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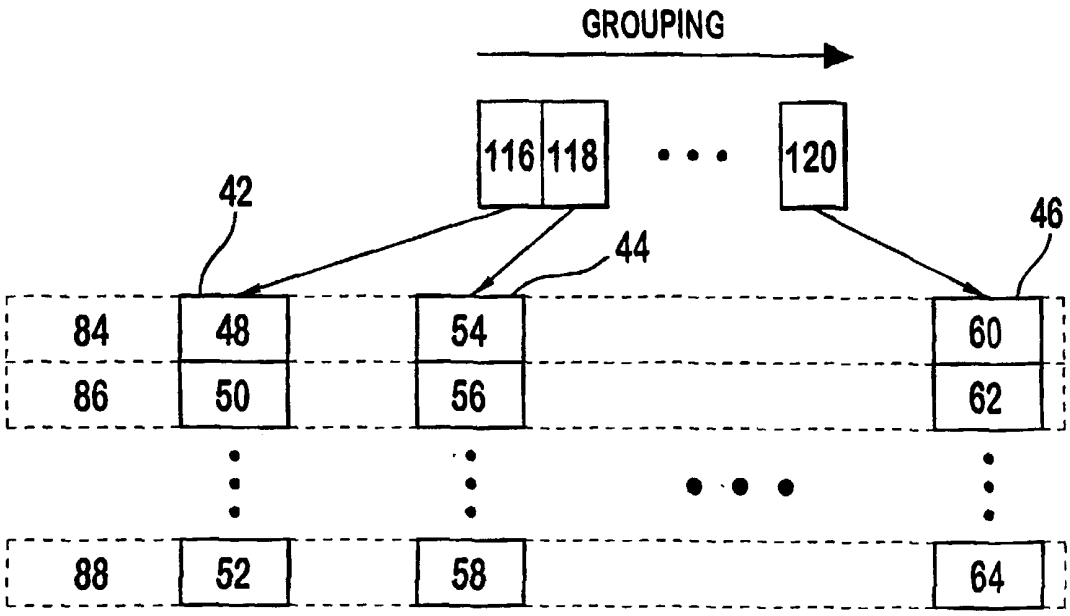

(57) Abstract

A selected user equipment transmits a signature in a selected one of the common packet channel's time slots. The base station, in response to receiving the transmitted signature, selects a currently unused code, if available, out of a plurality of code associated with the access opportunity defined by the selected signature and selected time slot. The base station transmits an acknowledgment signal comprising an identifier of the selected code. The selected user equipment receives the acknowledgment signal. The selected user equipment and the base station communicate using the selected code.

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CHANNEL ASSIGNMENT IN A SPREAD SPECTRUM CDMA COMMUNICATION SYSTEM

BACKGROUND

The invention relates generally to resource allocation in a wireless code division multiple access communication system. More specifically, the invention relates to assigning uplink and downlink channels in response to access requests of user equipment.

Figure 1 depicts a wireless spread spectrum Code Division Multiple Access (CDMA) communication system **18**. A base station **20** communicates with user equipment (UE) **22- 26** in its operating area. In a spread spectrum CDMA system **18**, data signals are communicated between UEs **22-26** and the base station **20** over the same spread bandwidth. Each data signal in the shared bandwidth is spread with a unique chip code sequence. Upon reception, using a replica of the chip code sequence, a particular data signal is recovered.

Since signals are distinguished by their chip code sequences (code), separate dedicated communication channels are created using different codes. Signals from the base station **20** to the UEs **22-26** are sent on downlink channels and signals from the UEs **22-26** to the base station **20** are sent on uplink channels. For coherent detection of downlink transmissions by the UEs **22-26**, pilot signals are transmitted to all the UEs **22-26** within the base station's operating range. The UEs **22-26** condition their receivers based on the pilot signals to enable data reception.

In many CDMA systems, a common packet channel (CPCH) is used for

uplink transmissions. A CPCH is capable of carrying packets of data from different UEs **22-26**. Each packet is distinguishable by its code. For detection by the base station **20**, the packets have a preamble which also distinguishes it from other packets. The CPCH is typically used to carry infrequently communicated data at high rates.

Figure 2 depicts a CPCH access scheme **28**. The CPCH access scheme **28** is time divided into intervals having time slots **30-34**, such as 8 time slots proposed for the Third Generation Mobile Telecommunications System (IMT-2000). A group of predetermined signatures **36-40** are assigned to the time slots **30-34** to allow more than one UE **22-26** to use the same time slot **30-34**. A particular signature used within a particular time slot is referred to as an access opportunity **66-82**. For instance, for each of the 8 time slots in the proposal for IMT-2000, one out of 16 signatures is available to be chosen, resulting in 128 access opportunities. Each signature **36-40** is preassigned a virtual channel. A virtual channel uniquely defines operating parameters for both the uplink and downlink, i.e., an uplink spreading factor and a unique code for the downlink.

Broadcast from the base station **20** to each UE **22-26** is the availability of each virtual channel over an acknowledge indication channel (AICH). The UE **22-26** monitors the AICH to determine the availability of each virtual channel. Based on the operating parameters required by the UE **22-26** and the availability of the virtual channels, the UE determines the access opportunity to select. Upon identifying a particular access opportunity, the base station **20** sends out an acknowledgment

message (ACK) if the corresponding downlink channel is still available. In the proposal for IMT-2000, the ACK simply repeats the signatures **36-40** associated with the access attempt. If the downlink channel is not available, a negative acknowledge (NAK) is sent.

After receiving a corresponding acknowledgment, the UEs **22-26** determine the proper code to recover communications on the downlink channel based on the access opportunity **66-82** used to send the UEs' packet. Either stored in the UEs **22-26** or transmitted on a Base Station's Broadcast Channel is a list of the code assigned to each access opportunity **66-82**. This scheme severely increases the packet collision probability and therefore the packet delay which is undesirable.

In some situations, monitoring the AICH is not desirable. At a particular moment, some UEs **22-26** will be operating in a "sleep" mode. In the "sleep" mode, the UE **22-26** only runs when there is a need to send data. Monitoring the AICH during "sleep" mode will both reduce battery life and introduce a delay in the transmission of the first packet. Additionally, when a UE **22-26** borders between two base station's operating areas, monitoring multiple AICHs further exacerbates these drawbacks.

Monitoring creates other problems. It further complicates the UE's receiving circuitry, making the UE **22-26** more expensive.

Monitoring results in a suboptimum use of the CPCH. AICH monitoring provides information when a channel becomes busy. The time at which the channel becomes free is deduced on a worst case maximum packet length. If a packet is not

maximum length, the channel will be idle while the UEs **22-26** are waiting to transmit. On the other hand, if monitoring is not performed in such a system, channel availability information is unavailable. The UE **22-26** may randomly choose a busy virtual channel increasing the packet delay by causing a collision. Accordingly, it would be desirable to allow the UEs **22-26** to wait a period shorter than the maximum packet length and provide for some other collision reducing mechanism.

One technique to reduce the possibility of collision is to raise the number of codes, for instance to 128 different codes. In the proposal for IMT-2000 the 128 sequences represent approximately half of the sequences available at the base station **20**. Accordingly, this solution is undesirable. Additionally, since monitoring the AICH complicates the UE receiver circuitry increasing its cost, it is undesirable. Accordingly, an alternate approach to assign virtual channels is desirable.

SUMMARY

A selected user equipment transmits a signature in a selected one of the common packet channel's time slots. The base station, in response to receiving the transmitted signature, selects a currently unused code, if available, out of a plurality of code associated with the access opportunity defined by the selected signature and selected time slot. The base station transmits an acknowledgment signal comprising an identifier of the selected code. The selected user equipment receives the acknowledgment signal. The selected user equipment and the base station

communicate using the selected code.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of a typical wireless spread spectrum CDMA communication system.

Figure 2 is an illustration of a common packet channel access scheme.

Figure 3 is an illustration assigning virtual channels.

Figure 4 is a graph of the probability of a collision versus demand for the prior art and the virtual channel assignment.

Figure 5 illustrates a simplified base station and user equipment.

Figure 6 is an identifier transmitter circuit.

Figure 7 is an identifier receiver circuit.

Figure 8 is a table of an assignment of Golay sequences.

Figure 9 is a circuit for detecting the Golay sequences of **Figure 8**.

Figure 10 is an assignment table for a system having physical channels with two time slots.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout. **Figure 3** illustrates a virtual channel assignment scheme. Each virtual channel **48-64** is defined by its operating parameters, such as uplink spreading factor and down link code.

Additionally, instead of assigning virtual channels **48-64**, the same principles may be applied to assigning physical channels which are defined by their downlink code.

To reduce the number of used physical channels and increase the power level of each channel, each physical channel may be multiplexed, such as by using two time slots. Using two time slots will increase the channel's effective data rate, such as from 8 Kbps to 16 Kbps. In such a system, the virtual channel **48-64** also defines which multiplexed signal is assigned to the UE **22-26**.

Instead of assigning a single virtual channel for each signature **36-40** as in the prior art, a set **42-46** of virtual channels are assigned for each grouping **116-120** of access opportunities. A grouping may contain all of the channels in one group or as few as 2 or 3 channels. One possible virtual channel grouping may group all virtual channels with the same data rate for the uplink. For groups having the same uplink data rate, the UE **22-26** selects an access opportunity out of the groups having the UE's desired uplink data rate. Another grouping may be formed based on the access opportunities' signature **36-40**. Based on the selected access request and the UE's priority, one of the virtual channels **48-64** assigned to the group **116-120** associated with the access attempt is used for the UE if available. Once the virtual channel is assigned, it will not be assigned again until the particular UE's transaction is complete. Additionally, a receiving circuit at the base station **20** with the proper data rate is assigned to the UE **22-26**.

In the prior art system, the UEs **22-26** determine which channel is assigned to the downlink based on the access opportunity **66-82**. Virtual channel assignment

transmits a channel identifier **84-88**, preferably along with the ACK, indicating which of the set **42-46** of channels assigned to the group **116-120** is selected. When all of the virtual channels are in the same group, the identifier **84-88** indicates the selected virtual channel. If no channel is available out of the set **42-46**, a no channel is available (NAK) identifier is sent. Since more than one virtual channel is potentially assigned to a particular access attempt, the probability of UE collisions is reduced.

Figure 4 is a graph **91** depicting the probability of a collision (Collisions) versus the number of UEs **22-26** requesting access (Demand). As shown, the collisions using 2 or 3 virtual channels per group (2 states/AP or 3 states/AP) is lower than the prior art (AICH monitor) regardless of demand.

Figure 5 illustrates a simplified base station **20** and a UE **22** for use in implementing channel assignment. The UE **22** has a controller **144** for determining the code of the uplink and downlink communications. A UE transmitter **140** sends communications, such as access opportunities and uplink packet signals, to the base station **20**. A UE receiver **142** receives communications, such as ACK messages, NAK messages and downlink signals.

The base station **20** has a controller **134** for determining the code of uplink and downlink communications as well as determining channel availability. A base station transmitter **136** sends communications, such as ACK messages, NAK messages and downlink signals, to the UE **22**. The base station receiver **138** receives communications, such as access opportunities and uplink packet signals.

Techniques for sending the identifiers are to attach extra bits to the ACK or to change the phase of the ACK to indicate the selected identifier. For a system using a single group of virtual channels, the extra bits identify the selected virtual channel. Circuits for sending the identifiers by phase shifting the ACK are depicted in **Figures 6** and **7**. The circuits are capable of sending up to four channel identifiers without a NAK identifier or three channel identifiers with a NAK identifier. In the transmitter circuit **92** of **Figure 6**, the ACK sequence is generated by a sequence generator **94**. The sequence itself is associated with the preamble access opportunity and is unique to the access attempt. Several such sequences may be transmitted to several users at the same time. The ACK sequence is passed through a mixer **96** which multiplies the signal with either +1 or -1. The mixed signal is subsequently passed through another mixer **98** where the signal is mixed with an in-phase carrier (cos wt) or a quadrature carrier (sin wt). As a result of the two mixers **96, 98**, the transmitted ACK is at one of four phases 0°, 90°, 180° or 270°. Each identifier **84-88** is preassigned to one of the phases.

The receiver circuit **14** of **Figure 7** is used to determine the phase of the ACK - sent

by the transmitter circuit **92** of **Figure 6**. The ACK is mixed with both an in-phase carrier by mixer **100** and a quadrature carrier by mixer **102**. Each of the mixed signals are correlated with a replica of the ACK's sequence by sequence correlators **104, 106**. The in-phase and quadrature correlation signals are each negated by mixers **108, 110** by multiplying the correlation signals by -1. The two correlated

signals and the two negated signals are supplied to an identifier circuit **112**. The identifier circuit **112** determines which of the four phased versions of the correlated signal has the highest magnitude. Since the downlink transmissions from the base station are synchronized and their phase is known, the identifier circuit **112** determines which identifier **84-88** was sent based on the phase of the ACK. A list stored either in the UEs **22-26** or transmitted on a Base Station's Broadcast Channel is used to determine the virtual channel **48-64** associated with the identifier **84-88** and the group **116-120** of the UE's access request. Using the determined virtual channel **48-64,** transmissions sent by the base station **20** using the selected downlink channel's code are recovered at the UE **22-26**.

Another technique for sending the identifier **84-88** is to use the ACK and a collision resolution signal (CR). After a collision between UEs **22-26** is detected at a base station **20**, in many spread spectrum systems the base station **20** sends a CR directed to the colliding UEs. The CR has a sequence which is associated with a specific UE **22** for detection by the UE **22**. By inverting the ACK and CR, an identifier **84-88** is sent to the specific UE **22**. An inverted ACK indicates a NAK. By inverting the CR, one virtual channel is assigned to +CR a second virtual channel is assigned to -CR. Accordingly, using the ACK and CR an identifier indicating either a NAK or one of two channels is sent. Additionally, using a CR with multiple states, such as three, one of multiple channels is assigned to the CR.

Alternatively, the identifier is sent with a signal using a Golay sequence. A Golay sequence is constructed out of short sequences, such as X and Y. By inverting

the shorter sequences and changing their order many unique longer sequences may be constructed as shown in table **122** of **Figure 8**. To reduce the size of the table **122**, only half of the possible sequences are shown. By negating each sequence, another unique Golay sequence results. As shown in **Figure 8**, each UE **22-26** is assigned a unique set of Golay sequences, such as 4. For instance, user 0 is assigned four sequences, the top two sequences and the negation of those sequences. By assigning each of the Golay sequences a virtual channel, upon reception, the receiving UE **22-26** determines the code of the downlink transmission.

A Golay sequence detector is shown in **Figure 9**. The received signal is correlated with a Golay Correlator **123** and interleaved by an interleaver **124** to detect the short codes. The arrangement of the short codes for two assigned sequences within the long codes is shown as Signature 0 and 1. Using mixers **125, 126**, the signatures are mixed with the detected short codes. Adders **127, 128** are coupled to the mixer and also to delay devices **129, 130**. The delay devices **129, 130** take the output of the adders **127, 128** and feed them back to those adders **127, 128** for correlation with the next short sequence. The output of each adder **127, 128** determines the Golay sequence of the received signal.

Figure 10 illustrates an assignment scheme for a system using two time slot multiplexing for the physical channels. In table **132**, each of the sixteen different signatures is assigned a downlink code and one of two time slots. The selected time slot is indicated by the transmitted identifier.

* * *

CLAIMS

What is claimed is:

1. A method for sending data in a spread spectrum code division multiple access communication system between a selected user equipment out of a plurality of user equipments and a base station, the system having a common packet channel defined by a predetermined set of codes, the common packet channel having a plurality of access opportunities, each defined by a time slot and signature, the method comprising:

transmitting from the selected user equipment a signature in a selected one of the common packet channel time slots;

in response to receiving the transmitted signature at the base station, selecting a currently unused code, if available, out of a plurality of codes associated with the access opportunity defined by the selected signature and selected time slot;

transmitting from the base station an identifier of the selected code;

receiving the identifier at the selected user equipment; and

communicating data between the selected user equipment and the base station using the selected code.

2. The method of claim 1 wherein the identifier is transmitted along with an acknowledgment signal.

3. The method of claim 1 wherein the identifier is transmitted by a acknowledgment signal and a collision resolution signal.

4. The method of claim 1 wherein the identifier indicates an uplink spreading factor for communications to be sent from the user equipment to the base station.

5. The method of claim 1 wherein the transmitted signature is selected from a set of sixteen signatures and the selected one time slot is selected from a set of eight time slots.

6. The method of claim 2 further comprising if no codes associated with the access opportunity are available, transmitting a negative acknowledgment signal indicating that no codes are available.

7. The method of claim 1 wherein the selected code is used to define a downlink physical channel for downlink communications.

8. The method of claim 7 wherein the downlink physical channel is time multiplexed into time slots and the identifier indicates a selected one of the time slots for the downlink communications between the base station and the selected user equipment.

9. The method of claim 1 wherein the plurality of codes associated with each access opportunity includes all of the codes available to all of the access opportunities.

10. The method of claim 1 wherein the plurality of codes associated with each access opportunity numbers from a range of two codes to all of the codes available to all of the access opportunities.

11. The method of claim 2 wherein the acknowledgment signal identifier is indicated by a selected one out of a set of phases of the acknowledgment signal.

12. The method of claim 2 wherein the acknowledgment signal identifier is attached extra bits.

13. The method of claim 2 wherein the acknowledgment signal identifier is indicated by a selected one out of a set of Golay sequences.

14. A base station for a spread spectrum code division multiple access system comprising:

a receiver for receiving access opportunities and packet data over a common packet channel, the common packet channel defined by a predetermined set of codes and having a plurality of access opportunities, each access opportunity defined by a

time slot and a signature;

a code selection controller associated with said receiver for selecting a currently unused code from a plurality of codes associated with a received access opportunity, such that a code, if available, is selected in response to receiving a signature in one of said time slots from a user equipment from the plurality of codes associated with the access opportunity defined by the received signature and said one time slot; and

a transmitter associated with said controller which transmits to the user equipment an identifier of the selected available code, whereby said transmitter sends communications to the user equipment encoded with said selected code.

15. The base station of claim 14 wherein the plurality of codes associated with each access opportunity includes all of the codes of all the access opportunities.

16. The base station of claim 14 further comprising:

a sequence generator for producing a replica of a received access opportunities' signature;

a first mixer for selectively inverting the signature replica in response to the code selection; and

a second mixer for selectively mixing the selectively inverted signature with an in-phase or quadrature phase carrier in response to the code selection to produce the identifier.

17. A spread spectrum code division multiple access communication system having a base station and a plurality of user equipments, the system using a common packet channel for communication, the common packet channel defined by a predetermined set of codes and having a plurality of access opportunities, each access opportunity defined by a time slot and signature, the system comprising:

the plurality of user equipments, each having:

means for transmitting a signature in a selected one of the common packet channel time slots;

means for receiving an identifier, the identifier indicating a selected code; and

means for communicating with the base station using the selected code; and

the base station having:

means, in response to receiving the transmitted signature, for determining the selected code by selecting a currently unused code, if available, out of a plurality of codes associated with the access opportunity defined by the selected signature and selected time slot; and

means for transmitting the identifier of the selected code.

18. The system of claim 17 wherein the identifier indicates an uplink spreading factor for communications to be sent from the user equipment to the base station.

19. The system of claim 17 wherein the transmitted signature is selected from a set of sixteen signatures and the selected one time slot is selected from a set of eight time slots.

20. The system of claim 17 wherein the base station further having means, if no codes associated with the access opportunity are available, for transmitting a negative acknowledgment signal indicating that no codes are available.

21. The system of claim 17 wherein the selected code is used to define a downlink physical channel for downlink communications.

22. The system of claim 21 wherein the downlink physical channel is time multiplexed into time slots and the identifier indicates a selected one of the time slots for the downlink communications between the base station and the user equipment.

23. The system of claim 17 wherein the plurality of codes associated with each access opportunity includes all of the codes of all access opportunities.

24. The system of claim 17 wherein the plurality of codes associated with each access opportunity numbers from a range of two codes to all of the codes of all access opportunities.

25. The system of claim 17 wherein the identifier is indicated by a selected one out of a set of phases of an acknowledgment signal.

26. The system of claim 17 wherein the identifier is attached extra bits to an acknowledgment signal.

27. The system of claim 17 wherein the identifier is indicated by a selected one out of a set of Golay sequences.

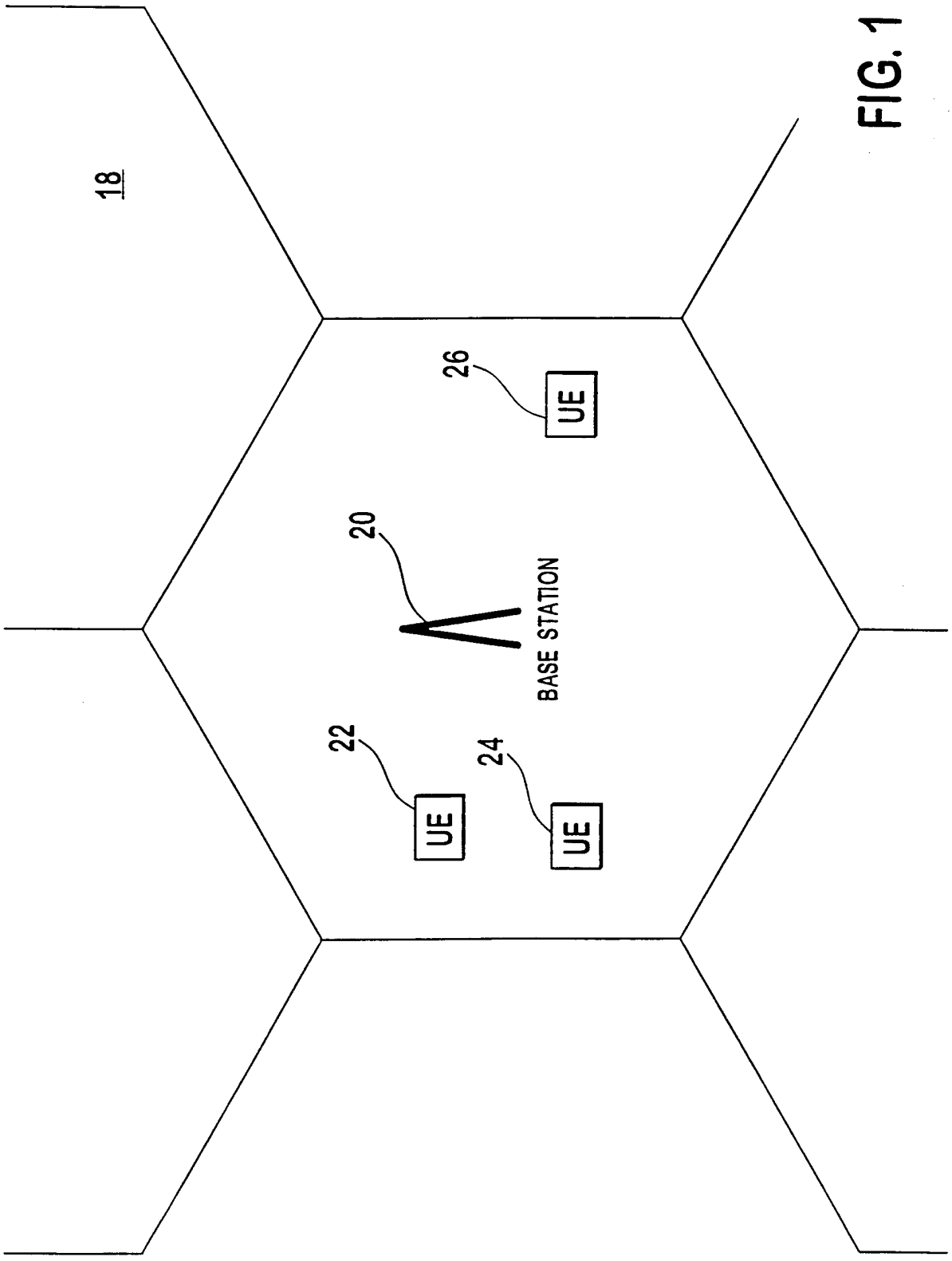


FIG. 1

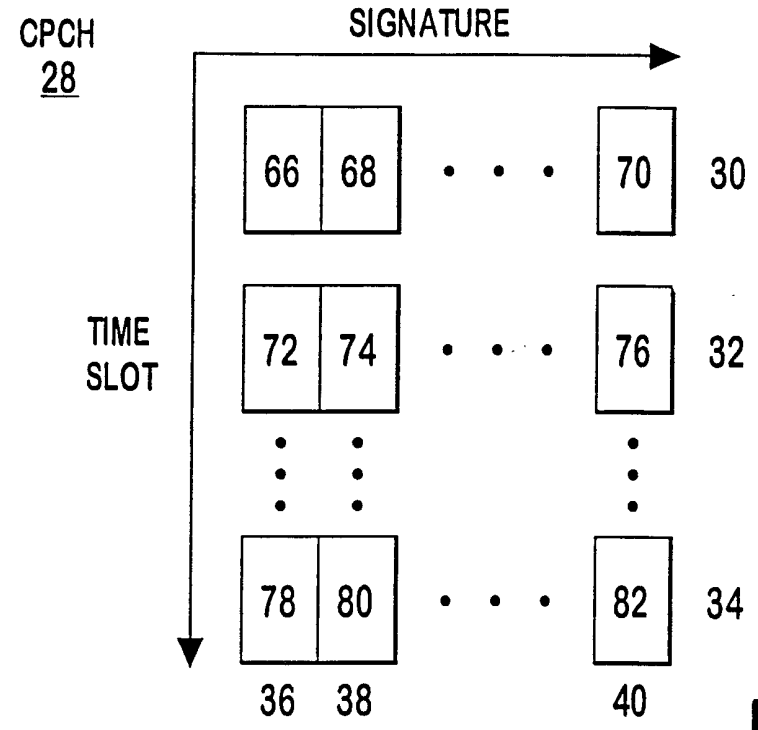

CPCH
28
SIGNATURE
TIME
SLOT
66
68
70
30
72
74
76
32
78
80
82
34
36
38
40

FIG. 2

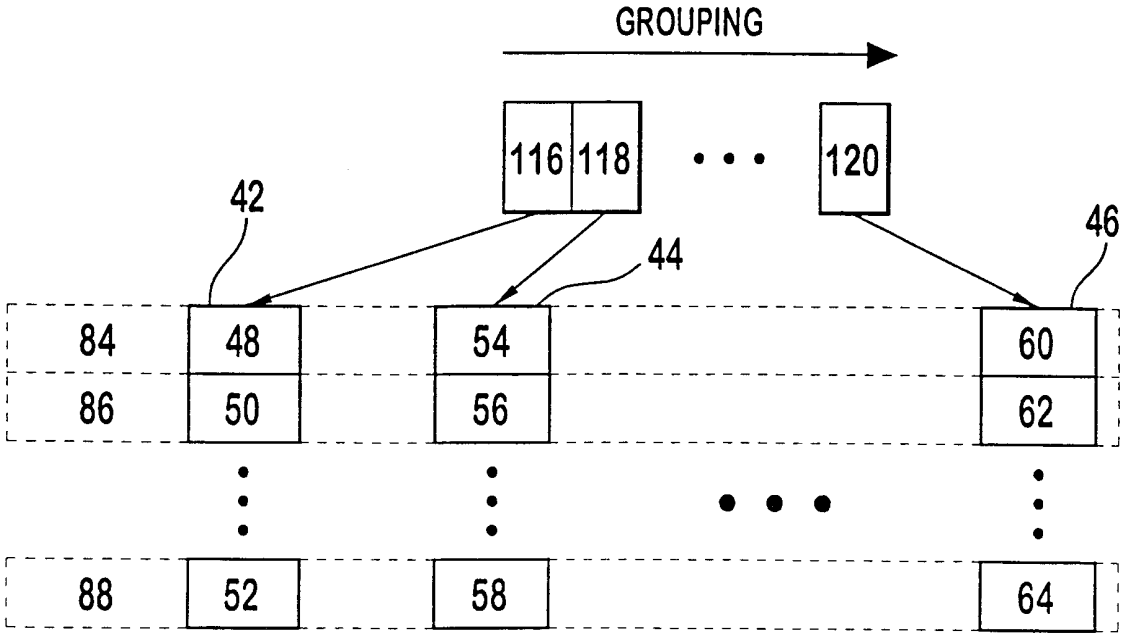

GROUPING
116
118
120
42
44
46
84
48
54
60
86
50
56
62
88
52
58
64

FIG. 3

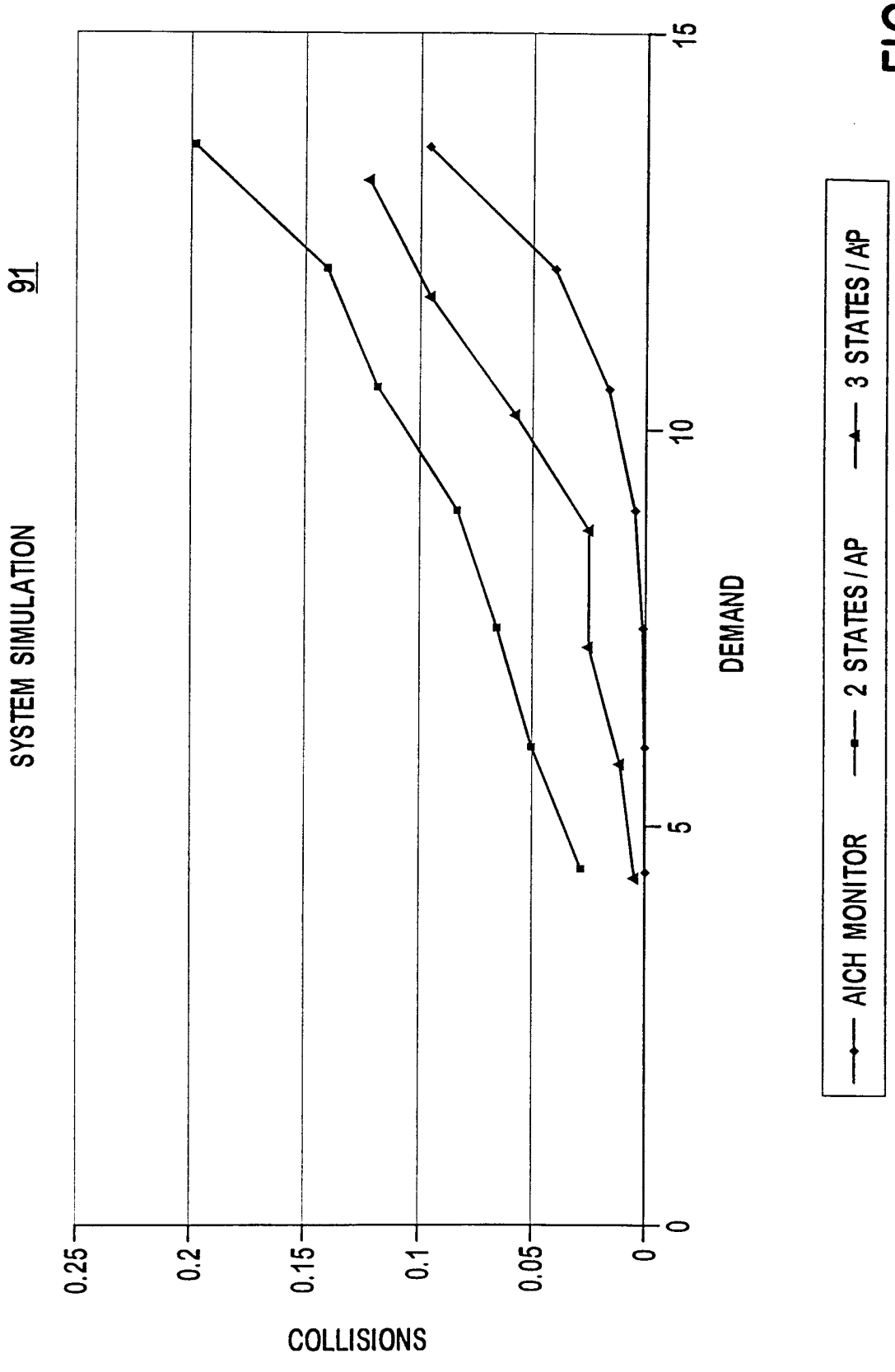
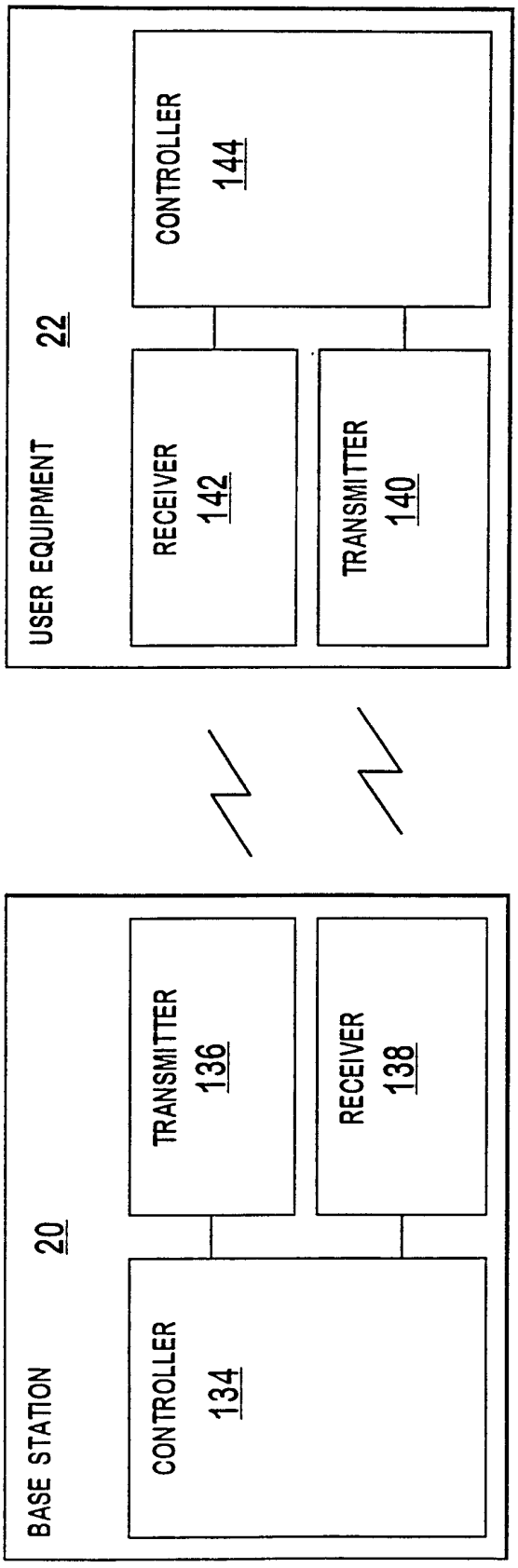

SYSTEM SIMULATION
91
COLLISIONS
0.25
0.2
0.15
0.1
0.05
0
DEMAND
0
5
10
15
AICH MONITOR
2 STATES / AP
3 STATES / AP

FIG. 4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CONTROLLER 144
RECEIVER 142
TRANSMITTER 140
BASE STATION 20
TRANSMITTER 136
RECEIVER 138
CONTROLLER 134

FIG. 5

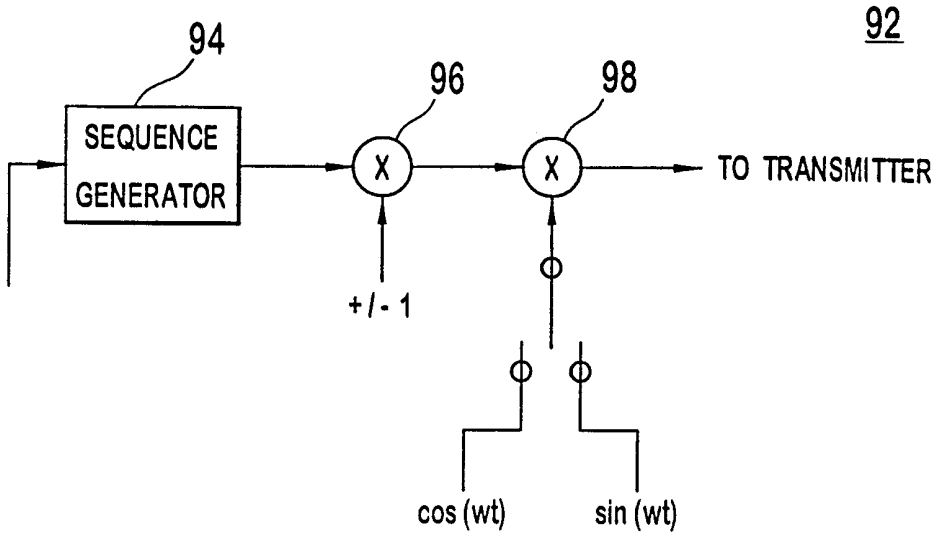

92
94
96
98
SEQUENCE GENERATOR
X
X
TO TRANSMITTER
+/- 1
cos (wt)
sin (wt)

FIG. 6

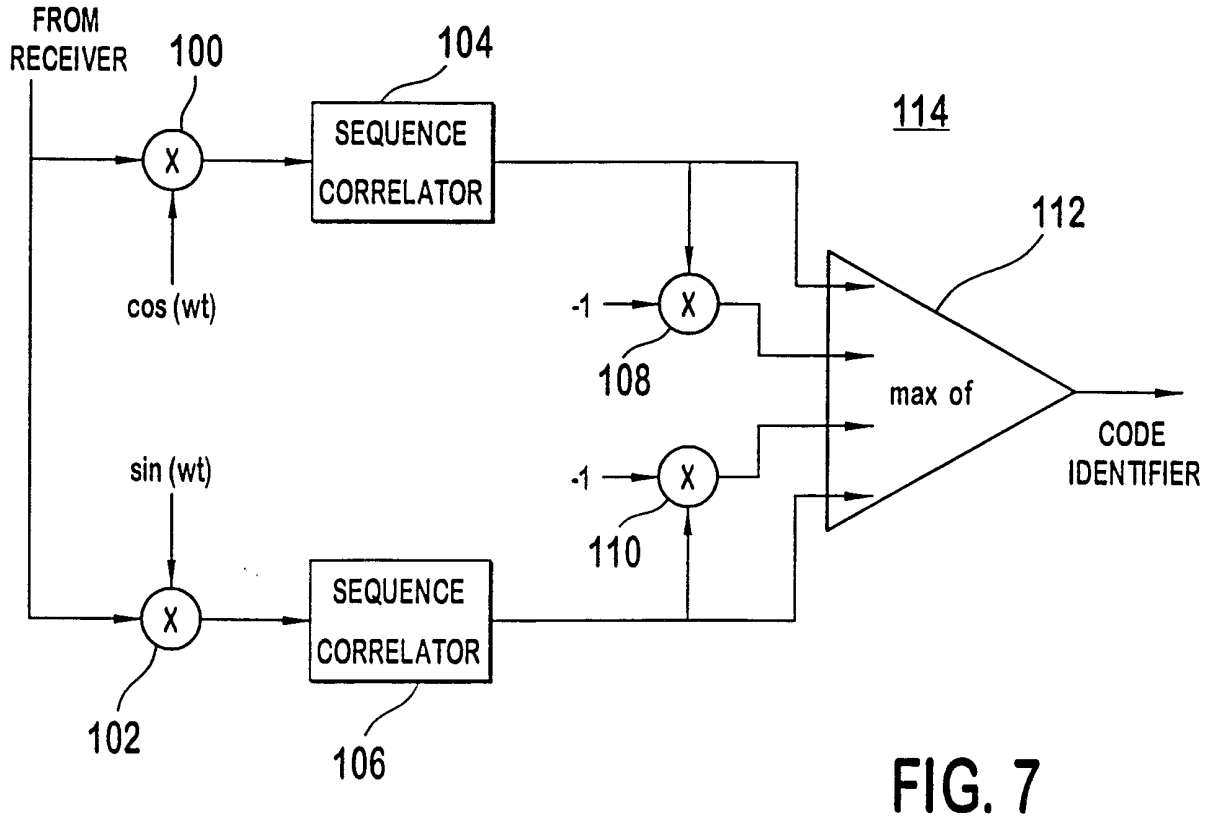

FROM RECEIVER
100
104
114
SEQUENCE CORRELATOR
112
cos (wt)
-1
X
108
max of
CODE IDENTIFIER
sin (wt)
-1
X
110
X
SEQUENCE CORRELATOR
102
106

FIG. 7

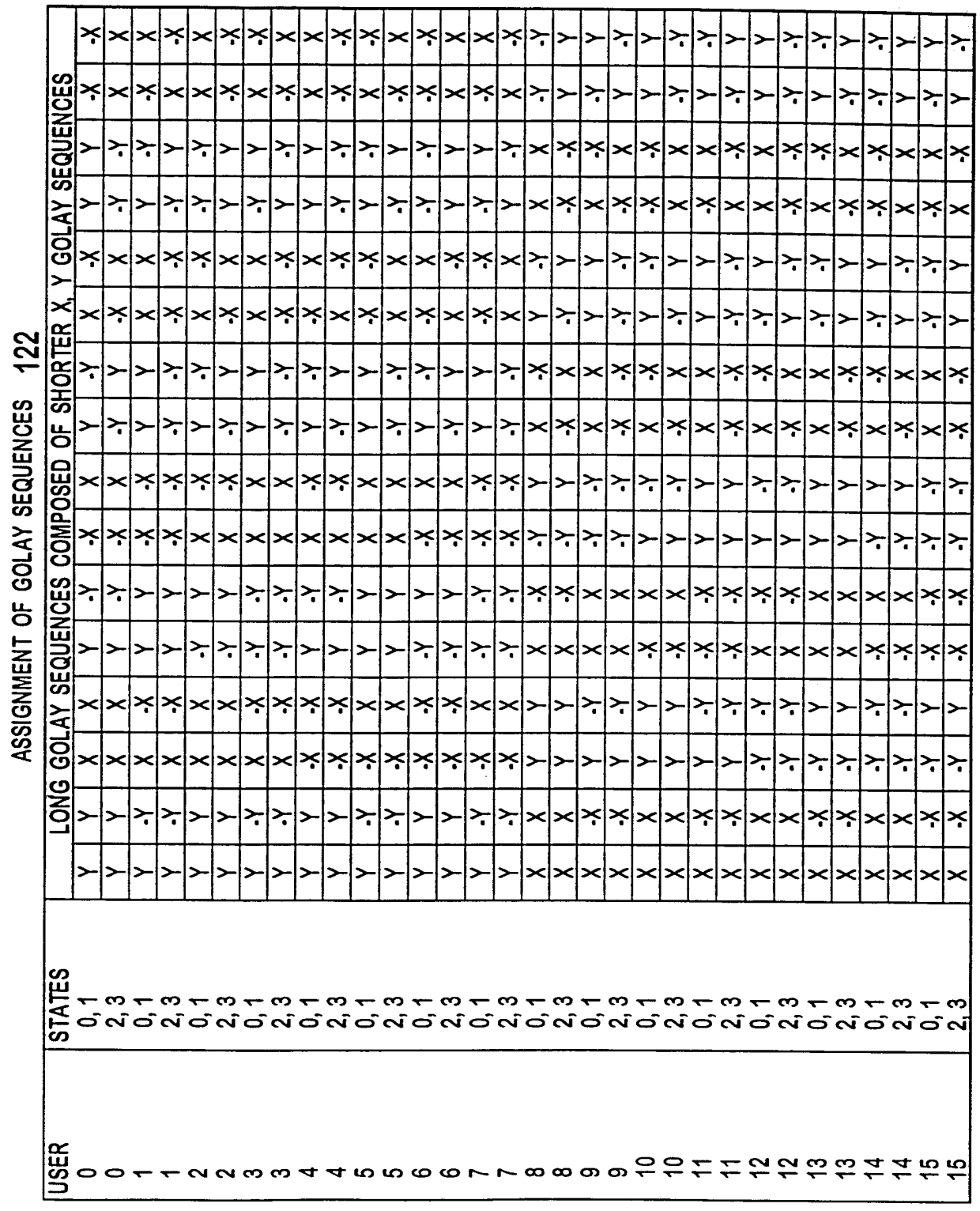
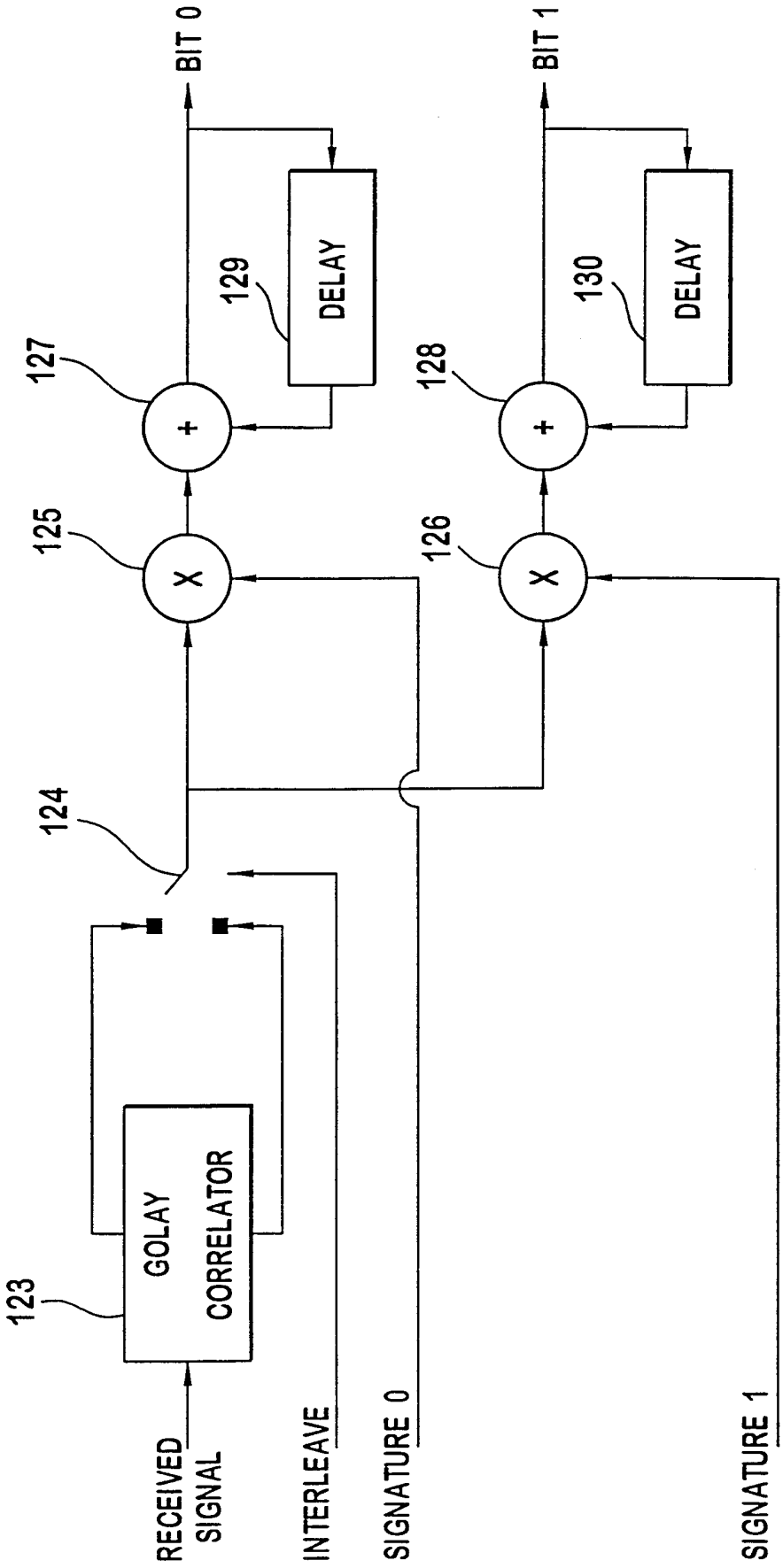

ASSIGNMENT OF GOLAY SEQUENCES 122
USER
STATES
LONG GOLAY SEQUENCES COMPOSED OF SHORTER X, Y GOLAY SEQUENCES

FIG. 8


BIT 0
BIT 1
DELAY
DELAY
129
130
127
128
+
+
125
126
X
X
124
GOLAY
CORRELATOR
123
RECEIVED
SIGNAL
INTERLEAVE
SIGNATURE 0
SIGNATURE 1

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PREAMBLE	DOWNLINK CODE	DOWNLINK SLOTS
1	1	1, 2
2	1	1, 2
3	1	1, 2
4	1	1, 2
5	2	1, 2
6	2	1, 2
7	3	1, 2
8	3	1, 2
9	3	1, 2
10	4	1, 2
11	4	1, 2
12	5	1, 2
13	5	1, 2
14	5	1, 2
15	5	1, 2
16	5	1, 2

FIG. 10

INTERNATIONAL SEARCH REPORT

Int. ..tional Application No
PCT/US 00/13924

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

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

Electronic data base consulted d.. ..ne international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 98 49857 A (ERICSSON TELEFON AB L M) 5 November 1998 (1998-11-05)	1,2,4,9, 10,12, 14,15, 17,18,26
A	page 3, line 11 - line 19 page 12, line 1 -page 13, line 14	3,5-8, 11,13, 16, 19-25,27
Y	TIA/EIA: "IS-95B" 1 March 1999 (1999-03-01) , TELECOMMUNICATIONS INDUSTRY ASSOCIATION , ARLINGTON, VA, USA XP002145285 page 7-186, line 1 -page 7-191, line 8	1,2,4,9, 10,12, 14,15, 17,18,26

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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

"P" document published prior to the international filing date but later than the priority date claimed

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2000	13/09/2000

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte .ional Application No
PCT/US 00/13924

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9849857 A	05-11-1998	AU 7458798 A	24-11-1998
		CN 1254487 T	24-05-2000
		EP 0979585 A	16-02-2000