(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 August 2008 (07.08.2008)

PCT

(10) International Publication Number
WO 2008/094022 A1

(51) International Patent Classification:
H04L 27/02 (2006.01)

(21) International Application Number:
PCT/KR2008/000665

(22) International Filing Date: 4 February 2008 (04.02.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/888,056 2 February 2007 (02.02.2007) US
10-2007-0082117 16 August 2007 (16.08.2007) KR

(71) Applicant (*for all designated States except US*): **LG ELECTRONICS INC.** [KR/KR]; 20, Yeouido-dong, Yeongdeungpo-gu, Seoul 150-721 (KR).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **KIM, Hak Seong** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR). **YUN, Young Woo** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR). **KIM, Ki Jun** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR). **LEE, Dae Won** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR). **YOON, Suk Hyon** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR). **AHN, Joon Kui** [KR/KR]; LG R & D Complex, 533, Hogye 1-dong, Dongan-gu, Anyang-si, Gyeongki-do 431-749 (KR).

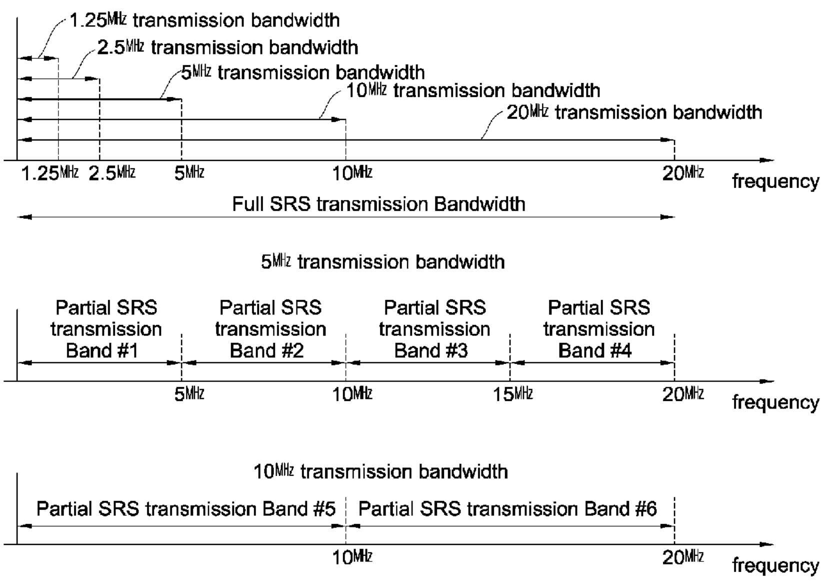
(74) Agent: **YANG, Moon Ock**; S & IP Patent & Law Firm, Pangaea Bldg., 2F., #67-8, Yangjae-dong, Seocho-gu, Seoul 137-130 (KR).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) **Title:** METHOD OF TRANSMITTING SCHEDULING REFERENCE SIGNAL



[Fig. 5]

(57) **Abstract:** A method of transmitting a scheduling reference signal (SRS) for uplink scheduling is provided. The method includes transmitting a SRS on a first partial SRS transmission band in a first transmitting time, and transmitting the SRS on a second partial SRS transmission band in a second transmitting time, wherein the first and the second partial SRS transmission bands are parts of a full SRS transmission band and have exclusive positions with each other in the full SRS transmission band, the full SRS transmission band selected for uplink scheduling, the full SRS transmission band comprising a plurality of partial SRS transmission bands.

WO 2008/094022 A1

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

Description

METHOD OF TRANSMITTING SCHEDULING REFERENCE SIGNAL

Technical Field

[1] The present invention relates to radio communication, and more particularly, to a method of transmitting a scheduling reference signal, that is, a reference signal for uplink scheduing.

Background Art

[2] The next-generation mobile communication system must be able to transmit high quality and high capacity multimedia data at high speed using limited frequency resources. In order to enable it, inter-symbol interference and frequency selective fading, which occur at the time of high-speed transmission, must be overcome while maximizing frequency efficiency.

[3] In order to improve the performance of the mobile communication system, a closed-loop transmission scheme employing channel response information between a Base Station (BS) and a User Equipment (UE) has emerged. An Adaptive Modulation and Coding (AMC) scheme is the technology of increasing the link performance by controlling the modulation and coding method in a BS using feedback channel response information. Alternatively, the channel response information can be used for a BS to pre-process a channel so as to reduce a complex equalization process in a UE.

[4] A method of obtaining downlink channel information is based on feedback information sent by a UE. The UE measures downlink channel response and constructs it as adequate feedback information. A BS that has received the feedback information performs downlink data scheduling using the feedback information. For example, the feedback information may have a quantization type of measured channel response.

[5] In contrast, there are two types of reference signals transmitted over the uplink. One is a reference signal for estimating a channel in order to demodulate the uplink data, and the other is a reference signal for scheduling the frequency domain of the uplink by confirming the channel state of the uplink. The former is also called a data demodulation (DM) reference signal and the latter is also called a scheduling reference signal or a sounding signal. The DM reference signal is transmitted in a limited frequency domain only when there exists data transmitted over the uplink, whereas the scheduling reference signal is transmitted periodically over the entire frequency bands of the uplink irrespective of the existence of data.

[6] The UE sends the scheduling reference signal through the uplink channel, and the BS confirms the channel state based on the scheduling reference signal and then performs scheduling for uplink transmission.

[7] The scheduling reference signal transmitted over the downlink within one cell is broadcasted by the BS, whereas the scheduling reference signal transmitted over the uplink within one cell is transmitted from the entire UEs, existing in the cell, to the BS over the entire frequency bands. If a plurality of UEs transmits the scheduling reference signals over the entire frequency bands in a radio communication system with limited uplink frequency resources, interference occurs between the scheduling reference signals transmitted by the respective UEs. Thus, there is a need for a method of transmitting the scheduling reference signals efficiently.

Disclosure of Invention

Technical Problem

[8] A method of transmitting and receiving scheduling reference signals is provided so as to guarantee orthogonality between scheduling reference signals of a plurality of UEs.

Technical Solution

[9] In an aspect, a method of transmitting a scheduling reference signal (SRS) for uplink scheduling is provided. The method includes transmitting a SRS on a first partial SRS transmission band in a first transmitting time, and transmitting the SRS on a second partial SRS transmission band in a second transmitting time, wherein the first and the second partial SRS transmission bands are parts of a full SRS transmission band and have exclusive positions with each other in the full SRS transmission band, the full SRS transmission band selected for uplink scheduling, the full SRS transmission band comprising a plurality of partial SRS transmission bands.

[10] In another aspect, a method of receiving a scheduling reference signal (SRS) for uplink scheduling is provided. The method includes allocating a transmission bandwidth to a user equipment, the transmission bandwidth being the bandwidth of a partial SRS transmission band, the partial SRS transmission band being a part of a full SRS transmission band, the full SRS transmission band for uplink scheduling comprising a plurality of partial SRS transmission bands, and receiving a SRS on the partial SRS transmission band.

Advantageous Effects

[11] Scheduling reference signals transmitted by a plurality of user equipments are mul-

tiplexed in frequency domain, time domain or code domain by keeping orthogonality between the scheduling reference signals. Interference between scheduling reference signals of respective user equiopments can be reduced. A base station can obtain uplink channel information more accurately, thereby enabling efficient uplink scheduling.

Brief Description of the Drawings

[12] Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[13] FIG. 1 is a block diagram of a radio communication system;

[14] FIG. 2 illustrates an example of a radio frame format;

[15] FIG. 3 illustrates the frame format of a Frequency Division Duplex (FDD) system;

[16] FIG. 4 is a block diagram showing a transmitter and a receiver according to an embodiment of the present invention;

[17] FIG. 5 is a view illustrating transmission bandwidths and partial SRS transmission bands set to have bandwidths of various sizes;

[18] FIG. 6 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 2 according to the present invention;

[19] FIG. 7 shows another example of a multiplexing method of a scheduling reference signal according to the present invention;

[20] FIG. 8 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 1 according to the present invention;

[21] FIG. 9 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 3 according to the present invention;

[22] FIG. 10 shows still another example of a multiplexing method of a scheduling reference signal according to the present invention;

[23] FIG. 11 shows further still another example of a multiplexing method of a scheduling reference signal according to the present invention; and

[24] FIG. 12 is a flowchart illustrating a method of transmitting a scheduling reference signal according to the present invention.

Mode for the Invention

[25] The present invention will now be described in detail in connection with specific embodiments with reference to the accompanying drawings.

[26] FIG. 1 is a block diagram of a radio communication system. The radio commu-

nication system is disposed over a wide area in order to provide various communication services such as voice and packet data.

[27] Referring to FIG. 1, the radio communication system includes UEs 20 and a BS 10. The UE 20 may be fixed or have mobility and can also be called other terms such as a Mobile Station (MS), a User Terminal (UT), a Subscriber Station (SS) and a wireless device. The BS 10 generally refers to a fixed station communicating with the UE 20, and can also be called other terms such as Node-B, a Base Transceiver System (BTS) and an access point. One or more cells may exist in one BS 10.

[28] Hereinafter, the downlink refers to transmission from the BS 10 to the UE 20, and the uplink refers to transmission from the UE 20 to the BS 10. In the downlink, a transmitter can be part of the BS 10 and a receiver can be part of the UE 20. In the uplink, a transmitter can be part of the UE 20 and a receiver can be part of the BS 10.

[29] FIG. 2 illustrates an example of a radio frame format.

[30] Referring to FIG. 2, the radio frame is comprised of ten subframes and one subframe may include two slots. One slot may include a plurality of OFDM symbols in the time domain and at least one subcarrier in the frequency domain. The slot may be referred to as a unit for allocating radio resources in the time domain and the frequency domain. For example, one slot may include seven or six OFDM symbols.

[31] The format of the radio frame is only illustrative. The number of subframes included in the radio frame, the number of slots included in the subframe, or the number of OFDM symbols included in the slot may be changed in various ways.

[32] FIG. 3 illustrates the frame format of a FDD system.

[33] Referring to FIG. 3, the frame includes a downlink frame and an uplink frame. The downlink frame and the uplink frame can be transmitted at the same time, but occupy different frequency bands. The arrangement of the uplink frame and the uplink frame is only illustrative, and the position in the frequency domain of the downlink frame and the uplink frame can be changed. A relative length between the uplink frame and the uplink frame can also be changed.

[34] FIG. 4 is a block diagram showing a transmitter and a receiver according to an embodiment of the present invention. The receiver refers to an apparatus for receiving scheduling reference signals and the transmitter refers to an apparatus for transmitting scheduling reference signals. In uplink transmission, the receiver may be part of a BS and the transmitter may be part of a UE.

[35] Referring to FIG. 4, a receiver 100 includes a scheduling unit 110, a control information generator 120, a transmitting unit 130, a receiving unit 140 and a channel

measuring unit 150. The scheduling unit 110 allocates a transmission bandwidth of a scheduling reference signal transmitted by a transmitter 200.

[36] The scheduling reference signal (SRS) is a reference signal transmitted over the uplink for the purpose of uplink scheduing and is also called a sounding reference signal.

[37] The transmission bandwidth is a basic bandwidth for deciding over how much bandwidth to send the scheduling reference signal in every transmitting time. Thus, if the transmission bandwidth is given, the transmitter 200 can divide uplink frequency band by the transmission bandwidth and transmit scheduling reference signal. Uplink frequency band is divided into a plurality of frequency domains by the transmission bandwidth. Each of the frequency domains as described above is called a partial SRS transmission band. The size of partial SRS transmission band is given in terms of resource block(RB), such as 2RB, 4RB, 6RB, and so on. The transmission bandwidth and the partial SRS transmission band are described later on with reference to FIG. 5.

[38] The scheduling unit 110 allocates a transmission bandwidth to the transmitter 200. The transmission bandwidth can be allocated differently in size to each transmitter 200. That is, the transmission bandwidth of 5MHz may be allocated to one transmitter and the transmission bandwidth of 10MHz may be allocated to the other transmitter.

[39] The control information generator 120 generates control information for a scheduling reference signal, including a transmission bandwidth, a frequency hopping method, an orthogonal code allocation method and/or its pertinent parameters. The transmitting unit 130 transmits the control information to the transmitter 200 through an antenna 190.

[40] The receiving unit 140 receives the scheduling reference signal, transmitted through the allocated partial SRS transmission band, from the transmitter 200. The channel measuring unit 150 measures a channel state using the received scheduling reference signal. The scheduling unit 110 decides radio resource allocation necessary for data transfer based on the channel information measured by the channel measuring unit 150.

[41] The transmitter 200 includes a receiving unit 210, a control information decoding unit 220, a scheduling reference signal generator 230 and a transmitting unit 240. The receiving unit 210 receives control information through an antenna 290. The control information decoding unit 220 decodes the control information and obtains a transmission bandwidth and/or its pertinent parameters. The scheduling reference signal generator 230 generates a preset scheduling reference signal and allocates it to

each subcarrier within a partial SRS transmission band.

[42] The transmitting unit 240 transmits the scheduling reference signal through the partial SRS transmission band. The transmitting unit 240 includes a Discrete Fourier Transform (DFT) unit 250 that performs DFT and an IFFT (Inverse Fast Fourier Transform) unit 260 that performs IFFT. The DFT unit 250 performs DFT on input data and outputs a frequency domain symbol. The IFFT unit 260 performs IFFT on the input frequency domain symbol and outputs a transmit (Tx) signal. The Tx signal becomes a time domain signal. The time domain symbol output through the IFFT unit 260 is referred to as an Orthogonal Frequency Division Multiplexing (OFDM) symbol or a Single Carrier-Frequency Division Multiple Access (SC-FDMA) symbol. A method of spreading a symbol by performing DFT at the front end of the IFFT unit 120 is called SC-FDMA. This method is advantageous in lowering the Peak-to-Average Power Ratio (PAPR) when compared with OFDM.

[43] Transmission of the SC-FDMA method has been described. However, a multi-access scheme to which the present invention is applied is not limited. For example, a variety of multi-access schemes, such as Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), SC-FDMA and OFDMA, may be used. In a radio communication system, the multi-access schemes of the uplink and the downlink may differ. For example, the uplink may use SC-FDMA and the downlink may use OFDMA.

[44] FIG. 5 is a view illustrating transmission bandwidths and partial SRS transmission bands set to have bandwidths of various sizes. It is assumed that a full SRS transmission band given hereinafter is 20MHz. The full SRS transmission band is selected for uplink scheduling which is divided into a plurality of partial SRS transmission bands.

[45] Referring to FIG. 5, five kinds of transmission bandwidths are illustrated. The five kinds of transmission bandwidths are 1.25MHz transmission bandwidth, 2.5MHz transmission bandwidth, 5MHz transmission bandwidth, 10MHz transmission bandwidth, and 20MHz transmission bandwidth. If the scheduling unit 110 has allocated the 5MHz transmission bandwidth to the transmitter 200, the transmitter 200 divides the full SRS transmission band of 20MHz into four every 5MHz and transmits scheduling reference signals through the divided partial SRS transmission bands #1 to #4, respectively. In a similar way, if the scheduling unit 110 has allocated the 10MHz transmission bandwidth to the transmitter 200, the transmitter 200 divides the uplink frequency band of 20MHz into two equal parts and transmits scheduling reference

signals through the divided partial SRS transmission bands #5 and #6, respectively.

[46] FIG. 6 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 2. It is assumed that an full SRS transmission band given hereinafter is 20MHz.

[47] Referring to FIG. 6, scheduling reference signals of two UEs (a first and a second UEs) to which the 5MHz transmission bandwidth has been allocated and one UE (a third UE) to which the 10MHz transmission bandwidth has been allocated are multiplexed in the frequency domain. In other words, the full SRS transmission band is divided into four partial SRS transmission bands #1 to #4 by the 5MHz transmission bandwidth and divided into two partial SRS transmission bands #5 and #6 by the 10MHz transmission bandwidth. In order for the first and second UEs to transmit the scheduling reference signals with respect to the full SRS transmission band, the first and second UEs must experience four transmitting times. In order for the third UE to transmit the scheduling reference signals with respect to the entire full SRS transmission band, the the third UE must experience two transmitting times.

[48] The term subcarrier interval refers to a subcarrier interval allocated to a UE so as to transmit the scheduling reference signal. The term transmitting time(T) refers to a temporal distance at which a UE transmits the scheduling reference signal. When the subcarrier interval is 2, respective UEs are allocated with subcarriers in different exclusive positions on the full SRS transmission band. For example, the first and second UEs can transmit the scheduling reference signals through subcarriers having even-numbered indices in the respective partial SRS transmission bands every transmitting time, and the third UE can transmit the scheduling reference signal through a subcarrier having an odd-numbered index in the partial SRS transmission band every transmitting time.

[49] At T_1, the first UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #1, the second UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #2, and the third UE transmits the scheduling reference signal using a subcarrier having an odd-numbered index through the partial SRS transmission band #6.

[50] At T_2, the first UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #2, the second UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #3, and the third UE transmits the

scheduling reference signal using a subcarrier having an odd-numbered index through the partial SRS transmission band #5.

[51] At T_3, the first UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #3, the second UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #4, and the third UE transmits the scheduling reference signal using a subcarrier having an odd-numbered index through the partial SRS transmission band #6.

[52] At T_4, the first UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #4, the second UE transmits the scheduling reference signal using a subcarrier having an even-numbered index through the partial SRS transmission band #1, and the third UE transmits the scheduling reference signal using a subcarrier having an odd-numbered index through the partial SRS transmission band #5.

[53] In this manner, each UE transmits the scheduling reference signal using a subcarrier allocated thereto while hopping each partial SRS transmission band at an allocated transmission bandwidth every transmitting time and span(cover) all the full SRS transmission band. Even in the case of UEs with different transmission bandwidths, even though the scheduling reference signals are transmitted at the same time from overlapping partial SRS transmission band, orthogonality can be maintained since the subcarrier intervals differ.

[54] FIG. 7 shows another example of a multiplexing method of a scheduling reference signal.

[55] Referring to FIG. 7, scheduling reference signals of different UEs to which the same transmission bandwidth has been allocated even employ the entire subcarriers within one partial SRS transmission band. The scheduling reference signals of different UEs undergo a Code Division Multiplexing (hereinafter, referred to as CDM) and are thus orthogonal to one another. That is, the scheduling reference signals of different UEs maintain orthogonality in the code domain. A BS can determine which scheduling reference signal corresponds to which UE from multiplexed scheduling reference signals based on a correlation characteristic of the orthogonal scheduling reference signals. This is called CDM.

[56] In order to multiplex the scheduling reference signals, an orthogonal symbol, such as a Constant Amplitude Zero Auto-Correlation (CAZAC) sequence or a Walsh code, can be used.

[57] Assuming that N is the length of the CAZAC sequence having a positive integer and an index M is a prime relatively to the N in Zadoff-Chu CAZAC, a k th entry of a Mth CAZAC sequence can be expressed in the following Mathematical Formula 1.

[58] [Mathematical Formula 1]

[59]

$$c(k;N,M)=\exp\left\{\frac{j\pi Mk(k+1)}{N}\right\}$$

where N is an odd number.

[60]

$$c(k;N,M)=\exp\left\{\frac{j\pi Mk^2}{N}\right\}$$

where N is an even number.

[61] The CAZAC sequence c (k;M,N) has the following three characteristics.

[62] [Mathematical Formula 2]

[63]

$$|c(k;N,M)|=1 \quad \text{for all } k,N,M$$

[64] [Mathematical Formula 3]

[65]

$$R_{M;N}(d)=\begin{cases}1, & \text{for } d=0\\ 0, & \text{for } d\neq 0\end{cases}$$

[66] [Mathematical Formula 4]

[67]

$$R_{M_1,M_2;N}(d)=p \quad \text{for all } M_1, M_2$$

[68] Mathematical Formula 2 is meant that the CAZAC sequence has always the amount of 1, and Mathematical Formula 3 is meant that auto correlation of the CAZAC sequence is expressed by the Dirac delta function. In the above, mutual correlation is based on circular correlation and the lengths of cyclic-shifted CAZAC sequences are identical. Mathematical Formula 4 is meant that cross correlation is always constant. The CAZAC sequences are orthogonal to each other when they are cyclic shifted or have different indices.

[69] When the CAZAC sequence is used as the scheduling reference signal, the orthogonality of the scheduling reference signal can be obtained by cyclic-shifting different UEs and setting indices to different cells.

[70] FIG. 8 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 1. It is assumed that an full SRS transmission band given hereinafter is 20MHz.

[71] Referring to FIG. 8, the full SRS transmission band is divided into four partial SRS transmission bands #1 to #4 by a 5MHz transmission bandwidth and into two partial SRS transmission bands #5 and #6 by a 10MHz transmission bandwidth. In order for a first and a second UEs to which the 5MHz transmission bandwidth has been allocated to transmit scheduling reference signals with respect to the entire full SRS transmission band, the first and second UEs must experience four transmitting times. In order for a third UE to which the 10MHz transmission bandwidth has been allocated to transmit a scheduling reference signal with respect to the entire full SRS transmission band, the third UE must experience two transmitting times.

[72] At this time, the UEs transmit the scheduling reference signals by employing the entire subcarriers of the partial SRS transmission bands given thereto unlike when the subcarrier interval is 2 since the subcarrier interval is 1. Thus, the scheduling reference signals must be transmitted after performing scheduling so that the partial SRS transmission bands are not overlapped in UEs with different transmission bandwidths.

[73] The first UE transmits the scheduling reference signal through the partial SRS transmission band #1 in T_1, through the partial SRS transmission band #3 in T_2, through the partial SRS transmission band #2 in T_3, and through the partial SRS transmission band #4 in T_4.

[74] The second UE transmits the scheduling reference signal through the partial SRS transmission band #2 in T_1, through the partial SRS transmission band #4 in T_2, through the partial SRS transmission band #1 in T_3, and through the partial SRS transmission band #3 in T_4.

[75] The third UE transmits the scheduling reference signal through the partial SRS transmission band #6 in T_1, through the partial SRS transmission band #5 in T_2, through the partial SRS transmission band #6 in T_3, and through the partial SRS transmission band #5 in T_4.

[76] A method of hopping the partial SRS transmission bands may be changed in various ways in addition to the above method. By transmitting the scheduling reference signals every transmission bandwidth while hopping the frequency domains as described above, the scheduling reference signals of the respective UEs can maintain the orthogonality of the frequency domains.

[77] Of course, the first UE and the second UE may transmit the scheduling reference signals while maintaining the orthogonality in the code domain and hopping the same partial SRS transmission band, as in FIG. 7, since they have the same transmission bandwidth.

[78] FIG. 9 shows an example of a multiplexing method of a scheduling reference signal when the distance of subcarriers is 3. It is assumed that an full SRS transmission band given hereinafter is 20MHz.

[79] Referring to FIG. 9, the types of transmission bandwidths are 5MHz, 10MHz and 20MHz, and the subcarrier interval is 3. A UE to which the 5MHz transmission bandwidth has been allocated transmits the scheduling reference signal through 1,4,7,10, ..., $(3k-2)^{th}$ subcarriers in the entire frequency bands. A UE to which the 10MHz transmission bandwidth has been allocated transmits the scheduling reference signal through 2,5,8,11, ..., $(3k-1)^{th}$ subcarriers in the entire frequency bands. A UE to which the 20MHz transmission bandwidth has been allocated transmits the scheduling reference signal through 3,6,9,12, ..., $(3k)^{th}$ subcarriers in the entire frequency bands. In other words, each UE transmits the scheduling reference signal through one subcarrier every three subcarriers in each partial SRS transmission band. Since the type of the allocated transmission bandwidth is 3 and the subcarrier interval is 3, orthogonality can be maintained even though UEs to which different transmission bandwidths are allocated transmit the scheduling reference signals through overlapped partial SRS transmission bands.

[80] The UE having the 5MHz transmission bandwidth divides the entire frequency bands into four partial SRS transmission bands #1 to #4, hops each partial SRS transmission band during 4 transmitting times, and transmits the scheduling reference signal. The UE having the 10MHz transmission bandwidth divides the entire frequency bands into two partial SRS transmission bands #5 and #6, hops each partial SRS transmission band during 2 transmitting time, and transmits the scheduling reference signal. The UE having the 20MHz transmission bandwidth transmits the scheduling reference signal of a partial SRS transmission band #7 every transmitting time since the entire frequency bands are one partial SRS transmission band #7.

[81] As in FIG. 7, the first UE and the second UE may transmit the scheduling reference signals while maintaining the orthogonality in the code domain and hopping the same partial SRS transmission band, since they have the same transmission bandwidth.

[82] In order to further secure the orthogonal domain in FDM, a greater subcarrier interval value can be used. Further, in order to further secure the orthogonal domain in the code division region, an orthogonal code generating method capable of generating a larger number of orthogonal codes can be used.

[83] Table 1 lists the number of orthogonal codes, which can be generated in the entire full SRS transmission bands according to transmission bandwidths and a subcarrier

interval, in the case where the CAZAC sequence is used when the length of a SC-FDMA (or OFDMA) symbol is approximately 60 to 70μs and a Cyclic Prefix (CP) length is about 5μs.

[84] Table 1

[Table 1]

[Table]

subcarrier interval	1.25MHz	2.5MHz	5MHz	10MHz	20MHz
1	192	96	48	24	12
2	96	48	24	12	6
3	64	32	16	8	4
4	48	24	12	6	3

[85] CP formats in SC-FDMA (or OFDMA) include a normal CP and an extended CP. When the normal CP is used, only the CP of the first one of seven symbols within one slot has 160 samples and the CPs of the remaining six symbols have 144 samples. When the extended CP is used, the CPs of the entire six symbols have 512 samples. Thus, in the case of the normal CP, the number of samples of one SC-FDMA symbol, including the CPs, is 2208 (the first symbol) or 2192 (symbols other than the first symbol).

[86] In the case of the normal CP, the number of samples included in one slot is samples/slot=(160+2048)×1+(144+2048)×6=15,360. Further, one sampling time is 1/(15000×2048)=3.26×0^{-8} sec. The number of shifted sequences, which can be obtained when the CAZAC sequence is used in this structure, is as follows.

[87] (1) When only the 20MHz transmission bandwidth is used

[88] When the subcarrier interval is 1, the CAZAC sequence value is loaded every subcarrier. Accordingly, there is no significant change in the time domain after IFFT is performed. That is, one (SC-FDMA or OFDMA) symbol is obtained. One symbol has 2048 samples except for the CP.

[89] If it is required for a shifted CAZAC sequence to maintain a correlation characteristic without change, the amount of shift must be at least greater than the number of CP samples. This is because the amount of the CP is decided by reflecting the delay spreading value of a channel that experiences frequency selective fading. Thus, it can be seen that the CAZAC sequence must shift at least greater than the CP length in

order to guarantee orthogonality in this channel.

[90] Since the number of CP samples is 144 or 160, one CAZAC sequence that is properly shifted can be obtained when the CAZAC sequence is shifted as many as the number of at least 160 samples when the number of CP samples of 160 is based. When one SC-FDMA (or OFDMA) symbol is 2048 samples, at least 12 shifted CAZAC sequence can be obtained since 2048/160=12.8. Accordingly, when the subcarrier interval is 1 in Table 1, the number of shifted CAZAC sequences that can be obtained in the 20MHz transmission bandwidth is 12.

[91] If the subcarrier interval becomes 2, an output value has a structure in which a specific value is repeated since the input is performed every other one in terms of the IFFT characteristic. Thus, a structure having an original 2048 sample length becomes a structure in which two 1024 sample lengths are repeated. In this case, the shifted CAZAC sequences that can be obtained are reduced in half. That is, since 1024/160=6.4, only six shifted CAZAC sequences can be obtained.

[92] When the subcarrier interval is 3, the value is input one by one every three subcarriers. Thus, the output value has a structure in which three values are repeated and the shifted CAZAC sequences are reduced by 1/3.

[93] (2) When the 10MHz transmission bandwidth is used

[94] When a UE transmits the scheduling reference signal, the full SRS transmission band of 20MHz is divided into two partial SRS transmission bands every 10MHz and the two divided partial SRS transmission bands can be used independently.

[95] If the subcarrier interval is 1, the number of the shifted CAZAC sequences that can be obtained in one independent 10MHz partial SRS transmission band is 1024 samples (one symbol)/80 samples (one CP)=12.8, resulting 12 in total. When samples are transmitted at 10MHz, the number of samples per symbol is reduced, but the time length of one symbol is the same. Consequently, the distance between the samples is doubled. In other words, the sample distance in 20MHz is different from that in 10MHz. Accordingly, in the length of the CP, if only 80 samples are caught, 160 sample lengths in 20MHz are the same. Since 12 shift sequences can be generated in each partial SRS transmission band, a total of 24 shift sequences can be obtained in the entire frequency band.

[96] When the subcarrier interval is 2, 512 samples have a repeated structure as mentioned earlier, leading to 512/80=6.4 and 6 CAZAC sequences. Accordingly, the number of the shifted CAZAC sequences is reduced in half.

[97] (3) When the 5MHz transmission bandwidth is used

[98] The frequency band of 20MHz is divided into four independent 5MHz bands. Since 12x4=48, 48 shifted CAZAC sequences can be obtained.

[99] As described above, if the entire frequency band are divided into small transmission bandwidths to be used rather than to be used as one transmission bandwidth, the number of UEs (a total number of the shifted CAZAC sequences), which can transmit the scheduling reference signals at the same time, is increased significantly.

[100] FIG. 10 shows still another example of a multiplexing method of a scheduling reference signal.

[101] Referring to FIG. 10, the subcarrier interval is 1 and the scheduling reference signals are multiplexed with FDM and CDM being combined together. That is, a first to a third UEs transmit the scheduling reference signals using different codes C1 to C3 in the same partial SRS transmission band. A fourth to a sixth UEs also transmit the scheduling reference signals using different codes C4 to C6 in the same partial SRS transmission band. A seventh to a ninth UEs also transmit the scheduling reference signals using different codes C7 to C9 in the same partial SRS transmission band. Since FDM and CDM are combined, the capacity of the UE that can transmit the scheduling reference signal within one cell can be increased.

[102] FIG. 11 shows further still another example of a multiplexing method of a scheduling reference signal. It is assumed that an full SRS transmission band given hereinafter is 20MHz.

[103] Referring to FIG. 11, the subcarrier interval is 1, a first and a second UEs are allocated with the 5MHz transmission bandwidth, a third UE is allocated with the 10MHz transmission bandwidth, and a fourth UE is allocated with the 20MHz transmission bandwidth. When the fourth UE transmits the scheduling reference signal, the remaining UEs cannot transmit the scheduling reference signals since the subcarrier interval is 1. Thus, in T_1, the first to third UEs transmit the scheduling reference signals, and in T_{12}, the fourth UE transmits the scheduling reference signal. That is, the scheduling reference signals are transmitted between the UEs with them undergoing Time Division Multiplexing (hereinafter, referred to as TDM).

[104] FIG. 12 is a flowchart illustrating a method of transmitting a scheduling reference signal.

[105] Referring to FIG. 12, a BS transmits control information to a UE (S310). In general, since the type of the transmission bandwidth and the number of UEs are changed as time goes by, the BS has to transmit adequate control information periodically or if appropriate. The control information can be broadcasted to the entire UEs or transmitted

through a dedicated channel.

[106] The control information includes a transmission bandwidth, a subcarrier interval value, a hopping or shift method, a CAZAC sequence allocation method and so on. The term hopping or shift method refers to a method of deciding how to hop respective divided partial SRS transmission bands every transmitting time to transmit the scheduling reference signal. Signaling is possible in an upper layer signaling and also a physical layer signaling.

[107] The UE transmits the scheduling reference signal to a BS (S320). The UE generates a scheduling reference signal using predetermined control information, such as an allocated transmission bandwidth, an allocated subcarrier interval value, a predetermined hopping or shift method, and a CAZAC sequence, and transmits a generated scheduling reference signal to the BS.

[108] The steps of a method described in connection with the embodiments disclosed herein may be implemented by hardware, software or a combination thereof. The hardware may be implemented by an application specific integrated circuit (ASIC) that is designed to perform the above function, a digital signal processing (DSP), a programmable logic device (PLD), a field programmable gate array (FPGA), a processor, a controller, a microprocessor, the other electronic unit, or a combination thereof. A module for performing the above function may implement the software. The software may be stored in a memory unit and executed by a processor. The memory unit or the processor may employ a variety of means that is well known to those skilled in the art.

[109] As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims. Therefore, all changes and modifications that fall within the metes and bounds of the claims, or equivalence of such metes and bounds are intended to be embraced by the appended claims.

Claims

[1] A method of transmitting a scheduling reference signal (SRS) for uplink scheduling, the method comprising:
transmitting a SRS on a first partial SRS transmission band in a first transmitting time; and
transmitting the SRS on a second partial SRS transmission band in a second transmitting time, wherein the first and the second partial SRS transmission bands are parts of a full SRS transmission band and have exclusive positions with each other in the full SRS transmission band, the full SRS transmission band selected for uplink scheduling, the full SRS transmission band comprising a plurality of partial SRS transmission bands.

[2] The method of claim 1, wherein information of the first partial SRS transmission band and the second partial SRS transmission band is transmitted from a base station.

[3] A method of receiving a scheduling reference signal (SRS) for uplink scheduling, the method comprising:
allocating a transmission bandwidth to a user equipment, the transmission bandwidth being the bandwidth of a partial SRS transmission band, the partial SRS transmission band being a part of a full SRS transmission band, the full SRS transmission band for uplink scheduling comprising a plurality of partial SRS transmission bands; and
receiving a SRS on the partial SRS transmission band.

[4] The method of claim 3, wherein the partial SRS transmission band comprises a plurality of subcarriers and the SRS is transmitted through different subcarriers of the partial SRS transmission band for each user equipment.

[5] The method of claim 3, wherein the sizes of transmission bandwidths are different for each user equipment.

[6] The method of claim 3, further comprising:
receiving a next SRS on a next partial SRS transmission band, the next partial SRS transmission band being one of the partial SRS transmission band in the full SRS transmission band.

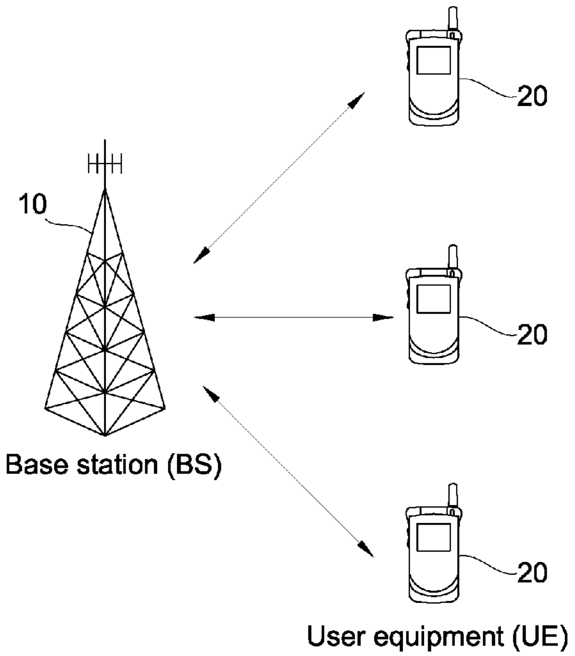
[7] The method of claim 6, wherein the next partial SRS transmission band for the next SRS is different from the partial SRS transmission band for the SRS.

[8] The method of claim 6, wherein the next partial SRS transmission band for the

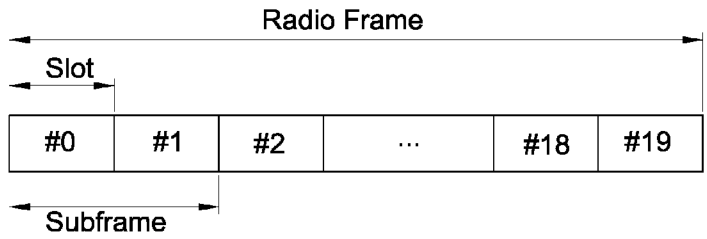
next SRS is contiguous with the partial SRS transmission band for the SRS.

[9] The method of claim 6, wherein the SRS and the next SRS are orthogonal to each other in code domain.

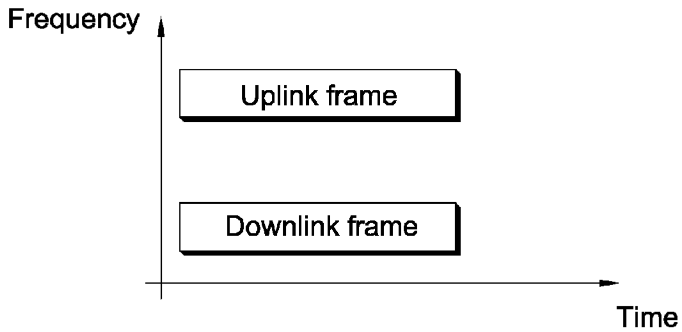
[Fig. 1]



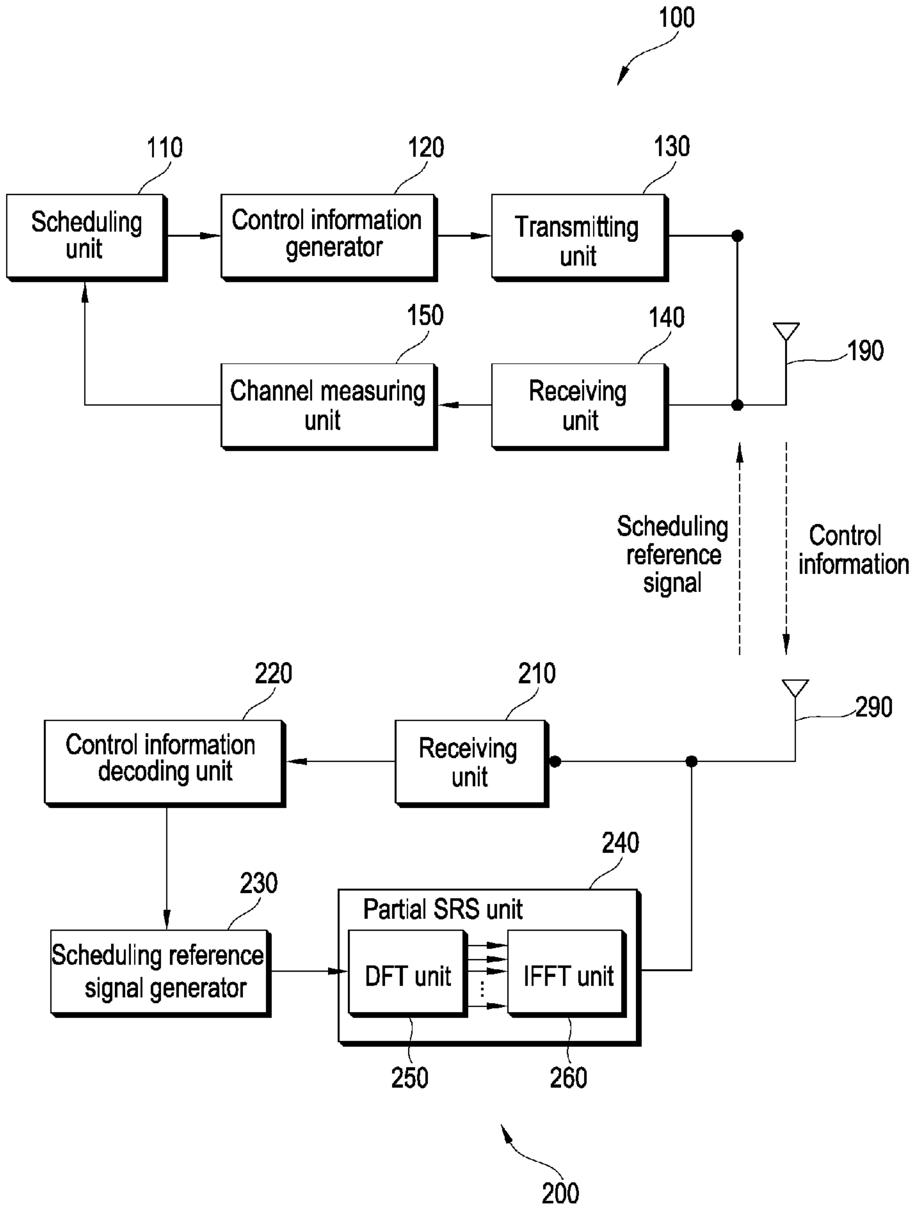
[Fig. 2]



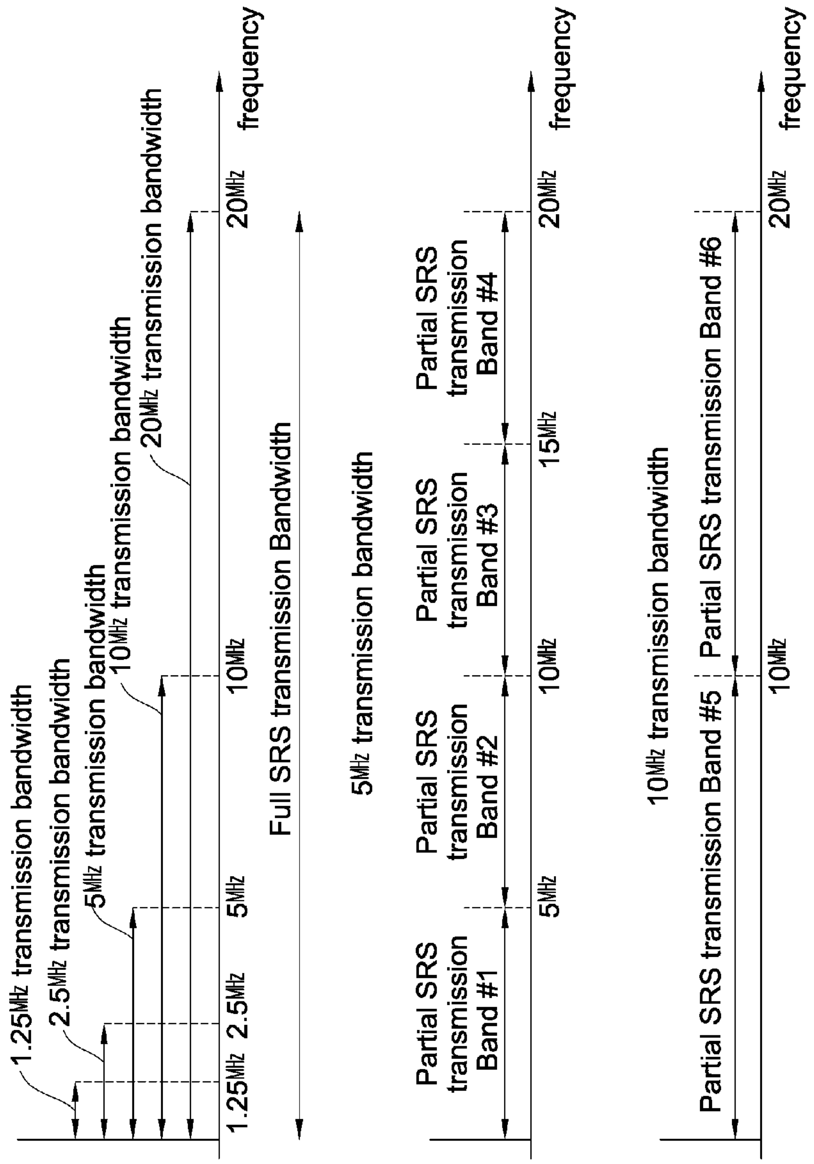
[Fig. 3]



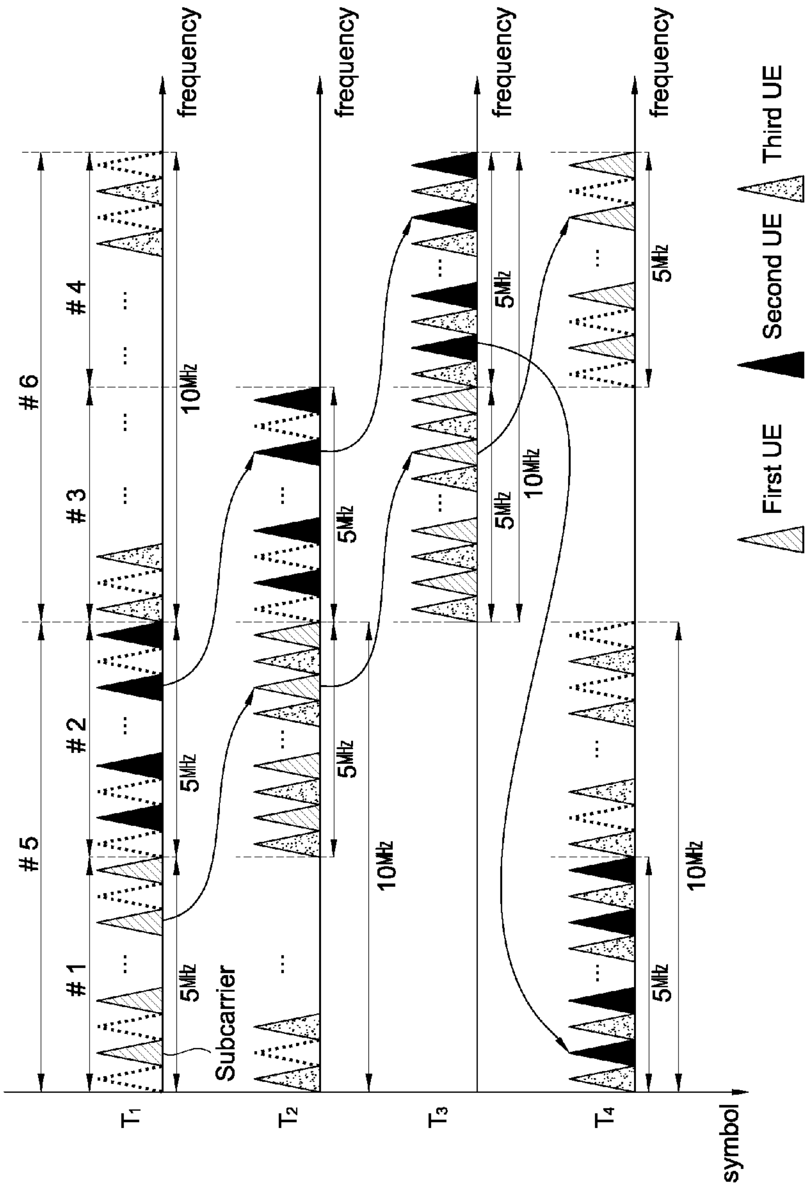
[Fig. 4]


100
110
Scheduling unit
120
Control information generator
130
Transmitting unit
150
Channel measuring unit
140
Receiving unit
190
Scheduling reference signal
Control information
220
Control information decoding unit
210
Receiving unit
290
240
230
Partial SRS unit
Scheduling reference signal generator
DFT unit
IFFT unit
250
260
200

[Fig. 5]

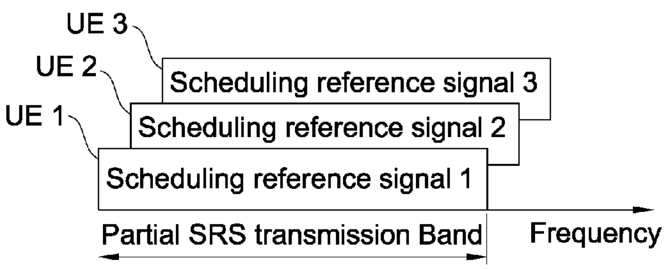

1.25MHz transmission bandwidth
2.5MHz transmission bandwidth
5MHz transmission bandwidth
10MHz transmission bandwidth
20MHz transmission bandwidth
1.25MHz 2.5MHz 5MHz 10MHz 20MHz
frequency
Full SRS transmission Bandwidth
5MHz transmission bandwidth
Partial SRS transmission Band #1
Partial SRS transmission Band #2
Partial SRS transmission Band #3
Partial SRS transmission Band #4
5MHz 10MHz 15MHz 20MHz
frequency
10MHz transmission bandwidth
Partial SRS transmission Band #5
Partial SRS transmission Band #6
10MHz 20MHz
frequency

[Fig. 6]



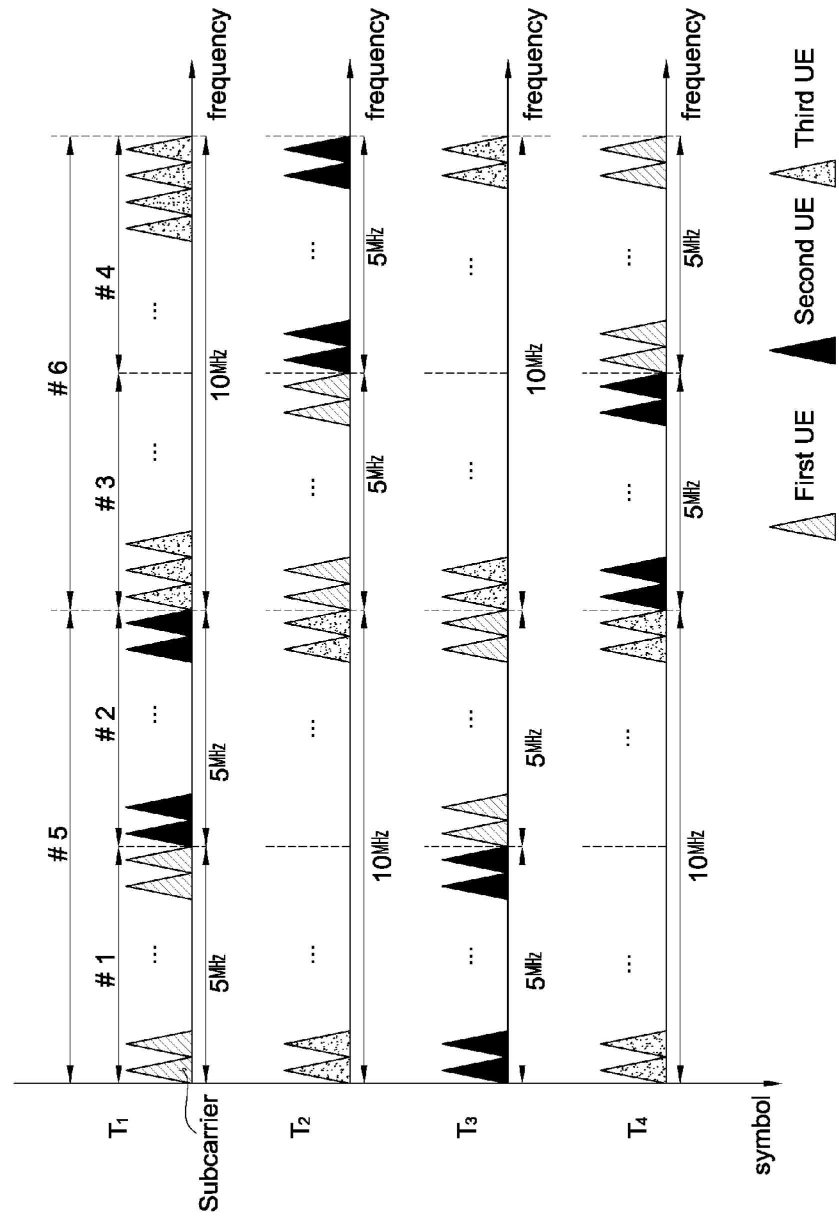
frequency
frequency
frequency
frequency
1
2
3
4
5
6
5MHz
10MHz
Subcarrier
T1
T2
T3
T4
symbol
First UE
Second UE
Third UE

[Fig. 7]



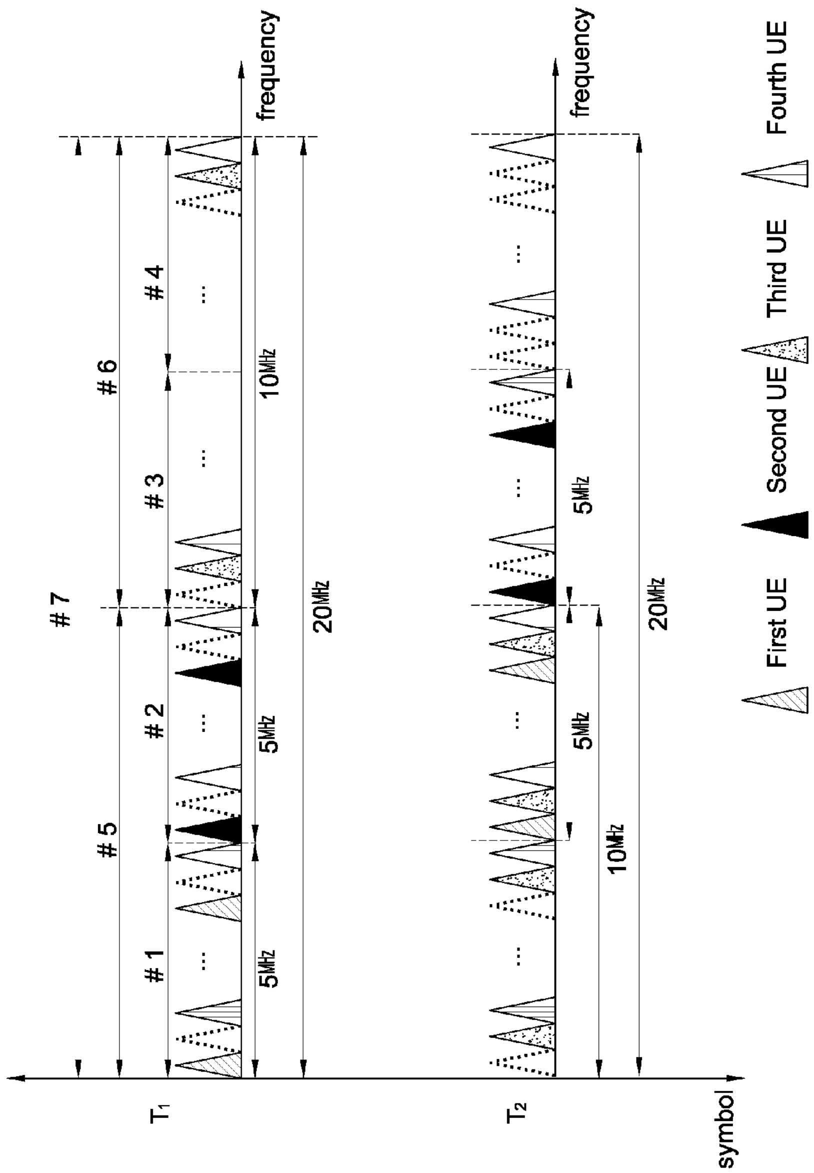
UE 3
UE 2
UE 1
Scheduling reference signal 3
Scheduling reference signal 2
Scheduling reference signal 1
Partial SRS transmission Band
Frequency

[Fig. 8]



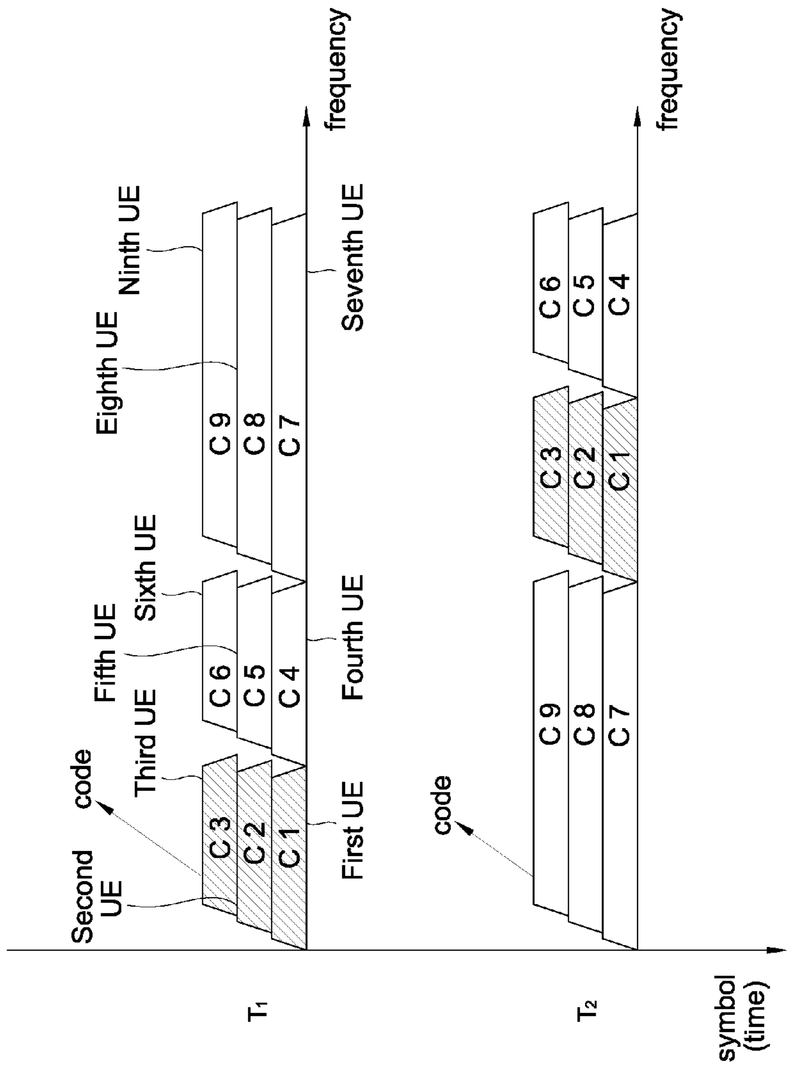
frequency
T1
T2
T3
T4
Subcarrier
symbol
1
2
3
4
5
6
5MHz
10MHz
First UE
Second UE
Third UE

[Fig. 9]

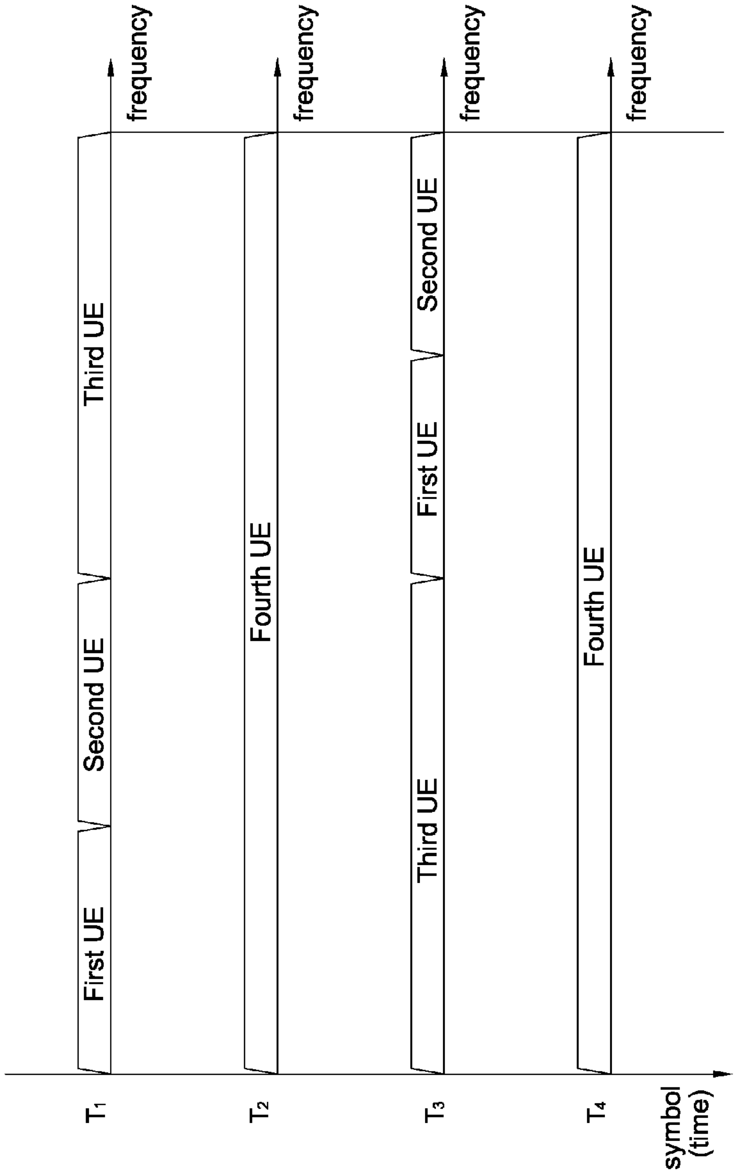


frequency
frequency
1
2
3
4
5
6
7
5MHz
5MHz
10MHz
20MHz
5MHz
5MHz
10MHz
20MHz
T1
T2
symbol
First UE
Second UE
Third UE
Fourth UE

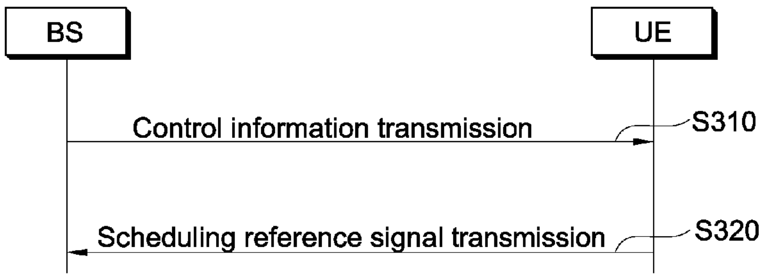
[Fig. 10]


frequency
Ninth UE
Eighth UE
Seventh UE
Sixth UE
Fifth UE
Fourth UE
Third UE
code
Second UE
First UE
C 9
C 8
C 7
C 6
C 5
C 4
C 3
C 2
C 1
T1
T2
symbol (time)

[Fig. 11]


frequency
frequency
frequency
frequency
Third UE
Second UE
First UE
Fourth UE
Second UE
First UE
Third UE
Fourth UE
T1
T2
T3
T4
symbol
(time)

[Fig. 12]


BS
UE
Control information transmission
S310
Scheduling reference signal transmission
S320

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/000665

A. CLASSIFICATION OF SUBJECT MATTER

H04L 27/02(2006.01)i

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 : H04L, H04B

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 applications for Utility Models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS(Searching system of KIPO), IEL : "UPLINK", "SCHEDULING","REFERENCE", "ORTHOGONAL"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/0078651 A1 (JU-HO LEE et al.) 14 APRIL 2005 See abstract, page 1 paragraph [0005] ~ page 2 paragraph [0024]	1 ~ 9
A	US 6,771,987 B1 (HENRIK DAM et al.) 3 AUGUST 2004 See abstract, column 2 line 24 ~ column 3 line 32, and Fig.1 ~ 4.	1, 3
A	JP 2004-248247 A (LUCENT TECHNOL INC) 2 SEPTEMBER 2004 See abstract, page 10-3 paragraph <8> ~ page 10-4 paragraph <17>, and Fig.1	1, 3

☐ 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
21 MAY 2008 (21.05.2008)	**21 MAY 2008 (21.05.2008)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

JEONG, Jae Heon

정재헌

Telephone No. 82-42-481-5672

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2008/000665

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005/0078651 A1	14.04.2005	KR1020050018540	23.02.2005
		CN1604687A	06.04.2005
		EP1509011A2	23.02.2005
		JP17065298	10.03.2005
		JP2005065298A2	10.03.2005
US 6,771,987 B1	03.08.2004	AR026280A1	05.02.2003
		AT275779E	15.09.2004
		AU200121537A1	08.05.2001
		AU200121537A5	08.05.2001
		CA2387094AA	03.05.2001
		CN1385008A	11.12.2002
		DE60013627C0	14.10.2004
		DE60013627T2	18.08.2005
		EP1096696A1	02.05.2001
		EP1224747A1	24.07.2002
		EP1224747B1	08.09.2004
		WO200131810A1	03.05.2001
JP 2004-248247 A	02.09.2004	EP01447943A1	18.08.2004
		JP16248247A	02.09.2004
		KR1020040073936A	21.08.2004
		KR2004073936A	21.08.2004
		US20040160936A1	19.08.2004