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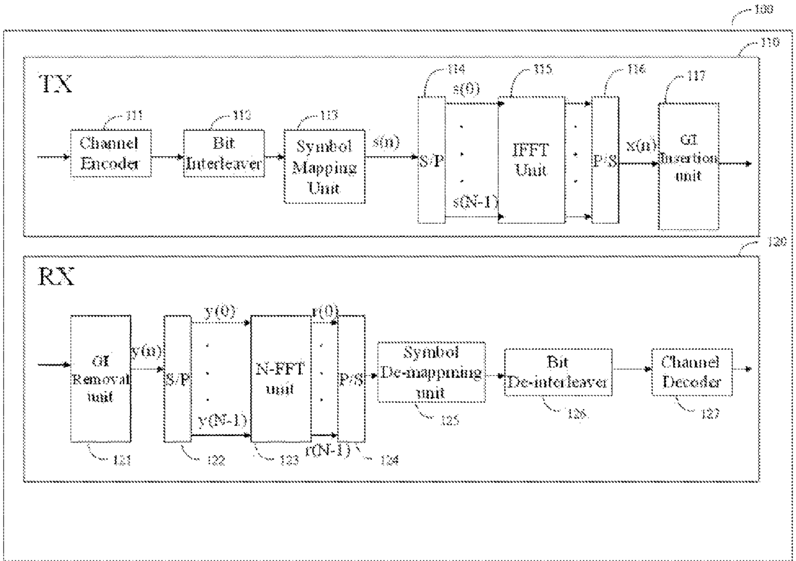

FIG. 1

(57) **Abstract:** A transmitter (200) for block transmissions includes a serial-to-parallel converter (240) for grouping data symbols into a number of M sub-blocks; a plurality of symbol phase rotation units (250-1, 250-M) for independently phase rotating each symbol in the M sub-blocks; a plurality of inverse fast Fourier transform (IFFT) units (260-1, 260-M) for transforming the phase rotated symbols into time domain symbols; and a parallel-to-serial converter (270) for concatenating the time domain symbols into a N-point time domain samples of an OFDM symbol.

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A BLOCK TRANSMISSION TECHNIQUE BASED ON SYMBOLS CONCATENATION

This application claims the benefit of U.S. Provisional Application No. 60/946,992 filed on July 27, 2007, the contents of which are herein incorporated by reference.

The invention relates generally to block transmission techniques.

The orthogonal frequency division multiplexing (OFDM) technique has been widely adopted by wideband/ultra-wideband communication standards, such as the WiMedia ultra wideband (UWB), 802.11n, and 802.16 WiMax. A typical OFDM communication system 100 including a transmitter 110 and a receiver 120 is shown Fig 1. At the transmitter 110, a channel encoder 111 encodes input information bits that are later interleaved at a bit level by a bit interleaver 112, and then mapped to symbols $s(n)$ by a symbol mapping unit 113. The symbols are then grouped into blocks by a serial-to-parallel (S/P) converter 114. Each block includes a number of N symbols. The symbol blocks are input to an N-point inverse fast Fourier transform (IFFT) unit 115 that together with a parallel-to-serial (P/S) converter 116 generate time-domain transmitted symbols $x(n)$. The size of the IFFT unit 115 is N, i.e., N data points (or sub-carriers) are transformed. A guard interval (GI) is added for each symbol block using a GI insertion unit 117. The GI may be one of a zero prefix, cyclic prefix, zero suffix, or cyclic suffix. The output of the GI insertion 117 unit is OFDM symbols.

At the receiver 120, the guard interval of each OFDM symbol is removed by a GI removal unit 121. Then, using a S/P converter 122 the time domain signal is converted to N-symbol blocks $y(n)$, $n=0,\ldots,N-1$ which are input to an N-point fast Fourier transform (FFT) unit 123 that together with P/S converter 124 generate frequency domain symbols $r(n)$. The size of the FFT unit 123 is N, i.e., N data points are transformed. The frequency domain symbols are then de-mapped to soft/hard bit streams using a symbol de-mapping unit 125. Through the de-interleaving process, carried out by a bit de-interleaver 126, and channel decoding process, performed by a channel decoder 127, the transmitted information bits are recovered.

The conventional OFDM technique has several drawbacks. One of the main drawbacks is a high value of a peak-to-average-power-ratio (PAPR) of transmitted signals. Specifically, a time-domain OFDM signal *x(n)* has a high PAPR value when the size of the IFFT unit 115 is large. A high value of PAPR greatly decreases the transmission power efficiency. To overcome this drawback several solutions have been proposed. These solutions include, for example, a coding method and a clipping method. However, these methods increase the system complexity and may degrade the overall performance.

Another drawback of a conventional OFDM technique is that the performance of transmissions with a weak channel code or without channel code is poor. This is due to the fact that a strong channel code is necessary to achieve frequency diversity. With a weak channel code, the OFDM technique cannot exploit the frequency diversity efficiently. In this case, its performance is mostly determined by sub-carriers with the lowest signal-to-noise-ratio (SNR). This limits the application of the conventional OFDM in high data rate wireless systems, such as high rate UWB systems. To overcome this drawback, precoding techniques have been proposed in the related art. Generally these techniques are based on joint modulation of symbols on multiple subcarriers. This ensures the recovery of symbols by a receiver even in deep fading conditions. However, the proposed precoding techniques significantly increase the complexity of the transmitter and receiver and in most cases are not feasible.

Certain embodiments of the invention include a transmitter for block transmissions. The transmitter comprises a serial-to-parallel converter for grouping data symbols into a number of M sub-blocks; a plurality of symbol phase rotation units for independently phase rotating each symbol in the M sub-blocks; a plurality of inverse fast Fourier transform (IFFT) units for transforming the phase rotated symbols into time domain symbols; and a parallel-to-serial converter for concatenating the time domain symbols into N-point time domain samples of an OFDM symbol.

Certain embodiments of the invention also include a method for block transmissions. The method comprises grouping data symbols into a number of M sub-blocks, wherein each sub-block includes a number of N divided by M (N/M) symbols; independently phase rotating each of the N/M symbols in each of the M sub-blocks; transforming the phase rotated symbols in each of the M sub-blocks into time domain symbols using a (N/M)-point inverse fast Fourier transform (IFFT) operation; and concatenating the time domain symbols in all the M sub-blocks into N-point time domain samples of an OFDM symbol.

Certain embodiments of the invention further include a computer readable medium for having stored thereon computer executable code, that when executed by a computer performs the process of grouping data symbols into a number of M sub-blocks, wherein each sub-block includes a number of N divided by M (N/M) symbols; independently phase rotating each of the N/M symbols in each of the M sub-blocks; transforming the phase rotated symbols into time domain symbols using (N/M)-point inverse fast Fourier transform (IFFT) operations; and concatenating the time domain symbols into N-point time domain samples of an OFDM symbol.

The subject matter that is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings.

Figure 1 is a schematic diagram of an OFDM based communication system;

Figure 2 is a block diagram of a transmitter according to one embodiment of the present invention;

Figure 3 illustrates the concatenation of symbols;

Figure 4 shows a block diagram of a receiver for decoding OFDM symbols according to one embodiment of the present invention;

Figure 5 illustrates examples of a PAPR reduction achieved using the block transmission technique;

Figure 6 illustrates the diversity product of symbols generated according to one embodiment of the present invention; and

Figure 7 is a flowchart describing the operation of the block transmission technique implemented according to certain embodiments of the present invention.

It is important to note that the embodiments disclosed by the invention are only examples of the many advantageous uses of the innovative teachings herein. In general, statements made in the specification of the present application do not necessarily limit any of the various claimed inventions. Moreover, some statements may apply to some inventive features but not to others. In general, unless otherwise indicated, singular elements may be in plural and vice versa with no loss of generality. In the drawings, like numerals refer to like parts through several views.

Fig. 2 shows an exemplary and non-limiting block diagram of a transmitter 200 for performing a block transmission technique according to one embodiment of the present invention. The transmitter 200 includes a channel encoder 210, a bit interleaver 220, a symbol mapping unit 230, a S/P converter 240, and a GI insertion unit 280 having similar functionality to the respective components described above.

The transmitter 200 further includes a P/S converter 270 and a number of M symbol phase rotation units 250-1 through 250-M coupled to a number of M IFFT units 260-1 through 260-M. The size of each IFFT unit 260-X (where X is greater than or equal to 1) is N/M, where N denotes the number of sub-carriers in an OFDM symbol. The ratio N/M is an integer number. For example, if M=4 and N=128, the size of an IFFT unit 260-X is 32, which means that the number of sampling points of the IFFT operation is 32. It is appreciated that by using M IFFT units the IFFT size of each such unit is reduced by a factor of M.

In accordance with the principles of the invention input information bits are encoded and interleaved, then mapped to data symbols *s(n)*, which may be taken from QAM constellations or PSK constellations. The *s(n)* data symbols are divided into a number of M sub-blocks s_i, $0 \le i \le M-1$. Each sub-block s_i consists of (N/M) symbols $s_i(k)$ $0 \le k \le N/M-1$. The mapping between the data symbols *s(n)* and the symbols $s_i(k)$ can be any one-to-one mapping. In one embodiment, the mapping may be defined as follows:

$$s_i(k)=s(i*N/M+k)$$

where, i=0,1, …, M-1 and k=0,1, …, (N/M)-1.

Thereafter, each symbol $s_i(k)$ is independently phase rotated by the symbol phase rotation units 250-i to output a phase rotated symbol $\hat{s}_i(k)$. In one embodiment, the phase rotation operation may be defined as follows:

$$\hat{s}_i(k)=s_i(k)*e^{j\theta_i(k)}$$

The rotation angle $\theta_i(k)$ can be chosen to optimize the performance of the transmitter 200. For example, if *s(n)* are taken from QAM constellations (integer lattice) and $M=2^v, v=1,2...$, the optimal rotation angle depends on the sub-block index $i \in [0, M-1]$ and the sub-carrier index $k \in [0, N/M-1]$, and can be calculated as follows:

$$\theta_i(k)=2\pi*i*(\frac{k}{N}-\frac{1}{4M})$$

It would be appreciated by one of ordinary skill in the art that the phase rotation operation performed by a symbol phase rotation unit 250-X is different from a linear precoding operation, as such operation rotates a symbol vector with an unitary rotation matrix, while a symbol phase rotation unit 250-X rotates each symbol (not symbol vectors) independently. Subsequently, IFFT units 260-

i transform the phase rotated symbols $\hat{s}_i(k)$ into time domain symbols $\hat{x}_i(l)$. The N/M time domain symbols, $\hat{x}_i(l), 0 \le l \le N/M - 1$, are grouped in a time domain sub-blocks $\hat{x}_i$, where the total number of sub-blocks is M. In one embodiment, the operation of an IFFT unit 260-i includes sampling only N/M points and may be defined as follows:

$$\hat{x}_i(l) = \frac{1}{\sqrt{N/M}} \sum_{k=0}^{N/M-1} \hat{s}_i(k) * e^{j2\pi\frac{lk}{N/M}}, 0 \le l \le N/M - 1; 0 \le k \le M - 1;$$

The M output time-domain sub-blocks $\hat{x}_i$ {i = 0,1, ..., M-1} are concatenated by the P/S converter 270 to generate the transmitted N-point time domain samples $x(n)$ of an OFDM symbol, as follows:

$$x(i + l * M) = \hat{x}_i(l), 0 \le l \le N/M - 1, 0 \le i \le M - 1$$

That is, the concatenation process includes linking the respective j^{th} {j = 0, 1,..., N/M-1} symbols $\hat{x}_i(j)$ of the time domain sub-blocks $\hat{x}_i$. The concatenation process is further illustrated in Fig. 3. The GI interval insertion unit 280 inserts a guard interval (GI) which may be a zero-prefix, zero-suffix, cyclic-prefix, or cyclic-suffix.

It is appreciated that the transmitter 200 requires only a number of M (N/M)-point IFFT units to generate OFDM symbols. Therefore, the complexity of the transmitter 200 is $M * (N/M)\log_2(N/M) = N\log_2(N/M)$. In a conventional OFDM transmitter, where a single N-point IFFT is utilized, the complexity is $N\log_2(N)$. Thus, in comparison to a conventional OFDM transmitter, the block transmission technique reduces the complexity by $N\log_2(M)$ each OFDM symbol calculation.

Fig. 4 shows an exemplary and non-limiting block diagram of a receiver 400 for decoding OFDM symbols, for example OFDM symbols generated by the transmitter 200, according to one embodiment of the present invention. The receiver 400 includes a GI removal unit 410, a S/P converter 420, a P/S converter 450, a bit de-interleaver 460, and a channel decoder 470 having similar functionality to the respective components described above. The receiver 400 further includes a number of M FFT units 430-1 through 430-M, each of which having a size of N/M sampling points and M symbol de-mapping units 440-1 through 440-M.

The GI removal unit 410 remove the GI from a received OFDM symbol to generate time domain signals y(n), which are then grouped into M sub-blocks $y_i, 0 \le i \le M-1$. Each sub-sub block includes N/M symbols $y_i(k)$ $0 \le k \le N/M-1$. The grouping is performed by the S/P converter as follows:

$$y_i(l) = y(i + l * M).$$

In accordance with certain principles of the invention, the M FFT units 430-X are utilized to transform the M sub-blocks $y_i(k)$ into frequency domain symbols $\hat{r}_i(k)$. In one embodiment, the transformation is performed as follows:

$$\hat{r}_i(k) = \frac{1}{\sqrt{N/M}} \sum_{l=0}^{N/M-1} y_i(l) * e^{-j2\pi \frac{lk}{N/M}}$$

Using the symbol de-mapping units 440-X, frequency domain symbols $\hat{r}_i(k)$ are grouped into N/M M-point symbol vectors: $\vec{r}(k), k = 0,1 \ldots N/M - 1$ as follows:

$$\vec{r}(k) = [r_0(k), r_1(k), \ldots, r_{M-1}(k)]^T, k = 0,1 \ldots N/M - 1.$$

Then, a de-mapping operation is performed to compute soft/hard coded bit information. This can be achieved using, for example, a log-sum maximum likelihood (ML) method, a minimum-mean-square-error (MMSE) linear demapper method, and a Zero-Forcing (ZF) linear demapper method. All of these methods are known in the related art.

In either of these methods the values of frequency domain channel parameters should be first computed. Typically, these parameters can be computed using a preamble transmitted as part of an OFDM symbol. In accordance with an embodiment of the invention, a preamble generated by a conventional N-point OFDM system can be used to directly compute the channel estimation (CE) parameters. In accordance with another embodiment, a modified preamble can be generated and transmitted by the transmitter 200. This preamble can be utilized by the symbol de-mapping unit 440-X to compute the CE parameters. In accordance with the embodiment, the CE preamble may have the following sequence:

$$s_i(k) = \begin{cases} t(k) & k = i + aM \\ 0 & ,otherwise \end{cases}$$

where, $s_i(k)$ are signals in the CE preamble, and $t(k), k = 0,1,...,N/M-1$ are frequency domain training symbols.

The receiver 400 requires only a number of M (N/M)-point FFT units to generate OFDM symbols. Therefore, the complexity of the transmitter 200 is $M*(N/M)\log_2(N/M) = N\log_2(N/M)$. Again, in comparison to a conventional OFDM transmitter the block transmission technique described herein reduces the complexity by $N\log_2(M)$ for each OFDM symbol calculation. It should be noted that the parameter M provides a degree of freedom to make a trade-off between the performance and the complexity of the receiver.

Fig. 5 shows an example of how a block transmission technique reduces the PAPR in comparison to conventional techniques. A curve 510 is the PARP of a transmitter that includes a single 256-point IFFT unit; a curve 520 is the measured PARP of a transmitter that includes two 128-point IFFT units; a curve 530 represents the PARP of a transmitter that includes four 64-point IFFT units; and a curve 540 is the measured PARP of a transmitter that includes eight 32-point IFFT units. As can be noticed, using lower size IFFT units reduces the PARP of transmitted symbols.

Fig. 6 shows the diversity product of a (N/M)-point IFFT unit for each sub-block $\hat{x}_i$ {i = 0, 1, 2,…, 31}. (i.e., N=128 and M=4}. In this case, the quadrature phase shift keying (QPSK) modulation is used. The curve 610 shows the achieved diversity product of a symbol phase rotated sub-block, while curve 620 is the achieved diversity product when the input sub-block is not phase rotated. As can be noticed from curve 620, some of the sub-blocks have zero diversity product, which means that such sub-blocks cannot achieve diversity order of 4. On the other hand, using symbol phase rotation, all the sub-blocks achieve diversity order of 4 and diversity product of 16.

Fig. 7 shows an exemplary and non-limiting flowchart 700 describing the operation of the block transmission technique implemented according to certain embodiments of the invention. At S710, encoded and interleaved information bits are mapped to data symbols *s(n)*. The symbols *s(n)* may be constellation values of a modulation technique, such as QAM, PSK, and the like. At S720, the data symbols *s(n)* are divided into a number of M sub-blocks s_i, each of which includes N/M symbols $s_i(k)$. At S730, each symbol $s_i(k)$ is independently phase rotated by, for example, the symbol phase rotation units 250-i to output phase rotated symbol $\hat{s}_i(k)$. At S740, the phase rotated symbols $\hat{s}_i(k)$ are transformed into time domain symbols $\hat{x}_i(l)$ using M (N/M)-point IFFT units. Each N/M time domain symbols are grouped into a time domain sub-block $\hat{x}_i$. At S750, the M output time-domain sub-blocks $\hat{x}_i$ {i = 0,1, ..., M-1} are concatenated to generate a N-point time domain symbol $x(n)$ of an OFDM symbol. The concatenation step includes linking the respective j^{th} {j = 0, 1,..., N/M-1} time domain symbols of time domain sub blocks $\hat{x}_i$. At S760, a guard interval is inserted to the N-point time domain symbol to generate an N-point OFDM.

The block transmission technique, transmitter 200 and receiver 400 described herein can be implemented in communication systems including, but not limited to, a WiMedia UWB system (including future generations of UWB systems), a 802.11n system, a 802.16 system (WiMax), and the like.

The foregoing detailed description has set forth a few of the many forms that the invention can take. It is intended that the foregoing detailed description be understood as an illustration of selected forms that the invention can take and not as a limitation to the definition of the invention. It is only the claims, including all equivalents that are intended to define the scope of this invention.

Most preferably, the principles of the invention are implemented as a combination of hardware, firmware and software. Moreover, the software is preferably implemented as an application program tangibly embodied on a program storage unit or computer readable medium. The application program may be uploaded to, and executed by, a machine comprising any suitable architecture. Preferably, the machine is implemented on a computer platform having hardware such as one or more central processing units ("CPU"), a memory, and input/output interfaces. The computer platform may also include an operating system and microinstruction code. The various processes and functions described herein may be either part of the microinstruction code or part of the application program, or any combination thereof, which may be executed by a CPU, whether or not such computer or processor is explicitly shown. In addition, various other peripheral units may be connected to the computer platform such as an additional data storage unit and a printing unit.

Claims

What we claim is:

1. A transmitter (200) for block transmissions, comprising:

a serial-to-parallel converter (240) for grouping data symbols into a number of M sub-blocks;

a plurality of symbol phase rotation units (250-1, 250-M) for independently phase rotating each symbol in the M sub-blocks;

a plurality of inverse fast Fourier transform (IFFT) units (260-1, 260-M) for transforming the phase rotated symbols into time domain symbols; and

a parallel-to-serial converter (270) for concatenating the time domain symbols into N-point time domain samples of an OFDM symbol.

2. The transmitter of claim 1, further comprising:

a guard interval insertion unit (280) for inserting a guard interval into the OFDM symbol.

3. The transmitter of claim 2, further comprising:

a channel encoder (210) for encoding input information bits;

a bit interleaver (220) for bit interleaving the encoded information bits; and

a symbol mapping unit (230) for mapping the interleaved bits to the data symbols.

4. The transmitter of claim 1, wherein the number of phase rotation units and the number of IFFT units equal the number of sub-blocks, wherein each of the sub-block includes a number of N divided by M (N/M) symbols.

5. The transmitter of claim 1, wherein each of the plurality of phase rotation units multiplies each symbol by a value of $e^{j\theta_i(k)}$, wherein $\theta_i(k)$ is rotation angle.

6. The transmitter of claim 1, wherein the size of each of the plurality of IFFT units is N/M, where N is the number of sub-carriers in the OFDM symbols.

7. The transmitter of claim 6, wherein each of IFFT units samples N/M points to generate a time domain symbol.

8. The transmitter of claim 8, wherein the P/S converter concatenates the time domain symbols by linking the respective time domain symbols of time domain sub-blocks, wherein each of the time domain sub-blocks includes N/M time domain symbols.

9. The transmitter of claim 1, wherein a channel estimate (CE) preamble is generated, the (CE) preamble including a sequence of symbols s_i

$$s_i(k) = \begin{cases} t(k) & k = i + aM \\ 0 & , otherwise \end{cases}.$$

10. A method (700) for block transmissions, comprising:

grouping data symbols into a number of M sub-blocks, wherein each sub-block includes a number of N divided by M (N/M) symbols (S720);

independently phase rotating each of the N/M symbols in each of the M sub-blocks (S730);

transforming the phase rotated symbols into time domain symbols (S740) using an inverse fast Fourier transform (IFFT) operation; and

concatenating the time domain symbols into a N-point time domain samples of an OFDM symbol (S750).

11. The method of claim 10, further comprising:
inserting a guard interval into the OFDM symbol (S760).

12. The method of claim 11, further comprising:
encoding input information bits;
bit interleaving the encoded information bits; and
mapping the interleaved bits to the data symbols (S710).

13. The method of claim 10, wherein the IFFT operation comprises sampling N/M points to generate a time domain symbol.

14. The method of claim 10, wherein concatenating the time domain symbols further includes linking the respective time domain symbols of time domain sub-blocks.

15. A computer readable medium having stored thereon computer executable code, the execution of the code causing:

grouping data symbols into a number of M sub-blocks, wherein each sub-block includes a number of N divided by M (N/M) symbols (S720);

independently phase rotating each of the N/M symbols in the M sub-blocks (730);

transforming the phase rotated symbols into time domain symbols (S740) using an inverse fast Fourier transform (IFFT) operation; and

concatenating the time domain symbols into a N-point time domain samples of an OFDM symbol (S750).

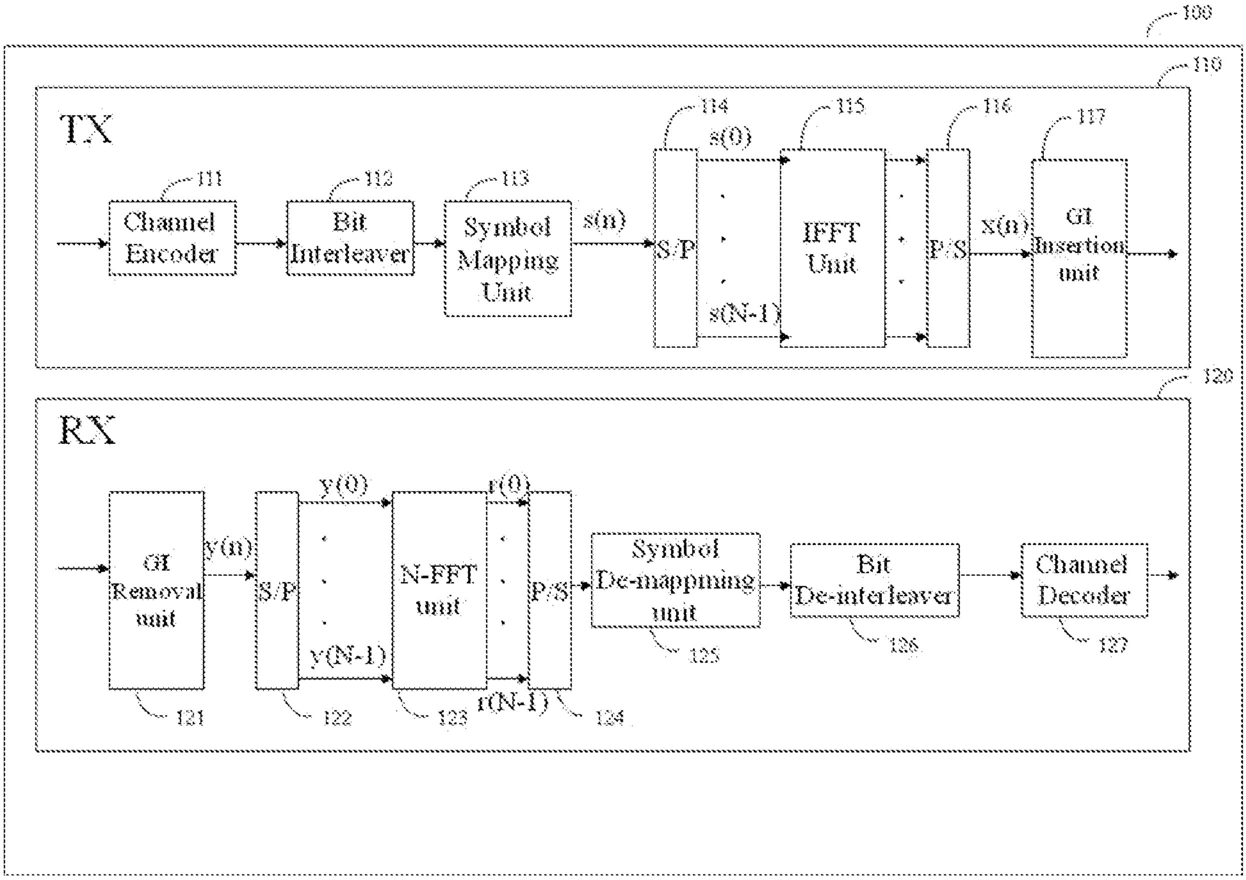

100
110
TX
111
112
113
114
115
116
117
Channel Encoder
Bit Interleaver
Symbol Mapping Unit
s(n)
S/P
s(0)
s(N-1)
IFFT Unit
P/S
x(n)
GI Insertion unit
120
RX
GI Removal unit
y(n)
S/P
y(0)
y(N-1)
N-FFT unit
r(0)
r(N-1)
P/S
Symbol De-mappming unit
Bit De-interleaver
Channel Decoder
121
122
123
124
125
126
127

FIG. 1

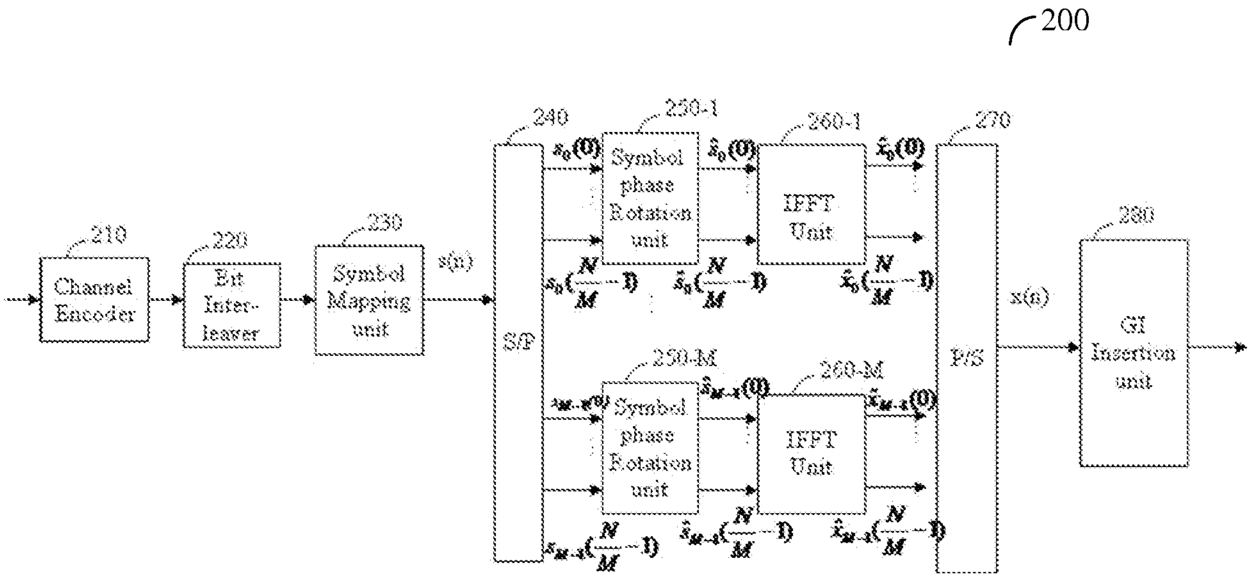
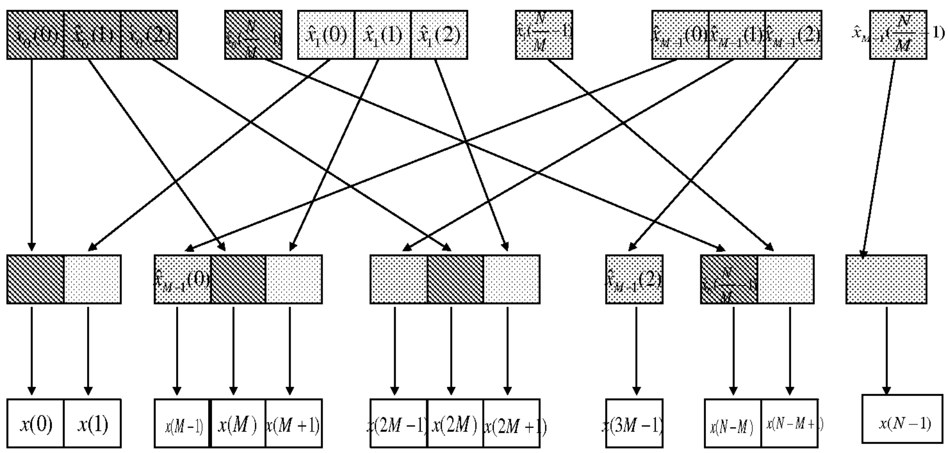

200
210
Channel Encoder
220
Bit Inter-leaver
230
Symbol Mapping unit
s(n)
240
S/P
250-1
Symbol phase Rotation unit
260-1
IFFT Unit
250-M
Symbol phase Rotation unit
260-M
IFFT Unit
270
P/S
x(n)
280
GI Insertion unit

FIG. 2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x(1)
x(M-1)
x(M)
x(M+1)
x(2M-1)
x(2M)
x(2M+1)
x(3M-1)
x(N-M)
x(N-M+1)
x(N-1)

FIG. 3

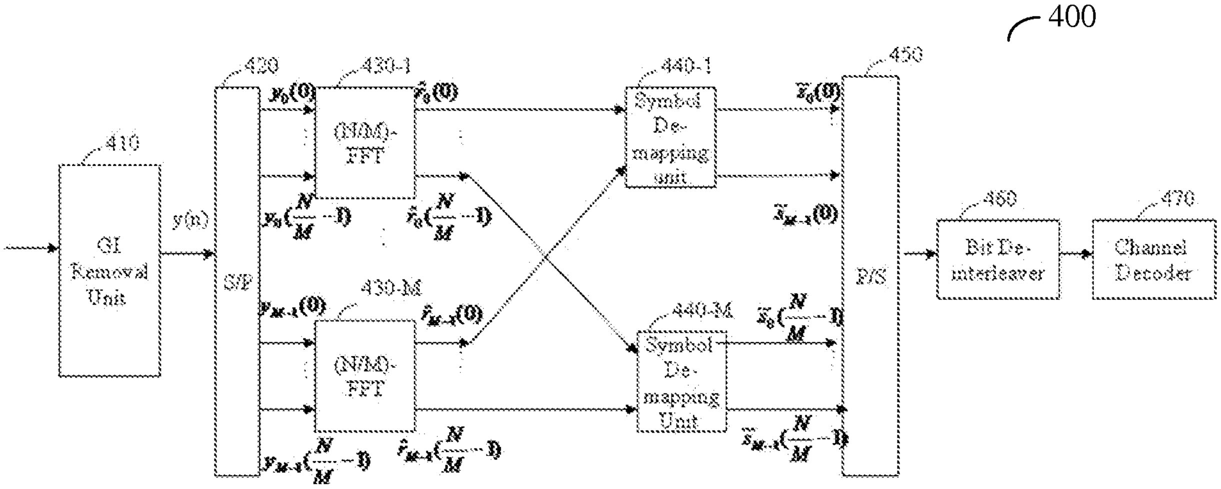
400
410
GI Removal Unit
y(n)
420
S/P
430-1
(N/M)-FFT
430-M
(N/M)-FFT
440-1
Symbol De-mapping unit
440-M
Symbol De-mapping Unit
450
P/S
460
Bit De-interleaver
470
Channel Decoder

FIG. 4

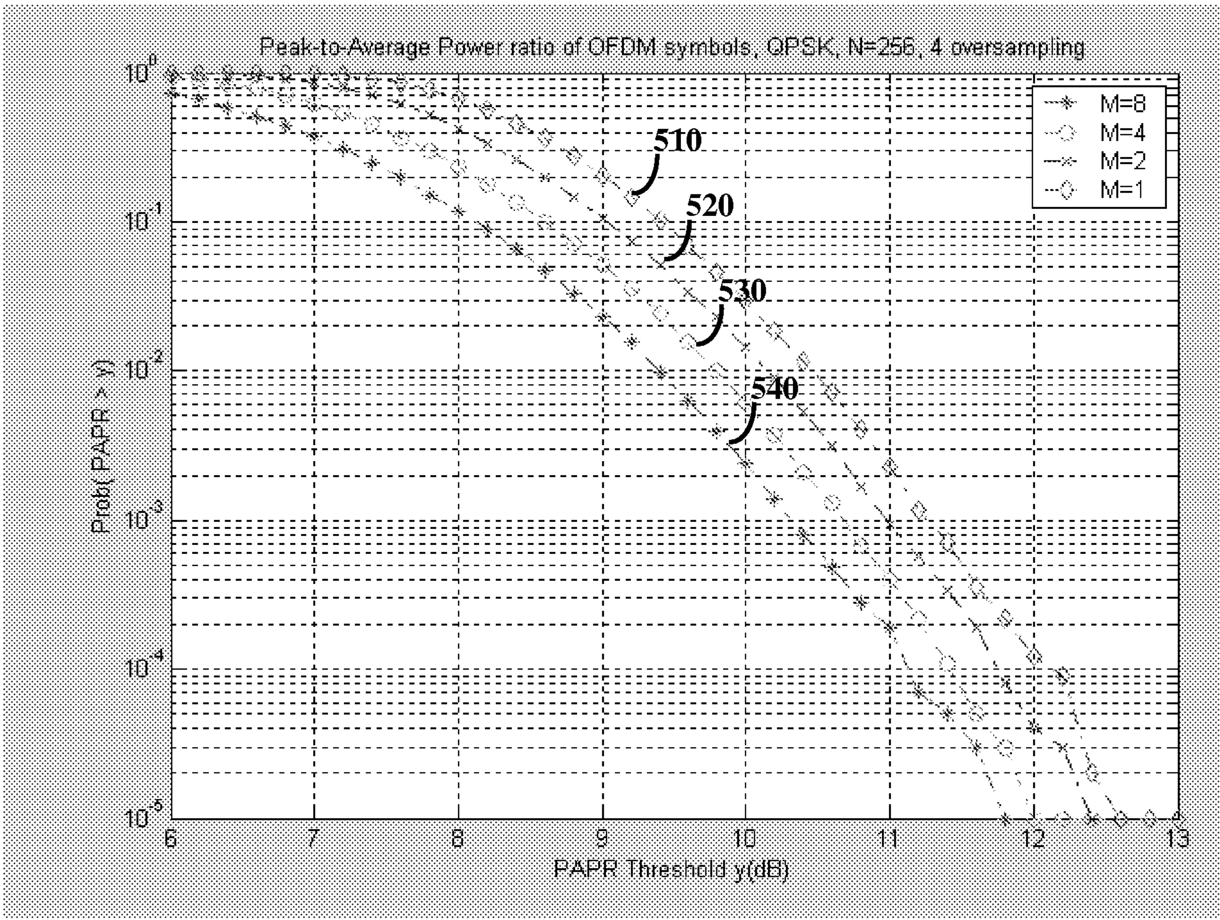
Peak-to-Average Power ratio of OFDM symbols, QPSK, N=256, 4 oversampling
Prob(PAPR > y)
PAPR Threshold y(dB)
M=8
M=4
M=2
M=1
510
520
530
540
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
6
7
8
9
10
11
12
13

Fig. 5

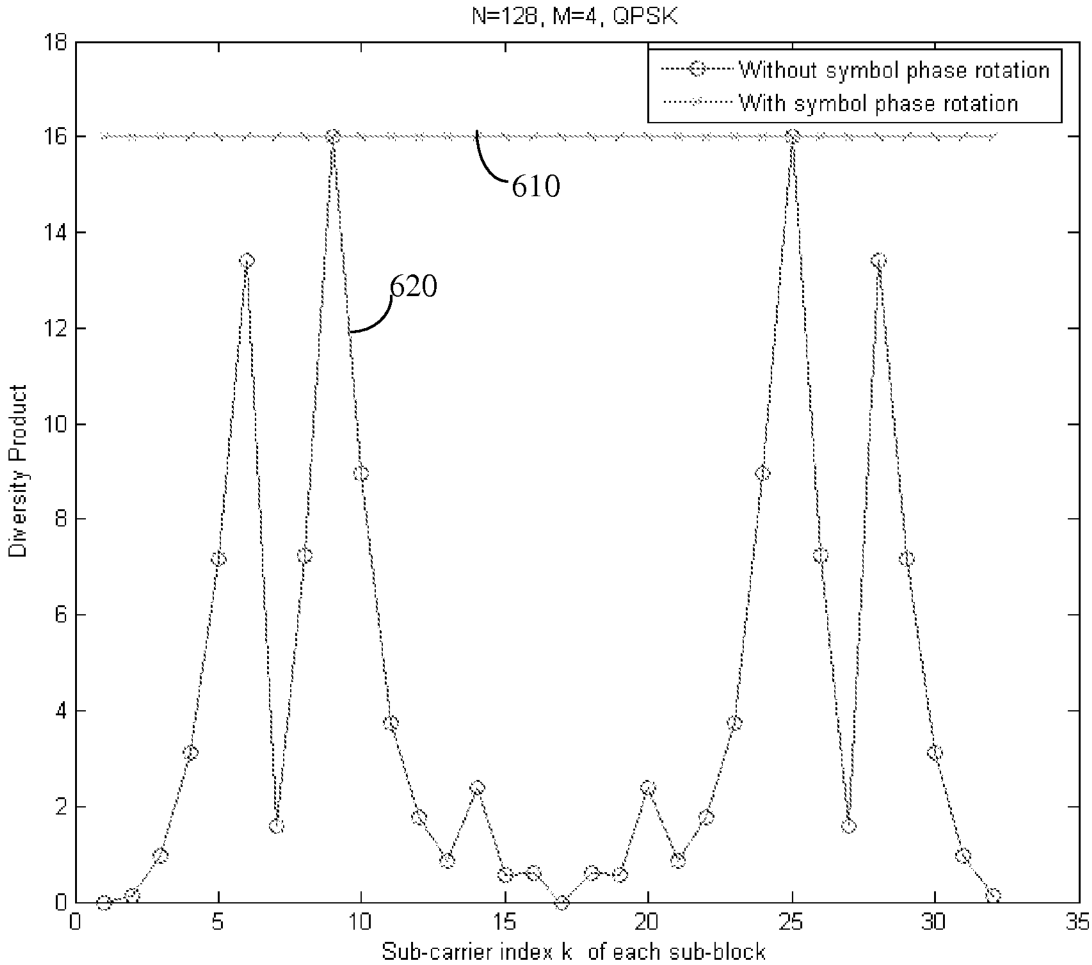
N=128, M=4, QPSK
Without symbol phase rotation
With symbol phase rotation
610
620
Diversity Product
Sub-carrier index k of each sub-block
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35

FIG. 6

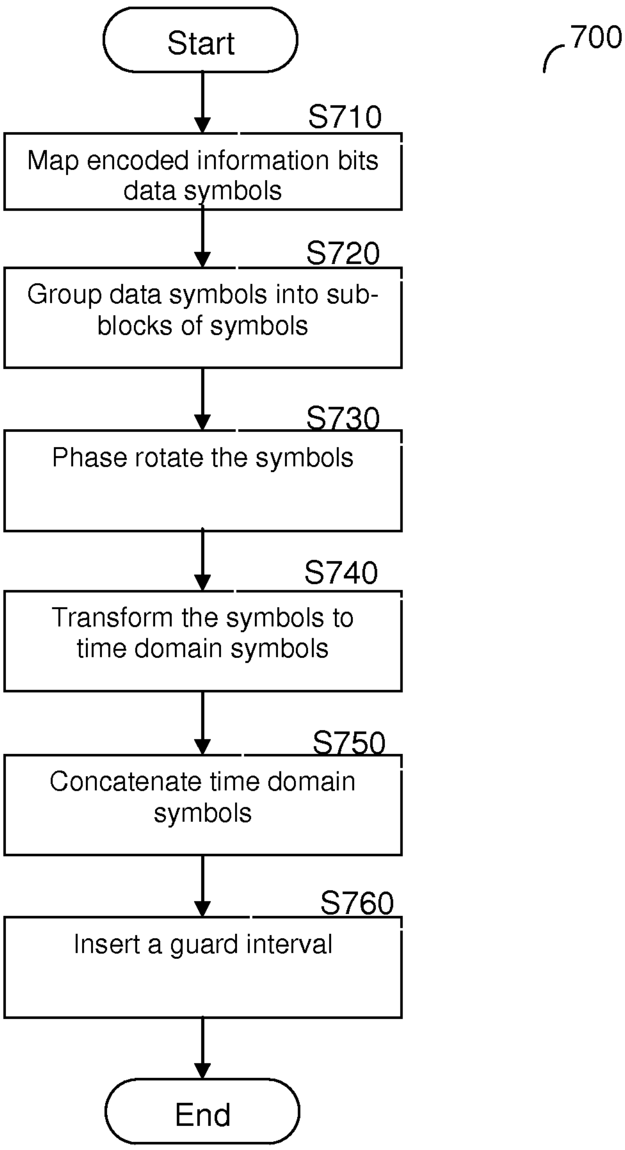
700
Start
S710
Map encoded information bits data symbols
S720
Group data symbols into sub-blocks of symbols
S730
Phase rotate the symbols
S740
Transform the symbols to time domain symbols
S750
Concatenate time domain symbols
S760
Insert a guard interval
End

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/053005

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L27/26

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)
H04L

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, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 381 196 A (SAMSUNG ELECTRONICS CO LTD [KR]) 14 January 2004 (2004-01-14) paragraphs [0008] - [0010], [0018], [0024] - [0026], [0032] - [0046]; claims 1,7; figures 2,3	1-15
X	JAYALATH A D S ET AL: "REDUCED COMPLEXITY PTS AND NEW PHASE SEQUENCES FOR SLM TO REDUCE PAP OF AN OFDM SIGNAL" VTC 2000-SPRING. 2000 IEEE 51ST. VEHICULAR TECHNOLOGY CONFERENCE PROCEEDINGS. TOKYO, JAPAN, MAY 15-18, 2000; [IEEE VEHICULAR TECHNOLGY CONFERENCE], NEW YORK, NY : IEEE, US, vol. 3, 15 May 2000 (2000-05-15), pages 1914-1917, XP000968337 ISBN: 978-0-7803-5719-8 page 1916, left-hand column; figures 1,2	1-15

-/--

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

[X] See patent family annex.

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"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 December 2008	15/12/2008

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/053005

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 1 357 718 A (SAMSUNG ELECTRONICS CO LTD [KR]) 29 October 2003 (2003-10-29) paragraphs [0019] - [0024], [0047] - [0057], [0062] - [0071]; figures 1,5,9	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2008/053005

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			US	2003202460	A1	30-10-2003
			US	2008049602	A1	28-02-2008