the adaptively controllable transfer device configured in the base station, the uplink indicates multi-carrier signals with the same number of subcarriers as that of downlink lines, and the base station includes array antennas 300-1 to 300-m having a plurality of elements.

Therefore, in the case of an uplink, the signals transmitted by a mobile station are provided to the respective elements of the array antennas 300-1 to 300-m, guard intervals are eliminated from the signals by the guard interval inserters and eliminators 400-1 to 400-m, and the executed signals are FFT-performed by the FFT unit 217 to thus obtain subcarrier signals. The adaptive control blocks 501-1 to 501-m adaptively control the weights of the subcarrier signals. Hence, a received characteristic by the receiving device 500 of the base station in the case of the uplink is improved according to the above-noted adaptive control.

In the case of the TDD method, since the channel qualities of the uplink and the downlink are almost the same, the weight determined for adaptive control in the uplink is applicable to the subcarrier signals in the downlink. That is, the respective adaptive control blocks 601-1 to 601-m receive a weight for adaptive control from the adaptive control blocks 501-1 to 501-m, that is, the weight controller 509 to adaptively control the subcarrier signals which are generated by converting input serial data into parallel data to perform frequency hopping and spreading the frequency-hopped data by the spreader 115, and outputs the adaptively controlled subcarrier signals to the IFFT unit 117. Since the channel qualities measured through the adaptive control in the uplink are reflected to the downlink, a transmitted characteristic by the transmitting device 600 is improved, and in particular, since the channel in the downlink is measured to thus apply transmission diversity to the uplink, a transmission diversity effect is obtained.

In the above embodiment, the adaptive control has been described to be executed for each subcarrier in the uplink and the downlink, and in addition, without being restricted to this, it is also possible to arrange the subcarriers into blocks and adaptively control the weight for each block, or define a common weight for the subcarriers and adaptively control the common weight.

The weight control method includes the MRC method for maximizing the SN ratio of signals and allowing directivity in the desired signal direction, and the MMSE method for using a reference signal to suppress the interference signal and maximizing the signal to interference and noise ratio (SINR).

While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

According to the present invention, the frequency diversity is obtainable and inter-cell and inter-code interference reduction is optimized in the MC-CDMA method.

The same code is used in the case of inter-cell movement to thus allow soft handoff and obtain site diversity gains of the uplink and downlink, and the application of soft handoff increases cell coverage.

Further, changes of frequency hopping reduce temporal variations of channels thereby preventing deterioration of the SN ratio.

The PAPR is efficiently reduced by controlling the number of multiplexed users and the number of carriers.

In addition, capacity is further increased by suppressing the inter-cell and within-cell interference.

Also, the present invention is applicable to the uplink since no great deterioration is generated by the PAPR.

Also, transmission diversity is easily performed by application of TDD.

WHAT IS CLAIMED IS:

1. A transmitting device for the multi-carrier CDMA based on frequency hopping, comprising:

a serial to parallel converter for converting input data into parallel data;

a frequency hopper for using a predetermined frequency hopping pattern to frequency-hop the parallel data;

a spreader for copying the data output by the frequency hopper by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks; and

an IFFT unit for performing inverse fast Fourier transform (IFFT) on the spread data and transmitting the IFFT-performed data through a transmit antenna.

2. The transmitting device of claim 1, further comprising:

an encoder/interleaver for encoding the input data, interleaving the encoded data, and outputting interleaved data;

a mapper for converting the data output by the encoder/interleaver into signals of a predetermined modulation method, and outputting the signals; and

a pilot inserter for multiplexing and inserting a pilot into the data output by the mapper, and outputting the data to the serial to parallel converter.

3. The transmitting device of claim 1, further comprising:

a parallel to serial converter for converting the parallel data output by the IFFT unit into serial data, and outputting the serial data; and

a guard interval inserter for inserting a guard interval into the data output by the parallel to serial converter, and outputting the executed data to the transmit antenna.

4. The transmitting device of one of claims 1 to 3, wherein the frequency hopper determines the predetermined frequency hopping pattern so as to use different frequencies to the parallel data input by the serial to parallel converter with respect to time.

5. A receiving device for the multi-carrier CDMA based on frequency hopping, comprising:

an FFT unit for performing fast Fourier transform (FFT) on signals received through a receive antenna, and outputting data;

a despreader for despreading the data with different spread codes;

a combiner for dividing the data despread by the despreader into a predetermined number of blocks, combining data of the respective blocks, and outputting the combined data;

a frequency dehopper for frequency-dehopping the data output by the combiner by using a predetermined frequency dehopping pattern; and

a parallel to serial converter for converting the data output by the frequency dehopper into serial data, and outputting the serial data.

6. The receiving device of claim 5, further comprising:

a guard interval eliminator for eliminating a guard interval from the signal received through the receive antenna, and outputting data; and

a serial to parallel converter for converting the output data into parallel data, and outputting the parallel data to the FFT unit.

7. The receiving device of claim 5, further comprising:

a channel estimator for using the data despread by the despreader to estimate a channel, and outputting an estimate to the combiner; and

a decoder/de-interleaver for decoding and de-interleaving the data output by the parallel to serial converter to output restored data.

8. The transmitting device of one of claims 5 to 7, wherein the frequency dehopper determines the predetermined frequency dehopping pattern so as to use different frequencies to the parallel data output by the combiner with respect to time.

9. The transmitting device of claim 8, wherein the predetermined frequency dehopping pattern is established to be opposite to the frequency hopping pattern of the corresponding transmitting device.

10. A transmitting device for the multi-carrier CDMA based on frequency hopping, comprising:

an array antenna having a plurality of antenna elements;

a frequency hopper for frequency-hopping input data by using a predetermined frequency hopping pattern;

a spreader for copying the data output by the frequency hopper by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks;

N adaptive transmission controllers for applying weights to the respective data spread by the spreader, performing IFFT on the weighted data, and outputting the executed data to a corresponding antenna element wherein N corresponds to the number of antenna elements of the array antenna; and

a weight controller for controlling the weight of the adaptive transmission controller according to a channel quality.

11. The transmitting device of claim 10, wherein the adaptive transmission controller comprises:

a plurality of multipliers for multiplying the data output by the spreader by a weight controlled by the weight controller; and

an IFFT unit for performing IFFT on the data output by the multipliers, and outputting IFFT-performed data to the antenna element.

12. The transmitting device of claim 10 or 11, wherein the weight controller uses the same weight as the weight to which the channel quality measured by the receiving device is reflected, and controls the adaptive transmission controller.

13. A receiving device for the multi-carrier CDMA based on frequency hopping, comprising:

an array antenna having a plurality of antenna elements;

N adaptive receiving controllers for performing FFT on the signals output by the array antenna, applying corresponding weights to the executed signals, and outputting weighted signals wherein N corresponds to the number of antenna elements of the array antenna;

a weight controller for controlling the weight of the adaptive receiving controller according to a channel quality;

a despreader for despreading the data output by the adaptive receiving controller with different spread codes;

a combiner for dividing the data despread by the despreader into a predetermined number of blocks, combining the data of the respective blocks, and outputting data; and

a frequency dehopper for frequency-dehopping the data output by the combiner by using a predetermined frequency dehopping pattern, and outputting executed data.

14. The receiving device of claim 13, wherein the adaptive receiving controller comprises:

an FFT unit for performing fast Fourier transform (FFT) on the data output by the array antenna; and

a plurality of multipliers for multiplying the data output by the FFT unit by a weight controlled by the weight controller, and outputting weighted data to the despreader.

15. The receiving device of claim 1 or 10, wherein the spreader spreads the data output by the frequency hopper by using carriers with less correlation in the frequency domain.

16. The receiving device of claim 1 or 10, wherein the transmitting device is an orthogonal variable spreading factor (OVSF) system for varying a code spread factor and transmitting the same depending on a multi-cell environment.

17. The receiving device of claim 1 or 10, wherein the transmitting device is an adaptive modulation system for adaptively varying the modulation method and transmitting the same depending on the channel quality.

18. The receiving device of claim 5 or 13, wherein the despreader despreads the FFT-performed data by using carriers with less correlation in the frequency domain.

19. The receiving device of claim 5 or 13, wherein the receiving device uses the same code while moving to another cell, thereby enabling a soft handoff.

20. The receiving device of claim 5 or 13, wherein the combiner uses an equalizer to reduce inter-code interference, by using the equal gain combining (EGC) method, the minimum mean-square error (MMSE) method, and the maximal likelihood detection (MLD) method.

21. A transfer device comprising:

an array antenna having a plurality of antenna elements;

a transmitter for applying a weight to the respective transmission data and transmitting the weighted transmission data through the array antenna according to the multi-carrier CDMA method based on frequency hopping, the weight allowing adaptive control; and

a receiver for receiving the data through the array antenna and respectively applying a weight to the received data according to the multi-carrier CDMA method based on the frequency hopping, the weight allowing adaptive control.

22. The transfer device of claim 21, wherein the weights determined to be applicable to the receiver are used for the weights applicable to the transmitter.

23. The transfer device of claim 21 or 22, wherein the transmitter comprises:

a frequency hopper for frequency-hopping transmission data by using a predetermined frequency hopping pattern;

a spreader for copying the data output by the frequency hopper by as many as a predetermined number of blocks, and spreading the copied data with different spread codes according to the copied data blocks;

N adaptive transmission controllers for applying weights to the respective data spread by the spreader, performing IFFT on the weighted data, and outputting the executed data to a corresponding antenna element wherein N corresponds to the number of antenna elements of the array antenna; and

a weight controller for controlling the weight of the adaptive transmission controller.

24. The transfer device of claim 21 or 22, wherein the receiver comprises:

N adaptive receiving controllers for performing FFT on the signals output by the array antenna, applying corresponding weights to the executed signals, and outputting weighted signals wherein N corresponds to the number of antenna elements of the array antenna;

a received weight controller for controlling the weight of the adaptive receiving controller according to a channel quality.

a despreader for despreading the data output by the adaptive receiving controller with different spread codes;

a combiner for dividing the data despread by the despreader into a predetermined number of blocks, combining the data of the respective blocks, and outputting data; and

a frequency dehopper for frequency-dehopping the data output by the combiner by using a predetermined frequency dehopping pattern, and outputting executed data.

25. A transmission method for the multi-carrier CDMA based on frequency hopping, comprising:

(a) converting input data into parallel data;

(b) frequency-hopping the converted parallel data by using a predetermined frequency hopping pattern;

(c) copying the frequency-hopped data by as many as a predetermined number of blocks, and spreading the data with different spread codes according to the copied data blocks; and

(d) performing IFFT on the spread data and transmitting the executed data through a transmit antenna.

26. The transmission method of claim 25, wherein the predetermined frequency hopping pattern is determined so as to use different frequencies to the parallel data with respect to time in (b).

27. A receiving method for the multi-carrier CDMA based on frequency hopping, comprising:

(a) performing FFT on the signal received through a receive antenna, and outputting FFT-performed data;

(b) despreading the FFT-performed data with different spread codes, dividing the despread data into a predetermined number of blocks, combining the data, and outputting combined data;

(c) frequency-dehopping the combined and output data by using a predetermined frequency dehopping pattern; and

(d) converting the frequency-dehopped data into serial data, and outputting the serial data.

28. The receiving method of claim 27, wherein the predetermined frequency dehopping pattern is determined so as to use different frequencies to the combined and output parallel data with respect to time in (c).

FIG. 1

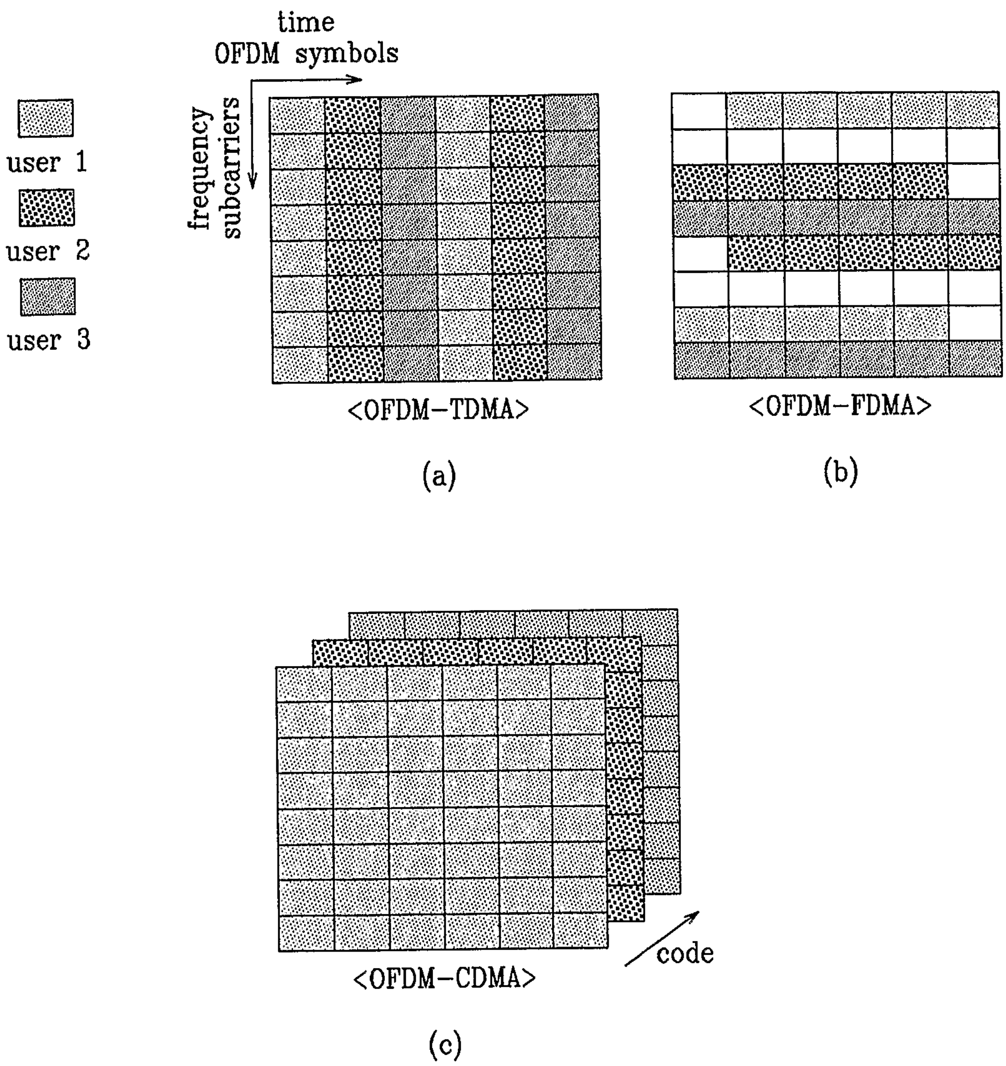

time
OFDM symbols
frequency
subcarriers
user 1
user 2
user 3
<OFDM-TDMA>
(a)
<OFDM-FDMA>
(b)
code
<OFDM-CDMA>
(c)

FIG. 2

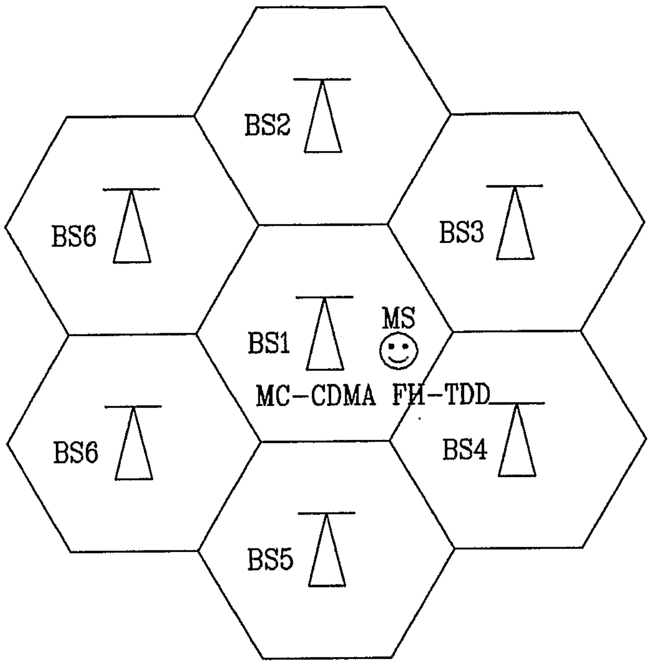
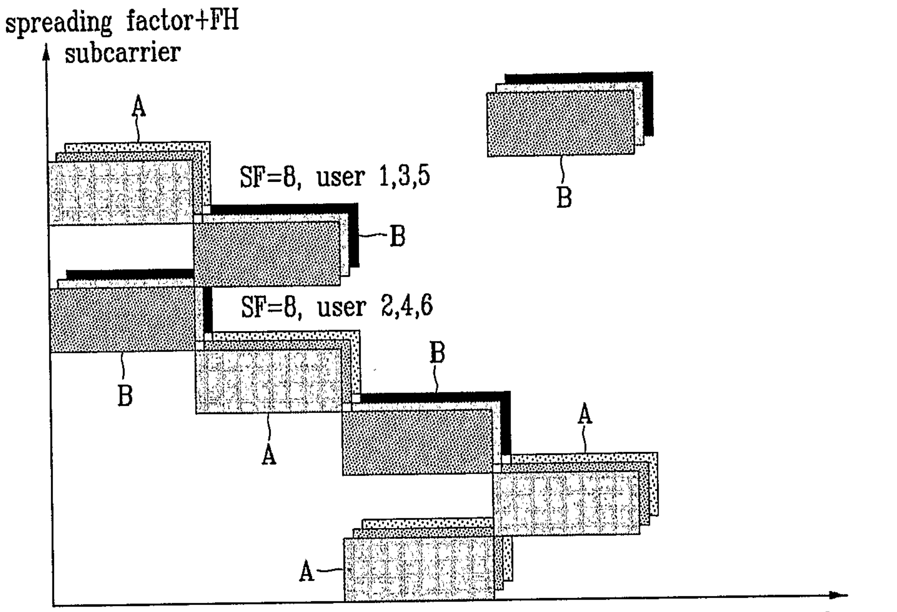


FIG. 3



A : SF=8, user 1,3,5

B : SF=8, user 2,4,6

FIG. 4

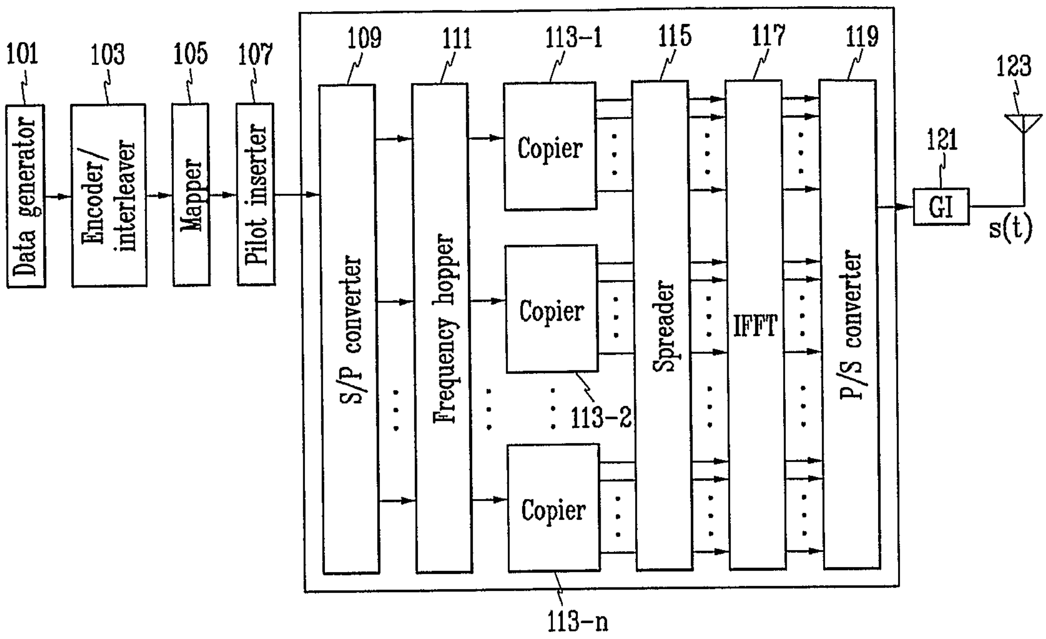

101
103
105
107
109
111
113-1
115
117
119
123
121
Data generator
Encoder/ interleaver
Mapper
Pilot inserter
S/P converter
Frequency hopper
Copier
Copier
Copier
113-2
113-n
Spreader
IFFT
P/S converter
GI
s(t)

FIG. 5

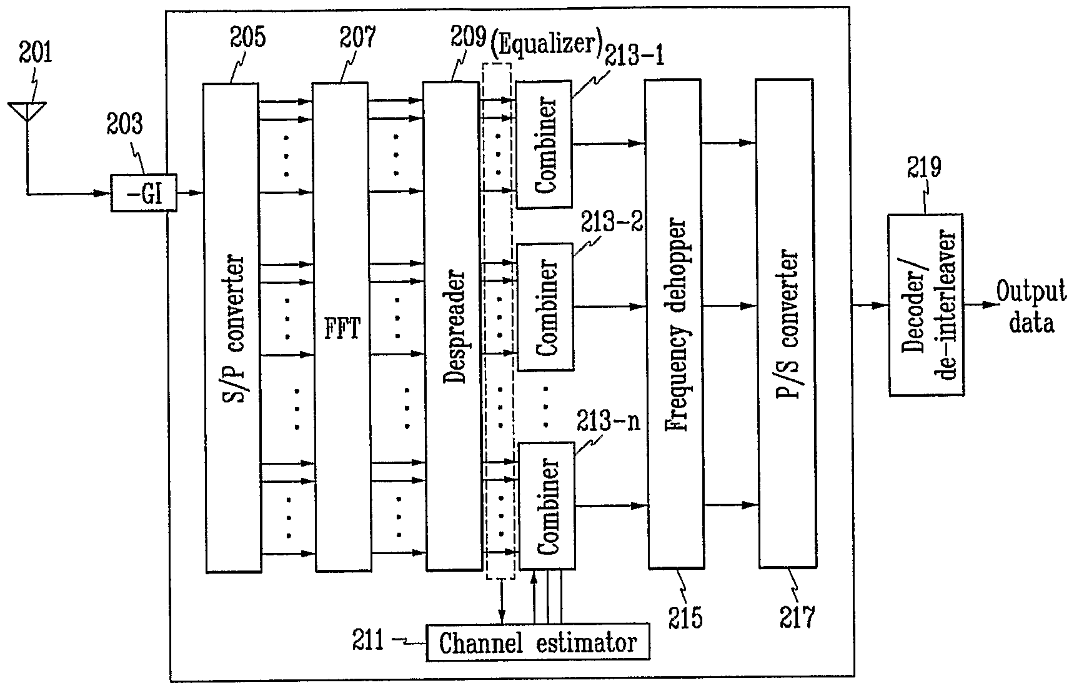

201
203
-GI
205
S/P converter
207
FFT
209
(Equalizer)
Despreader
213-1
Combiner
213-2
Combiner
213-n
Combiner
211
Channel estimator
Frequency dehopper
215
P/S converter
217
219
Decoder/
de-interleaver
Output
data

FIG. 6

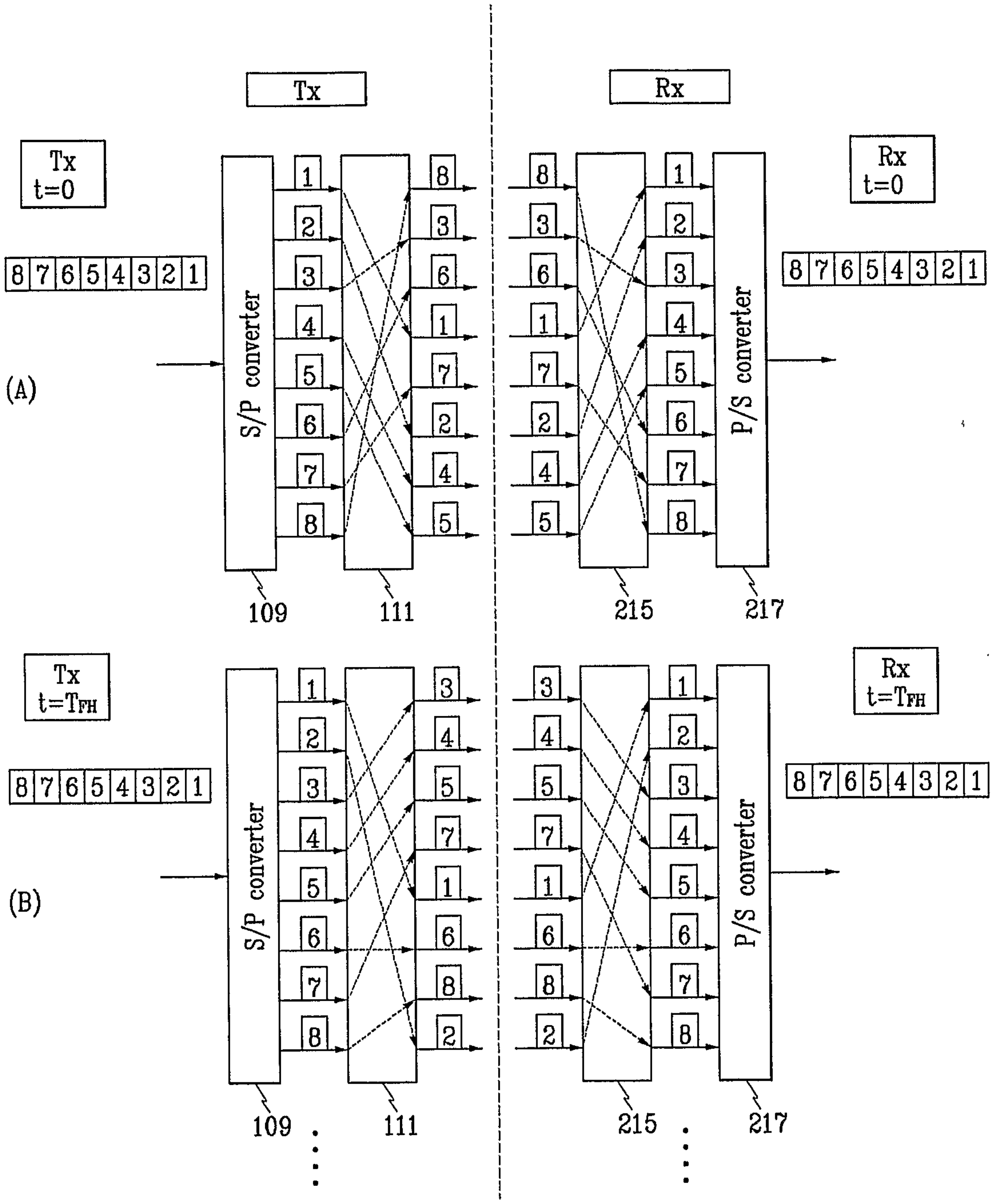

Tx
Rx
Tx t=0
8 7 6 5 4 3 2 1
(A)
S/P converter
1
2
3
4
5
6
7
8
8
3
6
1
7
2
4
5
109
111
8
3
6
1
7
2
4
5
1
2
3
4
5
6
7
8
P/S converter
Rx t=0
8 7 6 5 4 3 2 1
215
217
Tx t=TFH
8 7 6 5 4 3 2 1
(B)
S/P converter
1
2
3
4
5
6
7
8
3
4
5
7
1
6
8
2
109
111
3
4
5
7
1
6
8
2
1
2
3
4
5
6
7
8
P/S converter
Rx t=TFH
8 7 6 5 4 3 2 1
215
217

FIG. 7

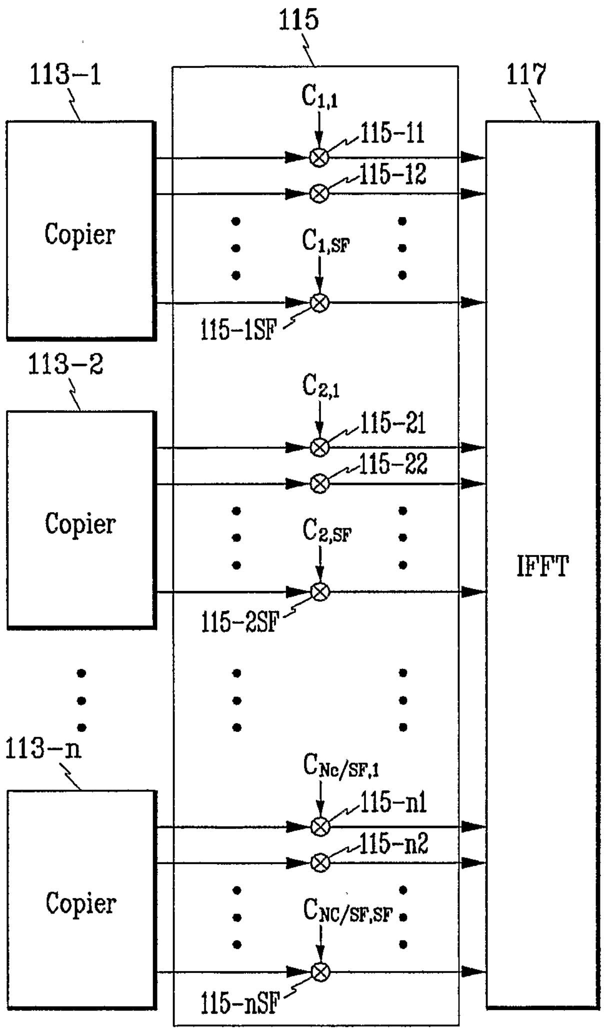

115
113-1
117
Copier
C1,1
115-11
115-12
C1,SF
115-1SF
113-2
Copier
C2,1
115-21
115-22
C2,SF
115-2SF
IFFT
113-n
Copier
CNc/SF,1
115-n1
115-n2
CNc/SF,SF
115-nSF

FIG. 8

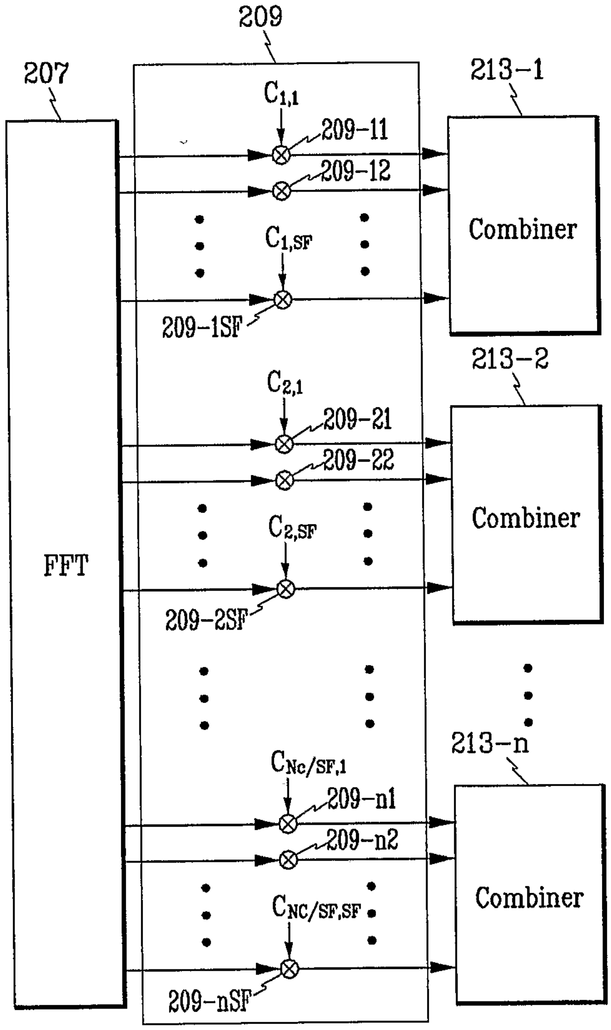

209
207
213-1
$C_{1,1}$
209-11
209-12
Combiner
$C_{1,SF}$
209-1SF
213-2
$C_{2,1}$
209-21
209-22
Combiner
$C_{2,SF}$
FFT
209-2SF
213-n
$C_{Nc/SF,1}$
209-n1
209-n2
Combiner
$C_{NC/SF,SF}$
209-nSF

FIG. 9

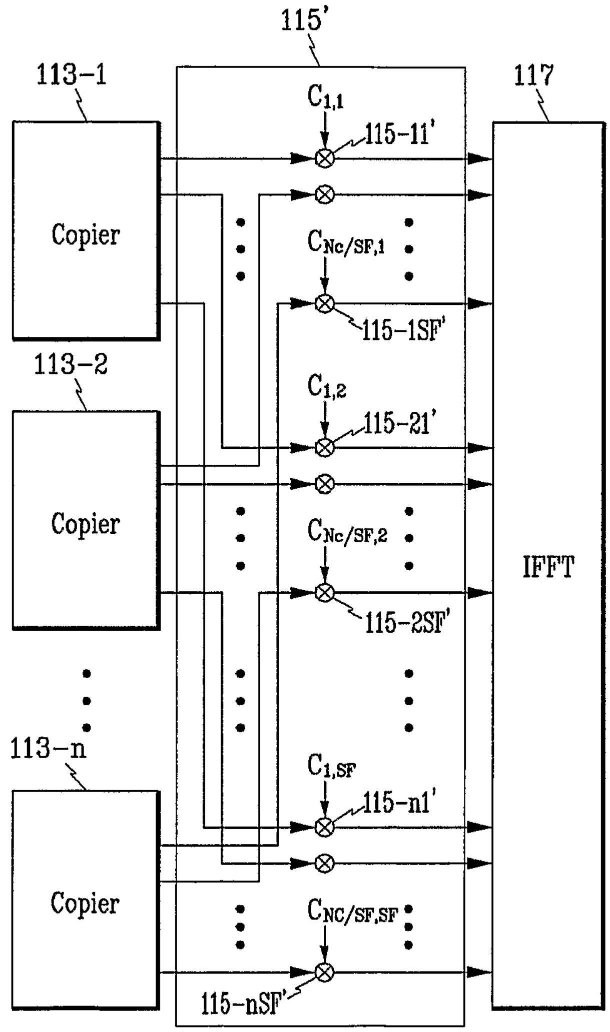

115'
113-1
117
Copier
C1,1
115-11'
CNc/SF,1
115-1SF'
113-2
C1,2
115-21'
Copier
CNc/SF,2
IFFT
115-2SF'
113-n
C1,SF
115-n1'
Copier
CNc/SF,SF
115-nSF'

FIG. 10

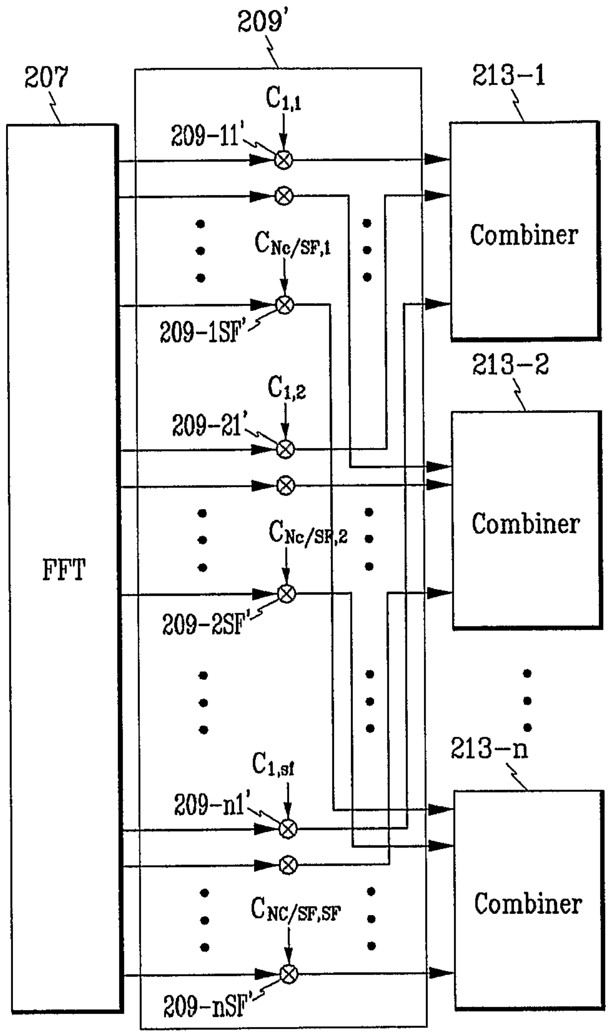
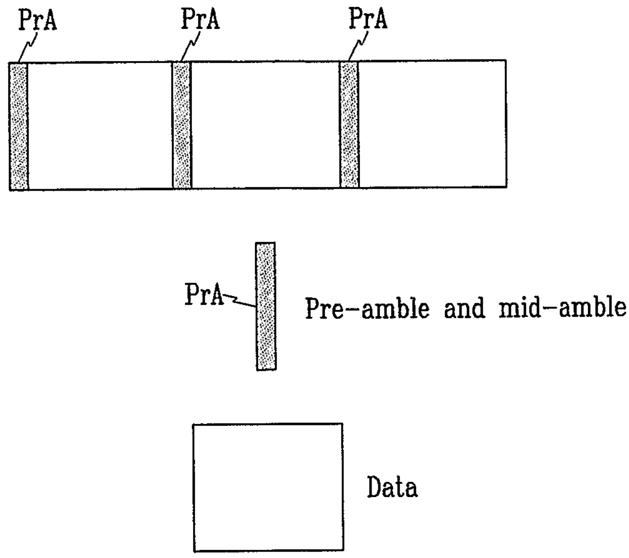

209'
207
213-1
$C_{1,1}$
209-11'
Combiner
$C_{Nc/SF,1}$
209-1SF'
213-2
$C_{1,2}$
209-21'
Combiner
$C_{Nc/SF,2}$
FFT
209-2SF'
213-n
$C_{1,sf}$
209-n1'
Combiner
$C_{NC/SF,SF}$
209-nSF'

FIG. 11

(A)


PrA
PrA
PrA
PrA
Pre-amble and mid-amble
Data

(B)

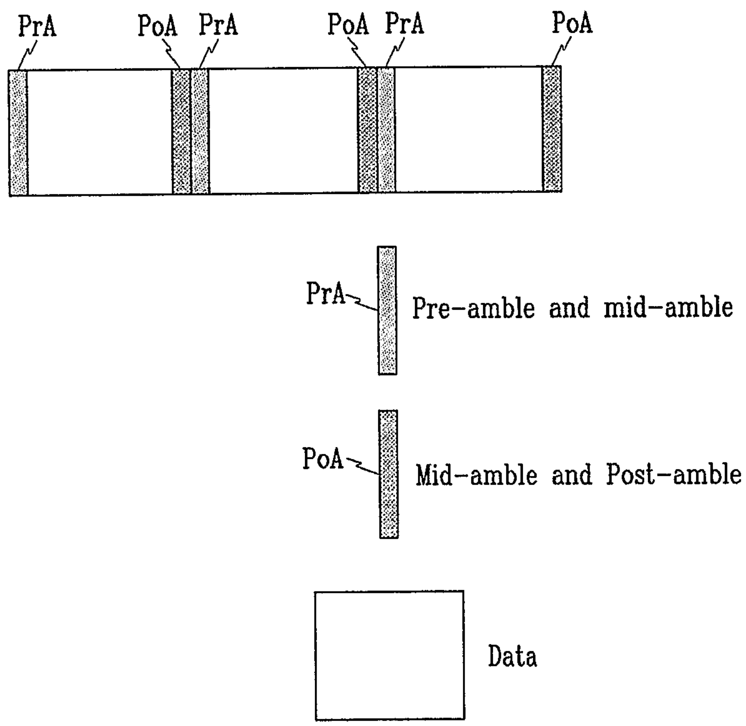
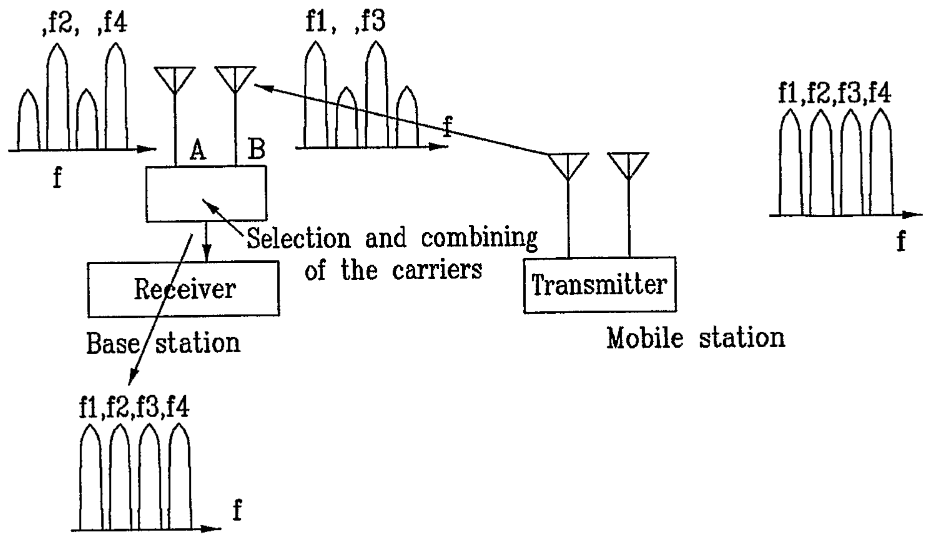
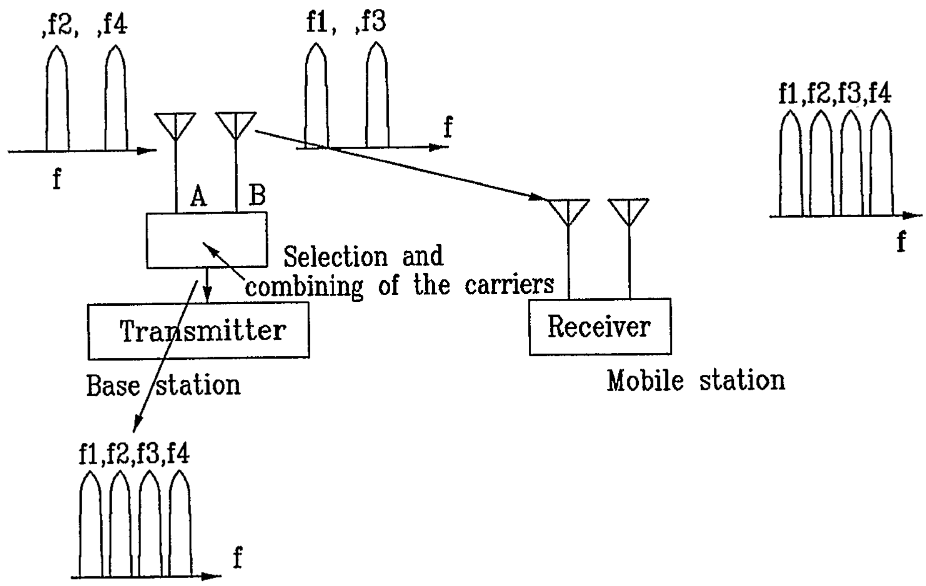

PrA
PoA
PrA
PoA
PrA
PoA
PrA
Pre-amble and mid-amble
PoA
Mid-amble and Post-amble
Data

FIG. 12

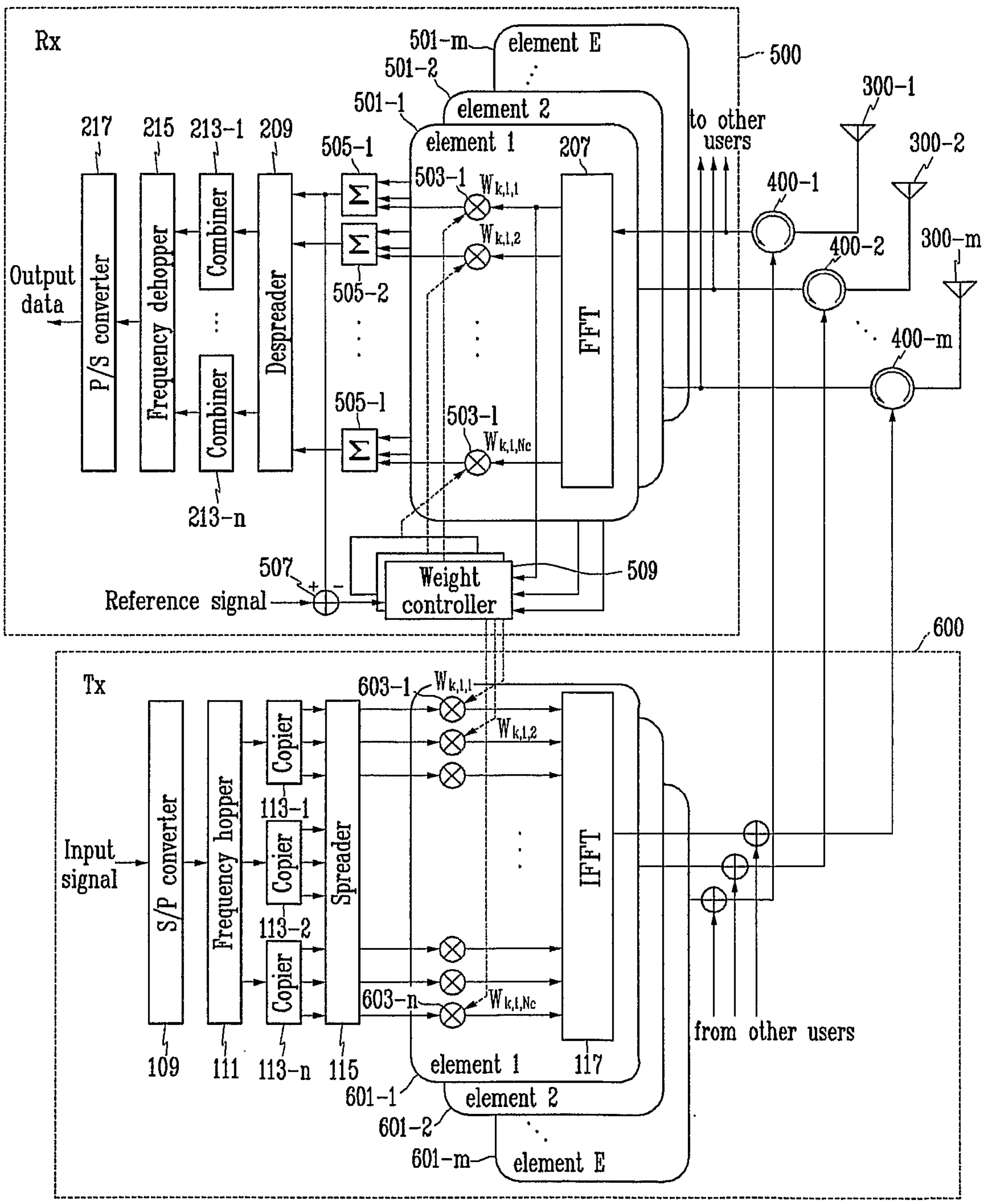

,f2, ,f4
f
f1, ,f3
f
A
B
Selection and combining of the carriers
Receiver
Base station
f1,f2,f3,f4
f
Transmitter
Mobile station
f1,f2,f3,f4
f

(A)


,f2, ,f4
f
f1, ,f3
f
A
B
Selection and combining of the carriers
Transmitter
Base station
f1,f2,f3,f4
f
Receiver
Mobile station
f1,f2,f3,f4
f

(B)

FIG. 13



Rx
500
501-m
element E
501-2
element 2
501-1
element 1
207
FFT
217
215
213-1
209
505-1
503-1
$W_{k,l,1}$
$W_{k,l,2}$
$W_{k,l,Nc}$
P/S converter
Frequency dehopper
Combiner
Despreader
Output data
505-2
213-n
507
Reference signal
Weight controller
509
to other users
300-1
300-2
300-m
400-1
400-2
400-m
600
Tx
603-1
603-n
Input signal
S/P converter
Frequency hopper
Copier
Spreader
113-1
113-2
113-n
IFFT
109
111
115
117
601-1
601-2
601-m
from other users

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2003/002635

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H04B 1/713

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7 H04B 1/69 713 7/26, H04J 11/00 13/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
search terms : frequency hopping, OFDM, array antenna, transmission diversity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1039683 A3 4 Oct. 2000 (Lucent Technologies Inc.) claims 1, 2, 8, 11, 13, 14, 17	1-9
Y	US 20030119534 A1 26 June 2003 (AT&T Corp.) claims 1-7	1-9
A	EP 0719003 A3 13 Sep. 2000 (Roke Manor Research Limited) claims 1-4, 9	1-9
A	JP 2001156739 A2 8 June 2001 (Victor Co.) see summary of the invention	1-9
A	US 6215810 BA 10 Apr. 2001 (Samsung Electronics Co.) see summary of the invention, claim 1	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 MAY 2004 (28.05.2004)	29 MAY 2004 (29.05.2004)

Name and mailing address of the ISA/KR
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2003/002635

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1039683 A3	4 Oct. 2000	US 6473418 BA	29 Oct. 2002
		JP 2000299680 A2	24 Oct. 2000
		EP 1039683 B1	27 Mar. 2002
		AU 200019567 A5	14 Sep. 2000
US 2003119534 AA	26 June 2003	US 6549784 BA	15 Apr. 2003
EP 0719003 A3	13 Sep. 2000	GB 2296407 A1	26 June 1996
JP 2001156739 A2	8 June 2001	None	
US 6215810 BA	10 Apr. 2001	JP 11261439 A2	24 Sep. 1999
		AU 1317199 A1	12 Aug. 1999