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(54) **ORTHOGONAL COMPLEX SPREADING METHOD FOR MULTICHANNEL AND APPARATUS THEREOF**

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(73) Assignee: **Electronics and Telecom Research Institute**, Daejeon (KR)

(21) Appl. No.: **10/932,227**

(22) Filed: **Sep. 2, 2004**

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Filed: **Mar. 27, 2001**

U.S. Applications:

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04B 1/707 (2006.01)

(52) **U.S. Cl.** **375/141**; 375/146; 375/298

(58) **Field of Classification Search** 375/130, 375/140, 141, 146, 259, 261, 295, 298
See application file for complete search history.

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(74) *Attorney, Agent, or Firm*—Hunton & Williams LLP

(57) **ABSTRACT**

An orthogonal complex spreading method for a multichannel and an apparatus thereof are disclosed. The method includes the steps of complex-summing $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{M,n1}$ by a first data X_{n1} of a n-th block and $\alpha_{n2}W_{M,n2}X_{n2}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{1,n2}$ by a second data X_{n2} of a n-th block; complex-multiplying $\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2}$ which is summed in the complex type and $W_{M,n3}+jPW_{M,n4}$ of the complex type using a complex multiplier and outputting as an in-phase information and quadrature phase information; and summing only in-phase information outputted from a plurality of blocks and only quadrature phase information outputted therefrom and spreading the same using a spreading code.

287 Claims, 21 Drawing Sheets

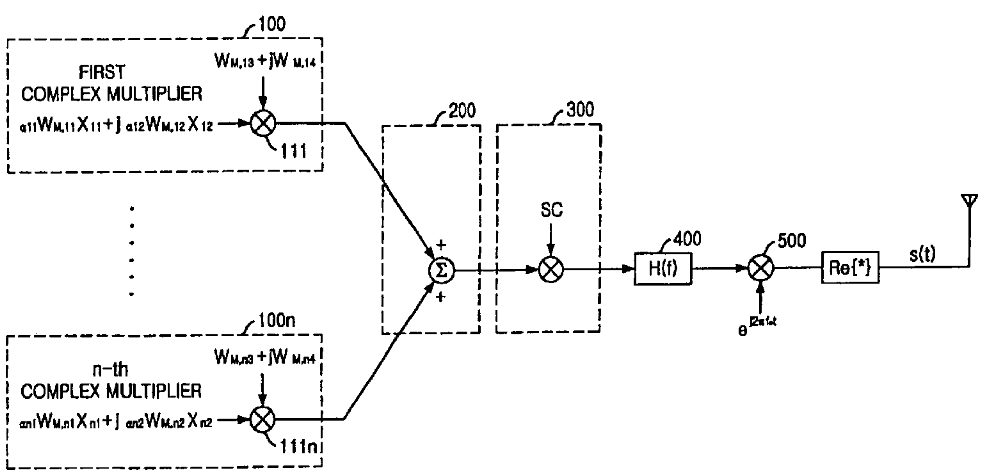

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FIG. 1
(CONVENTIONAL ART)

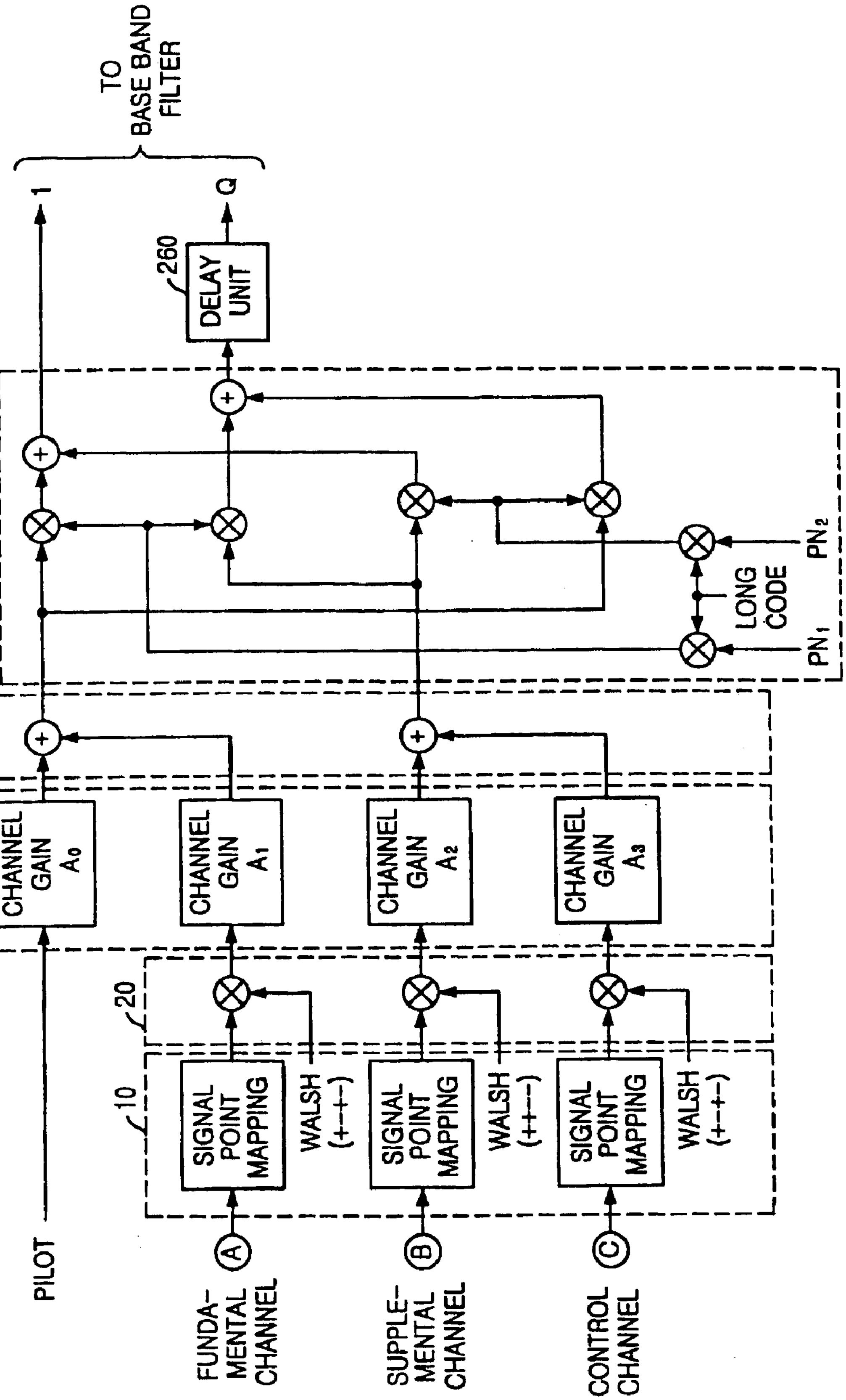


FIG. 2a

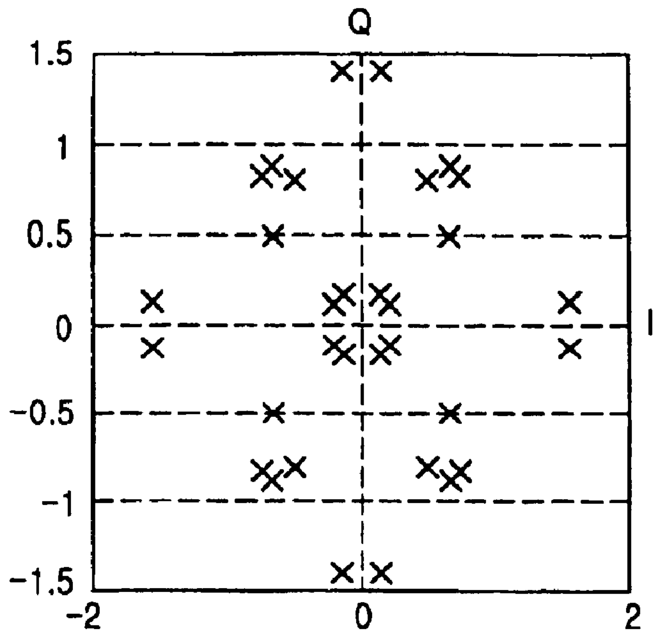


FIG. 2b

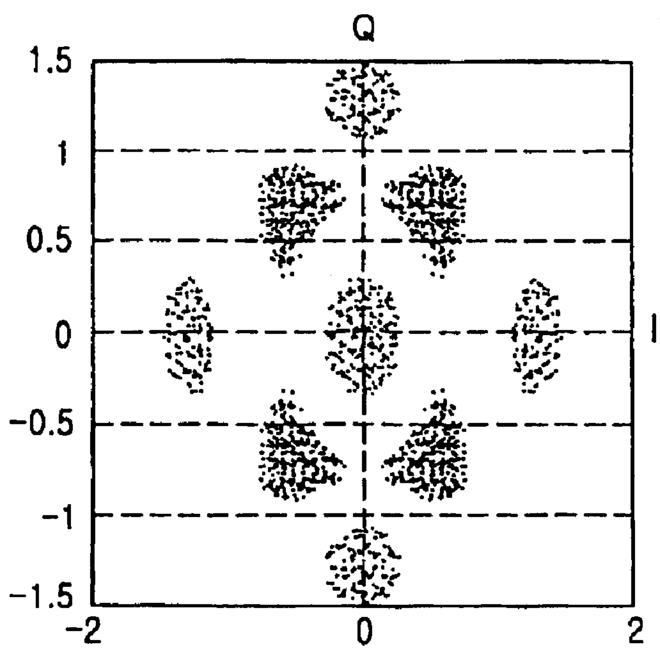


FIG. 3a
(CONVENTIONAL ART)

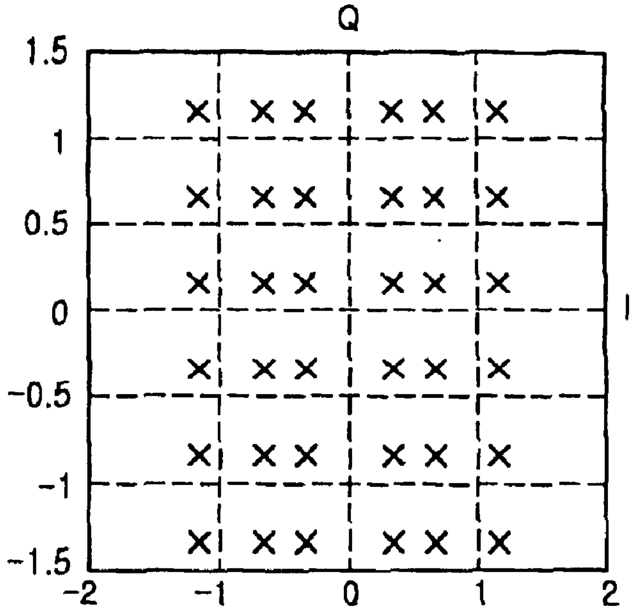


FIG. 3b
(CONVENTIONAL ART)

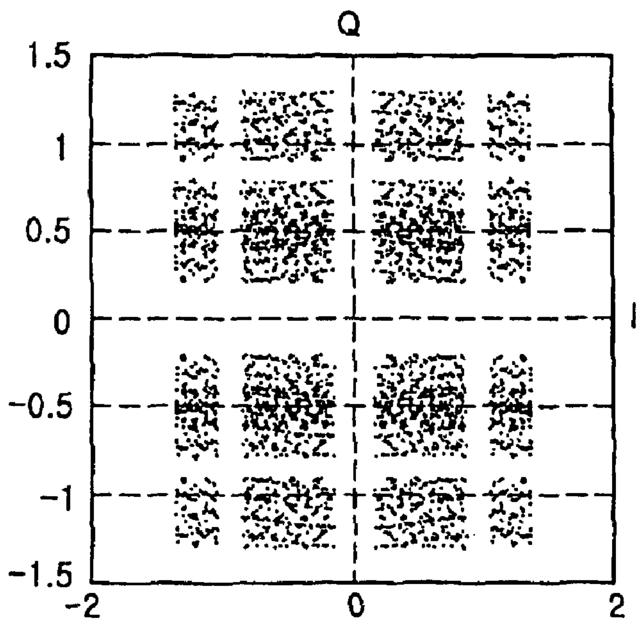
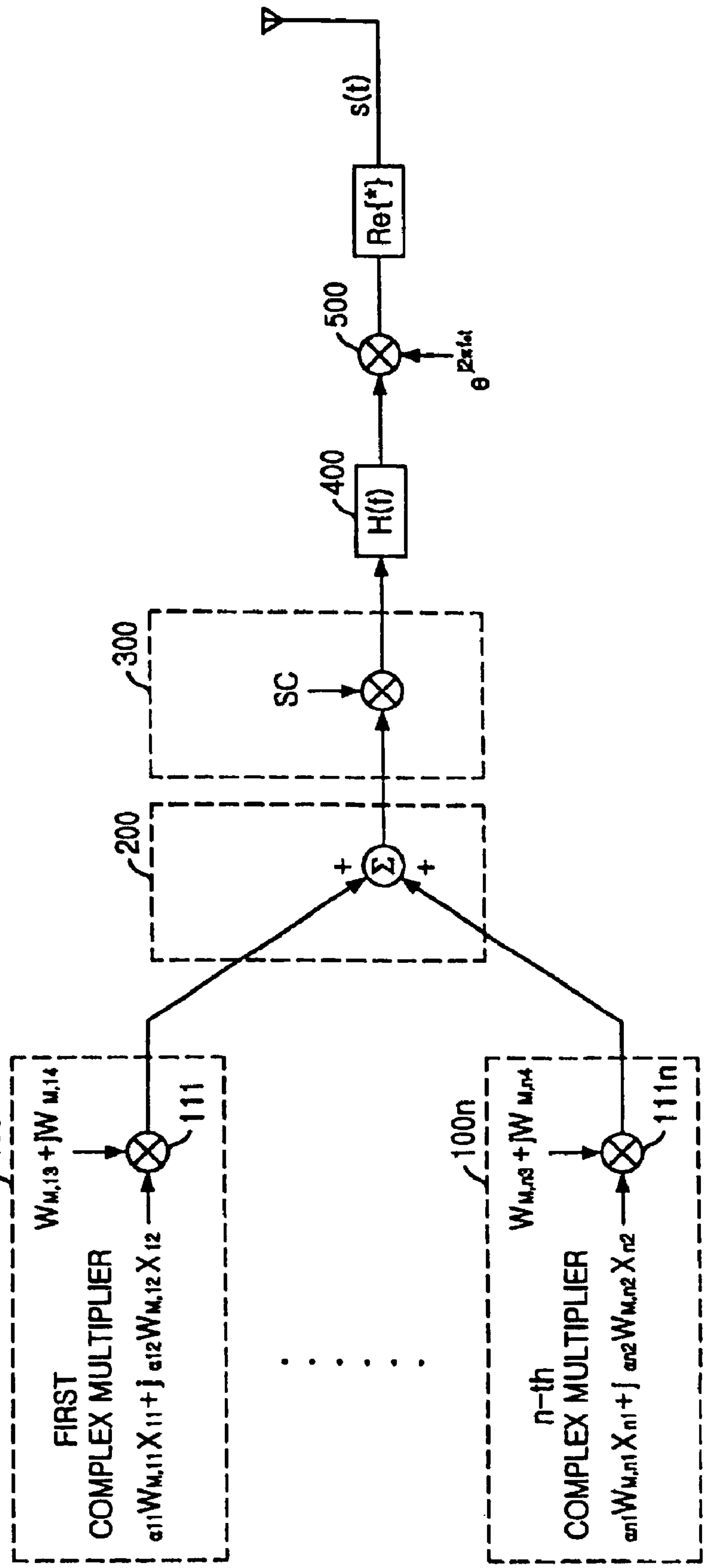


FIG. 4



FIRST
COMPLEX MULTIPLIER
n-th
COMPLEX MULTIPLIER
100
100n
111
111n
200
300
SC
400
H(f)
500
Re{*}
s(t)

FIG. 5a

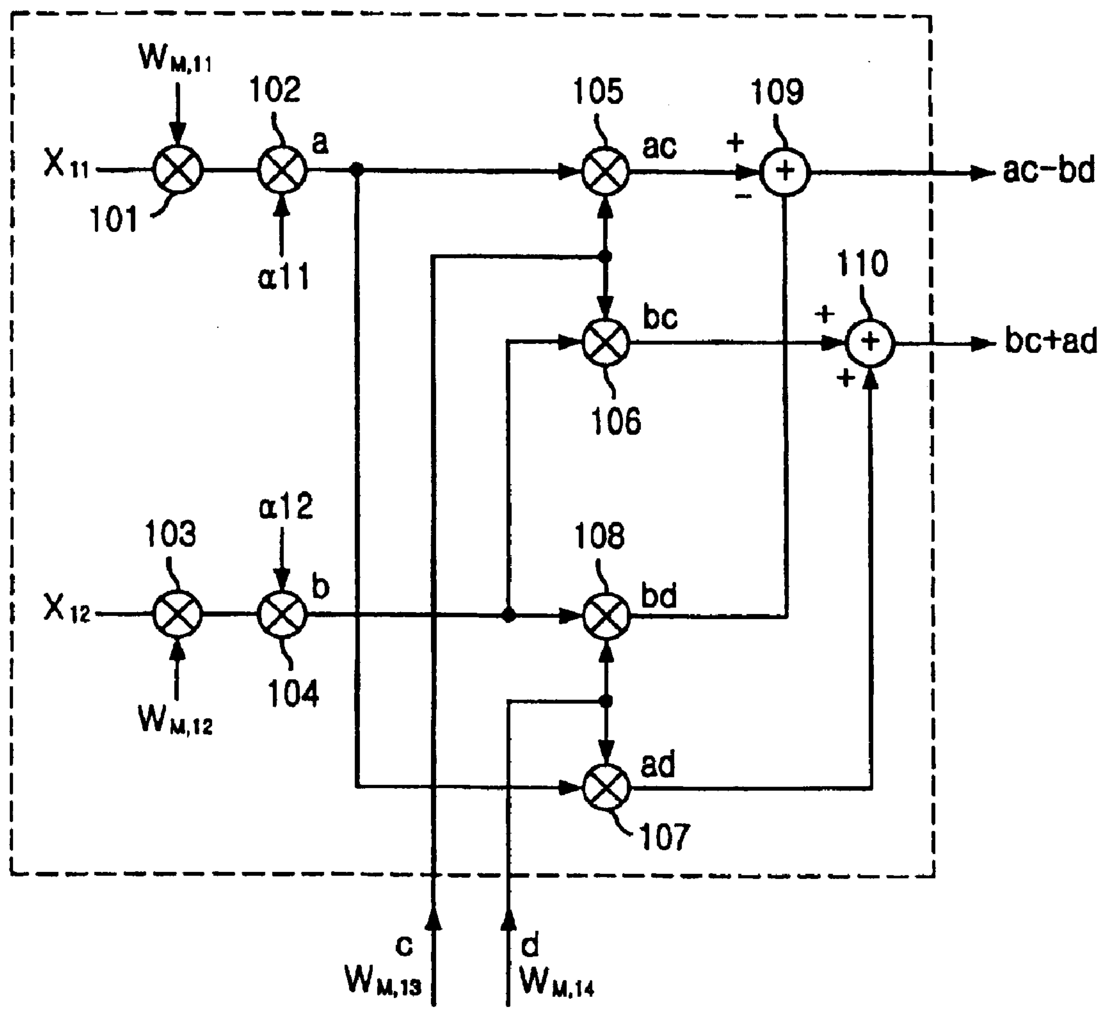

W_M,11
102
105
109
X11
a
ac
+
ac−bd
−
101
α11
110
bc
+
bc+ad
+
106
α12
103
108
X12
b
bd
104
W_M,12
ad
107
c
W_M,13
d
W_M,14

FIG. 5b

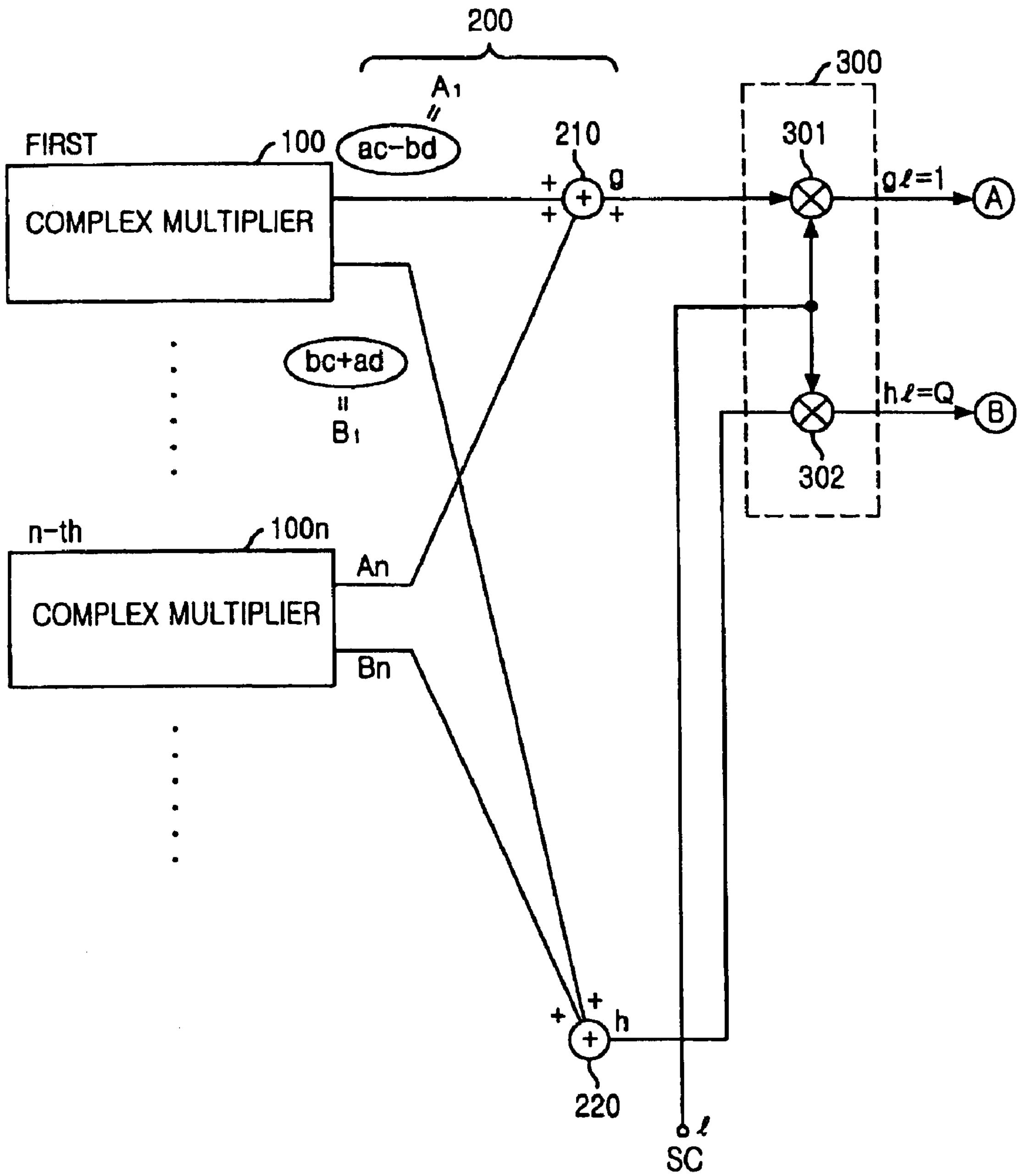

200
300
A1
ac-bd
FIRST
100
210
301
COMPLEX MULTIPLIER
g
gℓ=1
A
bc+ad
B1
hℓ=Q
B
302
n-th
100n
An
COMPLEX MULTIPLIER
Bn
h
220
ℓ
SC

FIG. 5c

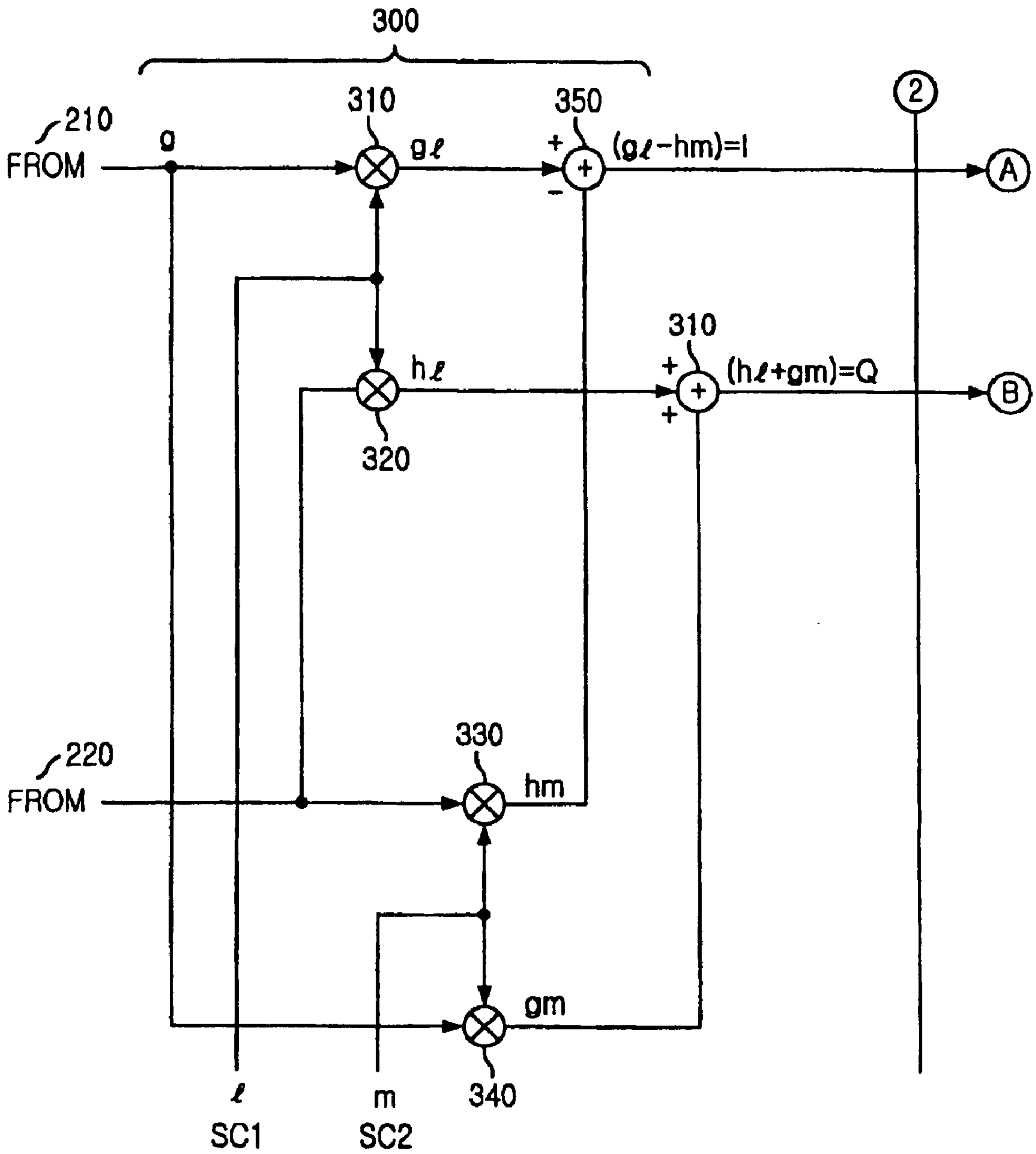

300
210
FROM
g
310
gℓ
350
+
−
(gℓ−hm)=I
2
A
310
hℓ
+
+
(hℓ+gm)=Q
B
320
220
FROM
330
hm
gm
340
ℓ
SC1
m
SC2

FIG. 5d

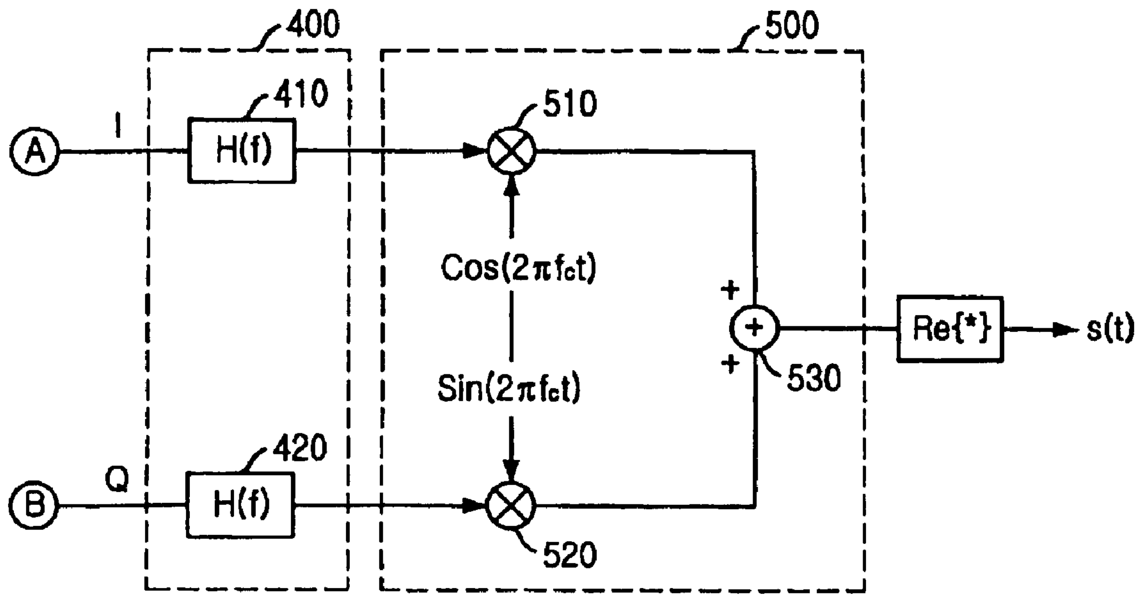


FIG. 6a

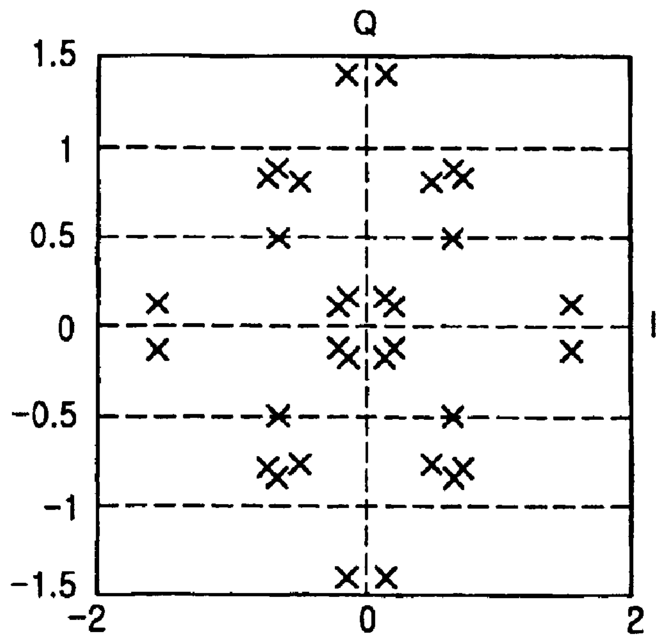


FIG. 6b

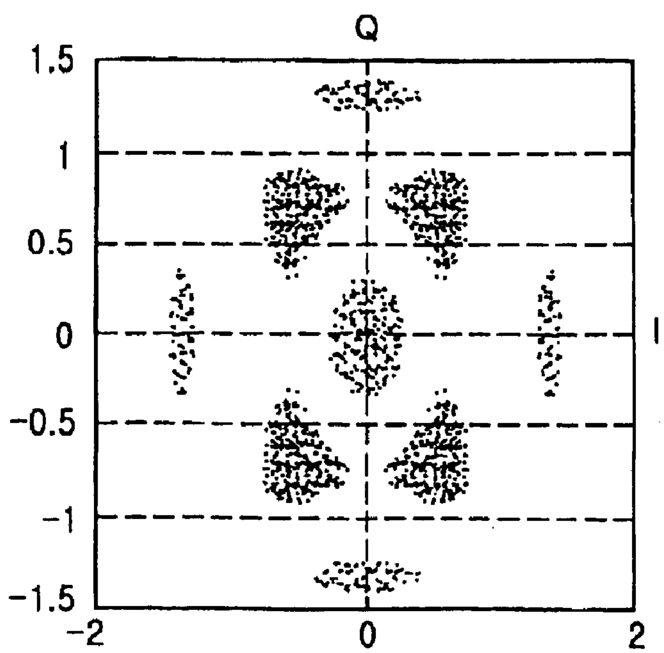


FIG. 7

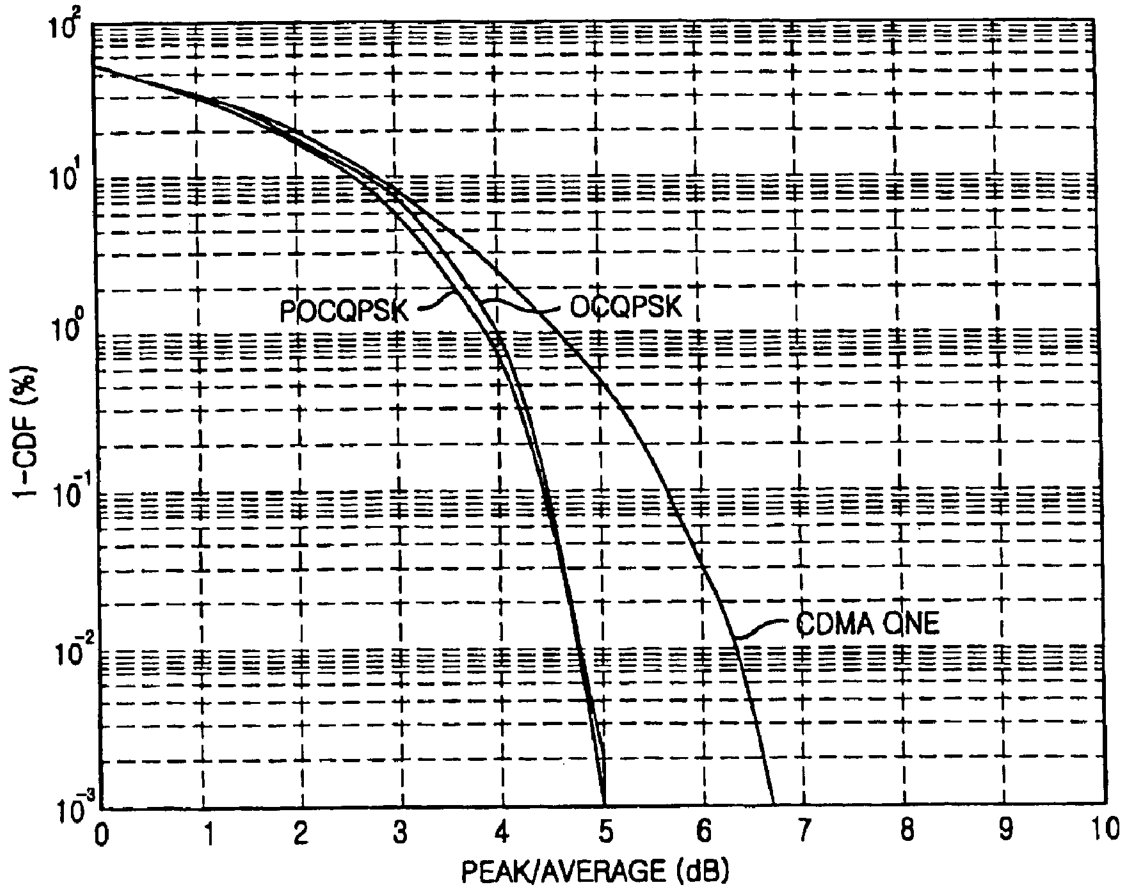

1-CDF (%)
PEAK/AVERAGE (dB)
POCQPSK
OCQPSK
CDMA ONE
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
1
2
3
4
5
6
7
8
9
10

FIG. 8

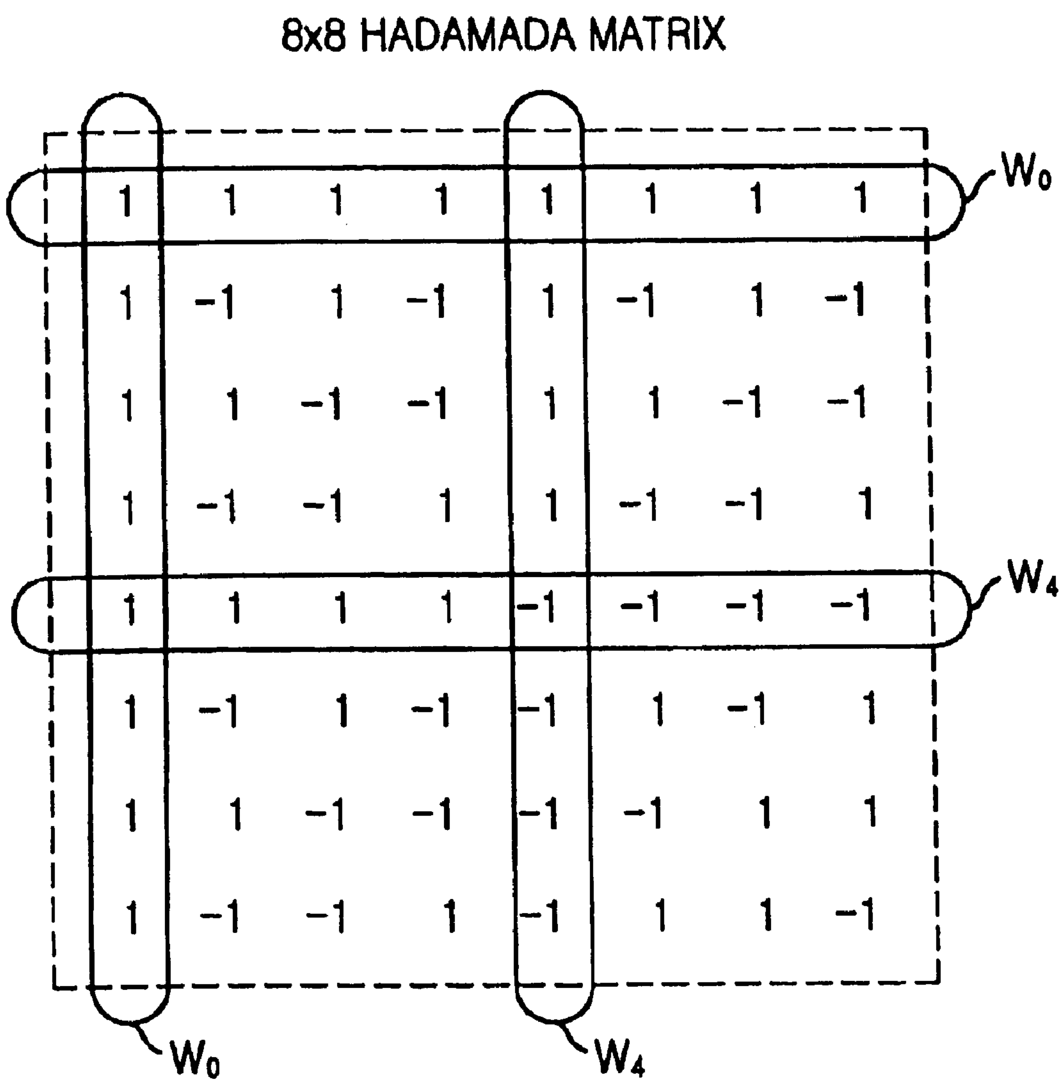

8x8 HADAMADA MATRIX
1 1 1 1 1 1 1 1
1 -1 1 -1 1 -1 1 -1
1 1 -1 -1 1 1 -1 -1
1 -1 -1 1 1 -1 -1 1
1 1 1 1 -1 -1 -1 -1
1 -1 1 -1 -1 1 -1 1
1 1 -1 -1 -1 -1 1 1
1 -1 -1 1 -1 1 1 -1
W0
W4
W0
W4

FIG. 9

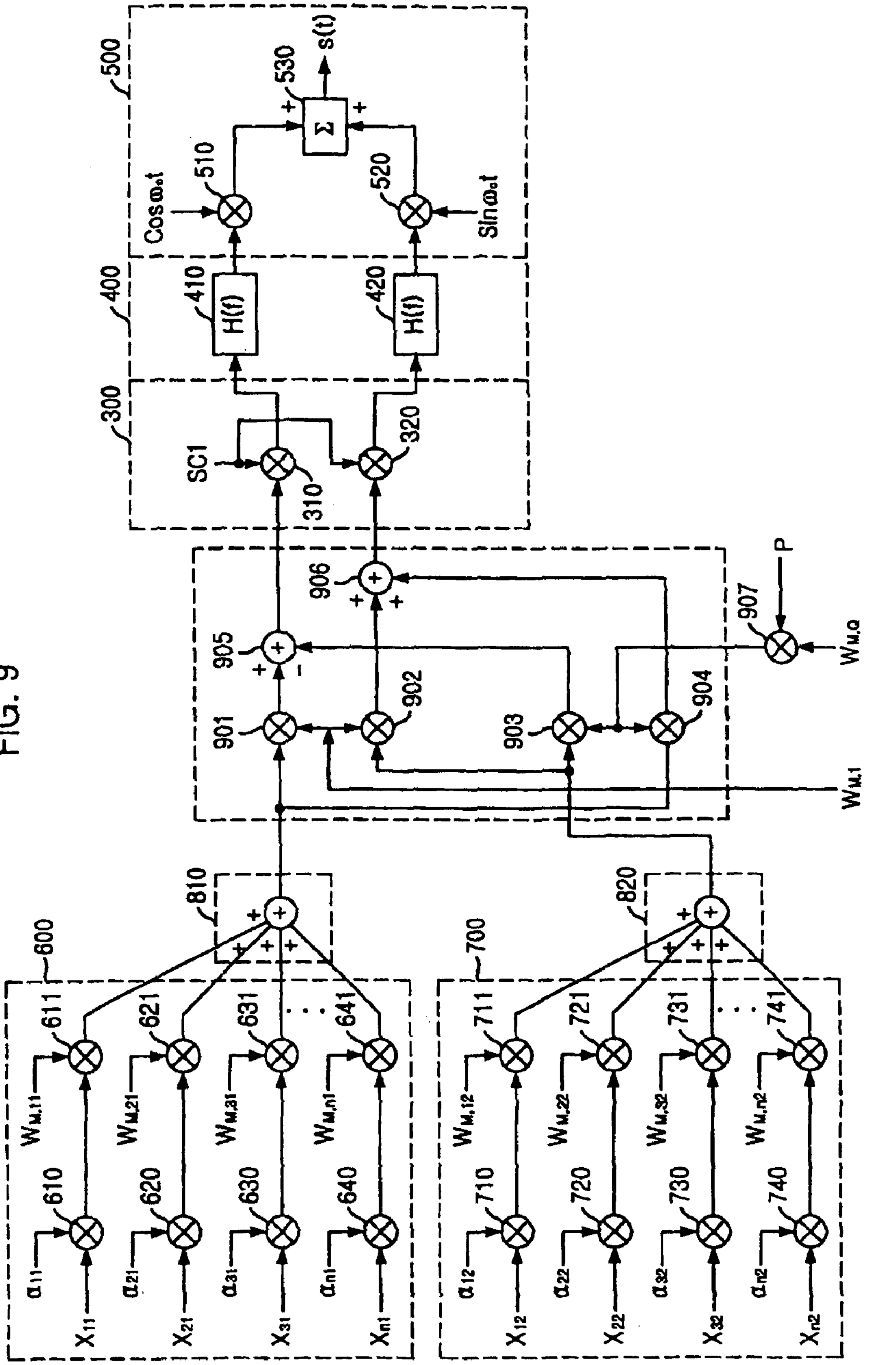

500
530
s(t)
Σ
510
520
Cosω₀t
Sinω₀t
400
410
420
H(f)
H(f)
300
SC1
310
320
905
906
907
P
W_M,Q
901
902
903
904
W_M,I
810
820
600
700
611
621
631
641
610
620
630
640
711
721
731
741
710
720
730
740
W_M,11
W_M,21
W_M,31
W_M,n1
W_M,12
W_M,22
W_M,32
W_M,n2
α11
α21
α31
αn1
α12
α22
α32
αn2
X11
X21
X31
Xn1
X12
X22
X32
Xn2

FIG. 10

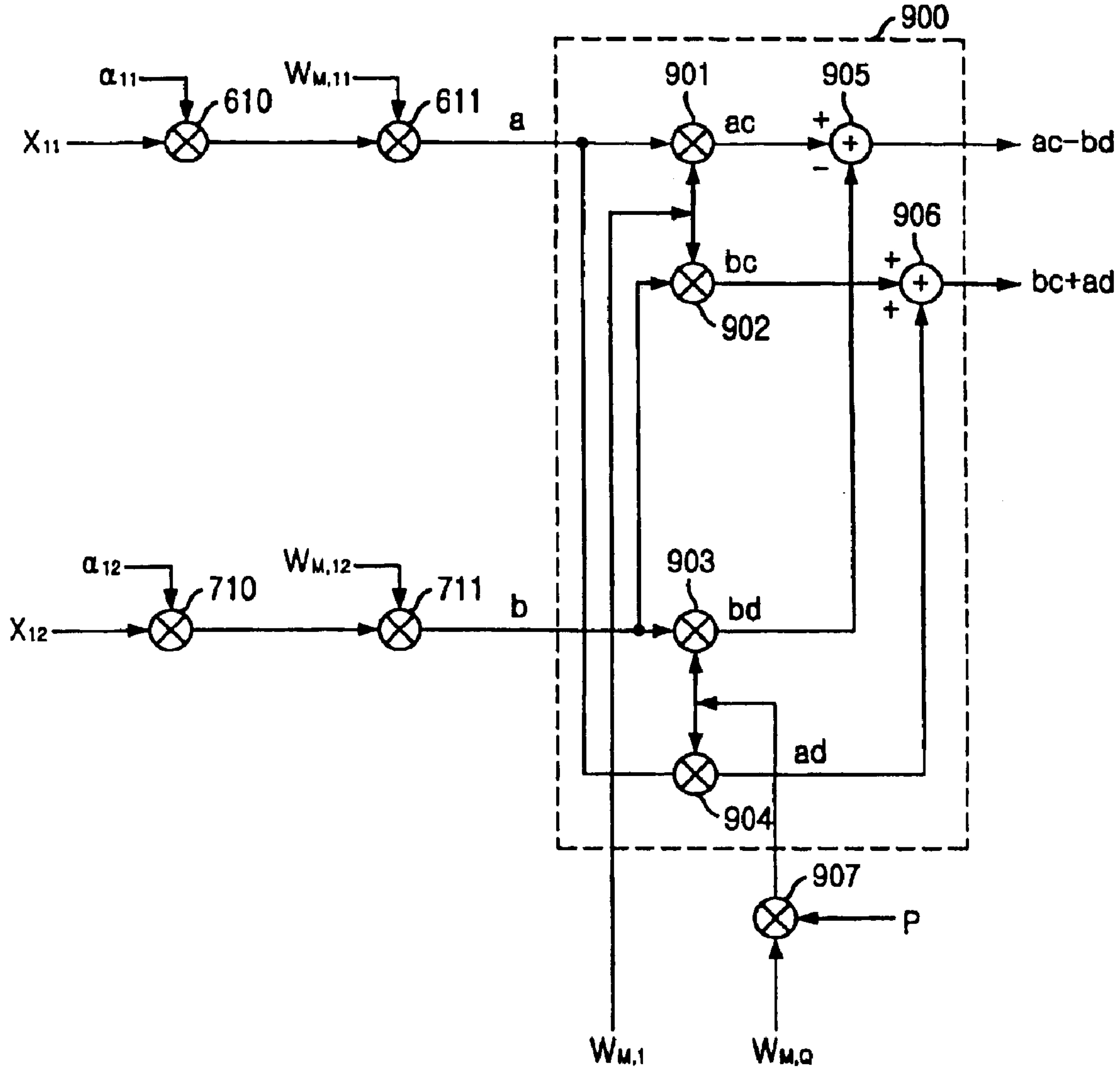

900
α_{11}
610
$W_{M,11}$
611
a
901
ac
905
+
−
X_{11}
ac−bd
906
bc
+
+
902
bc+ad
α_{12}
710
$W_{M,12}$
711
b
903
bd
X_{12}
ad
904
907
P
$W_{M,I}$
$W_{M,Q}$

FIG. 11

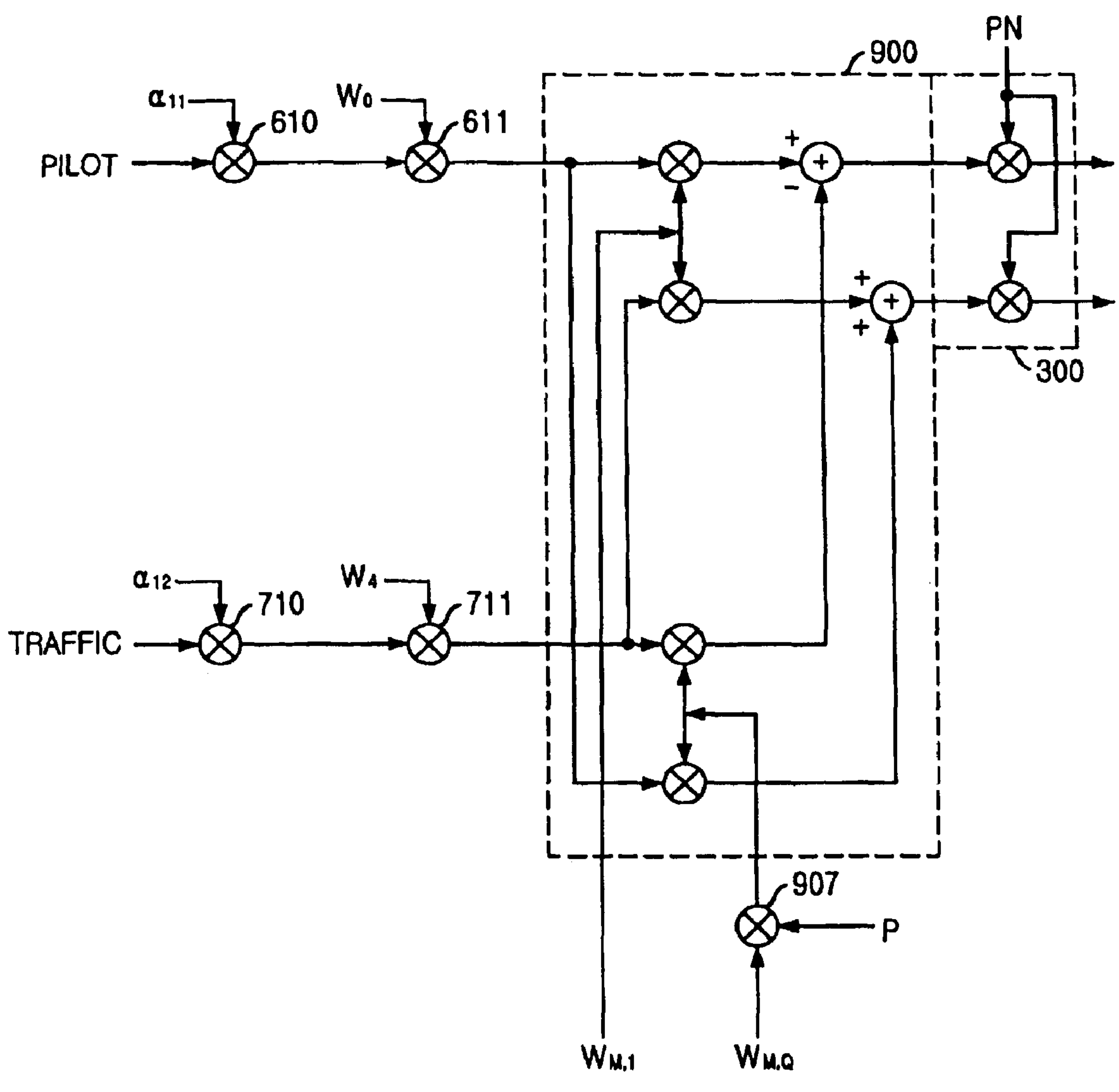
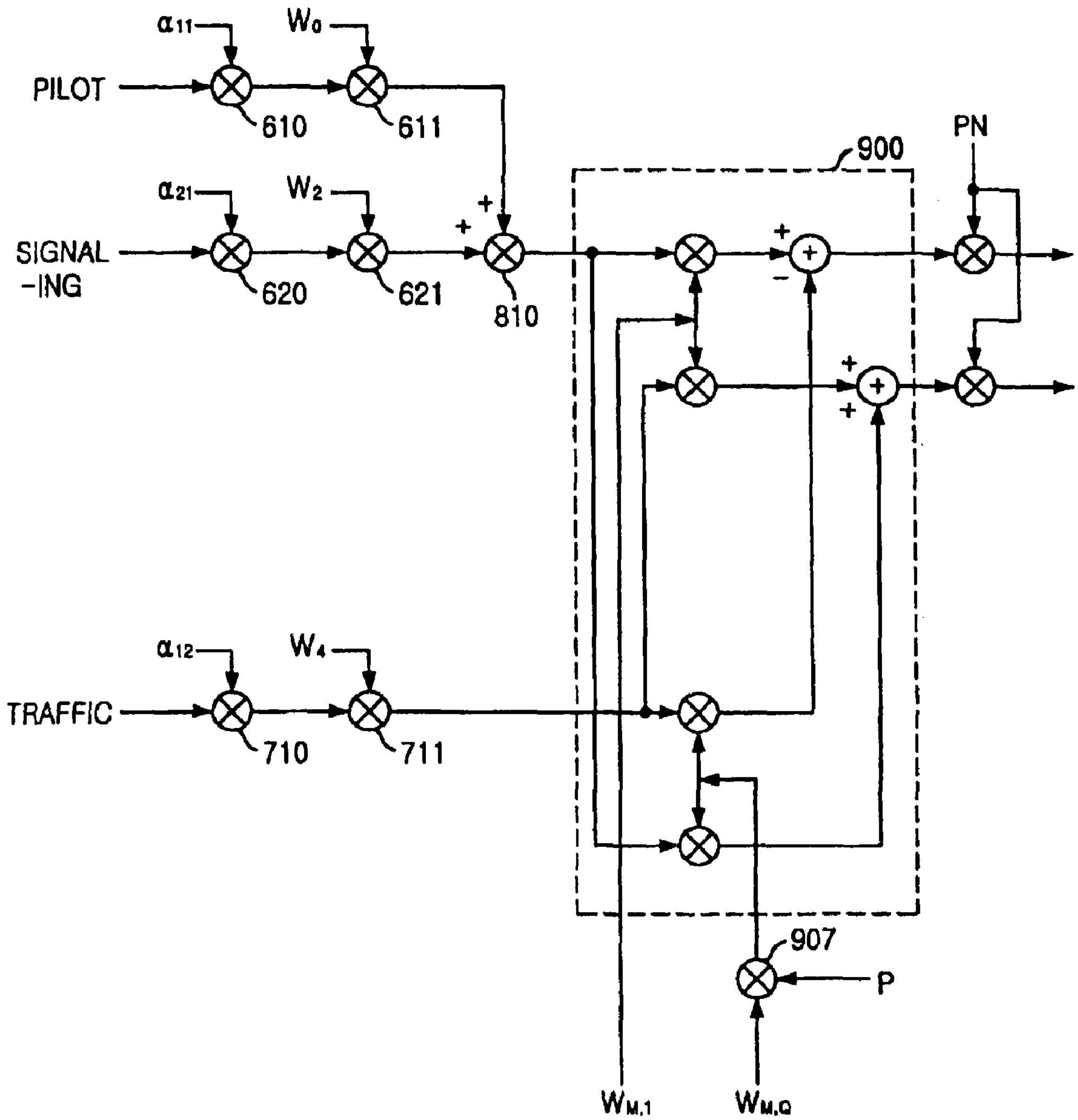
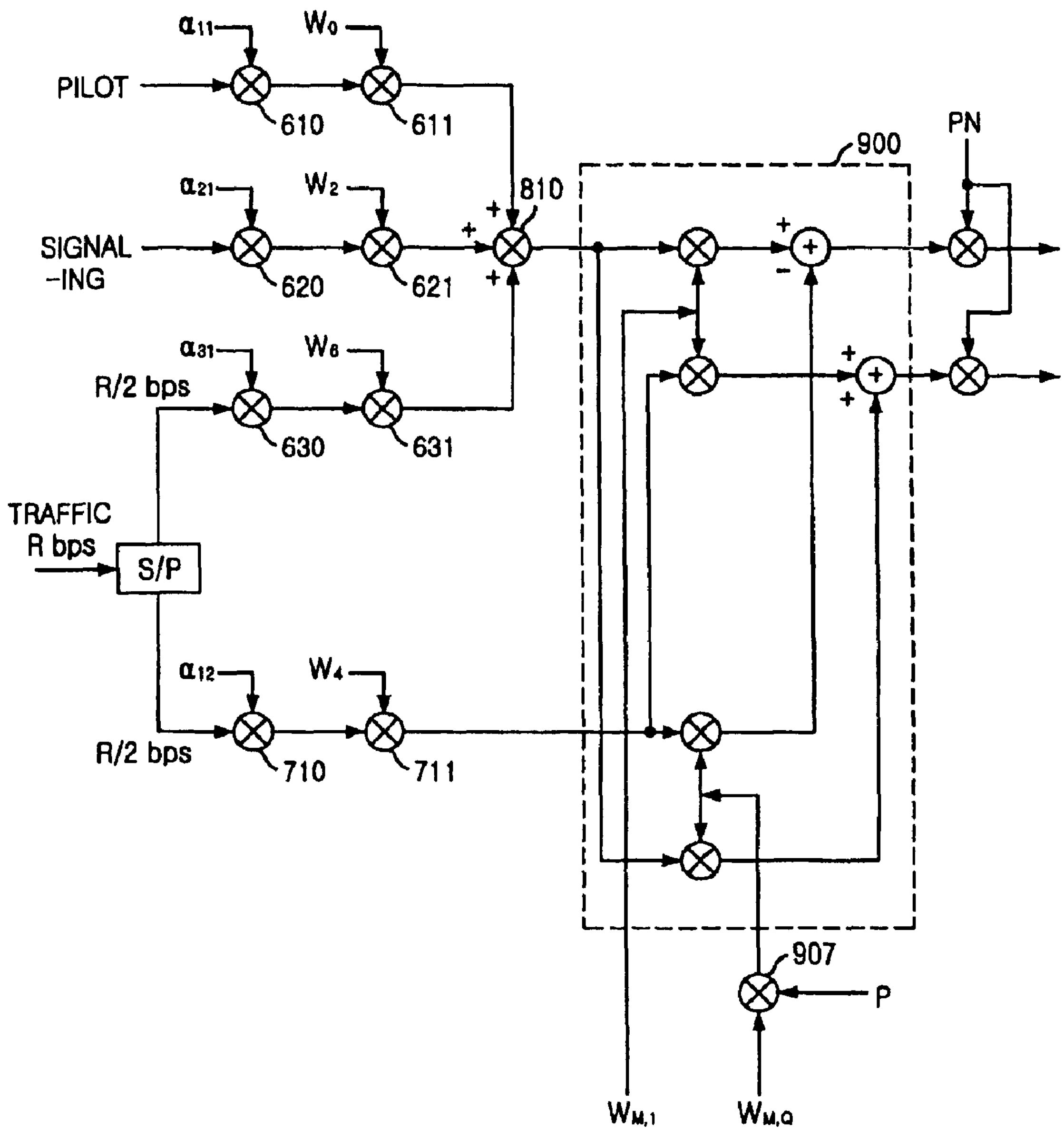

PN
900
α_{11}
610
W_0
611
PILOT
+
−
+
+
300
α_{12}
710
W_4
711
TRAFFIC
907
P
$W_{M,1}$
$W_{M,Q}$

FIG. 12



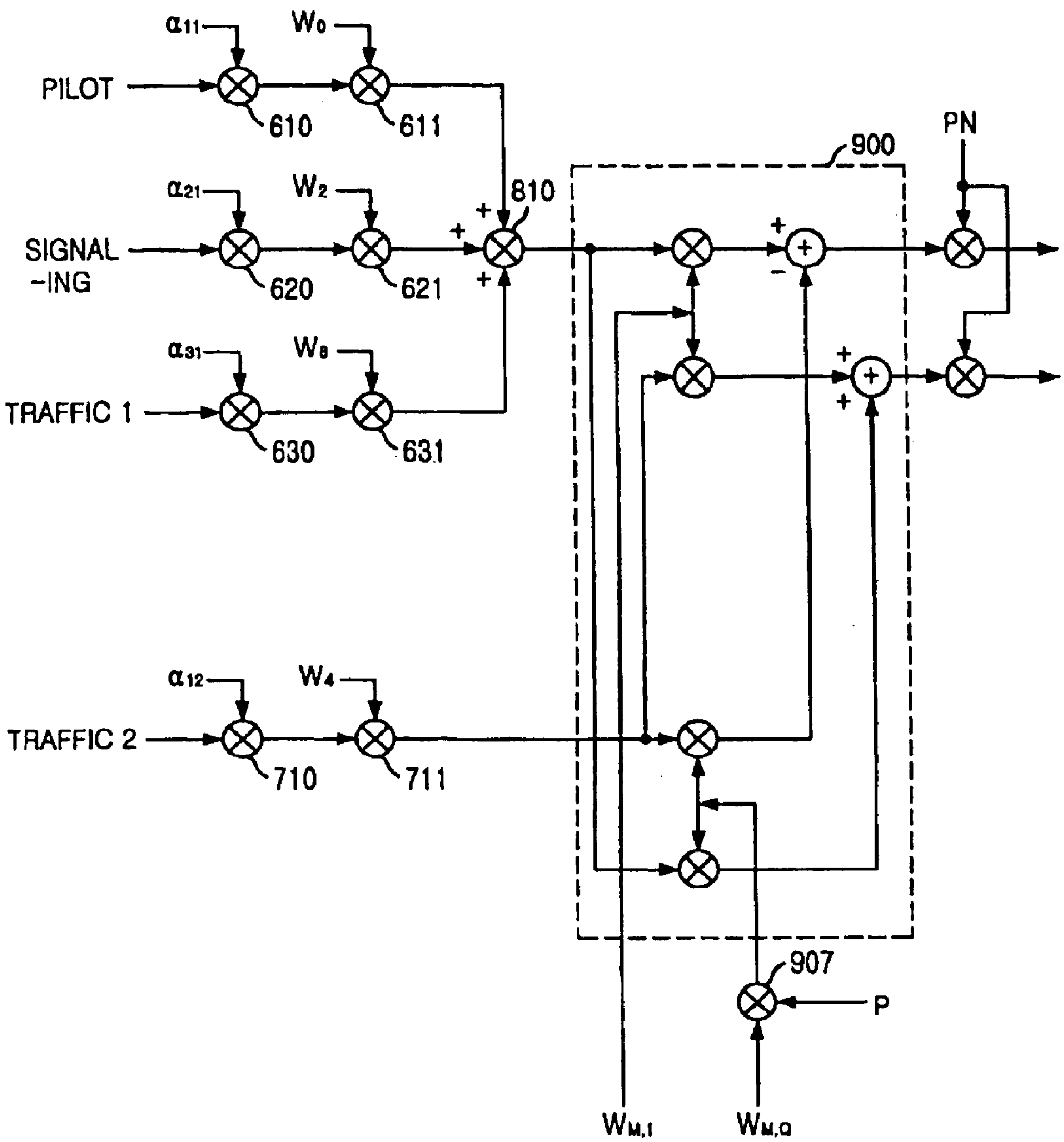
PILOT
SIGNAL -ING
TRAFFIC
610
611
620
621
810
710
711
900
907
PN
P

FIG. 13a



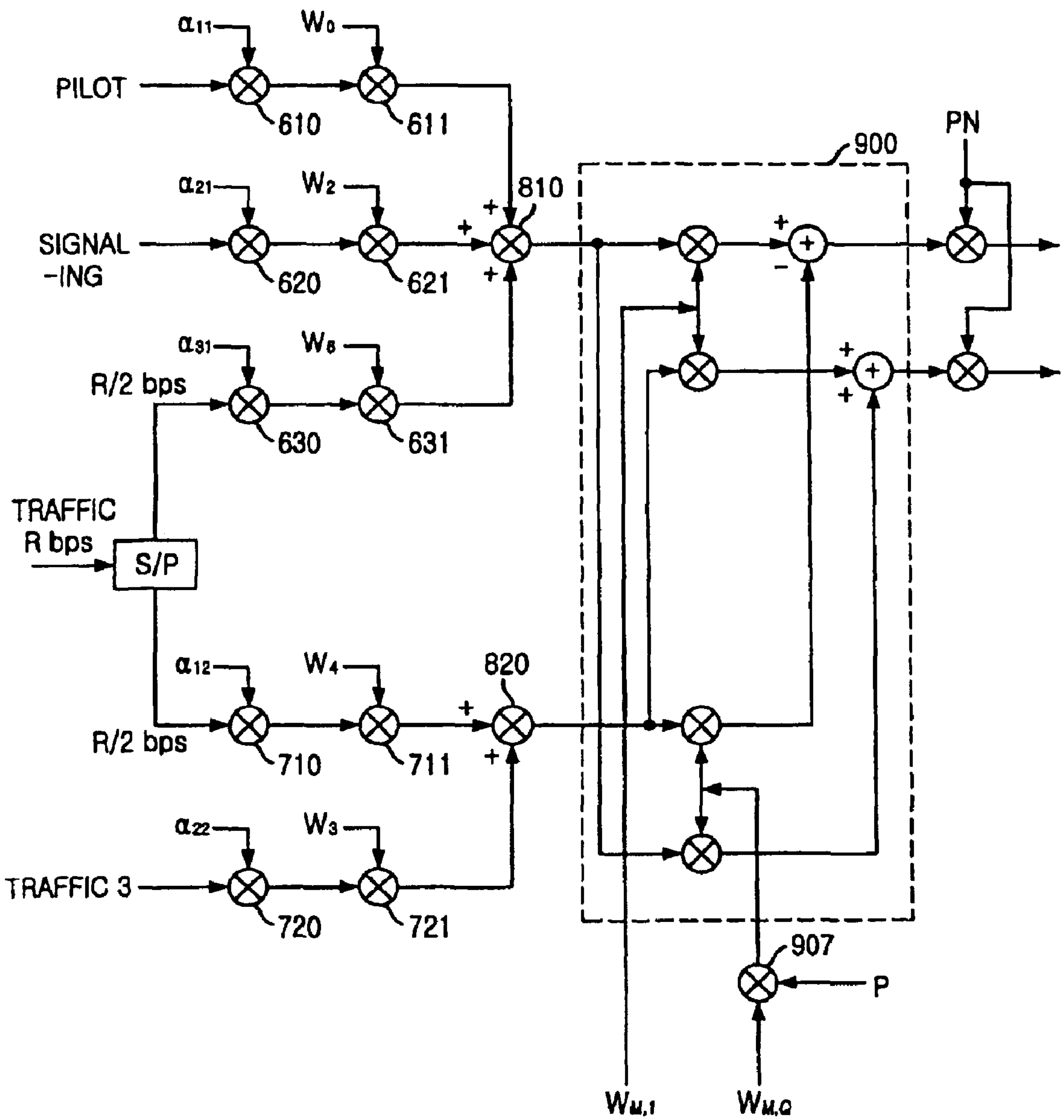
α_{11}
W_0
PILOT
610
611
900
PN
α_{21}
W_2
810
SIGNAL -ING
620
621
α_{31}
W_6
R/2 bps
630
631
TRAFFIC R bps
S/P
α_{12}
W_4
R/2 bps
710
711
907
P
$W_{M,I}$
$W_{M,Q}$

FIG. 13b



α11
W0
PILOT
610
611
900
PN
α21
W2
810
+
+
+
SIGNAL -ING
620
621
+
−
α31
W8
+
+
TRAFFIC 1
630
631
α12
W4
TRAFFIC 2
710
711
907
P
WM,I
WM,Q

FIG. 14a



α11
W0
PILOT
610
611
900
PN
α21
W2
810
SIGNAL -ING
620
621
α31
W6
R/2 bps
630
631
TRAFFIC R bps
S/P
α12
W4
820
R/2 bps
710
711
α22
W3
TRAFFIC 3
720
721
907
P
WM,I
WM,Q

FIG. 14b

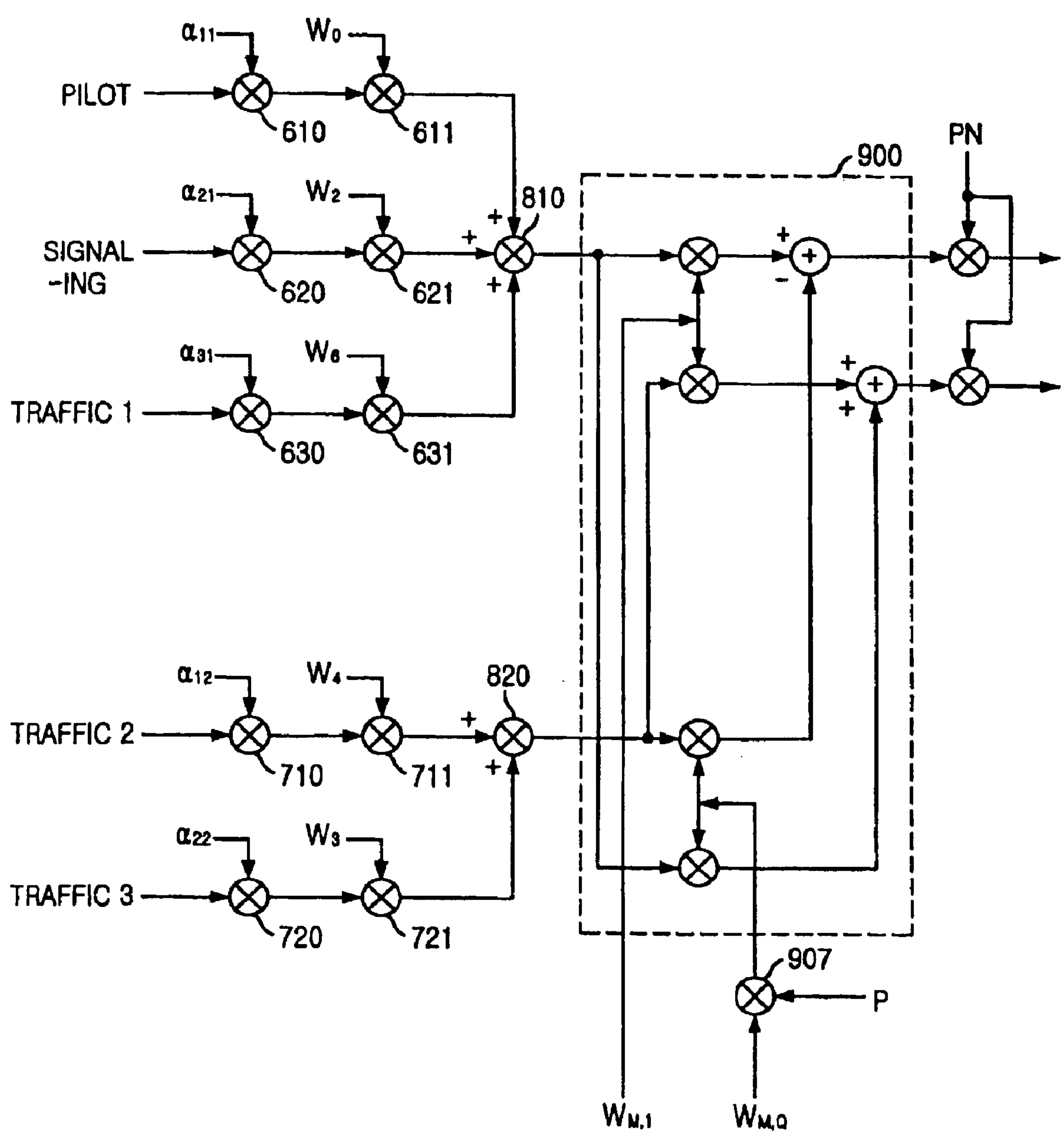

α11
W0
PILOT
610
611
PN
900
α21
W2
810
SIGNAL
-ING
620
621
α31
W6
TRAFFIC 1
630
631
α12
W4
820
TRAFFIC 2
710
711
α22
W3
TRAFFIC 3
720
721
907
P
WM,I
WM,Q

FIG. 15a

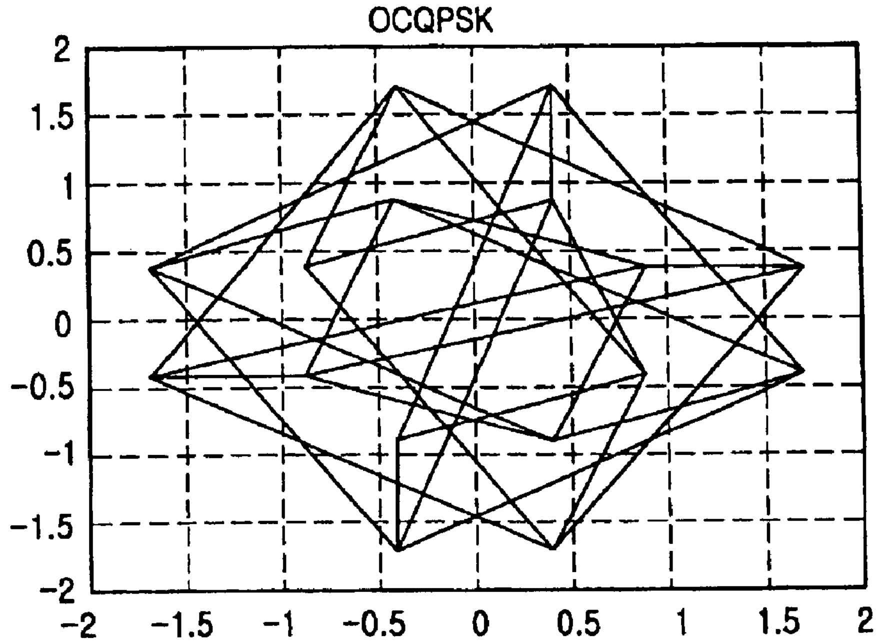


FIG. 15b

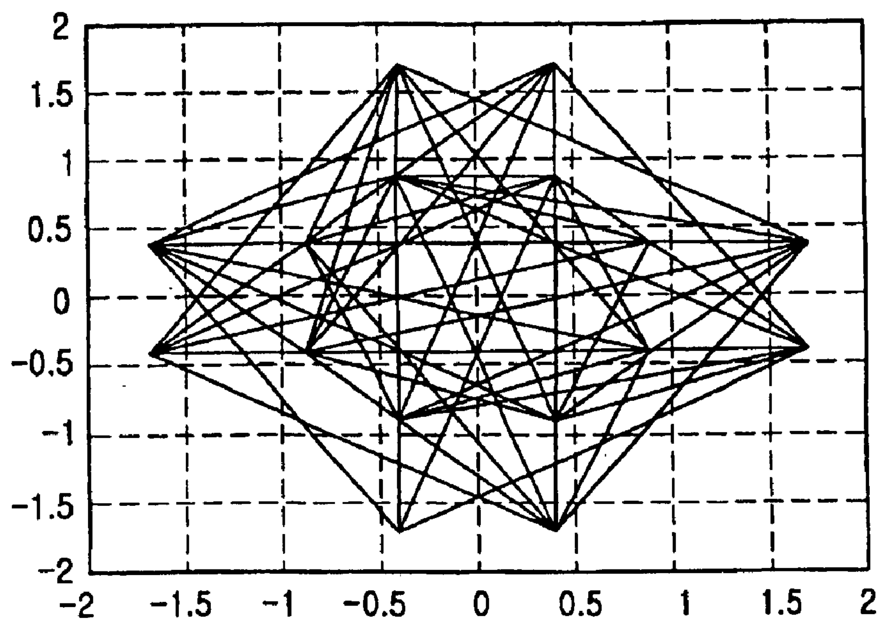
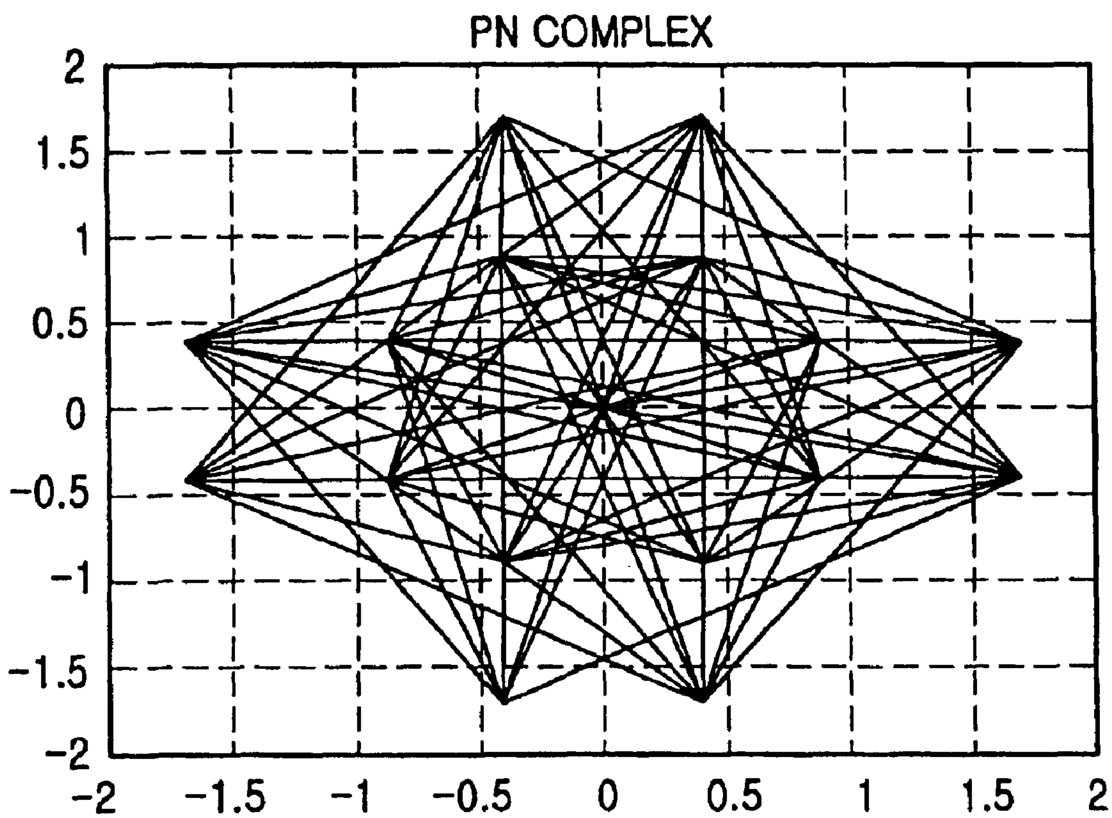


FIG. 15c



ORTHOGONAL COMPLEX SPREADING METHOD FOR MULTICHANNEL AND APPARATUS THEREOF

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

Notice: More than one reissue application has been filed for the reissue of U.S. Pat. No. 6,449,306. The reissue applications are application Ser. Nos. 10/932,227 (this application), which was filed on Sep. 2, 2004 and 11/648,915, a continuation reissue application of 10/932,227, which was filed on Jan. 3, 2007 and is still pending.

This application is a continuation of application Ser. No. 09/162,764, now U.S. Pat. No. 6,222,873.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an orthogonal complex spreading method for a multichannel and an apparatus thereof, and in particular, to an improved orthogonal complex spreading method for a multichannel and an apparatus thereof which are capable of decreasing a peak power-to-average power ratio by introducing an orthogonal complex spreading structure and spreading the same using a spreading code, implementing a structure capable of spreading complex output signals using a spreading code by adapting a permutated orthogonal complex spreading structure for a complex-type multichannel input signal with respect to the summed values, and decreasing a phase dependency of an interference based on a multipath component (when there is one chip difference) of a self signal, which is a problem that is not overcome by a permutated complex spreading modulation method, by a combination of an orthogonal Hadamard sequence.

2. Description of the Conventional Art

Generally, in the mobile communication system, it is known that a linear distortion and non-linear distortion affect power amplifier. The statistical characteristic of a peak power-to-average power ratio has a predetermined interrelationship for a non-linear distortion.

The third non-linear distortion which is one of the factors affecting the power amplifier causes an inter-modulation product problem in an adjacent frequency channel. The above-described inter-modulation product problem is generated due to a high peak amplitude for thereby increasing an adjacent channel power (ACP), so that there is a predetermined limit for selecting an amplifier. In particular, the CDMA (Code Division Multiple Access) system requires a very strict condition with respect to a linearity of a power amplifier. Therefore, the above-described condition is a very important factor.

In accordance with IS-97 and IS-98, the FCC stipulates a condition on the adjacent channel power (ACP). In order to satisfy the above-described condition, a bias of a RF power amplifier should be limited.

According to the current IMT-2000 system standard recommendation, a plurality of CDMA channels are recommended. In the case that a plurality of channels are provided, the peak power-to-average power ratio is considered as an important factor for thereby increasing efficiency of the modulation method.

The IMT-2000 which is known as the third generation mobile communication system has a great attention from people as the next generation communication system following the digital cellular system, personal communication system, etc. The IMT-2000 will be commercially available as one of the next generation wireless communication system which has a high capacity and better performance for thereby introducing various services and international loaming services, etc.

Many countries propose various IMT-2000 systems which IC require high data transmission rates adapted for an internet service or an electronic commercial activity. This is directly related to the power efficiency of a RF amplifier.

The CDMA based IMT-2000 system modulation method introduced by many countries is classified into a pilot channel method and a pilot symbol method. Of which, the former is directed to the ETRI 1.0 version introduced in Korea and is directed to CDMA ONE introduced in North America, and the latter is directed to the NTT-DOCOMO and ARIB introduced in Japan and is directed to the FMA2 proposal in a reverse direction introduced in Europe.

Since the pilot symbol method has a single channel effect based on the power efficiency, it is superior compared to the pilot channel method which is a multichannel method. However since the accuracy of the channel estimation is determined by the power control, the above description does not have its logical ground.

FIG. **1** illustrates a conventional complex spreading method based on a CDMA ONE method. As shown therein, the signals from a fundamental channel, a supplemental channel, and a control channel are multiplied by a Walsh code by each multiplier of a multiplication unit **20** through a signal mapping unit **10**. The signals which are multiplied by a pilot signal and the Walsh signal and then spread are multiplied by channel gains A**0**, A**1**, A**2** and A**3** by a channel gain multiplication unit **30**.

In a summing unit **40**, the pilot signal multiplied by the channel gain A**0** and the fundamental channel signal multiplied by the channel gain A**1** are summed by a first adder for thereby obtaining an identical phase information, and the supplemental channel signal multiplied by the channel gain A**2** and the control channel signal multiplied by the channel gain A**3** are summed by a second adder for thereby obtaining an orthogonal phase information.

The thusly obtained in-phase information and quadrature-phase information are multiplied by a PN**1** code and PN**2** code by a spreading unit **50**, and the identical phase information multiplied by the PN**2** code is subtracted from the identical phase information multiplied by the PN**1** code and is outputted as an I channel signal, and the quadrature-phase information multiplied by the PN**1** code and the in-phase information multiplied by the PN**2** code are summed and are outputted through a delay unit as a Q channel signal.

The CDMA ONE is implemented using a complex spreading method. The pilot channel and the fundamental channel spread to a Walsh code **1** are summed for thereby forming an in-phase information, and the supplemental channel spread to the Walsh code **2** and the control channel spread to a Walsh code **3** are summed for thereby forming an quadrature-phase information. In addition, the in-phase information and quadrature-phase information are complex-spread by PN codes.

FIG. **2**A is a view illustrating a conventional CDMA ONE method, and FIG. **2**B is a view illustrating a maximum eye-opening point after the actual shaping filter of FIG. **2**A.

As shown therein, in the CDMA ONE, the left and right information, namely, the in-phase information (I channel) and the upper and lower information, namely, the quadrature-phase information (Q channel) pass through the actual phase shaping filter for thereby causing a peak power, and in the ETRI version 1.0 shown in FIGS. **3**A and **3**B, a peak power may occur in the transverse direction for thereby causing deterioration.

In view of the crest factor and the statistical distribution of the power amplitude, in the CDMA ONE, the peak power is generated in vertical direction, so that the irregularity problem of the spreading code and an inter-interference problem occur.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof overcome the aforementioned problems encountered in the conventional art.

The CDMA system requires a strict condition for a linearity of a power amplifier, so that the peak power-to-average power ratio is important. In particular, the characteristic of the IMT-2000 system is determined based on the efficiency of the modulation method since multiple channels are provided, and the peak power-to-average power ratio is adapted as an important factor.

It is another object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof which have an excellent power efficiency compared to the CDMA-ONE introduced in U.S.A. and the W-CDMA introduced in Japan and Europe and is capable of resolving a power unbalance problem of an in-phase channel and a quadrature-phase channel as well as the complex spreading method.

It is still another object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof which is capable of stably maintaining a low peak power-to-average power ratio.

It is still another object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof in which a spreading operation is implemented by multiplying a predetermined channel data among data of a multichannel by an orthogonal Hadamard sequence and a gain and, multiplying a data of another channel by an orthogonal Hadamard sequence and a gain, summing the information of two channels in complex type, multiplying the summed information of the complex type by the orthogonal Hadamard sequence of the orthogonal type, obtaining a complex type, summing a plurality of channel information of the complex type in the above-described manner and multiplying the information of the complex type of the multichannel by a spreading code sequence.

It is still another object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof which is capable of decreasing the probability that the power becomes a zero state by preventing the FIR filter input state from exceeding ±90° in an earlier sample state, increasing the power efficiency, decreasing the consumption of a bias power of a back-off of the power amplifier and saving the power of a battery.

It is still another object of the present invention to provide an orthogonal complex spreading method for a multichannel and an apparatus thereof which is capable of implementing a POCQPSK (Permutated Orthogonal Complex QPSK) which is another modulation method and has a power efficiency similar with the OCQPSK (Orthogonal Complex QPSK).

In order to achieve the above objects, there is provided an orthogonal complex spreading method for a multichannel which includes the steps of complex-summing $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{M,n1}$ by a first data X_{n1} of a n-th block and $\alpha_{n2}W_{M,n2}X_{n2}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{M,n2}$ by a second data X_{n2} of a n-th block; complex-multiplying $\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2}$ which is summed in the complex type and $W_{M,n3}+jW_{M,n4}$ of the complex type using a complex multiplier and outputting as an in-phase information and quadrature-phase information; and summing only in-phase information outputted from a plurality of blocks and only quadrature-phase information outputted therefrom and spreading the same using a spreading code.

In order to achieve the above objects, there is provided an orthogonal complex spreading apparatus according to a first embodiment of the present invention which includes a plurality of complex multiplication blocks for distributing the data of the multichannel and complex-multiplying $\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2}$ in which $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n1}$ with the first data X_{n1} of the n-th block and the gain α_{n1} and $\alpha_{n2}W_{M,n2}X_{n2}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n2}$ with the second data X_{n2} of the n-th block and the gain α_{n2} and $W_{M,n3}+W_{M,n4}$ using the complex multiplier; a summing unit for summing only the in-phase information outputted from each block of the plurality of the complex multiplication blocks and summing only the quadrature-phase information; and a spreading unit for multiplying the in-phase information and the quadrature-phase information summed by the summing unit with the spreading code and outputting an I channel and a Q channel.

In order to achieve the above objects, there is provided an orthogonal complex spreading apparatus according to a second embodiment of the present invention which includes first and second Hadamard sequence multipliers for allocating the multichannel to a predetermined number of channels, splitting the same into two groups and outputting $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying the data X_{n1} of each channel by the gain α_{n1} and the orthogonal Hadamard sequence $W_{M,n1}$;

a first adder for outputting

$$\sum_{n=1}^{K}(\alpha_{n1}W_{M,n1}X_{n1})$$

which is obtained by summing the output signals from the first Hadamard sequence multiplier;

a second adder for outputting

$$\sum_{n=1}^{K}(\alpha_{n2}W_{M,n2}X_{n2})$$

which is obtained by summing the output signals from the second Hadamard sequence multiplier; a complex multiplier for receiving the output signal from the first adder and the output signal from the second adder in the complex form of

$$\sum_{n=1}^{K}(\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2})$$

and complex-multiplying $W_{M,j}+jPW_{M,Q}$ which n=1 consist of the orthogonal Hadamard code $W_{M,j}$, and the permutated orthogonal Hadamard code $PW_{M,Q}$ that $W_{M,Q}$ and a predetermined sequence P are complex-multiplied; a spreading unit for multiplying the output signal from the complex multiplier by the spreading code; a filter for filtering the output signal from the spreading unit; and a modulator for multiplying and modulating the modulation carrier wave, summing the in-phase signal and the quadrature-phase signal and outputting a modulation signal of the real number.

Additional advantages, objects and other features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objects and advantages of the invention may be realized and attained as particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. **1** is a block diagram illustrating a conventional multichannel complex spreading method of a CDMA (Code Division Multiple Access) ONE method;

FIG. **2**A is a view illustrating a constellation plot of a conventional CDMA ONE method;

FIG. **2**B is a view illustrating a maximum open point after the actual shaping filter of FIG. **2**A;

FIG. **3**A is a view illustrating a constellation plot of a conventional ETRI version 1.0 method;

FIG. **3**B is a view illustrating a maximum open point after the actual pulse shaping filter of FIG. **3**A;

FIG. **4** is a block diagram illustrating a multichannel orthogonal complex spreading apparatus according to the present invention;

FIG. **5**A is a circuit diagram illustrating the complex multiplexor of FIG. **4**;

FIG. **5**B is a circuit diagram illustrating the summing unit and spreading unit of FIG. **4**;

FIG. **5**C is a circuit diagram illustrating another embodiment of the spreading unit of FIG. **4**;

FIG. **5**D is a circuit diagram illustrating of the filter and modulator of FIG. **4**;

FIG. **6**A is a view illustrating a constellation plot of an OCQPSK according to the present invention;

FIG. **6**B is a view illustrating a maximum open point after the actual pulse shaping filter of FIG. **6**A;

FIG. **7** is a view illustrating a power peak occurrence statistical distribution characteristic with respect to an average power between the conventional art and the present invention;

FIG. **8** is a view illustrating an orthogonal Hadamard sequence according to the present invention;

FIG. **9** is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus according to the present invention;

FIG. **10** is a circuit diagram illustrating the complex multiplier according to the present invention;

FIG. **11** is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus for a voice service according to the present invention;

FIG. **12** is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus having a high quality voice service and a low transmission rate according to the present invention;

FIG. **13**A is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus for a QPSK having a high transmission rate according to the present invention;

FIG. **13**B is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus for a data having a high transmission rate according to the present invention;

FIG. **14**A is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus for a multimedia service having a QPSK data according to the present invention;

FIG. **14**B is a circuit diagram illustrating a multichannel permutated orthogonal complex spreading apparatus for a multimedia service according to the present invention;

FIG. **15**A is a phase trajectory view of an OCQPSK according to the present invention;

FIG. **15**B is a phase trajectory view of a POCQPSK according to the present invention; and

FIG. **15**C is a phase trajectory view of a complex spreading method according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The complex summing unit and complex multiplier according to the present invention will be explained with reference to the accompanying drawings. In the present invention, two complexes (a+jb) and (c+jd) are used, where a, b, c and d represent predetermined real numbers.

A complex summing unit outputs (a+c)+j(b+d), and a complex multiplier outputs ((a×c)−(b×d))+j((b×c)+(a×d)). Here, a spreading code sequence is defined as SC, an information data is defined as X_{n1}, and X_{n2}, a gain constant is defined as α_{n1} and α_{n2}, and an orthogonal Hadamard sequence is defined as $W_{M,n1}$, $W_{M,n2}$, $W_{M,n3}$, $W_{M,n4}$, $W_{M,I}$, $W_{M,Q}$, where M represents a M×M Hadamard matrix, and n**1**, n**2**, n3 and n**4** represents index of a predetermined vector of the Hadamard matrix. For example, n**3** represents a Hadamard vector which is a third vector value written into the n-th block like the n-th block **100**n of FIG. **4**. The Hadamard M represents a Hadamard matrix. For example, if the matrix W has values of 1 and −1, in the W_T×W, the main diagonal terms are M, and the remaining products are zero. Here, T represents a transpose.

The data X_{n1}, X_{n2}, $W_{M,n1}$, $W_{M,n2}$, $W_{M,n3}$, $W_{M,n4}$, $W_{M,I}$, and $W_{M,Q}$, and SC are combined data consisting of +1 or −1, and any and α_{n2} represent real number.

FIG. **4** is a block diagram illustrating a multichannel orthogonal complex spreading apparatus according to the present invention.

As shown therein, there is provided a plurality of complex multipliers **100** through **100**n in which a data of a predetermined channel is multiplied by a gain and orthogonal Hadamard sequence, and a data of another channel is multiplied by the orthogonal Hadamard sequence for thereby complex-summing two channel data, the orthogonal Hadamard sequence of the complex type is multiplied by the complex-summed data, and the data of other two channels are complex-multiplied in the same manner described above. A summing unit **200** sums and outputs the output signals from the complex multipliers **100** through **100**n. A spreading unit **300** multiplies the output signal from the summing unit **200** with a predetermined spreading code SC for thereby spreading the signal. A pulse shaping filter **400** filters the data spread by the spreading unit **300**. A modulation wave multiplier **500** multiplies the output signal from the filter **400** with a modulation carrier wave and outputs the modulated data through an antenna.

As shown in FIG. **4**, the first complex multiplier **100** complex-sums $\alpha_{11}W_{M,11}X_{11}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,11}$ with the data X_{11} of one channel and the gain α_{11} and $\alpha_{12}W_{M,12}X_{12}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,12}$ with the data X_{12} of another channel and the gain α_{12}, and complex-multiplies $\alpha_{11}W_{M,11}X_{11}+j\alpha_{12}W_{M,12}X_{12}$ and the complex-type orthogonal sequence $W_{M,13}X_{11}+jW_{M,14}$ using the complex multiplier **111**.

In addition, the n-th complex multiplier **100**n complex-sums $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n1}$ with the data X_{n1} of another channel and the gain α_{n1} and $\alpha_{n2}W_{M,n2}X_{n2}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n2}$ with the data X_{n2} of another channel and the gain α_{n2}, and complex-multiplies $\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2}$ and the complex-type orthogonal sequence $W_{M,n3}X_{11}+jW_{M,n4}$ using the complex multiplier **100**n.

The complex multiplication data outputted from the n-number of the complex multipliers are summed by the summing unit **200**, and the spreading code SC is multiplied and spread it by the spreading unit **300**. The thusly spread data are filtered by the pulse shaping filter **600**, and the modulation carried $e^{j2\pi fct}$ is multiplied by the multiplier **700**, and then the function Re{*} is processed, and the real data s(t) is outputted through the antenna. Here, Re{*} represents that a predetermined complex is processed to a real value through the Re{*} function.

The above-described function will be explained as follows:

$$\left(\sum_{n=1}^{K}((\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2})\otimes(W_{M,n3}+jW_{M,n4}))\right)\otimes SC$$

where K represents a predetermined integer greater than or equal to 1, n represents an integer greater than or equal to 1 and less than K and is identical with each channel number of the multichannel.

Each of the complex multipliers **110** through **100**n is identically configured so that two different channel data are complex-multiplied.

As shown in FIG. **5**A, one complex multiplier includes a first multiplier **101** for multiplying the data X_{11} by the orthogonal Hadamard sequence $W_{M,11}$ a second multiplier for multiplying the input signal from the first multiplier by the gain α_{11}, a third multiplier **103** for multiplying the data X_{12} of the other channel by another orthogonal Hadamard sequence $W_{M,12}$, a fourth multiplier **104** for multiplying the output signal from the third multiplier **103** by the gain α_{12}, fifth and sixth multipliers **105** and **106** for multiplying the output signals $\alpha_{11}W_{M,11}X_{11}$ from the second multiplier **102** and the output signals $\alpha_{11}W_{M,12}X_{12}$ from the fourth multiplier **102** by the orthogonal Hadamard sequence $W_{M,13}$, respectively, seventh and eighth multipliers **107** and **108** for multiplying the output signal $\alpha_{11}W_{M,11}X_{11}$ from the second multiplier **102** and the output signal $\alpha_{12}W_{M,12}X_{12}$ from the fourth multiplier **102** by the orthogonal Hadamard sequence $W_{M,14}$, sequentially, a first adder **109** for summing the output signal (+ac) from the fifth multiplier **105** and the output signal (−bd) from the eighth multiplier **108** and outputting in-phase information (ac−bd), and a second adder **110** for summing the output signal (bc) from the sixth multiplier **106** and the output signal (ad) from the seventh multiplier **107** and outputting the quadrature-phase information (bc+ad).

Therefore, the first and-second multipliers **101** and **102** multiply the data X_{11} by the orthogonal Hadamard sequence $W_{M,11}$ and the gain α_{11} for thereby obtaining $\alpha_{11}W_{M,11}X_{11}$ (−a). In addition, the third and fourth multipliers **103** and **104** multiply the orthogonal Hadamard sequence $W_{M,12}$ and the gain α_{12} for thereby obtaining $\alpha_{12}W_{M,12}X_{12}$ (=b). The fifth and sixth multipliers **105** and **106** multiply $\alpha_{11}W_{M,11}X_{11}$ (=a) and $\alpha_{12}W_{M,12}X_{12}$ (=b) by the orthogonal Hadamard sequence $W_{M,13}$ (=c), respectively, for thereby obtaining $\alpha_{11}W_{M,11}X_{11}W_{M,13}$ (=ac) and $\alpha_{12}W_{M,12}X_{12}W_{M,13}$ (=bc), and the fifth and sixth multipliers **105** and **106** multiply $\alpha_{11}W_{M,11}X_{11}$ (=a) and $\alpha_{12}W_{M,12}X_{12}$ (=b) by the orthogonal Hadamard sequence $W_{M,14}$ (=d) for thereby obtaining $\alpha_{11}W_{M,11}X_{11}W_{M,14}$ (=ad) and $\alpha_{12}W_{M,12}X_{12}W_{M,14}$ (=bd). In addition, the first adder **109** computes $(\alpha_{11}W_{M,11}X_{11}W_{M,13})-(\alpha_{12}W_{M,12}X_{12}W_{M,14})$ (=ac−bd), namely, $\alpha_{12}W_{M,12}X_{12}W_{M,14}$ is subtracted from $\alpha_{11}W_{M,11}X_{11}W_{M,13}$. In addition, the second adder **110** computes $(\alpha_{11}W_{M,11}X_{11}W_{M,14})+(\alpha_{12}W_{M,12}X_{12}W_{M,13})$ (ad+bc), namely, $\alpha_{11}W_{M,11}X_{11}W_{M,14}$ (=ad) is added with $\alpha_{12}W_{M,12}X_{12}W_{M,13}$ (=bc).

FIG. **4** illustrates the first complex multiplier **100** which is configured identically with the n-th complex multiplier **100**n. Assuming that $\alpha_{11}W_{M,11}X_{11}$ is "a", $\alpha_{12}W_{M,12}X_{12}$ is "b". the orthogonal Hadamard sequence $W_{M,13}$ is "c", and the orthogonal Hadamard sequence $W_{M,14}$ is "d", the expression "(a+jb) (c+jd)=ac−bd+j (bc+ad)" is obtained. Therefore, the signal outputted from the first complex multiplier **100** becomes the in-phase information "ac−bd" and the quadrature-phase information "bc+ad".

In addition, FIG. **5**B is a circuit diagram illustrating the summing unit and spreading unit of FIG. **4**, and FIG. **5**C is a circuit diagram illustrating another embodiment of the spreading unit of FIG. **4**.

As shown therein, the summing unit **200** includes a first summing unit **210** for summing the in-phase information A_1(=(ac−bd), . . . , An outputted from a plurality of complex multipliers, and a second summing unit **220** for summing the quadrature-phase information B_1(=bc+ad) outputted from the complex multipliers.

The spreading unit **300** includes first and second multipliers **301** and **302** for multiplying the output signals from the first adder **210** and the second adder **220** of the summing unit **200** by the spreading sequence SC, respectively. Namely, the signals are spread to the in-phase signal (I channel signal) and the quadrature-phase signal (Q channel signal) using one spreading code SC.

In addition, as shown in FIG. **5**C, the spreading unit **300** includes first and second multipliers **310** and **320** for multiplying the output signals from the first and second adders **210** and **220** of the summing unit **200** by the spreading sequence SC**1**, third and fourth multipliers **330** and **340** for multiplying the output signals from the first and second adders **210** and **220** by a spreading sequence SC**2**, respectively, a first adder **350** for summing the output signal (+) from the first multiplier **310** and the output signal (−)

from the third multiplier **330** and outputting an I channel signal, and a second summing unit **360** for summing the output signal (+) from the second multiplier **320** and the output signal (+) from the fourth multiplier **340** and outputting a Q channel signal.

Namely, in the summing unit **200**, the in-phase information and the quadrature-phase information of the n-number of the complex multipliers are summed by the first and second summing units **210** and **220**. In the spreading unit **300**, the in-phase information summing value (g) and the quadrature phase information summing value (h) from the summing unit **200** are multiplied by the first spreading code SC**1** (**1**) by the first and second multipliers **310** and **320** for thereby obtaining g1 and h**1**, and the in-phase information summing value (g) and the quadrature phase information summing value (h) from the summing unit **200** are multiplied by the second spreading code SC**2**(m) by the third and fourth multipliers **330** and **340** for thereby obtaining gm and hm, and the first adder **350** computes gl−hm in which hm is subtracted from gl, and the second adder **360** computes hl+gm in which hl is added by gm.

As shown in FIG. **5**D, the filter **400** includes first and second pulse shaping filters **410** and **420** for filtering the I channel signal which is the in-phase information shown in FIGS. **5**B and **5**C and the Q channel signal which is the quadrature phase information signal. The modulation unit **500** includes first and second multipliers **510** and **520** for multiplying the output signals from the first and second pulse shaping filters **410** and **420** by $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$, and an adder **530** for summing the output signals from the multipliers **510** and **520** and outputting a modulation data S(t).

Here, the orthogonal Hadamard sequences may be used as a Walsh code or other orthogonal code.

For example, from now on, the case that the orthogonal Hadamard sequence is used for the 8×8 Hadamard matrix shown in FIG. **8** will be explained.

FIG. **8** illustrates an example of the Hadamard (or Walsh) code. Namely, the case that the sequence vector of a k-th column or row is set to W_{k-1} based on the 8×8 Hadamard matrix is shown therein. In this case, if k is 1, W_{k-1} represents W_0 of the column or row, and if k is 5, W_{k-1} represents W_4 of the column or row.

Therefore, in order to enhance the efficiency of the present invention, the orthogonal Hadamard sequence which multiplies each channel data is determined as follows.

In the M×M Hadamard matrix, the sequence vector of the k-th column or row is set to W_{k-1}, and $W_{M,n1}=W_0$, $W_{M,n2}=W_{2p}$ (where p represents a predetermined number of (M/2)−1), and $W_{M,n3}=W_{2n-2}$, $W_{M,n4}=W_{2n-1}$ (where n represents the number of n-th blocks), and $\alpha_{n1}W_0X_{n1}+j\alpha_{n2}W_{2p}X_{n2}$ and $W_{2n-2}+jW_{2n-1}$. The case that only first complex multiplier is used in the embodiment of FIG. **4**, namely, the data of two channels are complex-multiplied will be explained. In the M×M (M=8) Hadamard matrix, if the k-th column or row sequence vector is set to W_{k-1}, it is possible to determine $W_{M,11}=W_0$, $W_{M,12}=W_2$, or $W_{M,12}=W_4$, and $W_{M,13}=W_0$, $W_{M,14}=W_1$. In addition, it is possible to complex-multiply $\alpha_{11}W_0X_{11}+j\alpha_{12}W_2X_{12}$ or $\alpha_{11}W_0X_{11}+j\alpha_{12}W_4X_{12}$ and W_0+jW_1.

In the case that two complex multipliers shown in FIG. **4** are used, the second complex multiplier determines $W_{M,21}=W_0$, $W_{M,22}=W_4$, and $W_{M,23}=W_2$, and $W_{M,24}=W_3$, so that it is possible to complex-multiply $\alpha_{21}W_0X_{21}+j\alpha_{22}W_4X_{22}$ and W_2+jW_3.

In addition, as shown in FIG. **5**, when the spreading is implemented by using the spreading code SC, one spreading code may be used, and as shown in FIG. **5**C, two spreading codes SC**1** and SC**2** may be used for thereby implementing the spreading operation.

In order to achieve the objects of the present invention, the orthogonal Hadamard sequence directed to multiplying each channel data may be determined as follows.

The combined orthogonal Hadamard sequence may be used instead of the orthogonal Hadamard sequence for removing a predetermined phase dependency based on the interference generated in the multiple path type of self-signal and the interference generated by other users.

For example, in the case of two channels, when the sequence vector of the k-th column or row is set to W_{k-1} in the M×M (M=8) Hadamard matrix, and the sequence vector of the m-th column or row is set to W_m, the first M/2 or the last M/2 is obtained based on the vector W_{k-1} and the last M/2 or the first M/2 is obtained based on W_{m-1}, so that the combined orthogonal Hadamard vector is set to $W_{k-1//m-1}$, and $W_{M,11}=W_0$, $W_{M,12}=W_{4//1}$, $W_{M//}=W_0$, $W_{M,Q=W1/4}$ are determined, so that it is possible to complex-multiply $\alpha_{11}W_0X_{11}+j\alpha_{12}W_{4//1}X_{11}$ and $W_0+jPW_{1//4}$.

In the case of three channels, the sequence vector of the k-th column or row is set to W_{k-1} based on the M×M (M=8) Hadamard matrix, and the sequence vector of the m-th column or row is set to W_M, so that the first M/2 or the last M/2 is obtained from the vector W_{k-1}, and the last M/2 or the first M/2 is obtained from W_{m-1}, and the combined orthogonal Hadamard vector is set to $W_{k-1//m-1}$, and the summed value of $\alpha_{11}W_0X_{11}+j\alpha_{12}W_{4//1}X_{12}$ and $\alpha_{21}W_2X_{21}$ and $W_0+jPW_{1//4}$ are complex multiplied based on $W_{M,11}=W_0$, $W_{M,12}=W_{4//1}$, $W_{M,21}=W_1$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1//4}$.

In addition, in the case of two channels, when the sequence vector of the k-th column or row of the M×M (M=8) Hadamard vector matrix is set to W_{k-1}, and the sequence vector of the m-th column or row is set to W_m, the first M/2 or the last M/2 is obtained from the vector W_{k-1}, and the last M/2 or the first M/2 is obtained from W_{m-1}, so that the combined orthogonal Hadamard vector is set to $W_{-1//m-1}$, and the summed value of $\alpha_{11}W_0X_{11}+j\alpha_{12}W_{2//1}X_{12}$ and $W_0+jPW_{1//2}$ are complex-multiplied based on $W_{M,11}=W_0$, $W_{M,12}=W_{2//1}$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1//2}$.

In addition, in the case of three channels, when the sequence vector of the k-th column or row of the M×M (M=8) Hadamard vector matrix is set to W_{k-1}, and the sequence vector of the m-th column or row is set to W_m, the first M/2 or the last M/2 is obtained from the vector W_{k-1}, and the last M/2 or the first M/2 is obtained from W_{m-1}, so that the combined orthogonal Hadamard vector is set to $W_{k-1//m-1}$, and the summed value of $\alpha_{11}W_0X_{11}+j\alpha_{12}W_{2//}\mathbf{1}X_{12}$ and $\alpha_{21}W_4W_{2l}$ and $W_0+jPW_{1//2}$ are complex-multiplied based on $W_{M,11}=W_0$, $W_{M,12}=W_{2//1}$, $W_{M,21}=W_4$, and $W_{M,I=W0}$, $W_{M,Q}=W_{1//2}$.

Here, so far the cases of two channels and three channels were explained. The cases of two channels and three channels may be selectively used in accordance with the difference of the impulse response characteristic difference of the pulse shaping bandpass filter.

FIG. **6**A is a view illustrating a constellation plot of the OCQPSK according to the present invention, FIG. **6**B is a view illustrating a maximum eye-opening point after the actual pulse shaping filter of FIG. **6**A, and FIG. **7** is a view illustrating a power peak occurrence statistical distribution characteristic with respect to an average power between the OCQPSK according to the present invention and the conventional CDMA ONE and version ETRI 1.0. As shown therein, the embodiment of FIG. **6**A is similar with that of FIG. **2**A. However, there is a difference in the point of the maximum eye-opening point after the actual pulse shaping filter. Namely, in FIG. **6**B, the range of the upper and lower information (Q channel) and the left and right information (I channel) are fully satisfied. This causes the difference of the statistical distribution of the peak power-to-average power.

FIG. **7** illustrates the peak power-to-average power ratio obtained based on the result of the actual simulation between the present invention and the conventional art.

In order to provide the identical conditions, the power level of the control or signal channel is controlled to be the same as the power level of the communication channel (Fundamental channel, supplemental channel or the In-phase channel and the Quadrature channel), and the power level of the pilot channel is controlled to be lower than the power level of the communication channel by 4 dB. In the above-described state, the statistical distributions of the peak power-to-average power are compared.

In the case of OCQPSK according to the present invention, the comparison is implemented using the first complex multiplier **100** and the n-th complex multiplier **100**n shown in FIG. **4**. The first block **100** is implemented based on $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,13}=W_0$, and $W_{M,14}=W_1$, and the n-th block **100**n is implemented based on $W_{M,n1}=W_0$, $W_{M,n2}=W_4$, $W_{M,n3}=W_2$, and $W_{M,n4}=W_3$. In addition, the SCI is used as the SC**1** for the spreading code. In this case, the SC**2** is not used.

In the case of OCQPSK, the probability that the instantaneous power exceeds the average power value (0 dB) by 4 dB is 0.03%, and in the case of CDMA ONE, the same is 0.9%, and in the case of the ETRI version 1.0, the same is 4%. Therefore, in the present invention, the system using the CDMA technique has very excellent characteristic in the peak to average power ratio sense, and the method according to the present invention is a new modulation method which eliminates the cross talk problem.

FIG. **9** illustrates a permutated orthogonal complex spreading modulation (POCQPSK) according to the present invention.

As shown therein, one or a plurality of channels are combined and complex-multiplied by the permutated orthogonal Hadamard code and then are spread by the spreading code.

As shown therein, there are provided first and second Hadamard sequence multipliers **600** and **700** for allocating the multichannel to a predetermined number of channels, splitting the same into two groups and outputting $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying the data X_{n1} of each channel by the gain α_{n1} and the orthogonal Hadamard sequence $W_{M,n1}$, a first adder **810** for outputtin

$$\sum_{n=1}^{K}(\alpha_{n1}W_{M,n1}X_{n1})$$

which is obtained by summing the output signals from the first Hadamard sequence multiplier **600**, a second adder **820** for outputting

$$\sum_{n=1}^{K}(\alpha_{n2}W_{M,n2}X_{n2})$$

which is obtained by summing the output signals from the second Hadamard sequence multiplier **700**, a complex multiplier **900** for receiving the output signal from the first adder **810** and the output signal from the second adder **820** in the complex form of

$$\sum_{n=1}^{K}(\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2})$$

and complex-multiplying $W_{M,I}+jPW_{M,Q}$ which consist of the orthogonal Hadamard code $W_{M,I}$, and the permutated orthogonal Hadamard code $PW_{M,Q}$ that $W_{M,Q}$ and a predetermined sequence P are complex-multiplied, a spreading unit **300** for multiplying the output signal from the complex multiplier **900** by the spreading code, a filter **400** for filtering the output signal from the spreading unit **300**, and a modulator **500** for multiplying and modulating the modulation carrier wave, summing the in-phase signal and the quadrature phase signal and outputting a modulation signal of the real number.

Here, the construction of the spreading unit **300**, the filter **400** and the modulator **500** is the same as the embodiment of FIG. **4** except for the following construction. Namely, comparing to the embodiment of FIG. **4**, in the construction of FIG. **9**, the multiplication of the complex type orthogonal Hadamard sequence performed by the complex multipliers **100** through **100**n are separated and connected in the rear portion of the summing unit, and the channel-wise multiplication by the complex type orthogonal Harmard sequence is not implemented. Namely, the two group summed signal is multiplied by the complex type orthogonal Hadamard sequence.

The first orthogonal Hadamard sequence multiplier **600** outputs

$$\sum_{n=1}^{K}(\alpha_{n1}W_{M,n1}X_{n1})$$

which is summed by the first adder **810** by summing $\alpha_{11}W_{M,11}X_{11}$ which is obtained by the first adder **810** by multiplying the orthogonal Hadamard sequence $W_{M,11}$ by the first data X_{11} of the first block and the gain α_{11}, respectively, $\alpha_{21}W_{M,21}X_{21}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,21}$ by the second data X_{21} of the first block and the gain α_{21}, respectively, and $\alpha_{n1}W_{M,n1}X_{n1}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n1}$ by the n-th data X_{n1} of the first block and the gain α_{n1}.

The second orthogonal Hadamard sequence multiplier **700** outputs

$$\sum_{n=1}^{K}(\alpha_{n2}W_{M,n2}X_{n2})$$

which is summed by the second adder **820** by summing $\alpha_{12}W_{M,12}X_{12}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,12}$ by the first data X_{12} of the second block and the gain α_{12}, respectively, $\alpha_{22}W_{M,22}X_{22}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,22}$ by the second data X_{22} of the second block and the gain α_{22}, respectively, and $\alpha_{n2}W_{M,n2}X_{n2}$ which is obtained by multiplying the orthogonal Hadamard sequence $W_{M,n2}$ by the n-th data X_{n2} of the second block and the gain α_{n2}. Here, the block represents one group split into 1 group.

The signal outputted from the first adder **810** forms an in-phase data, and the signal outputted from the second adder **820** forms an quadrature phase data and outputs

$$\sum_{n=1}^{K} (\alpha_{n1} W_{M,n1} X_{n1} + j\alpha_{n2} W_{M,n2} X_{n2}).$$

In addition, the complex multiplier **900** multiplies the complex output signals from the first and second adders **810** and **820** by a complex type signal that is comprised of an orthogonal Harmard code $W_{M,I}$ and $PW_{M,Q}$ which results from the multiplication of the orthogonal Hardmard code $W_{M,Q}$ by the sequence P and outputs an in-phase signal and a quadrature phase signal. Namely, the complex output signals from the first and second adders **810** and **820** are complex-multiplied by the complex type signals of $W_{M,I}$+j$PW_{M,Q}$ by the complex multiplier.

The spreading unit **300** multiplies the output signal from the complex multiplier **900** by the spreading code SCI and spreads the same. The thusly spread signals are filtered by the pulse shaping filters **410** and **420**. The modulation carrier waves of $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$ are summed by the modulation multipliers **510** and **520** and then modulated for thereby outputting s(t).

Namely, the following equation is obtained.

$$\left(\sum_{n=1}^{K} (\alpha_{n1} W_{M,n1} X_{n1} + j\alpha_{n2} W_{M,n2} X_{n2})\right) \otimes (W_{M,1} + jPW_{M,Q}) \otimes SCI.$$

where K represents an integer greater than or equal to 1.

FIG. **10** illustrates an embodiment that two channel data are complex-multiplied. A channel data X_{11} is allocated to the first orthogonal Hadamard sequence multiplier **600** and another channel data X_{12} is allocated to the second orthogonal Hadamard sequence multiplier **700**.

Here, the orthogonal Hadamard sequence multiplier includes a first multiplier **610** for multiplying the first data X_{11} by the gain α_{11}, a second multiplier **611** for multiplying the output signal from the first multiplier **610** by the orthogonal Hadamard sequence $W_{M,11}$, a third multiplier **710** for multiplying the second data X_{12} by the gain α_{12}, and a fourth multiplier **711** for multiplying the output signal from the third multiplier **710** by the orthogonal Hadamard sequence $W_{M,12}$. At this time, since one channel is allocated to one group, the summing unit is not used.

The complex multiplier **900** includes fifth and sixth multipliers **901** and **902** for multiplying the output signal $\alpha_{11} W_{M,11} X_{11}$ from the second multiplier **611** and the output signal $\alpha_{12} W_{M,12} X_{12}$ from the fourth multiplier **711** by the orthogonal Hadamard sequence $W_{M,I}$, seventh and eighth multipliers **903** and **904** for multiplying the output signal $\alpha_{11} W_{M,11} X_{11}$ from the second multiplier **611** and the output signal $\alpha_{12} W_{M,12} X_{12}$ from the fourth multiplier **711** by the permutated orthogonal Hadamard sequence $PW_{M,Q}$, a first adder **905** for summing the output signal (+ac) from the fifth multiplier **901** and the output signal (−bd) from the seventh multiplier **903** and outputting an in-phase information (ac−bd), and a second adder **906** for summing the output signal (bc) from the sixth multiplier **902** and the output signal (ad) from the eighth multiplier **904** and outputting an quadrature phase information (bc+ad).

Therefore, the first and second multipliers **610** and **611** multiply the data X_{11} by the orthogonal Hadamard sequence $W_{M,11}$ and the gain α_{11} for thereby obtaining $\alpha_{11} W_{M,11} X_{11}$ (=a). In addition, the third and fourth multipliers **710** and **711** multiply the data X_{12} by the orthogonal Hadamard sequence $W_{M,12}$ and the gain α_{12} for thereby obtaining $\alpha_{12} W_{M,12} X_{12}$ (=b). The fifth and sixth multipliers **901** and **902** multiply $\alpha_{11} W_{M,11} X_{11}$ (=a) and $\alpha_{12} W_{M,12} X_{12}$ (=b) by the orthogonal Hadamard sequence $W_{M,I}$ (=c) for thereby obtaining $\alpha_{11} W_{M,11} X_{11} W_{M,I}$ (=ac) and $\alpha_{12} W_{M,12} X_{12} W_{M,i}$ (=bc).

The seventh and eighth multipliers **903** and **904** multiply $\alpha_{11} W_{M,11} X_{11}$ (=a) and $\alpha_{12} W_{M,12} X_{12}$ (=b) by the permutated orthogonal Hadamard sequence $PW_{M,Q}$ for thereby obtaining $\alpha_{11} W_{M,11} X_{11} PW_{M,Q}$ (=ad) and $\alpha_{12} W_{M,12} X_{12} PW_{M,Q}$ (=bd).

In addition, the first adder **905** obtains $(\alpha_{11} W_{M,11} X_{11} W_{M,I})-(\alpha_{12} W_{M,12} X_{12} PW_{M,Q})$ (=ac−bd), namely, $\alpha_{12} W_{M,12} X_{12PWM,Q}$(bd) is subtracted from $\alpha_{11} W_{M,11} X_{11} W_{M,I}$ (=ac), and the second adder **906** obtains $(\alpha_{11} W_{M,11} X_{11} PW_{M,Q})+(\alpha_{12} W_{M,12} X_{12} W_{M,I})$ (ad+bc), namely, $(\alpha_{11} W_{M,11} X_{11} PW_{M,Q})$ (=ad) is summed by $(\alpha_{12} W_{M,12} X_{12} W_{M,I})$ (bc).

FIG. **10** illustrates the complex multiplier **900** shown in FIG. **9**. Assuming that $\alpha_{11} W_{M,11} X_{11}$ is "a", $\alpha_{12} W_{M,12} X_{12}$ is "b", the orthogonal Hadamard sequence $W_{M,I}$ is "c", and the permutated orthogonal Hadamard sequence $PW_{M,Q}$ is "d", since (a+jb) (c+jd)=ac−bd+jc (bc+ad), the signal from the complex multiplier **900** becomes the in-phase information ac−bd and the quadrature phase information bc+ad.

The in-phase data and the quadrature phase data are spread by the spreading unit **300** based on the spreading code (for example, PN code). In addition, the I channel signal which is the in-phase information and the Q channel signal which is the quadrature phase information signal are filtered by the first and second pulse shaping filters **410** and **420**. The first and second multipliers **510** and **520** multiply the output signals from the first and second pulse shaping filters **410** and **420** by $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$. The output signals from the multipliers **510** and **520** are summed and modulated by the adder **530** which outputs S(t).

In the embodiment as shown in FIG. **9**, identically to the embodiment as shown in FIG. **4**, for the orthogonal Hadamard sequence, the Walsh code or other orthogonal code may be used. In addition, in the orthogonal Hadamard sequence of each channel, the sequence vector of the k-th column or row is set to W_{k-1} in the M×M Hadamard matrix. (where p represents a predetermined number in a range from 0 to (M/2)−1.

The orthogonal Hadamard sequence is allocated to each channel based on the above-described operation, and if there remain other channels which are not allocated the orthogonal Hadamard sequence by the above-described operation, and if there remain other channel which are not allocated the orthogonal Hadamard sequence by the above-described operation, then any row or column vector from the Hamard matrix can be selected.

FIG. **11** illustrates an embodiment of the POCQPSK for the voice service. In this case, two channels, namely, the pilot channel and the data of traffic channels are multiplied by the gain and orthogonal Hadamard sequence, and two channel signals are inputted into the complex multiplier **900** in the complex type, and the orthogonal Hadamard sequence of the complex type is multiplied by the complex multiplier **900**.

FIG. **12** illustrates the construction of a data service having a good quality voice service and low transmission rate. In this case, the pilot channel and signaling channel are allocated to the first orthogonal Hadamard sequence multiplier **700**, and the traffic channel is allocated to the second orthogonal Hadamard sequence multiplier **700**.

FIG. **13**A illustrates the construction for a data service of a high transmission rate. As shown therein, the data transmitted at a rate of R bps has the QPSK data type and are transmitted at R/2 bps through the serial to parallel converter. As shown in FIG. **13**B, the system may be constituted so that the input data (traffic **1** and traffic **2**) have the identical gains ($\alpha_{31}=\alpha_{12}$). Here, when the data having high transmission rate are separated into two channels, the gain allocated to each channel should be determined to the identical gain for thereby eliminating the phase dependency.

FIGS. **14**A and **14**B illustrate the construction of the multichannel service. In this case, the data (traffic) having a high transmission rate is converted into the QPSK data for R/2 bps through the serial to parallel converter and then is distributed to the first orthogonal Hadamard sequence multiplier **600** and the second Hadamard sequence multiplier **700**, and three channels are allocated to the first orthogonal Hadamard sequence multiplier **600** and two channels are allocated to the second orthogonal Hadamard sequence multiplier **700**.

As shown in FIG. **14**B, the serial to parallel converter is not used, and when the data (traffic) is separated into two channel data (Traffic **1**) and (traffic **2**) and then is inputted, the gain adapted to each channel adapts the identical gains ($\alpha 31=\alpha 12$).

FIG. **15**A is a phase trajectory view of an OCQPSK according to the present invention, FIG. **15**B is a phase trajectory view of a POCQPSK according to the present invention, and FIG. **15**C is a phase trajectory view of a complex spreading method according to PN complex spreading method of the present invention.

As shown therein, when comparing the embodiments of FIGS. **15**A, **15**B and **15**C, the shapes of the trajectories and the zero points are different. In a view of the power efficiency, there is also a difference. Therefore, the statistical distribution of the peak power-to-average power ratio is different.

FIG. **7** illustrates a characteristic illustrating a statistical distribution of a peak power-to-average power ratio of the CDMA ONE method compared to the OCQPSK method and the POSQPSK.

In order to provide the identical condition, the power level of the signal channel is controlled to be the same as the power level of the communication channel, and the power level of the pilot channel is controlled to be lower than the power level of the communication channel by 4 dB, and then the statistical distribution of the peak power-to-average power ratio is compared.

In the case of the POCQPSK according to the present invention, in the first block **600** of FIG. **9**, $W_{M,11}=W_0$, and $W_{M,21}=W_2$ are implemented, and in the second block **700**, $W_{M,12}=W_4$, and $W_{M,I}=W_0$ and $M_{M,Q}=W_1$ are implemented. For the value of P, the spreading code is used so that consecutive two sequences have the identical value.

For example, the probability that the instantaneous power exceeds the average power value (0 dB) by 4 dB is 0.1% based on POCQPSK, and the complex spreading method is 2%. Therefore, in view of the power efficiency, the method adapting the CDMA technique according to the present invention is a new modulation method having excellent characteristic.

As described above, in the OCQPSK according to the present invention, the first data and the second data are multiplied by the gain and orthogonal code, and the resultant values are complex-summed, and the complex summed value is complex-multiplied by the complex type orthogonal code. The method that the information of the multichannel of the identical structure is summed and then spread is used. Therefore, this method statistically reduces the peak power-to-average power ratio to the desired range.

In addition, in the POCQPSK according to the present invention, the data of the first block and the data of the second block are multiplied by the gain and the orthogonal code, respectively, and the permutated orthogonal spreading code of the complex type is complex-multiplied and then spread. Therefore, this method statistically reduces the peak power-to-average power ratio to the desired range, and it is possible to decrease the phase dependency based in the multichannel interference and the multiuser interference using the combined orthogonal Hadamard sequence.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, tat additions and substitutions are possible, without departing from the scope and spirit of the invention as recited in the accompanying claims.

What is claimed is:

1. An orthogonal complex spreading method for multiple channels, comprising the steps of:

complex-summing $W_{M,n1}X_{n1}$, which is obtained by multiplying an orthogonal code sequence $W_{M,n1}$ by first data group X_{n1} of a n-th block, and $W_{M,n2}X_{n2}$, which is obtained by multiplying an orthogonal code sequence $W_{M,n2}$ by second data group X_{n2} of a n-th block, M and n being positive integers;

complex-multiplying the complex summed form of $W_{M,n1}X_{n1}+jW_{M,n2}X_{n2}$, by a complex form of $W_{M,n3}+jW_{M,n4}$ and outputting $(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})\times(W_{M,n3}+jW_{M,n4})$ as an output signal; and

summing in-phase and quadrature phase parts of the output signal outputted from a plurality of blocks as

$$\left(\sum_{n=1}^{K}((W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})\times(W_{M,n3}+jW_{M,n4}))\right),$$

K is a predetermined integer greater than or equal to 1 to generate I channel and Q channel signal.

2. The method of claim **1** wherein a spreading code spreads the summed in-phase and quadrature-phase signals outputted from the summing step.

3. The method of claim **1** wherein said orthogonal code sequence includes a Hadamard code sequence.

4. The method of claim **1** wherein said orthogonal code sequence includes a Walsh code.

5. The method of claim **2** wherein said spreading code is one spreading code.

6. The method of claim **5** wherein said spreading code sequence includes a PN code.

7. The method of claim **5** wherein said spreading code includes a first spreading code for the in-phase signal and a second spreading code for the quadrature-phase signal.

8. The method of claim **7** wherein the first and second spreading codes are PN codes.

9. The method of claim **3** wherein $W_{M,11}=W_0$, $W_{M,12}=W_2$, and $W_{M,13}=W_0$, $W_{M,14}=W_1$, when M=4.

10. The method of claim **9** wherein M=8 and $W_{M,12}=W_4$.

11. The method of claim **3** wherein $W_{M,n1}=W_0$, $W_{M,n2}=W_{2p}$, where p represents a predetermined number in a range from 0 to (M/2)−1, and $W_{M,n3}=W_{2n-2}$, $W_{M,n4}=W_{2n-1}$.

12. The method of claim **3** wherein $W_{M,21}=W_0$, $W_{M,22}=W_4$, $W_{M,23}=W_2$, $W_{M,24}=W_3$ when M=8 in case of two channels.

13. The method of claim **12** wherein $W_{M,12}=W_6$, and $W_{M,22}=W_6$.

14. An orthogonal complex spreading apparatus, comprising:

a plurality of complex multiplication blocks, each for complex-multiplexing a complex signal $W_{M,n1}X_{n1}+$

$jW_{M,n2}X_{n2}$ by $W_{M,n3}+jW_{M,n4}$ wherein $W_{M,n1}X_{n1}$ is obtained by multiplying an orthogonal code sequence $W_{M,n1}$ by first data group X_{n1} of n-th block and $W_{M,n2}X_{n2}$ is obtained by multiplying orthogonal sequence $W_{M,n2}$ by second data group X_{n2} of the n-th block, wherein M and n are positive integers and $W_{M,n1}$, $W_{M,n2}$, $W_{M,n3}$ and $W_{M,n4}$ are predetermined orthogonal sequences; and

a summing unit for summing in-phase and quadrature phase parts of an output signal from each block of the plurality of the complex multiplication blocks as

$$\left(\sum_{n=1}^{K}((\alpha_{n1}W_{M,n1}X_{n1}+j\alpha_{n2}W_{M,n2}X_{n2})\times(W_{M,n3}+jW_{M,n4}))\right),$$

K is a predetermined integer greater than or equal to 1.

15. The apparatus of claim **14** further comprising a spreading unit for multiplying the summed in-phase and quadrature phase signals inputted from the summing unit by spreading code.

16. The apparatus of claim **15** wherein said spreading unit multiplies the in-phase and quadrature phase part by different spreading codes.

17. The apparatus of claim **14** wherein each said complex multiplication block includes:

a first multiplier for multiplying the first data group X_{n1} by the orthogonal code sequence $W_{M,n1}$;

a second multiplier for multiplying the second data group X_{n2} by the orthogonal code sequence $W_{M,n2}$;

third and fourth multipliers for multiplying the output signal $W_{M,n1}X_{n1}$ from the first multiplier and the output signal $W_{M,n2}X_{n2}$ from the second multiplier by orthogonal code sequence $W_{M,n3}$;

fifth and sixth multipliers for multiplying the output signal $W_{M,n1}X_{n1}$ from the first multiplier and the output signal $W_{M,n2}X_{n2}$ from the second multiplier by orthogonal code sequence $W_{M,n4}$;

a first adder for subtracting output signal from the sixth multiplier from output signal (ac) from the third multiplier and outputting an in-phase information; and

a second adder for summing output signal from the fourth multiplier and output signal from the fifth multiplier and outputting quadrature phase information.

18. The apparatus of claim **17** wherein said orthogonal code sequence includes a Hadamard code sequence.

19. The apparatus of claim **17** wherein said orthogonal code sequence includes a Walsh code.

20. A permuted orthogonal complex spreading method for multiple channels allocating at least two input channels to first and second groups, comprising the steps of:

multiplying a predetermined orthogonal code sequence $W_{M,n1}$ by first data group X_{n1};

multiplying orthogonal code sequence $M_{M,n2}$ by second data group X_{n2};

summing output signals $W_{M,n1}X_{n1}$ and $W_{M,n2}X_{n2}$ in the complex form of

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2});$$

and

complex-multiplying the received output signal

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})\text{ by }W_{M,1}+jPW_{M,Q}$$

wherein P is a predetermined sequence, and $W_{M,I}$ and $W_{M,Q}$ are orthogonal code sequences.

21. The method of claim **20** wherein *a spreading code spreads the output of the step of complex-multiplying, and* the spreading code is *generated based on at least* a PN code.

22. The method of claim **20** wherein P represents said predetermined sequence or predetermined spreading code or predetermined integer configured so that two consecutive sequences have identical values.

23. The method of claim **20** wherein said orthogonal code sequence includes a Hadamard code sequence.

24. The method of claim **20** wherein said orthogonal code sequence includes a Walsh code.

25. The method of claim **23** wherein $W_{M,I}=W_0$, $W_{M,Q}=W_{2q+1}$ (where q represents a predetermined number in a range from 0 to (M/2)−1).

26. The method of claim **23** further comprising the steps of:

multiplying the first data group X_{n1} by gain α_{n1}; and

multiplying the second data group X_{n2} by gain α_{n2}.

27. The method of claim **23** wherein $W_{M,11}=W_0$, $W_{M,12}=W_2$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$, when M=4.

28. The method of claim **27** wherein M=8 and $W_{M,12}=W_4$.

29. The method of claim **23** wherein $W_{M,n1}=W_0$, $W_{M,n2}=W_{2q+1}$, wherein q represents a predetermined number in a range from 0 to (M/2)−1 and $W_{M,I}=W_0$, $W_{M,Q}=W_1$.

30. The method of claim **20** wherein each group has at least two channels and the receiving step includes the steps of:

summing output signals $W_{M,n1}X_{n1}$ from a first sequence multiplier; and

summing output signals $W_{M,n2}X_{n2}$ from a second sequence multiplier.

31. A permuted orthogonal complex spreading apparatus for multiple channels, allocating at least two input channels to first and second groups, comprising:

a first multiplier block having at least one channel contained in a first group of channels, each for outputting $W_{M,n1}X_{n1}$ which is obtained by multiplying first data group X_{n1} by orthogonal code sequence $W_{M,n1}$, and M and n are positive integers;

a second multiplier block having a number of channels having at least one channel contained in a second group of channels, each for outputting $W_{M,n2}X_{n2}$ which is obtained by multiplying a first data group X_{n2} by orthogonal code sequence $W_{M,n2}$;

a complex multiplier for receiving the output signals from the first and the second multiplier blocks in a complex form of

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})$$

and complex-multiplying received output signal by $W_{M,I}+jPW_{M,Q}$, wherein $W_{M,I}$ and $W_{M,Q}$ are predetermined orthogonal code sequence permuted and P is a predetermined sequence.

32. The apparatus of claim **31** wherein said orthogonal code sequence includes a Hadamard code sequence.

33. The apparatus of claim **31** wherein said orthogonal code sequence includes a Walsh code.

34. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,21}=W_2$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$, when M=8 in case of three input channels.

35. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_2$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$ in case of three input channels.

36. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,21}=W_2$, $W_{M,31}=W_6$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$ in case of four input channels.

37. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,31}=W_2$, $W_{M,I}=W_0$, $W_{M,Q}=W_1$ and $W_{M,21}=W_8$ in case of four input channels.

38. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,21}=W_2$, $W_{M,31}=W_6$, $W_{M,22}=W_1$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$ in case of five input channels.

39. The apparatus of claim **32** wherein $W_{M,n1}=W_0$, $W_{M,12}=W_4$, $W_{M,21}=W_2$, $W_{M,31}=W_6$, $W_{M,22}=W_3$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$ in case of five input channels.

40. The apparatus of claim **31** wherein $W_{M,11}=W_0$, $W_{M,12}=W_4$, $W_{M,31}W_2$, $W_{M,22}=W_6$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$ and $W_{M,21}=W_8$ in case of five input channels.

41. The apparatus of claim **32** wherein $W_0X_{11}+jW_4X_{12}$, W_2X_{21} and W_6X_{31} are replaced by $\alpha_{11}W_0X_{11}+j\alpha_{12}W_4X_{12}$, $\alpha_{21}W_2X_{21}$ and $\alpha_{31}W_6X_{31}$, and a gain α_{n1} and a gain α_{n2} are the identical gain in order to remove the phase dependency by an interference occurring in a multipath of a self signal and an interference occurring by other users.

42. The apparatus of claim **31** wherein $W_{M,n1}=W_0$, $W_{M,n2}=W_2$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$.

43. The apparatus of claim **31** wherein the first multiplier block comprises at least a third multiplier for multiplying the first data group X_{n1} by gain α_{n1}, and the second multiplier block comprises at least a fourth multiplier the second data group X_{n2} by gain α_{n2}.

44. The apparatus of claim **31** wherein $W_{M,11}=W_0$, $W_{M,12}=W_{4/1}$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1/4}$, when M=8 in case of two input channels.

45. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_{4/1}$, $W_{M,21}=W_2$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1/4}$, when M=8 in case of three input channels.

46. The method of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_{2/1}$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1/2}$, when M=8 in case of two input channels.

47. The apparatus of claim **32** wherein $W_{M,11}=W_0$, $W_{M,12}=W_{2/1}$, $W_{M,21}=W_4$, and $W_{M,I}=W_0$, $W_{M,Q}=W_{1/2}$, when M=8 in case of three input channels.

48. The apparatus of claim **31** wherein each group has at least the two input channels, further comprising:

a first adder for outputting

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1})$$

by summing output signals from the first multiplier block; and

a second adder for outputting

$$\sum_{n=1}^{K}(W_{M,n2}X_{n2})$$

by summing output signals from the second multiplier block.

49. The apparatus of claim **31** further comprising:

a spreading unit for multiplying the signal

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})$$

received by the complex multiplier by a spreading code.

50. The apparatus of claim **49** wherein the spreading unit respectively multiplies the in-phase and quadrature-phase parts by different spreading codes.

51. The apparatus of claim **31** wherein $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, and $W_{M,Q}$ are orthogonal Hadamard sequences.

52. The apparatus of claim **31** wherein the complex multiplier includes:

fifth and sixth multipliers for multiplying said output signal from the first multiplier block and said output signal from the second sequence multiplier by orthogonal sequence $W_{M,I}$;

seventh and eighth multipliers for multiplying said output signal from the first multiplier block and output signal $\alpha_{n2}W_{M,n2}X_{n2}$ from the second multiplier block by orthogonal sequence $W_{M,Q}$;

a third adder for subtracting output signal from the eighth multiplier from output signal from the fifth multiplier to output an in-phase information; and

a second adder for summing output signal from the sixth multiplier and output signal from the seventh multiplier to output quadrature-phase information.

53. A permuted orthogonal complex spreading apparatus for multiple channels, allocating at least two input channels into first and second groups, comprising:

first and second multiplier blocks for respectively multiplying first and second data group X_{n1}, and X_{n2} with a set of predetermined orthogonal sequences $W_{M,n1}$, and $W_{M,n2}$ to output $W_{M,n1}X_{n1}$ and $W_{M,n2}X_{n2}$;

a complex multiplier for receiving the output signals $W_{M,n1}X_{n1}$ and $W_{M,n2}X_{n2}$ from the first and the second multiplier blocks in the complex form of

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})$$

and multiplying a received signal

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1}+jW_{M,n2}X_{n2})$$

by a predetermined sequence $(W_{M,I}+jPW_{M,Q})\times SC$, wherein $W_{M,I}$, $W_{M,Q}$ are predetermined orthogonal sequences, P is a predetermined sequence and SC is a spreading sequence.

54. The apparatus of claim **53** wherein each group has at least two input channels, further comprising:

a first adder for outputting

$$\sum_{n=1}^{K}(W_{M,n1}X_{n1})$$

by summing output signals from the first sequence multiplier; and

a second adder for outputting

$$\sum_{n=1}^{K}(W_{M,n2}X_{n2})$$

by summing output signals from the second sequence multiplier.

55. The apparatus of claim **53** wherein the first sequence multiplier comprises at least one first gain multiplier for multiplying the data X_{n1}, of each channel of the first group by gain α_{n1}, and the second sequence multiplier comprises at least one second gain multiplier for multiplying the data X_{n2} of each channel of the second group by gain α_{n2}.

56. The apparatus of claim **53** wherein $W_{M,n1}=W_0$, $W_{M,n2}W_{2p}$, and $W_{M,I}=W_0$, $W_{M,Q}=W_1$, where p represents a predetermined integer in a range from 0 to (M/2)−1.

57. The apparatus of claim **53** wherein $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, and $W_{M,Q}$ are orthogonal Hadamard sequences.

58. The method of claim 20 wherein

the step of summing of output signals $W_{M,n1}X_{n1}$ and $W_{M,n2}X_{n2}$ includes adjusting values of the output signals $W_{M,n1}X_{n1}$ and $W_{M,n2}X_{n2}$ based on gains.

59. The method of claim 58 wherein

said step of complex-multiplying

$$\sum_{n=1}^{K}(W_{n1}X_{n1}+jW_{n2}X_{n2})$$

by $(W_{M,I}+jPW_{M,O})$ includes multiplying

$$\sum_{n=1}^{K}(W_{n1}X_{n1}+jW_{n2}X_{n2})$$

by $(W_{M,1}+jPW_{M,O})$ and by a spreading sequence, wherein $W_{M,I}=W_0$ and $W_{M,O}=W_1$.

60. The method of claim 59 wherein,

P comprises a sequence, said sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

61. The apparatus of claim 53 wherein

the first multiplier block is configured to adjust the values of $W_{M,n1}X_{n1}$ based on first relative gains, and

the second multiplier block is configured to adjust the values of $W_{M,n2}X_{n2}$ based on second relative gains.

62. The apparatus of claim 53 wherein

$W_{M,n1}$ and $W_{M,n2}$ comprise gain adjusted sequence elements.

63. The method of claim 20, wherein

$W_{M,1}=W_0$ and $W_{M,O}=W_1$.

64. The method of claim 63, further comprising:

adjusting the values of $W_{M,n1}X_{n1}$ based on first relative gains, and

adjusting the values of $W_{M,n2}X_{n2}$ based on second relative gains.

65. The method of claim 63, wherein

$W_{M,n1}$ and $W_{M,n2}$ comprise gain adjusted sequence elements.

66. The method of claim 63, wherein

P is generated based on a spreading sequence.

67. The method of claim 63, wherein

the spreading sequence is generated based on a PN code.

68. The apparatus of claim 53, wherein

$W_{M,1}=W_0$ and $W_{M,O}=W_1$.

69. The method of claim 68, wherein

P is generated based on a spreading sequence.

70. The method of claim 69, wherein

the spreading sequence is generated based on a PN code.

71. A spreading method, comprising:

generating

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1})$$

based on at least one or more first input signals $X_{11}, \ldots, X_{K1}$, one or more first orthogonal code sequences $OS_{11}, \ldots, OS_{K1}$, and one or more first gains $\alpha_{11}, \ldots, \alpha_{K1}$, K being a positive integer;

generating

$$\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

based on at least one or more second input signals $X_{12}, \ldots, X_{L2}$, one or more second orthogonal code sequences $OS_{12}, \ldots, OS_{L2}$, and one or more second gains $\alpha_{12}, \ldots, \alpha_{L2}$, L being a positive integer; and

complex-multiplying

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1})+j\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

by $(W_0+jP\cdot W_1)\times SC$,

wherein P is a third sequence and SC is a first sequence comprising at least a first element having a first value and a second element having a second value.

72. The method of claim 71 wherein,

P comprises a second sequence, said second sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

73. The method of claim 71, wherein the first sequence is generated based on at least a PN code.

74. The method of claim 73 wherein,

P comprises a second sequence, said second sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

75. The method of claim 71, wherein at least one of the one or more first orthogonal code sequences consists of a plurality of ones.

76. The method of claim 75, wherein SC is a PN code and at least one of the one or more first gains has a value of 1.

77. A spreading apparatus comprising:

first multiplier mechanism for generating

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1})$$

based on at least one or more first input signals $X_{11}, \ldots, X_{K1}$, *one or more first orthogonal code sequences* $OS_{11}, \ldots, OS_{K1}$, *and one or more first gains* $\alpha_{11}, \ldots, \alpha_{K1}$, *K being a positive integer;*

second multiplier mechanism for generating

$$\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

based on one or more second input signals $X_{12}, \ldots, X_{L2}$, *one or more second orthogonal code sequences* $OS_{12}, \ldots, OS_{L2}$, *and one or more second gains* $\alpha_{12}, \ldots, \alpha_{L2}$, *L being a positive integer;*

a complex multiplier for multiplying

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1}) + j\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

by $(W_0+jP\cdot W_1)\times SC$, *wherein P is a third sequence and SC is a first sequence comprising at least a first element having a first value and a second element having a second value.*

78. The apparatus of claim 77 wherein,

P comprises a second sequence, said second sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

79. The apparatus of claim 77, wherein the first sequence is generated based on at least a PN code.

80. The apparatus of claim 79 wherein,

P comprises a second sequence, said sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

81. The apparatus of claim 77, wherein at least one of the one or more first orthogonal code sequences consists of a plurality of ones.

82. The apparatus of claim 81, wherein SC is a PN code.

83. The apparatus of claim 81, wherein at least one of the one or more first gains has a value of 1.

84. A spreading apparatus, comprising:

a first multiplier mechanism configured to generate

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1})$$

based on at least one or more first input signals $X_{11}, \ldots, X_{K1}$, *one or more first orthogonal code sequences* $OS_{11}, \ldots, OS_{K1}$, *and one or more first gains* $\alpha_{11}, \ldots, \alpha_{K1}$, *K being a positive integer;*

a second multiplier mechanism configured to generate

$$\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

based on at least one or more second input signals $X_{12}, \ldots, X_{L2}$, *one or more second orthogonal code sequences* $OS_{12}, \ldots, OS_{L2}$, *and one or more second gains* $\alpha_{12}, \ldots, \alpha_{L2}$, *L being a positive integer; and*

a complex multiplier configured to multiply

$$\sum_{n=1}^{K}(\alpha_{n1}OS_{n1}X_{n1}) + j\sum_{n=1}^{L}(\alpha_{n2}OS_{n2}X_{n2})$$

by $(W_0+jP\cdot W_1)\times SC$, *wherein P is a third sequence and SC is a spreading sequence.*

85. The apparatus of claim 84 wherein,

P comprises a sequence, said sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

86. The apparatus of claim 84, wherein SC is generated based on at least a PN code.

87. The apparatus of claim 86 wherein,

P comprises a sequence, said sequence including pairs of consecutive sequence elements, respective sequence elements of any one of the pairs having a same value.

88. The apparatus of claim 84, wherein at least one of the one or more first orthogonal code sequences consists of a plurality of ones.

89. The apparatus of claim 88, wherein at least one of the one or more first gains has a value of 1.

90. A spreading method, comprising:

generating a first signal, a, based on at least a first input, a first code, and a first gain;

generating a second signal, b, based on at least a second input, a second code, and a second gain;

generating a third signal, d, based on at least a first sequence of sequence elements, the sequence elements in the first sequence systematically alternating between a first value and a second value, the first value being different from the second value;

systematically generating $SC\cdot a-SC\cdot b\cdot d$; *and*

systematically generating $SC\cdot b+SC\cdot a\cdot d$, *wherein*

SC is a first PN code.

91. The method of claim 90, wherein the first sequence of sequence elements is W_1.

92. The method of claim 90, wherein d is generated based on at least the first sequence and a second sequence.

93. The method of claim 92, wherein the second sequence is generated based on a second PN code.

94. The method of claim 92 wherein the second sequence is generated based on a spreading sequence.

95. The method of claim 92 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

96. The method of claim 92 wherein d is generated by multiplying the first sequence and the second sequence.

97. The method of claim 90, wherein the first value is 1 and the second value is −1.

98. The method of claim 92, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

99. The method of claim 98, wherein the second sequence is generated based on a second PN code.

100. The method of claim 90, wherein the first orthogonal code and the second orthogonal code include Walsh codes.

101. The method of claim 90 wherein the first code and the second code are even-numbered Walsh codes.

102. A spreading method, comprising:

generating a first signal, a, based on at least a first input, a first Walsh code, and a first gain;

generating a second signal, b, based on at least a second input, a second Walsh code, and a second gain;

receiving a first sequence, SC, comprising a first element having a first value and a second element having a second value, the first value being different from the second value;

generating a third signal, d, based on at least a third Walsh code, the third Walsh code being a second sequence of sequence elements and the sequence elements in the second sequence systematically alternating between the first value and the second value;

systematically generating SC·a−SC·b·d; and

systematically generating SC·b+SC·a·d.

103. The method of claim 102, wherein the third Walsh code is W_1.

104. The method of claim 102, wherein d is generated based on at least the third Walsh code and a third sequence.

105. The method of claim 104, wherein the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

106. The method of claim 105, wherein SC is a first PN code.

107. The method of claim 106, wherein the third sequence is generated based on a second PN code.

108. The method of claim 104 wherein the third sequence is generated based on a spreading sequence.

109. The method of claim 104 wherein the third sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

110. The method of claim 104 wherein d is generated by multiplying the third sequence and the third Walsh code.

111. The method of claim 104, wherein SC is a first PN code.

112. The method of claim 111, wherein the third sequence is generated based on a second PN code.

113. The method of claim 102, wherein the first value is 1 and the second value is −1.

114. The method of claim 102, wherein SC is generated based on at least a PN code.

115. The method of claim 102 wherein the first sequence is a spreading sequence.

116. The method of claim 102 wherein the first and the second Walsh codes are even-numbered Walsh codes.

117. The method of claim 102, wherein SC is a first PN code.

118. An apparatus for wireless communications, comprising:

a first multiplier mechanism configured to generate a first signal, a, the first multiplier mechanism having at least a first set of multipliers and a first adder;

a second multiplier mechanism configured to generate a second signal, b, the second multiplier mechanism having at least a second set of multipliers and a second adder;

an input generator configured to generate an input, d, based on at least a first sequence of sequence elements, the sequence elements in the first sequence systematically alternating between a first value and a second value, the first value being different from the second value;

a third multiplier mechanism configured to receive at least the first signal, a, the second signal, b, a second sequence, SC, and the input, d, and to systematically generate SC·a−SC·b·d and SC·b+SC·a·d, the third multiplier mechanism having at least a third set of multipliers and a set of adders, wherein the second sequence comprises at least a first element having the first value and a second element having the second value.

119. The apparatus of claim 118, wherein the first sequence of sequence elements is W_1.

120. The apparatus of claim 118, wherein d is generated based on at least the first sequence and a third sequence.

121. The apparatus of claim 120, wherein the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

122. The apparatus of claim 121, wherein SC is a first PN code.

123. The apparatus of claim 122, wherein the third sequence is generated based on a second PN code.

124. The apparatus of claim 120 wherein the third sequence is generated based on a spreading sequence.

125. The apparatus of claim 118 wherein the third sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

126. The method of claim 120 wherein d is generated by multiplying the third sequence and the first sequence.

127. The apparatus of claim 120, wherein SC is a first PN code.

128. The apparatus of claim 127, wherein the third sequence is generated based on a second PN code.

129. The apparatus of claim 118, wherein the first value is 1 and the second value is −1.

130. The apparatus of claim 118 wherein the second sequence is a spreading sequence.

131. The apparatus of claim 118 wherein the first signal and the second signal are generated based on at least even numbered Walsh codes.

132. The apparatus of claim 118 wherein the second sequence is generated based on at least a PN code.

133. The apparatus of claim 118, wherein SC is a first PN code.

134. A system for wireless communications, comprising:

a sequence mechanism configured to provide a first sequence, SC, the first sequence comprising at least a first element having a first value and a second element having a second value;

a first input generator configured to generate at least a first input, a, and a second input, b;

a second input generator configured to generate at least a third input, d, based on at least a second sequence of sequence elements, the sequence elements in the second sequence systematically alternating between the first value and the second value;

a multiplier mechanism configured to receive at least a, b, SC, and d and to systematically generate SC·a−SC·b·d and SC·b+SC·a·d.

135. The system of claim 134, wherein the second sequence of sequence elements is W_1.

136. The system of claim 134, wherein d is generated based on at least the second sequence and a third sequence.

137. The system of claim 136, wherein the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

138. The system of claim 137 wherein the first signal and the second signal are generated based on at least even numbered Walsh codes.

139. The system of claim 137, wherein SC is a first PN code.

140. The system of claim 139, wherein the third sequence is generated based on a second PN code.

141. The system of claim 136 wherein the third sequence is generated based on a spreading sequence.

142. The system of claim 136 wherein the third sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

143. The system of claim 136 wherein d is generated by multiplying the third sequence and the second sequence.

144. The system of claim 136, wherein SC is a first PN code.

145. The system of claim 144, wherein the third sequence is generated based on a second PN code.

146. The system of claim 134, wherein the first value is 1 and the second value is −1.

147. The system of claim 134 wherein the first sequence is a spreading sequence.

148. The system of claim 134 wherein the first sequence is generated based on at least a PN code.

149. The system of claim 134, wherein SC is a first PN code.

150. An apparatus for wireless communications, comprising:

means for generating a first signal, a, based on at least a first input signal, a first code, and a first relative gain;

means for generating a second signal, b, based on at least a second input signal, a second code, and a second relative gain;

a sequence mechanism configured to provide a first sequence, SC, the first sequence comprising at least a first element having a first value and a second element having a second value;

an input generator configured to generate an input, d, based on at least a second sequence of sequence elements, the sequence elements in the second sequence systematically alternating between the first value and the second value; and

means for receiving at least the first signal, a, the second signal, b, the first sequence, SC, and the input, d, and for systematically generating SC·a−SC·b·d and SC·b+SC·a·d.

151. The apparatus of claim 150, wherein the second sequence is W_1.

152. The apparatus of claim 150, wherein d is generated based on at least the second sequence and a third sequence.

153. The apparatus of claim 152, wherein the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

154. The apparatus of claim 153, whrein SC is a first PN code.

155. The apparatus of claim 154, wherein the third sequence is generated based on a second PN code.

156. The apparatus of claim 152 wherein the third sequence is generated based on a spreading sequence.

157. The apparatus of claim 152 wherein the third sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

158. The apparatus of claim 153 wherein the first signal and the second signal are generated based on at least even numbered Walsh codes.

159. The apparatus of claim 152, whrein SC is a first PN code.

160. The apparatus of claim 159, wherein the third sequence is generated based on a second PN code.

161. The apparatus of claim 150, wherein the first value is 1 and the second value is −1.

162. The apparatus of claim 150, wherein

the first orthogonal code and the second orthogonal code are even numbered Walsh codes.

163. The apparatus of claim 150, wherein SC is generated based on at least a PN code.

164. The apparatus of claim 150 wherein the first sequence is a spreading sequence.

165. The apparatus of claim 150, wherein SC is a first PN code.

166. A spreading method comprising:

receiving a complex input signal comprising in-phase data and quadrature-phase data;

receiving a first sequence of sequence elements, the sequence elements in the first sequence systematically alternating between a first value and a second value;

receiving a complex code comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

complex multiplying the complex input signal by the complex code.

167. The method of claim 166, wherein the in-phase component only comprises a spreading sequence.

168. The method of claim 167, wherein the spreading sequence is generated based on at least a PN code.

169. The method of claim 167, wherein the spreading sequence is a first PN code.

170. The method of claim 166, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

171. The method of claim 170, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

172. The method of claim 171, wherein the second sequence is generated based on a second PN code.

173. The method of claim 170 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

174. The method of claim 170, wherein the second sequence is generated based on a second PN code.

175. The method of claim 166, wherein the first value is 1 and the second value is −1.

176. The method of claim 166 wherein the first sequence of sequence elements is W_1.

177. A spreading unit comprising:

a first input unit configured to receive a complex input signal comprising in-phase data and quadrature-phase data;

a second input unit configured to receive a first sequence of sequence elements, the sequence elements in the first sequence systematically alternating between a first value and a second value;

a third input unit configured to receive a complex code comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

a complex multiplier configured to complex multiply the complex input signal by a complex code.

178. The unit of claim 177, wherein the in-phase component only comprises a spreading sequence.

179. The unit of claim 178, wherein the spreading sequence is generated based on at least a PN code.

180. The unit of claim 179 wherein the first sequence of sequence elements is W_1.

181. The unit of claim 178, wherein the spreading sequence is a PN code.

182. The unit of claim 177, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence, wherein the second sequence is generated based on a PN code.

183. The unit of claim 182, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

184. The unit of claim 182 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

185. The unit of claim 177, wherein the first value is 1 and the second value is −1.

186. The unit of claim 177 wherein the first sequence of sequence elements is W_1.

187. A spreading unit comprising:

a first input unit configured to receive a complex input signal comprising in-phase data and quadrature-phase data,

a second input unit configured to receive a first sequence of sequence elements, the sequence elements in the first sequence systematically alternating between a first value and a second value;

a third input unit configured to receive a complex code comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

means for complex multiplying the complex input signal by the complex code.

188. The unit of claim 187, wherein the in-phase component only comprises a spreading sequence.

189. The unit of claim 188, wherein the spreading sequence is a first PN code.

190. The unit of claim 188, wherein the spreading sequence is generated based on at least a PN code.

191. The unit of claim 187, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

192. The unit of claim 191 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

193. The unit of claim 191, wherein the second sequence is generated based on a second PN code.

194. The unit of claim 187, wherein the first value is 1 and the second value is −1.

195. The unit of claim 194, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

196. The unit of claim 195, wherein the second sequence is generated based on a second PN code.

197. A spreading method comprising:

generating a complex signal comprising an in-phase data signal and a quadrature-phase data signal;

receiving a first sequence of sequence elements, each (2N−1)th sequence element in the first sequence having a first value and each (2N)th sequence element in the first sequence having a second value, N being a positive integer;

receiving a complex code comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprises the in-phase component multiplied by the first sequence of sequence elements; and

complex multiplying the complex signal by the complex code.

198. The method of claim 197, wherein the in-phase component comprises only a spreading sequence.

199. The method of claim 198, wherein the spreading sequence is generated based on at least a PN code.

200. The method of claim 198, wherein the spreading sequence is a first PN code.

201. The method of claim 197, wherein the first value is 1 and the second value is −1.

202. The method of claim 197, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

203. The method of claim 202, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

204. The method of claim 203, wherein the second sequence is generated based on a second PN code.

205. The method of claim 202 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

206. The method of claim 202, wherein the second sequence is generated based on a second PN code.

207. The method of claim 197 wherein the first sequence of sequence elements is W_1.

208. A spreading unit comprising:

an output unit configured to generate a complex signal comprising an in-phase data signal and a quadrature-phase data signal, the output unit including a first adder configured to add one or more first signals to generate the in-phase data signal and a second adder configured to add one or more second signals to generate the quadrature-phase data signal;

a first input unit configured to receive a first sequence of sequence elements, each (2N−1)th sequence element in *the first sequence systematically having a first value and each (2N)th sequence element in the first sequence systematically having a second value, wherein N is a positive integer;*

a second input unit configured to receive a complex code comprising an in-phase component and a quadrature-phase component, quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

a complex multiplier configured to multiply the complex signal by the complex code.

209. The unit of claim 208, wherein the in-phase component comprises only a spreading sequence.

210. The unit of claim 209, wherein the spreading sequence is generated based on at least a PN code.

211. The unit of claim 209, wherein the spreading sequence is a first PN code.

212. The unit of claim 208, wherein the first value is 1 and the second value is −1.

213. The unit of claim 208, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

214. The unit of claim 213, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

215. The unit of claim 214, wherein the second sequence is generated based on a second PN code.

216. The unit of claim 213 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

217. The unit of claim 213, wherein the second sequence is generated based on a second PN code.

218. The unit of claim 208 wherein the first sequence of sequence elements is W_1.

219. A spreading unit comprising:

means for generating a complex data signal comprising an in-phase data signal and a quadrature-phase data signal;

an input unit configured to receive a first sequence of sequence elements, each (2N−1)th sequence element in the first sequence systematically having a first value and each (2N)th sequence element in the first sequence systematically having a second value, wherein N is a positive integer;

means for receiving a complex code comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

means for complex multiplying the complex data signal by the complex code.

220. The unit of claim 219, wherein the in-phase component comprises only a spreading sequence.

221. The unit of claim 220, wherein the spreading sequence is generated based on at least a PN code.

222. The unit of claim 220, wherein the spreading sequence is a first PN code.

223. The unit of claim 219, wherein the first value is 1 and the second value is −1.

224. The unit of claim 219, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

225. The unit of claim 224, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

226. The method of claim 265, wherein each (2N−1)th sequence element in the second sequence has a first value and each (2N)th sequence element in the second sequence has a second value, wherein N is a positive integer.

227. The unit of claim 224 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

228. The unit of claim 224, wherein the second sequence is generated based on a second PN code.

229. The unit of claim 219 wherein the first sequence of sequence elements is W_1.

230. A spreading method, comprising:

receiving a complex input signal comprising in-phase data and quadrature-phase data;

receiving a first sequence of sequence elements, each (2N−1)th sequence element in the first sequence systematically having a first value and each (2N)th sequence element in the first sequence systematically having a second value, N being a positive integer;

receiving a complex sequence comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by the first sequence of sequence elements; and

complex multiplying the complex input signal by the complex sequence.

231. The method of claim 230, wherein the first sequence of sequence elements is W_1.

232. The method of claim 230, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

233. The method of claim 232, wherein,

the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

234. The method of claim 233, wherein the second sequence is generated based on a PN code.

235. The method of claim 232, wherein the second sequence is generated based on a PN code.

236. The method of claim 232 wherein the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

237. The method of claim 236, wherein the second sequence is generated based on a PN code.

238. The method of claim 230 wherein the first value is 1 and the second value is −1.

239. The method of claim 230, wherein the in-phase component comprises a spreading sequence.

240. The method of claim 239, wherein the spreading sequence is generated based on at least a PN code.

241. The method of claim 239, wherein the spreading sequence is a PN code.

242. A spreading apparatus comprising:

a first input unit configured to receive a complex input signal comprising in-phase data and quadrature-phase data;

a second input unit configured to receive a first sequence of sequence elements, each (2N−1)th sequence element in the first sequence symmetrically having a first value and each (2N)th sequence element in the first sequence systematically having a second value, wherein N is a positive integer and the first value is different from the second value;

a third input unit configured to receive a complex sequence comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

a complex multiplier for complex multiplying the complex input signal by the complex sequence.

243. The apparatus of claim 242, wherein the first sequence of sequence elements is W_1.

244. The apparatus of claim 242, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

245. The apparatus of claim 244, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

246. The apparatus of claim 245, wherein the second sequence is generated based on a PN code.

247. The apparatus of claim 244, wherein, the second sequence consists of elements, one or more of the elements having the first value and the remaining elements having the second value, wherein for each (2N−1)th element, the value of the (2N−1)th element is the same as the value of a (2N)th element, where N is a positive integer.

248. The apparatus of claim 247, wherein the second sequence is generated based on a PN code.

249. The apparatus of claim 242 wherein the first value is 1 and the second value is −1.

250. The apparatus of claim 242, wherein the in-phase component comprises a spreading sequence.

251. The apparatus of claim 250, wherein the spreading sequence is generated based on at least a PN code.

252. The apparatus of claim 250, wherein the spreading sequence is a PN code.

253. The apparatus of claim 264, wherein the first sequence of sequence elements is W_1.

254. The apparatus of claim 264, wherein the quadrature-phase component comprises the in-phase component multiplied by at least the first sequence of sequence elements and a second sequence.

255. The apparatus of claim 254, wherein the second sequence is generated based on a PN code.

256. The apparatus of claim 254, wherein the second sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

257. The apparatus of claim 256, wherein the second sequence is generated based on a PN code.

258. The apparatus of claim 254, wherein, the second sequence comprises a sequence consisting of sequence elements, one or more of the sequence elements having the first value and the remaining sequence elements having the second value, wherein for each (2N−1)th sequence element, the value of the (2N−1)th sequence element is the same value of a (2N)th sequence element, where N is a positive integer.

259. The apparatus of claim 258, wherein the second sequence is generated based on a PN code.

260. The apparatus of claim 264 wherein the first value is 1 and the second value is −1.

261. The apparatus of claim 264, wherein the in-phase component comprises a spreading sequence.

262. The apparatus of claim 261, wherein the spreading sequence is generated based on at least a PN code.

263. The apparatus of claim 261, wherein the spreading sequence is a PN code.

264. A spreading apparatus comprising:

a first input unit configured to receive a complex input signal comprising in-phase data and quadrature-phase data;

a second input unit configured to receive a first sequence of sequence elements, with each (2N−1)th sequence element in the first sequence systematically having a first value and each (2N)th sequence element in the first sequence systematically having a second value, wherein N is a positive integer and the first value is different from the second value;

means for receiving a complex sequence comprising an in-phase component and a quadrature-phase component, the quadrature-phase component systematically comprising the in-phase component multiplied by at least the first sequence of sequence elements; and

means for complex multiplying the complex input signal by the complex sequence.

265. A spreading method, comprising:

generating a first output, a, based on at least one or more first inputs, one or more first orthogonal codes, and one or more first gains;

generating a second output, b, based on at least one or more second inputs, one or more second orthogonal codes, and one or more second gains;

receiving a first sequence, SC, comprising at least a first element having a first value and a second element having a second value, the first value being different from the second value;

receiving a second sequence of sequence elements, W;

receiving a third sequence, P; and

complex-multiplying a+jb by $(1+jP\cdot W)\times SC$.

266. The apparatus of claim 273, wherein SC is generated based on at least a PN code.

267. The method of claim 226, wherein

the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

268. The method of claim 267, wherein the third sequence is generated based on a PN code.

269. The method of claim 226, wherein SC is a spreading sequence.

270. The method of claim 226, wherein SC is generated based on at least a PN code.

271. The method of claim 226, wherein SC is a PN code.

272. A spreading apparatus comprising:

a first input unit configured to receive a complex input signal comprising in-phase data, a, and quadrature-phase data, b;

a second input unit configured to receive a first sequence, SC, comprising at least a first element having a first value and a second element having a second value;

a third input unit configured to receive a second sequence of sequence elements, W;

a fourth input unit configured to receive a third sequence, P; and

a complex multiplier for multiplying a+jb by $(1+jP\cdot W)\times SC$.

273. The apparatus of claim 272, wherein each (2N−1)th sequence element in the second sequence has a first value and each (2N)th sequence element in the second sequence has a second value, wherein N is a positive integer.

274. The apparatus of claim 273, wherein,

the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

275. The method of claim 274, wherein P is generated based on a PN code.

276. The apparatus of claim 273, wherein SC is a PN code.

277. The method of claim 276, wherein P is generated based on a PN code.

278. The apparatus of claim 244, wherein the second sequence is generated based on a PN code.

279. A spreading apparatus comprising:

a first input unit configured to receive a complex input signal comprising in-phase data, a, and quadrature-phase data, b;

a second input unit configured to receive a first sequence, SC, comprising at least a first element having a first value and a second element having a second value;

means for receiving a second sequence of sequence elements, W;

means for receiving a third sequence, P; and

means for multiplying a+jb by $(1+jP\cdot W)\times SC$.

280. The apparatus of claim 279, wherein each (2N−1)th sequence element in the second sequence has a first value and each (2N)th sequence element in the second sequence has a second value, wherein N is a positive integer.

281. The apparatus of claim 280, wherein,

the third sequence consists of a sequence of groups, wherein each of the groups consists of either two elements both having the first value or two elements both having the second value.

282. The apparatus of claim 281, wherein the third sequence is generated based on a PN code.

283. The apparatus of claim 280, wherein SC is a PN code.

284. The apparatus of claim 283, wherein the third sequence is generated based on a PN code.

285. The apparatus of claim 280, wherein SC is generated based on at least a PN code.

286. The apparatus of claim 152 wherein d is generated by multiplying the third sequence and the second sequence.

287. The unit of claim 225, wherein the second sequence is generated based on a second PN code.

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Bang et al.

(54) **ORTHOGONAL COMPLEX SPREADING METHOD FOR MULTICHANNEL AND APPARATUS THEREOF**

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CPC ***H04B 1/7097*** (2013.01); ***H04J 13/0048*** (2013.01); ***H04J 13/102*** (2013.01); *H04J 2013/0037* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

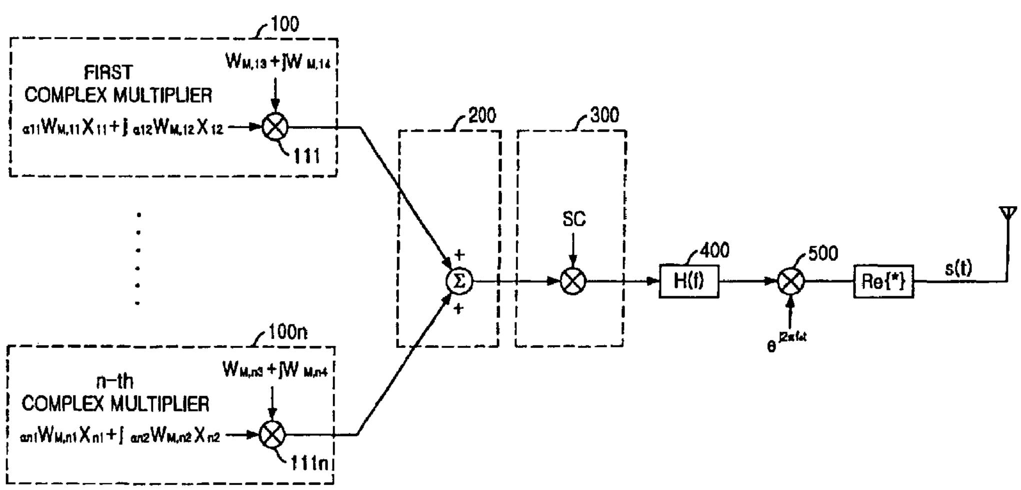
(56) **References Cited**

To view the complete listing of prior art documents cited during the proceeding for Reexamination Control Number 90/013,499, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Nick Corsaro

(57) **ABSTRACT**

An orthogonal complex spreading method for a multichannel and an apparatus thereof are disclosed. The method includes the steps of complex-summing $\alpha_{n1} W_{M,n1} X_{n1}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{M,n1}$ by a first data X_{n1} of a n-th block and $\alpha_{n2} W_{M,n2} X_{n2}$ which is obtained by multiplying an orthogonal Hadamard sequence $W_{1,n2}$ by a second data X_{n2} of a n-th block; complex-multiplying $\alpha_{n1} W_{M,n1} X_{n1} + j\alpha_{n2} W_{M,n2} X_{n2}$ which is summed in the complex type and $W_{M,n3} + jPW_{M,n4}$ of the complex type using a complex multiplier and outputting as an in-phase information and quadrature phase information; and summing only in-phase information outputted from a plurality of blocks and only quadrature phase information outputted therefrom and spreading the same using a spreading code.



EX PARTE REEXAMINATION CERTIFICATE

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but was deleted by the reissue patent; matter printed in italics was added by the reissue patent. Matter enclosed in heavy double brackets [[ ]] appeared in the reissue patent but is deleted by this reexamination certificate; matter printed in boldface is added by this reexamination certificate.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

The patentability of claims **20**, **31**, **53**, **58-61**, **68**, **77**, **90**, **118**, **129** and **272-274** is confirmed.

Claims **177** and **208** are cancelled.

New claims **288-333** are added and determined to be patentable.

Claims **1-19**, **21-30**, **32-52**, **54-57**, **62-67**, **69-76**, **78-89**, **91-117**, **119-128**, **130-176**, **178-207**, **209-271** and **275-287** were not reexamined.

288. The method of claim 20, wherein each element of each of $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}W_{M,Q}$, and P has a first value or a second value.

289. The method of claim 288, wherein the first value is 1 and the second value is −1.

290. The method of claim 288, wherein the first value is 1 and the second value is 0.

291. The method of claim 288, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

292. The apparatus of claim 31, wherein each element of each of $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, $W_{M,Q}$, and P has a first value or a second value.

293. The apparatus of claim 292, wherein the first value is 1 and the second value is −1.

294. The apparatus of claim 292, wherein the first value is 1 and the second value is 0.

295. The apparatus of claim 292, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

296. The apparatus of claim 53, wherein each element of each of $W_{M,n1}$,$W_{M,n2}$, $W_{M,I}$, $W_{M,Q}$, P and SC has a first value or a second value.

297. The apparatus of claim 296, wherein the first value is 1 and the second value is −1.

298. The apparatus of claim 296, wherein the first value is 1 and the second value is 0.

299. The apparatus of claim 296, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

300. The method of claim 60, wherein each element of each of $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, $W_{M,Q}$, and P has a first value or a second value.

301. The method of claim 300, wherein the first value is 1 and the second value is −1.

302. The method of claim 300, wherein the first value is 1 and the second value is 0.

303. The method of claim 300, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

304. The apparatus of claim 61, wherein each element of each of $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, $W_{M,Q}$, P and SC has a first value or a second value.

305. The apparatus of claim 304, wherein the first value is 1 and the second value is −1.

306. The apparatus of claim 304, wherein the first value is 1 and the second value is 0.

307. The apparatus of claim 304, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

308. The apparatus of claim 68, wherein each element of each of $W_{M,n1}$, $W_{M,n2}$, $W_{M,I}$, $W_{M,Q}$, SC and P has a first value or a second value.

309. The apparatus of claim 308, wherein the first value is 1 and the second value is −1.

310. The apparatus of claim 308, wherein the first value is 1 and the second value is 0.

311. The apparatus of claim 308, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

312. The apparatus of claim 77, wherein each element of each of OS_{11}, . . . , OS_{K1}, OS_{12}, . . . , OS_{L2}, W_0, W_1, P, and SC has a first value or a second value.

313. The apparatus of claim 312, wherein the first value is 1 and the second value is −1.

314. The apparatus of claim 312, wherein the first value is 1 and the second value is 0.

315. The apparatus of claim 312, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

316. The method of claim 90, wherein each element of each of the first code, the second code, d and SC has the first value or the second value.

317. The method of claim 316, wherein the first value is 1 and the second value is 0.

318. The method of claim 316, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

319. The method of claim 316, wherein the first value is −1 and the second value is 1.

320. The method of claim 316, wherein the first value is 0 and the second value is 1.

321. The apparatus of claim 118, wherein each element of each of d and SC has the first value or the second value.

322. The apparatus of claim 321, wherein the first value is 1 and the second value is 0.

323. The apparatus of claim 321, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

324. The apparatus of claim 321, wherein the first value is −1 and the second value is 1.

325. The apparatus of claim 321, wherein the first value is 0 and the second value is 1.

326. The apparatus of claim 118, wherein the third multiplier mechanism is configured to multiply elements of SC by elements of a, multiply elements of SC by elements of b, multiply elements of SC by elements of

b·d, and multiply elements of SC by elements of a·d, wherein SC is a pseudorandom code, and to add or subtract outcomes of said multiplications.

327. The apparatus of claim 272, wherein each of P, W and SC has the first value or the second value.

328. The apparatus of claim 327, wherein the first value is 1 and the second value is −1.

329. The apparatus of claim 327, wherein the first value is 1 and the second value is 0.

330. The apparatus of claim 327, wherein the first value represents a first voltage level and the second value represents a second voltage level, the first voltage level being different from the second voltage level.

331. The method of claim 90, wherein the steps of systematically generating SC·a-SC·b·d and systematically generating SC·b+SC·a·d comprise steps of multiplying elements of SC by elements of a, multiplying elements of SC by elements of b, multiplying elements of SC by elements of b·d, and multiplying elements of SC by elements of a·d, and steps of adding or subtracting outcomes of said multiplying steps.

332. The method of claim 90, wherein the steps of systematically generating SC·a-SC·b·d and systematically generating SC·b+SC·a·d comprise steps of multiplying a pseudorandom sequence by one or more non-pseudorandom sequences, and steps of adding or subtracting outcomes of said multiplying steps.

333. The apparatus of claim 118, wherein the third multiplier mechanism is configured to multiply a pseudorandom sequence by one or more non-pseudorandom sequences, and to add or subtract outcomes of said multiplications.

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