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(71) Applicant *(for all designated States except US)*: **INTERDIGITAL TECHNOLOGY CORPORATION** [US/US]; 3411 Silverside Road, Concord Plaza, Suite 105, Hagley Building, Wilmington, Delaware 19810 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ZHANG, Guodong** [CN/US]; 490 Main Street, Apt. C8, Farmingdale, New York 11735 (US). **PAN, Kyle, Jung-lin** [US/US]; 43 Avalon Circle, Smithtown, New York 11787 (US). **TSAI, Allan, Y.** [US/US]; 10 Jolie Court, Boonton, New Jersey 07005 (US).

(74) Agent: **BALLARINI, Robert, J.**; Volpe And Koenig, P.c., United Plaza, Suite 1600, 30 S. 17th Street, Philadelphia, Pennsylvania 19103 (US).

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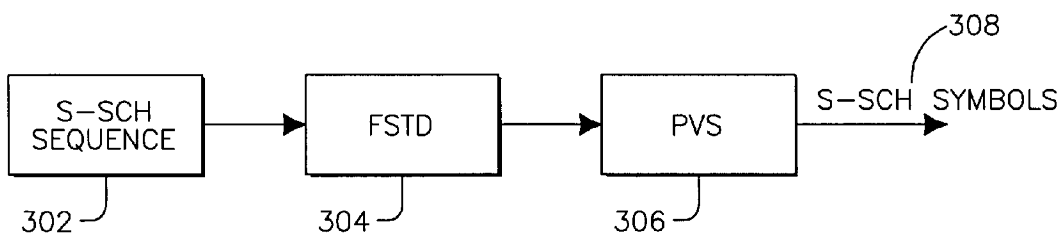

FIG.3

(57) Abstract: A method of providing transmit diversity for a secondary synchronization channel (S-SCH) includes generating a S-SCH signal, performing a frequency switched transmit diversity (FSTD) process on the S-SCH signal to create a first processed signal, performing a precoding vector switching (PVS) process on the first processed signal to create a processed S-SCH signal, and transmitting the processed S-SCH signal.

WO 2008/115508 A1

[0001] COMBINED PRECODING VECTOR SWITCH AND FREQUENCY SWITCH TRANSMIT DIVERSITY FOR SECONDARY SYNCHRONIZATION CHANNEL IN EVOLVED UTRA

[0002] FIELD OF INVENTION

[0003] This application is related to wireless communications.

[0004] BACKGROUND

[0001] The third generation partnership project (3GPP) and its progeny 3GPP2, are directed towards the advancement of technology for radio interfaces and network architectures for wireless communication systems. Part of 3GPP involves the use of orthogonal frequency division multiple access (OFDMA) as a technology for downlink (DL) communications in an evolved UMTS terrestrial radio access (e-UTRA) network. At initial access, a wireless transmit/receive unit (WTRU) may receive and process a primary synchronization channel (P-SCH) and a secondary synchronization channel (S-SCH) in order to acquire timing, frequency offset, and a cell identification (ID).

[0002] At initial cell search, the S-SCH may be received by the WTRU. However, the WTRU has no knowledge of the number of transmit antennas at the cell. Therefore, it is preferable that a transmit diversity scheme not requiring knowledge of the number of transmit antennas be used in the network. Several transmit diversity schemes, such as time switched transmit diversity (TSTD), frequency switched transmit diversity (FSTD) and precoding vector switching (PVS) have been considered.

[0005] It would be desirable to have a transmit diversity scheme for the S-SCH for an e-UTRA network that achieves high performance.

[0006] SUMMARY

A method and apparatus is disclosed for providing transmit diversity for a secondary synchronization channel (S-SCH). This may include applying a FSTD process and a PVS process to a S-SCH prior to transmitting the S-SCH.

More specifically, the S-SCH may be processed with an FSTD to a first orthogonal frequency domain multiplexed (OFDM) symbol with a first sequence in a lower bandwidth and a second sequence in an upper bandwidth and a second OFDM symbol with the first sequence in the upper bandwidth and the second sequence in the lower bandwidth. A precoding matrix may be applied to the first and second symbols.

[0007] BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0009] Figure 1 shows an example of a wireless communication system in accordance with an embodiment;

[0010] Figure 2 shows a functional block diagram of a WTRU and an eNB of Figure 1;

[0011] Figure 3 is a block diagram of a transmit diversity scheme in accordance with an embodiment;

[0012] Figure 4 shows a S-SCH symbol structure in accordance with the embodiment shown in Figure 3;

[0013] Figure 5 shows a S-SCH with precoding in accordance with the embodiment shown in Figure 3;

[0014] Figure 6 shows a S-SCH symbol structure using 2 interleaved sequences in accordance with the embodiment shown in Figure 4; and

[0015] Figure 7 shows a S-SCH symbol structure using 2 interleaved sequences and PVS in accordance with the embodiment shown in Figure 5.

[0016] DETAILED DESCRIPTION

[0017] When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0018] Figure 1 shows a wireless communication system 100 including a plurality of WTRUs 110 and an e Node-B (eNB) 120. As shown in Figure 1, the WTRUs 110 are in communication with the eNB 120. Although three WTRUs 110 and one eNB 120 are shown in Figure 1, it should be noted that any combination of wireless and wired devices may be included in the wireless communication system 100.

[0019] Figure 2 is a functional block diagram 200 of the WTRU 110 and the eNB 120 of the wireless communication system 100 of Figure 1. As shown in Figure 2, the WTRU 110 is in communication with the eNB 120. The WTRU 110 is configured to receive the primary synchronization channel (P-SCH) and secondary synchronization channel (S-SCH) from the eNB 120. Both the eNB and the WTRU are configured to process signals that are modulated and coded.

[0020] In addition to the components that may be found in a typical WTRU, the WTRU 110 includes a processor 215, a receiver 216, a transmitter 217, and an antenna 218. The receiver 216 and the transmitter 217 are in communication with the processor 215. The antenna 218 is in communication with both the receiver 216 and the transmitter 217 to facilitate the transmission and reception of wireless data.

[0021] In addition to the components that may be found in a typical eNB, the eNB 120 includes a processor 225, a receiver 226, a transmitter 227, and an antenna 228. The receiver 226 and the transmitter 227 are in communication with the processor 225. The antenna 228 is in communication with both the receiver 226 and the transmitter 227 to facilitate the transmission and reception of wireless data.

[0022] In one embodiment, a combined FSTD and PVS transmit diversity scheme is used for S-SCH symbol transmission in E-UTRA. This transmit diversity scheme allows S-SCH detection at the WTRU without prior knowledge of the number of transmit antennas of the cell. The number of transmit antennas using the transmit diversity technique is transparent to the WTRU, resulting in simple and efficient detection of the S-SCH. The transmit diversity technique also carries more information about the cell such as, but not limited to, reference signal hopping indicators and a number of transmit antennas for the broadcast channel

[0023] Figure 3 is a block diagram of an S-SCH transmit diversity scheme 300 in accordance with one embodiment. An S-SCH sequence 302 is input into a FSTD processor 304, as explained herein. The FSTD processor may be includes in processor 225 in the eNB of Figure 2. The signal is then input into a PVS processor 306, as explained herein. The PVS processor 306 may also be included in processor 225 of the eNB of Figure 2. The output of the PVS processor 306 are the S-SCH symbols 308 which are then transmitted. The S-SCH symbols 308 may be transmitted by the transmitter 227 as shown in Figure 2. A robust S-SCH design may provide full transmit diversity gain for S-SCH. A robust S-SCH transmission design may also provide a sufficient number of cell (group) IDs, cell-specific parameters, and other cell related information. The information carried by a plurality of S-SCH symbols may be used to convey the number of cell (group) IDs and cell specific information, such as a reference signal hopping indicator and the number of transmit antennas for the broadcast channel (BCH), for example.

[0024] Figure 4 is a diagram showing an S-SCH symbol structure 400 in accordance with the embodiment shown in Figure 3. After the S-SCH sequence 302 of Figure 3, is processed through the FSTD processor 304 of Figure 3, the result is two separate S-SCH transmission symbols, S1 (402) and S2 (404). S1 (402) is the first S-SCH symbol and has a Constant Amplitude Zero Auto-correlation Code (CAZAC) sequence, shown as G1 (406), transmitted in the lower band 408 of the central bandwidth, and a second CAZAC sequence, shown as G2 (410), transmitted in the upper band 412 of the central bandwidth. The central bandwidth may be, for example, 1.25 MHz or 2.5 Mhz. One skilled in the art may recognize that the methods and apparatus disclosed herein are not frequency specific. The CAZAC sequence may be, for example, a Generalized Chirp-like (GCL) sequence, a Zadoff-Chu sequence, or the like.

[0025] The second S-SCH symbol, S2 (404) is a mirror version of the first S-SCH symbol S1 (402). The sequence G2 (414) is transmitted in the lower band 408, and the sequence G1 (416) is transmitted in the upper band 412.

[0026] Figure 5 shows an S-SCH with a precoding matrix 500 in accordance with the embodiment shown in Figure 3. The precoding matrix is applied to S1 (402) and S2 (404) of Figure 4. The upper band 412 of S1 (402) is multiplied by $V_{1,2}$ (502) and the upper band 412 of S2 (404) is multiplied by $V_{2,2}$ (504). The lower band 408 of S1 (402) is multiplied by $V_{1,1}$ (506) and the lower band 408 of S2 (404) is multiplied by $V_{2,1}$ (508). $V_{1,1}$, $V_{2,2}$, $V_{2,1}$ and $V_{2,2}$ are the elements of a precoding matrix when PVS is used. The precoding matrix V is represented by:

$$V=\begin{bmatrix} V_{1,1} & V_{1,2} \\ V_{2,1} & V_{2,2} \end{bmatrix} \quad \text{(Equation 1)}$$

where V_{ij} is the $(1,j)^{th}$ element of the precoding matrix.

[0027] In general, let N_V denote the number of different precoding matrices used for S-SCH symbols. For each S-SCH symbol, its equivalent is multiplied by a precoding vector. Consider a precoding matrix:

$$V=\begin{bmatrix} 1 & j \\ -j & 1 \end{bmatrix}\cdot e^{jk\theta}, \text{ where } \theta = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}.$$

(Equation 2)

Then, $N_V = 4$. Furthermore, the value k can be fixed during one OFDM symbol duration or it can be in a range of $1 \le k \le K$, where $K \le N_G$, where N_G is the sequence length of CAZAC sequence G1 or G2.

N_{G_1} and N_{G_2} can be defined as the sequence lengths of G1(406) and G2 (408), respectively. The maximum number of hypotheses that can be supported is equal to:

$$N_{G_1} - 1 \times N_{G_2} - 1 \times N_V \ .$$

(Equation 3)

For example, if $N_{G_1} = N_{G_2} = 31$ and $N_V = 4$, then the maximum number of hypotheses that can be supported equals 3600 (30 x 30 x 4). The pair of S-SCH symbols can be transmitted Q times. For example, if $Q=1$, the symbols are transmitted every radio frame, where a radio frame is 10 ms in length. The time distance between two S-SCH symbols may be fixed.

[0028] Figure 6 shows a S-SCH symbol structure using 2 interleaved sequences in accordance with the embodiment shown in Figure 4. Integer M CAZAC sequences of length K may be mapped to subcarriers in an interleaved pattern to generate one S-SCH symbol. If M equals 2, for example, a first subcarrier 610 carries d1 (602) multiplied by $G_{1,1}$ (604)., where d_1 (602) is the first data symbol carried on the S-SCH and $G_{1,1}$ (604) is the first chip/symbol of the first CAZAC sequence with a length K. A third subcarrier 614 carries d1 (602) multiplied by $G_{1,2}$ (606). The fifth subcarrier 620 carries d_1 (602) multiplied by $G_{1,3}$ (608). The second subcarrier 612 carries d_2 (616), which is the second data symbol carried on the S-SCH, multiplied by $G_{2,1}$ (618), which is the first chip/symbol of the second CAZAC sequence with length K. Each CAZAC sequence may carry an information symbol (such as BPSK modulation or QPSK modulation). That is, each information symbol may be spread by a CAZAC sequence of length K. The K spread symbols may be mapped to equal-distant subcarriers in an interleaved pattern. Information symbols may be mapped to non-overlapping subcarriers after spreading.

[0029] Figure 7 shows an S-SCH symbol structure using 2 interleaved sequences and PVS 700 in accordance with the embodiment shown in Figure 5. Let M =2, for example. The two interleaved CAZAC sequences in the first S-SCH symbol S1 (702) are precoded by $\begin{bmatrix} V_{1,1} & V_{1,2} \end{bmatrix}$. Similarly, the two interleaved CAZAC sequences in the second S-SCH symbol (704) are precoded by $\begin{bmatrix} V_{2,1} & V_{2,2} \end{bmatrix}$. The precoding matrix for the pair of S-SCH symbols is equivalent to $\begin{bmatrix} V_{1,1} & V_{1,2} \\ V_{2,1} & V_{2,2} \end{bmatrix}$.

[0030] Turning to Figure 7, and by way of example, $G_{1,1}$ (706) is precoded by $V_{1,1}$ (708) in the first S-SCH symbol S1 (702). $G_{1,1}$ (706) is precoded by $V_{2,1}$ (722) in the second S-SCH symbol S2 (704). $G_{2,1}$ (716) is precoded by $V_{1,2}$ (718) in the first S-SCH symbol S1 (702) and $G2_{,1}$ (716) is precoded by $V_{2,2}$ (722) in the second SCH symbol S2 (704). More generally, in the first symbol S1 (702), $G_{1,k}$ (710) is precoded by $V_{1,1}$ (708) and $G_{2,K}$ (712) is precoded by $V_{1,2}$ (718) and in the second SCH symbol S2 (704) $G_{1,k}$ (710) is precoded by $V_{2,1}$ (720) and $G_{2,k}$ is precoded by $V_{2,2}$ (722). The maximum number of hypotheses supported is equal to $N_V \text{x} (K-1)^2$. For example, if $K = 31$ and $N_V = 4$, then the maximum number of hypotheses supported equals 3600. A pair of S-SCH symbols may be transmitted Q times every radio frame (10 ms). The time distance between any two S-SCH symbols is fixed.

[0031] EMBODIMENTS

[0032] 1. A method of providing transmit diversity for a secondary synchronization channel (S-SCH), the method comprising generating a S-SCH signal, performing a frequency switched transmit diversity (FSTD) process on the S-SCH signal to create a first processed signal, and performing a precoding vector switching (PVS) process on the first processed signal to create a processed S-SCH signal.

[0033] 2. The method as in embodiment 1 further comprising transmitting the processed S-SCH signal.

[0034] 3. The method as in embodiment 1 or 2 further comprising transmitting a cell identifier (ID) and cell specific information in the processed S-SCH signal.

[0035] 4. The method as in embodiment 3 wherein the cell specific information comprises reference signal hopping indicators and a number of broadcast channel (BCH) transmit antennas.

[0036] 5. The method as in any preceding embodiment further comprising processing the S-SCH signal with the FSTD process to obtain an orthogonal frequency domain multiplexed (OFDM) symbol with a first orthogonal sequence in a lower bandwidth and a second orthogonal sequence in an upper bandwidth.

[0037] 6. The method as in any preceding embodiment further comprising processing the S-SCH signal with the FSTD process to obtain a first orthogonal frequency domain multiplexed (OFDM) symbol with a first sequence in a lower bandwidth and a second sequence in an upper bandwidth, and a second OFDM symbol with the first sequence in the upper bandwidth and the second sequence in the lower bandwidth.

[0038] 7. The method as in embodiment 6 wherein first and second sequences are a Generalized Chirp-like (GCL) sequence.

[0039] 8. The method as in embodiment 6 or 7 wherein the first and second sequences are a Zadoff-Chu sequence.

[0040] 9. The method as in any one of embodiment 6-8 further comprising applying a precoding matrix to the first and second symbols.

[0041] 10. The method as in any one of embodiments 6-9 wherein a maximum number of hypotheses is a function of a sequence length of the first sequence, a sequence length of the second sequence and a number of different precoding matrices used for the symbols.

[0042] 11. A method of providing transmit diversity for a secondary synchronization channel (S-SCH), the method comprising generating a S-SCH symbol by multiplying the S-SCH symbol by a spreading sequence.

[0043] 12. The method as in embodiment 11 further comprising mapping the spread S-SCH symbol to non-overlapping subcarriers in an interleaved pattern.

[0044] 13. The method as in embodiment 12 wherein the subcarriers are equidistant across the bandwidth.

[0045] 14. The method as in embodiment 12 further comprising multiplying the mapped S-SCH symbols by a precoding vector.

[0046] Although features and elements are described above in particular combinations, each feature or element can be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0047] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0048] A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

* * *

CLAIMS

What is claimed is:

1. A method of providing transmit diversity for a secondary synchronization channel (S-SCH), the method comprising:

generating a S-SCH signal;

performing a frequency switched transmit diversity (FSTD) process on the S-SCH signal to create a first processed signal;

performing a precoding vector switching (PVS) process on the first processed signal to create a processed S-SCH signal; and

transmitting the processed S-SCH signal.

2. The method as in claim 1 further comprising transmitting a cell identifier (ID) and cell specific information in the processed S-SCH signal.

3. The method as in claim 2 wherein the cell specific information comprises reference signal hopping indicators and a number of broadcast channel (BCH) transmit antennas.

4. The method as in claim 1 further comprising processing the S-SCH signal with the FSTD process to obtain:

an orthogonal frequency domain multiplexed (OFDM) symbol with a first orthogonal sequence in a lower bandwidth and a second orthogonal sequence in an upper bandwidth.

5. The method as in claim 1 further comprising processing the S-SCH signal with the FSTD process to obtain:

a first orthogonal frequency domain multiplexed (OFDM) symbol with a first sequence in a lower bandwidth and a second sequence in an upper bandwidth; and

a second OFDM symbol with the first sequence in the upper bandwidth and the second sequence in the lower bandwidth.

6. The method as in claim 5 wherein first and second sequences are a Generalized Chirp-like (GCL) sequence.

7. The method as in claim 5 wherein the first and second sequences are a Zadoff-Chu sequence.

8. The method as in claim 5 further comprising applying a precoding matrix to the first and second symbols.

9. The method as in claim 5 wherein a maximum number of hypotheses is a function of a sequence length of the first sequence, a sequence length of the second sequence and a number of different precoding matrices used for the symbols.

10. A method of providing transmit diversity for a secondary synchronization channel (S-SCH), the method comprising;

generating a S-SCH symbol by multiplying the S-SCH symbol by a spreading sequence; and

mapping the spread S-SCH symbol to non-overlapping subcarriers in an interleaved pattern

11. The method as in claim 10 wherein the subcarriers are equidistant across the bandwidth.

12. The method as in claim 10 further comprising multiplying the mapped S-SCH symbols by a precoding vector.

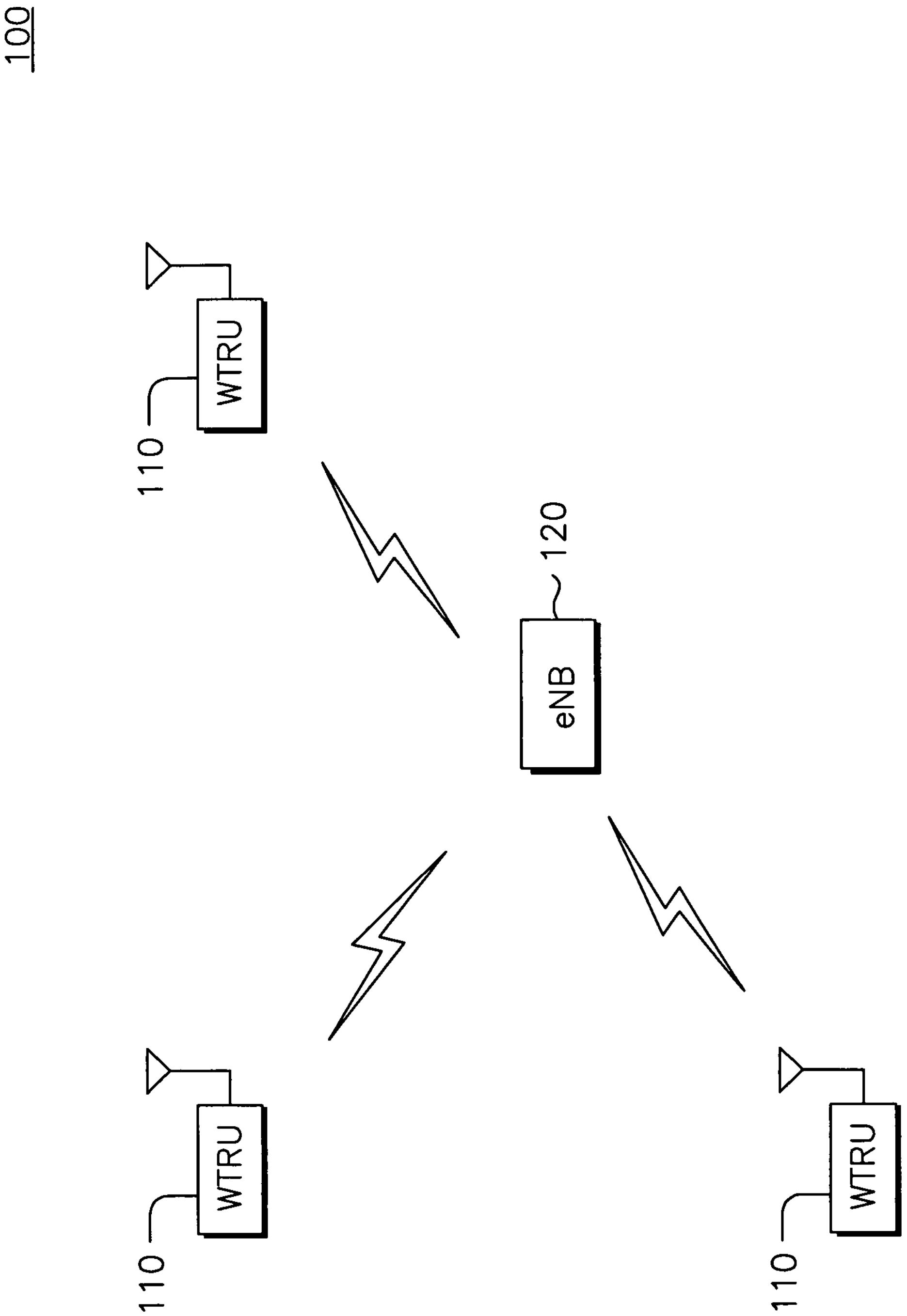

FIG.1

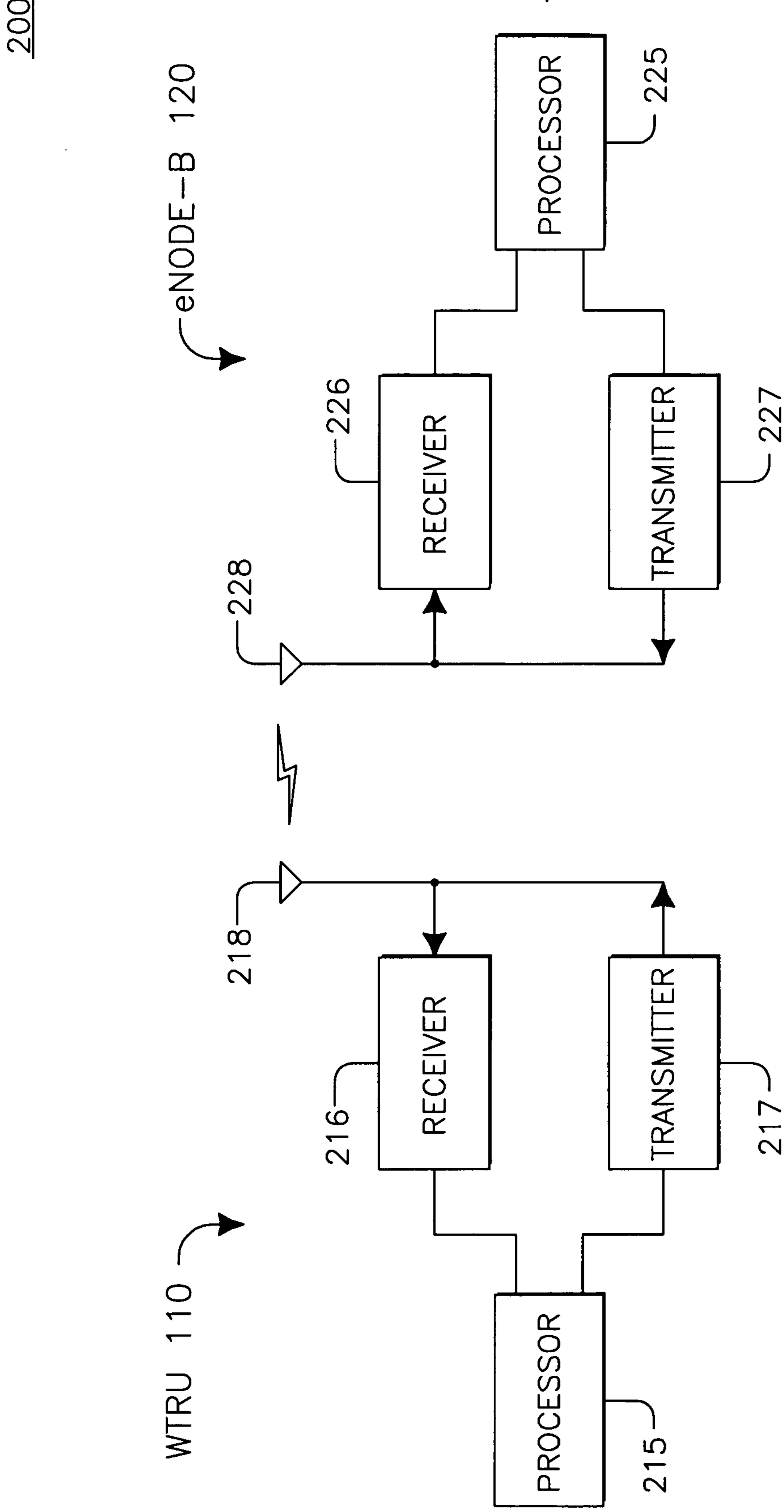
200
eNODE—B 120
PROCESSOR
225
RECEIVER
226
TRANSMITTER
227
228
218
RECEIVER
216
TRANSMITTER
217
WTRU 110
PROCESSOR
215

FIG.2

300

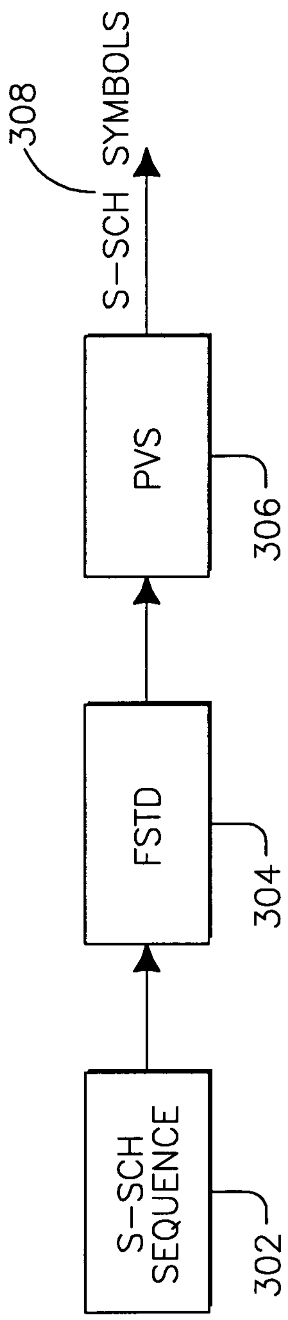

FIG.3

400

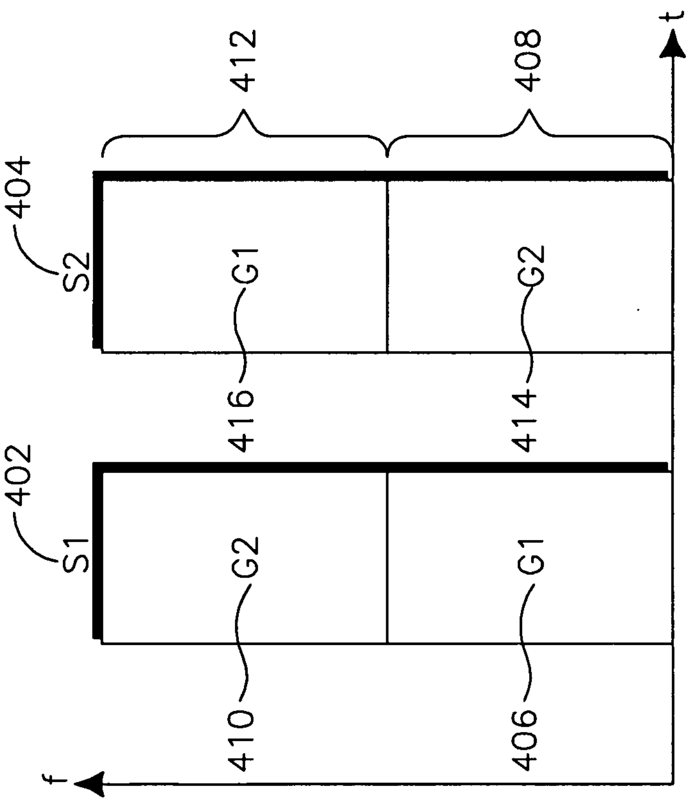

FIG.4

500

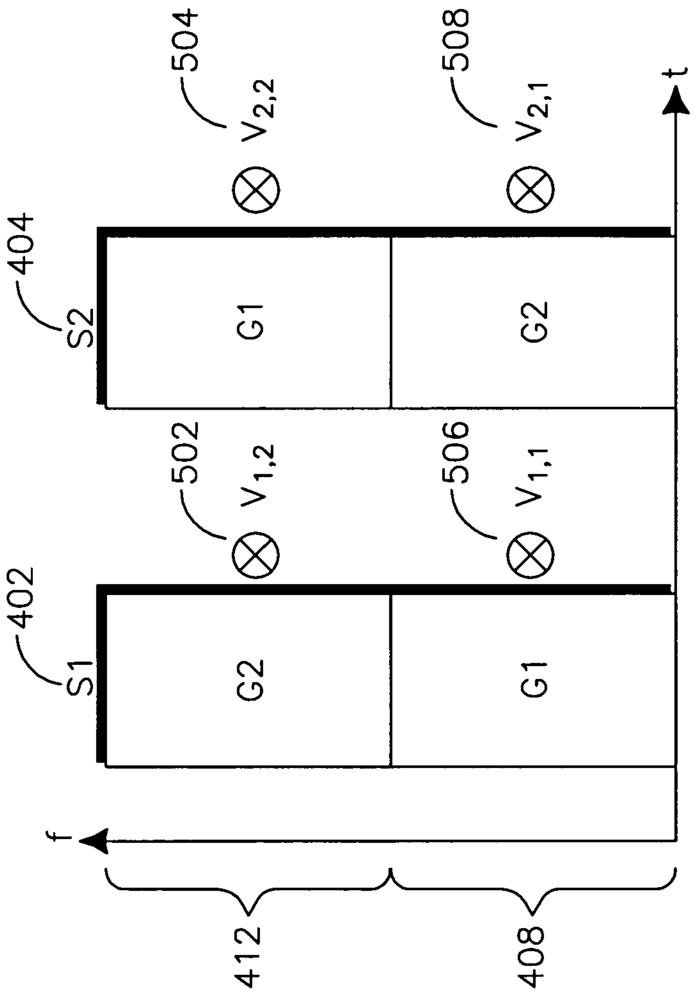
S1
402
S2
404
G2
G1
G1
G2
502
V1,2
506
V1,1
504
V2,2
508
V2,1
f
t
412
408

FIG.5

600

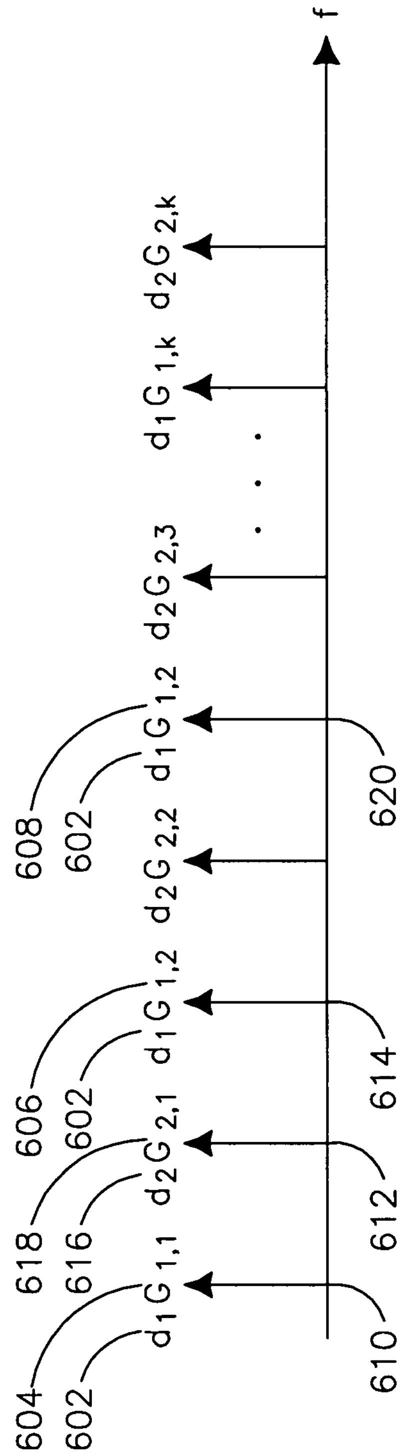
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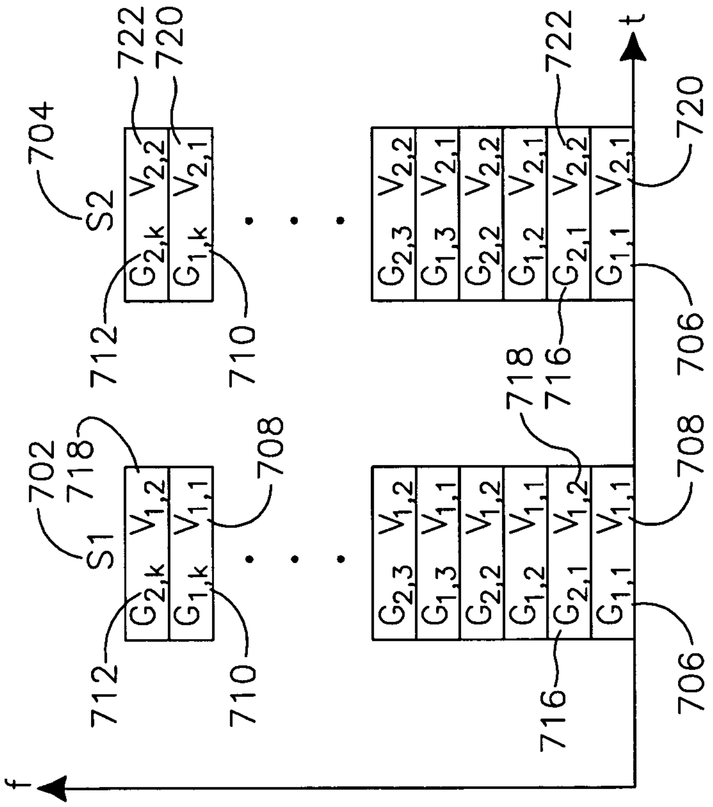
FIG.6

700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G2,3 V1,2
G1,k V1,1
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G2,1 V2,2
G1,2 V2,1
G2,2 V2,2
G1,3 V2,1
G2,3 V2,2
G1,k V2,1
G2,k V2,2

FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/003575

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/06

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)
H04B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 00/16437 A (SAMSUNG ELECTRONICS CO LTD [KR]) 23 March 2000 (2000-03-23) page 8, line 29 - page 13, line 6 page 14, line 25 - page 15, line 12 page 16, line 8 - page 17, line 13; figures 5,8	10-12 1-9
X A	US 6 574 267 B1 (KANTERAKIS EMMANUEL [US] ET AL) 3 June 2003 (2003-06-03) column 3, line 6 - column 5, line 35 column 6, lines 16-50; figures 3,4	9-12 1-9
X A	US 2004/085946 A1 (MORITA MINORI [JP] ET AL) 6 May 2004 (2004-05-06) paragraphs [0004] - [0007], [0027] - [0045], [0072] - [0078]	10-12 1-9

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2008	30/07/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ernst, Christian

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International application No
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