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CA 2628861 A1 2007/05/10

(21) 2 628 861

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2006/11/07
(87) Date publication PCT/PCT Publication Date: 2007/05/10
(85) Entrée phase nationale/National Entry: 2008/05/06
(86) N° demande PCT/PCT Application No.: KR 2006/004651
(87) N° publication PCT/PCT Publication No.: 2007/052995
(30) Priorités/Priorities: 2005/11/07 (US60/734,146); 2005/11/16 (US60/737,289); 2006/02/27 (US60/777,051); 2006/11/07 (KR10-2006-0109433)

(51) Cl.Int./Int.Cl. *H04L 27/26* (2006.01)

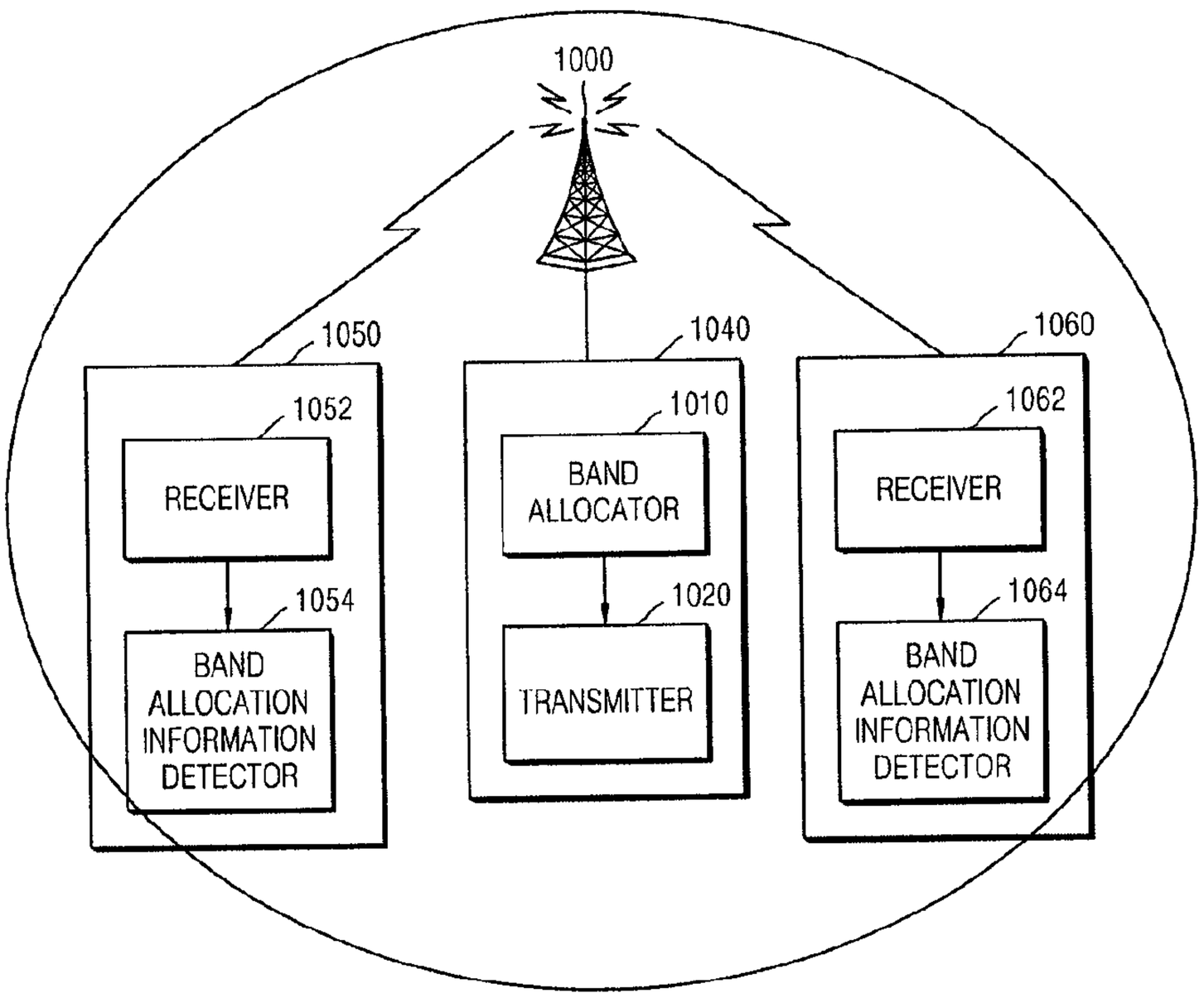
(71) Demandeurs/Applicants:
ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE, KR;
INDUSTRY ACADEMIC COOPERATION FOUNDATION OF KYUNGHEE UNIVERSITY, KR

(72) Inventeurs/Inventors:
HWANG, SUNG-HYUN, KR;
SONG, MYUNG-SUN, KR;
KIM, YUN-HEE, KR;
KIM, CHANG-JOO, KR;
KO, GWANGZEEN, KR;
UM, JUNG-SUN, KR

(74) Agent: SMART & BIGGAR

(54) Titre : PROCEDE PERMETTANT D'UTILISER UNE LARGEUR DE BANDE SOUPLE DANS UN SYSTEME RADIO COGNITIF A ACCES MULTIPLE PAR REPARTITION ORTHOGONALE DE LA FREQUENCE (OFDMA), STATION DE BASE ET STATION D'ABONNE UTILISANT UN TEL PROCEDE

(54) Title: METHOD FOR USING FLEXIBLE BANDWIDTH IN OFDMA-BASED COGNITIVE RADIO SYSTEM, BASE STATION AND SUBSCRIBER STATION USING THE SAME



(57) Abrégé/Abstract:
Provided are a method for using a flexible bandwidth in an orthogonal frequency division multiple access (OFDMA)-based cognitive radio system, and a base station (BS) and a subscriber station using the method. The method includes: allocating a channel band from among unused channel bands having a bandwidth that is a natural number times a bandwidth resolution to customer premises equipment (CPE), wherein the bandwidth resolution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band, and transmitting an OFDMA-based signal comprising band allocation information indicating information regarding the allocated channel band.

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 May 2007 (10.05.2007)

PCT

(10) International Publication Number
WO 2007/052995 A1

(51) International Patent Classification:
H04L 27/26 (2006.01)

(21) International Application Number:
PCT/KR2006/004651

(22) International Filing Date:
7 November 2006 (07.11.2006)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:

60/734,146	7 November 2005 (07.11.2005)	US
60/737,289	16 November 2005 (16.11.2005)	US
60/777,051	27 February 2006 (27.02.2006)	US
10-2006-0109433	7 November 2006 (07.11.2006)	KR

(71) Applicant *(for all designated States except US)*: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE** [KR/KR]; 161, Gajeong-dong, Yusong-gu, Daejeon-city 305-350 (KR).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HWANG, Sung-Hyun** [KR/KR]; 161, Gajeong-dong, Yusong-gu, Daejeon-city 305-700 (KR). **SONG, Myung-Sun** [KR/KR]; 161, Gajeong-dong, Yusong-gu, Daejeon-city 305-700 (KR). **KIM, Yun-Hee** [KR/KR]; 1, Seocheon-dong, Giheung-gu, Yongin-city, Gyeonggi-do 449-701 (KR). **KIM, Chang-Joo** [KR/KR]; 161, Gajeong-dong, Yusong-gu, Daejeon-city 305-700 (KR).

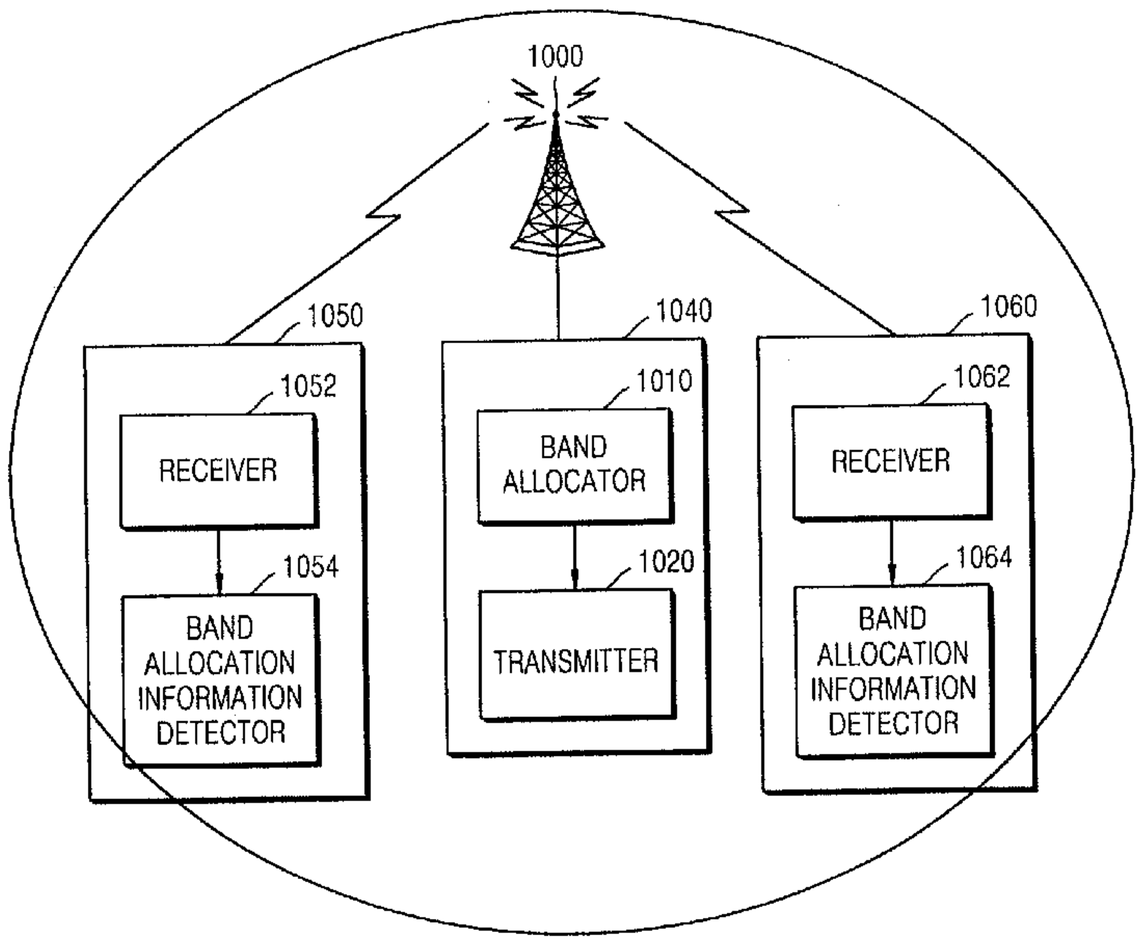
(74) Agent: **Y.P. LEE, MOCK & PARTNERS**; 1575-1, Seocho-dong, Seocho-gu, Seoul 137-875 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, 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, LV, LY, MA, MD, 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), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,

[Continued on next page]

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WO 2007/052995 A1

WO 2007/052995 A1

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*

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

METHOD FOR USING FLEXIBLE BANDWIDTH IN OFDMA-BASED COGNITIVE RADIO SYSTEM, BASE STATION AND SUBSCRIBER STATION USING THE SAME

TECHNICAL FIELD

The present invention relates to an orthogonal frequency division multiple access (OFDMA)-based cognitive radio system and a method therefor, and more particularly, to an OFDMA-based cognitive radio system effectively using a fractional band or an empty band corresponding to a bundle of fractional bands and a method therefor.

BACKGROUND ART

Demands for services using radio communications have increased. However, frequency bands that are suitable in terms of transmission characteristics and development of devices have been occupied. Thus, secondary users desiring to provide new services use radio cognitive technology to detect unused frequency channels through temporal and/or specific inspections of frequency channels allowed to primary users so as to use the unused frequency channels. In this case, primary and secondary users refer to communication systems operated by different services or businesses. Primary users correspond to incumbent users (IUs), and secondary users correspond to users of cognitive radio systems.

The IEEE802.22 standard desires to provide data, voice(VoIP) and audio/video services in frequency bands used in televisions (TVs) (e.g., a band from 54 MHz to 698 MHz corresponding to U.S. TV channels 2 through 51 or an international band from 41 MHz to 910 MHz) using times and spaces, which are not used by primary users of televisions (TVs) or radio devices. In order to use an allocated TV frequency band in an IEEE802.22 system (a base station (BS), customer premises equipment (CPE), or a core network), a BS and CPE of a secondary user must know about the current state of a channel. For this purpose, the BS and CPE of the secondary user must scan a band from 41 MHz to 910 MHz in order to monitor the use state of the channel, wherein the band is a current TV channel. Thus, the channel can be changed to another channel when a primary user desires to use the channel while the secondary user is using the channel.

The IEEE802.22 system uses a plurality of broadcast channel bands each having a bandwidth of 6, 7, or 8 MHz within the band from 41 MHz to 910 MHz allocated to a

TV broadcast. In detail, a BS and CPE of the IEEE802.22 system use a currently unu sed broadcast channel band of the plurality of broadcast channel bands. In other word s, the IEEE802.22 system accesses each broadcast channel band.

In the present specification, a fraction of a broadcast channel band is referred to as a fractional band to describe a method and a system for using a flexible bandwidth i n a cognitive radio system.

In an existing cognitive radio system, if a system of a primary user uses a fractio n of a bandwidth of a broadcast channel a system of a secondary user may not use mo st of the broadcast channel band except for the fraction of the bandwidth. For exampl e, if a 200 kHz narrowband radio device uses a broadcast channel band having a band width of 6 MHz, systems of secondary users may not use a bandwidth of 5.8 MHz of th e broadcast channel band. In this case, a band having bandwidths of 200 kHz and 5.8 MHz corresponds to the above-described fractional band.

The efficiency of a cognitive radio system depends on whether a currently unuse d channel is effectively detected so as to appropriately select a service suitable for the c urrently unused channel and provide the service to a secondary user. In other words, t he efficiency of the cognitive radio system depends on how much a confined channel b andwidth is effectively used. Thus, according to existing cognitive radio systems, a ba ndwidth of 5.8 MHz corresponding to 96.6% of a broadcast channel bandwidth of 6 MH z is not used and is thus inefficient.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

The present invention provides a method for effectively using a fractional band of a broadcast channel band in a flexible bandwidth orthogonal frequency division multipl e access (OFDMA)-based cognitive radio system, and a base station (BS) and a subscr iber station using the same.

The method includes a method of allocating a flexible bandwidth, a method of co nstituting OFDMA parameters, and a method of detecting the allocated flexible bandwid th.

TECHNICAL SOLUTION

According to an aspect of the present invention, there is provided a base station

(BS) of an orthogonal frequency division multiple access (OFDMA)-based cognitive radi o system including: a band allocator allocating a channel band of unused channel band s having a bandwidth that is a natural number times a bandwidth resolution to CPE (cus tomer premises equipment), wherein the bandwidth resolution is a predetermined band width smaller than a bandwidth of a broadcast channel band; and a transmitter transmitt ing an OFDMA-based signal comprising band allocation information indicating informati on regarding the allocated channel band.

According to another aspect of the present invention, there is provided a CPE of an OFDMA-based cognitive radio system including: a receiver receiving an OFDMA-ba sed signal comprising band allocation information indicating information regarding a cha nnel band allocated from a BS; and a band allocation information detector detecting the band allocation information based on the received OFDMA-based signal, wherein the allocated channel band is a channel band of unused channel bands having a bandwidth that is a natural number times a bandwidth resolution, wherein the bandwidth resolutio n is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band.

According to another aspect of the present invention, there is provided a metho d of using a flexible bandwidth through a BS in an OFDMA-based cognitive radio syste m, including: allocating a channel band of unused channel bands having a bandwidth th at is a natural number times a bandwidth resolution to CPE, wherein the bandwidth res olution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band; and transmitting an OFDMA-based signal comprising band allocation information indicating information regarding the allocated channel band.

According to another aspect of the present invention, there is provided a metho d of using a flexible bandwidth through CPE in an OFDMA-based cognitive radio syste m, including: allocating a channel band of unused channel bands having a bandwidth th at is a natural number times a bandwidth resolution to CPE, wherein the bandwidth res olution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band; and transmitting an OFDMA-based signal comprising band allocation information indicating information regarding the allocated channel band.

According to another aspect of the present invention, there is provided a comput er-readable recording medium having embodied thereon a computer program for execu ting the method of using the flexible bandwidth through the BS in the OFDMA-based co gnitive radio system.

According to another aspect of the present invention, there is provided compute r-readable recording medium having embodied thereon a computer program for executi ng the method of using the flexible bandwidth through the CPE in the OFDMA-based co gnitive radio system.

ADVANTAGEOUS EFFECTS

According to the present invention, fractional bands and an empty band including a bundle of fractional bandwidths can be flexibly and efficiently used. Also, maximize d spectrum efficiency and a flexible data speed can be achieved at a lower complexity i n a cognitive radio system having confined frequency resources.

DESCRIPTION OF THE DRAWINGS

FIGS. 1A through 1E illustrate channel bands flexibly used by a base station (B S) and customer premises equipment (CPE) of an OFDMA-based cognitive radio syste m according to an embodiment of the present invention.

FIG. 2 illustrates a relationship between the number of bonded channel bands a nd a Fourier Transform (FT) size when an OFDMA-based cognitive radio system of an embodiment of the present invention uses a bundle of four broadcast channel bands.

FIGS. 3A through 3C illustrate orthogonal frequency division multiple access (O FDMA) parameters necessary for flexibly using empty fractional bands, with respect to FFT sizes of 1K, 2K, 4K, and 8K, according to embodiments of the present invention.

FIGS. 4A through 4C illustrate orthogonal frequency division multiple access (O FDMA) parameters necessary for flexibly using empty fractional bands, with respect to FFT sizes of 1K, 2K, 4K, and 6K, according to another embodiments of the present inve ntion.

FIG. 5 illustrates a start position of a fractional band based on a largest broadca st channel bandwidth of 8 MHz.

FIG. 6 illustrates a various fractional bandwidth modes, with respect to fractional bandwidth and start position of a fractional band illustrated in FIG. 5.

FIG. 7 illustrates a downlink frame structure which can be applied to an OFDMA -based signal used in a cognitive radio system according to an embodiment of the pres ent invention.

FIG. 8 illustrates a method of inserting information regarding 36 kinds of fraction

al bandwidth modes illustrated in FIG. 6 into a preamble.

FIGS. 9A through 9C illustrate methods of inserting channel bonding information into preambles, in regard to methods of bonding a plurality of channels according to an embodiment of the present invention.

FIG. 10 illustrates an OFDMA-based cognitive radio system using a flexible ban dwidth according to an embodiment of the present invention.

FIG. 11 is a flowchart of a method of detecting a method of using a flexible band width by means of a second user CPE illustrated in FIG. 10, according to an embodime nt of the present invention.

FIG. 12 is a flowchart of a method of computing correlation values of received pr eambles in order to detect a method of using a flexible bandwidth according to an embo diment of the present invention.

FIG. 13 illustrates an example of the method illustrated in FIG. 12.

FIG. 14 is a flowchart of a method of using a flexible bandwidth in an OFDMA-ba sed cognitive radio system according to an embodiment of the present invention.

MODE OF THE INVENTION

Hereinafter, the present invention will be described in detail with reference to the attached drawings.

The present invention provides technology for flexibly using a bandwidth by a ba se station (BS) and customer premises equipment (CPE) of a secondary user in a multi -FA (Frequency Assignment) system. The technology is a method of using an empty fr actional band besides bonded channel bands in an orthogonal frequency division multip le access (OFDMA)-based cognitive radio system so as to maximize use efficiency of a spectrum. A fractional band may be used by itself or may be bonded to a broadcast c hannel band. Thus, technology suggested for use in a cognitive radio system frequent ly generating a fractional band may be used to maximize use efficiency of a spectrum.

In order to aid understanding, an IEEE802.22 wireless regional area network (W RAN) system may be described as an example to provide a service to a cognitive radio user as a secondary user, wherein the broadcast channel bandwidths 6, 7, and 8 MHz are not used as broadcast frequency bands in very high frequency (VHF)/ultra high freq uency (UHF) bands.

FIGS. 1A through 1E illustrate channel bands flexibly used by a base station (B

S) and customer premises equipment (CPE) of an OFDMA-based cognitive radio syste m according to an embodiment of the present invention. Here, broadcast channel ban ds are 6 MHz.

Referring to FIGS. 1A through 1E, reference numerals 102, 106, 120, 126, 140, 144, 150, 165, and 172 denote channel bands which are being used, and reference nu merals 100, 104, 108, 110, 122, 124, 142, 146, 148, 163, and 174 denote channel ban ds which are not currently being used. The channel bands102, 106, 120, 126, 140, 14 4, 150, 165, and 172 are shadowed and currently being used by CPE of a primary user or CPE of a secondary user belonging to an OFDMA-based cognitive radio system of th e present invention. Information illustrated in FIGS. 1A through 1E may be obtained b ased on a result of sensing a spectrum using a system of the secondary user, i.e., the OFDMA-based cognitive radio system of an embodiment of the present invention.

FIG. 1A illustrates a method of allocating empty fractional bands to the seconda ry user. Referring to FIG. 1A, bandwidths 3 MHz and 1 MHz of empty fractional bands 104 and 108 of each broadcast channel band having a bandwidth of 6 MHz are allocat ed to the secondary user so as to be able to flexibly use bandwidths.

In general, when primary user occupies a fraction of a bandwidth of a broadcast channel band, or secondary user is not able to access a fraction of a channel bandwidt h so as not to interfere with adjacent channels, the existing cognitive radio system may not use the rest of the channel bandwidth. However, in an embodiment of the present invention, an empty fractional band can be effectively used without affecting an allowed system of a primary user. A reduction in interference between adjacent channels will b e described later with reference to FIGS. 1D and 1E.

FIG. 1B illustrates a method of allocating a bundle of a plurality of empty broadc ast channel bands. Referring to FIG. 1B, two broadcast channel bands 122 and 124 (each having a bandwidth of 6 MHz) are bonded to form a channel band 130 having a b andwidth of 12 MHz, and the channel band 130 is allocated to the secondary user so as to be able to flexibly use a bandwidth. If several empty channel bands are bonded an d used, a high-speed data service may be provided to a secondary user.

FIG. 1C illustrates a method of binding fractional bands and a broadcast channe l band and allocating the bonded band to a secondary user. A fractional band 146 is b onded with a broadcast channel band 148 having a bandwidth of 9 MHz, and then alloc ated to a secondary user so as to be able to flexibly use a bandwidth. Fractional band

s 142 and 146 may be bonded together and then allocated to the secondary user. Alt ernatively, the fractional bands 142 and 146 may be bonded with the broadcast channel band 148 so as to form a channel band 160, and the channel band 160 is allocated to the secondary user. Thus, it will be understood by those of ordinary skill in the art that the fractional bands 142 and 146 and the broadcast channel band 148 may be allocate d and bonded using various methods.

FIG. 1D illustrates a method of reducing the interference with the adjacent incu mbent user. If a narrowband incumbent user (IU) in a narrowband 165 is positioned in a broadcast channel band 164, which is partially being occupied by narrowband incumb ent user (IU) in a narrowband 165, a system of a secondary user uses only the fraction al band 163 of the broadcast channel band 162 in consideration of a guard band for red ucing interference with the adjacent narrowband IU in a narrowband 165. The system of the secondary user cannot use an entire fraction of the broadcast channel band 162 due to a concern about the interference with the adjacent narrowband IU in a narrowba nd 165. However, according to the present embodiment, the fractional band 163 may be effectively used without interfering with the adjacent narrowband IU in a narrowband 165.

FIG. 1E illustrates a method of using a fractional bandwidth of an explicit signali ng channel for switching a channel. Referring to FIG. 1E, when a secondary user uses an entire fraction of a broadcast channel band 170, a narrowband IU appears in a narr owband 172.

In this case, the secondary user must empty the broadcast channel band 170, w hich is being used for the narrowband IU and then move to another broadcast channel band (not shown) which is not being used. In general, a channel move time is less tha n or equal to 2 seconds.

Emptying a currently used channel and moving to another channel is called cha nnel switching. To perform channel switching, first and second messages must be exc hanged between a BS and CPE of the secondary user. Here, the first message is to r equest to change channel A to channel B, and the second message is to response the f act that channel A has been changed into channel B according to the first message.

Thus, the explicit channel switching information such as first and second messa ges must be exchanged during the channel move time. In an existing method, the exp licit channel switching information is exchanged through the broadcast channel band 17

0 during the channel move time. However, in the method of the present embodiment, t he explicit channel switching information is exchanged through only a fractional band 17 4 of the broadcast channel band 170. Thus, interference affecting the narrowband IU such as a part 74 device appearing in the broadcast channel band 170 is more reduced than in the existing method.

In other words, as shown in FIGS. 1A through 1E, a method of flexibly using an empty channel band in the OFDMA-based cognitive radio system may be classified into two methods. In the first method, a broadcast channel band or a fraction of the broad cast channel band is allocated as a channel band for the CPE of a secondary user. In the second method, broadcast channel bands or a plurality of fractions of a broadcast c hannel band are bonded to form a channel band, and the channel band is allocated as a channel band for the CPE of a secondary user. In the first method, various channel bands can be flexibly used depending on bandwidths of fractional bands and positions of frequency phases in a broadcast channel band. In the second method, various cha nnel bands can be flexibly used depending on bandwidths of fractional bands, positions of frequency phases in a broadcast channel band, and the number of bonded channel bands.

In the specification, for convenience, a unit of a minimum bandwidth of a fractio nal band is referred to as a bandwidth resolution. In other words, the bandwidth resolu tion indicates a minimum bandwidth used in the OFDMA-based cognitive radio system of the present invention. If the bandwidth resolution is 1 MHz, and four broadcast cha nnel bands each having a bandwidth of 6 MHz are used, the OFDMA-based cognitive r adio system of an embodiment of the present invention may allocate various channel b ands having bandwidths 1MHz, 2MHz, through to 23MHz, and 24MHz and various freq uency positions of the bandwidths to a secondary user.

FIG. 2 illustrates a relationship between the number of bonded channel bands a nd the size of Fourier Transform (FT) when an OFDMA-based cognitive radio system of an embodiment of the present invention uses a bundle of four broadcast channel band s. Here, FT is generally a Fast Fourier Transform (FFT) which is advantageous in ter ms of realization complexity but the FT is not necessarily limited to an FFT. A Discrete Fourier Transform (DFT) may also be used.

When the number of bonded channel bands is “1,” the size of the FFT may be w ithin a range between 1K and 8K.

If the number of bonded channel bands is "2," and a basic FFT size is 1K, an FFT size of 2K may be used to maintain a fixed interval of sub-carriers. If the basic FFT size is 2K, an FFT size of 4K may be used to maintain a fixed interval of sub-carriers. If the basic FFT size is 4K, an FFT size of 8K may be used to maintain a fixed interval of sub-carriers. If the basic FFT size is 8K, an FFT size is not available. Here, the basic FFT size is defined as an FFT size which is used for single broadcast channel band.

Even when the number of bonded channel bands is "3" and "4," the above-described method is applied.

Referring to FIG. 2, an FFT is performed once on a plurality of bonded channel bands. Alternatively, the FFT may be performed several times. For example, the FFT may be performed four times on a channel band formed of a bundle of four broadcast channels at the FFT size of 2K or two times at the FFT size of 4K. However, if the FFT is performed several times, null sub-carriers must be included between bonded channel bands. Thus, the FFT may be inefficient in terms of the use of a spectrum. A method of controlling several outputs of the FFT may be complicated. For this reason, the method of performing the FFT once in order to flexibly use a channel bandwidth has been described with reference to FIG. 2. However, it will be understood by those of ordinary skill in the art that a method of performing an FFT several times may be applied.

In the embodiment described with reference to FIGS. 1A through 1E, a fractional band of a broadcast channel band is use. A partial FFT may be easily performed on the fractional band. In other words, as shown in FIG. 2, only a fraction of an output of the FFT may be selectively output in order to support a fractional band.

FIGS. 3A through 3C illustrate OFDMA parameters that are necessary for flexibly using empty fractional bands, with respect to FFT sizes of 1K, 2K, 4K, and 8K, according to embodiments of the present invention.

FIGS. 4A through 4C illustrate OFDMA parameters that are necessary for flexibly using empty fractional bands, with respect to FFT sizes of 1K, 2K, 4K, and 6K, according to another embodiments of the present invention.

Referring to FIGS. 3A through 3C, a sampling factor is fixed while a sampling frequency varies in each of broadcast channel band bandwidths of 6, 7, and 8 MHz. Referring to FIGS. 4A through 4C, the sampling factor varies while the sampling frequency is fixed in each of the broadcast channel bandwidths of 6, 7, and 8 MHz. In this case, it is assumed that the ratio of a guard interval time to an FFT time is 1:4.

OFDMA parameters for the broadcast channel bandwidth of 6 MHz will now be described with reference to FIG. 3A. The sampling factor suitable for a bandwidth of t he broadcast channel band is selected so as to determine the sampling frequency. If t he sampling factor is 8/7, the sampling frequency is constantly maintained at 48/7 MHz regardless of the FFT size and a fractional bandwidth. Thus, sub-carrier spacing is res pectively 6.696 kHz, 3.348 kHz, 1.674 kHz, and 0.837 kHz with respect to the FFT siz e of 1K, 2K, 4K, and 8K as shown in FIG. 3A. A number of sub-carriers used in a fract ional band having a bandwidth k times a bandwidth resolution is defined as140*k, 280*k , 560*k, and 1120*k with respect to a basic FFT size of 1K, 2K, 4K, and 8K, wherein the number of sub-carriers is proportional to a bandwidth of a fractional band. In other w ords, if the basic FFT size is 1K, 2K, 4K, and 8K, the number of used sub-carriers within the bandwidth resolution is defined as 140, 280, 560, and 1120. If the bandwidth of t he fractional band is k times the bandwidth resolution, the constant is multiplied by k so that the number of used sub-carriers in the fractional band is proportional to the bandwi dth of the fractional band.

Even if the bandwidth of the broadcast channel band is 7 MHz as shown in FIG. 3B or 8 MHz as shown in FIG. 3C, the sampling factor is 8/7. However, the number o f used sub-carriers within the bandwidth resolution corresponding to the FFT size of 1K, 2K, 4K, or 8K is defined as the constant of 120, 240, 480, or 960 in the embodiment ill ustrated in FIG. 3B but as the constant of 105, 210, 420, or 840 in the embodiment illus trated in FIG. 3C, so that the number of used sub-carriers within the broadcast channel bandwidth is equal to that illustrated in FIG. 3A. In this case, the number of used sub-carriers for the FFT size of 1K is always fixed as 140*6=120*7=105*8. Thus, the numb er of used sub-carriers within the broadcast channel band is kept constant regardless of the bandwidth of the broadcast channel band. In other words, such a constant is sele cted so that the total number of used sub-carriers is equal at bandwidths of 6, 7, and 8 MHz of a broadcast channel band. The total number of used sub-carriers is 840, 1680 , 3360, or 6720 at a basic FFT size of 1K, 2K, 4K, or 8K, respectively, regardless of the bandwidth of the broadcast channel band.

The OFDMA parameters as defined above are characterized in that the total nu mber of used sub-carriers is maintained constant regardless of the bandwidth of a broa dcast channel band for equally applying a sub-channel allocation rule. The OFDMA p arameters according to the embodiments illustrated in FIGS. 3A through 3C are charact

erized in that a sampling frequency varies with a bandwidth of a broadcast channel ban d while a number of used sub-carriers is equal so as to maintain use efficiency of a ban d constant. Thus, a sampling frequency must vary in a nation using a different type of channel bandwidth. However, an identical sub-channel constitution method may be ap plied in all nations.

The OFDMA parameters according to an embodiment illustrated in FIGS. 4A thr ough 4C are characterized in that a sampling frequency does not vary regardless of a b andwidth of a broadcast channel band while the number of used sub-carriers varies wit h the bandwidth of the broadcast channel band in order to maintain use efficiency of a b and constant. Thus, a cognitive radio system using an identical sampling frequency m ay be used in a nation using broadcast channel bands having different bandwidths. H owever, a sub-channel constitution method must vary. The OFDMA parameters defin ed above are set so that intervals of sub-carriers are maintained constant regardless of the bandwidth of the broadcast channel band at an identical FFT size in order to mainta in a robustness of frequency offset constant regardless of the bandwidth of the broadca st channel band.

FIG. 5 illustrates a start position of a fractional band based on the largest broad cast channel bandwidth of 8 MHz. It is assumed that a bandwidth resolution is 1MHz. Referring to FIG. 5, reference numerals 500, 510, through to 570 denote bands. Two bands, which are not adjacent to each other, e.g., the bands 510 and 560, are bonded and then allocated to a secondary user. For convenience, it will be described that onl y adjacent bands are bonded and then allocated to the secondary user. In other word s, positions of available fractional bands may be adjacent to each other or may be sepa rated from each other. For convenience, if fractional bands are adjacent to each other at all times, 8 kinds of bandwidths of an available fractional band exist. When the OF DMA parameters for a broadcast channel bandwidth of 8 MHz are defined as illustrated in FIG. 3C, a real bandwidth illustrated in FIG. 5 is about 9.142 MHz, and a real bandw idth resolution for a bandwidth resolution of 1 MHz is 0.937 MHz. Since a sampling fa ctor is 8/7, a used sub-carrier is defined to substantially occupy a band 9.142 MHz, whic h is slightly greater than the broadcast channel bandwidth of 8 MHz and satisfies a 93.7 % use efficiency of a band. Thus, a fractional bandwidth occupied by the used sub-ca rrier is 0.937 MHz of 1 MHz. As a result, the fractional band has 8 kinds of bandwidths 1, 2, 3, 4, 5, 6, 7, and 8 MHz and 8 kinds of start positions 0, 1, 2, 3, 4, 5, 6, and 7 as il

lustrated in FIG. 5. Therefore, combinations between the bandwidth and a frequency position (start position in the present embodiment) of the fractional band may be as ma ny as 64. However, when the bandwidth of the fractional band is 8 MHz, the start posit ion of the fraction band may be 1 as illustrated in FIG. 5. When the bandwidth of the fr actional band is 7 MHz, the start position is 1 and 2 as illustrated in FIG. 5. Thus, only 36 kinds of methods may be substantially adopted.

FIG. 6 illustrates a various fractional bandwidth modes, with respect to fractional bandwidth and start position of a fractional band illustrated in FIG. 5. In other words, a channel band having a bandwidth that is a natural number times a bandwidth resoluti on belonging to the broadcast channel band is allocated to a secondary user. Howeve r, 36 kinds of fractional bandwidth modes using methods obtained by allocating only adj acent channel bands are expressed using fractional bandwidths and start positions of fr actional bandwidths. A shadowed part denotes 36 fractional bandwidth modes which may be used by the OFDMA-based cognitive radio system of an embodiment of the pre sent invention under the above-described conditions. Also, a horizontal axis denotes t he start position of each of the fractional bandwidth modes, and a vertical axis denotes a fractional bandwidth of each of the fractional bandwidth modes.

If a channel band which is not adjacent within the broadcast channel band is all ocated to the secondary user, much more fractional bandwidth modes may exist than ar e illustrated with reference to FIGS. 5 and 6.

FIG. 7 illustrates a downlink frame structure which can be applied to an OFDMA -based signal used in an OFDMA-based cognitive radio system according to an embodi ment of the present invention. The downlink frame illustrated in FIG. 7 includes super frames and frames. The super frame includes a preamble 700, a super frame control header (SCH) 710, and m frames. Each of the m frames includes at least one data sy mbol 740, a preamble having at least one symbol, and a symbol 730 corresponding to a frame control header (FCH) and message (MAP).

User CPE belonging to the OFDMA-based cognitive radio system of an embodi ment of the present invention must effectively detect a method of using a bandwidth, w herein the method is changed during power on of the OFDM-based cognitive radio syst em or communications. In other words, the CPE must detect fractional bandwidth mod e information of a currently allocated channel band from 36 fractional bandwidth modes as illustrated in FIGS. 5 and 6.

The OFDMA-based cognitive radio system of an embodiment of the present inv ention includes band allocation information regarding the allocated channel band in the preamble 700 or 720 of an OFDMA-based signal and then transmits the band allocation information to the CPE or includes the band allocation information in the preamble 700 or 720 and a control header and then transmits the band allocation information to the CPE. The CPE receives the OFDMA signal including the band allocation information t o detect information regarding the allocated channel band. In this case, the control he ader corresponds to the SCH 710 and the FCH 730 in an embodiment of the present in vention.

In this case, the band allocation information includes fractional bandwidth mode information. If the OFDMA-based cognitive radio system allocates a bundle of channel s, the band allocation information may also include channel bonding information. The fractional bandwidth mode information may include bandwidth information and band po sition information. The bandwidth information and the band position information may b e respectively the fractional bandwidth and the start position of the fractional bandwidth illustrated in FIG. 6. Also, the channel bonding information refers to information regard ing a plurality of broadcast channel bands bonded and allocated to a secondary user. In detail, the band allocation information basically includes bandwidth information of a fr actional band of each broadcast channel band and frequency position information of th e fractional band. If a plurality of a whole or a fraction of broadcast channel bands are bonded and used as the allocated channel band, the band allocation information must i nclude channel bonding information regarding a method of bonding the broadcast chan nel bands.

FIG. 8 illustrates a method of inserting 36 kinds of fractional bandwidth mode inf ormation illustrated in FIG. 6 into a preamble.

Contents in the first column on the left denote indices corresponding to fractiona l bandwidth modes, the second and third column of contents denote fractional bandwidt hs and start positions of fractional bandwidth, and the last column of contents denote pr eamble sequences corresponding to the fractional bandwidth modes on a one-to-one b asis. In particular, the preamble sequences illustrated in FIG. 8 are pseudo noise (PN) sequences but are not limited to this.

The fractional bandwidth modes respectively correspond to the indices including values from “0” to “35,” and the indices correspond to fractional bandwidths and start p

ositions of the fractional bandwidths on a one-to-one basis. In this case, the fractional bandwidths correspond to the above-described bandwidth information, and the start positions correspond to the above-described position information.

A BS of the OFDMA-based cognitive radio system of an embodiment of the present invention inserts a preamble sequence specifying a fractional bandwidth mode into the preamble 700 or 720 so as to insert information regarding a channel band allocated to the secondary user into an OFDMA-based signal. CPE detects the preamble sequence or a preamble sequence index from the preamble 700 or 720 inserted into the OFDMA-based signal and then a channel band (in detail, bandwidth information, position information) currently allocated thereto based on the detection result. In other words, referring to FIG. 8, the OFDMA-based cognitive radio system allocates different preamble sequences to different flexible bandwidth using methods on a one-to-one basis. A preamble sequence may be designed to minimize a peak-to-average power ratio (PAPR).

The BS may generate the preamble sequence using various methods, i.e., a method of storing a preamble sequence in a memory in advance and then reading the preamble sequence, a method of generating a preamble sequence using a generator polynomial, etc. In the former method, a PAPR is superior, but all of the preamble sequences must be stored in the memory. In the latter method, a memory storing preamble sequences is not required, and preamble sequences can be easily generated whenever necessary. However, it is difficult to optimize a PAPR. Equation 1 is an 11^{th}-order generator polynomial.

$$g(x) = x^{11} + x^2 + 1 \qquad \ldots(1)$$

A maximum order of the generator polynomial illustrated in Equation 1 is 11, and a period of the generator polynomial is 2047. Thus, the BS uses 36 of 2047 in the above-described embodiment.

FIGS. 9A through 9C illustrate methods of inserting channel bonding information into a preamble, in regard to a method of bonding a plurality of channels. In the methods, elements and nulls of a preamble sequence are inserted into sub-carriers of the preamble at fixed periods in order to obtain a repetition characteristic of the preamble. CPE detects a flexible bandwidth information using method having the repetition characte

ristic.

FIG. 9A illustrates a method of inserting an element of a preamble sequence into each sub-carrier at every three sub-carrier interval starting from a zeroth sub-carrier according to an embodiment of the present invention. FIG. 9B illustrates a method of inserting an element of a preamble sequence into each sub-carrier at every three sub-carrier interval starting from a first sub-carrier according to an embodiment of the present invention. FIG. 9C illustrates a method of inserting an element of a preamble sequence into each sub-carrier at every three sub-carrier staring from a second sub-carrier according to an embodiment of the present invention. Nulls are inserted into sub-carriers into which elements of the preamble sequence are not inserted.

A case where an OFDMA-based cognitive radio system uses three broadcast channel bands will now be described. If a channel band allocated to user CPE includes three broadcast channel bands, a BS inserts a preamble sequence into the preamble 700 or 720 of an OFDMA-based signal using the method illustrated in FIG. 9A. If the channel band allocated to the user CPE includes two broadcast channel bands, the BS inserts a preamble sequence into the preamble 700 or 720 of the OFDMA-based signal using the method illustrated in FIG. 9B. If the channel band allocated to the user CPE includes one broadcast channel band, the BS inserts a preamble sequence into the preamble 700 or 720 of the OFDMA-based signal using the method illustrated in FIG. 9C. Next, the user CPE detects preamble sequence insertion patterns as illustrated in FIGS. 9A through 9C from the preamble of the OFDMA-based signal in order to detect whether the channel band allocated thereto includes what number of a whole or a fraction of broadcast channel bands. FIGS. 9A through 9C illustrate preamble sequence insertion patterns, and FIG. 8 illustrates the contents of inserted preamble sequences. Band allocation information regarding allocated channel bands as illustrated in FIGS. 1A through 1C may be included by using combinations of the preamble sequence insertion patterns and the contents of the preambles.

In FIGS. 8 and 9A through 9C, an FFT size is 2K, and the modulation method is BPSK. Thus, the number of bits of a preamble is equal to the number of sub-carriers illustrated in FIGS. 3A through 3C, i.e., 1680.

FIG. 10 illustrates an OFDMA-based cognitive radio system using a flexible bandwidth according to an embodiment of the present invention. Referring to FIG. 10, the OFDMA-based cognitive radio system includes a BS 1000, a first user CPE 1050, and

a second CPE 1060. It is assumed that a flexible channel has been allocated to the fir st CPE 1050 and used, and a channel band is to be allocated to the second user CPE 1060.

The BS 1000 includes an apparatus 1040 using a flexible bandwidth. The app aratus 1040 includes a band allocator 1010 and a transmitter 1020. The first and seco nd user CPEs 1050 and 1060 include receivers 1052 and 1062 and band allocation info rmation detectors 1054 and 1064, respectively.

The receivers 1052 and 1062 receive an OFDMA-based signal, and the band all ocation information detectors 1054 and 1064 detect band allocation information from th e received OFDMA-based signal. Here, examples of the band allocation information may include fractional bandwidth mode information and channel bonding information, w hich will be described later.

The band allocator 1010 allocates all fractions or fractions of unused bands to C PE. Unused bands 100, 104, 108, 110, 122, 124, 142, 146, 148, 163, and 174 are illu strated in FIGS. 1A through 1E. Used bands 102, 106, 120, 126, 140, 144, 150, 165, and 172 illustrated in FIGS. 1A through 1E are used by an IU (not shown) or the first us er CPE 1050.

The band allocator 1010 allocates a broadcast channel band or a fraction of the broadcast channel band as a channel band for the second user CPE 1060 or allocates a channel band formed by bonding broadcast channel bands or a plurality of fractions o f the broadcast channel bands as a channel band for the second user CPE 1060.

The transmitter 1020 transmits an OFDMA-based signal including the band alloc ation information regarding the allocated channel band. If the allocated channel band i ncludes a plurality of bonded channel bands, the transmitter 1020 may perform an FT o nce or a plurality of times in order to generate the OFDMA-based signal or may perform a partial FFT in order to support fractional bands.

The OFDMA-based signal may be generated using the OFDMA parameters illus trated in FIGS. 3A through 3C and FIGS. 4A through 4C. In other words, the transmitt er 1020 may set OFDMA parameters so that the total number of used sub-carriers withi n a broadcast channel band using an identical FFT size is constant regardless of a ban dwidth of the broadcast channel band as illustrated in FIGS. 3A through 3C, so as to ge nerate the OFDMA-based signal. Alternatively, the transmitter 1020 may set OFDMA parameters so that intervals of sub-carriers of a broadcast channel band using an identi

cal FFT size are constant regardless of a size of a bandwidth of the broadcast channel band as illustrated in FIGS. 4A through 4C, in order to generate the OFDMA-based sign al. An example of a method of setting OFDMA parameters so that the total number of used sub-carriers within a broadcast channel band is constant regardless of a bandwidt h of the broadcast channel band may include a method of using an identical sampling f actor regardless of a bandwidth of a broadcast channel band and an FFT size and setti ng the total number of used sub-carriers within a bandwidth resolution to be proportiona l to the FFT size so as to generate an OFDMA-based signal. An example of a method of setting OFDMA parameters so that intervals between sub-carriers are equal regardle ss of the size of a bandwidth of a broadcast channel band using an identical FFT size m ay include a method of setting a sampling factor to be inversely proportional to the band width of the broadcast channel band.

The transmitter 1020 must transmit the band allocation information regarding th e allocated channel band to the second user CPE 1060. Examples of a method of tra nsmitting the band allocation information may include a method of transmitting the band allocation method using a preamble inserted into the OFDMA-based signal and a meth od of transmitting the band allocation information using a preamble and control header i ncluded in the OFDMA-based signal. In this case, the band allocation information may include fractional bandwidth mode information and channel bonding information.

If the allocated channel band is a whole or a fraction of a broadcast channel ban d and the transmitter 1020 inserts a preamble sequence corresponding to fractional ban dwidth mode information of the allocated channel band into a preamble of the OFDMA-based signal corresponding to a broadcast channel band to which the allocated channel band belongs, the second user CPE 1060 detects the fractional bandwidth mode infor mation of the allocated channel band based on the preamble of the OFDMA-based sign al. In this case, this is applied to the above-described two transmission methods.

If the allocated channel band is formed by bonding of a whole or a fraction of tw o or more broadcast channel bands, the transmitter 1020 inserts a preamble sequence corresponding to fractional bandwidth mode information of the two or more broadcast c hannel bands into a preamble of the OFDMA-based signal corresponding to the two or more broadcast channel bands to which the allocated channel band belongs. In this c ase, the preamble sequence includes channel bonding information indicating a method of bonding two or more channel bands. An example of a method of inserting channel

bonding information into the preamble sequence may include a method of carrying ele ments of the preamble sequence in sub-carriers of the preamble of the OFDMA-based signal at predetermined intervals of sub-carriers with the positions of the sub-carriers va rying as illustrated in FIGS. 9A through 9C. In this case, the second user CPE 1060 m ay detect a preamble sequence included in a received signal corresponding to the prea mble of the OFDMA-based signal, detect fractional bandwidth mode information of the allocated channel band based on the detected preamble sequence, detect the positions of the sub-carriers carrying the elements of the preamble sequence from the preamble of the OFDMA-based signal, and detect channel bonding information based on the det ected results. This method corresponds to the former of the two above-described tran smission methods.

If the allocated channel band is formed by bonding of a whole or a fraction of tw o or more broadcast channel bands, the transmitter 1020 inserts a preamble sequence corresponding to fractional bandwidth mode information of each of the two or more bro adcast channel bands into a preamble of the OFDMA-based signal corresponding to ea ch of the two or more broadcast channel bands to which the allocated channel bands b elongs and inserts channel bonding information indicating a method of bonding two or more channel bands into the SCH 710 or the FCH 730 of the OFDMA-based signal. In this case, the second user CPE 1060 may detect the preamble sequence included in t he OFDMA-based signal, detect the fractional bandwidth mode information of the alloca ted channel band based on the detected preamble sequence, and detect channel bondi ng information based on the SCH 710 or the FCH 730 included in the OFDMA-based si gnal. This method corresponds to the latter of the two above-described transmission methods.

The second user CPE 1060 may calculate a correlation value between a pream ble sequence detected from a previous preamble and the OFDMA-based signal in a cur rent preamble position, use previously detected band allocation information as current b and allocation information if the correlation value is greater than a predetermined thresh old value, and calculate all correlation values between the OFDMA-based signal in the current preamble position and other preamble sequences if the correlation value is smal ler than the predetermined threshold value, so as to efficiently detect information regard ing the allocated channel band. An example of a period for calculating a correlation va lue of a preamble for detecting band allocation information may include a super frame ti

me interval. However, the correlation value may be calculated at each preamble perio d at which a preamble sequence is inserted. Thus, the method of computing the perio d is not limited.

FIG. 11 is a flowchart of a method of detecting a method of using a flexible band width by means of the second user CPE 1060 illustrated in FIG. 10, according to an em bodiment of the present invention. Referring to FIG. 11, in operation S1100, the secon d user CPE 1060 is powered on by a user.

In operation S1110, the second user CPE 1060 performs signal detection and a utomatic gain control.

In operation S1120, the second CPE 1060 detects a start position of a preamble from an OFDMA-based signal having a downlink frame structure as illustrated in FIG. 7. Here, the preamble is a super frame preamble or a frame preamble.

In operation S1130, the second CPE 1060 performs synchronization based on t he detection result in operation S1120.

In operation S1140, the second user CPE 1060 detects fractional bandwidth mo de information using the preamble included in the OFDMA-based signal. In this case, i f the BS 1000 uses the former of the two above-described transmission methods, the s econd user CPE 1060 may also detect channel bonding information.

In operation S1150, the second user CPE 1060 performs channel estimation. I n operation S1160, the second user CPE 1060 decodes an SCH or an FCH. If the BS 1000 uses the latter of the two above-described transmission methods, the second us er CPE 1060 may detect the channel bonding information in operation S1160.

In operation S1170, the second user CPE 1060 restores or decodes a frame usi ng the fractional bandwidth mode information and the channel bonding information.

FIG. 12 is a flowchart of a method of computing correlation values of received pr eambles in order to detect a method of using a flexible bandwidth according to an embo diment of the present invention. In the present embodiment, a method of using a flexi ble bandwidth using a received signal (received preamble) corresponding to a preamble using a method illustrated in FIG. 8 is detected. If a preamble sequence insertion pat tern as illustrated in FIG. 9A, 9B, or 9C is used together, a correlation value may be cal culated with positions of sub-carriers that are changed.

The received preamble used for calculating the correlation value may be a recei ved signal corresponding to a super frame preamble or a received signal corresponding

to a frame preamble. Thus, it will be understood by those of ordinary skill in the art th at a correlation value may be calculated in each super frame, in each frame, in every pl urality of super frames, or in every plurality of frames.

For convenience, in the present embodiment, the correlation value will be calcul ated in each super frame.

Referring to FIG. 12, operations S1200, S1210, S1220, and S1230 are perform ed in order to detect a method of using a flexible bandwidth of a first stage, and operati ons S1240, S1250, and S1260 are performed in order to detect a detection process of a second stage using the detection result of the first stage.

In operation S1200, CPE is powered on. In operation S1210, a correlation valu e between a received preamble of a currently received super frame and each preamb le sequence is calculated. A method of using a flexible bandwidth corresponding to a preamble sequence having a greater correlation value than a threshold value or the largest correlation value corresponds to a method of using an initial flexible bandwidt h. In particular, the former method, i.e., the method of detecting the preamble sequ ence having a correlation value greater than the threshold value is illustrated in the pr esent embodiment. If the currently calculated correlation value is greater than a thre shold value in operation S1220, a method of using a flexible bandwidth correspondin g to a preamble sequence used for computing the currently correlation value is deter mined as a method of using an initial flexible bandwidth in operation S1230. If the c urrently calculated correlation value is smaller than or equal to the threshold value in operation S1220, the process returns to operation S1210 in order to calculate a correl ation value of another preamble sequence which is not used for calculating a correlati on value.

The method of using the initial flexible bandwidth is detected by performing oper ations S1200, S1210, S1220, and S1230. The detection result in operations S1200, S 1210, S1220, and S1230 is applied to the next super frames.

In operation S1240, a correlation value between a received preamble of a curre nt super frame and a preamble sequence detected from a previous super frame is com puted. If it is determined that the correlation value is greater than a threshold value in operation S1250, it is determined in operation S1260 that a method of using a flexible b andwidth of the current super frame is equal to a method of using a flexible bandwidth o f the previous super frame. If the correlation value is smaller than the threshold value i

n operation S1250, the process returns to operation S1210 in order to obtain correlation values of all preamble sequences so as to detect a new method of using a flexible ban dwidth. This method may contribute to reducing the time required for confirming the m ethod for a time for which a method of using a flexible bandwidth is maintained equal.

FIG. 13 illustrates an example of the detection method illustrated in FIG. 12. When preamble indices corresponding to continuous preambles are 0, 0, ..., 0, 17, 17, ..., 17, 31, 31, ..., 31, 25, 25, ..., correlation values between a received preamble and a ll preamble sequences are calculated at the first stage (in operations S1200, S1210, S1 220, and S1230), and only a correlation value with a preamble sequence detected imm ediately previously is calculated at the second stage (in operations 1240, 1250, and 126 0). A correlation value is smaller than a threshold value when a band allocation metho d is changed. Thus, correlation values with all preamble sequences must be calculate d again to detect a new band allocation method.

FIG. 14 is a flowchart of a method of using a flexible bandwidth in an OFDMA-ba sed cognitive radio system according to an embodiment of the present invention. Refe rring to FIG. 14, the method includes operations serially processed in the OFDMA-base d cognitive radio system illustrated in FIG. 10. Thus, although omitted contents are th e above-described contents of the OFDMA-based cognitive radio system illustrated in F IG. 10, the omitted contents may be applied to the method of using the flexible bandwid th according to the present embodiment.

The present embodiment will now be described with reference to FIGS. 10 and 14.

In operation S1400, the band allocator 1010 allocates a channel band from amo ng unused channel bands for the second user CPE 1060. In this case, the band alloc ator 1010 may allocate a broadcast channel band or a fraction of the broadcast channel band as a channel band for the second user CPE 1060 or allocate a channel band for med by bonding broadcast channel bands or a plurality of fractions of a broadcast chan nel band as a channel band for the second user CPE 1060.

In operation S1410, the transmitter 1020 transmits an OFDMA-based signal incl uding information regarding the allocated channel band. A method of including the inf ormation regarding the allocated channel band in the OFDMA-based signal, an FT met hod, and a method of setting OFDMA parameters are the same as those described abo ve. Thus, detailed descriptions thereof will be omitted.

In operation S1420, the second user CPE 1060 detects fractional bandwidth mo de information of the allocated channel band based on the received OFDMA-based sig nal. A method of detecting the fractional bandwidth mode information is the same as t hat described above and thus a detailed description thereof will be omitted.

The invention can also be embodied as computer readable codes on a comput er readable recording medium. The computer readable recording medium is any data storage device that can store data which can be thereafter read by a computer system.

Examples of the computer readable recording medium include read-only memory (R OM), random-access memory (RAM), CD-ROMs, magnetic tapes, floppy disks, optical data storage devices, and carrier waves (such as data transmission through the Internet). The computer readable recording medium can also be distributed over network cou pled computer systems so that the computer readable code is stored and executed in a distributed fashion. Also, functional programs, codes, and code segments for accompl ishing the present invention can be easily construed by programmers skilled in the art to which the present invention pertains.

While this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that vario us changes in form and details may be made therein without departing from the spirit a nd scope of the invention as defined by the appended claims. The preferred embodim ents should be considered in descriptive sense only and not for purposes of limitation. T herefore, the scope of the invention is defined not by the detailed description of the inve ntion but by the appended claims, and all differences within the scope will be construed as being included in the present invention.

CLAIMS

1. A BS (base station) of an OFDMA (orthogonal frequency division multiple access)-based cognitive radio system comprising:

a band allocator allocating a channel band of unused channel bands having a bandwidth that is a natural number times a bandwidth resolution to CPE (customer premises equipment), wherein the bandwidth resolution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band; and

a transmitter transmitting an OFDMA-based signal comprising band allocation information indicating information regarding the allocated channel band.

2. The BS of claim 1, wherein the band allocator allocates a broadcast channel band or a fraction of the broadcast channel band as a channel band for the CPE or allocates a channel band formed by bonding broadcast channel bands or a plurality of fractions of a broadcast channel band as a channel band for the CPE.

3. The BS of claim 1, wherein if the allocated channel band is formed by bonding a plurality of channel bands, the transmitter performs an FFT (Fast Fourier Transform) once in order to generate the OFDMA-based signal.

4. The BS of claim 1, wherein if the allocated channel band is formed by bonding a plurality of channel bands, the transmitter performs an FFT a plurality of times to generate the OFDMA-based signal.

5. The BS of claim 1, wherein the transmitter sets OFDMA parameters so that a total number of used sub-carriers in a broadcast channel band having an identical FFT size remains constant regardless of a bandwidth of the broadcast channel band, in order to generate the OFDMA-based signal.

6. The BS of claim 5, wherein the transmitter uses a sampling factor, which remains constant regardless of a bandwidth of a broadcast channel band and an FFT size, and sets a total number of used sub-carriers within a bandwidth resolution to be pr

oportional to the FFT size.

7. The BS of claim 1, wherein the transmitter sets OFDMA parameters so t hat intervals among sub-carriers within a broadcast channel band having an identical F FT size are equal to each other regardless of a bandwidth of the broadcast channel ban d, in order to generate the OFDMA-based signal.

8. The BS of claim 7, wherein the transmitter sets a sampling factor to be p roportional to a bandwidth of a broadcast channel band.

9. The BS of claim 1, wherein if the allocated channel band is an entire bro adcast channel band or a fraction of a broadcast channel band, the transmitter inserts a preamble sequence corresponding to fractional bandwidth mode information of the all ocated channel band into a preamble of the OFDMA-based signal corresponding to the broadcast channel band to which the allocated channel band belongs, wherein the fracti onal bandwidth mode information comprises bandwidth information and band position i nformation of the allocated channel band.

10. The BS of claim 1, wherein if the allocated channel band is formed by b onding all fractions or fractions of two or more broadcast channel bands, the transmitter inserts a preamble sequence corresponding to fractional bandwidth mode information of each of the two or more broadcast channel bands as an insertion pattern correspondi ng to a method of bonding two or more channel bands into a preamble of the OFDMA-b ased signal corresponding to each of the two or more broadcast channel bands to whic h the allocated channel band belongs.

11. The BS of claim 10, wherein the transmitter changes positions of sub-c arriers carrying elements of the preamble sequence depending on the method of the bo nding the two or more channel bands so as to carry the elements of the preamble sequ ence in sub-carriers of the preamble of the OFDMA-based signal at predetermined inter vals of sub-carriers and carry nulls in other sub-carriers.

12. The BS of claim 1, wherein if the allocated channel band is formed by b

onding all fractions or fractions of two or more broadcast channel bands, the transmitter inserts a preamble sequence corresponding to fractional bandwidth mode information of each of the two or more broadcast channel bands into a preamble of the OFDMA-based signal corresponding to each of the two or more broadcast channel bands to which the allocated channel band belongs and inserts channel bonding information indicating a method of bonding two or more channel bands into a control header of the OFDMA-based signal.

13. The BS of any one of claims 9 through 12, wherein the preamble sequence is a sequence designed to minimize a PAPR (peak-to-average power ratio)

14. A CPE of an OFDMA-based cognitive radio system comprising:

a receiver receiving an OFDMA-based signal comprising band allocation information indicating information regarding a channel band allocated from a BS; and

a band allocation information detector detecting the band allocation information based on the received OFDMA-based signal,

wherein the allocated channel band is a channel band of unused channel bands having a bandwidth that is a natural number times a bandwidth resolution, wherein the bandwidth resolution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band.

15. The CPE of claim 14, wherein the allocated channel band is one of a broadcast channel band, a fraction of the broadcast channel band, and a channel band formed by bonding broadcast channel bands or a plurality of fractions of a broadcast channel band.

16. The CPE of claim 14, wherein:

the allocated channel band is one of an entire broadcast channel band and a fraction of a broadcast channel band;

a preamble sequence corresponding to fractional bandwidth mode information of the allocated channel band is inserted into the preamble, wherein the fractional bandwidth mode information comprises bandwidth information and band position information of the allocated channel band; and

the bandwidth allocation information detector detects the fractional bandwidth m ode information based on the preamble of the received OFDMA-based signal.

17. The CPE of claim 14, wherein:

the allocated channel band is formed by bonding all fractions or fractions of two or more broadcast channel bands;

a preamble sequence corresponding to fractional bandwidth mode information o f each of the two or more broadcast channel bands is inserted as an insertion pattern c orresponding to a method of bonding two or more channel bands into a preamble of ea ch of the two or more broadcast channel bands to which the allocated channel band of t he OFDMA-based signal belongs; and

the bandwidth allocation information detector detects a preamble sequence of e ach of the two or more broadcast channel bands from the received OFDMA-based sign al in order to detect the fractional bandwidth mode information of each of the two or mor e broadcast channel bands and detects channel bonding information indicating the met hod of bonding the two or more channel bands based on the insertion pattern of the det ected preamble sequence.

18. The CPE of claim 14, wherein:

the allocated channel band is formed by bonding all fractions or fractions of two or more broadcast channel bands;

a preamble of each of the two or more broadcast channel bands to which the all ocated channel band of the OFDMA-based signal belongs comprises a preamble seque nce corresponding to fractional bandwidth mode information of each of the two or more broadcast channel bands, wherein the fractional bandwidth mode information comprise s bandwidth information and band position information of the allocated channel band;

a control header of the OFDMA-based signal comprises channel bonding inform ation indicating a method of bonding the two or more channel bands; and

the band allocation information detector detects a preamble sequence of each o f the two or more broadcast channel bands from the received OFDMA-based signal in o rder to detect fractional bandwidth mode information of each of the two or more broadc ast channel bands and detects the channel bonding information based on the control h eader included in the OFDMA-based signal.

19. The CPE of any one of claims 16 through 18, wherein the band allocati on information detector calculates a correlation value between a preamble sequence de tected from a previously received preamble and a currently received preamble, uses pr evious band allocation information as current band allocation information if the correlati on value is greater than a predetermined threshold value, and calculates correlation val ues between the currently received preambles and other preamble sequences in order t o detect the band allocation information if the correlation value is smaller than the prede termined threshold value.

20. The CPE of any one of claims 14 through 18, wherein the band allocati on information detector detects the band allocation information at each super frame tim e interval or each frame time interval.

21. A method of using a flexible bandwidth through a BS in an OFDMA-bas ed cognitive radio system, comprising:

allocating a channel band of unused channel bands having a bandwidth that is a natural number times a bandwidth resolution to CPE, wherein the bandwidth resolution is a predetermined bandwidth smaller than a bandwidth of a broadcast channel band; and

transmitting an OFDMA-based signal comprising band allocation information ind icating information regarding the allocated channel band.

22. The method of claim 21, wherein a broadcast channel band or a fractio n of the broadcast channel band is allocated as a channel band for the CPE or a chann el band formed by bonding broadcast channel bands or a plurality of fractions of a broa dcast channel band is allocated as a channel band for the CPE.

23. The method of claim 21, wherein if the allocated channel band is forme d by bonding a plurality of channel bands, an FFT is performed once in order to generat e the OFDMA-based signal.

24. The method of claim 21, wherein if the allocated channel band is forme

d by bonding a plurality of channel bands, an FFT is performed a plurality of times in or der to generate the OFDMA-based signal.

25. The method of claim 21, wherein OFDMA-based parameters are set so that a total number of used sub-carriers within a broadcast channel band having an ide ntical FFT size remains constant regardless of a bandwidth of the broadcast channel ba nd, in order to generate the OFDMA-based signal.

26. The method of claim 25, wherein a sampling factor equal that remains constant regardless of a bandwidth of a broadcast channel band and an FFT size is use d, and a total number of used sub-carriers within a bandwidth resolution is set to be pro portional to the FFT size.

27. The method of claim 21, wherein OFDMA parameters are set so that in tervals among sub-carriers within a broadcast channel band having an identical FFT siz e are equal to each other regardless of a bandwidth of the broadcast channel band in o rder to generate the OFDMA-based signal.

28. The method of claim 27, wherein a sampling factor is set to be proporti onal to a bandwidth of a broadcast channel band.

29. The method of claim 21, wherein if the allocated channel band is one o f an entire broadcast channel band and a fraction of a broadcast channel band, a prea mble sequence corresponding to fractional bandwidth mode information of the allocated channel band is inserted into a preamble of the OFDMA-based signal corresponding t o the broadcast channel band to which the allocated channel band belongs, wherein th e fractional bandwidth mode information comprises bandwidth information and band po sition information of the allocated channel band.

30. The method of claim 21, wherein if the allocated channel band is forme d by bonding all fractions or fractions of two or more broadcast channel bands, a pream ble sequence corresponding to fractional bandwidth mode information of each of the tw o or more broadcast channel bands is inserted as an insertion pattern corresponding to

a method of bonding two or more channel bands into a preamble of the OFDMA-based signal corresponding to each of the two or more broadcast channel bands to which the allocated channel band belongs, wherein the fractional bandwidth mode information co mprises bandwidth information and band position information of the allocated channel b and.

31. The method of claim 30, wherein positions of the sub-carriers carrying elements of the preamble sequence are changed so as to carry the elements of the pre amble sequence in sub-carriers of a preamble of the OFDMA-based signal at predeter mined intervals among sub-carriers and carry nulls in other sub-carriers.

32. The method of claim 21, wherein if the allocated channel band is forme d by bonding all fractions or fractions of two or more broadcast channel bands, a pream ble sequence corresponding to fractional bandwidth mode information of each of the tw o or more broadcast channel bands into a preamble of the OFDMA-based signal corres ponding to each of the two or more broadcast channel bands to which the allocated cha nnel band belongs, and channel bonding information indicating a method of bonding tw o or more channel bands is inserted into a control header of the OFDMA-based signal, wherein the fractional bandwidth mode information comprises bandwidth information an d band position information of the allocated channel band.

33. The method of any one of claims 29 through 32, wherein the preamble sequence is a sequence designed to minimize a PAPR.

34. A method of using a flexible bandwidth in CPE in an OFDMA-based co gnitive radio system, comprising:

receiving an OFDMA-based signal comprising band allocation information indica ting information regarding a channel band allocated from a BS; and

detecting the band allocation information based on the received OFDMA-based signal,

wherein the allocated channel band is a channel band of unused channel bands having a bandwidth that is a natural number times a bandwidth resolution, wherein the bandwidth resolution is a predetermined bandwidth smaller than a bandwidth of a broa

dcast channel band.

35. The method of claim 34, wherein the allocated channel band is one of a broadcast channel band, a fraction of the broadcast channel band, and a channel band formed by bonding broadcast channel bands or a plurality of fractions of a broadcast channel band.

36. The method of claim 34, wherein:

the allocated channel band is one of an entire broadcast channel band and a fraction of a broadcast channel band;

a preamble sequence corresponding to fractional bandwidth mode information of the allocated channel band is inserted into the preamble, wherein the fractional bandwidth mode information comprises bandwidth information and band position information of the allocated channel band; and

the fractional bandwidth mode information is detected based on a preamble of the received OFDMA-based signal.

37. The method of claim 34, wherein:

the allocated channel band is formed by bonding all fractions or fractions of two or more broadcast cast channel bands;

a preamble sequence corresponding to fractional bandwidth mode information of each of the two or more broadcast channel bands is inserted as an insertion pattern corresponding to a method of bonding two or more channel bands into a preamble of each of the two or more broadcast channel bands to which the allocated channel band of the OFDMA-based signal belongs;

a preamble sequence of each of the two or more broadcast channel bands is detected from the received OFDMA-based signal to detect the fractional bandwidth mode information of each of the two or more broadcast channel bands, and channel bonding information indicating a method of bonding two or more channel bands is detected based an insertion pattern of the detected preamble sequence.

38. The method of claim 34, wherein:

the allocated channel band is formed by bonding all fractions or fractions of two

or more broadcast channel bands;

a preamble of each of the two or more broadcast channel bands to which the all ocated channel band of the OFDMA-based signal belongs comprises a preamble seque nce corresponding to fractional bandwidth mode information of each of the two or more broadcast channel bands, wherein the fractional bandwidth mode information comprise s bandwidth information and band position information of the allocated channel band;

a control header of the OFDMA-based signal comprises channel bonding inform ation indicating a method of bonding two or more channel bands; and

a preamble sequence of each of the two or more broadcast channel bands is de tected from the received OFDMA-based signal in order to detect the fractional bandwidt h mode information of each of the two or more broadcast channel bands, and the chan nel bonding information is detected based on the control header of the OFDMA-based s ignal.

39. The method of any one of claims 36 through 38, wherein a correlation v alue between a preamble sequence detected from a previously received preamble and a currently received preamble is calculated, previous band allocation information is use d as current band allocation information if the correlation value is greater than a predete rmined threshold value, and correlation values between the currently received preamble and other preambles are calculated in order to detect the band allocation information if the correlation value is smaller than the predetermined threshold value.

40. The method of any one of claims 34 through 38, wherein the band alloc ation information is detected at each super frame time interval or each frame time interv al.

41. A computer-readable recording medium having embodied thereon a co mputer program for executing the method of any one of claims 21 through 33.

42. A computer-readable recording medium having embodied thereon a co mputer program for executing the method of any one of claims 34 through 40.

FIG. 1A

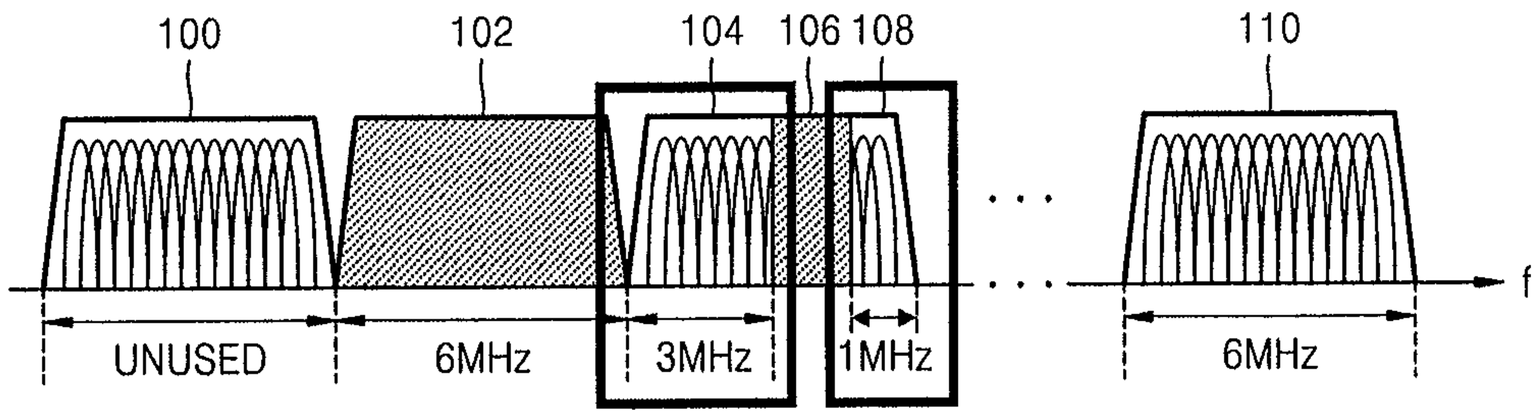


FIG. 1B

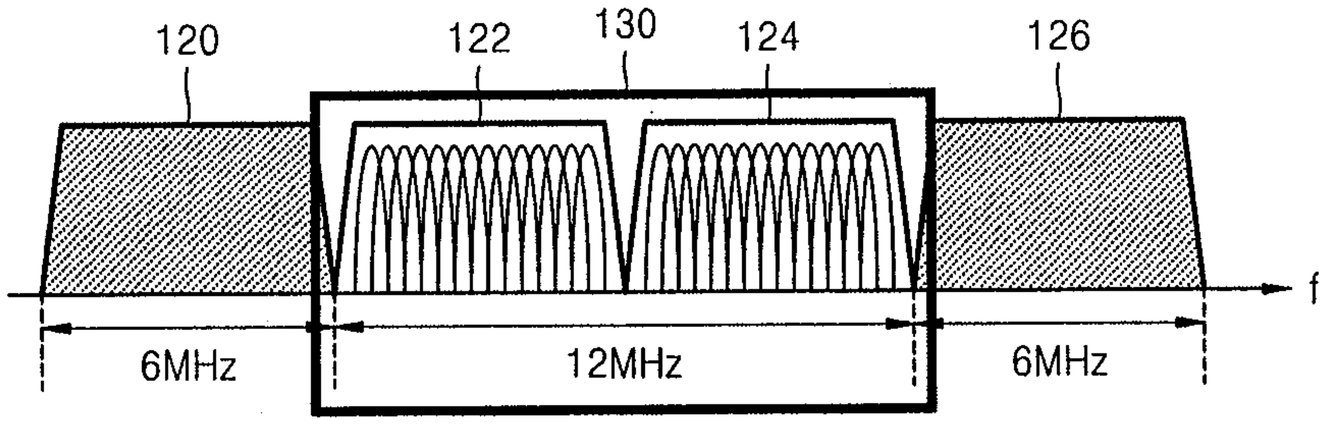


FIG. 1C

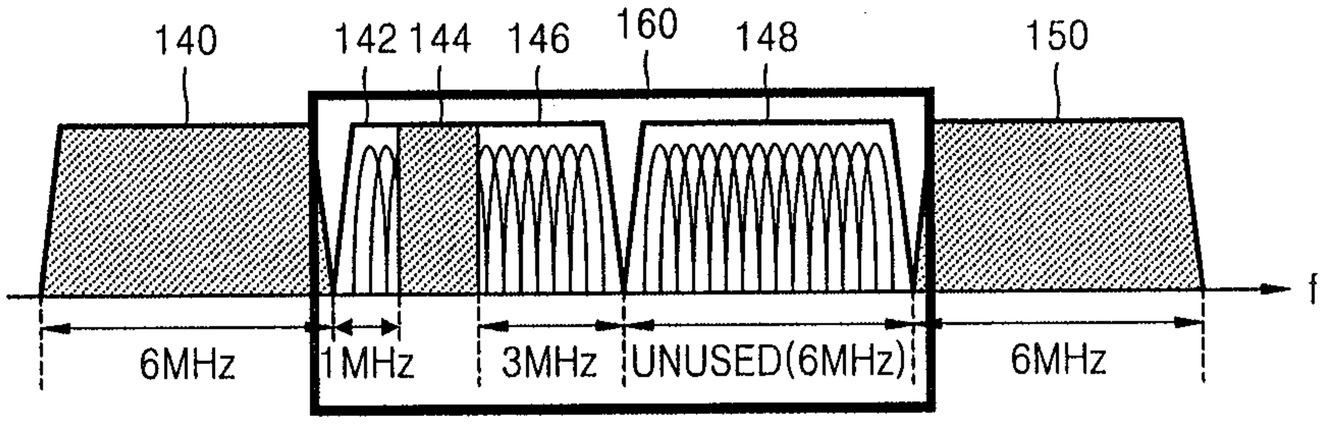


FIG. 1D

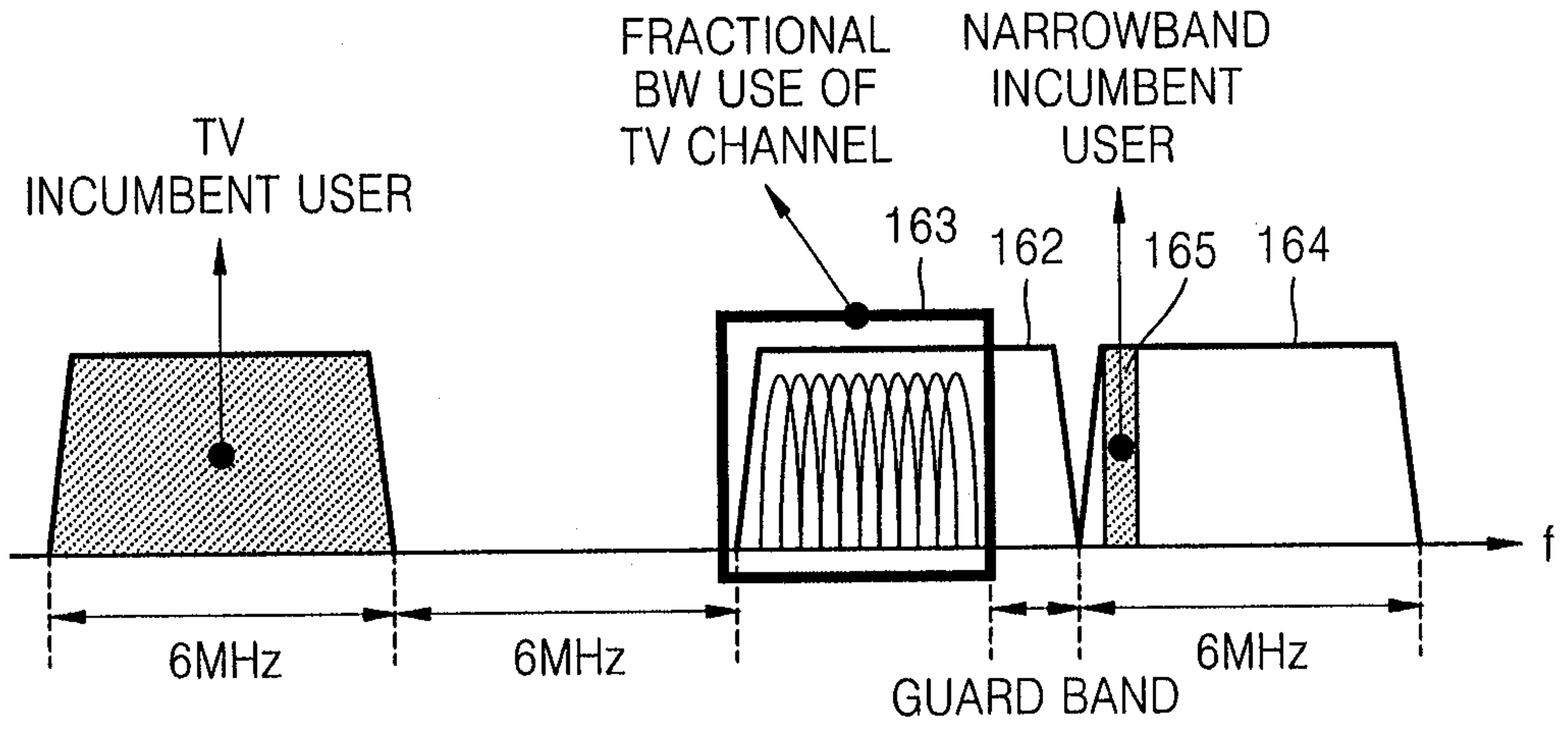

TV
INCUMBENT USER
FRACTIONAL
BW USE OF
TV CHANNEL
NARROWBAND
INCUMBENT
USER
163
162
165
164
f
6MHz
6MHz
GUARD BAND
6MHz

FIG. 1E

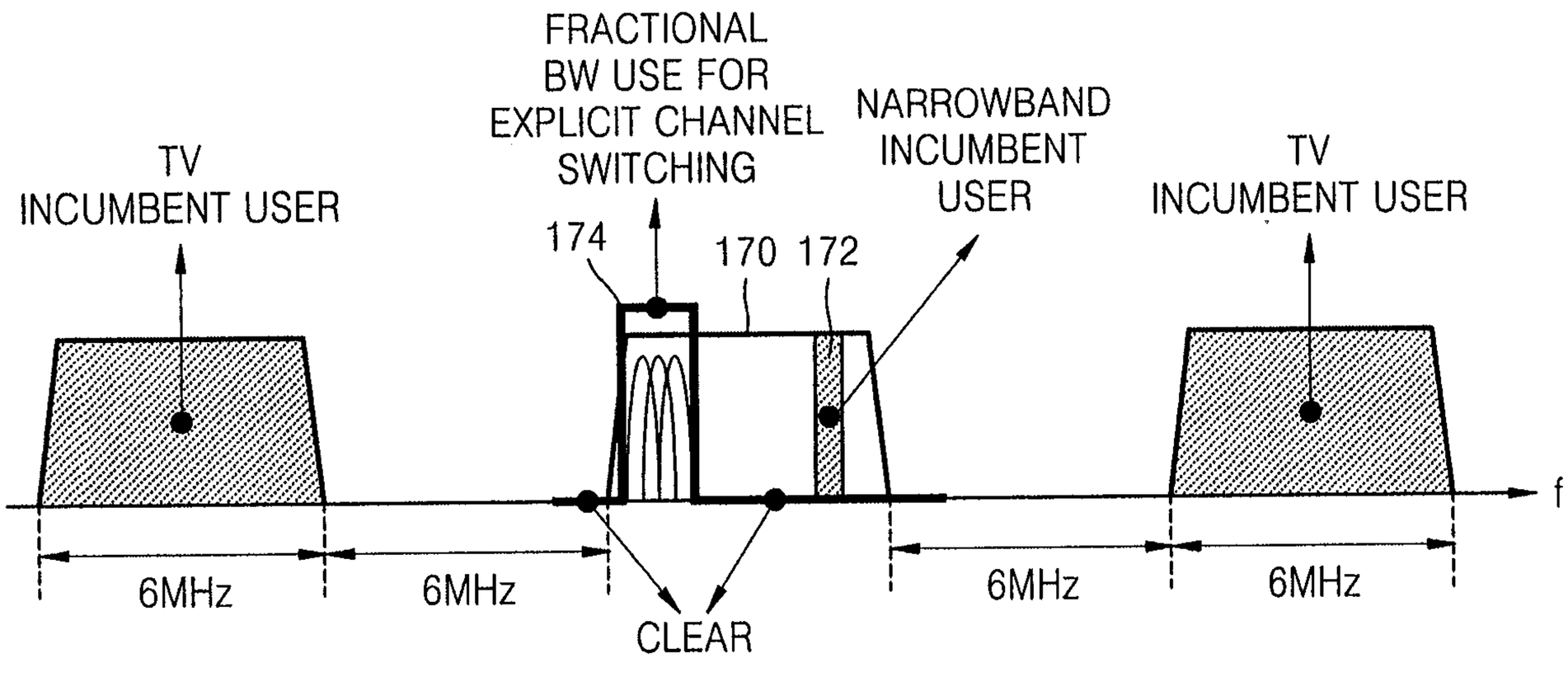

TV
INCUMBENT USER
FRACTIONAL
BW USE FOR
EXPLICIT CHANNEL
SWITCHING
NARROWBAND
INCUMBENT
USER
TV
INCUMBENT USER
174
170
172
f
6MHz
6MHz
CLEAR
6MHz
6MHz

FIG. 2

BASIC FFT SIZE \ NO. OF BONDED CHANNEL BAND	1	2	3	4
1K	1K	2K	4K	4K
2K	2K	4K	8K	8K
4K	4K	8K	NA	NA
8K	8K	NA	NA	NA

(NA: NOT AVAILABLE)

FIG. 3A

Mode	1K	2K	4K	8K
FFT Size	1024	2048	4096	8192
Bandwidth (k = 1, 2, …, 6)	k MHz			
Sampling Factor	8/7			
No. of Used Subcarriers (including pilot, but not DC)	140 * k	280 * k	560 * k	1120 * k
Sampling Frequency	48/7 MHz			
Subcarrier Spacing	*6.696 kHz*(***)*	*3.348 kHz*	*1.674 kHz*	*0.837 kHz*
Occupied Bandwidth	*6.696* kHz*140*k	*3.348* kHz*280*k	*1.674* kHz*560*k	*0.837* kHz*1120*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	*149.33 us*	*298.66 us*	*597.33 us*	*1194.66 us*
Cyclic Prefix Time(**)	*37.33 us*	*74.66 us*	*149.33 us*	*298.66 us*
OFDMA Symbol Time	*186.66 us*	*373.33 us*	*746.66 us*	*1493.3 us*

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 3B

Mode	1K	2K	4K	8K
FFT Size	1024	2048	4096	8192
Bandwidth (k = 1, 2, …, 7)	k MHz			
Sampling Factor	8/7			
No. of Used Subcarriers (including pilot, but not DC)	120 * k	240 * k	480 * k	960 * k
Sampling Frequency	8 MHz			
Subcarrier Spacing	*7.812 kHz*(***)	*3.906 kHz*	*1.953 kHz*	*0.976 kHz*
Occupied Bandwidth	*7.812* kHz*120*k	*3.906* kHz*240*k	*1.953* kHz*480*k	*0.976* kHz*960*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	128 us	256 us	512 us	1024 us
Cyclic Prefix Time(**)	32 us	64 us	128 us	256 us
OFDMA Symbol Time	160 us	320 us	640 us	1280 us

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 3C

Mode	1K	2K	4K	8K
FFT Size	1024	2048	4096	8192
Bandwidth (k = 1, 2, …, 8)	k MHz			
Sampling Factor	8/7			
No. of Used Subcarriers (including pilot, but not DC)	105 * k	210 * k	420 * k	840 * k
Sampling Frequency	64/7 MHz			
Subcarrier Spacing	*8.928 kHz*(***)	*4.464 kHz*	*2.232 kHz*	*1.116 kHz*
Occupied Bandwidth	*8.928* kHz*105*k	*4.464* kHz*210*k	*2.232* kHz*420*k	*1.116* kHz*840*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	112 us	224 us	448 us	896 us
Cyclic Prefix Time(**)	28 us	56 us	112 us	224 us
OFDMA Symbol Time	140 us	280 us	560 us	1120 us

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 4A

Mode	1K	2K	4K	6K
FFT Size	1024	2048	4096	6144
Bandwidth (k = 1, 2, …, 6)	k MHz			
Sampling Factor	4/3			
No. of Used Subcarriers (including pilot, but not DC)	120 * k	240 * k	480 * k	720 * k
Sampling Frequency	8 MHz			
Subcarrier Spacing	*7.812 kHz*(***)	*3.906 kHz*	*1.953 kHz*	*1.302 kHz*
Occupied Bandwidth	*7.812* kHz*120*k	*3.906* kHz*240*k	*1.953* kHz*480*k	*1.302* kHz*720*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	128 us	256 us	512 us	768 us
Cyclic Prefix Time(**)	32 us	64 us	128 us	192 us
OFDMA Symbol Time	160 us	320 us	640 us	960 us

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 4B

Mode	1K	2K	4K	6K
FFT Size	1024	2048	4096	6144
Bandwidth (k = 1, 2, …, 7)	k MHz			
Sampling Factor	8/7			
No. of Used Subcarriers (including pilot, but not DC)	120 * k	240 * k	480 * k	720 * k
Sampling Frequency	8 MHz			
Subcarrier Spacing	*7.812 kHz*(***)	*3.906 kHz*	*1.953 kHz*	*1.302 kHz*
Occupied Bandwidth	*7.812* kHz*120*k	*3.906* kHz*240*k	*1.953* kHz*480*k	*1.302* kHz*720*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	128 us	256 us	512 us	768 us
Cyclic Prefix Time(**)	32 us	64 us	128 us	192 us
OFDMA Symbol Time	160 us	320 us	640 us	960 us

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 4C

Mode	1K	2K	4K	6K
FFT Size	1024	2048	4096	6144
Bandwidth (k = 1, 2, …, 8)	k MHz			
Sampling Factor	1			
No. of Used Subcarriers (including pilot, but not DC)	120 * k	240 * k	480 * k	720 * k
Sampling Frequency	8 MHz			
Subcarrier Spacing	*7.812 kHz*(***)*	*3.906 kHz*	*1.953 kHz*	*1.302 kHz*
Occupied Bandwidth	*7.812* kHz*120*k	*3.906* kHz*240*k	*1.953* kHz*480*k	*1.302* kHz*720*k
Bandwidth Efficiency(*)	*93~94 %*			
FFT Time	112 us	224 us	448 us	672 us
Cyclic Prefix Time(**)	28 us	56 us	112 us	168 us
OFDMA Symbol Time	140 us	280 us	560 us	840 us

(*) Bandwidth Efficiency = Subcarrier Spacing * (Number of Used Subcarriers + 1)/BW
(**) It is assumed that cyclic prefix mode is 1/4.
(***) Italics indicate an approximated value.

FIG. 5

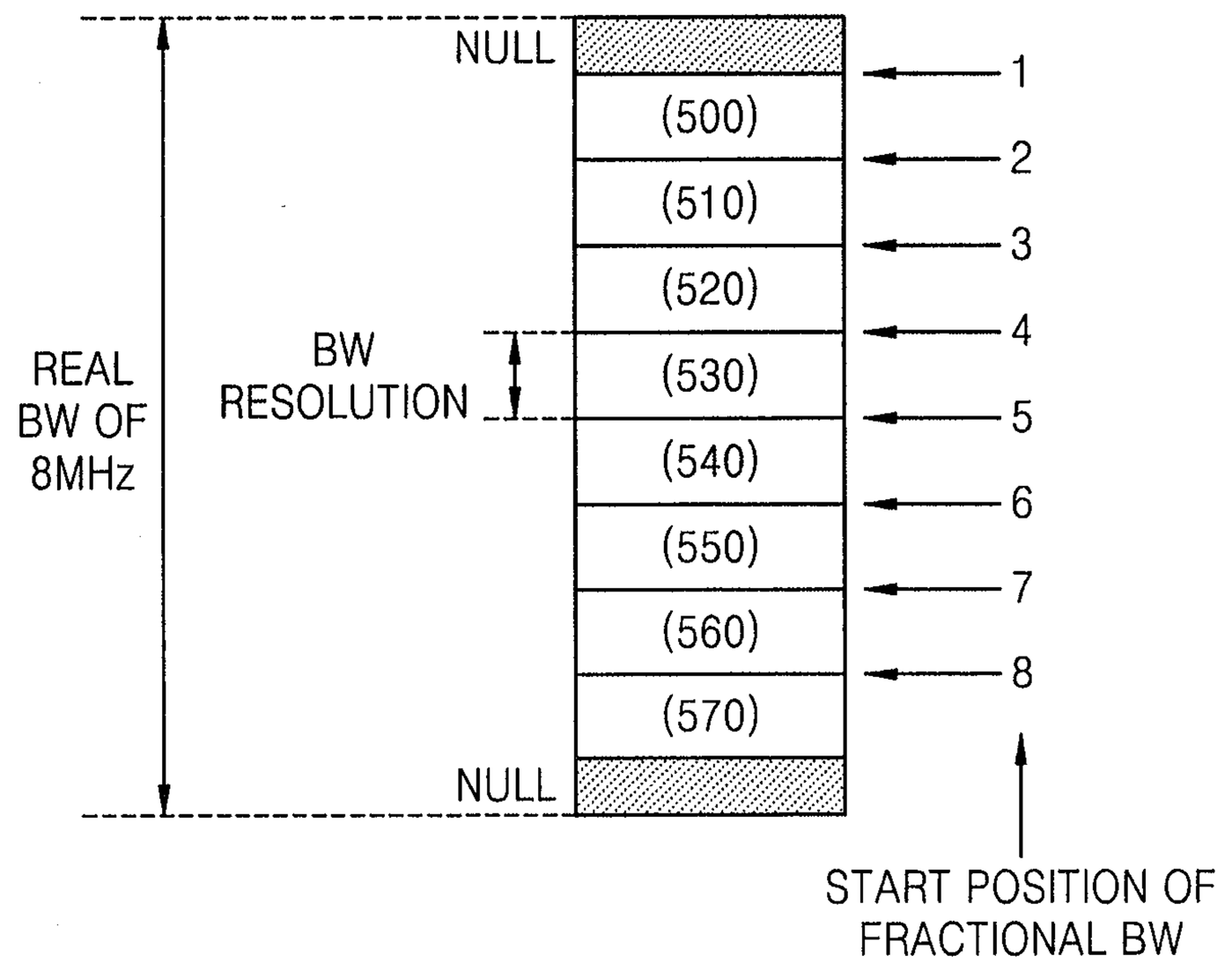


FIG. 6

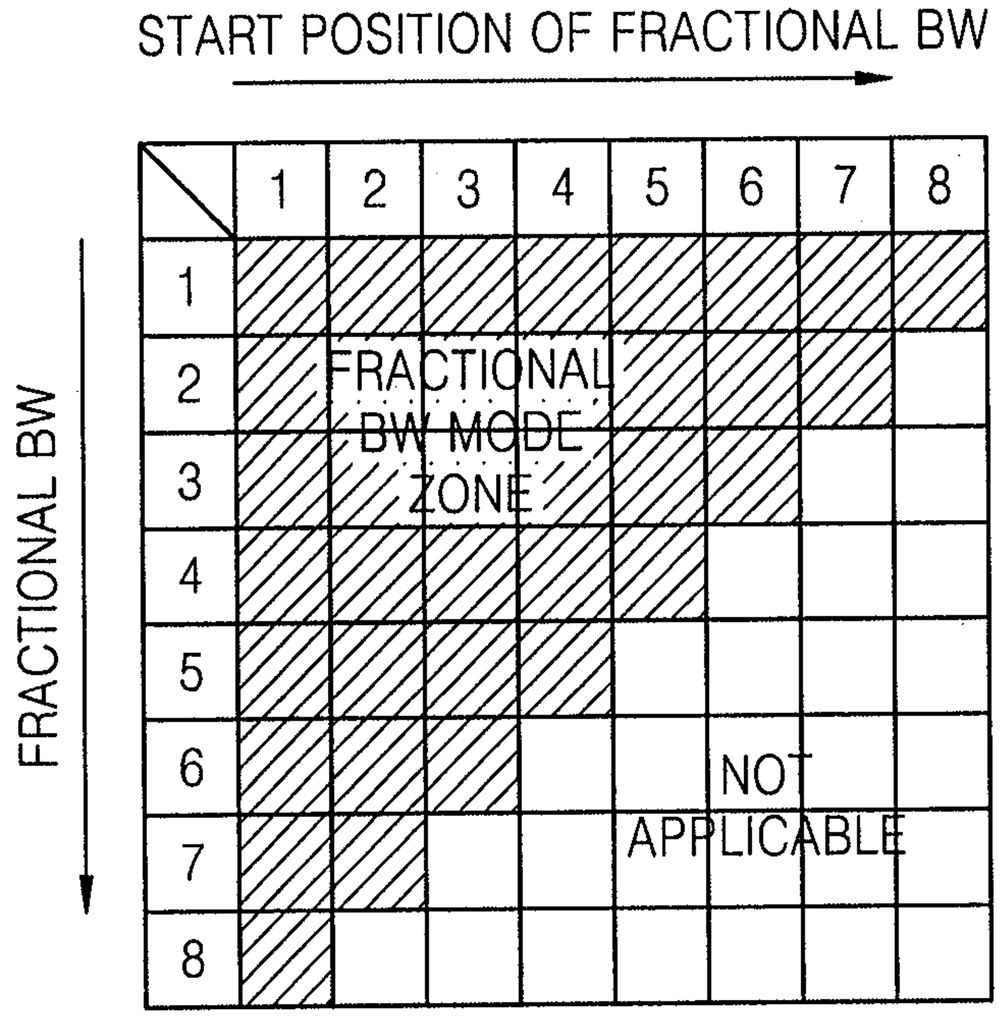

START POSITION OF FRACTIONAL BW
FRACTIONAL BW
1
2
3
4
5
6
7
8
FRACTIONAL BW MODE ZONE
NOT APPLICABLE

FIG. 7

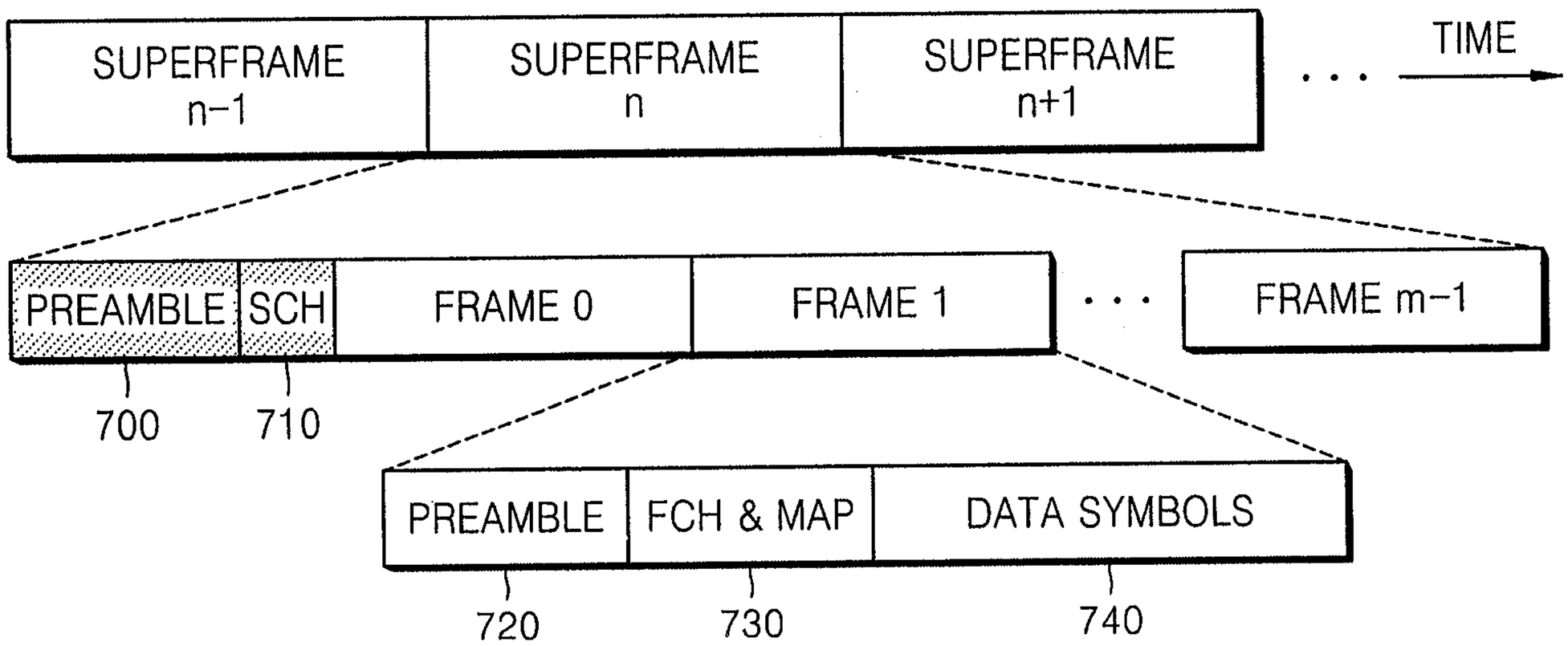

SUPERFRAME n-1
SUPERFRAME n
SUPERFRAME n+1
TIME
PREAMBLE
SCH
FRAME 0
FRAME 1
FRAME m-1
700
710
PREAMBLE
FCH & MAP
DATA SYMBOLS
720
730
740

FIG. 8

Index	Fractional BW	Start Position	PN Sequence (1680 bits)
0	1	0	0x251D994101EDA04D8BD0B8EA6FA20AE590C2CC199AB083C6AE61F091F2DD41D989EC164B1481D611BE9CE A0094AFE9DB56A4763F55B26E54EAB73ACD7D4BBA64C1421BC3EB9D67113A5FB9C529AADC9CAB1FB882905 601778659CDB69AFCBADDF8B42314A7985B5F87C20692309D350454FF9326481683FADAE4711DD0CC5DACEDF 7CD5DF1177D60EBA4DBE657F19F08189EFC6B5DE6C2CFDCD13195DE077586B8EE01E00B6468B10A53FAAC1D D846E2A01681980D444B6AD0D34C34EC9CFD9341507878EC9FBAE498F5A20614BDF3E4B22D
1	1	1	
2	1	2	
3	1	3	
4	1	4	
5	1	5	
6	1	6	
7	1	7	
8	2	0	
9	2	1	
10	2	2	
11	2	3	
12	2	4	
13	2	5	
14	2	6	
...	...	...	...
33	7	1	
34	7	2	
35	8	1	

This sequence can be selected to minimize the PAPR

FIG. 9A

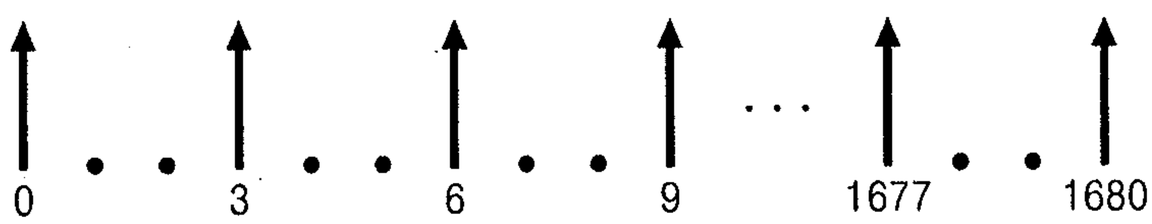


FIG. 9B

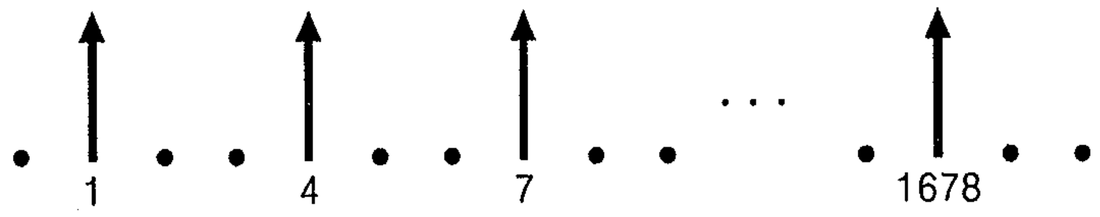


FIG. 9C

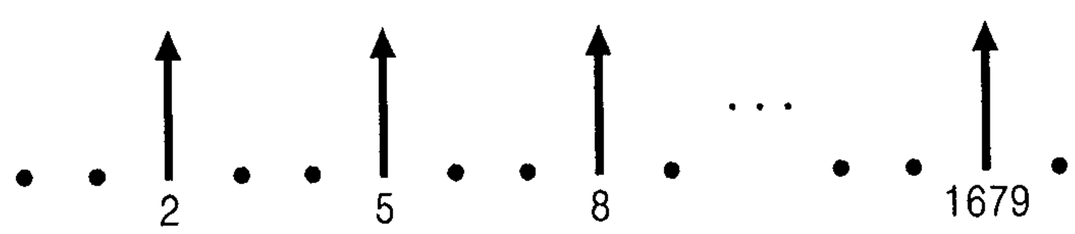

2
5
8
1679

FIG. 10

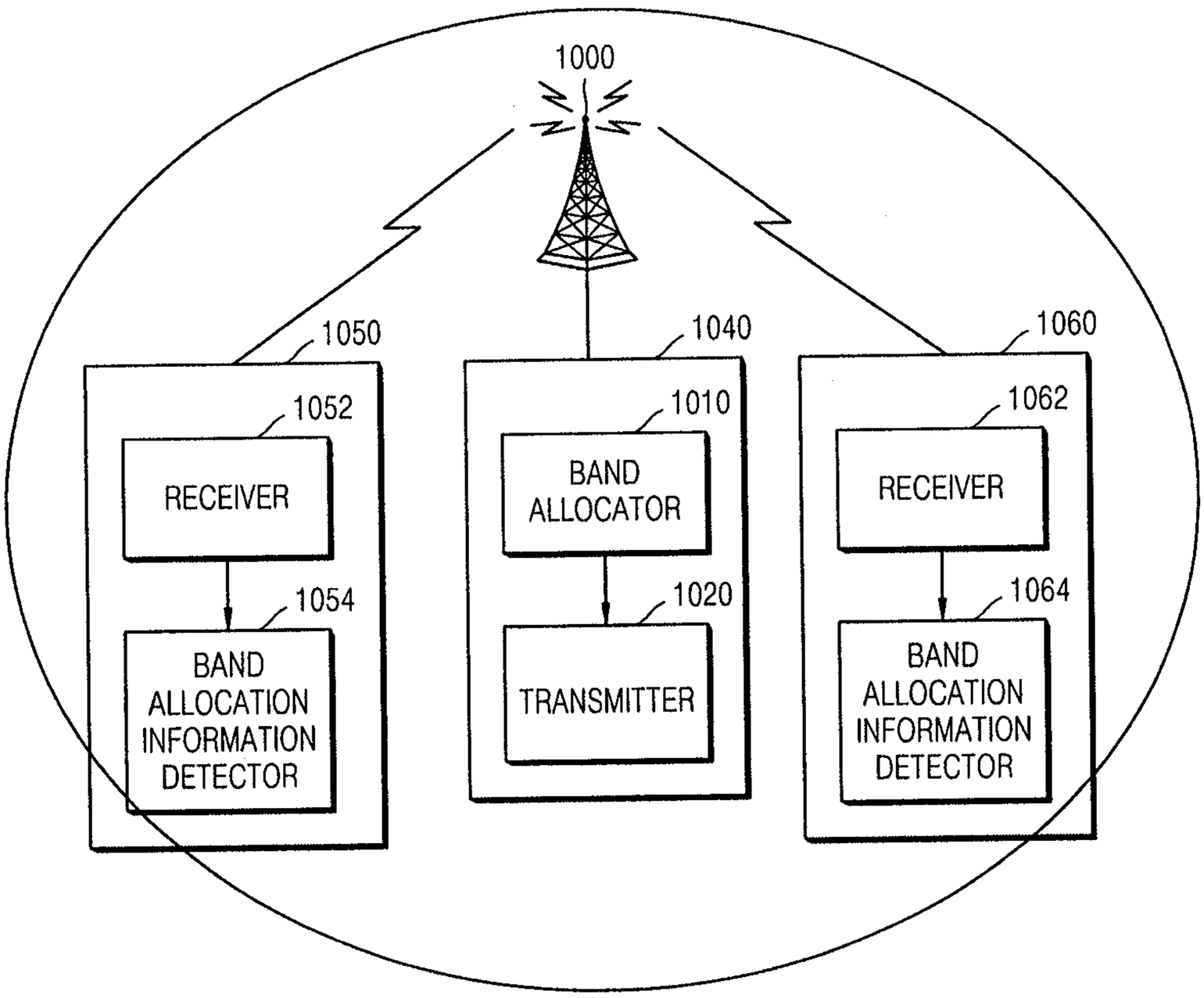

1000
1050
1052
RECEIVER
1054
BAND ALLOCATION INFORMATION DETECTOR
1040
1010
BAND ALLOCATOR
1020
TRANSMITTER
1060
1062
RECEIVER
1064
BAND ALLOCATION INFORMATION DETECTOR

FIG. 11

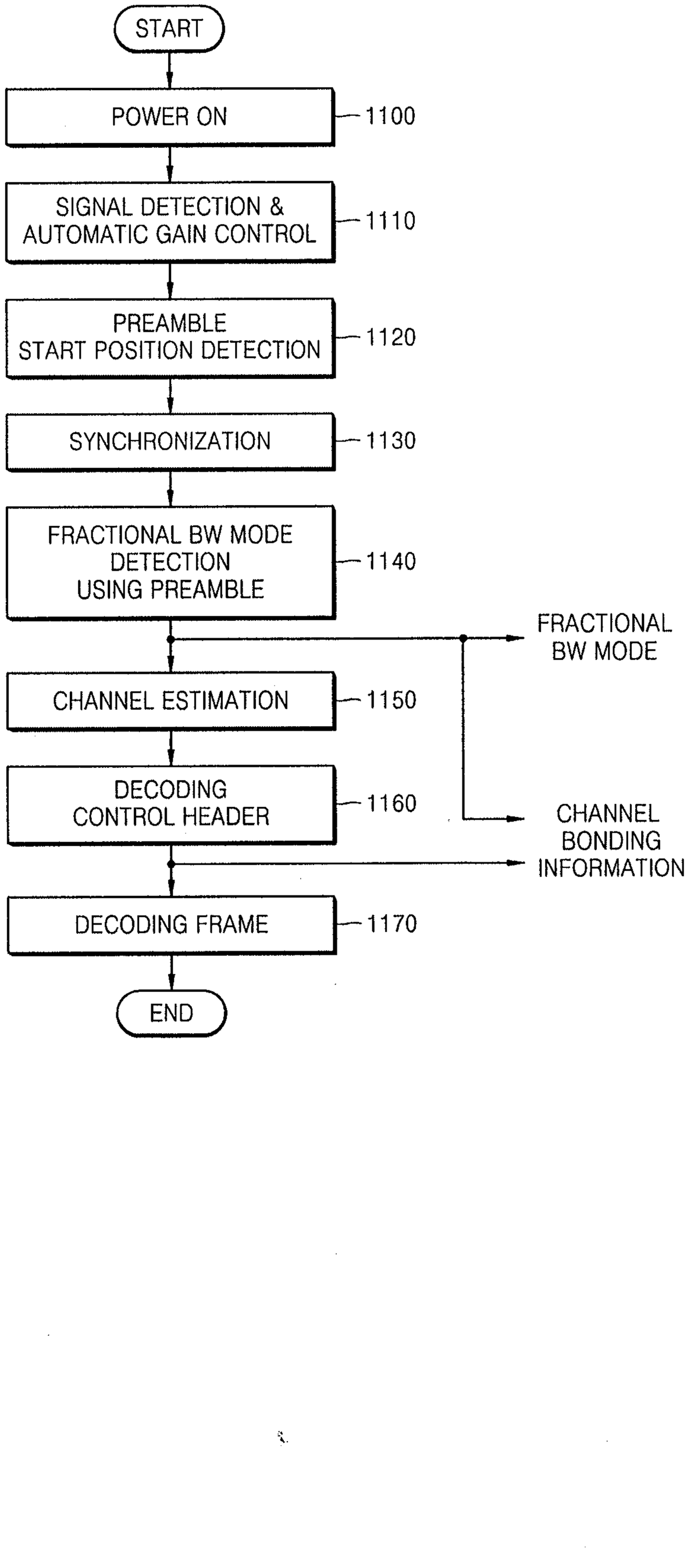

START
POWER ON
1100
SIGNAL DETECTION & AUTOMATIC GAIN CONTROL
1110
PREAMBLE START POSITION DETECTION
1120
SYNCHRONIZATION
1130
FRACTIONAL BW MODE DETECTION USING PREAMBLE
1140
FRACTIONAL BW MODE
CHANNEL ESTIMATION
1150
DECODING CONTROL HEADER
1160
CHANNEL BONDING INFORMATION
DECODING FRAME
1170
END

FIG. 12

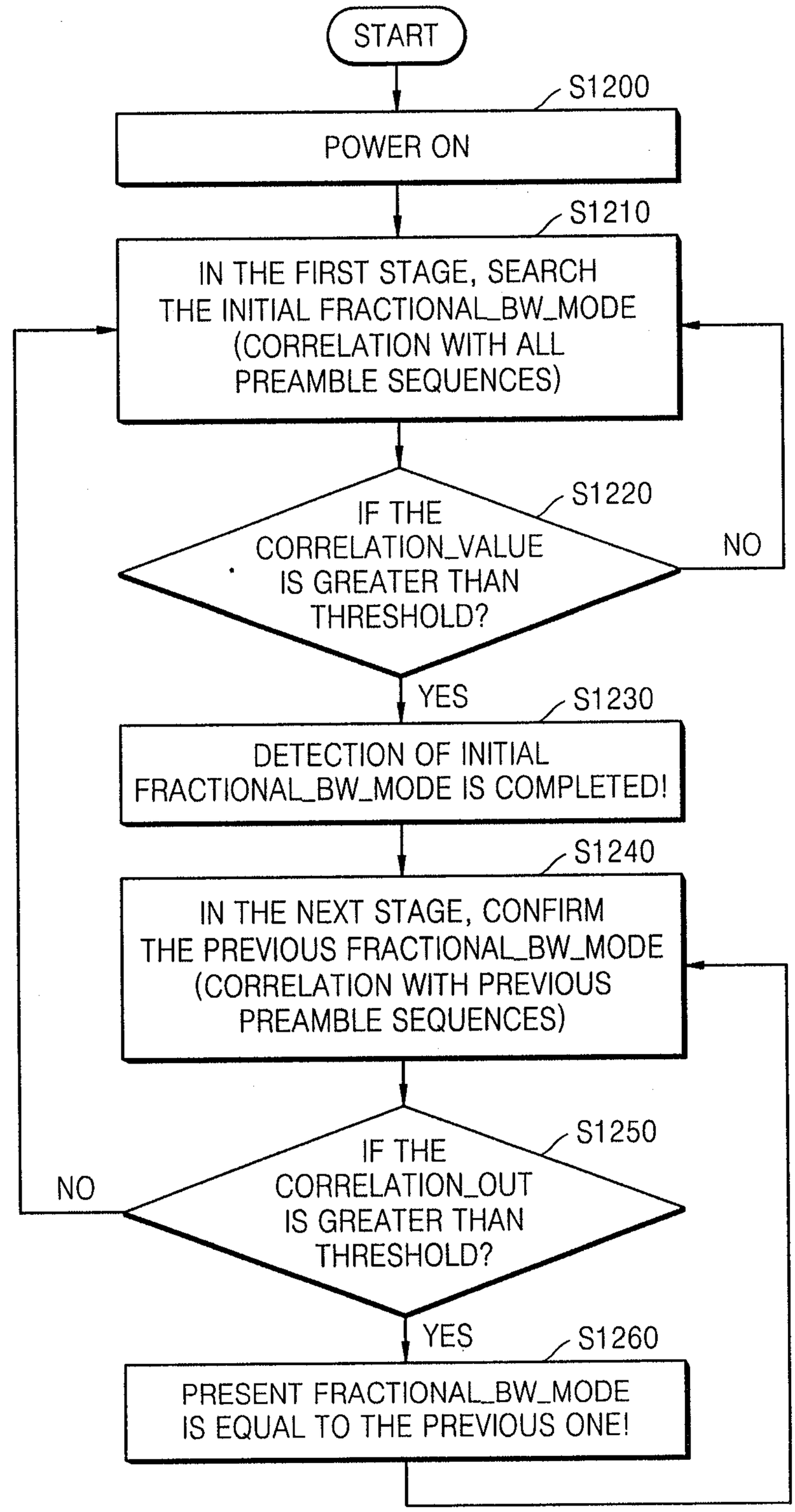

START
S1200
POWER ON
S1210
IN THE FIRST STAGE, SEARCH THE INITIAL FRACTIONAL_BW_MODE (CORRELATION WITH ALL PREAMBLE SEQUENCES)
S1220
IF THE CORRELATION_VALUE IS GREATER THAN THRESHOLD?
NO
YES
S1230
DETECTION OF INITIAL FRACTIONAL_BW_MODE IS COMPLETED!
S1240
IN THE NEXT STAGE, CONFIRM THE PREVIOUS FRACTIONAL_BW_MODE (CORRELATION WITH PREVIOUS PREAMBLE SEQUENCES)
S1250
IF THE CORRELATION_OUT IS GREATER THAN THRESHOLD?
NO
YES
S1260
PRESENT FRACTIONAL_BW_MODE IS EQUAL TO THE PREVIOUS ONE!

FIG. 13

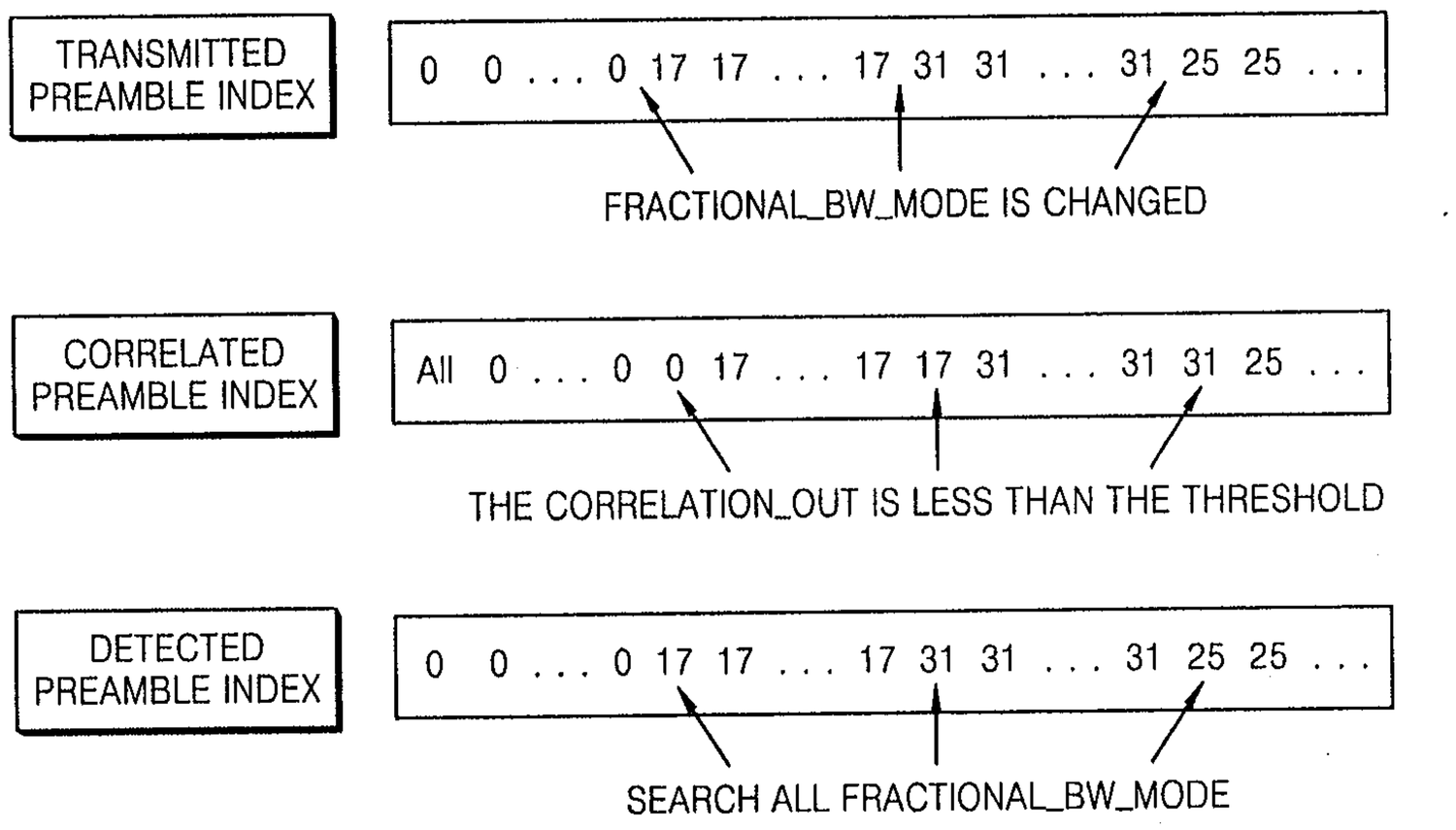
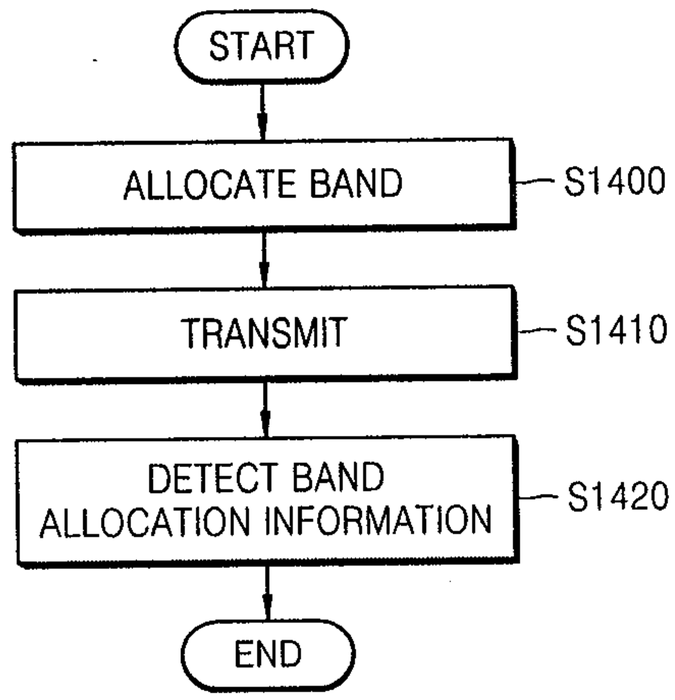
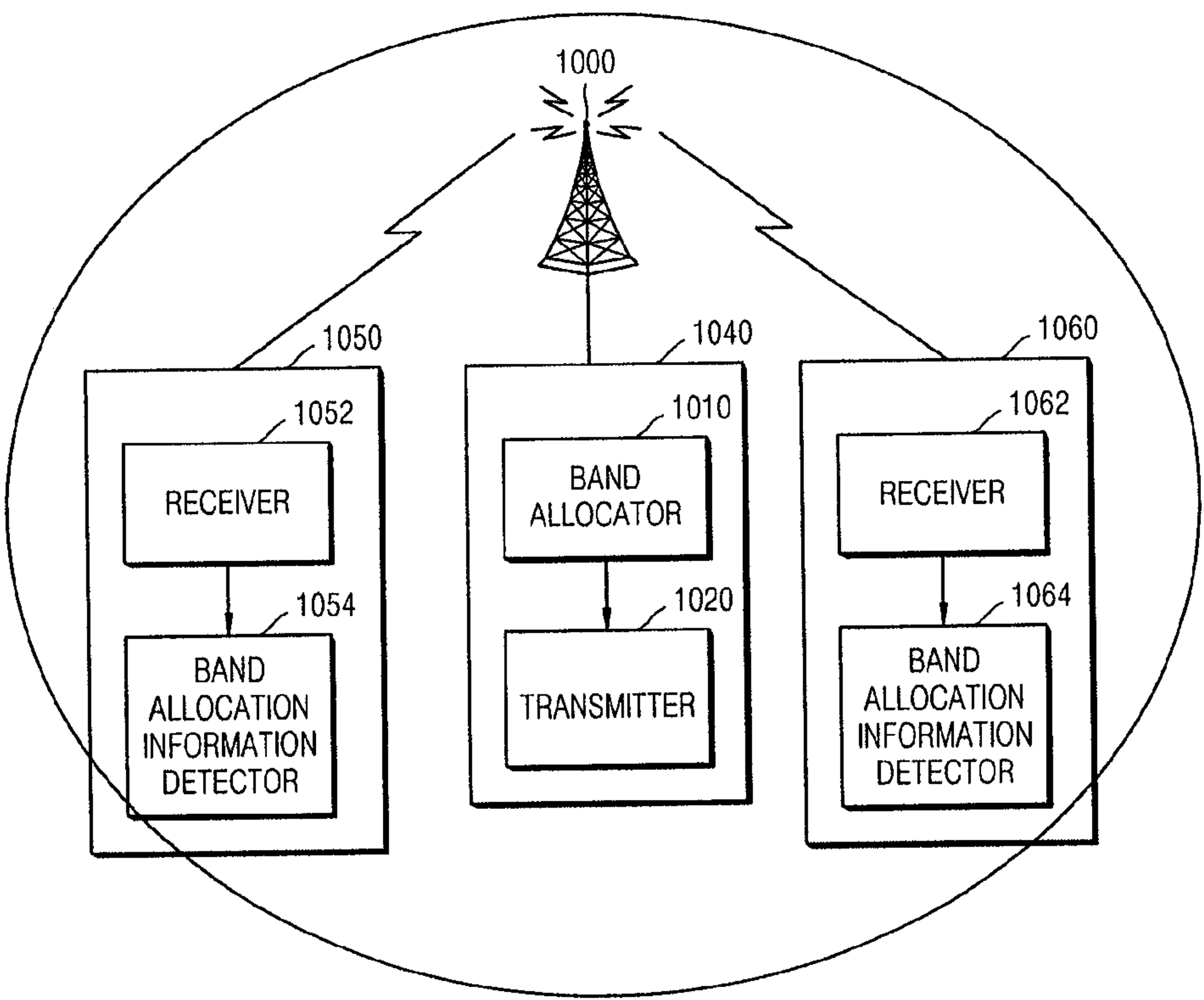

TRANSMITTED PREAMBLE INDEX
0 0 . . . 0 17 17 . . . 17 31 31 . . . 31 25 25 . . .
FRACTIONAL_BW_MODE IS CHANGED
CORRELATED PREAMBLE INDEX
All 0 . . . 0 0 17 . . . 17 17 31 . . . 31 31 25 . . .
THE CORRELATION_OUT IS LESS THAN THE THRESHOLD
DETECTED PREAMBLE INDEX
0 0 . . . 0 17 17 . . . 17 31 31 . . . 31 25 25 . . .
SEARCH ALL FRACTIONAL_BW_MODE

FIG. 14


START
ALLOCATE BAND
S1400
TRANSMIT
S1410
DETECT BAND ALLOCATION INFORMATION
S1420
END


1000
1050
1052
RECEIVER
1054
BAND ALLOCATION INFORMATION DETECTOR
1040
1010
BAND ALLOCATOR
1020
TRANSMITTER
1060
1062
RECEIVER
1064
BAND ALLOCATION INFORMATION DETECTOR