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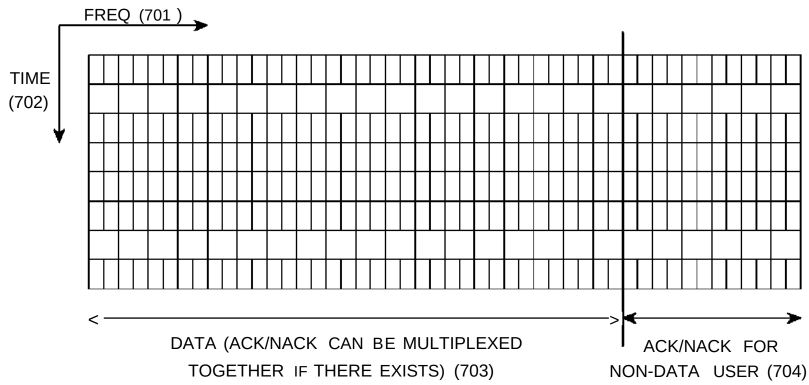
(54) Title: METHOD AND APPARATUS FOR TRANSMITTING/RECEIVING UPLINK SIGNALING INFORMATION IN A SINGLE CARRIER FDMA SYSTEM



(57) Abstract: A method and an apparatus for transmitting uplink information items having various characteristics by using a single Fast Fourier Transform (FFT) block. The method includes determining whether uplink signaling information exists to be transmitted when uplink data exists to be transmitted; multiplexing the uplink data and control information for the uplink data and transmitting multiplexed data through a first frequency resource allocated for the uplink data, when no uplink signaling information exists; multiplexing the uplink data, control information for the uplink data, and the uplink signaling information, and transmitting multiplexed data through a first frequency resource allocated for the uplink data, when the uplink signaling information exists; and transmitting the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no uplink data is to be transmitted and the uplink signaling information exists to be transmitted.

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Description

METHOD AND APPARATUS FOR TRANSMITTING/ RECEIVING UPLINK SIGNALING INFORMATION IN A SINGLE CARRIER FDMA SYSTEM

Technical Field

[1] The present invention relates to a method and an apparatus for transmitting/ receiving uplink signaling information and uplink data in a Frequency Division Multiple Access (FDMA) wireless communication system using a single carrier.

Background Art

[2] An Orthogonal Frequency Division Multiplexing (OFDM) scheme or a Single Carrier-Frequency Division Multiple Access (SC-FDMA) scheme similar to the OFDM scheme have been actively researched as a scheme available for high speed data transmission through a wireless channel in a mobile communication system.

[3] An OFDM scheme, which transmits data using multiple carriers, is a special type of a Multiple Carrier Modulation (MCM) scheme in which a serial symbol sequence is converted into parallel symbol sequences, and the parallel symbol sequences are modulated with a plurality of mutually orthogonal subcarriers (or subcarrier channels) before being transmitted.

[4] FIG. 1 shows a transmitter of a typical OFDM system. The OFDM transmitter includes a channel encoder 101, a modulator 102, a serial-to-parallel (S/P) converter 103, an Inverse Fast Fourier Transform (IFFT) block or a Digital Fourier Transform (DFT) block 104, a parallel-to-serial (P/S) converter 105, and a Cyclic Prefix (CP) inserter 106.

[5] The channel encoder 101 receives and channel-encodes a information bit sequence. In general, a convolutional encoder, a turbo encoder, or a Low Density Parity Check (LDPC) encoder are used as the channel encoder 101. The modulator 102 modulates the channel-encoded bit sequence according to a modulation scheme, such as a Quadrature Phase Shift Keying (QPSK) scheme, a 8PSK scheme, a 16ary Quadrature Amplitude Modulation (16QAM) scheme, a 64QAM scheme, a 256QAM scheme, etc. Meanwhile, although not shown in FIG. 1, it is obvious that a rate matching block for performing repetition and puncturing may be inserted between the channel encoder 101 and the modulator 102.

[6] The S/P converter 103 receives output data from the modulator 102 and converts the received data into parallel data. The IFFT block 104 receives the parallel data output from the S/P converter 103 and performs an IFFT operation on the parallel data. The data output from the IFFT block 104 is converted to serial data by the P/S converter

105. The CP inserter 106 inserts a CP into the serial data output from the P/S converterl05, thereby generating an OFDM symbol to be transmitted.

[7] The IFFT block 104 converts the input data of the frequency domain to output data of the time domain. In a typical OFDM system, because input data is processed in the frequency domain, a Peak to Average Power Ratio (PAPR) of the data may increase when the data have been converted into the time domain.

[8] A PAPR is one of the most important factors to be considered in the uplink transmission. As PAPR increases, the cell coverage decreases, so signal power required by a terminal increases. Therefore, it is necessary to first reduce the PAPR, and it is thus possible to use an SC-FDMA scheme, which is a scheme modified from the typical OFDM scheme, for the OFDM-based uplink transmission. That is to say, it is possible to effectively reduce the PAPR by enabling processing in the time domain without performing processing (channel encoding, modulation, etc.) of data in the frequency domain.

[9] FIG. 2 shows a transmitter in a system employing an SC-FDMA scheme, which is a typical uplink transmission scheme. The SC-FDMA transmitter includes a channel encoder 201, a modulator 202, a serial-to-parallel (S/P) converter 203, a Fast Fourier Transform (FFT) block 204, a sub-carrier mapper 205, an IFFT block 206, a parallel-to-serial (P/S) converter 207, and a CP inserter 208.

[10] The channel encoder 201 receives and channel-encodes a information bit sequence. The modulator 202 modulates the output of the channel encoder 201 according to a modulation scheme, such as a QPSK scheme, an 8PSK scheme, a 16QAM scheme, a 64QAM scheme, a 256QAM scheme, etc. A rate matching block may be omitted between the channel encoder 201 and the modulator 202.

[11] The S/P converter 203 receives data output from the modulator202 and converts the received data into parallel data. The FFT block 204 performs an FFT operation on the data output from the S/P converter 203, thereby converting the data into data of the frequency domain. The sub-carrier mapper205 maps the output data of the FFT block 204 to the input of the IFFT block 206. The IFFT block 206 performs an IFFT operation on the data output from the sub-carrier mapper 205. The output data of the IFFT block 206 is converted to parallel data by the P/S converter 207. The CP inserter 208 inserts a CP into the parallel data output from the P/S converter 207, thereby generating an OFDM symbol to be transmitted.

[12] FIG. 3 shows in more detail the structure for resource mapping shown in FIG. 2. Hereinafter, the operation of the sub-carrier mapper 205 will be described with reference to FIG. 3. Data symbols 301 having been subjected to the channel encoding and modulation are input to an FFT block 302. The output of the FFT block302 is input to an IFFT block 304. A sub-carrier mapper 303 maps the output data of the FFT

block 302 to the input data of the IFFT block 304.

[13] The sub-carrier mapper 303 maps the information symbols of the frequency domain data converted by the FFT block 302 to corresponding input points or input taps of the IFFT block 304 so the information symbols can be carried by proper subcarriers.

[14] During the mapping procedure, when the output symbols of the FFT block302 are sequentially mapped to neighboring input points of the IFFT block 304, the output symbols are transmitted by sub-carriers that are consecutive in the frequency domain. This mapping scheme is called a Localized Frequency Division Multiple Access (LFDMA) scheme.

[15] Further, when the output symbols of the FFT block 302 are mapped to input points of the IFFT block 304 having a predetermined interval between them, the output symbols are transmitted by sub-carriers having equal intervals between them in the frequency domain. This mapping scheme is called either an Interleaved Frequency Division Multiple Access (IFDMA) scheme or a Distributed Frequency Division Multiple Access (DFDMA) scheme.

[16] Although FIGs. 2 and 3 show one method of implementing the SC-FDMA technology in the frequency domain, it is also possible to use various other methods, such as a method of implementing the technology in the time domain.

[17] Diagrams (a) and (b) in FIG. 4 are views for comparison between the positions of subcarriers used for the DFDMA and the LFDMA in the frequency domain. In diagram (a), the transmission symbols of a terminal using the DFDMA scheme are distributed with equal intervals over the entire frequency domain (that is, the system band). In diagram (b), the transmission symbols of a terminal using the LFDMA scheme are consecutively located at some part of the frequency domain.

[18] According to the LFDMA scheme, because consecutive parts of the entire frequency band are used, it is possible to obtain a frequency scheduling gain by selecting a partial frequency band having good channel gain in the frequency selective channel environment in which severe channel change of frequency bands occurs. In contrast, according to the DFDMA scheme, it is possible to obtain a frequency diversity gain as transmission symbols have various channel gains by using a large number of sub-carriers distributed over a wide frequency band.

[19] In order to maintain a characteristic of a single carrier as described above, simultaneously transmitted information symbols should be mapped to the IFFT block so they can always satisfy the LFDMA or DFDMA after passing through a single FFT block (or DFT block).

[20] In an actual communication system, various information symbols may be transmitted. For example, in the uplink of a Long Term Evolution (LTE) system using the SC-FDMA based on a Universal Mobile Telecommunications System (UMTS),

uplink data, control information regulating a transport scheme of the uplink data (which includes Transport Format (TF) information of the uplink data and/or Hybrid Automatic Repeat reQuest (HARQ) information), an ACKnowledgement/Negative ACKnowledgment (ACK/NACK) for a HARQ operation for downlink data, a Channel Quality Indication (CQI) indicating the channel status reported to be used for scheduling of a base station, etc. may be transmitted. Those enumerated information items have different transmission characteristics, respectively.

[21] Uplink data can be transmitted in a situation in which a terminal has data in a transmission buffer of the terminal and has received permission for uplink transmission from a base station. The control information regulating the transport scheme of the uplink data is transmitted only when the uplink data is transmitted. Sometimes, uplink data may be transmitted without transmission of control information. In contrast, the ACK/NACK, which is transmitted in response to downlink data, has no relation to transmission of uplink data. That is, either both the uplink data and the ACK/NACK may be simultaneously transmitted or only one of them may be transmitted. Further, the CQI, which is transmitted at a given time, also has no relation to transmission of uplink data. That is, either both the uplink data and the CQI may be simultaneously transmitted or only one of them may be transmitted.

[22] As described above, various types of uplink information are transmitted in the SC-FDMA system. Under the restriction of use of a single FFT block, which is a characteristic of a single sub-carrier, it is necessary to effectively control transmission of information in order to transmit various types of information as described above. That is to say, it is necessary to arrange a specific transmission rule when only uplink data is transmitted, when only an ACK/NACK or a CQI is transmitted, and when both uplink data and uplink signaling information (ACK/NACK or CQI) are transmitted.

Disclosure of Invention

Technical Solution

[23] Accordingly, the present invention has been made to solve the abovementioned problems occurring in the prior art, and provides a method and an apparatus for transmitting uplink information items having various characteristics by using a single FFT block.

[24] The present invention also provides a method and an apparatus for transmitting uplink signaling information, such as ACK/NACK or CQI, according to existence or absence of uplink data.

[25] The present invention also provides a method and an apparatus for indicating whether the uplink signaling information, such as ACK/NACK or CQI, uses resources allocated to uplink data in transmission of the uplink data.

[26] In order to accomplish this object, there is provided a method for transmitting multiple types of uplink information in an SC-FDMA wireless communication system, the method including determining whether uplink signaling information exists to be transmitted when uplink data exists to be transmitted; multiplexing the uplink data and control information for the uplink data and transmitting multiplexed data through a first frequency resource allocated for the uplink data, when no uplink signaling information exists; multiplexing the uplink data, control information for the uplink data, and the uplink signaling information, and transmitting multiplexed data through a first frequency resource allocated for the uplink data, when the uplink signaling information exists; and transmitting the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no uplink data is to be transmitted and the uplink signaling information exists to be transmitted.

[27] In accordance with another aspect of the present invention, there is provided an apparatus for transmitting multiple types of uplink information in an SC-FDMA wireless communication system, the apparatus including a multiplexer for multiplexing uplink data and control information for the uplink data when the uplink data exists to be transmitted and no uplink signaling information is to be transmitted, and multiplexing uplink data, control information for the uplink data, and the uplink signaling information when both the uplink data exists to be transmitted and the uplink signaling information exists to be transmitted; a data resource mapper for transmitting information multiplexed by the multiplexer through a first frequency resource allocated for the uplink data; and an uplink signaling resource mapper for transmitting the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no uplink data is to be transmitted.

[28] In accordance with another aspect of the present invention, there is provided a method for receiving multiple types of uplink information in an SC-FDMA wireless communication system, the method including determining whether uplink data has been received through a first frequency resource allocated for the uplink data; determining whether information received through the first frequency resource includes uplink signaling information, when the uplink data has been received; demultiplexing the information received through the first frequency resource into the uplink data and control information for the uplink data, when the information received through the first frequency resource does not include uplink signaling information; demultiplexing the information received through the first frequency resource into the uplink data, control information for the uplink data, and uplink signaling information, when the information received through the first frequency resource includes the uplink signaling information; and receiving the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when the uplink data

has not been received.

[29] In accordance with another aspect of the present invention, there is provided an apparatus for receiving multiple types of uplink information in an SC-FDMA wireless communication system, the apparatus including a determination unit for determining whether information includes uplink signaling information, when the information has been received through a first frequency resource allocated for uplink data; a demultiplexer for demultiplexing the information received through the first frequency resource into the uplink data and control information for the uplink data when the information received through the first frequency resource does not include uplink signaling information, and demultiplexing the information received through the first frequency resource into the uplink data, control information for the uplink data, and uplink signaling information, when the information received through the first frequency resource includes the uplink signaling information; and a receiver unit for receiving the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no information is received through the first frequency resource.

Advantageous Effects

[30] The present invention presents a scheme for multiplexing and resource mapping of uplink data and uplink signaling information, in order to satisfy the single sub-carrier characteristic in the transmission of the uplink data and uplink signaling information in an SC-FDMA wireless communication system. The present invention can eliminate factors disturbing the single carrier transmission and prevent PAPR increase, which may occur when uplink data occurring according to determination of a scheduler, ACK/NACK occurring according to transmission of downlink data, and uplink signaling information such as CQI indicating the channel status are transmitted without relation to each other.

Brief Description of the Drawings

[31] The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

[32] FIG. 1 is a block diagram illustrating a structure of a transmitter of a typical OFDM system;

[33] FIG. 2 is a block diagram illustrating a structure of a transmitter in a system employing an SC-FDMA scheme, which is a typical uplink transmission scheme;

[34] FIG. 3 is a block diagram illustrating in more detail the structure for resource mapping shown in FIG. 2;

[35] FIG. 4 are views for comparison between the positions of sub-carriers used for the

DFDMA and the LFDMA in the frequency domain;

[36] FIG. 5 illustrates structures of an uplink transmission frame and its sub-frame of an LTE system according to the present invention;

[37] FIG. 6 illustrates the sub-frame 502 of FIG. 5 on the time domain and the frequency domain according to the present invention;

[38] FIG. 7 illustrates the resources allocated to uplink data and ACK/NACK according to the present invention;

[39] FIG. 8 illustrates use of frequency-time resources according to the first embodiment of the present invention;

[40] FIG. 9 is a flow diagram of an operation of a transmitter according to the first embodiment of the present invention;

[41] FIG. 10 is a block diagram illustrating the structure of the transmitter according to the first embodiment of the present invention;

[42] FIG. 11 is a flow diagram of an operation of a receiver according to the first embodiment of the present invention;

[43] FIG. 12 is a block diagram illustrating the structure of the receiver according to the first embodiment of the present invention;

[44] FIG. 13 is a flow diagram of an operation of a transmitter according to the second embodiment of the present invention;

[45] FIG. 14 is a block diagram illustrating the structure of the transmitter according to the second embodiment of the present invention;

[46] FIG. 15 is a flow diagram of an operation of a receiver according to the second embodiment of the present invention;

[47] FIG. 16 is a block diagram illustrating the structure of the receiver according to the second embodiment of the present invention;

[48] FIG. 17 illustrates a sub-frame according to the third embodiment of the present invention in which the ACK/NACK and the CQI are multiplexed at the same time;

[49] FIG. 18 illustrates use of frequency-time resources according to the third embodiment of the present invention;

[50] FIG. 19 illustrates a structure of CQI information according to the third embodiment of the present invention;

[51] FIG. 20 is a flow diagram of an operation of a transmitter according to the third embodiment of the present invention; and

[52] FIG. 21 is a flow diagram of an operation of a receiver according to the third embodiment of the present invention.

Best Mode for Carrying Out the Invention

[53] Hereinafter, preferred embodiments of the present invention will be described with

reference to the accompanying drawings. In the following description, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear. Further, in the following description of the present invention, various specific definitions are provided only to help general understanding of the present invention, and it is apparent to those skilled in the art that the present invention can be implemented without such definitions.

[54] The present invention multiplexes different types of uplink information to enable transmission of the uplink information, which can satisfy a single carrier (SC) characteristic in a wireless communication system using a Single Carrier Frequency Division Multiple Access (SC-FDMA) scheme. The following description discusses multiplexing for uplink transmission of uplink data, control information, Acknowledgement/Negative ACKnowledgement (ACK/NACK), Channel Quality Indication (CQI), etc. in an SC-FDMA wireless communication system. As used herein, the other information except for the uplink data and control information thereof, that is, information including ACK/NACK and CQI, is referred to as uplink signaling information.

[55] A Long Term Evolution (LTE) system, which is being standardized by the 3rd Generation Partnership Project (3GPP), is discussed in order to describe the present invention. The LTE system employs a SC-FDMA scheme for uplink transmission. FIG.5 shows an uplink transmission frame and its sub-frame according to the present invention.

[56] In FIG. 5, reference numeral 501 denotes a radio frame, which is an uplink transmission unit and is defined to have a length of 10 ms. One radio frame 501 includes20 sub-frames 502, each of which has a length of 0.5 ms. Further, each subframe 502 includes six Long Blocks (LBs) 503, 505, 506, 507, 508, and 510, two Short Blocks (SBs) 504 and 509, and CPs 511 and 512 located before the blocks one before one. The LBs 503 to 510 carry information except for pilots used as a reference for coherent modulation, and SBs 504 and 509 are used to carry the pilots.

[57] FIG. 6 shows the sub-frame 502 of FIG. 5 on the time domain and the frequency domain according to the present invention. The horizontal axis indicates the frequency domain 601 and the vertical axis indicates the time domain 602. The range of the frequency domain 601 corresponds to the entire frequency band 604 and the range of the time domain 602 corresponds to one sub-frame 603. As noted, the SBs605 and 607 carry pilots, and the LBs 607 and 608 carry other information except for the pilots.

[58] As described above, uplink data transmitted according to resource allocation by a base station, control information in relation to the uplink data, ACK/NACK for indicating success or failure in reception of downlink data, CQI for indicating a

channel status, etc. are transmitted by using the uplink resource.

[59] A determination to transmit the uplink data is made according to scheduling of a base station, and a determination of a resource to be used is also made according to allocation by the base station. The control information transmitted together with the uplink data is also transmitted according to the resources allocated by the base station. In contrast, since the ACK/NACK is generated based on downlink data, the ACK/NACK is transmitted using an uplink resource automatically allocated according to whether the downlink data is transmitted, in response to the control channel defining the downlink data or the downlink data channel. Further, since it is usual that the CQI is periodically transmitted, the CQI is transmitted using a resource determined in advance through setup by higher signaling.

[60] Because the information items use a variety of resource allocation methods as described above, the variety of resource allocation methods are simultaneously used when various types of information are transmitted together. In order to satisfy a characteristic of a single sub-carrier, the resource used during one subframe must necessarily maintains a characteristic of the LFDMA or DFDMA. For example, when uplink data and ACK/NACK are transmitted simultaneously, that is, during one Transmission Time Interval (TTI), the uplink data uses the resource allocated by the base station, and the ACK/NACK uses a resource determined by another method, for example, a resource determined according to a control channel for downlink data. Therefore, use of the two resources may cause a contradiction to a characteristic of a single sub-carrier, thereby increasing the PAPR. Therefore, the present invention provides a method by which simultaneously transmitted information items can always maintain a characteristic of a single sub-carrier.

[61] Specifically, transmission of uplink data and ACK/NACK together will be described hereinafter. The transmission of uplink data may be accompanied with transmission of control information of the uplink data. Further, the discussion below may also be applied to other uplink signaling information, such as the CQI instead of the ACK/NACK.

[62] In order to always maintain a characteristic of a single sub-carrier either when only one of the ACK/NACK and the uplink data is transmitted or when both of them are simultaneously transmitted, the present invention provides the following method. That is, when only one of the ACK/NACK and the uplink data is transmitted, a resource allocated to the corresponding information is used. Specifically, when only the uplink data is transmitted, the uplink data is transmitted by using the resource allocated by the base station. When only the ACK/NACK is transmitted, the ACK/NACK is transmitted by using the resource determined for the transmission of the ACK/NACK. However, when both of the ACK/NACK and the uplink data are simultaneously

transmitted, the ACK/NACK and the uplink data are transmitted by using only the resource allocated for the uplink data, and the resource determined for the transmission of the ACK/NACK is disregarded. In other words, the ACK/NACK and the uplink data are simultaneously transmitted by using the resource allocated for the uplink data.

[63] FlG. 7 shows resources allocated to uplink data and ACK/NACK according to the present invention. Reference numeral 701 denotes a frequency domain and reference numeral 702 denotes a time domain. Further, within one time interval, sub-carriers allocated to data corresponds to a first resource 703 and sub-carriers allocated to the ACK/NACK corresponds to a second resource 704. The resources 703 and 704 allocated to the uplink data and the ACK/NACK as described above are separated on the frequency domain. Although F1G.7 shows logical separation between the resources 703 and 704 allocated to the uplink data and the ACK/NACK, the resources 703 and 704 are separated into two sub-carrier sets not only when the LFDMA is used but also when the DFDMA is used.

[64] When the entire frequency resources have been divided into two sub-carrier sets, uplink data is transmitted by using a first resource 703 when there exists only the uplink data, while ACK/NACK is transmitted by using a second resource 704 when only the ACK/NACK exists. In contrast, when both the uplink data and the ACK/NACK exist, both the uplink data and the ACK/NACK are multiplexed and transmitted by using only the first resource 703 without using the second resource 704.

[65] That is, the transmission position of the ACK/NACK changes according to whether uplink data exists. In transmitting the uplink data, the quantity of information is different and the transport format of the uplink data is thus different according to whether the ACK/NACK exists. Therefore, the type and quantity of information to be transmitted should be promised in advance between the base station and the terminal.

[66] When the terminal transmits only the uplink data and the base station misunderstands that the terminal has transmitted both the uplink data and the ACK/NACK, it is impossible to expect a normal communication because encoding and decoding are performed according to different encoding/decoding schemes. For example, such a communication error may occur when the terminal has successfully received scheduling information for the uplink data but has failed to receive downlink data, and determines that there is no downlink data without sending an ACK/NACK. Therefore, it is necessary for the base station to exactly understand the type and quantity of information transmitted by the terminal. For example, the base station determines the type of the information received from the terminal either by analyzing the information transmitted by the terminal or according to whether the base station has transmitted downlink data to the terminal. For another example, the terminal may clearly report the type of uplink information to the base station.

[67]

[68] First Embodiment

[69] According to the first embodiment of the present invention, the terminal may inform the base station whether the uplink signaling information (specifically, the ACK/NACK) will be transmitted. Hereinafter, use of frequency-time resources according to the first embodiment of the present invention will be described with reference to FIG. 8.

[70] In FIG. 8, reference numeral 801 denotes one sub-frame used in the uplink of an LTE system, and reference numeral 808 denotes the frequency band allocated for transmission of data. In the frequency band 808, reference numeral 802 denotes a first subcarrier set allocated to a first terminal that transmits uplink data without ACK/NACK, and reference numeral 803 denotes a second sub-carrier set allocated to a second terminal that transmits uplink data together with ACK/NACK.

[71] In the first sub-carrier set 802, pilots 804 and 806 for channel estimation are transmitted through the allocated time resource. Pilots 804 and 806 have a sequence with a pilot pattern known to the base station and the terminal, representatives of which includes an all 1 sequence (all bits of which have a value of 1). That is, pilots 804 and806 for sub-carrier set 802 without ACK/NACK are set to have a representative sequence such as an all 1 sequence. In contrast, pilots 805 and807 for the second sub-carrier set 803 carrying the ACK/NACK are set to have a sequence different from that of pilots 804 and 806. That is, sub-carrier set 803 uses a pilot other than the all 1 sequence. For example, it uses a pilot having a sequence in which 1 and -1 are alternately repeated. At this time, by setting the minimum distance between the two different sequences to be largest, it is possible to minimize the probability of error in discriminating between the two sequences by the base station.

[72] In brief, the terminal informs the base station through pilots having sequences of different pilot patterns of whether the ACK/NACK is simultaneously transmitted together with uplink data.

[73] FIG. 9 shows an operation of a transmitter (terminal) according to the first embodiment of the present invention, and FIG. 10 shows the transmitter (terminal). Referring to FIG. 9, when the operation of the terminal has started, the terminal determines whether data to be transmitted exists in step 902. When data exists to be transmitted by the terminal, the terminal is instructed through scheduling of the base station, etc. When the determination in step 902 concludes that data exists to be transmitted and the base station has allocated a resource for transmission of the data, the terminal determines whether ACK/NACK exists to be transmitted (step 903). When ACK/NACK exists to be transmitted the information is determined through an HARQ operation for downlink data and based on whether the downlink data has been

received.

[74] When it has been determined in step 903 that there is ACK/NACK to be transmitted, the terminal sets pilot pattern #2 having a predetermined sequence as a pilot signal for the data and multiplexes the data, the ACK/NACK, and control information for the data in step 905. Then, in step 908, the terminal maps the multiplexed information to the data resource allocated by the base station, as described above, and then transmits the mapped information. At this time, the pilot signal of pilot pattern #2 is also transmitted through short blocks, which are predetermined time resources of the data resources.

[75] In contrast, when it has been determined in step 903 that no ACK/NACK is to be transmitted, the terminal sets pilot pattern # 1 having a predetermined sequence as a pilot signal for the data and multiplexes the data and control information for the data in step 906. Then, in step 909, the terminal maps the multiplexed information to the data resource allocated by the base station as described above and then transmits the mapped information. At this time, the pilot signal of pilot pattern # 1 is also transmitted through short blocks, which are predetermined time resources of the data resources. Steps 905 and906 may be omitted when the terminal does not clearly inform the base station whether the terminal will transmit ACK/NACK.

[76] Meanwhile, when the determination in step 902 concludes that no uplink data is to be transmitted, the terminal determines whether ACK/NACK exists to be transmitted in step 904. When ACK/NACK exists to be transmitted, the terminal transmits the ACK/NACK by using a resource allocated for the ACK/NACK, that is, by using an ACK/NACK resource corresponding to the resource of the downlink data in step907. In contrast, when no ACK/NACK is to be transmitted, the process is terminated.

[77] Referring to the transmitter shown in FlG. 10, ACK/NACKIOOI for downlink data is subjected to an encoding, such as a repetition coding by a channel encoder 1006, and is then input to a demultiplexer (DEMUX) 1016. The output path from the DEMUX 1016 depends on a signal 104 indicating whether uplink data 1002 exists. Specifically, the DEMUX1016 is connected to output to path 1009 when uplink data 1002 exists. Otherwise, the DEMUX 1016 is connected to output path 1008.

[78] The uplink data 1002 is encoded by a channel encoder 1013 and is then input to a multiplexer 1015, while the control information 1003 indicating the transport format of the uplink data 1002 is encoded by a channel encoder 1014, and is then input to the multiplexer 1015. Further, the encoded ACK/NACK may be input to the multiplexer 1015 through output path 1009. One of the pilot signals 1011 and 1012 for the resource (data resource) allocated for the uplink data 1002 is input through the switchlO12 to the multiplexer 1015. The selection by the switch 1012 depends on a signal 105 indicating whether ACK/NACK exists. Specifically, the switchlO12 selects

the pilot signal 1011 of pilot pattern #1 when the ACK/NACK is not transmitted to the data resource, and selects the pilot signal 1012 of pilot pattern #2 when the ACK/NACK is transmitted to the data resource.

[79] The information multiplexed by the multiplexer 1015 is mapped to the data resource by a data resource mapper 1021 and is then transmitted. The data resource mapper 1021 includes an FFT (or DFT) block, a sub-carrier mapper, and an IFFT block as described above with reference to FIG. 2. That is, when both the uplink datal002 and the ACK/NACK 1001 exist, the uplink data 1002 and the ACK/NACKlOOl are multiplexed before the FFT operation. In contrast, when no uplink data exists, the encoded ACK/NACK output through output path 1008 is mapped to a resource (ACK/NACK resource) appointed for the ACK/NACK by an ACK/NACK resource mapper 1020 and is then transmitted.

[80] FIG. 11 shows an operation of a receiver (base station) according to the first embodiment of the present invention, and FIG. 12 shows the receiver (base station). Referring to FIG. 11, when the operation of the base station has started, the base station determines whether it will receive data from the terminal in step 1102. The determination is made as to whether the base station will receive data from the terminal based on whether the base station has allocated a data resource for uplink to the terminal. When the determination in step 1102 concludes that data exists to be received, the base station receives information through a resource allocated for the data, that is, through the data resource in step 1103, and determines the pattern of the pilot signal included in the data resource in step 1105.

[81] In step 1105, the base station determines the pilot pattern of the pilot signal by correlating the pilot signal with pilot pattern #1 and pilot #2, which are already known, by using a correlator, etc. When the pilot signal has pilot pattern #1, the base station determines that the data resource does not include ACK/NACK, and acquires the uplink data and control information through demultiplexing and decoding of the received information. In contrast, when the pilot signal has pilot pattern #2, the base station determines that the data resource includes ACK/NACK, and acquires the uplink data, control information, and ACK/NACK through demultiplexing and decoding of the received information. When the terminal does not clearly inform the base station of whether to transmit ACK/NACK, the base station may determine whether it will receive ACK/NACK, according to whether a downlink scheduler has previously allocated the resource for the downlink data, instead of using the pilot pattern of the pilot signal in step 1105.

[82] When the determination in step 1102 concludes that no data is to be received, the base station determines in step 1104 whether ACK/NACK exists to be received, based on whether a downlink scheduler has previously allocated the resource for the

downlink data. When ACK/NACK exists to be received, the base station receives information through the resource (ACK/NACK resource) allocated for ACK/NACK in step 1106, and acquires ACK/NACK by decoding the received information in step 1109. When the determination in step 1104 concludes that no ACK/NACK is to be received, the process is terminated.

[83] Referring to FlG. 12, the base station receives a radio signal through a receiver block 1201. Then, a demultiplexer (DEMUX) 1202 demultiplexes the radio signal and then extracts a signal for a specific terminal. At this time, the DEMUX 1202 operates by using a control signal of a scheduler 1215. That is, when a data resource has been allocated to the terminal by the scheduler 1215, the DEMUX 1202 outputs only the data resource information 1204 in the extracted signal. In contrast, when receiving the ACK/NACK without data, the DEMUX1202 outputs only the ACK/NACK resource information 1212 in the extracted signal. A channel decoder 1213 decodes the ACK/NACK resource information 1212 and outputs the decoded ACK/NACK.

[84] The data resource information 1204 is provided to a pilot determination block 1203 and a demultiplexer (DEMUX) 1205. The pilot determination block 1203 determines the pilot pattern of the pilot signal included in the data resource information 1204, and makes a determination based on the pilot pattern whether the ACK/NACK exists. Based on a result of the determination, a control signall216 indicating existence or absence of the ACK/NACK is input to the DEMUX 1205. When the control signal 1216 indicates that the ACK/NACK exists, the DEMUX 1205 demultiplexes the demultiplexed information 1204 again into encoded uplink data 1222, encoded control information 1221, and encoded ACK/NACK 1223. The outputs 1221, 1222, and 1223 of the DEMUX 1205 are decoded by the channel decoders 1206, 1207, and 1208 and are then output as uplink data 1210, control information 1209, and ACK/NACK 1211.

[85] In contrast, when the control signal 1216 indicates that no ACK/NACK exists, the DEMUX 1205 demultiplexes the demultiplexed information 1204 again into encoded uplink data 1222 and encoded control information 1221. The outputs 1221 and 1222 of the DEMUX 1205 are decoded by the channel decoders 1206 and 1207 and are then output as uplink data 1210 and control information 1209. At this time, the channel decoder 1208 for the ACK/NACK 1211 does not operate.

[86]

[87] Second Embodiment

[88] According to the second embodiment of the present invention, an ACK/NACK field of one bit or multiple bits is arranged within control information. When ACK/NACK is transmitted together with uplink data, the ACK/NACK is carried by the ACK/NACK field predefined in the control information. Therefore, only the encoded data and encoded control information are multiplexed before resource mapping. The ACK/

NACK field is set to have a value indicating ACK or NACK according to success or failure in reception of downlink data when ACK/NACK exists. Otherwise, the ACK/NACK field is set to have a value indicating or the NACK.

[89] FlG. 13 shows an operation of a transmitter (terminal) according to the second embodiment of the present invention, and FlG. 14 shows the transmitter (terminal). Referring to FlG. 13, when the operation of the terminal has started, the terminal determines whether data exists to be transmitted in step 1302. When data exists to be transmitted by the terminal, the terminal is instructed through scheduling of the base station, etc. When the determination in step 1302 concludes that data exists to be transmitted and the base station has allocated a resource for transmission of the data, the terminal determines whether ACK/NACK exists to be transmitted in step 1303. The determination of whether ACK/NACK exists to be transmitted is performed through an HARQ operation for downlink data, and is based on whether the downlink data has been received.

[90] When it has been determined in step 1303 that there is ACK/NACK to be transmitted, the terminal sets ACK/NACK in the ACK/NACK field of control information and multiplexes the data and control information in step 1305. Then, in step 1308, the terminal maps the multiplexed information to the data resource and then transmits the mapped information. In contrast, when it has been determined in step 1303 that no ACK/NACK is to be transmitted, the terminal sets NACK in the ACK/NACK field of control information and multiplexes the data and control information in step 1307. Then, in step 1308, the terminal maps the multiplexed information to the data resource and then transmits the mapped information.

[91] Meanwhile, when the determination in step 1302 concludes that no uplink data is to be transmitted, the terminal determines whether ACK/NACK exists to be transmitted in step 1304. When ACK/NACK exists to be transmitted, the terminal transmits the ACK/NACK by using a resource allocated for the ACK/NACK, that is, by using the ACK/NACK resource in step 1309. In contrast, when no ACK/NACK is to be transmitted, the process is terminated.

[92] Referring to the transmitter shown in FlG. 14, the uplink data 1401 is encoded by a channel encoder 1408 and is then input to a multiplexer (MUX) 141 1. In contrast, the ACK/NACK 1402 indicating success or failure in reception of downlink data is transferred through a demultiplexer (DEMUX) 1415 to output path 1417 or output pathl416 according to the control signal 1420 indicating existence or absence of the uplink data 1401. When the uplink data 1401 is not transmitted, the ACK/NACK 1402 transferred to output path 1416 is subjected to encoding, such as repetition encoding by a channel encoder 1406, and is then transmitted using an ACK/NACK resource by an ACK/NACK resource mapper 1410.

[93] When the uplink data 1401 is not transmitted, the ACK/NACK 1402 transferred to output path 1417 is input to the switch 1405. The switch 1405 selects between a predetermined NACK 1404 and the ACK/NACK 1402. Specifically, the switch 1405 selects the ACK/NACK 1402 when the ACK/NACK 1402 exists in output path 1417, and selects the NACK 1404 when the ACK/NACK 1402 does not exist in output path 1417.

[94] The output of the switch 1405 is multiplexed with control information 1403 by a MUX 1409, and the multiplexed information is encoded by a channel encoderl407 and is then input to the multiplexer (MUX) 141 1. The MUX141 1 multiplexes the data encoded by the channel encoder 1408 and the control information encoded by the channel encoder 1407, and the multiplexed information is then transmitted using the data resource by a data resource mapper 1412.

[95] In the transmitter as described above, when uplink data exists, the ACK/NACK is encoded and transmitted together with control information. At this time, the control information including the ACK/NACK uses a superior decoding performance than the control information that does not include the ACK/NACK. This is because an error requirement of the control information is usually lower than an error requirement of the ACK/NACK. In the structure shown in FlG. 14, the control information and the ACK/NACK are simultaneously encoded by one channel encoder 1407, and the channel encoder 1407 operates in accordance with the lower error requirement of the ACK/NACK.

[96] When the channel encoding scheme of the control information including the ACK/NACK has a characteristic of unequal error protection, information bits input to the channel encoder 1407 have different error probabilities according to their positions. Therefore, by locating the ACK/NACK field at a position capable of minimizing the error probability within the control information, it is possible to satisfy both the error requirement of the ACK/NACK and the error requirement of the control information. For example, section 4.7.1.2 of 3GPP TS 25.212 v6.6.0 describes a channel encoding scheme having an unequal error protection property which can cause the Most Significant Bit (MSB) to have the lowest error probability. Therefore, when the described channel encoding scheme is used, it is possible to lower the error probability of the ACK/NACK and to properly maintain the error probability of the control information by setting the ACK/NACK field as the MSB within the control information and by using proper transmission power.

[97] FlG. 15 shows an operation of a receiver (base station) according to the second embodiment of the present invention, and FlG. 16 shows the receiver (base station). Referring to FlG. 15, when the operation of the base station has started, the base station determines whether the base station will receive data from the terminal in step 1502.

The determination of whether the base station will receive data from the terminal is based on whether the base station has allocated a data resource for uplink to the terminal. When the determination in step 1502 concludes that data exists to be received, the base station receives information through a resource allocated for the data, that is, through the data resource in step 1503, decodes control information included in the data resource in step 1504, and obtains the ACK/NACK by reading the ACK/NACK field included in the control information in step 1505.

[98] In contrast, when the determination in step 1502 concludes that no data is to be received, the base station determines in step 1506 whether ACK/NACK exists to be received. When ACK/NACK exists to be received, the base station receives information through the resource (ACK/NACK resource) allocated for the ACK/NACK in step 1507, and acquires ACK/NACK by decoding the received information in step 1508. When the determination in step 1506 concludes that no ACK/NACK is to be received, the process is terminated.

[99] Referring to FIG. 16, the base station receives a radio signal through a receiver block 1601. Then, a demultiplexer (DEMUX) 1602 demultiplexes the radio signal and then extracts a signal for a specific terminal. At this time, the DEMUX 1602 operates by using a control signal of a base station scheduler 1603. That is, when a data resource has been allocated to the terminal by the scheduler 1603, the DEMUX 1602 outputs only the data resource information 1604 in the extracted signal. In contrast, when receiving the ACK/NACK without data, the DEMUX 1602 outputs only the ACK/NACK resource information 1605 in the extracted signal. A channel decoder 1613 decodes the ACK/NACK resource information 1605 and outputs the decoded ACK/NACK 1614.

[100] The data resource information 1604 is demultiplexed into encoded data and encoded control information by a demultiplexer 1606. A channel decoder 1607 obtains the uplink data 1609 by decoding the encoded data. Further, a channel decoder 1608 decodes the encoded control information, and a demultiplexer 1610 demultiplexes the decoded information and separately outputs pure control information 1611 and the ACK/NACK 1612.

[101]

[102] Third Embodiment

[103] Hereinafter, a third embodiment of the present invention will be described for a case where the ACK/NACK and the CQI, which are uplink signaling information of uplink data to be transmitted, are multimplexed at the same time, and the uplink data is transmitted at a separate time from that for the uplink signaling information.

[104] FIG. 17 shows a sub-frame according to the third embodiment of the present invention in which the ACK/NACK and the CQI are multiplexed at the same time.

One sub-frame 1708 includes five long blocks LB#1 ~ LB#5, four short locks SB#1, SB#2, SB#3, SB#4, and CPs 511 and 512 located before the blocks one before one. In comparison with the sub-frame shown in FlG. 5, one long block 503 is replaced by two short blocks SB#1, SB#2 1700 and 1702 in the sub-frame shown in HG. 17.

[105] For example, SB#1 1700 carries ACK/NACK and CQI, and SB#2 1702 carries a pilot used in order to demodulate the ACK/NACK and CQI. Further, the other blocks 1706 carry uplink data, control information, and other information. A pilot used for demodulation of the uplink data can be transmitted through SB#3 or SB#4.

[106] FlG. 18 shows an example of mapping of the ACK/NACK and the CQI in the frequency domain, which are carried by SB#1 1800 and SB#2 1802 in the sub-frame shown in FlG. 17. In FlG. 18, the horizontal axis indicates logical mapping of frequency resources 1808. As shown, N number of ACK/NACK channels (ACKCHs) 1804 and K number of CQI channels (CQICHs) 1806 are allocated to the frequency resources of SB#1 1800. According to the applied transmission scheme from among the IFDMA scheme and the LFDMA scheme, the ACK and CQI channels may use a sub-carrier set including discontinuous sub-carriers as shown in (a) of FlG. 4 or continuous sub-carriers as shown in (b) of FlG. 4 in the physical frequency domain. In order to transmit the ACK/NACK and/or the CQI, a corresponding terminal multiplexes the ACK/NACK and/or the CQI by using an ACK/NACK channel and/or a CQI channel allocated within a corresponding sub-frame (that is, at the same time).

[107] Therefore, when a terminal simultaneously transmits the ACK/NACK and the CQI, the CQI information transmitted through the CQI channel may have a structure as shown in FlG. 19, in order to enable the ACK/NACK and the CQI to be transmitted by a single sub-carrier.

[108] FlG. 19 shows a structure of CQI information according to the third embodiment of the present invention. Reference numeral 1900 denotes a CQI field, and reference numeral 1902 denotes an ACK/NACK field. Although the ACK/NACK field is expressed to have a size of 1 bit in FlG. 19, the ACK/NACK field may have a size of multiple bits according to a method of expressing the ACK/NACK and the HARQ transmission scheme, etc.

[109] FlG. 20 shows a process for transmitting ACK/NACK and CQI by a transmitter (terminal) according to the third embodiment of the present invention. Upon starting to operate, the terminal determines whether it is the time to transmit CQI (step2002). The time to transmit CQI is determined, for example, by a specific short block allocated for a CQI channel within a periodically determined specific sub-frame. When it is the time to transmit CQI, the terminal proceeds to step 2003 in which the terminal determines whether ACK/NACK exists to be transmitted.

[110] When the determination in step 2003 concludes that it is necessary to simul-

taneously transmit both the CQI and the ACK/NACK, the terminal sets a value of ACK/NACK in the ACK/NACK field within the CQI information and sets a CQI value in the CQI field in step 2010. Then, the terminal proceeds to step 2014, in which the terminal channel-encodes both the CQI field and the ACK/NACK field and performs single-carrier transmission through a frequency-time resource (hereinafter, referred to as CQI resource) allocated to the CQI channel.

[Ill] When the determination in step 2003 concludes that no ACK/NACK is to be transmitted or it is not the time to transmit the ACK/NACK, the terminal sets NACK in the ACK/NACK field within the CQI information and sets a CQI value in the CQI field in step 2012. Then, the terminal proceeds to step 2014, in which the terminal channel-encodes the CQI information including both the CQI field and the ACK/NACK field and performs the single-carrier transmission.

[112] Meanwhile, when the determination in step 2002 concludes that it is not the time to transmit CQI, the terminal determines whether ACK/NACK exists to be transmitted in step 2004. When ACK/NACK exists to be transmitted and it is the time to transmit the ACK/NACK, the terminal sets a value of ACK/NACK in the ACK/NACK information to be transmitted through the ACK/NACK channel in step2018. Then, in step 2020, the terminal encodes the ACK/NACK information and then performs single-carrier transmission through a frequency-time resource (hereinafter, referred to as ACK/NACK resource) allocated to the ACK channel. When the determination in step2004 concludes that no ACK/NACK is to be transmitted, the process is terminated.

[113] FlG. 21 shows an operation of a receiver (base station) according to the third embodiment of the present invention.

[114] According to the third embodiment of the present invention, when only theCQI without the ACK/NACK is transmitted, the ACK/NACK field within the CQI information is set as NACK. Therefore, the receiver (base station) can improve the decoding performance of the CQI decoding by setting the NACK value with a value which the receiver has already known. This method can be also applied when decoding the control information according to the second embodiment of the present invention.

[115] Upon starting to operate, the terminal determines whether it is the time to receive CQI information from the terminal in step 2102. When it is the time to receive CQI information from the terminal, the base station proceeds to step 2103 in which the base station receives the CQI information through a CQI resource. Then, in step 2105, the base station determines whether ACK/NACK exists to be received. Then, when ACK/NACK exists to be received and it is the time to receive the ACK/NACK, the base station proceeds to step 2107 in which the base station decodes the CQI field and the ACK/NACK field included in the CQI information. Then, in step 2109, the base station determines the ACK/NACK and the CQI.

[116] In contrast, when no ACK/NACK is to be received or it is not the time to receive the ACK/NACK, the base station sets a field value of NACK in the ACK/NACK field within the CQI information in step 2112. Then, in step 2114, the base station decodes the CQI field included in the CQI information, thereby determining the CQI. In step 2112, the base station may forcibly set the field value of NACK in the ACK/NACK field.

[117] Meanwhile, when the determination in step 2102 concludes that it is not the time to receive the CQI information, the base station determines whether ACK/NACK exists to be received in step 2104. When ACK/NACK exists to be received and it is the time to receive the ACK/NACK, the base station receives the ACK/NACK information through a resource allocated for the ACK/NACK channel, that is, through the ACK/NACK resource in step 2120. Then, in step 2122, the base station decodes the received ACK/NACK, thereby acquiring the ACK/NACK. When the determination in step 2104 concludes that no ACK/NACK is to be received, the process is terminated.

[118] While the invention has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

[1] A method for transmitting multiple types of uplink information in a Single Carrier Frequency Division Multiple Access (SC-FDMA) wireless communication system, the method comprising the steps of:
determining whether uplink signaling information exists to be transmitted when uplink data exists to be transmitted;
multiplexing the uplink data and control information for the uplink data and transmitting multiplexed data through a first frequency resource allocated for the uplink data when no uplink signaling information exists;
multiplexing the uplink data, control information for the uplink data, and the uplink signaling information, and transmitting multiplexed data through a first frequency resource allocated for the uplink data when uplink signaling information exists; and
transmitting the uplink signaling information through a second frequency resource allocated for the uplink signaling information when no uplink data is to be transmitted and uplink signaling information exists to be transmitted.

[2] The method as claimed in claim 1, further comprising transmitting a pilot having a predetermined first pilot pattern, which indicates that no uplink signaling information is to be transmitted, through a predetermined time resource of the first frequency resource.

[3] The method as claimed in claim 2, further comprising transmitting a pilot having a predetermined second pilot pattern, which indicates that uplink signaling information exists to be transmitted, through a predetermined time resource of the first frequency resource.

[4] The method as claimed in claim 1, wherein the uplink signaling information is included in an uplink signaling field within the control information.

[5] The method as claimed in claim 4, wherein the uplink signaling field within the control information is set to have a predetermined value when no uplink signaling information is to transmit.

[6] The method as claimed in claim 1, wherein the uplink signaling information includes at least one of ACK/NACK, which indicates success or failure in reception of downlink data, and a Channel Quality Indicator (CQI), which indicates a status of a channel.

[7] The method as claimed in claim 6, wherein the ACK/NACK and the CQI are transmitted using sub-carriers allocated for the CQI within a predetermined time resource when the uplink signaling information to be transmitted includes both the ACK/NACK and the CQI.

[8] The method as claimed in claim 7, wherein one of the ACK/NACK and the CQI is transmitted using one of a first sub-carrier set allocated for the CQI and a second sub-carrier set allocated for the ACK/NACK within the time resource when the uplink signaling information to be transmitted includes one of the ACK/NACK and the CQI.

[9] The method as claimed in claim 8, wherein each of the first sub-carrier set and the second sub-carrier set includes sub-carriers having equal intervals between them.

[10] The method as claimed in claim 1, wherein the first sub-carrier set and the second sub-carrier set include sub-carriers having equal intervals or between them or sub-carriers adjacent to each other.

[11] An apparatus for transmitting multiple types of uplink information in a Single Carrier Frequency Division Multiple Access (SC-FDMA) wireless communication system, the apparatus comprising:
a multiplexer for multiplexing uplink data and control information for the uplink data when uplink data exists to be transmitted and no uplink signaling information is to be transmitted, and multiplexing uplink data, control information for the uplink data, and the uplink signaling information when both the uplink data exists to be transmitted and the uplink signaling information exists to be transmitted;
a data resource mapper for transmitting information multiplexed by the multiplexer through a first frequency resource allocated for the uplink data; and an uplink signaling resource mapper for transmitting the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no uplink data is to be transmitted.

[12] The apparatus as claimed in claim 11, wherein the multiplexer transmits a pilot having a predetermined first pilot pattern, which indicates that no uplink signaling information is to be transmitted, through a predetermined time resource of the first frequency resource.

[13] The apparatus as claimed in claim 12, wherein the multiplexer transmits a pilot having a predetermined second pilot pattern, which indicates that the uplink signaling information is to be transmitted, through a predetermined time resource of the first frequency resource.

[14] The apparatus as claimed in claim 11, wherein the uplink signaling information is included in an uplink signaling field within the control information.

[15] The apparatus as claimed in claim 14, wherein the uplink signaling field within the control information is set to have a predetermined value when no uplink signaling information is to transmit.

[16] The apparatus as claimed in claim 11, wherein the uplink signaling information includes at least one of ACKnowledgement/Negative ACKnowledgement (ACK/NACK), which indicates success or failure in reception of downlink data, and a Channel Quality Indicator (CQI), which indicates a status of a channel.

[17] The apparatus as claimed in claim 16, wherein the ACK/NACK and the CQI are transmitted using sub-carriers allocated for the CQI within a predetermined time resource when the uplink signaling information to be transmitted includes both the ACK/NACK and the CQI.

[18] The apparatus as claimed in claim 17, wherein one of the ACK/NACK and the CQI is transmitted using one of a first sub-carrier set allocated for the CQI and a second sub-carrier set allocated for the ACK/NACK within the time resource, when the uplink signaling information to be transmitted includes one of the ACK/NACK and the CQI.

[19] The apparatus as claimed in claim 18, wherein each of the first subcarrier set and the second sub-carrier set includes sub-carriers having equal intervals between them.

[20] The apparatus as claimed in claim 11, wherein the first sub-carrier set and the second sub-carrier set include sub-carriers having equal intervals or between them or sub-carriers adjacent to each other.

[21] A method for receiving multiple types of uplink information in a Single Carrier Frequency Division Multiple Access (SC-FDMA) wireless communication system, the method comprising the steps of:
(1) determining whether uplink data has been received through a first frequency resource allocated for the uplink data;
(2) determining whether information received through the first frequency resource includes uplink signaling information, when the uplink data has been received;
(3) demultiplexing the information received through the first frequency resource into the uplink data and control information for the uplink data, when the information received through the first frequency resource does not include uplink signaling information;
(4) demultiplexing the information received through the first frequency resource into the uplink data, control information for the uplink data, and uplink signaling information, when the information received through the first frequency resource includes the uplink signaling information; and
(5) receiving the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when the uplink data has not been received.

[22] The method as claimed in claim 21, wherein determining in step (2) is based on a pilot pattern of a pilot for the uplink data, which is received through a predetermined time resource of the first frequency resource.

[23] The method as claimed in claim 22, wherein the pilot has one of a predetermined first pilot pattern, which indicates that no uplink signaling information exists, and a predetermined second pilot pattern, which indicates that the uplink signaling information exists.

[24] The method as claimed in claim 21, wherein the uplink signaling information is included in an uplink signaling field within the control information.

[25] The method as claimed in claim 24, wherein the uplink signaling field within the control information is set to have a predetermined value when no uplink signaling information exists.

[26] The method as claimed in claim 21, wherein the uplink signaling information includes at least one of ACKnowledgement/Negative ACKnowledgement (ACK/NACK), which indicates success or failure in reception of downlink data, and a Channel Quality Indicator (CQI), which indicates a status of a channel.

[27] The method as claimed in claim 26, wherein the ACK/NACK and the CQI are received using sub-carriers allocated for the CQI within a predetermined time resource when the uplink signaling information includes both the ACK/NACK and the CQI.

[28] The method as claimed in claim 27, wherein one of the ACK/NACK and the CQI is received using one of a first sub-carrier set allocated for the CQI and a second sub-carrier set allocated for the ACK/NACK within the time resource when the uplink signaling information includes one of the ACK/NACK and the CQI.

[29] The method as claimed in claim 28, wherein each of the first sub-carrier set and the second sub-carrier set includes sub-carriers having equal intervals between them.

[30] The method as claimed in claim 21, wherein the first sub-carrier set and the second sub-carrier set include sub-carriers having equal intervals between them or sub-carriers adjacent to each other.

[31] An apparatus for receiving multiple types of uplink information in a Single Carrier Frequency Division Multiple Access (SC-FDMA) wireless communication system, the apparatus comprising:
a determination unit for determining whether information includes uplink signaling information, when the information has been received through a first frequency resource allocated for uplink data;
a demultiplexer for demultiplexing the information received through the first frequency resource into the uplink data and control information for the uplink

data when the information received through the first frequency resource does not include uplink signaling information, and demultiplexing the information received through the first frequency resource into the uplink data, control information for the uplink data, and uplink signaling information, when the information received through the first frequency resource includes the uplink signaling information; and

a receiver unit for receiving the uplink signaling information through a second frequency resource allocated for the uplink signaling information, when no information is received through the first frequency resource.

[32] The apparatus as claimed in claim 31, wherein determination by the determination unit is based on a pilot pattern of a pilot for the uplink data, which is received through a predetermined time resource of the first frequency resource.

[33] The apparatus as claimed in claim 32, wherein the pilot has one of a predetermined first pilot pattern, which indicates that no uplink signaling information exists, and a predetermined second pilot pattern, which indicates that the uplink signaling information exists.

[34] The apparatus as claimed in claim 31, wherein the uplink signaling information is included in an uplink signaling field within the control information.

[35] The apparatus as claimed in claim 34, wherein the uplink signaling field within the control information is set to have a predetermined value when there is no uplink signaling information.

[36] The apparatus as claimed in claim 31, wherein the uplink signaling information includes at least one of ACKnowledgement/Negative ACKnowledgement (ACK/NACK), which indicates success or failure in reception of downlink data, and a Channel Quality Indicator (CQI), which indicates a status of a channel.

[37] The apparatus as claimed in claim 36, wherein the ACK/NACK and the CQI are received using sub-carriers allocated for the CQI within a predetermined time resource when the uplink signaling information includes both the ACK/NACK and the CQI.

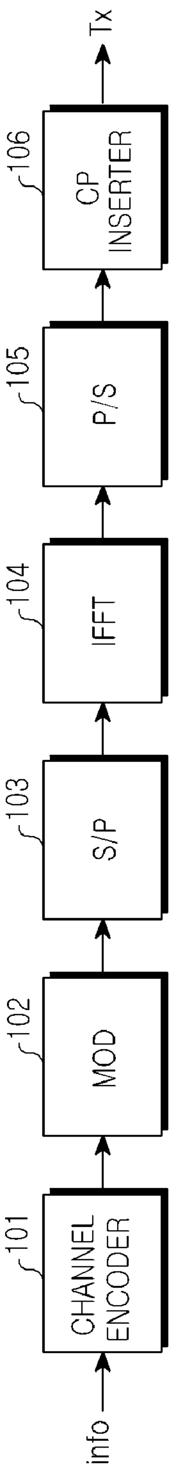
[38] The apparatus as claimed in claim 37, wherein one of the ACK/NACK and the CQI is received using one of a first sub-carrier set allocated for the CQI and a second sub-carrier set allocated for the ACK/NACK within the time resource when the uplink signaling information includes one of the ACK/NACK and the CQI.

[39] The apparatus as claimed in claim 38, wherein each of the first subcarrier set and the second sub-carrier set includes sub-carriers having equal intervals between them.

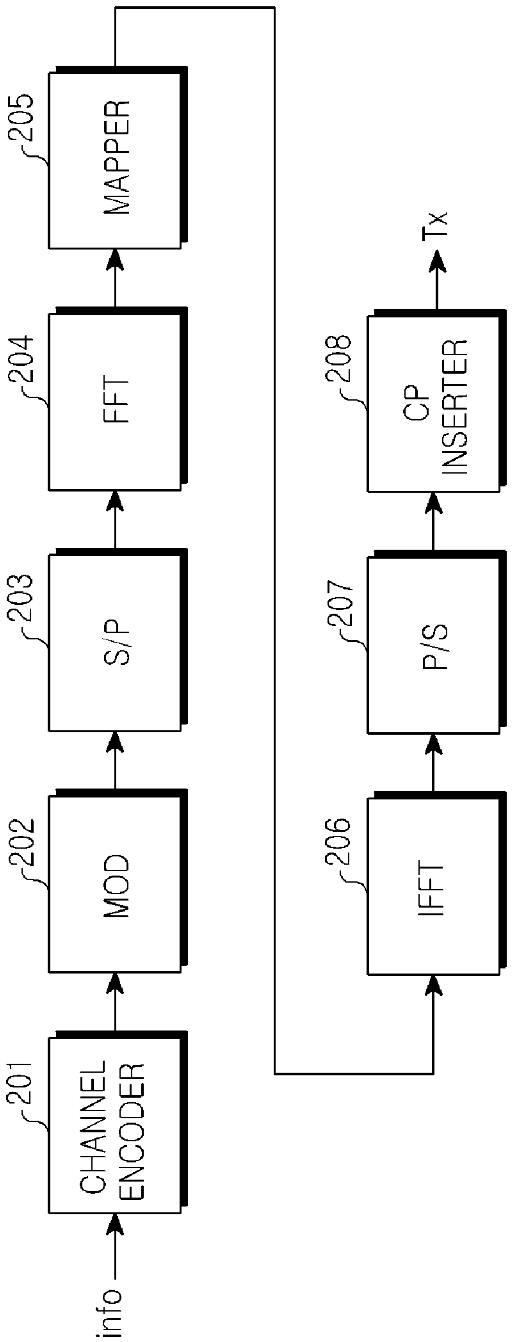
[40] The apparatus as claimed in claim 31, wherein the first sub-carrier set and the

second sub-carrier set include sub-carriers having equal intervals between them or sub-carriers adjacent to each other.

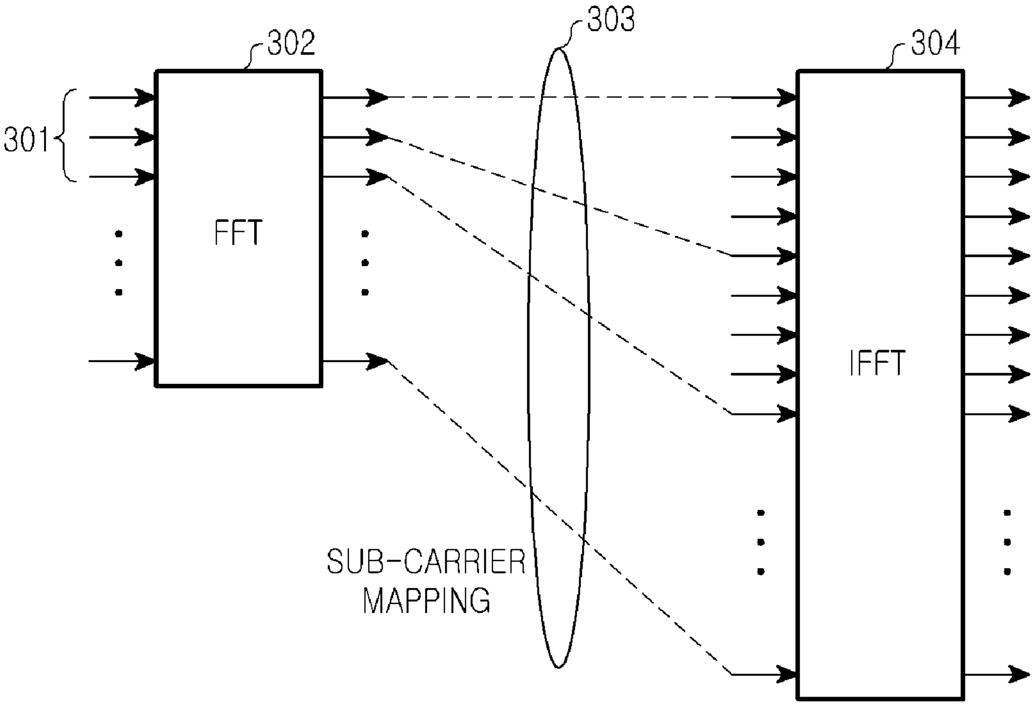
[Fig. 1]


info
101
CHANNEL ENCODER
102
MOD
103
S/P
104
IFFT
105
P/S
106
CP INSERTER
Tx

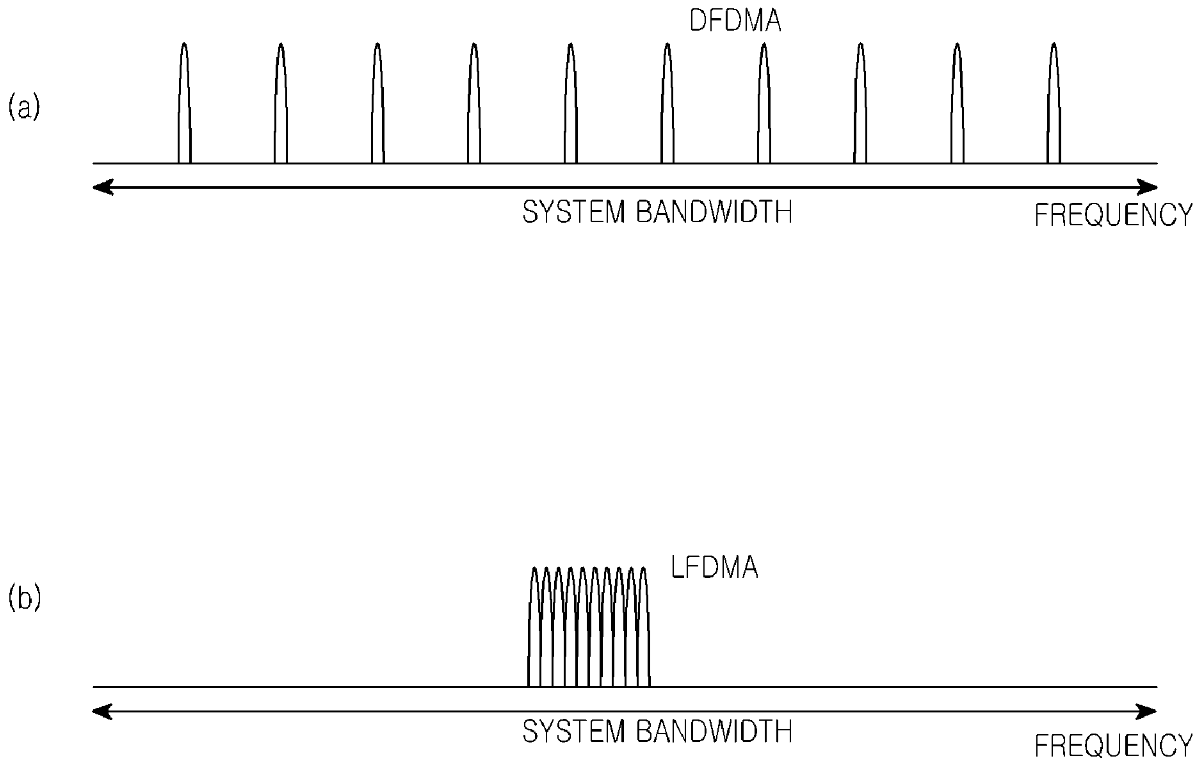
[Fig. 2]


info
CHANNEL ENCODER
201
MOD
202
S/P
203
FFT
204
MAPPER
205
IFFT
206
P/S
207
CP INSERTER
208
Tx

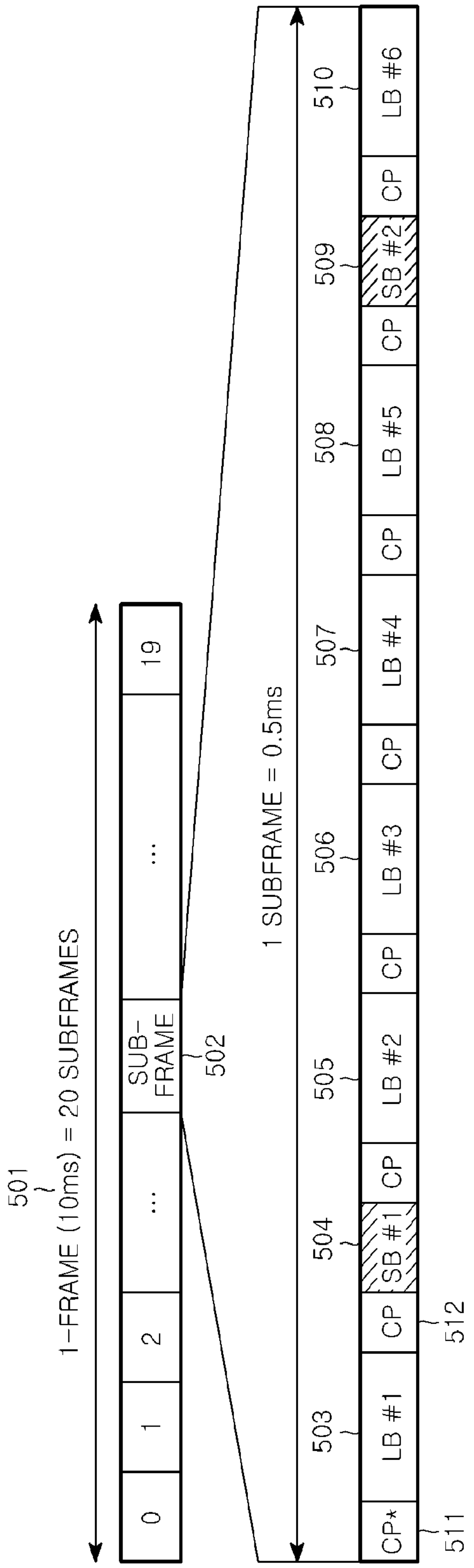
[Fig. 3]


301
302
FFT
303
SUB-CARRIER
MAPPING
304
IFFT

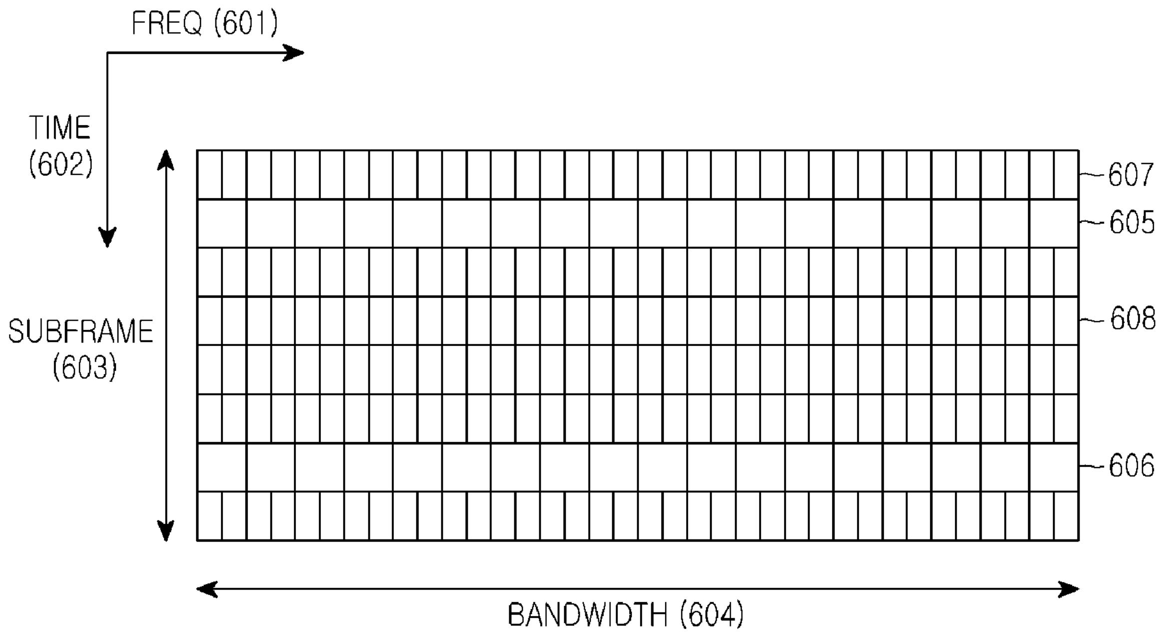
[Fig. 4]


(a)
DFDMA
SYSTEM BANDWIDTH
FREQUENCY
(b)
LFDMA
SYSTEM BANDWIDTH
FREQUENCY

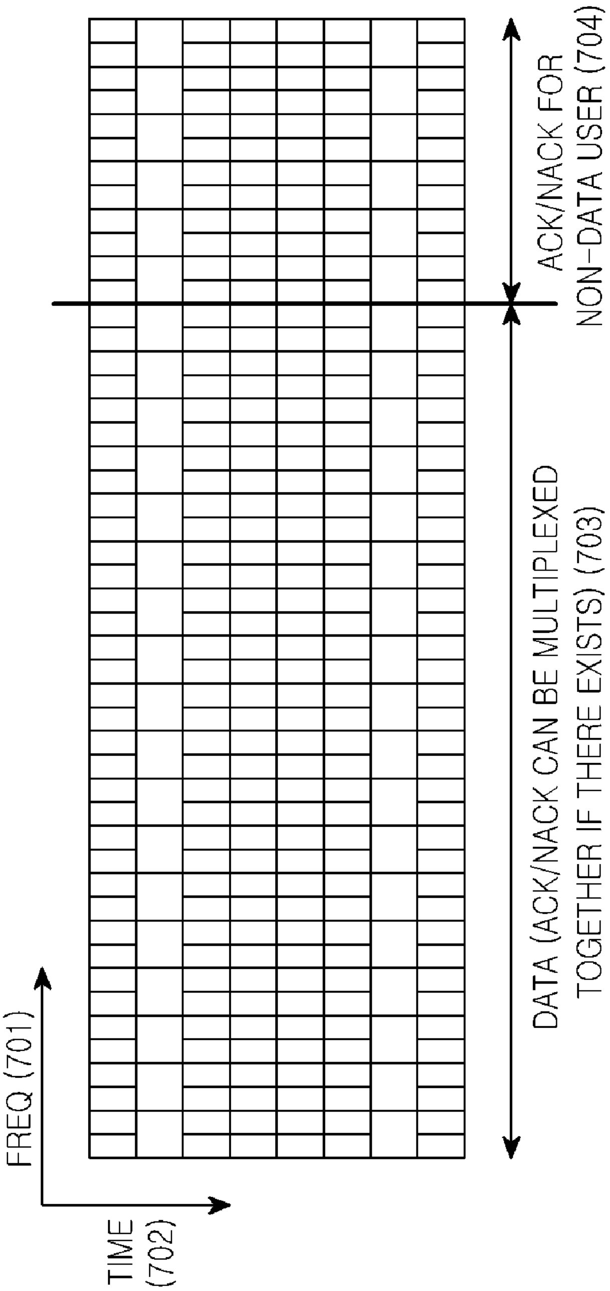
[Fig. 5]


1-FRAME (10ms) = 20 SUBFRAMES
501
0
1
2
...
SUB-FRAME
502
...
19
1 SUBFRAME = 0.5ms
CP*
LB #1
CP
SB #1
CP
LB #2
CP
LB #3
CP
LB #4
CP
LB #5
CP
SB #2
CP
LB #6
503
504
505
506
507
508
509
510
511
512

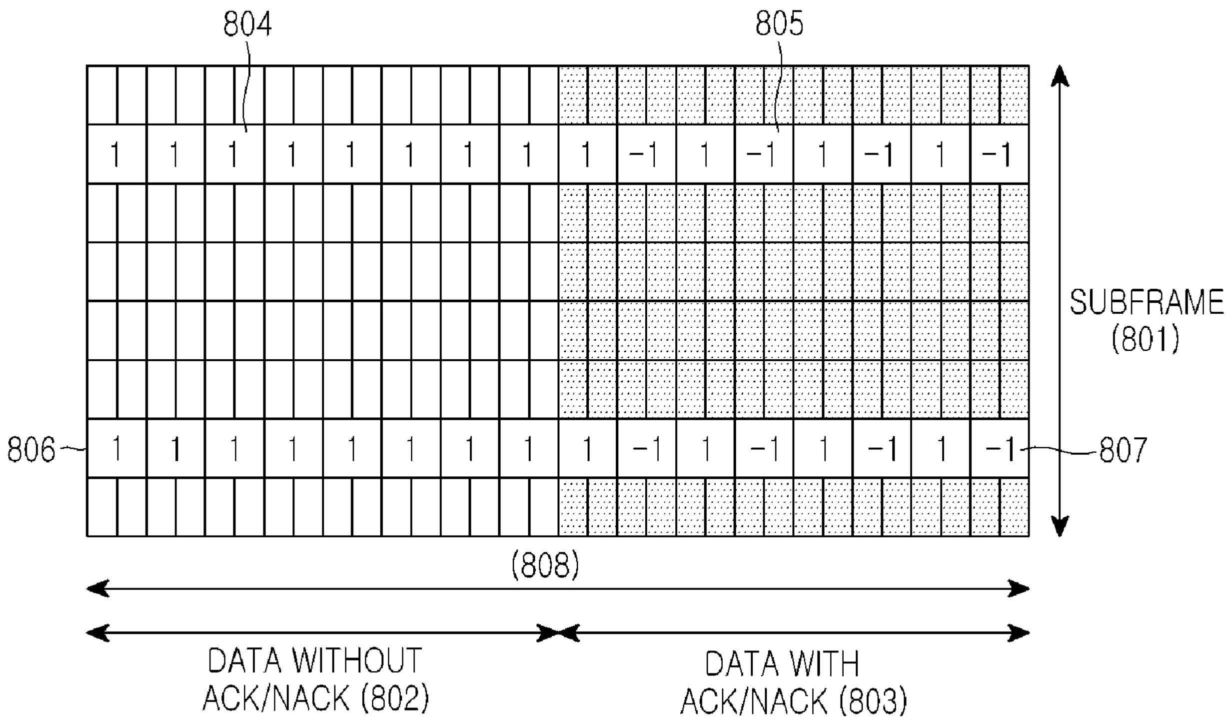
[Fig. 6]



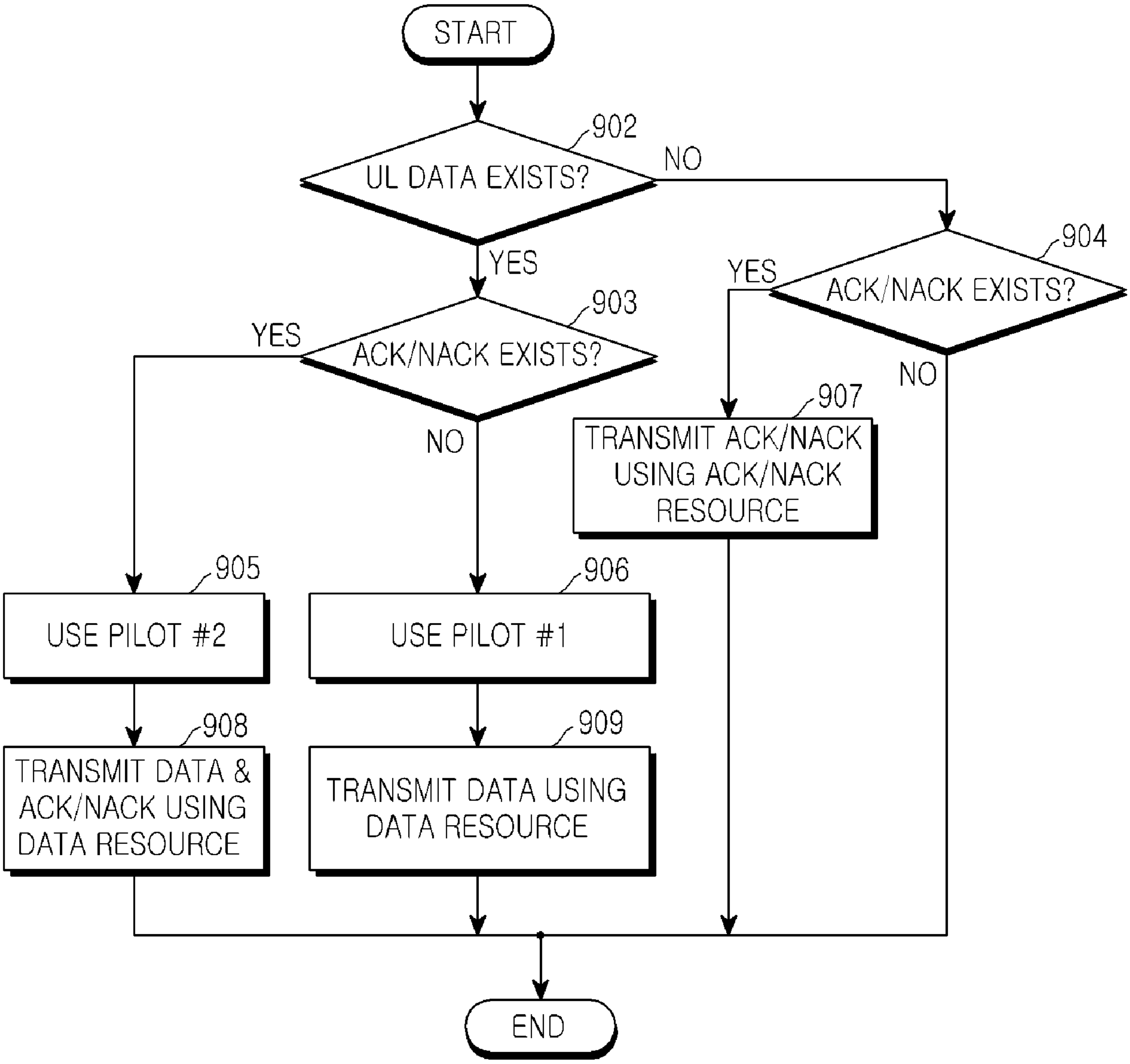
[Fig. 7]


ACK/NACK FOR
NON-DATA USER (704)
DATA (ACK/NACK CAN BE MULTIPLEXED
TOGETHER IF THERE EXISTS) (703)
FREQ (701)
TIME
(702)

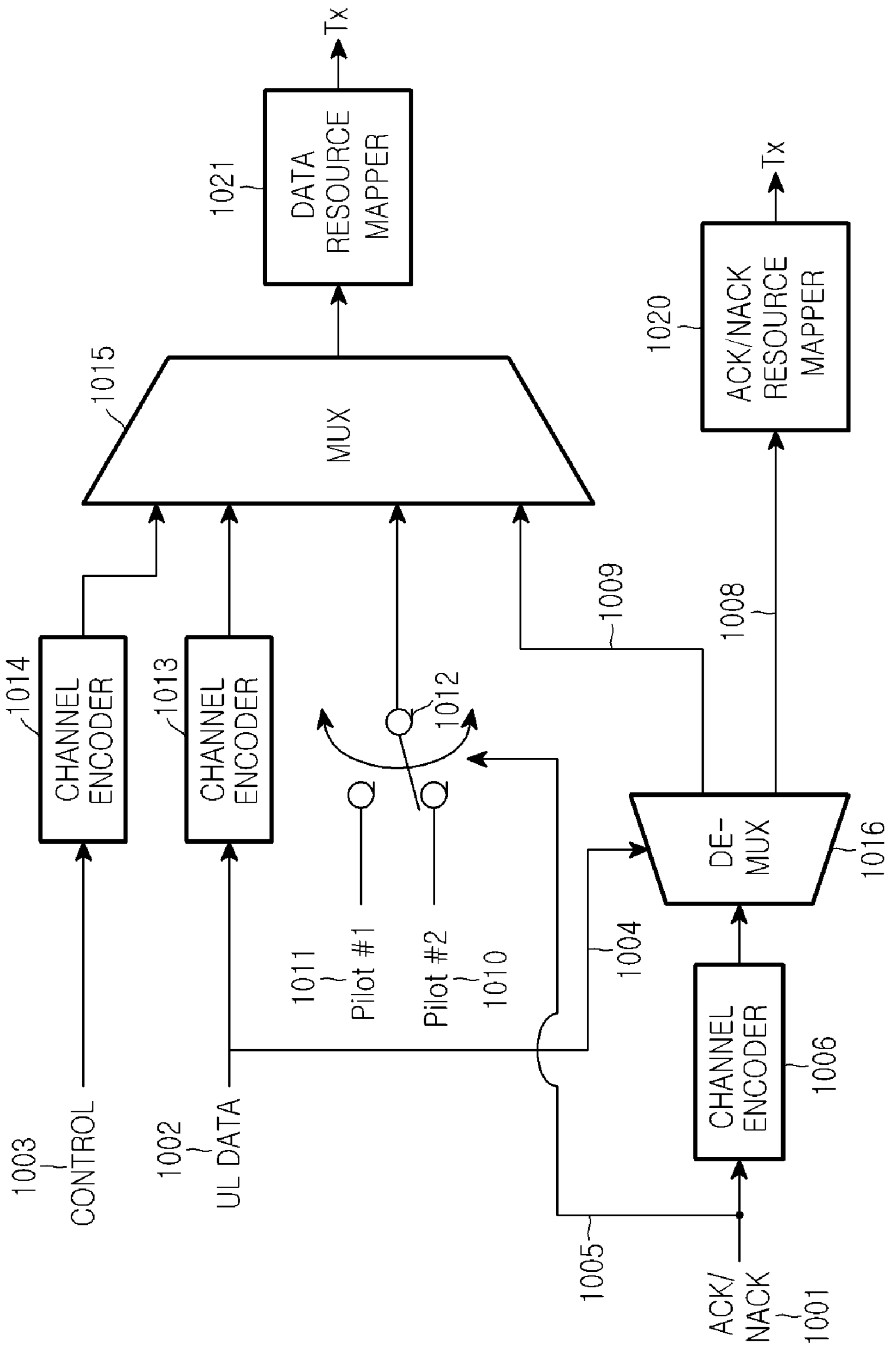
[Fig. 8]


804
805
1 1 1 1 1 1 1 1 1 −1 1 −1 1 −1 1 −1
SUBFRAME (801)
806
1 1 1 1 1 1 1 1 1 −1 1 −1 1 −1 1 −1
807
(808)
DATA WITHOUT ACK/NACK (802)
DATA WITH ACK/NACK (803)

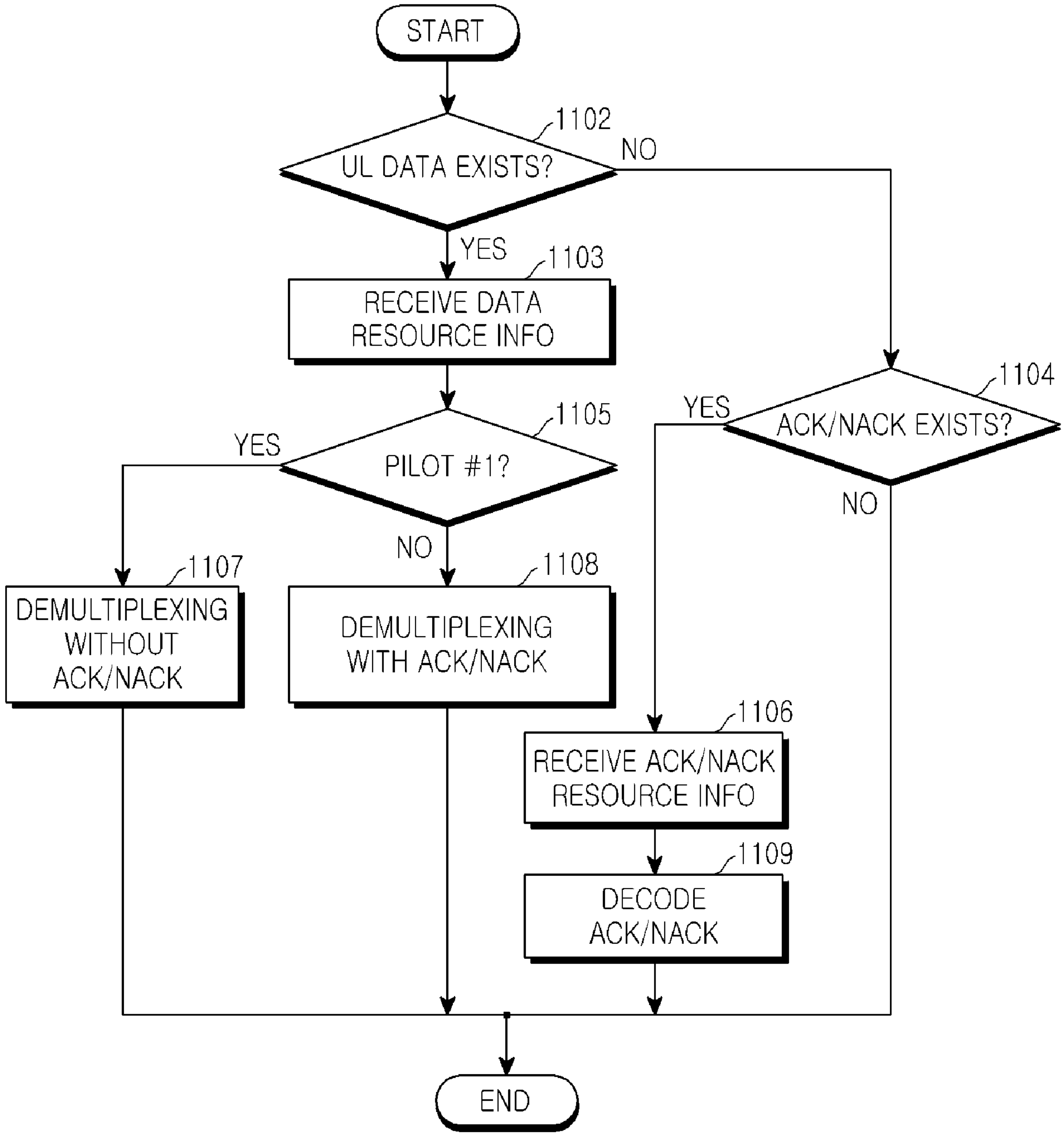
[Fig. 9]


START
902
UL DATA EXISTS?
NO
YES
904
ACK/NACK EXISTS?
YES
903
ACK/NACK EXISTS?
YES
NO
NO
907
TRANSMIT ACK/NACK USING ACK/NACK RESOURCE
905
USE PILOT #2
906
USE PILOT #1
908
TRANSMIT DATA & ACK/NACK USING DATA RESOURCE
909
TRANSMIT DATA USING DATA RESOURCE
END

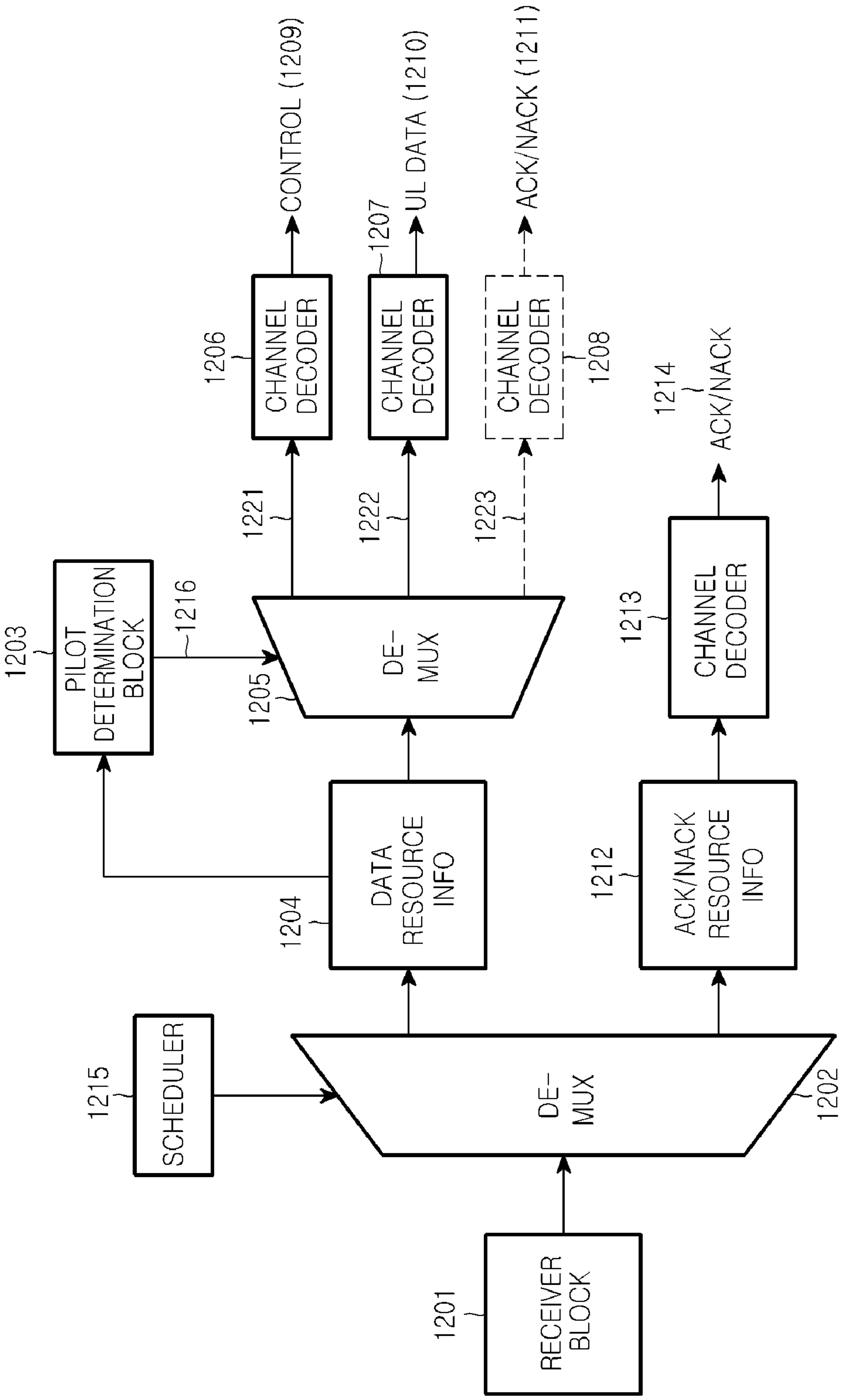
[Fig. 10]


Tx
DATA RESOURCE MAPPER
1021
Tx
ACK/NACK RESOURCE MAPPER
1020
1015
MUX
CHANNEL ENCODER
1014
CHANNEL ENCODER
1013
1009
1008
1012
DE-MUX
1016
1004
Pilot #1
1011
Pilot #2
1010
CHANNEL ENCODER
1006
1003
CONTROL
1002
UL DATA
1005
ACK/NACK
1001

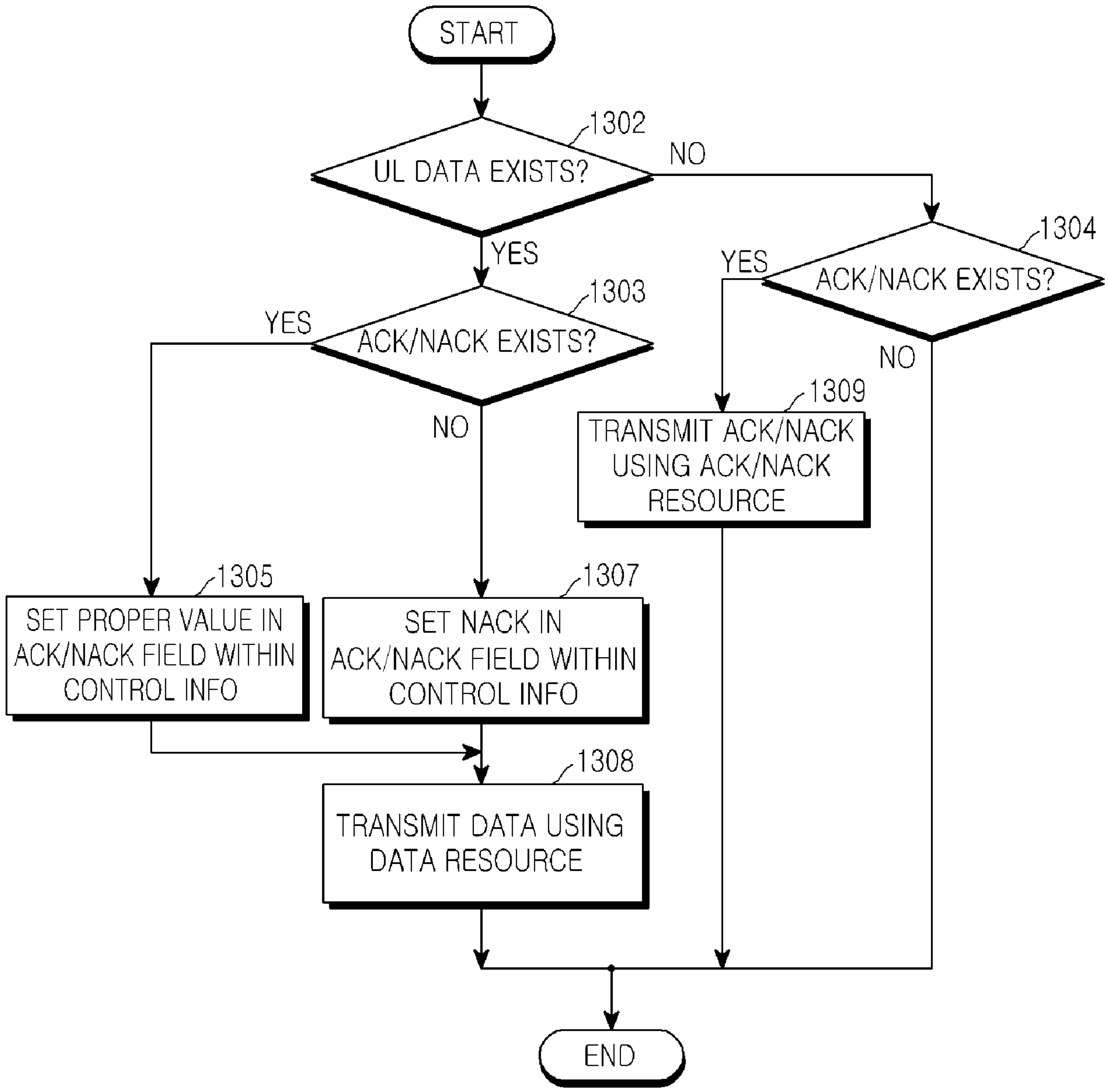
[Fig. 11]


START
1102
UL DATA EXISTS?
NO
YES
1103
RECEIVE DATA RESOURCE INFO
1104
ACK/NACK EXISTS?
YES
NO
1105
PILOT #1?
YES
NO
1107
DEMULTIPLEXING WITHOUT ACK/NACK
1108
DEMULTIPLEXING WITH ACK/NACK
1106
RECEIVE ACK/NACK RESOURCE INFO
1109
DECODE ACK/NACK
END

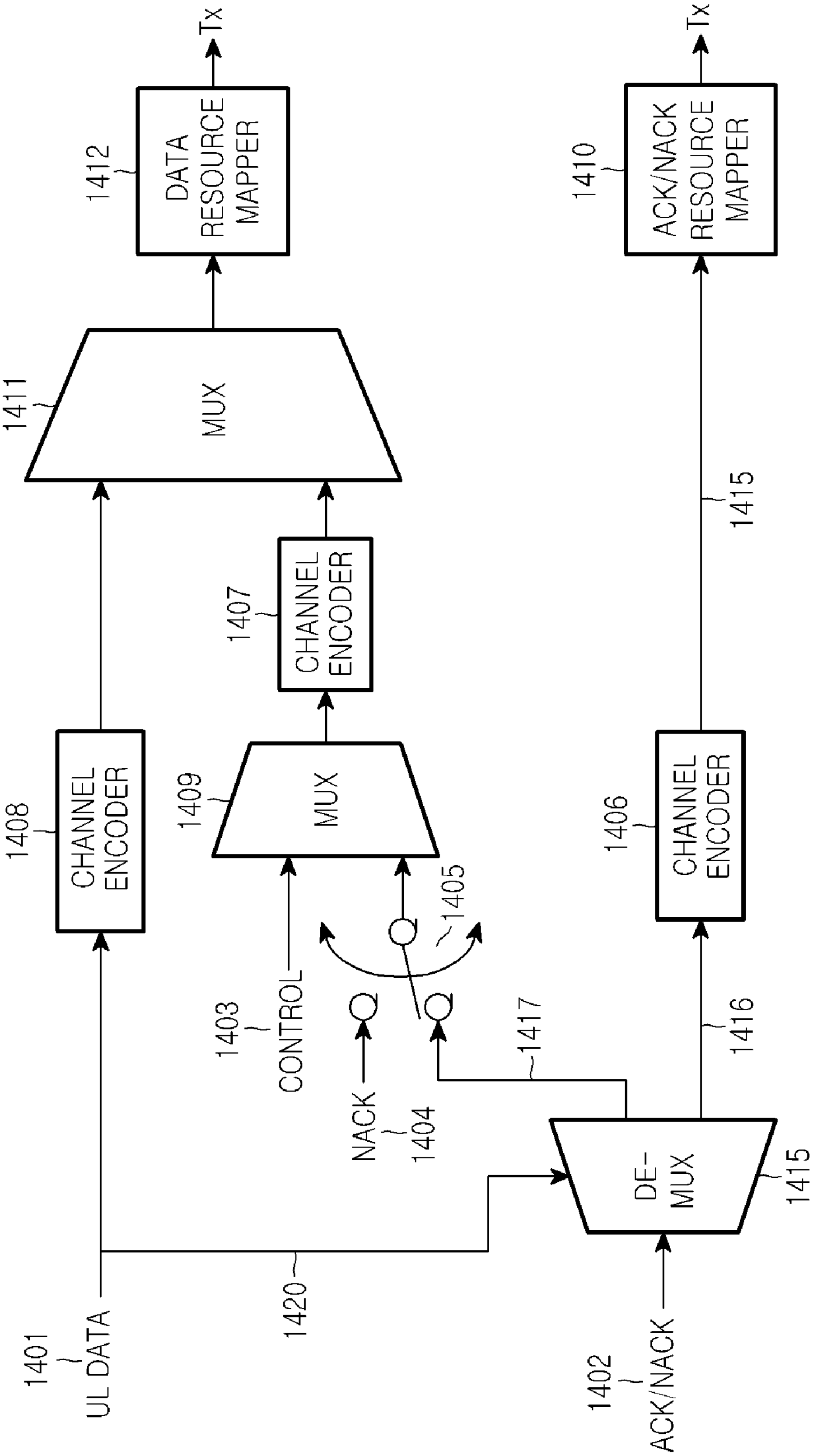
[Fig. 12]


RECEIVER BLOCK
1201
DE-MUX
1202
SCHEDULER
1215
DATA RESOURCE INFO
1204
ACK/NACK RESOURCE INFO
1212
PILOT DETERMINATION BLOCK
1203
1216
DE-MUX
1205
1221
1222
1223
CHANNEL DECODER
1206
CHANNEL DECODER
1207
CHANNEL DECODER
1208
CONTROL (1209)
UL DATA (1210)
ACK/NACK (1211)
CHANNEL DECODER
1213
ACK/NACK
1214

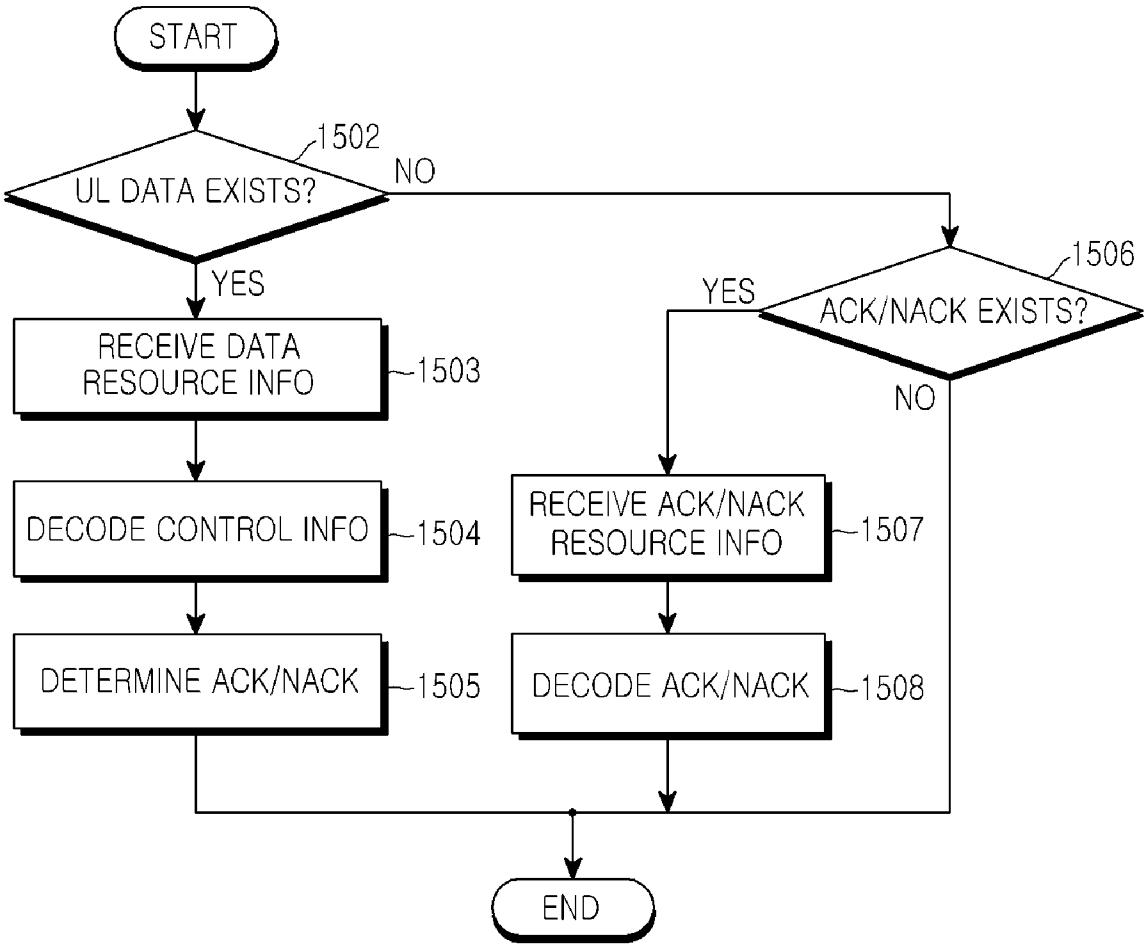
[Fig. 13]


START
UL DATA EXISTS?
1302
NO
YES
ACK/NACK EXISTS?
1304
YES
NO
ACK/NACK EXISTS?
1303
YES
NO
TRANSMIT ACK/NACK USING ACK/NACK RESOURCE
1309
SET PROPER VALUE IN ACK/NACK FIELD WITHIN CONTROL INFO
1305
SET NACK IN ACK/NACK FIELD WITHIN CONTROL INFO
1307
TRANSMIT DATA USING DATA RESOURCE
1308
END

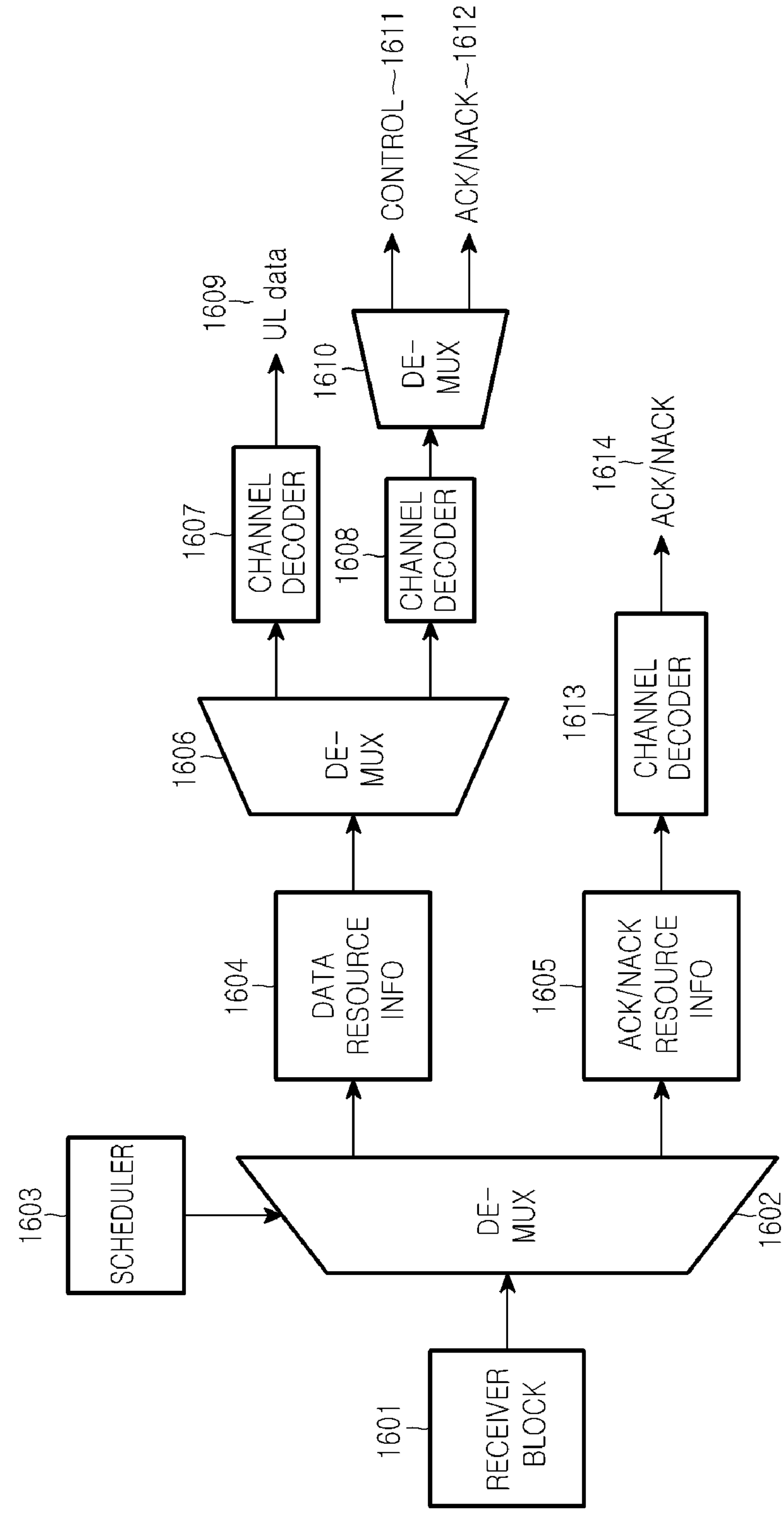
[Fig. 14]


Tx
1412
DATA RESOURCE MAPPER
Tx
1410
ACK/NACK RESOURCE MAPPER
1411
MUX
1415
1407
CHANNEL ENCODER
1408
CHANNEL ENCODER
1409
MUX
1406
CHANNEL ENCODER
1405
1403
CONTROL
NACK
1404
1417
1416
DE-MUX
1415
1420
1401
UL DATA
1402
ACK/NACK

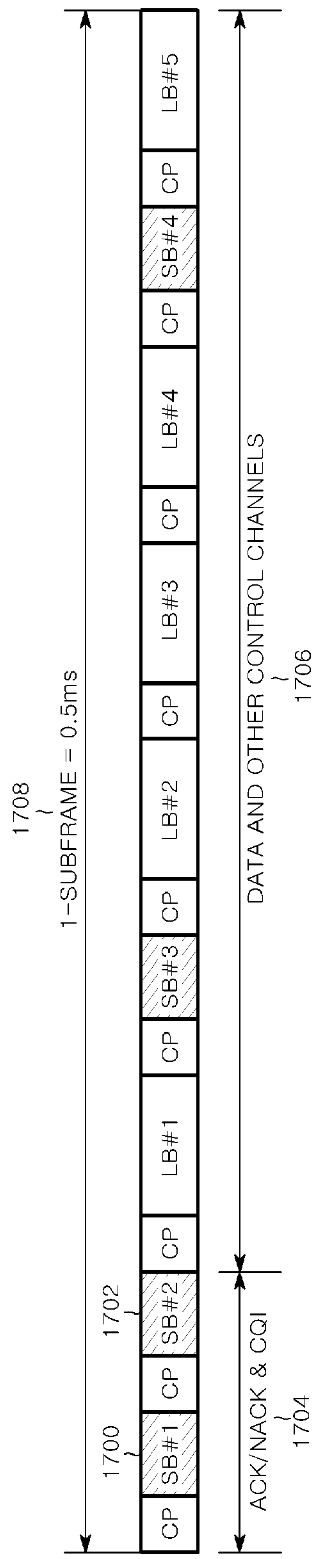
[Fig. 15]


START
1502
UL DATA EXISTS?
NO
YES
RECEIVE DATA RESOURCE INFO
1503
DECODE CONTROL INFO
1504
DETERMINE ACK/NACK
1505
1506
ACK/NACK EXISTS?
YES
NO
RECEIVE ACK/NACK RESOURCE INFO
1507
DECODE ACK/NACK
1508
END

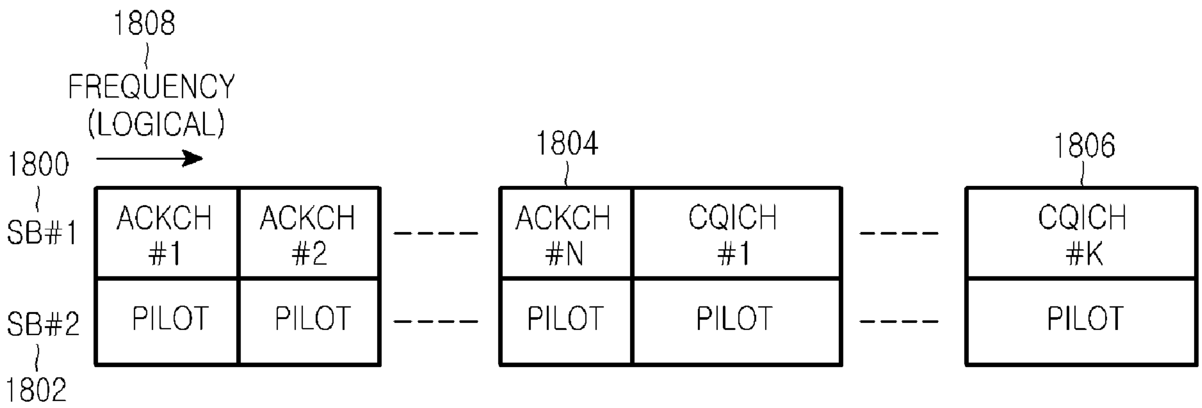
[Fig. 16]


1601
RECEIVER BLOCK
1602
DE-MUX
1603
SCHEDULER
1604
DATA RESOURCE INFO
1605
ACK/NACK RESOURCE INFO
1606
DE-MUX
1607
CHANNEL DECODER
1608
CHANNEL DECODER
1609
UL data
1610
DE-MUX
CONTROL
1611
ACK/NACK
1612
1613
CHANNEL DECODER
1614
ACK/NACK

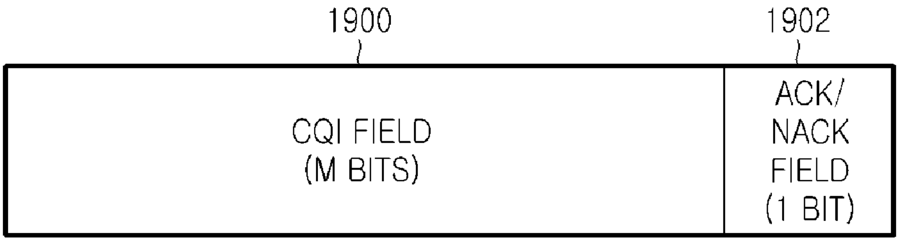
[Fig. 17]


1708
1-SUBFRAME = 0.5ms
1700
1702
CP
SB#1
CP
SB#2
CP
LB#1
CP
SB#3
CP
LB#2
CP
LB#3
CP
LB#4
CP
SB#4
CP
LB#5
ACK/NACK & CQI
1704
DATA AND OTHER CONTROL CHANNELS
1706

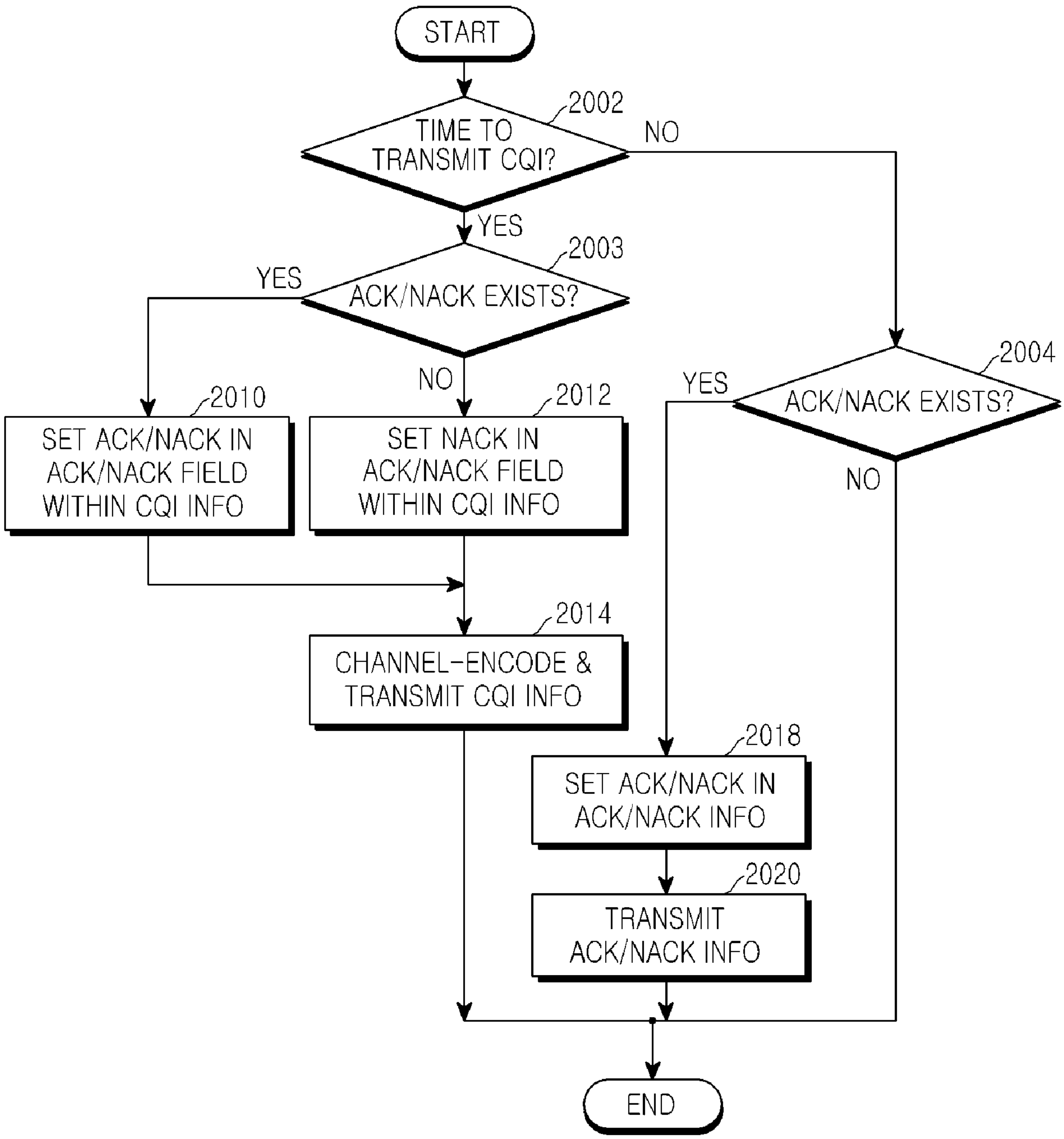
[Fig. 18]


1808
FREQUENCY
(LOGICAL)
1800
SB#1
SB#2
1802
1804
1806
ACKCH
#1
ACKCH
#2
ACKCH
#N
CQICH
#1
CQICH
#K
PILOT
PILOT
PILOT
PILOT
PILOT

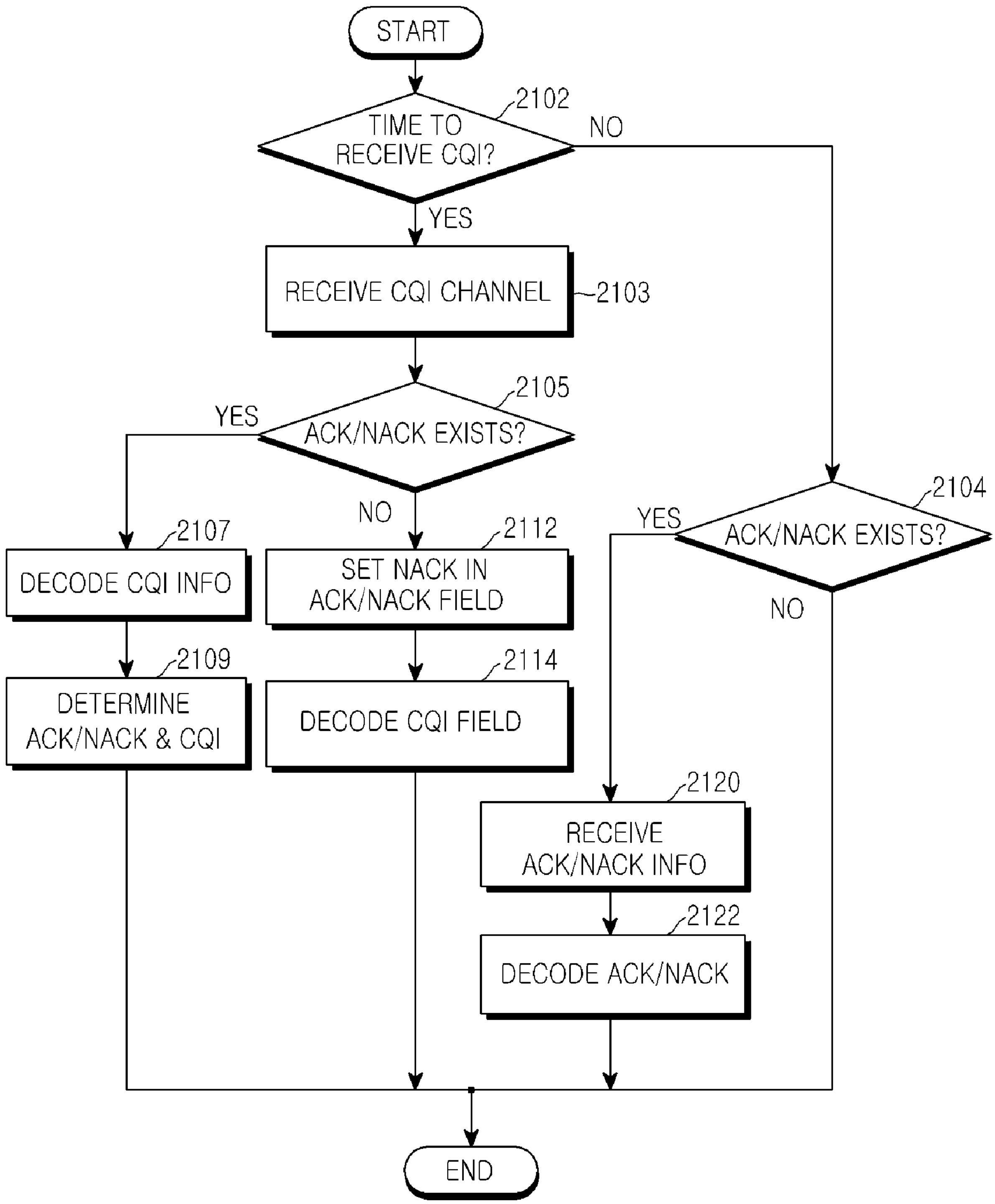
[Fig. 19]


1900
1902
CQI FIELD
(M BITS)
ACK/
NACK
FIELD
(1 BIT)

[Fig. 20]


START
TIME TO TRANSMIT CQI?
2002
NO
YES
ACK/NACK EXISTS?
2003
YES
NO
ACK/NACK EXISTS?
2004
YES
NO
SET ACK/NACK IN ACK/NACK FIELD WITHIN CQI INFO
2010
SET NACK IN ACK/NACK FIELD WITHIN CQI INFO
2012
CHANNEL-ENCODE & TRANSMIT CQI INFO
2014
SET ACK/NACK IN ACK/NACK INFO
2018
TRANSMIT ACK/NACK INFO
2020
END

[Fig. 21]


START
TIME TO RECEIVE CQI?
2102
NO
YES
RECEIVE CQI CHANNEL
2103
ACK/NACK EXISTS?
2105
YES
NO
DECODE CQI INFO
2107
SET NACK IN ACK/NACK FIELD
2112
DETERMINE ACK/NACK & CQI
2109
DECODE CQI FIELD
2114
ACK/NACK EXISTS?
2104
YES
NO
RECEIVE ACK/NACK INFO
2120
DECODE ACK/NACK
2122
END

INTERNATIONAL SEARCH REPORT

International application No
PCT/KR2007/000029

A. CLASSIFICATION OF SUBJECT MATTER

H04L 27/26(2006.01)1

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)
IPC 8 H04J 11/00, H04B 7/005 , H04L 25/02 , H04L 27/24 , H04L 27/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility Models since 1975
Japanese Utility Models and application for Utility Models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
eKIPASS (KIPO internal) "FDMA", "uplink", "single carrier"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Physical Layer Aspects for Evolved UTRA(3GPP TR 25 814), http //www 3gpp org/ftp/Specs/html-info/25814 htm Nov 2005 SeeChapter 9,	1-40
A	3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Requirements for Evolved UTRA and UTRAN(3GPP TR 25 913), http //www 3gpp org/ftp/Specs/html-info/25913 htm, May 2005 Seethe whole documents,	1-40
A	3GPP, R1-050701, NTT DoCoMo, et al , "Channel-Dependent Scheduling Method for Single-Carrier FDMA Radio Access in Evolved UTRA Uplink", Aug 2005 See chapter 2,	1-40

☐ 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
16 APRIL 2007 (16 04 2007)	16 APRIL 2007 (16.04.2007)
Name and mailing address of the ISA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No 82-42-472-7140	Authorized officer NAM, Ock Woo Telephone No 82-42-481-5713

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/KR2007/000029

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
3GPP TR 25.814	Nov. 2005	NONE	
3GPP TR 25.913	May 2005	NONE	
3GPP, R1-050701	Aug .2005	NONE	