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Attorneys for Plaintiffs
KYOCERA WIRELESS CORPORATION
KYOCERA SANYO TELECOM, INC., and
KYOCERA CORPORATION

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

KYOCERA WIRELESS CORPORATION, a Delaware company, KYOCERA SANYO TELECOM, INC., a Delaware company, and KYOCERA CORPORATION, a Japanese company, Plaintiffs, vs. SPH AMERICA, LLC, a Virginia company, Defendant.	Civil No.: '09 CV 0299 W JMA **COMPLAINT FOR DECLARATORY RELIEF** Courtroom: Judge:

Kyocera Wireless Corporation, Kyocera Sanyo Telecom, Inc., and Kyocera Corporation (collectively, "Kyocera") allege for its complaint against SPH America, LLC ("SPH") as follows:

PARTIES

1. Kyocera Wireless Corporation is a corporation organized and existing under the laws of the state of Delaware, with its principal place of business in San Diego, California.

2. Kyocera Sanyo Telecom, Inc. is a corporation organized and existing under the laws of the state of Delaware, with its principal place of business in Chatsworth, California.

3. Kyocera Corporation is a Japanese corporation with its principal place of business in Kyoto, Japan.

4. On information and belief, SPH is a Virginia limited liability company, with its principal place of business located in Reston, Virginia, which does business in this District and elsewhere in the State of California.

JURISDICTION AND VENUE

5. This action seeks a declaratory judgment under the Declaratory Judgment Act, 28 U.S.C. §§ 2201 and 2202. It presents an actual case or controversy under Article III of the United States Constitution and serves a useful purpose in clarifying and settling the legal rights at issue.

6. SPH has already sued Kyocera alleging infringement of three patents SPH licensed from the Electronics and Telecommunications Research Institute ("ETRI") involving wireless communication technology. The case was transferred to this District on November 20, 2008 as Case No. 08cv2146 DMS (RBB) and is currently ongoing.

7. SPH claims to have a license from ETRI to the following additional patents involving wireless communication technology (collectively, "the Patents-in-Suit"):

U.S. Patent No. 5,940,434 ("the '434 Patent") entitled "WALSH-QPSK CHIP MODULATION APPARATUS FOR GENERATING SIGNAL WAVEFORM IN A DIRECT SEQUENCE SPREAD SPECTRUM COMMUNICATION SYSTEM," a true and correct copy of which is attached hereto as Exhibit A;

U.S. Patent No. 7,443,906 B1 ("the '906 Patent") entitled "APPARATUS AND METHOD FOR MODULATING DATA MESSAGE BY EMPLOYING ORTHOGONAL VARIABLE SPREADING FACTOR (OVSF) CODES IN MOBILE COMMUNICATION SYSTEM," a true and correct copy of which is attached hereto as Exhibit B;

U.S. Patent No. 5,781,861 ("the '861 Patent") entitled "METHOD FOR SHEDDING TRAFFIC LOAD IN CODE DIVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM," a true and correct copy of which is attached hereto as Exhibit C; and

U.S. Patent No. 6,377,563 B1 (the '563 Patent") entitled "METHOD FOR HANDOFFING IN A CODE DEVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM," a true and correct copy of which is attached hereto as Exhibit D.

8. SPH has explicitly and repeatedly threatened Kyocera and its products with lawsuits over SPH's additional licensed patents, including the Patents-in-Suit identified above.

9. Kyocera seeks a judgment against SPH that Kyocera's products and processes have not infringed and do not infringe the Patents-in-Suit and/or that the Patents-in-Suit are invalid.

10. This Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331, 1338(a), 2201, and 35 U.S.C. § 1 *et seq*.

11. Venue is appropriate in this district pursuant to 28 U.S.C. §§ 1391 and 1400.

12. This Court has personal jurisdiction over SPH. On information and belief, SPH is a resident of Virginia, but conducts business in this District, and elsewhere in the State of California. This Court has personal jurisdiction over SPH because SPH has established minimum contacts with the forum and the exercise of jurisdiction over SPH would not offend traditional notions of fair play and substantial justice.

FACTS

13. SPH filed a lawsuit against Kyocera in the District Court for the Eastern District of Virginia on July 9, 2008, alleging infringement of three U.S. Patents relating to wireless communication technology, including the WCDMA and CDMA2000 wireless technology standards. SPH subsequently dismissed one of the patents from that lawsuit because Kyocera's

products do not use WCDMA technology. The case was transferred to this Disitrct on November 20, 2008 as Case No. 08cv2146 DMS (RBB) ("the SPH lawsuit") and is currently ongoing.

14. On January 9, 2009, representatives from SPH and Kyocera met via telephone and discussed a potential settlement of the SPH lawsuit. SPH offered to license various additional patents to Kyocera that were not the subject of the SPH lawsuit. During the January 9 telephone call, SPH explicitly threatened additional patent infringement litigation against Kyocera "in the near future" and in multiple jurisdictions if Kyocera refused to take a license to the additional patents. Specifically, SPH stated that it planned to bring an ITC case as well as up to three cases in various District Courts. SPH further suggested that these new cases would be based on non-standards based patents involving wireless technology that SPH obtained from ETRI and that Kyocera could avoid the new lawsuits by accepting SPH's offer to license the additional patents.

15. SPH confirmed its explicit threats of imminent, multiple patent infringement lawsuits in writing on January 12, 2009. There, SPH repeated that it "has been preparing some additional cases, including an ITC case, against Kyocera, and is planning to proceed with those cases unless SPH is convinced that Kyocera is seriously interested in an early settlement." In connection with these threats, SPH offered a license to the patents and patent applications SPH had obtained and/or would obtain from ETRI.

16. In response to an email from Kyocera requesting that SPH identify the ETRI patents to which it was offering a license, SPH provided a list of such patents on January 14, 2009 identifying the four Patents-in-Suit, in addition to the three patents asserted in the ongoing SPH lawsuit.

17. On January 26, 2009, SPH sent an email to Kyocera repeating its threats of patent infringement litigation yet again. Specifically, SPH wrote that it "is planning to bring another patent infringement action against Kyocera" if Kyocera does not accept SPH's license proposal regarding the Patents-in-Suit and the three patents originally asserted in the SPH lawsuit.

18. SPH further emphasized its intentions to engage in patent infringement lawsuits against Kyocera on multiple different fronts in a series of emails in late January and early

February 2009. On January 28, 2009, February 3, 2009, and February 10, 2009, SPH sent emails to Kyocera threatening still more patent lawsuits, this time based on patents newly-acquired from a third party other than ETRI. SPH offered to provide patent numbers and claim charts in exchange for an agreement that Kyocera would not file a declaratory judgment action for a certain period of time.

19. Based on SPH's repeated and explicit threats to initiate additional litigation against Kyocera in the "near future" and in multiple jurisdictions unless Kyocera takes a license to the Patents-in-Suit, Kyocera believes that it is imminently in danger of a lawsuit on the Patents-in-Suit.

20. Kyocera is not liable for infringing any valid claim of the Patents-in-Suit because each such claim is invalid and/or unenforceable, and the accused Kyocera products and processes have not infringed and do not infringe any such valid claim.

21. There is an actual, substantial and continuing justiciable controversy between Kyocera and SPH regarding the validity and enforceability of the Patents-in-Suit and regarding alleged infringement of the Patents-in-Suit by Kyocera or by use of Kyocera's products and processes.

FIRST CLAIM FOR RELIEF

(Declaratory Relief — the '434 Patent)

22. Kyocera incorporates by reference each and every allegation set forth paragraphs 1-21 as if fully set forth herein.

23. Kyocera has not directly or indirectly infringed and is not directly or indirectly infringing the '434 Patent.

24. One or more of the claims of the '434 Patent are invalid and/or unenforceable for failing to meet one or more of the requisite statutory and decisional requirements and/or conditions for Patentability under Title 35 of the United States Code, including without limitation, §§ 101, 102, 103, and/or 112.

25. Kyocera is entitled to a declaratory judgment that it has not infringed and is not infringing the '434 Patent and/or that the '434 Patent is invalid.

SECOND CLAIM FOR RELIEF

(Declaratory Relief — the '906 Patent)

26. Kyocera incorporates by reference each and every allegation set forth paragraphs 1-21 as if fully set forth herein.

27. Kyocera has not directly or indirectly infringed and is not directly or indirectly infringing the '906 Patent.

28. One or more of the claims of the '906 Patent are invalid and/or unenforceable for failing to meet one or more of the requisite statutory and decisional requirements and/or conditions for Patentability under Title 35 of the United States Code, including without limitation, §§ 101, 102, 103, and/or 112.

29. Kyocera is entitled to a declaratory judgment that it has not infringed and is not infringing the '906 Patent and/or that the '906 Patent is invalid.

THIRD CLAIM FOR RELIEF

(Declaratory Relief — the '861 Patent)

30. Kyocera incorporates by reference each and every allegation set forth paragraphs 1-21 as if fully set forth herein.

31. Kyocera has not directly or indirectly infringed and is not directly or indirectly infringing the '861 Patent.

32. One or more of the claims of the '861 Patent are invalid and/or unenforceable for failing to meet one or more of the requisite statutory and decisional requirements and/or conditions for Patentability under Title 35 of the United States Code, including without limitation, §§ 101, 102, 103, and/or 112.

33. Kyocera is entitled to a declaratory judgment that it has not infringed and is not infringing the '861 Patent and/or that the '861 Patent is invalid.

FOURTH CLAIM FOR RELIEF

(Declaratory Relief — the '563 Patent)

34. Kyocera incorporates by reference each and every allegation set forth paragraphs 1-21 as if fully set forth herein.

35. Kyocera has not directly or indirectly infringed and is not directly or indirectly infringing the '563 Patent.

36. One or more of the claims of the '563 Patent are invalid and/or unenforceable for failing to meet one or more of the requisite statutory and decisional requirements and/or conditions for Patentability under Title 35 of the United States Code, including without limitation, §§ 101, 102, 103, and/or 112.

37. Kyocera is entitled to a declaratory judgment that it has not infringed and is not infringing the '563 Patent and/or that the '563 Patent is invalid.

PRAYER FOR RELIEF

WHEREFORE, Kyocera requests the Court to enter a declaratory judgment in its favor and against SPH as follows:

a. An order entering judgment in favor of Kyocera and against SPH;

b. An order declaring that Kyocera has not directly or indirectly infringed, and is not directly or indirectly infringing, the '434 Patent;

c. An order declaring that Kyocera has not directly or indirectly infringed, and is not directly or indirectly infringing, the '906 Patent;

d. An order declaring that Kyocera has not directly or indirectly infringed, and is not directly or indirectly infringing, the '861 Patent;

e. An order declaring that Kyocera has not directly or indirectly infringed, and is not directly or indirectly infringing, the '563 Patent;

f. An order declaring that one or more claims of the '434 Patent are invalid.

g. An order declaring that one or more claims of the '906 Patent are invalid.

h. An order declaring that one or more claims of the '861 Patent are invalid.

i. An order declaring that one or more claims of the '563 Patent are invalid.

j. An order awarding Kyocera its costs (including expert fees), disbursements, and reasonable attorneys' fees incurred in this action, pursuant to 35 U.S.C. § 285; and

k. An order granting such further relief as is just and proper.

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JURY DEMAND

Pursuant to Federal Rule of Civil Procedure 38(b), Kyocera demands a trial by jury for all issues so triable.

Dated: February 18, 2009

Respectfully submitted,
FOLEY & LARDNER LLP

David E. Kleinfeld
Kurt M. Kjelland
Steven A. Moore
Samuel R. Hellfeld

Attorneys for Plaintiffs KYOCERA WIRELESS CORPORATION, KYOCERA SANYO TELECOM, INC., and KYOCERA CORPORATION

EXHIBIT A

US005940434A

United States Patent [19]

Lee et al.

[11] **Patent Number: 5,940,434**

[45] **Date of Patent: Aug. 17, 1999**

[54] **WALSH-QPSK CHIP MODULATION APPARATUS FOR GENERATING SIGNAL WAVEFORM IN A DIRECT SEQUENCE SPREAD SPECTRUM COMMUNICATION SYSTEM**

[75] Inventors: **Dong Wook Lee**; **Hun Lee**; **Myoung Jin Kim**, all of Daejon-Shi, Rep. of Korea

[73] Assignees: **Electronics and Telecommunications Research Institute**, Daejon-Shi; **Dacom Corporation**, Seoul, both of Rep. of Korea

[21] Appl. No.: **08/911,398**

[22] Filed: **Aug. 14, 1997**

[30] **Foreign Application Priority Data**

Aug. 14, 1996 [KR] Rep. of Korea 96-33691

[51] **Int. Cl.**[6] **H04B 1/707**

[52] **U.S. Cl.** **375/206**; 370/335

[58] **Field of Search** 375/206, 200; 370/320, 335, 342, 441, 479, 209

[56] **References Cited**

U.S. PATENT DOCUMENTS

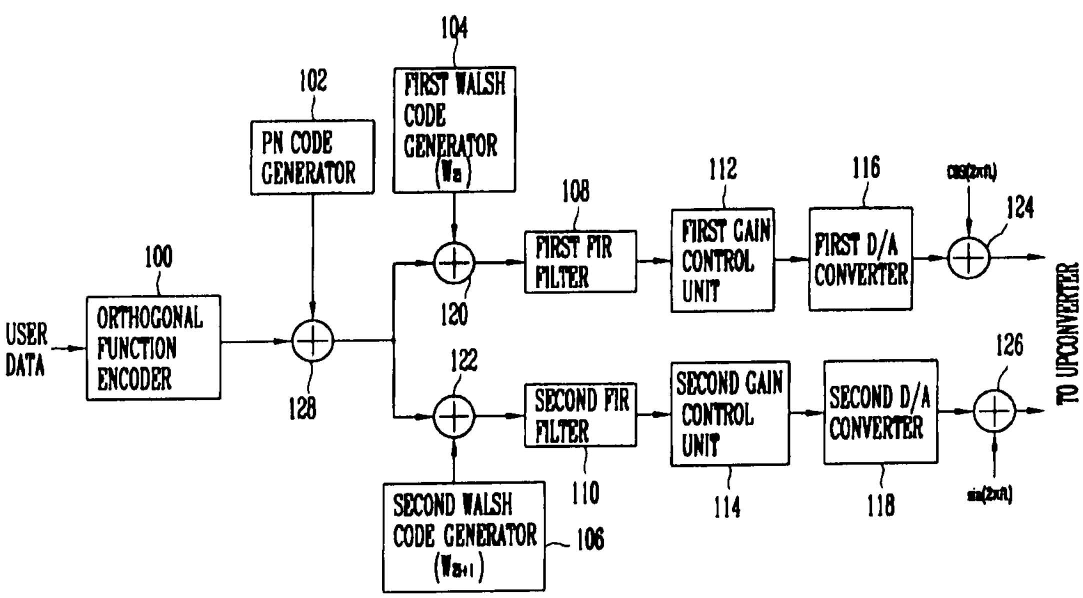
5,103,459	4/1992	Gilhousen et al.	370/209
5,309,474	5/1994	Gilhousen et al.	370/209
5,511,073	4/1996	Padovani et al.	370/471
5,608,722	3/1997	Miller	370/320
5,680,395	10/1997	Weaver, Jr. et al.	370/331
5,712,869	1/1998	Lee et al.	375/206

Primary Examiner—Don N. Vo
Assistant Examiner—Lenny Jiang
Attorney, Agent, or Firm—Cohen, Pontani, Lieberman & Pavane

[57] **ABSTRACT**

In a direct sequence spread spectrum communications system wherein user binary information symbols are spread spectrum modulated and transmitted to the other party, a non-coherent Walsh QPSK and a coherent Walsh QPSK modulation methods, wherein the PN spreading sequences for inphase and quadrature data in a conventional QPSK PN modulation scheme are coded by Walsh sequences indexed by a special rule to reduce the envelope variation of the transmitted signal, can reduce the envelope variation of transmit signal. And, in a direct sequence spread spectrum communications system wherein several user binary information symbols are spread spectrum modulated, the information symbols of each user are covered by user-specified different Walsh codes and transmitted to the other party, a QPSK modulation methods, wherein the polarity of quadrature PN spreading sequence of a user is controlled by a system controller to make the number of users using the quadrature PN sequence equal to that of users using NOT of the sequence, can reduce the envelope variation of transmit signal.

3 Claims, 4 Drawing Sheets



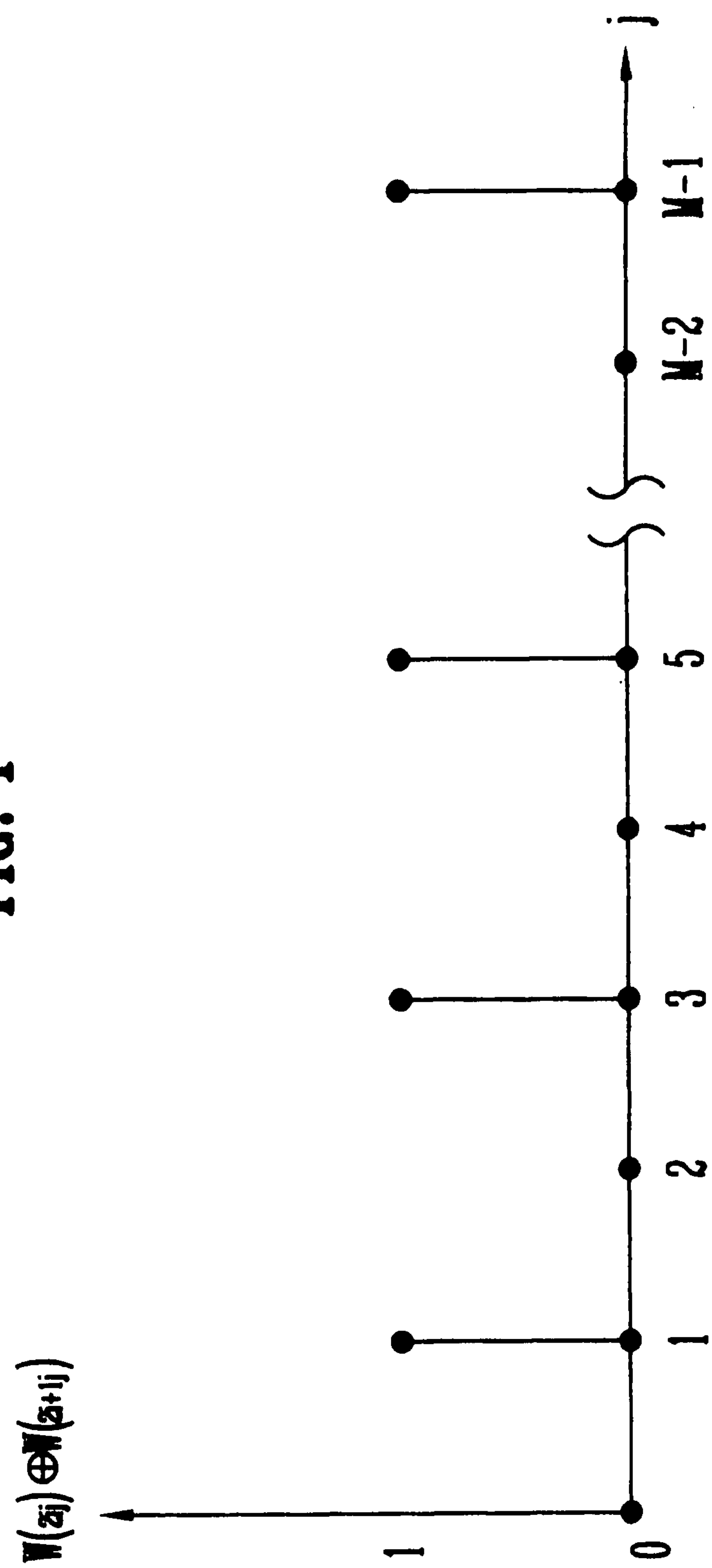


FIG. 1

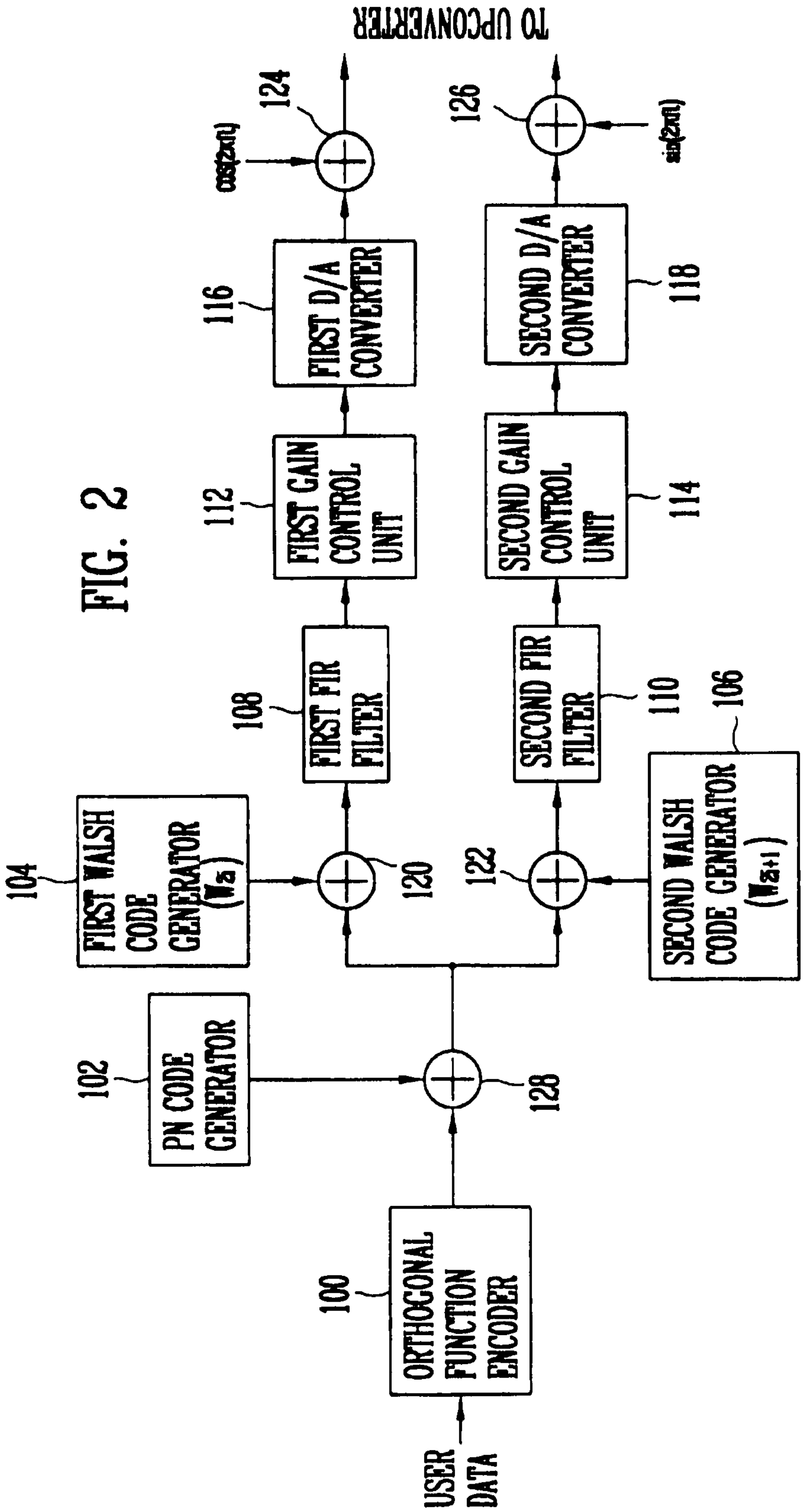
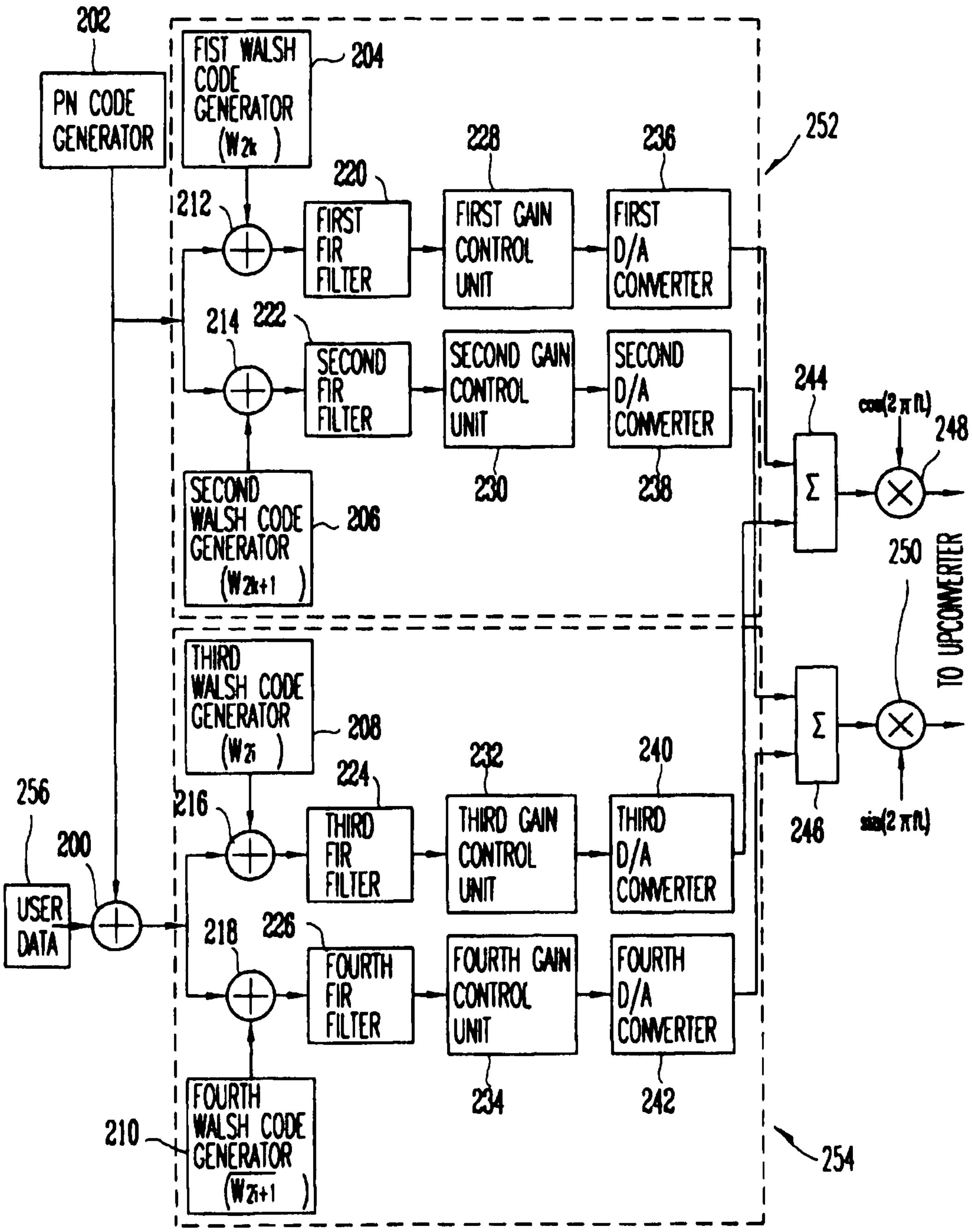

TO UPCONVERTER
USER DATA
ORTHOGONAL FUNCTION ENCODER
100
PN CODE GENERATOR
102
FIRST WALSH CODE GENERATOR (W_{2i})
104
SECOND WALSH CODE GENERATOR (W_{2i+1})
106
FIRST FIR FILTER
108
SECOND FIR FILTER
110
FIRST GAIN CONTROL UNIT
112
SECOND GAIN CONTROL UNIT
114
FIRST D/A CONVERTER
116
SECOND D/A CONVERTER
118
120
122
124
126
128
cos(2πft)
sin(2πft)

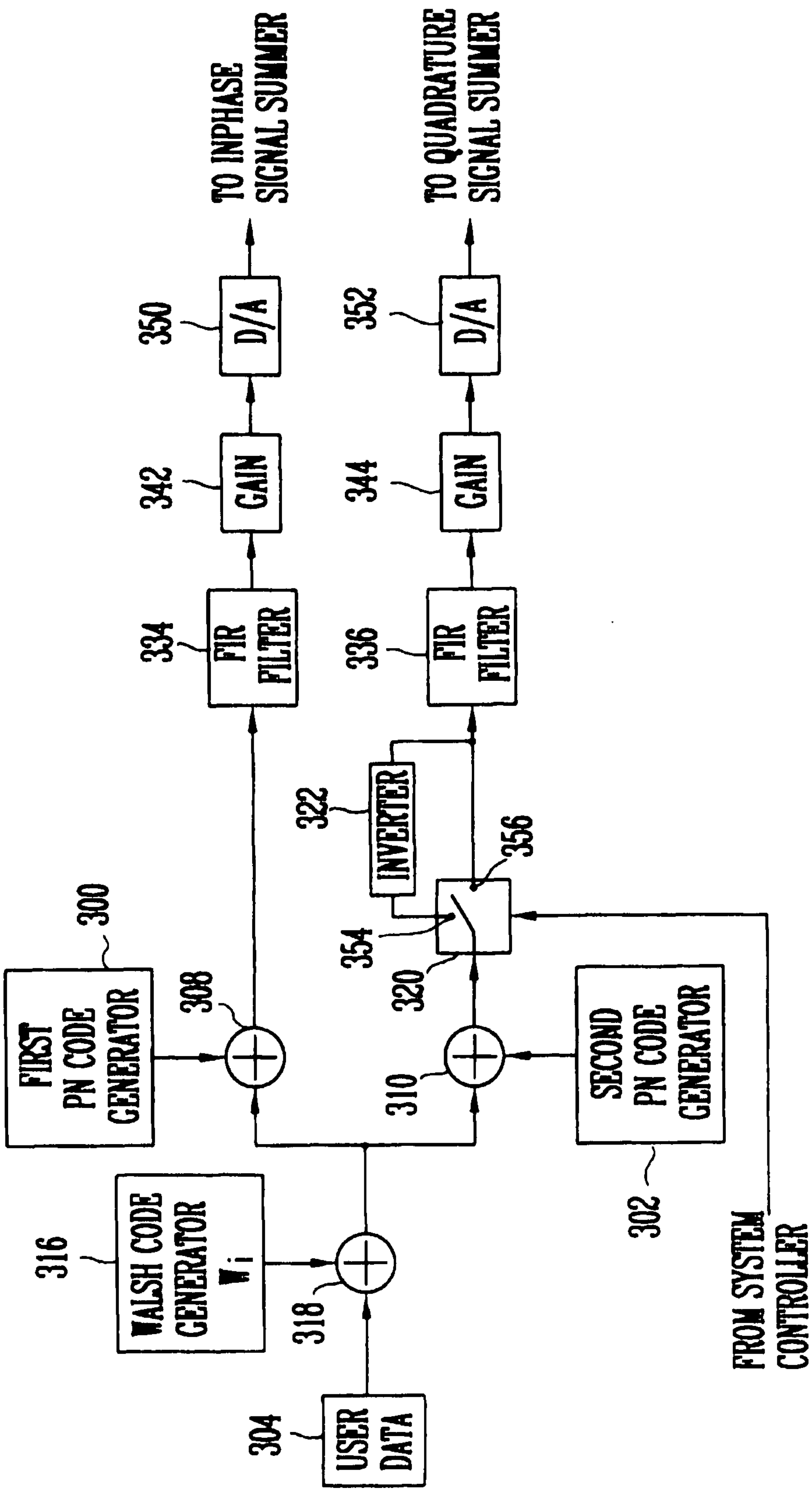
FIG. 2

FIG. 3



202
PN CODE GENERATOR
FIST WALSH CODE GENERATOR (W2k)
204
252
212
220
FIRST FIR FILTER
228
FIRST GAIN CONTROL UNIT
236
FIRST D/A CONVERTER
214
222
SECOND FIR FILTER
SECOND GAIN CONTROL UNIT
SECOND D/A CONVERTER
230
238
244
cos(2πfL)
248
Σ
SECOND WALSH CODE GENERATOR (W2k+1)
206
250
TO UPCONVERTER
THIRD WALSH CODE GENERATOR (W2i)
208
Σ
232
240
224
216
THIRD FIR FILTER
THIRD GAIN CONTROL UNIT
THIRD D/A CONVERTER
246
sin(2πfL)
256
200
USER DATA
218
226
FOURTH FIR FILTER
FOURTH GAIN CONTROL UNIT
FOURTH D/A CONVERTER
234
242
FOURTH WALSH CODE GENERATOR (W2i+1)
210
254

FIG. 4


TO INPHASE SIGNAL SUMMER
TO QUADRATURE SIGNAL SUMMER
350
D/A
352
D/A
342
GAIN
344
GAIN
334
FIR FILTER
336
FIR FILTER
322
INVERTER
356
354
320
300
FIRST PN CODE GENERATOR
308
310
SECOND PN CODE GENERATOR
302
316
WALSH CODE GENERATOR W_i
318
304
USER DATA
FROM SYSTEM CONTROLLER

WALSH-QPSK CHIP MODULATION APPARATUS FOR GENERATING SIGNAL WAVEFORM IN A DIRECT SEQUENCE SPREAD SPECTRUM COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to a PN code chip modulation apparatus for direct sequence spread spectrum communication systems.

BACKGROUND OF THE INVENTION

Generally, a direct sequence code division multiple access (DS-CDMA) is one of multi-user communication methods, in which several users can communicate simultaneously by using direct-sequence spread-spectrum(DSSS) techniques in which user data are transmitted after multiplied by an unique code allocated to each user. The chip rate of the code is tens or hundreds times higher than transmit data rate.

Several chip modulation methods for DS-CDMA systems have been proposed for cellular, personal communications services and wireless local loop applications.

Important requirements for a portable terminal in wireless applications with mobility are low cost, low power consumption, small size and light-weight. To meet the requirements of low power consumption, an efficient power amplifier might be used. From the point of view of service providers, spectral efficiency is also an important requirement. However, usually a spectrally efficient signal has large envelope variation. The large envelope variation of the transmitted signal results in increasing the adjacent channel interference and degrading the system performance due to spectral regeneration at the output of a nonlinear power amplifier.

Both non-coherent M-ary orthogonal signaling for data modulation with OQPSK chip modulation [EIA/TIA/IS-95, "Mobile station-base station compatibility standard for dual-mode wideband spread spectrum cellular system," July 1993], and coherent QPSK data modulation with the QPSK data modulation with the QPSK chip modulation [Proposed Wideband CDMA PCS Standard, October 1994, OKI Co.], have been proposed for a DS-CDMA portable terminal. Also coherent QPSK data modulation with the QPSK chip modulation has been proposed for a for a base station of a DS-CDMA cellular telephone system [System and Method for Generating Signal Waveforms in a CDMA Cellular Telephone System, Jun. 25 1990, U.S. application Ser. No. 543,496, Issue No. 5,103,456].

In the conventional non-coherent M-ary orthogonal signaling for data modulation with OQPSK chip modulation, $\log_2 M$ bits of user data are mapped into one element of a set of M orthogonal binary sequences. Two different PN codes, called inphase and quadrature PN codes, allocated to the user are multiplied by the selected binary sequence, respectively, and input to inphase and quadrature data input port of the conventional OQPSK modulator, respectively. Using the non-coherent OQPSK PN modulation for a portable terminal, due to a delay of a half PN chip duration in the quadrature component of a transmitted signal, there is some self interference between the inphase and the quadrature components, although it is typically much smaller than the multiple access interference from the other users.

In a coherent direct sequence spread spectrum communication system, a pilot signal should be sent with the data signal to inform the other party on the phase information of the carrier modulated by the data signal. Commonly, the pilot signal is also a direct sequence spread spectrum signal in which a sequence with all zero's in logical value is spread by PN codes. The correlation coefficients of PN codes used in spreading data and those in spreading pilot symbols are zero or very low values such that the other party can distinguish between the pilot signal and the user data signal.

In the conventional coherent QPSK data modulation with the QPSK chip modulation, there are three channels; pilot, data and signaling channels. In this method, the pilot symbols, signaling symbols and user data bits, are spread by a same PN code, respectively. After spreading, they are covered by different Walsh sequences, where different Walsh sequences are orthogonal to each other, to be distinguished among them at the other party. The sum of pilot and data signals and the sum of signaling and data signals are input to the inphase data and quadrature data input ports of the conventional QPSK modulator, respectively. Due to the sum of two signals the envelope variation of transmitted signal becomes very high.

Using the coherent QPSK data modulation with QPSK chip modulation for a portable terminal, the sum of the pilot and the data channels exhibits a high envelope variation and a large phase change. Even though the envelope variation of transmitted signal is a minor problem in a base station since in the base station the power consumption is not critical, the reduction of envelope variation of transmitted signal might be helpful for improvement of whole system performance since the portable terminal might use a limiter at the receiver to reduce the terminal cost by eliminating the emphasis of the receiver AGC chain [J. Boccuzzi, "Performance Evaluation of Non-linear Transmit Power Amplifier," IEEE Transactions on Vehicular technology, No. 2, pp. 220–228, May 1995].

It is an object of this invention to provide a special case of QPSK PN modulation, called Walsh-QPSK, which can exhibit lower envelope variation and smaller phase changes than the conventional PN modulation schemes.

SUMMARY OF THE INVENTION

The Walsh-QPSK chip modulation uses a property of the exclusive-OR of two adjacent-indexed rows of the Hadamard matrix which is newly found in this invention from the binary representation of Walsh function indexes [J. L. Shanks, "Computation of the Fast Walsh-Fourier transform," IEEE Transaction on Computers, pp. 457–459, May 1969], in which W(i,j), the element on the (i+1)-th row and (j+1)-th column (i and j=0, 1, 2, . . . , M−1) of the M-dimensional Hadamard matrix, has a binary value, 0 or 1. The exclusive-OR of W(2i, j) and W(2i+1, j) becomes 2nd row of the Hadamard matrix which has 0 for even number of j and 1 for odd number of j.

In the QPSK modulator, the transmitted signal is the sum of two carriers modulated by the input from the inphase data input port and the input from the quadrature data input port, of which frequencies are the same but the phase difference of the two carriers is 90° . In the conventional QPSK chip modulation, the inphase and the quadrature sequences, which are the result of multiplying inphase data with inphase PN code and quadrature data with quadrature PN code, respectively, are input to inphase and quadrature input data ports of conventional QPSK modulator. In the conventional OQPSK chip modulation, inphase and quadrature sequences are input to the inphase and the quadrature data input ports of the conventional QPSK modulator after delaying the quadrature sequences by a half PN chip.

The reason why the phase shift of the transmitted signal of the conventional OQPSK chip modulation is limited to 90° is because the half chip delay between inphase and quadrature sequences prevents from changing their polarities at the same time.

If two sequences, called Walsh sequences with index 2i and the (2i+1), which are repeats of the (2i+1) and the (2i+2) rows of the Hadamard matrix, respectively, are input to inphase and quadrature input data ports of the QPSK modulator, we can limit the phase shift of the transmitted signal to 90° since, from the property of the exclusive-OR of two adjacent-indexed rows of the Hadamard matrix, the inphase and the quadrature sequences do not change their polarities at the same time. However, this scheme cannot be used for DS-CDMA systems since the correlation between Walsh sequences with different time delay is very high and, as a result, the interference from the other user arrived at the receiver with different time delay is too high for several users to communicate simultaneously. Therefore, we need sequences which have same property of the the exclusive-OR of two adjacent-indexed rows of the Hadamard matrix and a small correlation value between sequences with different time delay. We can obtain those sequences by multiplying Walsh sequences with a PN code. The PN code has a small correlation values between sequences with different time delays. The sequences obtained by multiplying Walsh sequences with a PN code also have small correlation values between sequences with different time delay. Two sequences obtained by multiplying two adjacent-indexed Walsh sequences with a PN code also have the same property of the exclusive-OR of two adjacent-indexed rows of the Hadamard matrix. Therefore, if these two sequences multiplied by the same data bit, respectively, are input to the inphase and the quadrature data input ports of the conventional QPSK modulator, without a half chip delay operation, the phase shift of the transmitted signal can be limited to 90° as does the conventional OQPSK chip modulation. Further, since the two inphase and quadrature sequences are orthogonal, under an ideal condition, the self-interference between inphase and quadrature components of transmitted signal can be eliminated.

A new coherent DS-CDMA QPSK chip modulation using the property of the exclusive-OR of two adjacent-indexed rows of the Hadamard matrix might be able to reduce the envelope variation and a large phase shift which occurs in the conventional coherent DS-CDMA QPSK chip modulation. From the property, we know that $W(2i, j) \oplus W(2i+1, j) = W(2k, j) \oplus W(2k+1, j) = W(1, j)$. This means that if $W(2i, j) = W(2k, j)$, then $W(2i+1, j) = W(2k+1, j)$, and if $W(2i, j) = \overline{W(2k, j)}$, then $W(2i+1, j) = \overline{W(2k+1, j)}$. When we used these four sequences, which are repeats of (2i+1)-th, (2i+2)-th, (2k+1)-th and (2k+2)-th rows of Hadamard matrix, as inphase and quadrature sequences of pilot signal and those of data signal, if the sum of inphase sequences of pilot and data signals increases, the sum of quadrature sequences of pilot and data signals also increases, and if the sum of inphase sequences of pilot and data signals decreases, the sum of quadrature sequences of pilot and data signals also decreases. When one of four sequences is replaced with logical NOT of the sequence, for example, four sequences, which are repeats of (2i+1)-th, (2i+2)-th, (2k+1)-th and logical NOT of (2k+2)-th rows of Hadamard matrix are used for inphase and quadrature sequences of pilot signal and those of data signals, then if the sum of inphase sequences of pilot and data signals increases, the sum of quadrature sequences of pilot and data signals decreases, and if the sum of inphase sequences of pilot and data signals decreases, the sum of quadrature sequences of pilot and data signals increases. This makes the envelope variation of the transmitted signal reduced. Using this method, we can obtain a similar signal constellation to that of π/4-QPSK, if the transmit power of the pilot signal is 6 db less than that of the data signal.

To reduce the envelope variation of transmitted signal of a base station currently used in the CDMA cellular system [EIA/TIA/IS-95, "Mobile station-base station compatibility standard for dual-mode wideband spread spectrum cellular system," July 1993], we consider a new simple method. [Data transmitter and receiver of a spread spectrum communication system using a pilot channel, U.S. Pat. No. 562,281]. In this system, each user data bit is spread by a unique Walsh sequence allocated to the user for other party to be able to extract the user data among received signals. This spread signal is multiplied by two PN codes, celled inphase and quadrature PN codes, respectively. The inphase and quadrature sequences of all users are summed, respectively. The sums of inphase and quadrature sequences of all users are input to the inphase and the quadrature data input ports of the conventional QPSK modulator. Let assume that there are only two user channels in a base station. For the same reason mentioned above, we can reduce the envelope variation of the transmitted signal by replacing a sequence of the four sequences with logical NOT of the sequence. For example, when the quadrature sequence of one of two users are replaced with logical NOT of the sequence, if the sum of inphase sequences of two users increases or decreases, the sum of quadrature sequences of two users decreases or increases. Therefore, the envelope variation of the transmitted signal can be reduced. When there are more than 2 users, a system controller controls the number of users, whose quadrature sequence is the logical NOT of the assigned sequence, is the half of the number of total users.

The present invention provides a substantial improvement over non-coherent and coherent direct sequence spread spectrum chip modulations with small envelope variation and a small phase shift.

BRIEF DESCRIPTION OF THE DRAWINGS

For fuller understanding of the nature and object of the invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is the property of exclusive-OR of two adjacent indexed Walsh sequences obtained from the Hadamard matrix.

FIG. 2 is a block diagram of the non-coherent Walsh-QPSK chip modulation apparatus.

FIG. 3 is a block diagram of the coherent Walsh-QPSK chip modulation apparatus.

FIG. 4 is a block diagram of coherent chip modulation apparatus for a base station.

Similar reference characters refer to similar parts in the several views of the drawings.

DESCRIPTION OF THE INVENTION

The present invention will be described in detail by reference to the accompanying drawings.

It is well known that the Hadamard matrix can be generated by means of the following recursive procedure [J. L. Shanks, "Computation of the Fast Walsh-Fourier transform," IEEE Transactions on Computers, pp. 457–459, May 1969]:

$$H_1[0],\ H_2=\begin{bmatrix}0 & 0\\ 0 & 1\end{bmatrix},\ H_{2M}=\begin{bmatrix}H_M & H_M\\ H_M & \overline{H_M}\end{bmatrix}$$

where $M=2^P$ for any integer p and $\overline{H}_M$ denotes the binary complement of H_M. The (i+1, j+1)-th element of the matrix H_M is denoted by W(i, j). Then the exclusive-OR of W(2i, j) and W(2i+1, j) is equal to W(1, j) as shown in FIG. **1**. The Walsh sequence with index of i, W_i, is a repeat of (i+1)-th row H_M.

FIG. **2** illustrates in block diagram an exemplary non-coherent DS-CDMA Walsh-QPSK modulation apparatus in which the present invention is embodied.

In FIG.**2**, the non-coherent DS-CDMA Walsh-QPSK modulation apparatus includes an orthogonal function encoder **100** which is commonly used to map several bits of user data into an element of a set of orthogonal sequence. Typically, 64 rows of a 64 dimensional Hadamard matrix is used as a set of orthogonal sequences [EIA/TIA/IS-95, "Mobile station-base station compatibility standard for dual-mode wideband spread spectrum cellular system," July 1993]. Then 6 bits of data is converted into 64 modulation symbols which are the elements of a row of the 64 dimensional Hadamard matrix mapped by orthogonal function encoder **100**. The modulation symbols and a PN code generated by a PN code generator **102** are combined in an exclusive-OR gate **128**. Typically, chip rate of the PN code is 4 times faster than the symbol rate of the modulation symbol [EIA/TIA/IS-95, "Mobile station-base station compatibility standard for dual-mode wideband spread spectrum cellular system," July 1993] Therefore, the spectrum of the modulation symbol is spread by 4 times. A spread symbol, which is output of exclusive-OR gate **128**, and a Walsh sequence with index 2i generated by a first Walsh code generator **104** are combined in exclusive-OR gate **120**. The same spread symbol and a Walsh sequence with index 2i+1 generated by a second Walsh code generator **106** are combined in exclusive-OR gate **122**. The symbol rates of codes generated by first Walsh code generator **104** and second Walsh code generator **106** are same as that of a code generated by PN code generator **102**.

The inphase and quadrature sequences which are output of exclusive-OR gates **120** and **122**, respectively, have binary values of 0 or 1. The binary values 0 and 1 in these sequences are converted into real values 1 or −1, respectively, in the first and second FIR (Finite Impulse Response) filters **108** and **110** before being passed through those FIR filters. Typically, first and second FIR filters **108** and **110** have the same finite impulse response which satisfies the spectrum specification of transmitted signal in a system. The values of outputs of first and second FIR filters **108** and **112** are multiplied by a gain in first and second gain control units **112** and **114**, respectively, before being converted into analog signals in first and second D/A converters **116** and **118**, respectively. Those two analog signals, outputs of first and second D/A converters **116** and **118**, modulate two IF (intermediate frequency) quadrature carriers in first and second mixers **124** and **126**, respectively. The frequency of modulated two if quadrature carriers, outputs of first and second mixer **124** and **126**, are summed and converted up to radio frequency band at up-converter (not shown) to be transmitted to the other party through an amplifier (not shown).

Since exclusive-OR of the inphase and the quadrature sequences is the same as exclusive-OR of two adjacent indexed Walsh sequences, one of two sequences changes its polarity at a time, as does the OQPSK modulation. This makes the phase shift of transmitted signal limited to 90° if the impulse response of FIR filters is rectangular and its duration is same as the input symbol rate.

Further, since the inphase and the quadrature sequences are orthogonal, there is no self-interference between inphase and quadrature components of transmitted signal, which occurs in the conventional O-QPSK chip modulation,—due to correlation between two PN codes used to spread the inphase and quadrature data, respectively.

In FIG. **2**, if we choose two Walsh sequences with index 0 and 1, first Walsh code generator **104** and exclusive-OR gate **120** do not need to exist since the walsh code with index 0 is consisted of 0's. Therefore, in that case, output of exclusive-OR gate **128** can directly input to first FIR filter **108**. If two spread symbols which input to exclusive-OR gates **120** and **122** are different user information symbols spread by the same PN code generated by PN code generator **102**, the signal constellation points pass through the vicinity area of the origin only in the symbol boundary. Therefore, even in that case, the phase shift of transmit signal can be limited to 90° and we can obtain the same signal characteristics as non-coherent Walsh-QPSK except only in the symbol boundary.

An exemplary coherent DS-CDMA Walsh-QPSK chip modulation apparatus in which present invention is embodied is illustrated in FIG. **3**. In coherent communications system, a pilot signal should be sent to other party along with a data signal such that from the pilot signal the other party can know the phase of unmodulated carrier. Typically, in the coherent DS-CDMA system, the pilot signal is also a direct-sequence spread spectrum signal, in which a PN code spreading a pilot symbols, typically all zero's, modulates the carrier which has the same phase of the carrier modulated by a PN code spreading data bits. The other party is able to know the phase of unmodulated carrier after detecting the pilot signal. Typically, the PN code spreading pilot symbols is orthogonal to the PN code spreading data bits. Therefore, the other party can detect a pilot signal from the received signal.

In FIG. **3**, a coherent DS-CDMA Walsh-QPSK chip modulation apparatus includes two signal generators, namely, a pilot signal generator **252** and a data signal generator **254**. Pilot signal generator **252** generates inphase and quadrature analog signals with the exactly same method used in a non-coherent DS-CDMA Walsh-QPSK chip modulation apparatus. Data signal generator **254** also generates inphase and quadrature analog signals with the same method used in a non-coherent DS-CDMA Walsh-QPSK chip modulation apparatus, but in data signal generator **254**, a Walsh code generated by fourth Walsh code generator **210** is logical NOT of the Walsh sequence with index 2i+1. In FIG. **3**, there is no action to spread pilot symbol since pilot symbols are all zero's and the output of exclusive-OR gate with input of a PN code and pilot symbols becomes the PN code itself. Therefore the input of pilot signal generator **252** is a PN code itself generated by PN code generator **202**. Gains of pilot signal controlled by gain control units and **230** **228** and data signal controlled by gain control units **232** and **234** are controlled such that the power of transmit signal of pilot signal is typically 6 dB less than that of data signal.

In summers **244** and **246**, pilot inphase and quadrature analog signals, outputs of first and second D/A converters **236** and **238**, are added to data inphase and quadrature analog signals, outputs of third and fourth D/A converters **240** and **242**, respectively. Inphase and quadrature analog signals, outputs of summers **244** and **246**, modulate two IF (intermediate frequency) quadrature carriers in first and second mixers **248** and **250**, respectively. The frequency of modulated two IF quadrature carriers, outputs of first and second mixer **248** and **250**, are summed and converted up to radio frequency band at up-converter (not shown) to be transmitted to the other party through an amplifier (not shown).

The signal constellation for each outputs of pilot signal generator **252** and data signal generator **254** is exactly same as that of inphase and quadrature analog signals in a non-coherent DS-CDMA Walsh-QPSK chip modulation. From the property of exclusive-OR of adjacent-indexed Walsh sequences, when first Walsh code generator **204** generates a code symbol same as that generated by second Walsh code generator **206**, third Walsh code generator **224** generates a code symbol opposite to that generated by fourth Walsh code generator **226**. And when first Walsh code generator **204** generates a code symbol opposite to that generated by second Walsh code generator **206**, third Walsh code generator **224** generates a code symbol same as that generated by fourth Walsh code generator **226**. Therefore, when the sum of pilot and data inphase analog signals, outputs of first and third D/A converters **236** and **240**, respectively, is constructive, the sum of pilot and data quadrature analog signals, outputs of second and fourth D/A converters **238** and **242**, respectively, is destructive. And when the sum of pilot and data inphase analog signals, outputs of first and third D/A converters **236** and **240**, respectively, is destructive, the sum of pilot and data quadrature analog signals, outputs of second and fourth D/A converters **238** and **242**, respectively, is constructive. For this reason, the envelope variation of transmitted signal, which is defined as the square root of square sum of inphase and quadrature analog signals, is greatly reduced in comparison with conventional coherent DS-CDMA chip modulation apparatus.

As dose $\pi/4$-QPSK modulation, this makes the phase shift of transmitted signal limited to 135° if the impulse response of FIR filters is rectangular and its duration is same as the input symbol rate and transmit power of pilot signal is 6 dB less than that of data signal.

FIG. **3** shows an exemplary coherent Walsh-QPSK chip modulation apparatus for convenience of explanation. Same characteristics of transmitted signal can be obtained when one of four Walsh sequence generators **204**,**206**,**208** and **210** generates a logical NOT of a Walsh sequence and three of them generate three Walsh sequences, in which the four Walsh sequences have indexes 2k, 2k+1, 2i and 2i+1.

In FIG. **4**, an exemplary DS-CDMA QPSK chip modulation apparatus for a channel in a base station in which present invention is embodied is illustrated.

In a base station, there are many CDMA channels; pilot channel, control signal channels and user data channels. Each channel is separated by different Walsh code spreading data of each channel. In FIG. **4**, a user data **304** and a Walsh code generated by Walsh code generator **316** are combined by exclusive-OR gate **318**. The Walsh code generated by Walsh code generator **316** of a channel is different from those of the other channels. This spread symbol, which is output of exclusive-OR **318**, and inphase PN code generated by first PN code generator **300** are combined in exclusive-OR **308**. The same spread symbol and quadrature PN code generated by second PN code generator **302** are combined in exclusive-OR **310**. The same inphase and quadrature PN codes are used in each channel. Inphase sequence, output of exclusive-OR gate **308**, is converted into analog signals after passing through first FIR filter **334**, first gain control unit **342** and first D/A converter **350** as does it in a non-coherent DS-CDMA Walsh-QPSK chip modulation apparatus. Quadrature sequence, output of exclusive-OR gate **310**, is switched at switch **320** to inverter **322** before being fed to second FIR filter **336** or directly to second FIR filter **336** under the control of system controller. Inverter **322** is a NOT gate. Inphase and quadrature analog signals, outputs of first and second D/A converters **350** and **352**, generated in each channel are summed at inphase and quadrature signal summers (not shown), respectively, before modulating carriers, frequency up-conversion, amplified and transmitted (not shown).

The method in which a system controller controls switch **320** of each channel is to make equal the number of channels in which the switch **320** set to the position **354** and the number of channels in which the switch **320** set to position **356**.

To explain the operation of this apparatus, assume that there are two channels in a base station, switch **320** of first channel set to position **354**, and switch **320** of second channel is set to position **356**. Then, the inphase and quadrature sequences with real value (0 to 1 and 1 to −1) of first channel are $D_1W_1PN_I$ and $D_1W_1PN_Q$, respectively, and the inphase and quadrature sequences of second channel are $D_2W_2PN_I$ and $-D_2W_2PN_Q$, respectively, where D,W, and PN denote data, Walsh code and PN code sequences, respectively. The sum of two inphase sequences of first and second channels is $(D_1W_1+D_2W_2)\ PN_I$, and the sum of two inphase sequences of first and second channels is $(D_1W_1-D_2W_2)\ PN_Q$.

Therefore, if sum of two inphase sequences increases, the sum of quadrature sequences is decreases. If there are many channels in a base station, the effect of this apparatus can be ignored since the sum of many channels has a small variation near its average value. However, if there are small number of channels in a base station as in personal communication service, the envelope variation of transmitted signal of a base station can be reduced. The small envelope variation of transmitted signal of a base station makes a portable terminal cost-effective since the portable terminal does not need to use an additional technique to linearize the received signal.

As explained above, as the present invention may be easily applicable to a chip modulation apparatus of various direct sequence spread spectrum QPSK series, it can provide a cost-effective miniatured system compared with the conventional system using a convention method even though the required dynamic amplification range of a large power amplifier is relatively narrow when sending signals.

The foregoing description, although described in its preferred embodiment with a certain degree of particularity, is only illustrative of the principles of the present invention. It is to be understood that the present invention is not to be limited to the preferred embodiments disclosed and illustrated herein. Accordingly, all expedient variations and any combination of our claims that may be made within the scope and spirit of the present invention are to be encompassed as further embodiments of the present invention.

What we claim:

1. In a direct sequence spread spectrum communications system wherein user binary information symbol sequence from one party are spread spectrum modulated and transmitted to another party for reducing the envelope variation of a transmitted signal, a spread spectrum modulating apparatus comprising:

means for generating a first and a second Walsh sequences of indexes (2i) and (2i+1), wherein i is an integer value greater than or equal to 0;

means for generating a pseudo-noise binary code;

means for generating spread symbol sequence operating exclusive-OR of said user binary information symbol sequence and said pseudo-noise binary code;

means for generating inphase sequence operating exclusive-OR of said spread symbol sequence and said first Walsh sequence, and for generating quadrature sequence operating exclusive-OR of said spread symbol sequence and said second Walsh sequence; and

means for generating inphase signal shaping waveform of said inphase sequence, adjusting the gain and converting said shaped waveform of said inphase sequence into an analog signal, and for generating quadrature signal shaping waveform of said quadrature sequence, adjusting the gain and converting the shaped waveform of said quadrature sequence into an analog signal in which the sum of an inphase carrier modulated by said inphase signal and a quadrature carrier modulated by said quadrature signal is transmitted to an antenna via a frequency up-converter and an amplifier.

2. In a direct sequence spread spectrum communications system wherein two spread spectrum modulating apparatus of claim **1** are used for transmitting, in parallel, pilot symbol sequence and user information symbol sequence, a spread spectrum modulating apparatus for reducing the envelope variation of a transmitted signal wherein two spread spectrum modulating apparatus of claim **1** are used as a pilot signal generating means and data signal generating means, said pilot signal generating means spread spectrum modulates said pilot symbol sequence, said data signal generating means spread spectrum modulates said user information symbol sequence, an inphase carrier modulated by the sum of said inphase signal of said pilot signal generating means and said inphase signal of said data signal generating means, a quadrature carrier modulated by the sum of said quadrature signal of said pilot signal generating means and said quadrature signal of said data signal generating means, the sum of said modulated inphase carrier and said modulated quadrature carrier is transmitted to an antenna via a frequency up-converter and an amplifier, said means for generating said first and second Walsh sequences in said pilot signal generating means and said data signal generating means generate Walsh sequences of indexes (2i), (2i+1), (2k), and (2k+1), where i and k are different integer values, but one of four said means for generating said first and second Walsh sequences in said pilot signal generating means and data signal generating means generate the logical NOT of the Walsh sequence assigned.

3. A direct sequence code division multiple access system which comprises a plurality of spread spectrum modulating apparatus and system controller means, and said spread spectrum modulating apparatus comprises:

means for generating a Walsh sequence of index i;

means for generating an inphase pseudo-noise code, and for generating a quadrature pseudo-noise code;

means for generating spread symbol sequence operating exclusive-OR of said user information binary symbol sequence and said Walsh sequence of index i;

means for generating inphase sequence operating exclusive-OR of said spread symbol sequence and said inphase pseudo-noise code;

means for generating quadrature sequence operating, under control of said system controller, exclusive-OR or exclusive-NOR of said spread symbol sequence and said quadrature pseudo-noise code;

means for generating inphase signal shaping waveform of said inphase sequence, adjusting the gain and converting said shaped waveform of said inphase sequence into analog signal, and for generating quadrature signal shaping waveform of said quadrature sequence, adjusting the gain and converting shaped waveform of said quadrature sequence into analog signal, in which an inphase carrier is modulated by the sum of inphase signals of said spread spectrum modulating apparatus, a quadrature carrier is modulated by the sum of quadrature signals of said spread spectrum modulating apparatus, and the sum of said modulated inphase and quadrature carriers are transmitted to an antenna via a frequency up-converter and an amplifier,

wherein said system controller means controls said means for generating quadrature sequence such that the number of said spread spectrum apparatus in which said means for generating quadrature sequence operates exclusive-OR is equal to the number of said spread spectrum apparatus in which said means for generating quadrature sequence operates exclusive-NOR.

* * * * *

US007443906B1

(12) **United States Patent**
Bang et al.

(10) **Patent No.:** **US 7,443,906 B1**
(45) **Date of Patent:** **Oct. 28, 2008**

(54) **APPARATUS AND METHOD FOR MODULATING DATA MESSAGE BY EMPLOYING ORTHOGONAL VARIABLE SPREADING FACTOR (OVSF) CODES IN MOBILE COMMUNICATION SYSTEM**

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(73) Assignee: **Electronics and Telecommunications Research Institute** (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 588 days.

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(22) Filed: **May 31, 2000**

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Aug. 30, 1999 (KR) 1999-36383

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

(52) **U.S. Cl.** **375/140**

(58) **Field of Classification Search** 375/140, 375/146, 142, 144, 145, 130, 141, 147, 295
See application file for complete search history.

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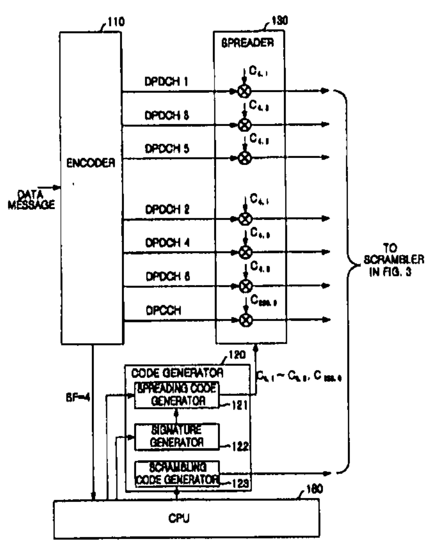
Primary Examiner—Kevin M Burd
(74) *Attorney, Agent, or Firm*—Hunton & Williams, LLP

(57) **ABSTRACT**

A method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, includes the steps of: a) encoding the source data to generate at least one data part and a control part; b) generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and c) spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal. The method is capable of improving a power efficiency of a mobile station by reducing a peak-to-average power ratio in a mobile communication system.

98 Claims, 22 Drawing Sheets



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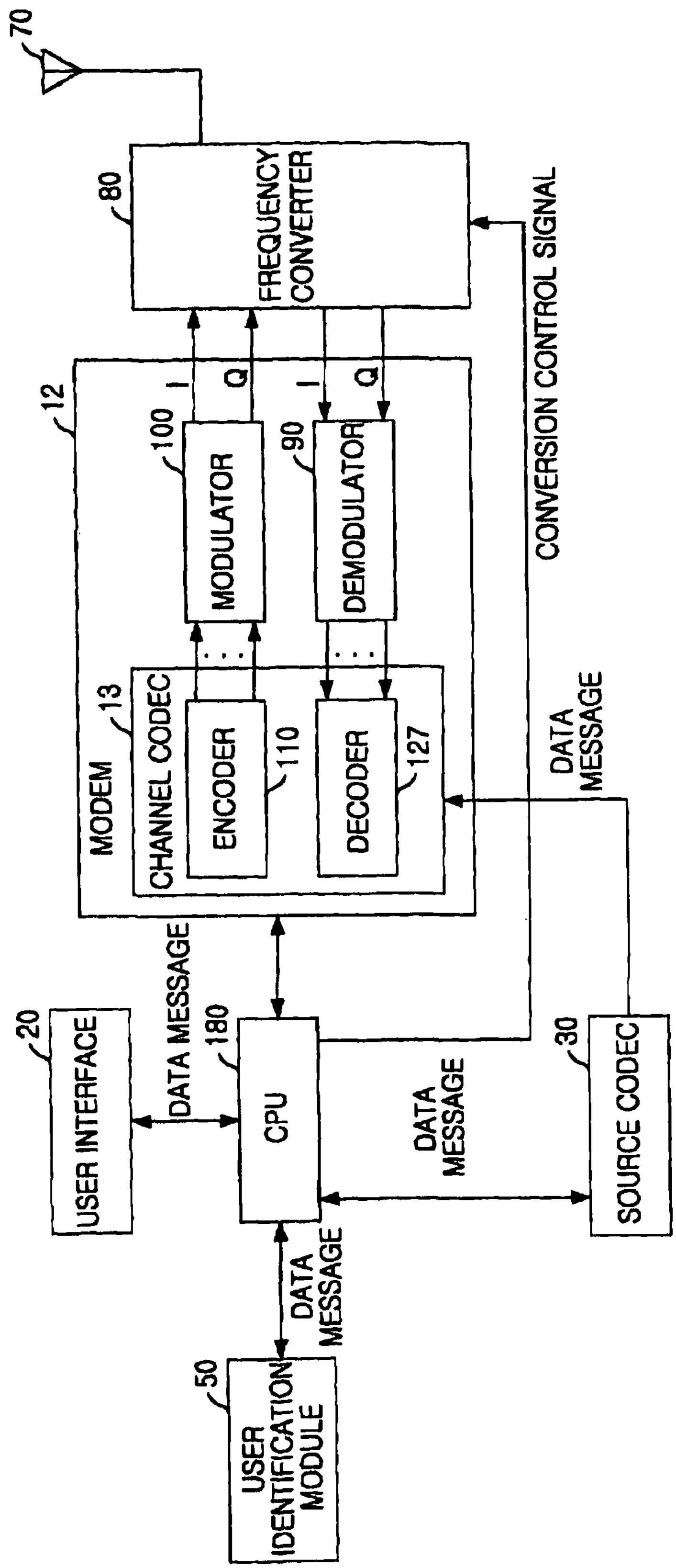
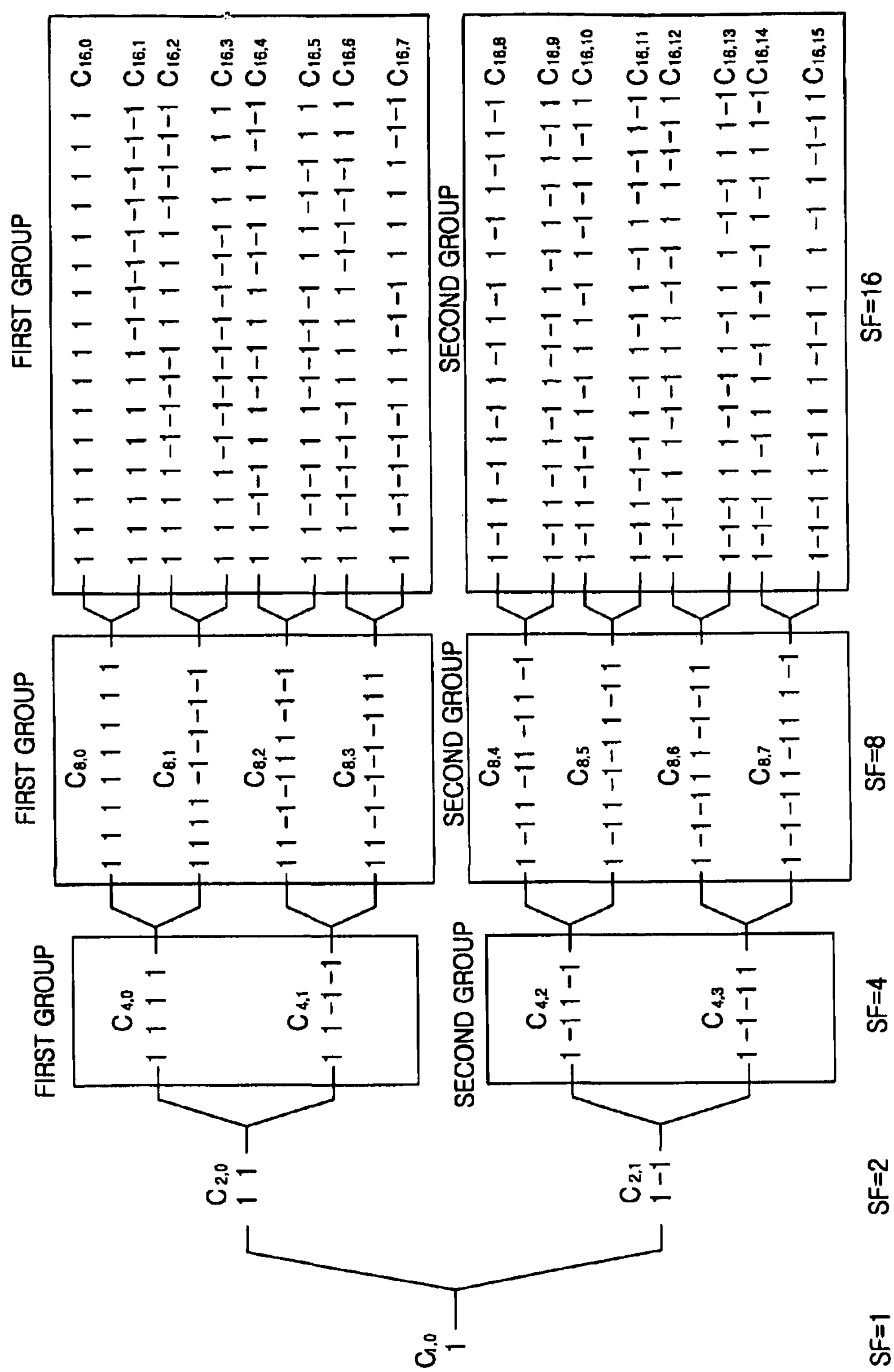

70
80
FREQUENCY CONVERTER
CONVERSION CONTROL SIGNAL
12
100
MODULATOR
90
DEMODULATOR
I
Q
I
Q
MODEM
13
CHANNEL CODEC
ENCODER
110
DECODER
127
DATA MESSAGE
DATA MESSAGE
20
USER INTERFACE
180
CPU
DATA MESSAGE
30
SOURCE CODEC
DATA MESSAGE
50
USER IDENTIFICATION MODULE

FIG. 1

FIG. 2


SF=1
SF=2
SF=4
SF=8
SF=16
FIRST GROUP
SECOND GROUP
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$C_{2,0}$ 1 1
$C_{2,1}$ 1 -1
$C_{4,0}$ 1 1 1 1
$C_{4,1}$ 1 1 -1 -1
$C_{4,2}$ 1 -1 1 -1
$C_{4,3}$ 1 -1 -1 1

FIG. 3

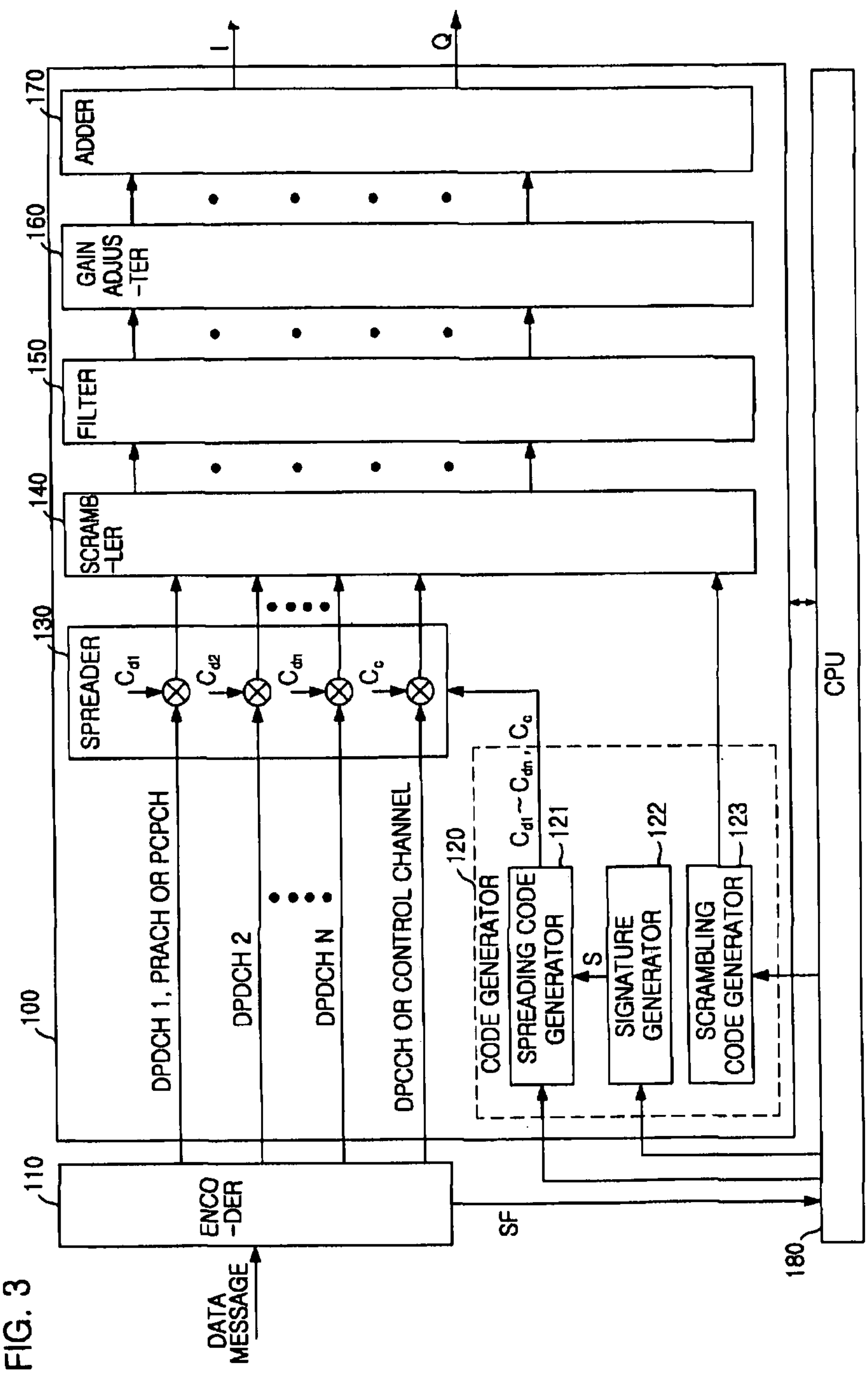

DATA MESSAGE
ENCO -DER
110
SF
100
DPDCH 1, PRACH OR PCPCH
DPDCH 2
DPDCH N
DPCCH OR CONTROL CHANNEL
SPREADER
130
C_{d1}
C_{d2}
C_{dn}
C_c
120
CODE GENERATOR
SPREADING CODE GENERATOR
121
C_{d1}~C_{dn}, C_c
S
SIGNATURE GENERATOR
122
SCRAMBLING CODE GENERATOR
123
SCRAMB -LER
140
FILTER
150
GAIN ADJUS -TER
160
ADDER
170
I
Q
CPU
180

FIG. 4

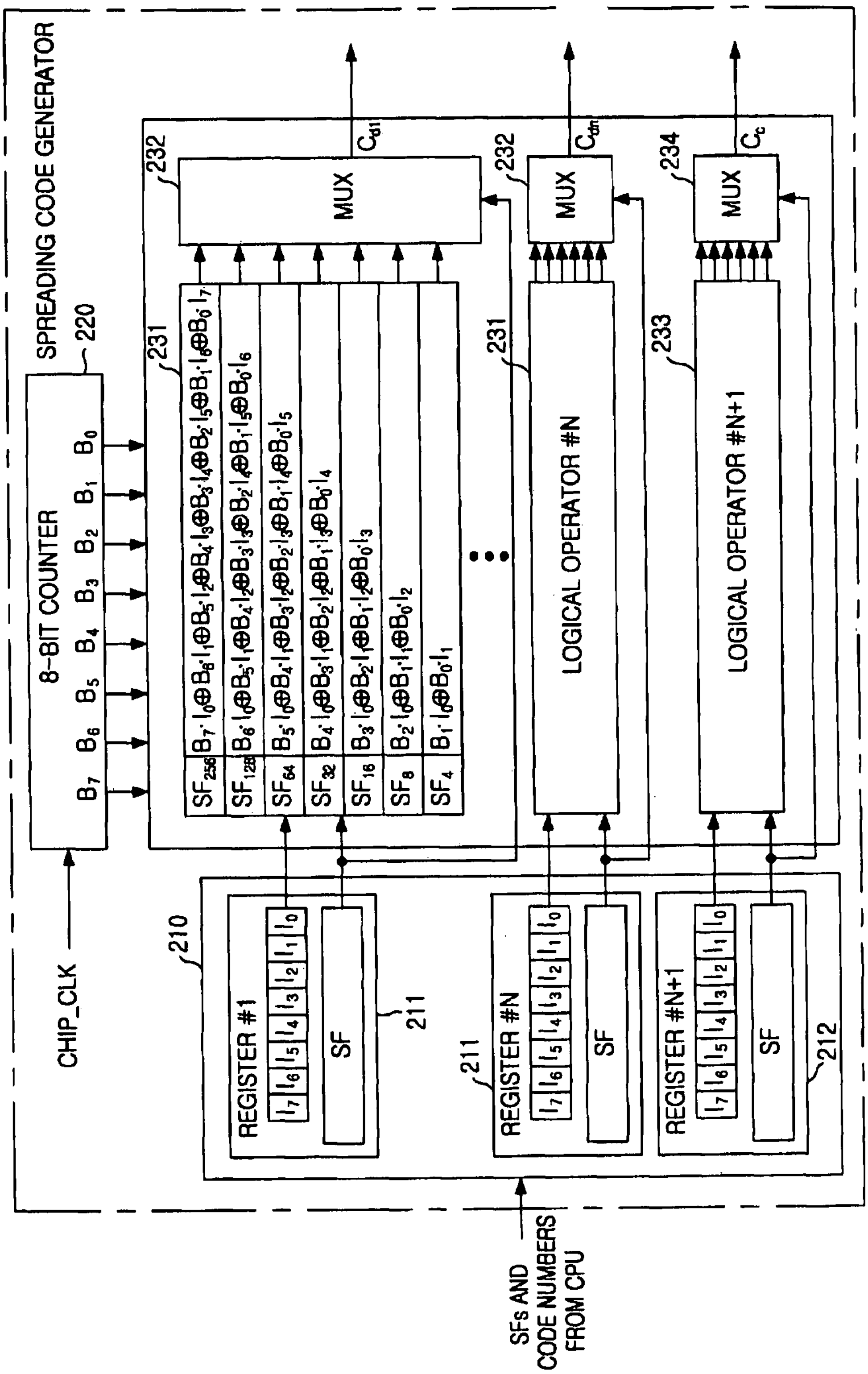

SPREADING CODE GENERATOR
220
8-BIT COUNTER
CHIP_CLK
210
REGISTER #1
SF
211
REGISTER #N
REGISTER #N+1
212
231
232
MUX
LOGICAL OPERATOR #N
LOGICAL OPERATOR #N+1
233
234
SFs AND CODE NUMBERS FROM CPU

FIG. 5

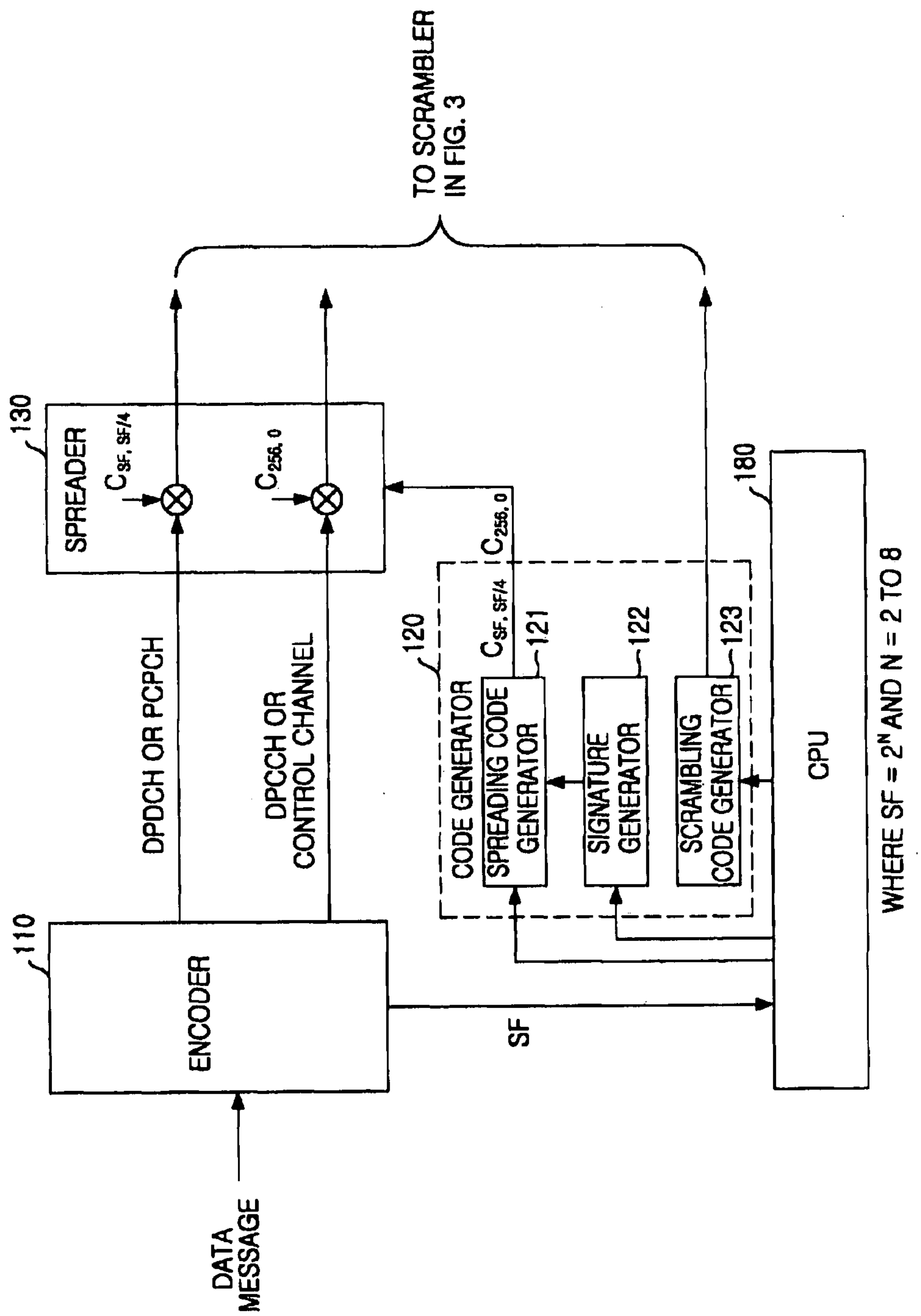

TO SCRAMBLER
IN FIG. 3
130
SPREADER
$C_{SF,\,SF/4}$
$C_{256,\,0}$
110
ENCODER
DATA
MESSAGE
DPDCH OR PCPCH
DPCCH OR
CONTROL CHANNEL
120
CODE GENERATOR
SPREADING CODE
GENERATOR
121
SIGNATURE
GENERATOR
122
SCRAMBLING
CODE GENERATOR
123
$C_{SF,\,SF/4}$
$C_{256,\,0}$
SF
180
CPU
WHERE SF = 2^N AND N = 2 TO 8

FIG. 6

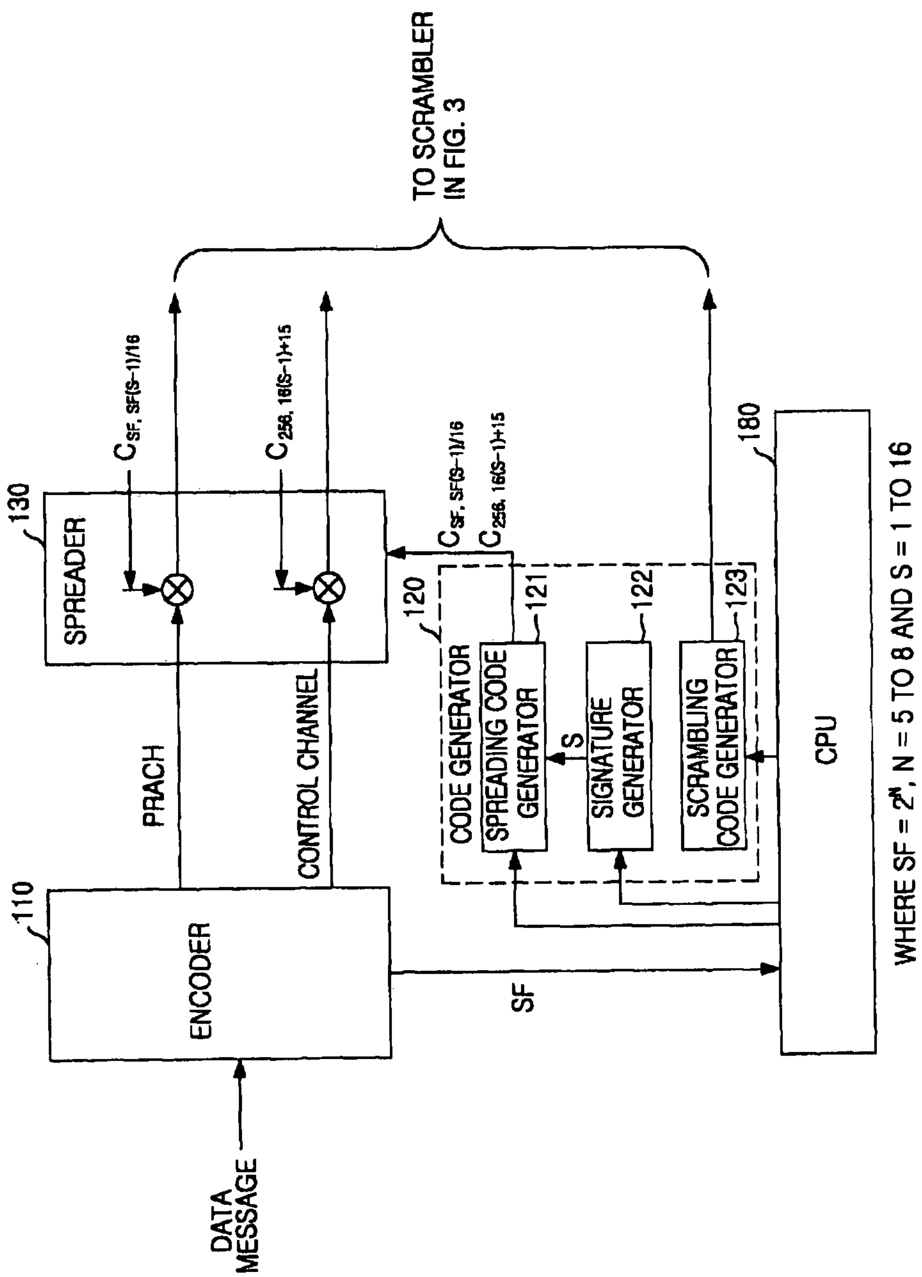
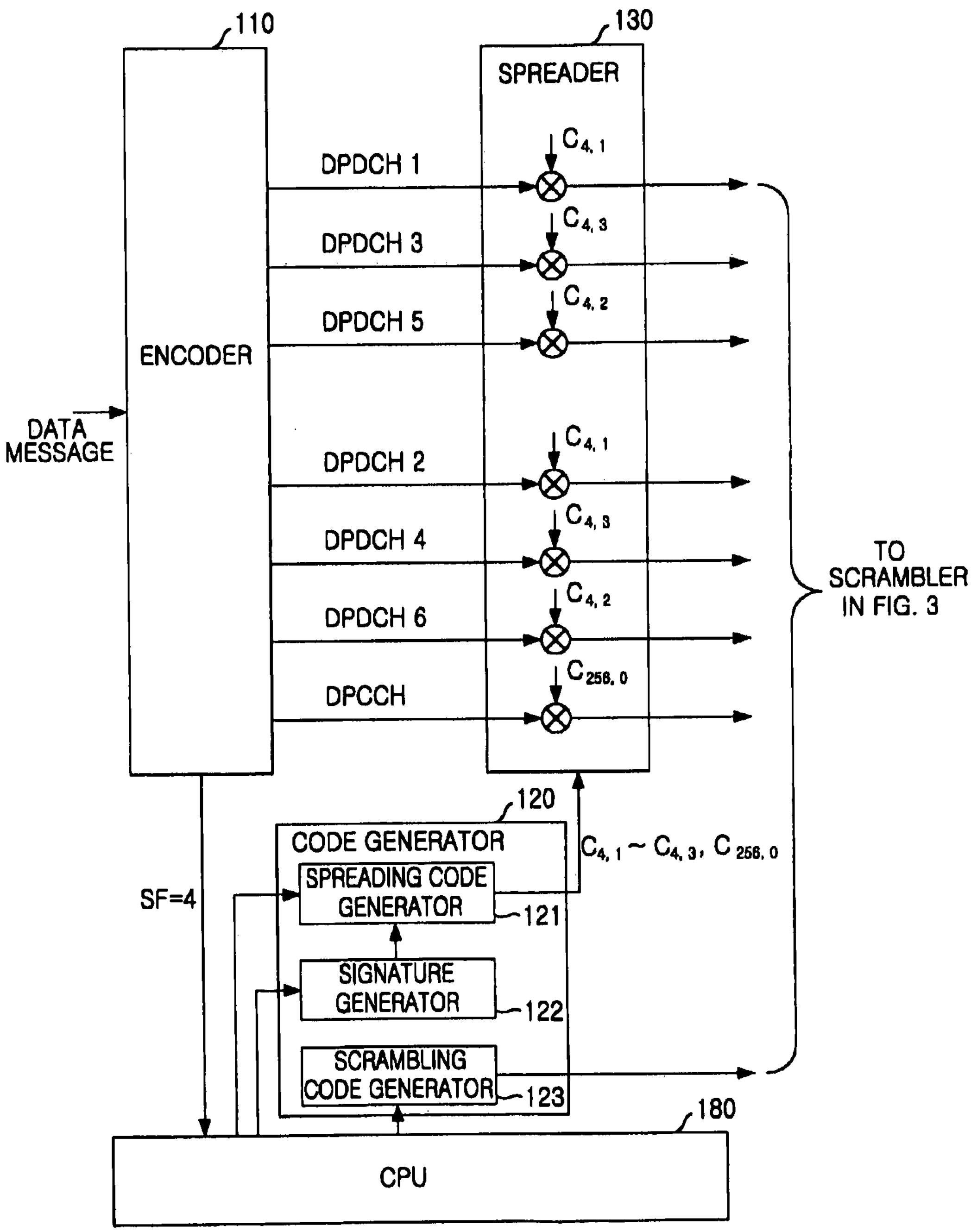

TO SCRAMBLER
IN FIG. 3
130
SPREADER
$C_{SF, SF(S-1)/16}$
$C_{256, 16(S-1)+15}$
110
ENCODER
DATA
MESSAGE
PRACH
CONTROL CHANNEL
SF
120
CODE GENERATOR
121
SPREADING CODE
GENERATOR
S
122
SIGNATURE
GENERATOR
123
SCRAMBLING
CODE GENERATOR
180
CPU
WHERE $SF = 2^N$, N = 5 TO 8 AND S = 1 TO 16

FIG. 7



110
130
SPREADER
ENCODER
DATA MESSAGE
DPDCH 1
DPDCH 3
DPDCH 5
DPDCH 2
DPDCH 4
DPDCH 6
DPCCH
C4, 1
C4, 3
C4, 2
C4, 1
C4, 3
C4, 2
C256, 0
TO SCRAMBLER IN FIG. 3
120
CODE GENERATOR
SPREADING CODE GENERATOR
121
SIGNATURE GENERATOR
122
SCRAMBLING CODE GENERATOR
123
C4, 1 ~ C4, 3, C 256, 0
SF=4
180
CPU

FIG. 8

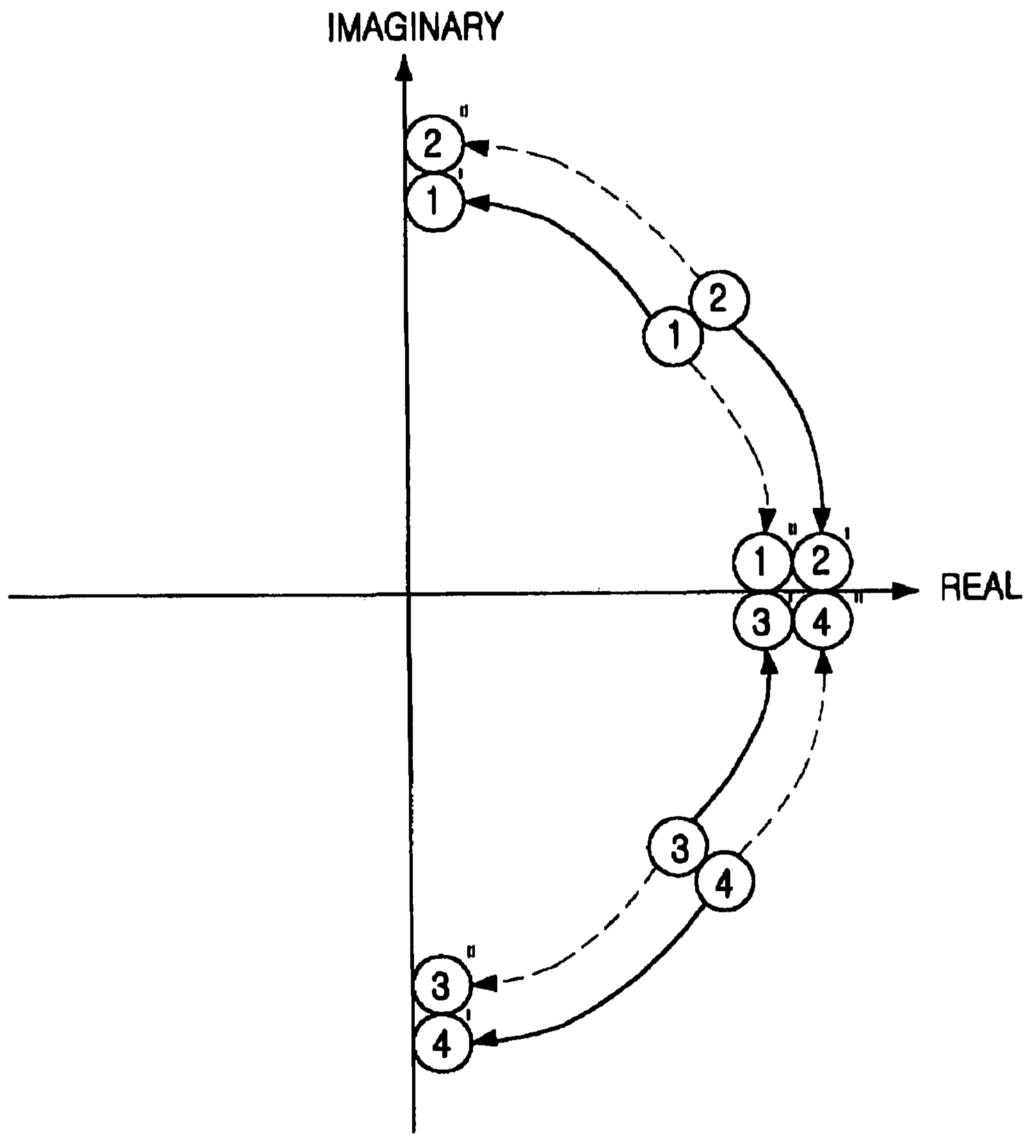


FIG. 9

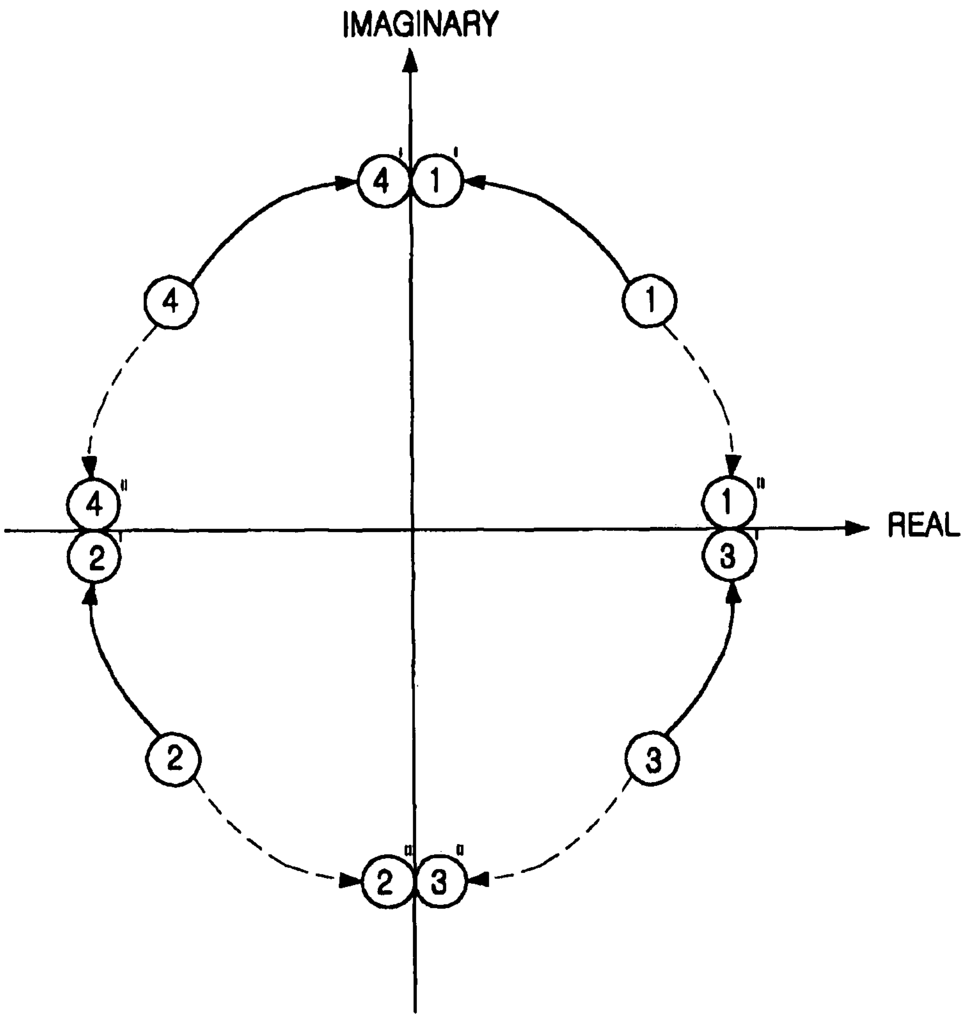


FIG. 10

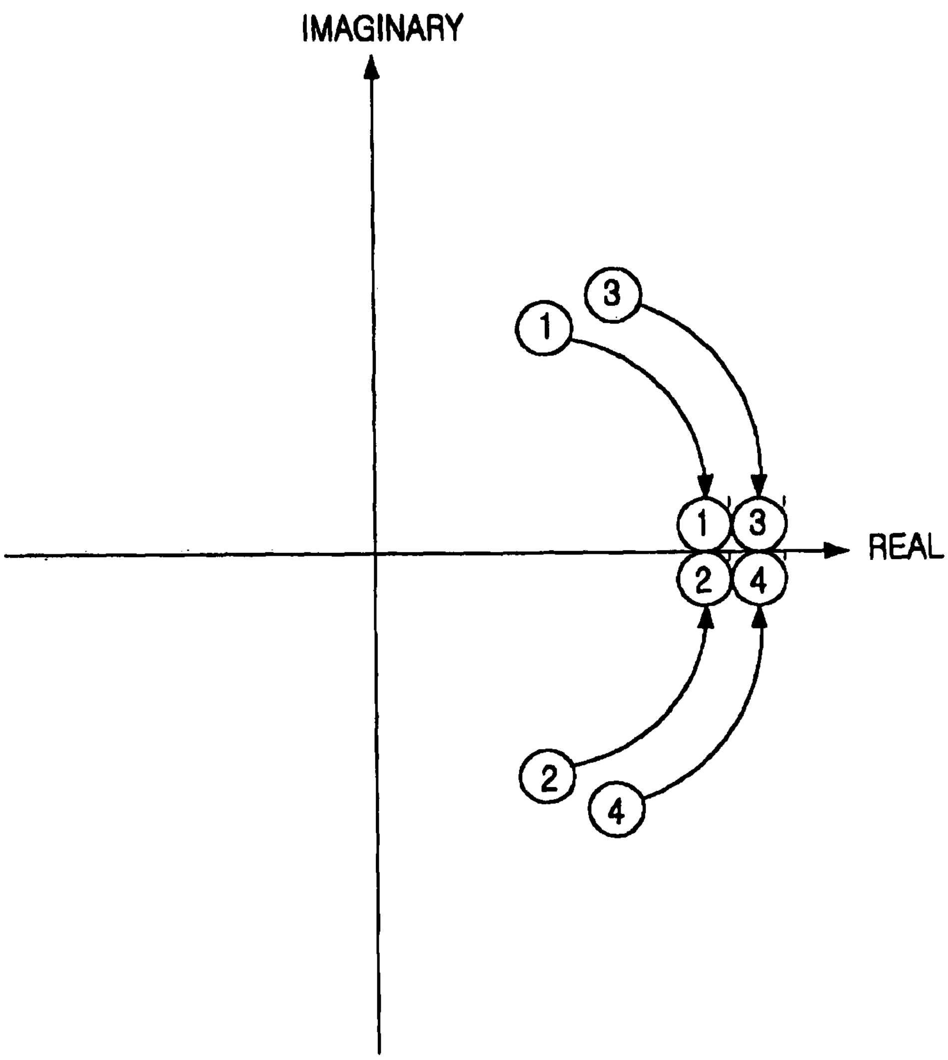


FIG. 11

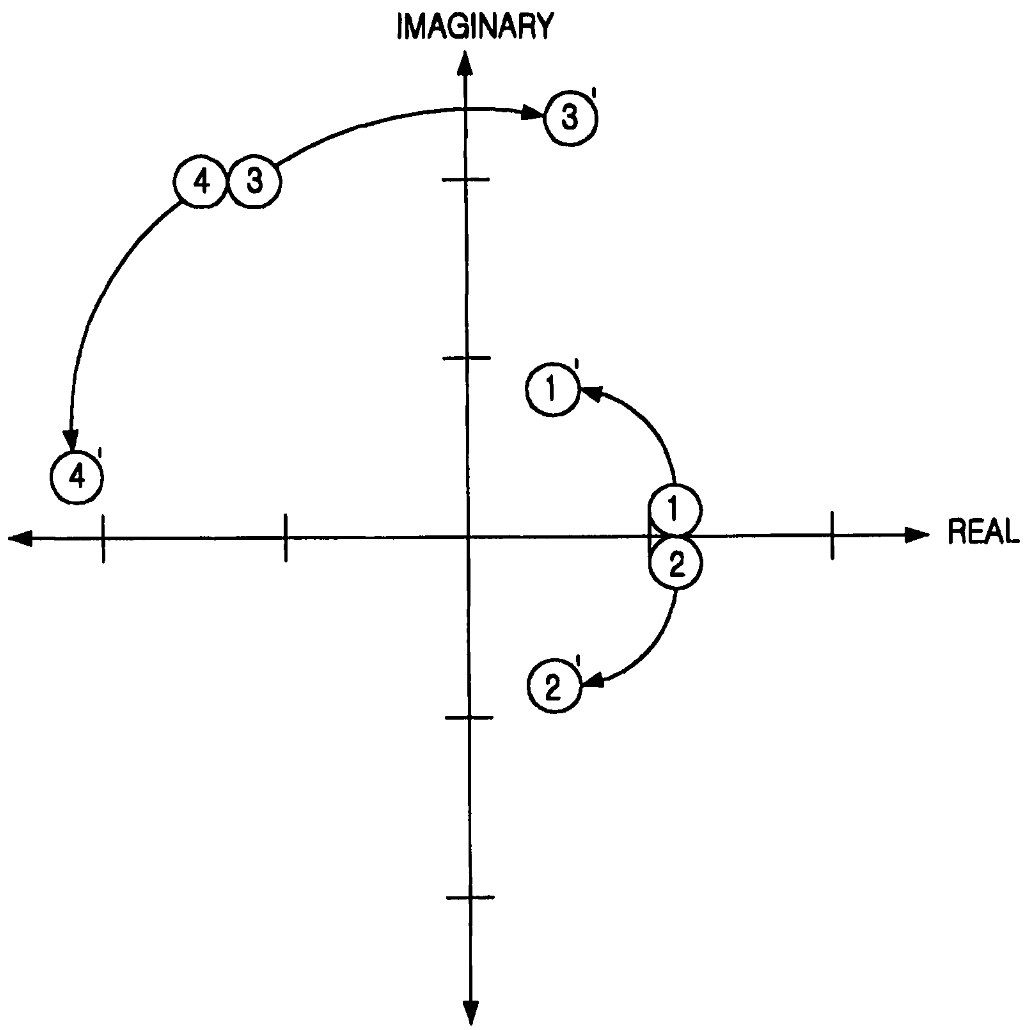


FIG. 12

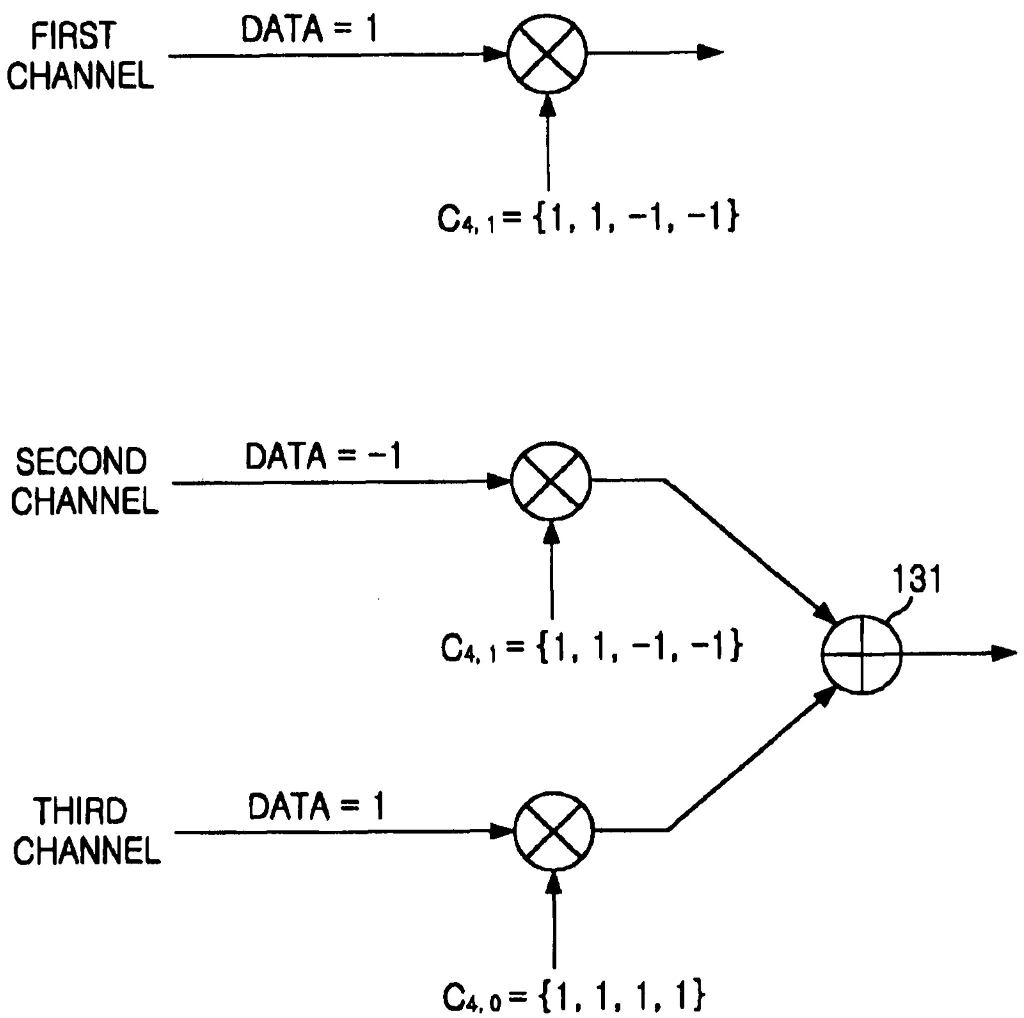

FIRST CHANNEL
DATA = 1
$C_{4,1} = \{1, 1, -1, -1\}$
SECOND CHANNEL
DATA = −1
$C_{4,1} = \{1, 1, -1, -1\}$
131
THIRD CHANNEL
DATA = 1
$C_{4,0} = \{1, 1, 1, 1\}$

FIG. 13

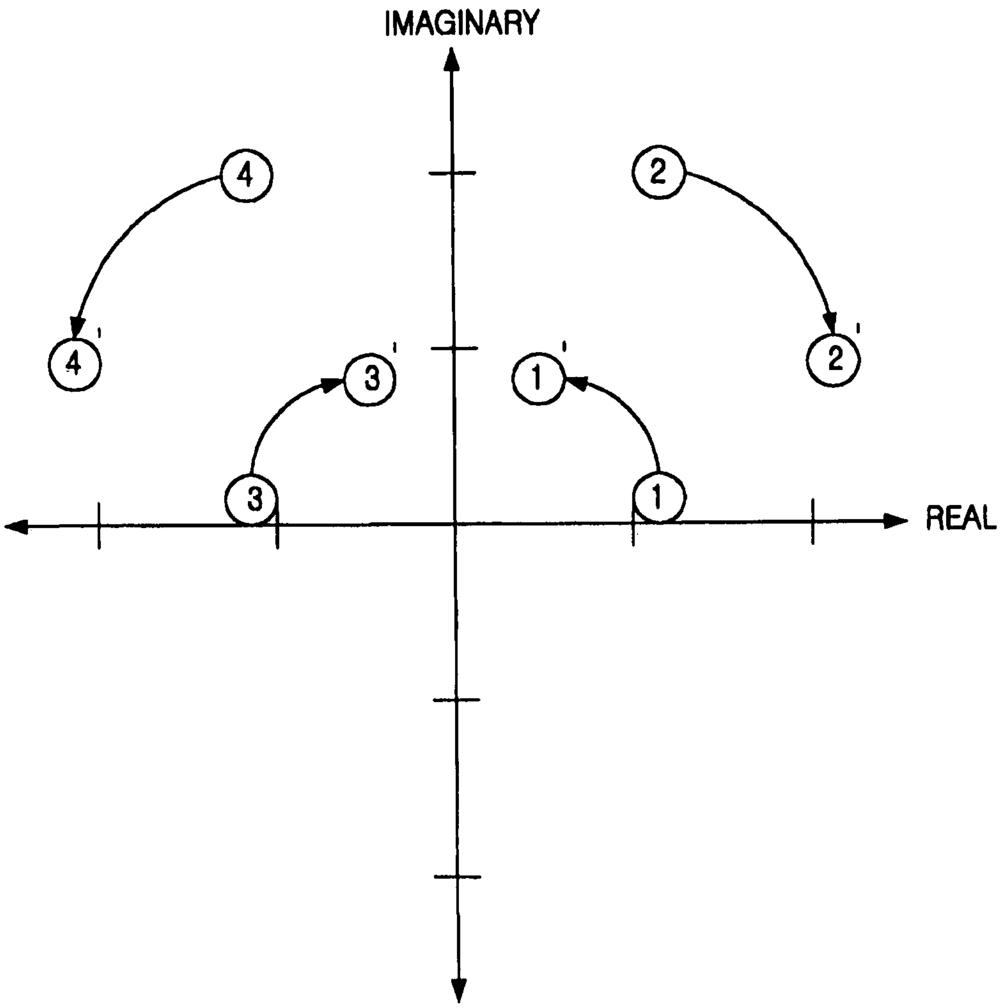


FIG. 14

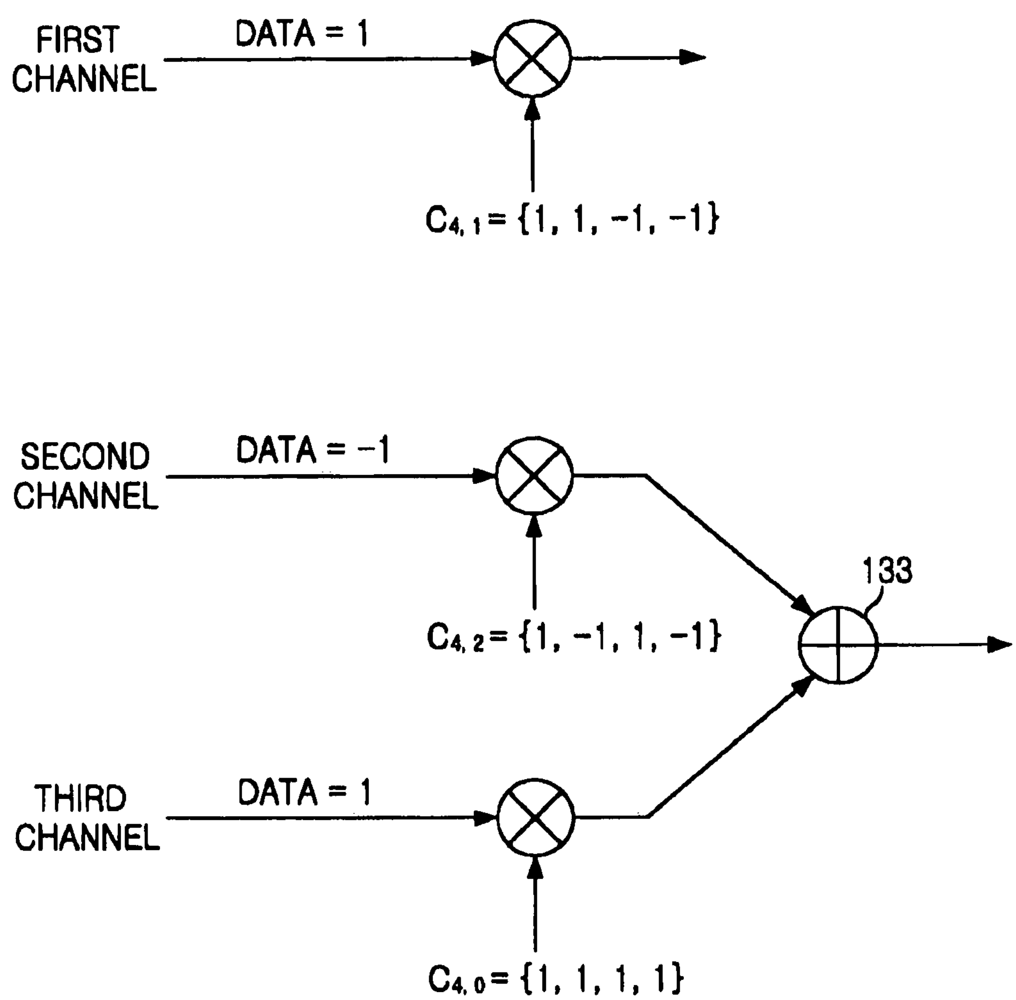

FIRST CHANNEL
DATA = 1
C4, 1 = {1, 1, -1, -1}
SECOND CHANNEL
DATA = -1
C4, 2 = {1, -1, 1, -1}
133
THIRD CHANNEL
DATA = 1
C4, 0 = {1, 1, 1, 1}

FIG. 15

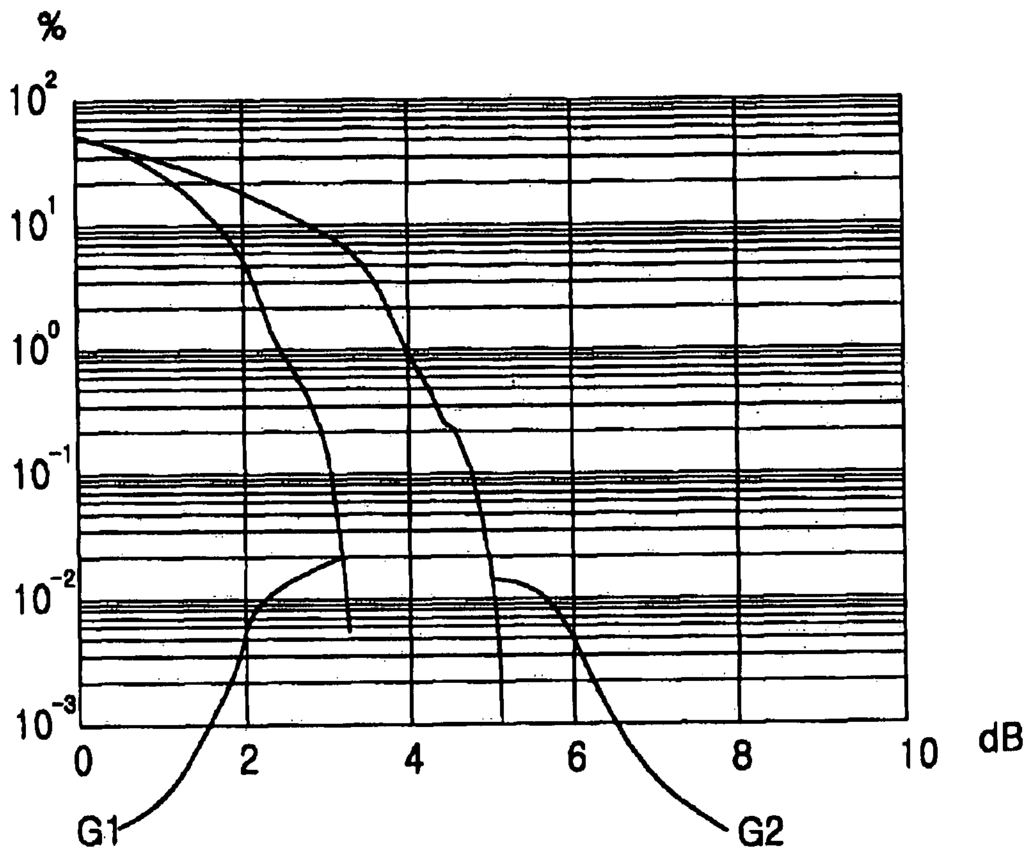
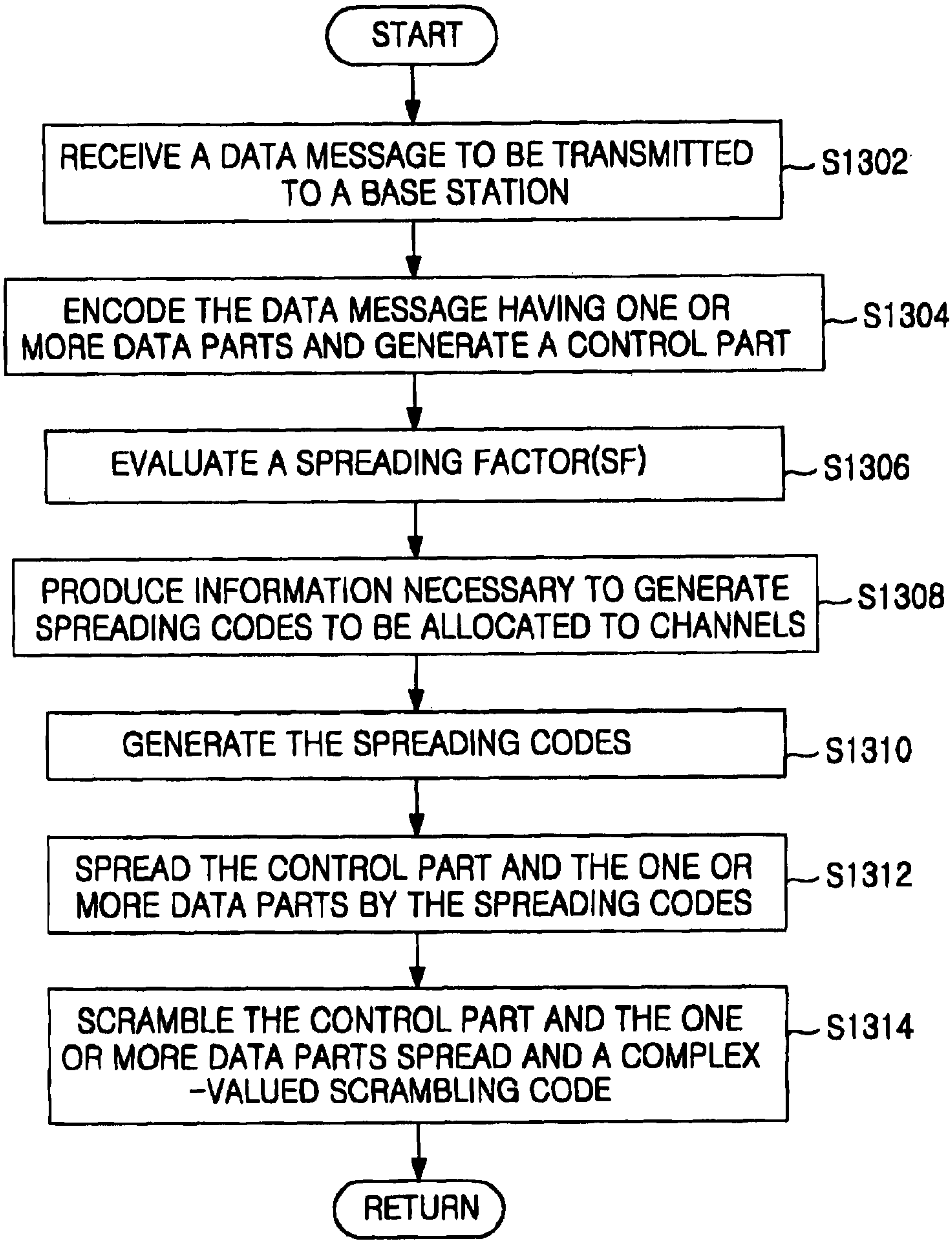


FIG. 16


START
RECEIVE A DATA MESSAGE TO BE TRANSMITTED TO A BASE STATION
S1302
ENCODE THE DATA MESSAGE HAVING ONE OR MORE DATA PARTS AND GENERATE A CONTROL PART
S1304
EVALUATE A SPREADING FACTOR(SF)
S1306
PRODUCE INFORMATION NECESSARY TO GENERATE SPREADING CODES TO BE ALLOCATED TO CHANNELS
S1308
GENERATE THE SPREADING CODES
S1310
SPREAD THE CONTROL PART AND THE ONE OR MORE DATA PARTS BY THE SPREADING CODES
S1312
SCRAMBLE THE CONTROL PART AND THE ONE OR MORE DATA PARTS SPREAD AND A COMPLEX -VALUED SCRAMBLING CODE
S1314
RETURN

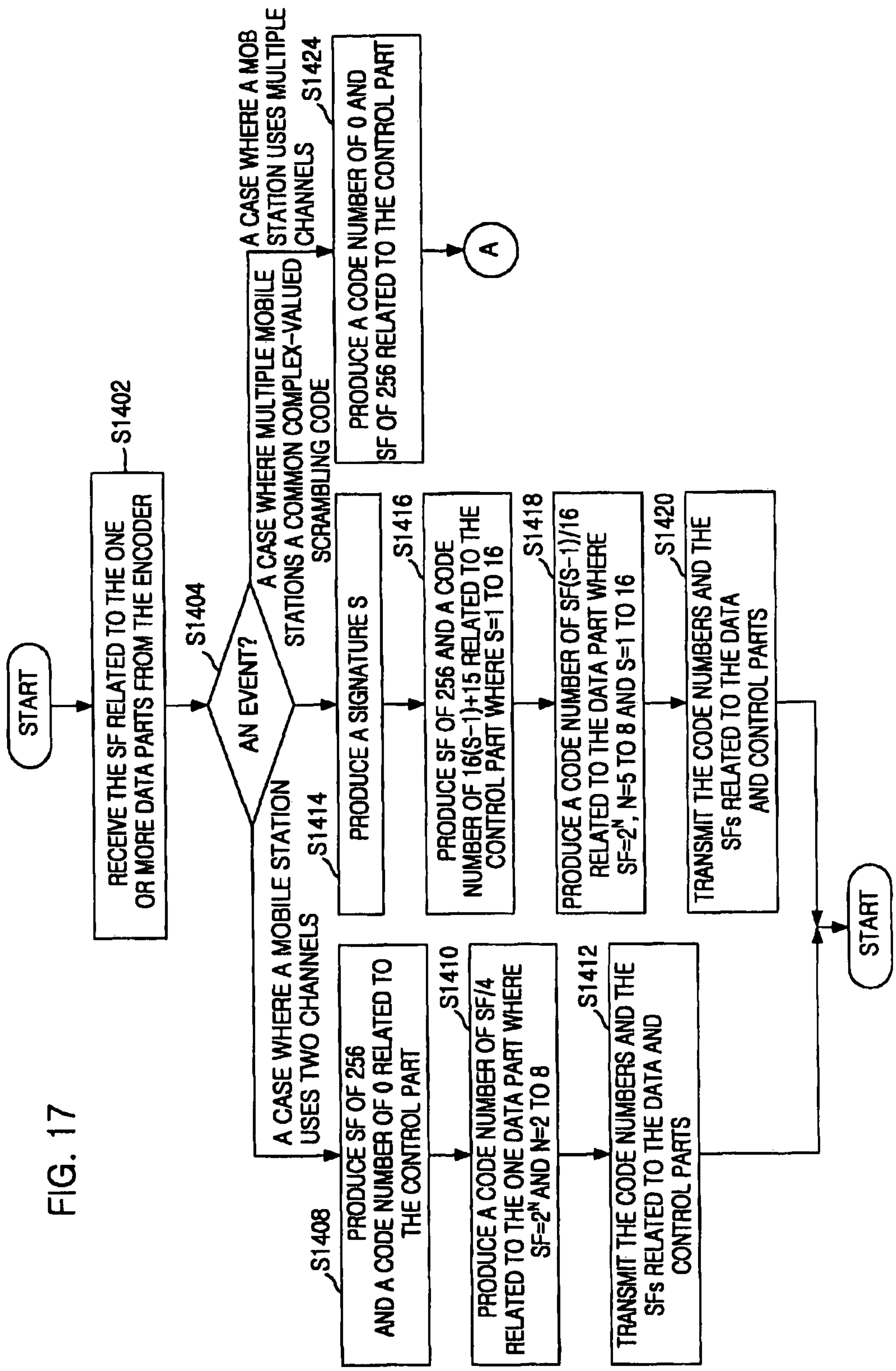

START
RECEIVE THE SF RELATED TO THE ONE OR MORE DATA PARTS FROM THE ENCODER
S1402
AN EVENT?
S1404
A CASE WHERE A MOBILE STATION USES TWO CHANNELS
A CASE WHERE MULTIPLE MOBILE STATIONS A COMMON COMPLEX-VALUED SCRAMBLING CODE
A CASE WHERE A MOB STATION USES MULTIPLE CHANNELS
S1408
PRODUCE SF OF 256 AND A CODE NUMBER OF 0 RELATED TO THE CONTROL PART
S1410
PRODUCE A CODE NUMBER OF SF/4 RELATED TO THE ONE DATA PART WHERE SF=2^N AND N=2 TO 8
S1412
TRANSMIT THE CODE NUMBERS AND THE SFs RELATED TO THE DATA AND CONTROL PARTS
S1414
PRODUCE A SIGNATURE S
S1416
PRODUCE SF OF 256 AND A CODE NUMBER OF 16(S−1)+15 RELATED TO THE CONTROL PART WHERE S=1 TO 16
S1418
PRODUCE A CODE NUMBER OF SF(S−1)/16 RELATED TO THE DATA PART WHERE SF=2^N, N=5 TO 8 AND S=1 TO 16
S1420
TRANSMIT THE CODE NUMBERS AND THE SFs RELATED TO THE DATA AND CONTROL PARTS
S1424
PRODUCE A CODE NUMBER OF 0 AND SF OF 256 RELATED TO THE CONTROL PART
A
START

FIG. 17

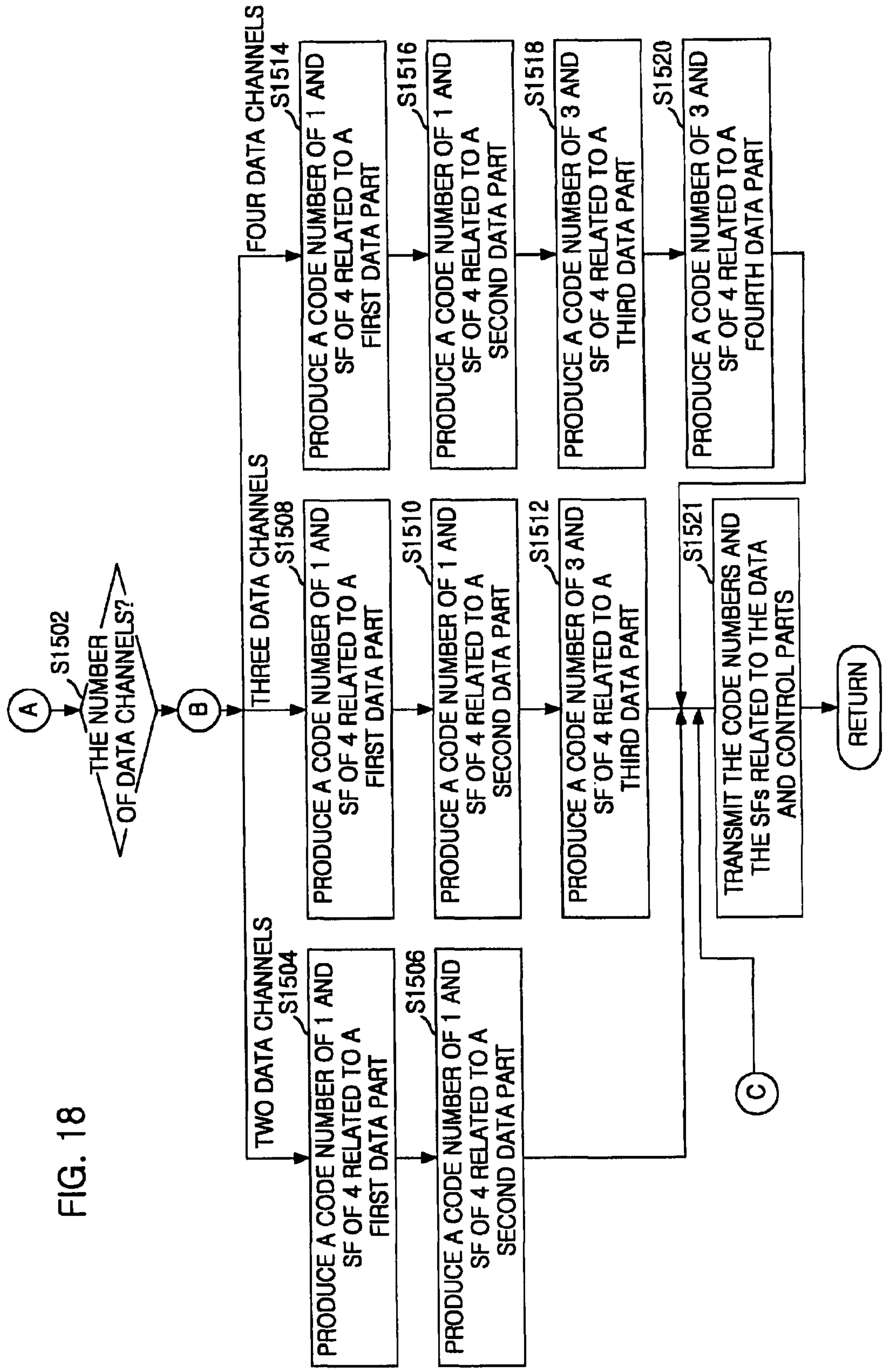

A
S1502
THE NUMBER OF DATA CHANNELS?
B
TWO DATA CHANNELS
S1504
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A FIRST DATA PART
S1506
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A SECOND DATA PART
THREE DATA CHANNELS
S1508
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A FIRST DATA PART
S1510
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A SECOND DATA PART
S1512
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A THIRD DATA PART
FOUR DATA CHANNELS
S1514
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A FIRST DATA PART
S1516
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A SECOND DATA PART
S1518
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A THIRD DATA PART
S1520
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A FOURTH DATA PART
S1521
TRANSMIT THE CODE NUMBERS AND THE SFs RELATED TO THE DATA AND CONTROL PARTS
RETURN
C

FIG. 18

FIG. 19

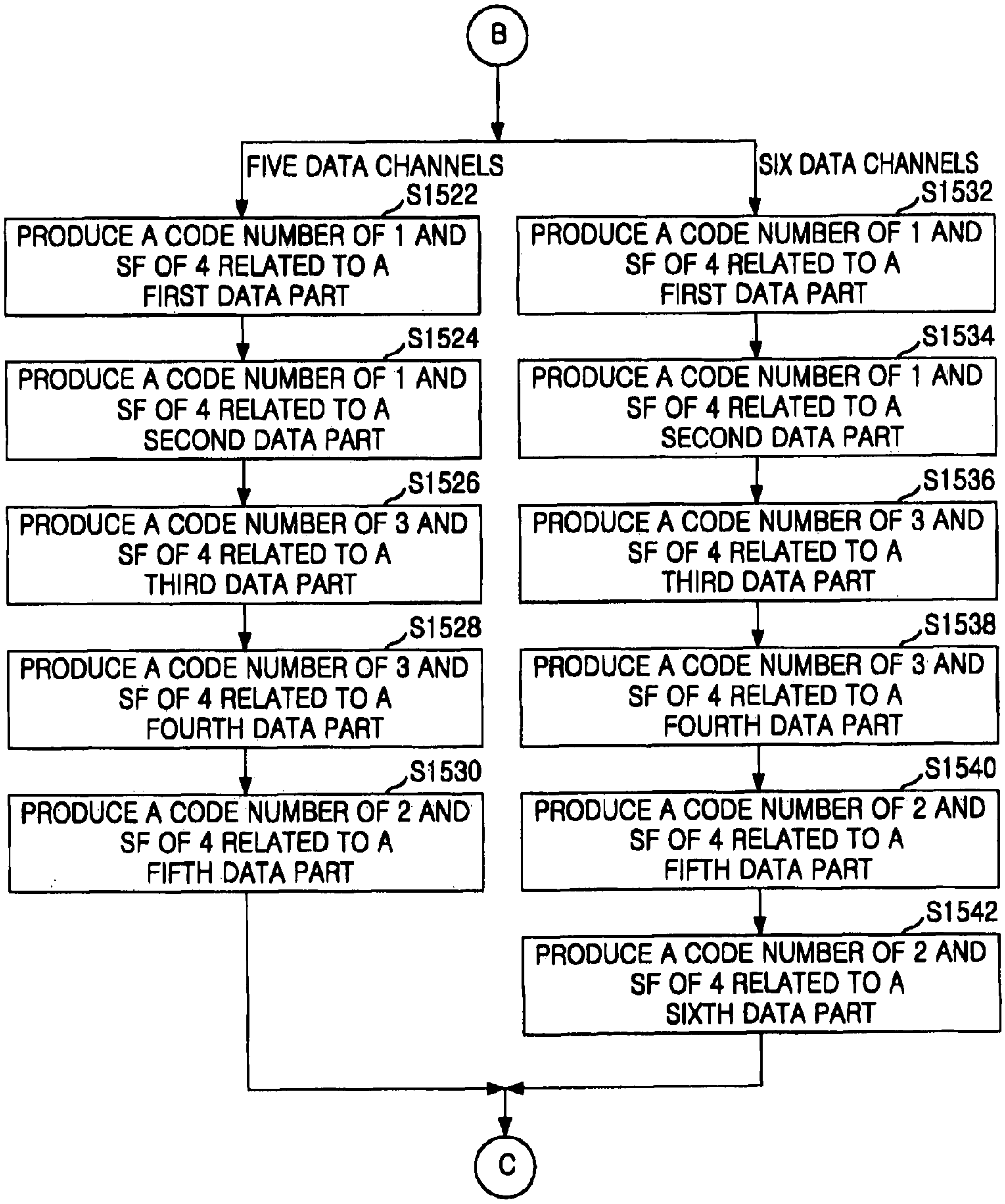

B
FIVE DATA CHANNELS
SIX DATA CHANNELS
S1522
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A FIRST DATA PART
S1524
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A SECOND DATA PART
S1526
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A THIRD DATA PART
S1528
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A FOURTH DATA PART
S1530
PRODUCE A CODE NUMBER OF 2 AND SF OF 4 RELATED TO A FIFTH DATA PART
S1532
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A FIRST DATA PART
S1534
PRODUCE A CODE NUMBER OF 1 AND SF OF 4 RELATED TO A SECOND DATA PART
S1536
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A THIRD DATA PART
S1538
PRODUCE A CODE NUMBER OF 3 AND SF OF 4 RELATED TO A FOURTH DATA PART
S1540
PRODUCE A CODE NUMBER OF 2 AND SF OF 4 RELATED TO A FIFTH DATA PART
S1542
PRODUCE A CODE NUMBER OF 2 AND SF OF 4 RELATED TO A SIXTH DATA PART
C

FIG. 20

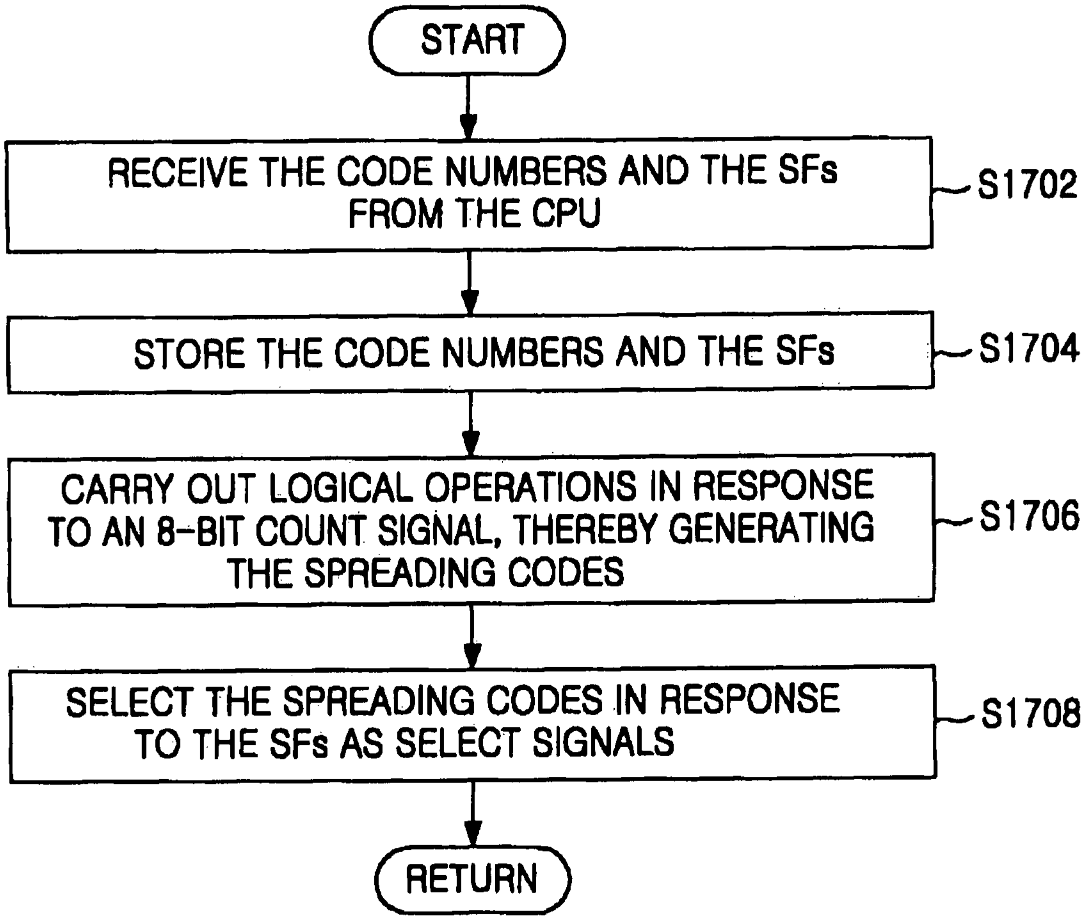

START
RECEIVE THE CODE NUMBERS AND THE SFs FROM THE CPU
S1702
STORE THE CODE NUMBERS AND THE SFs
S1704
CARRY OUT LOGICAL OPERATIONS IN RESPONSE TO AN 8-BIT COUNT SIGNAL, THEREBY GENERATING THE SPREADING CODES
S1706
SELECT THE SPREADING CODES IN RESPONSE TO THE SFs AS SELECT SIGNALS
S1708
RETURN

FIG. 21

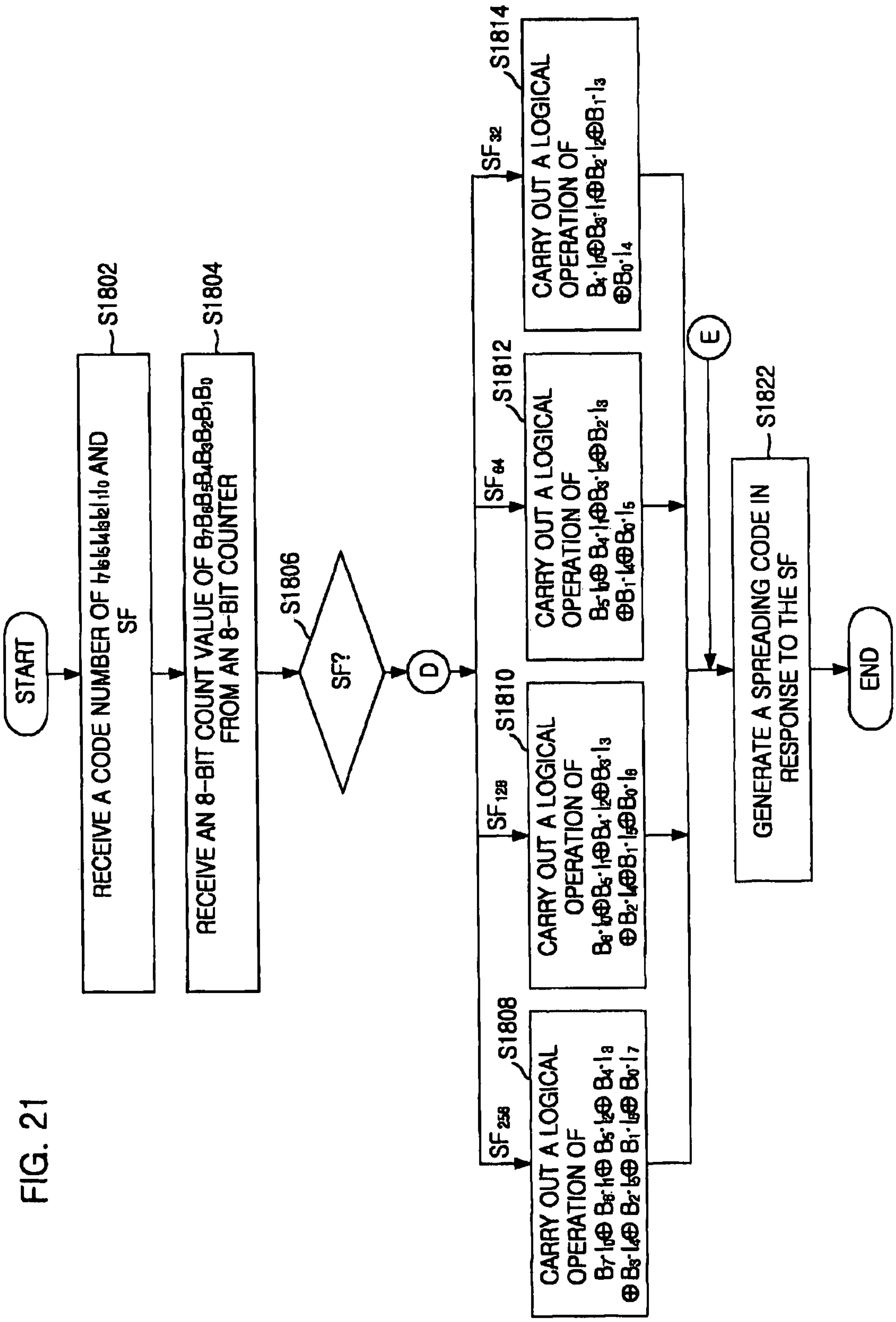
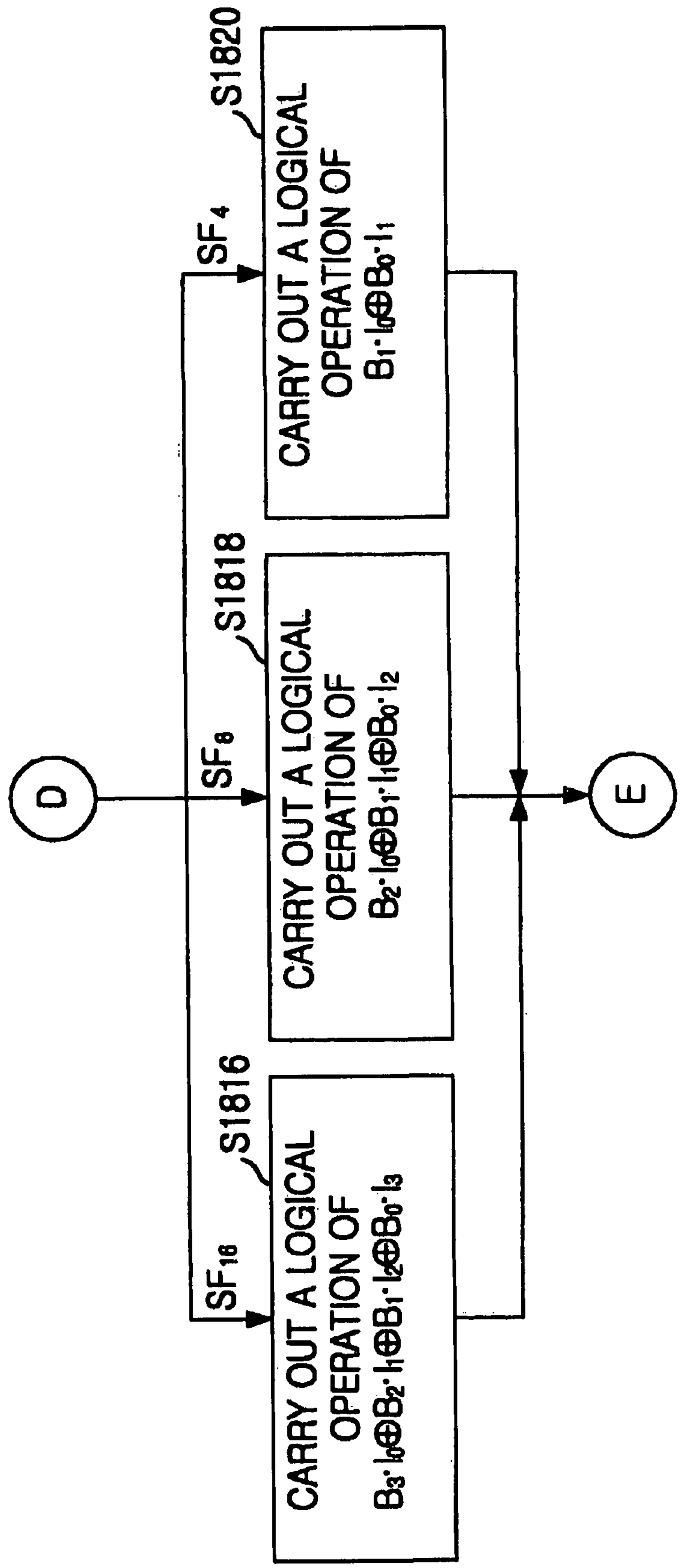

START
RECEIVE A CODE NUMBER OF I7I6I5I4I3I2I1I0 AND SF
S1802
RECEIVE AN 8-BIT COUNT VALUE OF B7B6B5B4B3B2B1B0 FROM AN 8-BIT COUNTER
S1804
SF?
S1806
D
SF256
CARRY OUT A LOGICAL OPERATION OF B7·I0⊕ B6·I1⊕ B5·I2⊕ B4·I3 ⊕ B3·I4⊕ B2·I5⊕ B1·I6⊕ B0·I7
S1808
SF128
CARRY OUT A LOGICAL OPERATION OF B6·I0⊕B5·I1⊕B4·I2⊕B3·I3 ⊕ B2·I4⊕B1·I5⊕B0·I6
S1810
SF64
CARRY OUT A LOGICAL OPERATION OF B5·I0⊕ B4·I1⊕B3·I2⊕B2·I3 ⊕B1·I4⊕B0·I5
S1812
SF32
CARRY OUT A LOGICAL OPERATION OF B4·I0⊕B3·I1⊕B2·I2⊕B1·I3 ⊕B0·I4
S1814
E
GENERATE A SPREADING CODE IN RESPONSE TO THE SF
S1822
END

FIG. 22


D
SF4
SF8
SF16
S1820
S1818
S1816
CARRY OUT A LOGICAL OPERATION OF B1·I0⊕B0·I1
CARRY OUT A LOGICAL OPERATION OF B2·I0⊕B1·I1⊕B0·I2
CARRY OUT A LOGICAL OPERATION OF B3·I0⊕B2·I1⊕B1·I2⊕B0·I3
E

APPARATUS AND METHOD FOR MODULATING DATA MESSAGE BY EMPLOYING ORTHOGONAL VARIABLE SPREADING FACTOR (OVSF) CODES IN MOBILE COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to an apparatus and method for modulating a data message in a mobile communication system; and, more particularly, to an apparatus and method for modulating a data message by employing orthogonal variable spreading factor (OVSF) codes in a mobile communication system.

DESCRIPTION OF THE PRIOR ART

Generally, a mobile communication system such as an international mobile telecommunication-2000 (IMT-2000) system is capable of providing various services of good quality and large capacity, an international roaming and so on. The mobile communication system can be applicable to high-speed data and multimedia services such as an Internet service and an electronic commerce service. The mobile communication system carries out orthogonal spread with respect to multiple channels. The mobile communication system allocates the orthogonal spread channels to an in-phase (I) branch and a quadrature-phase (Q) branch. A peak-to-average power ratio (PAPR) needed to simultaneously transmit I-branch data and Q-branch data affects power efficiency of a mobile station and a battery usage time of the mobile station.

The power efficiency and the battery usage time of the mobile station are closely related to a modulation scheme of the mobile station. As a modulation standard of IS-2000 and asynchronous wideband-CDMA, the modulation scheme of orthogonal complex quadrature phase shift keying (OCQPSK) has been adopted. The modulation scheme of OCQPSK is disclosed in an article by JaeRyong Shim and SeungChan Bang: '*Spectrally Efficient Modulation and Spreading Scheme for CDMA Systems*' in electronics letters, 12 Nov. 1998, vol. 34, No. 23, pp. 2210-2211.

As disclosed in the article, the mobile station carries out the orthogonal spread by employing a Hadamard sequence as a Walsh code in the modulation scheme of the OCQPSK. After the orthogonal spread, and Q channels are spread by a Walsh rotator and a spreading code, e.g., a pseudo noise (PN) code, a Kasami code, a Gold code and so on.

Further, as for multiple channels, the mobile station carries out the orthogonal spread by employing different Hadamard sequences. After the orthogonal spread, the orthogonal spread channels are coupled to I and Q branches. Then, the orthogonal spread channels coupled to the I branch and the orthogonal spread channels coupled to the Q branch is separately summed. The I and Q branches are scrambled by the Walsh rotator and the scrambling code. However, there is a problem that the above-mentioned modulation scheme can not effectively reduce the PAPR in the mobile communication system.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an apparatus and method for modulating a data message that is capable of improving a power efficiency of a mobile station by reducing a peak-to-average power ratio in a mobile communication system.

In accordance with an embodiment of an aspect of the present invention, there is provided an apparatus for convert-

ing source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising: channel coding means for encoding the source data to generate at least one data part and a control part; code generating means for generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal.

In accordance with another embodiment of the aspect of the present invention, there is provided an apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, comprising: channel coding means for encoding the source data to generate (N−1) number of data parts and a control part; code generating means for generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

In accordance with an embodiment of another aspect of the present invention, there is provided a mobile station for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data, wherein the mobile station uses N number of channels where N is a positive integer, comprising: channel coding means for encoding the source data to generate (N−1) number of data parts and a control part; code generating means for generating N number of spreading codes to be allocated to the first and the second channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

In accordance with an embodiment of further another aspect of the present invention, there is provided a method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising the steps of: a) encoding the source data to generate at least one data part and a control part; b) generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and c) spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal.

In accordance with another embodiment of further another aspect of the present invention, there is provided a method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, comprising: a) encoding the source data to generate (N−1) number of data parts and a control part; b) generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a Zero point on a phase domain; and c) spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the instant invention will become apparent from the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a block diagram illustrating a mobile station to which the present invention is applied;

FIG. **2** is an exemplary view illustrating a tree structure of spreading codes applied to the present invention;

FIG. **3** is an exemplary block diagram depicting a modulator shown in FIG. **1** in accordance with the present invention;

FIG. **4** is a block diagram describing a spreading code generator shown in FIG. **3**;

FIG. **5** is an exemplary diagram illustrating a case where a mobile station uses two channels;

FIG. **6** is an exemplary diagram depicting a case where multiple mobile stations share a common complex-valued scrambling code;

FIG. **7** is an exemplary diagram showing a case where a mobile station uses multiple channels;

FIG. **8** is a first exemplary view describing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

FIG. **9** is a second exemplary view showing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

FIG. **10** is a first exemplary view depicting an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

FIGS. **11** and **12** are third exemplary views illustrating a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

FIGS. **13** and **14** are second exemplary views illustrating an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

FIG. **15** is a graphical diagram describing the probability of peak power to average power; and

FIGS. **16** to **22** are flowcharts illustrating a method for modulating a data message in a mobile station in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, there is shown a block diagram illustrating a mobile station to which the present invention is applied. As shown, the mobile station includes a user interface **20**, a central processing unit (CPU) **180**, a modem **12**, a source codec **30**, a frequency converter **80**, a user identification module **50** and an antenna **70**. The modem **12** includes a channel codec **13**, a modulator **100** and a demodulator **120**. The channel codec **13** includes an encoder **110** and a decoder **127**.

The user interface **20** includes a display, a keypad and so on. The user interface **20**, coupled to the CPU **180**, generates a data message in response to a user input from a user. The user interface sends the data message to the CPU **180**.

The user identification module **50**, coupled to the CPU **180**, sends user identification information as a data message to the CPU **180**. The source codec **30**, coupled to the CPU **180** and the modem **12**, encodes source data, e.g., video, voice and so on, to generate the encoded source data as a data message. Then, the source codec **30** sends the encoded source data as the data message to the CPU **180** or the modem **12**. Further, the source codec **30** decodes the data message from the CPU **180** or the modem **12** to generate the source data, e.g., video, voice and so on. Then, the source codec **30** sends the source data to the CPU **180**.

The encoder **110**, contained in the channel codec **13**, encodes the data message from the CPU **180** or the source codec **30** to generate one or more data parts. Then, the encoder **110** generates a control part. The encoder **110** sends the one or more data parts to the modulator **100**. The modulator **100** modulates the one or more data parts and the control part to generate I and Q signals as baseband signals. The frequency converter **80** converts the baseband signals to intermediate frequency (IF) signals in response to a conversion control signal from the CPU **180**. After converting the baseband signals to the IF signals, the frequency converter **80** converts the IF signals to radio frequency (RF) signals. The frequency converter **80** sends the RF signals to the antenna **70**. Further, the frequency converter **80** controls a gain of the RF signals. The antenna **70** sends the RF signals to a base station (not shown).

The antenna **70** sends the RF signals from the base station to the frequency converter **80**. The frequency converter **80** converts the RF signals to the IF signals. After converting the RF signals to the IF signals, the frequency converter **80** converts the IF signals to the baseband signals as the I and Q signals. The demodulator **90** demodulates the I and Q signals to generate the one or more data parts and the control part. The decoder **127**, contained in the channel codec **13**, decodes the one or more data parts and the control part to generate the data message. The decoder **127** sends the data message to the CPU **180** or the source codec **30**.

Referring to FIG. **2**, there is shown an exemplary view illustrating a tree structure of spreading codes as orthogonal variable spreading factor (OVSF) codes applied to the present invention. As shown, a spreading code is determined by a spreading factor (SF) and a code number in a code tree, wherein the spreading code is represented by $C_{SF,\ code\ number}$. $C_{SF,\ code\ number}$ is made up of a real-valued sequence. The SF is 2^N where N is 0 to 8, and the code number is 0 to 2^N-1.

$$\begin{bmatrix} C_{2,0} \\ \hline C_{2,1} \end{bmatrix} = \begin{bmatrix} C_{1,0} & C_{1,0} \\ C_{1,0} & -C_{1,0} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \text{ where } C_{1,0} = 1 \qquad \text{Eq. (1)}$$

$$\begin{bmatrix} C_{2^{(N+1)},0} \\ C_{2^{(N+1)},1} \\ C_{2^{(N+1)},2} \\ C_{2^{(N+1)},3} \\ \vdots \\ C_{2^{(N+1)},2^{(N+1)}-2} \\ C_{2^{(N+1)},2^{(N+1)}-1} \end{bmatrix} = \begin{bmatrix} C_{2^N,0} & C_{2^N,0} \\ C_{2^N,0} & -C_{2^N,0} \\ C_{2^N,1} & C_{2^N,1} \\ C_{2^N,1} & -C_{2^N,1} \\ \vdots & \vdots \\ C_{2^N,2^N-1} & C_{2^N,2^N-1} \\ C_{2^N,2^N-1} & -C_{2^N,2^N-1} \end{bmatrix} \text{ where } N \text{ is 1 to 7} \qquad \text{Eq. (2)}$$

For example, a spreading code having an SF of 8 and a code number of 1 is represented by $C_{8,1}=\{1, 1, 1, 1, -1, -1, -1, -1\}$ according to Eqs. (1) and (2). In case where the SF is more than 2, the spreading codes are grouped by two groups, including a first group and a second group according to a code number sequence. The first group includes the spreading codes with the SF and code numbers of 0 to SF/2−1 and the second group includes the spreading codes with the SF and code numbers of SF/2 to SF−1. Therefore, the number of spreading codes contained in the first group is the same as that of spreading codes contained in the second group.

Each spreading code contained in the first or second group is made up of real values. Each spreading code contained in the first or second group can be employed in an OCQPSK modulation scheme. It is preferred that a spreading code, contained in the first group, is selected for the OCQPSK modulation scheme. However, where a spreading code, contained in the second group, is multiplied by another spreading code with a minimum code number, i.e., SF/2, contained in the second group, the multiplication of the spreading codes, contained in the second group, becomes the same as a spreading code contained in the first group. Accordingly, the multiplication of the spreading codes contained in the second group is represented by a spreading code of the first group. As a result, all the spreading codes, i.e., OVSF codes, of the first and second groups are useful for reducing the peak-to-average power ratio (PAPR) of the mobile station.

Referring to FIG. **3**, there is shown a block diagram depicting a modulator shown in FIG. **1** in accordance with the present invention. The mobile communication system includes a base station and a mobile station employing a plurality of channels, wherein the mobile station includes the modulator. The channels include a control channel and one or more data channels.

The one or more data channels include a physical random access channel (PRACH), a physical common packet channel (PCPCH) and dedicated physical channel (DPCH). In a PRACH or PCPCH application, a control channel and only one data channel, i.e., PRACH or PCPCH, are coupled between the encoder **110** and the spreader **130**. The DPCH includes dedicated physical data channels (DPDCHs). In a DPCH application, a dedicated physical control channel (DPCCH) as a control channel and up to six data channels, i.e., DPDCH **1** to DPDCH **5** are coupled between the encoder **110** and the spreader **130**. As shown, a modulator **100** includes an encoder **110**, a code generator **120**, a spreader **130**, a scrambler **140**, a filter **150**, a gain adjuster **160** and an adder **170**.

The encoder **110** encodes the data message to be transmitted to the base station to generate one or more data parts. The encoder **110** generates a control part having a control information. The encoder **110** evaluates an SF based on a data rate of the one or more data parts.

The CPU **180**, coupled to the encoder **110**, receives the SF related to the one or more data parts from the encoder **110**. The CPU **180** produces one or more code numbers related to the one or more data parts and an SF and a code number related to the control part.

The code generator **120** includes a spreading code generator **121**, a signature generator **122** and a scrambling code generator **123**. The code generator **120**, coupled to the CPU **180**, generates spreading codes, i.e., C_{d1} to C_{dn} and C_c, a signature S and a complex-valued scrambling code. The spreading code generator **121**, coupled to the CPU **180** and the spreader **130**, generates the spreading codes in response to the SF and the one or more code numbers related to the one or more data parts and an SF and a code number related to the control part from the CPU **180**. The spreading code generator **121** sends the spreading codes to the spreader **130**.

The signature generator **122**, coupled to the CPU **180** and the spreading code generator **121**, generates the signature S to send the signature S to the spreading code generator **121**. The scrambling code generator **123** generates the complex-valued scrambling code to send the complex-valued scrambling code to the scrambler **140**.

The spreader **130** spreads the control part and the one or more data parts from the encoder **110** by the spreading codes from the code generator **120**.

The scrambler **140** scrambles the complex-valued scrambling code, the one or more data parts and the control part spread by the spreader **130**, thereby generating scrambled signals. The scrambler **140** includes a Walsh rotator, which is typically employed in the OCQPSK modulation scheme. The Walsh rotator rotates the one or more data parts and the control part spread by the spreader **130**.

The filter **150**, i.e., a root raised cosine (PRC) filter, pulse-shapes the scrambled signals to generate pulse-shaped signals. The gain adjuster **160** multiplies each of the pulse-shaped signals by the gain of each channel, thereby generating gain-adjusted signals. The adder **170** sums the gain-adjusted signals related to an I branch or the gain-adjusted signals related to a Q branch, to thereby generate a channel-modulated signal having a plurality of pairs of I and Q data in the mobile station.

Referring to FIG. **4**, there is shown a block diagram describing a spreading code generator shown in FIG. **3**. As shown, the spreading code generator includes a storage device **210**, an 8-bit counter **220**, a plurality of logical operators **231** and **233** and a plurality of multiplexers **232** and **234**.

The storage device **240** includes one or more registers **211** related to the one or more data parts and a register **212** related to the control part. The one or more registers **211** stores an SF and code numbers related to the one or more data parts sent from the CPU **180** shown in FIG. **3**. The register **212** stores an SF and a code number related to the control part sent from the CPU **180**.

The 8-bit counter **220** consecutively produces a count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ as 8-bit count value in synchronization with a clock signal CHIP_CLK issued from an external circuit, wherein B_0 to B_7 are made up of a binary value of 0 or 1, respectively.

The one or more logical operators **231** carry out one or more logical operations with the SF and the code numbers related to the one or more data parts stored in the one or more register **211**, thereby generating the spreading codes related to the one or more data parts. A code number is represented by $I_7I_6I_5I_4I_3I_2I_1I_0$, wherein I_0 to I_7 are the binary value of 0 or 1, respectively.

The logical operator **233** carries out a logical operation with the SF and the code number of $I_7I_6I_5I_4I_3I_2I_1I_0$ related to the control part stored in the register **212**, thereby generating a spreading code related to the control part.

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i} \text{ where } 2 \le N \le 8 \qquad \text{Eq. (3)}$$

where "·" denotes a multiplication in modulo 2 and $\Pi^{\oplus}$ denotes an exclusive OR operation. Each logical operator **231** or **233** carries out a logical operation according to Eq. (3) where SF=2^N.

If the SF is 256, each logical operator **231** or **233** carries out a logical operation of $B_7 \cdot I_0 \oplus B_6 \cdot I_1 \oplus B_5 \cdot I_2 \oplus B_4 \cdot I_3 \oplus B_3 \cdot I_4 \oplus B_2 \cdot I_5 \oplus B_1 \cdot I_6 \oplus B_0 \cdot I_7$.

If the SF is 128, each logical operator **231** or **233** carries out a logical operation of $B_6 \cdot I_0 \oplus B_5 \cdot I_1 \oplus B_5 \cdot I_2 \oplus B_3 \cdot I_3 \oplus B_2 \cdot I_4 \oplus B_1 \cdot I_5 \oplus B_0 \cdot I_6$.

If the SF is 64, each logical operator **231** or **233** carries out a logical operation of $B_5 \cdot I_0 \oplus B_4 \cdot I_1 \oplus B_3 \cdot I_2 \oplus B_2 \cdot I_5 \oplus B_0 \cdot I_6$.

If the SF is 32, each logical operator **231** or **233** carries out a logical operation of $B_4 \cdot I_0 \oplus B_3 \cdot I_1 \oplus B_2 \cdot I_2 \oplus B_1 \oplus I_3 \oplus B_0 \cdot I_4$.

If the SF is 16, each logical operator **231** or **233** carries out a logical operation of $B_3 \cdot I_0 \oplus B_1 \cdot I_1 \oplus B_0 \cdot B_3$.

If the SF is 8, each logical operator **231** or **233** carries out a logical operation of $B_2 \cdot I_0 \oplus B_1 \cdot I_1 \oplus B_0 \cdot I_2$.

If the SF is 4, each logical operator **231** or **233** carries out a logical operation of $B_1 \cdot I_0 \oplus B_0 \cdot I_1$.

The one or more multiplexers **232** selectively output the one or more spreading codes from the one or more logical operators **231** in response to one or more select signals as the SF related to the one or more data parts.

The multiplexer **234** selectively outputs the spreading code from the logical operator **233** in response to a select signal as the SF related to the control part.

Referring to FIG. **5**, there is shown an exemplary diagram illustrating a case where a mobile station uses two channels.

As shown, when the mobile station uses the two channels and SF=2^N where N=2 to 8, the spreading code generator **121** generates a spreading code of $C_{SF,\ SF/4}$ to be allocated to the DPDCH or the PCPCH as a data channel. Further, the spreading code generator **121** generates a spreading code of $C_{256,\ 0}$ to be allocated to the DPCCH or the control channel. Then, the spreader **130** spreads the DPDCH or the PCPCH by the spreading code of $C_{SF,\ SF/4}$. Further, The spreader **130** spreads the control channel by the spreading code of $C_{256,\ 0}$. At this time, the scrambling code generator **123** generates a complex-valued scrambling code assigned to the mobile station. Further, the complex-valued scrambling code can be temporarily reserved in the mobile station.

Referring to FIG. **6**, there is shown an exemplary diagram depicting a case where multiple mobile stations share a common complex-valued scrambling code in the PRACH application.

As shown, where the multiple mobile stations share a common complex-valued scrambling code and SF=$_2$N where N=5 to 8 and S 1 to 16, the spreading code generator **121** generates a spreading code of $C_{SF,\ SF(S-1)/16}$ to be allocated to the PRACH. Further, the spreading code generator **121** generates a spreading code of $C_{256,\ 16(S-1)+15}$ to be allocated to the control channel.

Then, the spreader **130** spreads the PRACH by the spreading code of $C_{SF,\ SF(S-1)/16}$. Also, the spreader **130** spreads the control channel by the spreading code of $C_{256,\ 16(S-1)+15}$. At this time, the scrambling code generator **123** generates a common complex-valued scrambling code.

Referring to FIG. **7**, there is shown an exemplary diagram showing a case where a mobile station uses multiple channels. As shown, where the mobile station uses one control channel and two data channels and the SF related to the two data channels is 4, the spreading code generator **121** generates a spreading code of $C_{256,\ 0}$ to be allocated to the DPCCH. Further, the spreading code generator **121** generates a spreading code of $C_{4,\ 1}$ allocated to the DPDCH **1**. Furthermore, the spreading code generator **121** generates a spreading code of $C_{4,\ 1}$ allocated to the DPDCH **2**.

Then, the spreader **130** spreads the DPDCH **1** by the spreading code of $C_{4,\ 1}$. Further, the spreader **130** spreads the DPDCH **2** by the spreading code of $C_{4,\ 1}$. Furthermore, the spreader **130** spreads the DPCCH by the spreading code of $C_{256,\ 0}$. At this time, the scrambling code generator **123** generates a complex-valued scrambling codes assigned to the mobile station.

As shown, where the mobile station uses one control channel and three data channels and the SF related to the three data channels is 4, the spreading code generator **121** further generates a spreading code of $C_{4,\ 3}$ to be allocated to the DPDCH **3**. Then, the spreader **130** further spreads the DPDCH **3** by the spreading code of $C_{4,\ 3}$.

As shown, where the mobile station uses one control channel and four data channels and the SF related to the four data channels is 4, the spreading code generator **121** further generates a spreading code of $C_{4,\ 3}$ to be allocated to the DPDCH **4**. Then, the spreader **130** further spreads the DPDCH **4** by the spreading code of $C_{4,\ 3}$.

As shown, where the mobile station uses one control channel and five data channels and the SF related to the five data channels is 4, the spreading code generator **121** further generates a spreading code of $C_{4,\ 2}$ to be allocated to the DPDCH **5**. Then, the spreader **130** further spreads the DPDCH **5** by the spreading code of $C_{4,\ 2}$.

As shown, where the two mobile station uses one control channel and six data channels and the SF related to the six data channels is 4, the spreading code generator **121** further generates a spreading code of $C_{4,\ 2}$ to be allocated to the DPDCH **6**. Then, the spreader **130** further spreads the DPDCH **6** by the spreading code of $C_{4,\ 2}$.

Referring to FIG. **8**, there is shown a first exemplary view describing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

As shown, in case where an SF is 4 and a code number is 0, a spreading code of $C_{4,\ 0}$ is represented by {1, 1, 1, 1}. Further, in case where the SF is 4 and a code number is 1, a spreading code of $C_{4,\ 1}$ is represented by {1, 1, −1, −1}.

Assume that two channels are spread by the spreading code of $C_{4,\ 0}$={1, 1, 1, 1} and the spreading code of $C_{4,\ 1}$={1, 1, −1, −1}, respectively. At this time, real values contained in the spreading code of $C_{4,\ 0}$={1, 1, 1, 1} are represented by points on a real axis of a phase domain. Further, real values contained in the spreading code of $C_{4,\ 0}$={1, 1, −1, −1} are represented by points on an imaginary axis of the phase domain.

At a first or second chip, a point {1, 1}, i.e., a point ① or ②, is designated on the phase domain by first or second real values contained in the spreading codes of $C_{4,\ 0}$ and $C_{4,\ 1}$. At a third or fourth chip, a point {1, −1}, i.e., a point ③ or ④, is designated on the phase domain by third or fourth real values contained in the spreading codes of $C_{4,\ 0}$ and $C_{4,\ 1}$. The points ① and ② are positioned on the same point as each other. Also, the points ③ and ④ are positioned on the same point as each other. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°. Where the phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°, a peak-to-average power ratio (PAPR) of a mobile station can be reduced.

For another example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to the counterclockwise direction by the phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to the clockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①" and ②" or the rotated points ③" and ④" becomes 90°. Where the phase difference between the rotated points ①" and ②" or the rotated points ③" and ④" becomes 90°, the peak-to-average power ratio of the mobile station can be reduced.

Referring to FIG. **9**, there is shown a second exemplary view showing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

First, assume that two channels are spread by a spreading code of $C_{4,2}=\{1, -1, 1, -1\}$ and a spreading code of $C_{4,3}=\{1, -1, -1, 1\}$, respectively.

At a first chip, a point {1, 1}, i.e., a point ①, is designated on the phase domain by first real values contained in the spreading codes of $C_{4,2}$ and $C_{4,3}$. At a second chip, a point {−1, −1}, i.e., a point ②, is designated on the phase domain by second real values contained in the spreading codes of $C_{4,2}$ and $C_{4,3}$. The points ① and ② are symmetrical with respect to a zero point as a center point on the phase domain.

At a third chip, a point {1, −1}, i.e., a point ③, is designated on the phase domain by third real values contained in the spreading codes of $C_{4,2}$ and $C_{4,3}$. At a fourth chip, a point {−1, 1}, i.e., a point ④, is designated on the phase domain by fourth real values contained in the spreading codes of $C_{4,2}$ and $C_{4,3}$. The points ③ and ④ are symmetrical with respect to the zero point on the phase domain. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°. Where the phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°, a peak-to-average power ratio of a mobile station can be reduced.

For another example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to the counterclockwise direction by the phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to the clockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①" and ②" or the rotated points ③" and ④" becomes 90°. Where the phase difference between the rotated points ①" and ②" or the rotated points ③" and ④" becomes 90°, the peak-to-average power ratio of the mobile station can be reduced.

Referring to FIG. **10**, there is shown a first exemplary view depicting an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

First, assume that two channels are spread by the spreading code of $C_{4,0}=\{1, 1, 1, 1\}$ and the spreading code of $C_{4,2}=\{1, -1, 1, -1\}$, respectively.

At a first chip, a point {1, 1}, i.e., a point ①, is designated on the phase domain by first real values contained in the spreading codes of $C_{4,0}$ and $C_{4,2}$. At a second chip, a point {1, −1}, i.e., a point ②, is designated on the phase domain by second real values contained in the spreading codes of $C_{4,0}$ and $C_{4,2}$ The points ① and are symmetrical with respect to the real axis on the phase domain.

At a third chip, a point {1, 1}, i.e., a point ③, is designated on the phase domain by third real values contained in the spreading codes of $C_{4,0}$ and $C_{4,2}$. At a fourth chip, a point {1, −1}, i.e., a point ④, is designated on the phase domain by fourth real values contained in the spreading codes of $C_{4,0}$ and $C_{4,2}$. The points ③ and ④ are symmetrical with respect to the real axis on the phase domain. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a counterclockwise direction by a phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a clockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes zero. Where the phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' does not become 90°, a peak-to-average power ratio of a mobile station can not be reduced.

Referring to FIGS. **11** and **12**, there are shown third exemplary views illustrating a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

First, assume that data of 1 allocated to a first channel is spread by a spreading code of $C_{4,1}=\{1, 1, -1, -1\}$. Further, assume that data of −1 allocated to a second channel is spread by a spreading code of $C_{4,1}=\{1, 1, -1, -1\}$. Furthermore, assume that data of 1 allocated to a third channel is spread by a spreading code of $C_{4,0}=\{1, 1, 1, 1\}$.

In terms of the first channel, the spreader **130** shown in FIG. **3** multiplies the data of 1 by the spreading code of $C_{4,1}=\{1, 1, -1, -1\}$, thereby generating a code of {1, 1, −1, −1}. Further, in terms of the second channel, the spreader **130** multiplies the data of −1 by the spreading code of $C_{4,1}=\{1, 1, -1, -1\}$, thereby generating a code of {−1, −1, 1, 1}. Furthermore, in terms of the third channel, the spreader **130** multiplies the data of 1 by the spreading code of $C_{4,0}=\{1, 1, 1, 1\}$, thereby generating a code of {1, 1, 1, 1}.

Where the spreader **130** includes an adder **131** shown in FIG. **12**, the adder **131** generates a code of {0, 0, 2, 2} by adding the code of {−1, −1, 1, 1} to the code of {1, 1, 1, 1}.

TABLE 1

Chip	1	2	3	4
First Channel	1	1	−1	−1
Second Channel	−1	−1	1	1
Third Channel	1	1	1	1
Second channel + Third channel	0	0	2	2

Table 1 represents the spreading codes allocated to three channels and a sum of two channels depending upon chips. At a first or second chip, a point {1, 0}, i.e., a point ① or ②, is designated on the phase domain by first or second real values contained in the code of {1, 1, −1, −1} and the code of {0, 0, 2, 2}. At a third or fourth chip, a point {−1, 2}, i.e., a point ③ or ④, is designated on the phase domain by third or fourth real values contained in the code of {1, 1, −1, −1} and the code of {0, 0, 2, 2}. The points ① and ② are positioned on the same point as each other. Also, the points ③ and ④ are positioned on the same point as each other. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°. Where the phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes 90°, a peak-to-average power ratio of a mobile station can be reduced.

Referring to FIGS. **13** and **14**, there are shown second exemplary views illustrating an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

First, assume that data of 1 allocated to a first channel is spread by a spreading code of $C_{4,1}$={1, 1, −1, −1}. Further, assume that data of −1 allocated to a second channel is spread by a spreading code of $C_{4,2}$={1, −1, 1, −1}. Furthermore, assume that data of 1 allocated to a third channel is spread by a spreading code of $C_{4,0}$={1, 1, 1, 1}.

In terms of the first channel, the spreader **130** shown in FIG. **2** multiplies the data of 1 with the spreading code of $C_{4,1}$={1, 1, −1, −1}, thereby generating a code of {1, 1, −1, −1}. Further, in terms of the second channel, the spreader **130** multiplies the data of −1 by the spreading code of $C_{4,2}$={1, −1, 1, −1}, thereby generating a code of {−1, 1, −1, 1}. Furthermore, in terms of the third channel, the spreader **130** multiplies the data of 1 by the spreading code of $C_{4,0}$={1, 1, 1, 1}, thereby generating a code of {1, 1, 1, 1}.

Where the spreader **130** includes an adder **133** shown in FIG. **14**, the adder **133** generates a code of {0, 2, 0, 2} by adding the code of {−1, 1, −1, 1} to the code of {1, 1, 1, 1}.

TABLE 2

Chip	1	2	3	4
First Channel	1	1	−1	−1
Second Channel	−1	1	−1	1
Third Channel	1	1	1	1
Second channel + third channel	0	2	0	2

Table 2 represents the spreading codes allocated to three channels and a sum of two channels depending upon chips. At a first chip, a point {1, 0}, i.e., a point ①, is designated on the phase domain by first real values contained in the code of {1, 1, −1, −1} and the code of {0, 2, 0, 2}. At a second chip, a point {1, 2}, i.e., a point ②, is designated on the phase domain by second real values contained in the code of {1, 1, −1, −1} and the code of {0, 2, 0, 2}. At a third chip, a point {−1, 0}, i.e., a point ③, is designated on the phase domain by third real values contained in the code of {1, 1, −1, −1} and the code of {0, 2, 0, 2}. At a fourth chip, a point {−1, 2}, i.e., a point ④, is designated on the phase domain by third real values contained in the code of {1, 1, −1, −1} and the code of {0, 2, 0, 2}.

The points ① and ② or the points ③ and ④ are positioned on different points from each other. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of 45°. After rotating the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ③' and ④' does not become 90°. Where the phase difference between the rotated points ③' and ④' does not become 90°, a peak-to-average power ratio of a mobile station can increase.

Further, after rotating the points ① and ② at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' does not become 90°. Where the phase difference between the rotated points ①' and ②' does not become 90°, the peak-to-average power ratio of a mobile station can increase.

Referring to FIG. **15**, there is shown an exemplary graphical diagram describing the probability of peak to average power.

When a mobile station employs two channels and spreading codes of $C_{4,0}${1, 1, 1, 1} and $C_{4,1}$={1, 1, −1, −1} allocated to the two channels, a curve G1 is shown in the graphical diagram. At this time, the probability of the peak power exceeding the average power by 2.5 dB is approximately 1%.

Further, when a mobile station employs two channels and spreading codes of $C_{4,0}${1, 1, 1, 1} and $C_{4,2}$={1, −1, 1, −1} allocated to the two channels, a curve G2 is shown in the graphical diagram. At this time, the probability of the peak power exceeding the average power by 2.5 dB is approximately 7%.

Referring to FIG. **16**, there is shown a flowchart depicting a method for modulating a data message in a mobile station in accordance with the present invention.

As shown, at step **S1302**, an encoder receives a data message to be transmitted to a base station.

At step **S1304**, the encoder encodes the data message having one or more data parts and generates a control part.

At step **S1306**, the encoder evaluates an SF related to the one or more data parts to send the SF from an encoder to a CPU.

At step **S1308**, the CPU produces information necessary to generate spreading codes to be allocated to channels.

At step **S1310**, a code generator generates the spreading codes.

At step **S1312**, a spreader spreads the control part and the one or more data parts by the spreading codes.

At step **S1314**, a scrambler scrambles the control part and the one or more data parts spread and a complex-valued scrambling code, to thereby generate a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in the mobile station.

Referring to FIGS. **17** to **19**, there are flowcharts illustrative of a procedure for producing information necessary to generate spreading codes to be allocated to channels.

As shown, at step **S1402**, the CPU receives the SF related to the one or more data parts from the encoder.

At step **S1404**, the CPU determines a type of an event.

At step **S1408**, if the event is a case where a mobile station uses two channels, the CPU produces an SF of 256 and a code number of 0 related to the control part.

At step **S1410**, the CPU produces a code number of SF/4 related to the one data part where $SF=2^N$ and N=2 to 8.

At step **S1412**, the CPU sends the code numbers and the SFs related to the data and control parts to the code generator.

On the other hand, at step **S1414**, if the event is a case where multiple mobile stations share a common complex-valued scrambling code, the CPU produces a signature S.

At step **S1416**, the CPU produces the SF of 256 and a code number of 16(S−1)+15 related to the control part where S=1 to 16.

At step **S1418**, the CPU produces a code number of SF(S−1)/16 related to the one data part where $SF=2^N$, N=2 to 8 and S=1 to 16.

At step **S1420**, the CPU sends the code numbers and the SFs related to the data and control parts to the code generator.

On the other hand, at step **S1424**, if the event is a case where a mobile station uses multiple channels, the CPU produces a code number of 0 and the SF of 256 related to the control part allocated to the control channel.

At step **S1502**, the CPU determines the number of data channels.

At step **S1504**, if the number of data channels is two data channels, the CPU produces a code number of 1 and an SF of 4 related to a first data part allocated to a first data channel coupled to an I branch.

At step **S1506**, the CPU produces a code number of 1 and the SF of 4 related to a second data part allocated to a second data channel.

On the other hand, at step **S1508**, if the number of data channels is three data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

At step **S1510**, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step **S1512**, the CPU produces a code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

On the other hand, at step **S1514**, if the number of data channels is four data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

At step **S1516**, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step **S1518**, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

At step **S1520**, the CPU produces the code number of 3 and the SF of 4 related to a fourth data part allocated to a fourth data channel.

On the other hand, at step **S1522**, if the number of data channels is five data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

At step **S1524**, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step **S1526**, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

At step **S1528**, the CPU produces the code number of 3 and the SF of 4 related to the fourth data part allocated to the fourth data channel.

At step **S1530**, the CPU produces the code number of 2 and the SF of 4 related to a fifth data part allocated to a fifth data channel.

On the other hand, at step **S1532**, if the number of data channels is six data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

At step **S1534**, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step **S1536**, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

At step **S1538**, the CPU produces the code number of 3 and the SF of 4 related to the fourth data part allocated to the fourth data channel.

At step **S1540**, the CPU produces the code number of 2 and the SF of 4 related to the fifth data part allocated to the fifth data channel.

At step **S1542**, the CPU produces the code number of 2 and the SF of 4 related to a sixth data part allocated to a sixth data channel.

At step **S1521**, the CPU transmits the code numbers and the SFs related to the data and control parts to the code generator.

Referring to FIG. **20**, there is shown a flowchart showing a procedure of generating the spreading codes.

As shown, at step **S1702**, registers receive the code numbers and the SFs from the CPU.

At step **S1704**, registers store the code numbers and the SFs.

At step **S1706**, logical operators carry out logical operations in response to an 8-bit count value, thereby generating the spreading codes.

At step **S1708**, multiplexers select the spreading codes in response to the SFs as select signals.

Referring to FIGS. **21** and **22**, there are shown flowcharts describing a procedure of carrying out the logical operations in response to the 8-bit count value, thereby generating the spreading codes.

As shown, at step **S1802**, each register receives a code number of $I_7I_6I_5I_4I_3I_2I_1I_0$ and a predetermined SF.

At step **S1804**, each register receives an 8-bit count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ from an 8-bit counter.

At step **S1806**, a type of the predetermined SF is determined.

At step **S1808**, if the predetermined SF is SF_{256}, each logical operator carries out a logical operation of $B_7 \cdot I_0 \oplus B_6 \cdot I_1 \oplus B_5 \cdot I_2 \oplus B_4 \cdot I_3{}^{\oplus B}{}_3 \cdot I_4 \oplus B_2 \cdot I_5 \oplus B_1 \cdot I_6 \oplus B_0 \cdot I_7$.

At step **S1810**, if the predetermined SF is SF_{128}, each logical operator carries out a logical operation of $B_6 \cdot I_0 \oplus B_5 \cdot I_1 \oplus B_4 \cdot I_2 \oplus B_3 \cdot I_3{}^{\oplus B}{}_3 \cdot I_4 \oplus B_1 \cdot I_5 \oplus B_1 \cdot I_6$.

At step **S1812**, if the predetermined SF is SF_{64}, each logical operator carries out a logical operation of $B_5 \cdot I_0 \oplus B_4 \cdot I_1 \oplus B_3 \cdot I_2 \oplus B_2 \cdot I_3{}^{\oplus B}{}_1 \cdot I_4 \oplus B_0 \cdot I_5$.

At step **S1814**, if the predetermined SF is SF_{32}, each logical operator carries out a logical operation of $B_4 \cdot I_0 \oplus B_3 \cdot I_1 \oplus B_2 \cdot I_2 \oplus B_1 \cdot I_3 \oplus B_0 \cdot I_4$.

At step **S1816**, if the predetermined SF is SF_{16}, each logical operator carries out a logical operation of $B_3 \cdot I_0 \oplus B_2 \cdot I_1 \oplus B_1 \cdot I_2 \oplus B_0 \cdot I_3$.

At step S1818, if the predetermined SF is SF_8, each logical operator carries out a logical operation of $B_2 \cdot I_0 \oplus B_1 \cdot I_1 \oplus B_0 \cdot I_2$.

At step S1820, if the predetermined SF is SF_4, each logical operator carries out a logical operation of $B_1 \cdot I_0 \oplus B_0 \cdot I_1$.

At step S1822, each multiplexer generates a spreading code in response to the SF.

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

What is claimed is:

1. An apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses (N−1) data channels (N is an integer larger than two) and a control channel, the apparatus comprising:

channel coding means for encoding the source data to generate (N−1) data parts and a control part, wherein the data parts are allocated to the data channels and the control part is allocated to the control channel;

code generating means for generating spreading codes to be allocated to the channels, wherein each of the spreading codes is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on the same point or symmetrical with respect to a zero point on a phase domain; and

spreading means for spreading the control channel and the data channels by using the spreading codes to thereby generate the channel-modulated signal,

wherein:

the code generating means includes:

control means responsive to the spreading factor for generating code numbers for the channels; and

spreading code generation means responsive to the spreading factor and the code number for generating the spreading code to be allocated to the channels,

the spreading code generation means includes:

counting means for consecutively producing a count value in synchronization with a clock signal;

first spreading code generation means responsive to the count value and the spreading factor for generating the spreading codes to be allocated to the data channels; and

second spreading code generation means responsive to the count value and the spreading factor for generating the spreading code to he allocated to the control channel, the spreading codes correspond to an orthogonal variable spreading factor (OVSF) code, the spreading code allocated to the control channel is represented by $C_{256,0}$, where 256 denotes the spreading factor and 0 the code number,

the spreading codes allocated to first and second data channels are represented by $C_{4,1}=\{1, 1, -1, -1\}$,

when there are more than two data channels, the spreading codes allocated to a third data channel and, when present, a fourth data channel are represented by $C_{4,3}=\{1, -1, -1, 1\}$, and

when there are more than four data channels, the spreading codes allocated to a fifth data channel and, when present, a sixth data channel are represented by $C_{4,2}=\{1, -1, 1, -1\}$.

2. The apparatus as recited in claim 1, wherein the first spreading code generation means includes:

first logical operation means responsive to the count value for carrying out a logical operation with the spreading factor and the code number related to a data part, to thereby generate the spreading code related to the data part; and

first selection means for outputting the spreading code related to the data part in response to a select signal as the spreading factor related to the data part.

3. The apparatus as recited in claim 2, wherein said first logical operation means receives a code number of $I_7I_6I_5I_4I_3I_2I_1I_0$, a count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ and a predetermined spreading factor.

4. The apparatus as recited in claim 3, wherein the first logical operation means carries out a logical operation of

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the predetermined spreading factor is 2^N where N is 2 to 8.

5. The apparatus as recited in claim 2, wherein said first logical operation means includes a plurality of AND gates and a plurality of exclusive OR gates.

6. The apparatus as recited in claim 2, wherein said first selection means includes a multiplexer.

7. The apparatus as recited in claim 1, wherein the second spreading code generation means includes:

second logical operation means responsive to the count value for carrying out a logical operation with the spreading factor and the code number related to the control part, to thereby generate the spreading code related to the control part; and

second selection means for outputting the spreading code related to the control part in response to a select signal as the spreading factor related to the control part.

8. The apparatus as recited in claim 7, wherein said second logical operation means receives a code number of $I_7I_6I_5I_4I_3I_2I_1I_0$, a count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ and a predetermined spreading factor.

9. The apparatus as recited in claim 8, wherein the second logical operation means carries out a logical operation of

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the predetermined spreading factor is 2^N where N is 2 to 8.

10. The apparatus as recited in claim 1, wherein said counting means includes an 8-bit counter when the 2^N is a maximum spreading factor.

11. A method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses (N−1) data channels (N is an integer larger than two) and a control channel, the method comprising the steps of:

a) encoding the source data to generate (N−1) data parts and a control part, wherein the data parts are allocated to the data channels and the control part is allocated to the control channel;

b) generating spreading codes to be allocated to the channels, wherein each of the spreading codes is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on the same point or symmetrical with respect to a zero point on a phase domain; and

c) spreading the control channel and the data channels by using the spreading codes to thereby generate the channel-modulated signal,

wherein:

step a) includes the steps of:

a1) encoding the source data to generate the data part and the control part; and

a2) generating a spreading factor related to the data rate of the data part,

step b) includes the steps of:

b1) generating code numbers for the channels in response to the spreading factor; and

b2) generating the spreading code to be allocated to the channels in response to the spreading factor and the code number,

step b2) includes the steps of:

b2-a) producing a count value in synchronization with a clock signal; and

b2-b) carrying out a logical operation with the spreading factor and the code number related to the data part and the control part in response to the count value, to thereby generate the spreading code related to the data part,

the spreading codes correspond to an orthogonal variable spreading factor (OVSF) code,

the spreading code allocated to the control channel is represented by $C_{256,0}$, where 256 denotes a spreading factor and 0 the code number,

the spreading codes allocated to first and second data channels are represented by $C_{4,1}=\{1, 1, -1, -1\}$,

when there are more than two data channels, the spreading codes allocated to a third data channel and, when present, a fourth data channel are represented by $C_{4,3}=\{1, -1, -1, 1\}$, and

when there are more than four data channels, the spreading codes allocated to a fifth data channel and, when present, a sixth data channel are represented by $C_{4,2}=\{1, -1, 1, -1\}$.

12. The method as recited in claim 11, wherein the code number and the count value are represented by an 8-bit signal of $I_7I_6I_5I_4I_3I_2I_1I_0$ and an 8-bit signal of $B_7B_6B_5B_4B_3B_2B_1B_0$, respectively.

13. The method as recited in claim 12, wherein the logical operation is accomplished by

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the spreading factor is 2^N where N is 2 to 8.

14. An apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses (N−1) data channels (N is an integer larger than two) and a control channel, the apparatus comprising:

channel coding means for encoding the source data to generate (N−1) data parts and a control part, wherein the data parts are allocated to the data channels and the control part is allocated to the control channel;

code generating means for generating spreading codes to be allocated to the channels, wherein each of the spreading codes is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on the same point or symmetrical with respect to a zero point on a phase domain; and

spreading means for spreading the control channel and the data channels by using the spreading codes to thereby generate the channel-modulated signal,

wherein:

the spreading codes correspond to an orthogonal variable spreading factor (OVSF) code,

said channel coding means includes spreading factor generation means for generating a spreading factor related to the data rate of the data part,

the spreading code allocated to the control channel is represented by $C_{256,0}$, where 256 denotes the spreading factor and 0 the code number,

the spreading codes allocated to first and second data channels are represented by $C_{4,1}=\{1, 1, -1, -1\}$,

said code generating means includes control means responsive to the spreading factor for generating code numbers for the channels, and spreading code generation means responsive to the spreading factor and the code number for generating the spreading code to be allocated to the channels, said spreading code generation means including, counting means for consecutively producing a count value in synchronization with a clock signal, first spreading code generation means responsive to the count value and the spreading factor for generating the spreading code to be allocated to the data channel, and second spreading code generation means responsive to the count value and the spreading factor for generating the spreading code to be allocated to the control channel, and

the second spreading code generation means includes:

second logical operation means responsive to the count value for carrying out a logical operation with the spreading factor and the code number related to the control part, to thereby generate the spreading code related to the control part; and

second selection means for outputting the spreading code related to the control part in response to a select signal as the spreading factor related to the control part.

15. The apparatus as recited in claim 14, wherein the first spreading code generation means includes:

first logical operation means responsive to the count value for carrying out a logical operation with the spreading factor and the code number related to the data part, to thereby generate the spreading code related to the data part; and

first selection means for outputting the spreading code related to the data part in response to a select signal as the spreading factor related to the data part,

and wherein said first logical operation means receives a code number of $I_7I_6I_5I_4I_3I_2I_1I_0$, a count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ and a predetermined spreading factor.

16. The apparatus as recited in claim 15, wherein the first logical operation means carries out a logical operation of

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the predetermined spreading factor is 2^N where N is 2 to 8.

17. The apparatus as recited in claim 14, wherein said second logical operation means receives a code number of $I_7I_6I_5I_4I_3I_2I_1I_0$, a count value of $B_7B_6B_5B_4B_3B_2B_1B_0$ and a predetermined spreading factor.

18. The apparatus as recited in claim 17, wherein the second logical operation means carries out a logical operation of

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the predetermined spreading factor is 2^N where N is 2 to 8.

19. A method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses (N−1) data channels (N is an integer larger than two) and a control channel, the method comprising the steps of:

a) encoding the source data to generate (N−1) parts and a control part, wherein the data part are allocated to the data channel and the control part is allocated to the control channel;

b) generating spreading codes to be allocated to the channels, wherein each of the spreading codes is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on the same point or symmetrical with respect to a zero point on a phase domain; and

c) spreading the control channel and the data channels by using the spreading codes to thereby generate the channel-modulated signal,

wherein the spreading code is an orthogonal variable spreading factor (OVSF) code and the spreading code allocated to the control channel is represented by $C_{256,0}$, where 256 denotes spreading factor and 0 code number,

the spreading codes allocated to first and second data channels are represented by $C_{4,1}=\{1, 1, -1, -1\}$, and

said step a) includes:

a1) encoding the source data to generate the data part and the control part; and

a2) generating a spreading factor related to the data said step b) including,

b1) generating code numbers for the channels in response to the spreading factor; and

b2) generating the spreading code to be allocated to the channels in response to the spreading factor and the code number, said step b2) further including:

b2-a) producing a count value in synchronization with a clock signal; and

b2-b) carrying out a logical operation with the spreading factor and the code number related to the data parts and the control part in response to the count value to thereby generate the spreading code related to the data part.

20. The method as recited in claim 19, wherein the code number and the count value are represented by an 8-bit signal of $I_7I_6I_5I_4I_3I_2I_1I_0$ and an 8-bit signal of $B_7B_6B_5B_4B_3B_2B_1B_0$, respectively.

21. The method as recited in claim 20, wherein the logical operation is accomplished by

$$\prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i}$$

if the spreading factor is 2^N where N is 2 to 8.

22. A spreading method for a mobile station, wherein the mobile station is capable of using at least three data channels and at least one control channel, comprising:

systematically spreading a first one of the data channels by $C_{4,1}$;

systematically spreading a second one of the data channels by $C_{4,1}$; and

systematically spreading a third one of the data channels by $C_{4,3}$, wherein

$C_{4,1}$ is a first orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 1,

$C_{4,3}$ is a second orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 3, and

when three and not more than three of the data channels are used, the first one of the data channels, the second one of the data channels, and the third one of the data channels are used.

23. The method of claim 22, wherein $C_{4,1}$ represents $\{1, 1, -1, -1\}$ and $C_{4,3}$ represents $\{1, 1, -1, -1\}$.

24. The method of claim 23, further comprising:

spreading the at least one control channel by $C_{256,0}$, wherein $C_{256,0}$ is a third orthogonal variable spreading factor code with the spreading factor of 256 and the code number of 0.

25. The method of claim 24, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch, and

the mobile station uses the data channels and the at least one control channel such that at least the second one of the data channels and the at least one control channel are coupled to a quadrature-phase branch.

26. The method of claim 24, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch, and

allocating the at least one control channel and the second one of the data channels to a quadrature-phase branch.

27. The method of claim 24, further comprising:

generating $C_{4,1}$, $C_{4,3}$, and $C_{4,2}$.

28. The method of claim 22, further comprising:

when more than three of the data channels are used, systematically spreading a fourth one of the data channels by $C_{4,3}$, wherein

when four and not more than four of the data channels are used, the first one of the data channels, the second one of the data channels, the third one of the data channels, and the fourth one of the data channels are used.

29. The method of claim 28, further comprising:

spreading the at least one control channel by $C_{256,0}$ is a third orthogonal variable spreading factor code with the spreading factor of 256 and the code number of 0.

30. The method of claim 29, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch, and

the mobile station uses the data channels and the at least one control channel such that at least the second one of the data channels and the fourth one of the data channels and the at least one control channel are coupled to a quadrature-phase branch.

31. The method of claim 29, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch; and

allocating the second one of the data channels and the fourth one of the data channels and the at least one control channel to a quadrature-phase branch.

32. The method of claim 28, further comprising:

when more than four of the data channels, systematically spreading a fifth one of the data channels by $C_{4,2}$; and

when more than five of the data channels are used, systematically spreading a sixth one of the data channels by $C_{4,2}$, wherein

$C_{4,2}$ is a fourth orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 2,

when five and not more than five of the data channels are used, the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, and the fifth one of the data channels are used, and

when six of the data channels are used, the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, the fifth one of the data channels, and the sixth one of the data channels are used.

33. The method of claim 32, wherein

$C_{4,1}$ represents $\{1, 1, -1, -1\}$, $C_{4,2}$ represent $\{1, -1, 1, -1\}$, and $C_{4,3}$ represents $\{1, -1, -1, 1\}$.

34. The method of claim 33, further comprising:

spreading the at least one control channel by $C_{256,0}$, wherein $C_{256,0}$ is a third orthogonal variable spreading factor code with the spreading factor of 256 and the code number of 0.

35. The method of claim 34, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch;

the mobile station uses data channels and the at least one control channel such that at least the second one of the data channels and the at least one control channel are coupled to a quadrature-phase branch.

36. The method of claim 35, wherein

the mobile station uses the data channels such that the fourth one of the data channels is coupled to the quadrature-phase branch.

37. The method of claim 36, wherein

the mobile station uses the data channels such that the fifth one of the data channels is coupled to the in-phase branch, and

the mobile station uses the data channels such that the sixth one of the data channels is coupled to the quadrature-phase branch.

38. The method of claim 34, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch; and

allocating the at least one control channel and the second one of the data channels to a quadrature-phase branch.

39. The method of claim 38, further comprising:

allocating the fourth one of the data channels to the quadrature-phase branch.

40. The method of claim 39, further comprising:

allocating the fifth one of the data channels to the in-phase branch, and

allocating the sixth one of the data channels to the quadrature-phase branch.

41. The method of claim 34, further comprising:

generating $C_{4,1}$, $C_{4,3}$, and $C_{4,2}$.

42. The method of claim 22 where the third one of the data channels is systematically spread with $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

43. A spreading method for a mobile station, wherein the mobile station is capable of using at least three data channels and at least one control channel, comprising:

receiving first data on a first one of the data channels;

receiving second data on a second one of the data channels;

receiving third data on a third one of the data channels;

systematically spreading the first data by $C_{4,1}$;

systematically spreading the second data by $C_{4,1}$; and

systematically spreading the third data with $C_{4,3}$, wherein

when three and not more than three of the data channels are used, the first and second one of the data channels and the third one of the data channels are used, and

$C_{I,K}$ represents an orthogonal variable spreading factor code, with I being a spreading factor and K being a code number, wherein $0 \leqq K < I$.

44. The method of claim 43, wherein

$C_{4,1}$ represents $\{1, 1, -1, -1\}$ and $C_{4,3}$ represents $\{1, -1, -1, 1\}$.

45. The method of claim 44, further comprising:

allocating $C_{256,0}$ to the at least one control channel.

46. The method of claim 45, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch, and

the mobile station uses data channels and the at least one control channel such that at least the at least one control channel and the second one of the data channels are coupled to a quadrature-phase branch.

47. The method of claim 45, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch, and

allocating the at least one control channel and the second one of the data channels to a quadrature-phase branch.

48. The method of claim 45, further comprising:

generating $C_{4,1}$ and $C_{4,3}$.

49. The method of claim 43, further comprising:

receiving fourth data on a fourth one of the data channels; and

systematically spreading the fourth data by $C_{4,3}$; wherein

the mobile station uses the data channels such that when the mobile station uses four and not more than four of the data channels, the first one of the data channels, the second one of the data channels, the third one of the data channels, and the fourth one of the data channels are used.

50. The method of claim 49, further comprising:

allocating $C_{256,0}$ to the at least one control channel.

51. The method of claim 50, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch, and

the mobile station uses data channels and the at least one control channel such that at least the second one of the data channels, the fourth one of the data channels, and the at least one control channel are coupled to a quadrature-phase branch.

52. The method of claim **50**, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch; and

allocating the second one of the data channels and the fourth one of the data channels and the at least one control channel to a quadrature-phase branch.

53. The method of claim **49**, further comprising:

receiving fifth data on a fifth one of the data channels;

systematically spreading the fifth data with $C_{4,2}$;

receiving sixth data on a sixth one of the data channels; and

systematically spreading the sixth data with $C_{4,2}$, wherein

when five and not more than five of the data channels are used, the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, and the fifth one of the data channels are used, and

when six of the data channels used, the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, the fifth one of the data channels, and the sixth one of the data channels are used.

54. The method of claim **53**, wherein

$C_{4,1}$ represents {1, 1, −1, −1}, $C_{4,2}$ represents {1, −1, −1, 1}.

55. The method of claim **54**, further comprising:

allocating $C_{256,0}$ to the at least one control channel.

56. The method of claim **55**, wherein

the mobile station uses the data channels such that at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch;

the mobile station uses the data channels and the at least one control channel such that at least the second one of the data channels and the at least one control channel are coupled to a quadrature-phase branch.

57. The method of claim **54**, wherein

the mobile station uses the data channels such that the fourth one of the data channels is coupled to the quadrature-phase branch.

58. The method of claim **57**, wherein

the mobile station uses the data channels such that the fifth one of the data channels is coupled to the in-phase branch, and

the mobile station uses the data channels such that the sixth one of the data channels is coupled to the quadrature-phase branch.

59. The method of claim **55**, further comprising:

allocating the first one of the data channels and the third one of the data channels to an in-phase branch; and

allocating the at least one control channel and the second one of the data channels to a quadrature-phase branch.

60. The method of claim **59**, further comprising:

allocating the fourth one of the data channels to the quadrature-phase branch.

61. The method of claim **60**, further comprising:

allocating the fifth one of the data channels to the in-phase branch, and

allocating the sixth one of the data channels to the quadrature-phase branch.

62. The method of claim **55**, further comprising:

generating $C_{4,1}$, $C_{4,3}$, and $C_{4,2}$.

63. The method of claim **43** where the third data is systematically spread with $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

64. The method of claim **43** where the third one of the data channels is systematically spread with $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

65. A mobile station, wherein the mobile station is configured to use a plurality of data channels at least one control channel, comprising:

means for receiving data on the data channels,

wherein a first one of the data channels, a second one of the data channels, and a third one of the data channels are configured to be used when three and not more than three of the data channels are configured to be used,

the first one of the data channels, the second one of the data channels, the third one of the data channels, and a fourth one of the data channels are configured to be used when four and not more than four of the data channels are configured to be used,

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, and a fifth one of the data channels are configured to be used when five and not more than five of the data channels are configured to be used, and

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, the fifth one of the data channels, and a sixth one of the data channels are configured to be used when six of the data channels are configured to be used; and

means for spreading systematically the first one of the data channels by $C_{4,1}$, the second one of the data channel by $C_{4,1}$, the third one of the data channels by $C_{4,3}$, the fourth one of the data channels by $C_{4,3}$, the fifth one of the data channels by $C_{4,2}$, the sixth one of the data channels by $C_{4,2}$, and the at least one control channel by $C_{256,0}$, respectively, wherein $C_{I,K}$ represents an orthogonal variable spreading factor code, with I being a spreading factor and K being a code number, wherein 0≦K21 I.

66. The mobile station of claim **65**, wherein

$C_{4,1}$ represents {1, 1, −1, −1}, $C_{4,2}$ represents {1, −1, 1, −1}, and $C_{4,3}$ represents {1, −1, −1, 1}.

67. The mobile station of claim **6**, further comprising means for generating $C_{4,1}$, $C_{4,2}$, $C_{4,3}$, and $C_{256,0}$.

68. The mobile station of claim **65** wherein the third one of the data channels is systematically spread with $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

69. An apparatus for a mobile communication system, wherein the apparatus is configured to use a plurality of data channels at least one control channel, comprising:

a first spreading unit configured to spread systematically a first one of the data channels by $C_{4,1}$;

a second spreading unit configured to spread systematically a second one of the data channels by $C_{4,1}$; and

a third spreading unit configured to spread systematically a third one of the data channels by $C_{4,3}$; wherein

$C_{4,1}$ is a first orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 1,

$C_{4,3}$ is a second orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 3, and

the first one of the data channels, the second one of the data channels, and the third one of the data channels are configured to be used when three and not more than three of the data channels are configured to be used.

70. The apparatus of claim **69**, further comprising:

a fourth spreading unit configured to spread the at least one control channel by $C_{256,0}$; wherein

$C_{256,0}$ is a third orthogonal variable spreading factor code with the spreading factor of 256 and the code number of 0.

71. The apparatus of claim **69**, further comprising

an in-phase branch and a quadrature-phase branch, wherein

at least the first one of the data channels and the third one of the data channels are coupled to the in-phase branch, and

at least the second one of the data channels and the at least one control channel are coupled to the quadrature-phase branch.

72. The apparatus of claim **71**, further comprising:

a fifth spreading unit configured to spread systematically a fourth one of the data channels by $C_{4,3}$, wherein

the first one of the data channels, the second one of the data channels, the third one of the data channels, and the fourth one of the data channels are configured to be used when four and not more than four of the data channels are used, and

the fourth one of the data channels is coupled to the quadrature-phase branch.

73. The apparatus of claim **72**, further comprising:

a sixth spreading unit configured to spread systematically a fifth one of the data channels by $C_{4,2}$; and

a seventh spreading unit configured to spread systematically a sixth one of the data channels by $C_{4,2}$, wherein C_{42} is a first orthogonal variable spreading factor code with the spreading factor of 4 and the code number of 2,

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, and the fifth one of the data channels are configured to be used when five and not more than five of the data channels are configured to be used,

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, the fifth one of the data channels, and the sixth one of the data channels are configured to be used when six of the data channels are configured to be used,

the fifth one of the data channels is coupled to the in-phase branch, and

the sixth one of the data channels is coupled to the quadrature-phase branch.

74. The mobile station of claim **73**, further comprising:

a spreading code generation unit configured to generate $C_{4,1}$, $C_{4,2}$, $C_{4,3}$, and $C_{256,0}$.

75. The apparatus of claim **69** where the third one of the data channels data is systematically spread with $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

76. A mobile station, wherein the mobile station is configured to use a plurality of data channels and at least one control channel, comprising:

an allocation unit configured to allocate first data to a first one of the data channels, second data to a second one of the data channels, third data to a third one of the data channels, fourth data to a fourth one of the data channels, fifth data to a fifth one of the data channels, and sixth data to a sixth one of the data channels, and control data to the at least one control channel, respectively;

a first multiplier configured to multiply systematically the first data by $C_{4,1}$;

a second multiplier configured to multiply systematically the second data by $C_{4,1}$;

a third multiplier configured to multiply systematically the third data by $C_{4,3}$;

a fourth multiplier configured to multiply systematically the fourth data by $C_{4,3}$;

a fifth multiplier configured to multiply systematically the fifth data by $C_{4,2}$;

a sixth multiplier configured to multiply systematically the sixth data by $C_{4,2}$; and

a seventh multiplier configured to multiply the control data by $C_{256,0}$, wherein

the first one of the data channels and the second one of the data channels are configured to be used when two and not more than two of the data channels are used,

the first one of the data channels, the second one of the data channels, and the third one of the data channels are configured to be used when three and not more than three of the data channels are configured to be used,

the first one of the data channels, the second one of the data channels, the third one of the data channels, and the fourth one of the data channels are configured to be used when four and not more than four of the data channels are used,

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, and the fifth one of the data channels are configured to be used when five and not more than five of the data channels are configured to be used, and

the first one of the data channels, the second one of the data channels, the third one of the data channels, the fourth one of the data channels, the fifth one of the data channels, and the sixth one of the data channels are configured to be used when six of the data channels are configured to be used, and

$C_{I,K}$ represents an orthogonal variable spreading factor code, I being a spreading factor and K being a code number, wherein $0 \leqq K < I$.

77. The mobile station of claim **76**, further comprising:

an in-phase branch and a quadrature-phase branch, wherein

at least the first one of the data channels, the third one of the data channels, and the fifth one of the data channels are coupled to the in-phase branch, and

at least the at least one control channel and the second one of the data channels, the fourth one of the data channels, and the sixth one of the data channels are coupled to the quadrature-phase branch.

78. The mobile station of claim **77**, further comprising:

a spreading code generation unit configured to generate $C_{4,1}$, $C_{4,2}$, $C_{4,3}$, and $C_{256,0}$.

79. The mobile station of claim **76**, wherein $C_{4,1}$ represents $\{1, 1, -1, -1\}$, $C_{4,2}$ represents $\{1, -1, 1, -1\}$, and $C_{4,3}$ represents $\{1, -1, -1, 1\}$.

80. The mobile station of claim **76** wherein the third multiplier systematically multiplies the third data by $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

81. An apparatus for a mobile communication system, wherein the apparatus is configured to use a plurality of data channels and at least one control channel, comprising:

an allocation unit configured to allocate first data to a first one of the data channels, second data to a second one of the data channels, and third data to a third one of the data channels; and

a multiplying unit configured to multiply systematically the first data by $C_{4,1}$, the second data by $C_{4,1}$, and the third data by $C_{4,3}$, wherein

the first one of the data channels, the second one of the data channels, and the third one of the data channels are configured to be used when three and not more than three of the data channels are used, and

$C_{I,K}$ represents an orthogonal variable spreading factor code, I being a spreading factor and K being a code number, wherein 0≦K<I.

82. The apparatus of claim **81**, further comprising:

an in-phase branch and a quadrature-phase branch, wherein

at least the first one of the data channels and the third one of the data channels are coupled to the in-phase branch, and

at least the second one of the data channels is coupled to the quadrature-phase branch.

83. The apparatus of claim **81**, wherein

the allocation unit is further configured to allocate control data to the at least one control channel, and

the spreading unit is further configured to spread the control data by $C_{256,0}$.

84. The apparatus of claim **83**, further comprising:

an in-phase branch and a quadrature-phase branch, wherein

at least the first one of the data channels and the third one of the data channels are coupled to the in-phase branch, and

at least one control channel and the second one of the data channels are coupled to the quadrature-phase branch, wherein

the apparatus is configured to use the data channels such that the data channels are spread by one or more orthogonal variable spreading factor codes.

85. The apparatus of claim **81** where the third data is multiplied by $C_{4,3}$ instead of $C_{4,2}$ to reduce the peak to average power ratio of the mobile station.

86. A mobile station, wherein the mobile station is configured to spread at least one or more data channels by one or more orthogonal variable spreading factor codes, comprising:

a spreading unit configured to spread systematically a first one of the data channels and a second one of the data channels by $C_{4,1}$, and to spread systematically a third one of the data channels by $C_{4,3}$, wherein

the first one of the data channels, the second one of the data channels, and the third one of the data channels are configured to be spread by the one or more orthogonal variable spreading factor codes when three and not more than three of the data channels are configured to be spread by one or more orthogonal variable spreading factor codes, and

$C_{I,K}$ represents one of the orthogonal variable spreading factor codes, I being a spreading factor and K being a code number, wherein 0≦K<I.

87. The mobile station of claim **86**, further comprising:

an in-phase branch, at least the first one of the data channels and the third one of the data channels being coupled to the in-phase branch, and

a quadrature-phase branch, at least the second one of the data channels being coupled to the quadrature-phase branch.

88. The mobile station of claim **87**, wherein

the spreading unit is further configured to spread a control channel, the control channel being coupled to the quadrature-phase branch.

89. The mobile station of claim **86** wherein the third one of the data channels is systematically spread by $C_{4,3}$ instead of C_{42} to reduce the peak to average power ratio of the mobile station.

90. A mobile station, wherein the mobile station is configured to use at least one or more data channels, comprising:

a first spreading unit configured to spread systematically at least a first one of the data channels by $C_{4,1}$ and a third one of the data channels by $C_{4,3}$; and

a second spreading unit configured to spread systematically at least a second one of the data channels by C_4, wherein

the first one of the data channels, the second one of the data channels, and the third one of the data channels are configured to be used when three and not more than three of the data channels are configured to be used, and

$C_{I,K}$ represents an orthogonal variable spreading factor code, I being a spreading factor and K being a code number, wherein 0≦K<I.

91. The mobile station of claim **90**, further comprising:

an in-phase branch, at least the first one of the data channels and the third one of the data channels being coupled to the in-phase branch, and

a quadrature-phase branch, at least the second one of the data channels being coupled to the quadrature-phase branch.

92. The mobile station of claim **91**, wherein

the second spreading unit is further configured to spread a control channel, the control channel being coupled to the quadrature-phase branch, and

the mobile station is configured to use the data channels such that the data channels are spread by the one or more orthogonal variable spreading factor codes.

93. The mobile station of claim **90** wherein the third one of the data channels is systematically spread by $C_{4,3}$ instead of C_{42} to reduce the peak to average power ratio of the mobile station.

94. A method for a mobile station, wherein the mobile station is capable of transmitting at least three data channels and at least one control channel, comprising:

systematically spreading a first one of the data channels by $C_{4,1}$;

systematically spreading a second one of the data channels by $C_{4,1}$; and

systematically spreading a third one of the data channels by $C_{4,3}$; wherein

when the mobile station transmits three and not more than three of the data channels, the first one of the data channels, the second one of the data channels, and the third one of the data channels are transmitted, and

$C_{I,K}$ represents an orthogonal variable spreading factor code, with I being a spreading factor and K being a code number, wherein 0≦K<I.

95. The method of claim **93**, wherein $C_{4,1}$ represents $\{1, 1, -1, -1\}$ and $C_{4,3}$ represents $\{1, -1, -1, 1\}$.

96. The method of claim **94**, further comprising:

spreading the at least one control channel by $C_{256,0}$.

97. The method of claim **96**, wherein

at least the first one of the data channels and the third one of the data channels are coupled to an in-phase branch, and

at least the at least one control channel and the second one of the data channels are coupled to a quadrature-phase branch.

98. The method of claim **96**, further comprising:

assigning the first one of the data channels and the third one of the data channels to an in-phase branch; and

assigning the at least one control channel and the second one of the data channels to a quadrature-phase branch.

* * * * *

EXHIBIT C

US005781861A

United States Patent [19]

Kang et al.

[11] **Patent Number: 5,781,861**

[45] **Date of Patent: Jul. 14, 1998**

[54] **METHOD FOR SHEDDING TRAFFIC LOAD IN CODE DIVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **H04B 7/26**

[52] **U.S. Cl.** **455/442**; 370/332

[58] **Field of Search** 455/422, 436, 455/437, 439, 438, 442, 69; 370/335, 331, 332, 333; 375/200

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Primary Examiner—Amelia Au

Attorney, Agent, or Firm—Nixon & Vanderhye P.C.

[57] **ABSTRACT**

A method for shedding traffic load in a code division multiple access mobile communication system, the method performing a soft handoff operation using the ratio of the received forward link pilot signal power to the sum of all interference signals power to transfer a portion of traffic load in the present serving cell with a high traffic density to an adjacent cell with a low traffic density. When the amount of traffic load in the present serving cell is increased and thus exceeds a link capacity of the present serving cell, handoff parameters of all mobile stations in the present serving cell can be updated on the basis of a power allocation state managed by a base station without reducing the coverage of a forward link. On the basis of the updated handoff parameters, the soft handoff operation is performed from a part of the mobile stations in the present serving cell with the high traffic density (for example, mobile stations at the edge of the present serving cell) to the adjacent cell with the low traffic density. Therefore, the excessive traffic load amount in the present serving cell can effectively be shed.

6 Claims, 3 Drawing Sheets

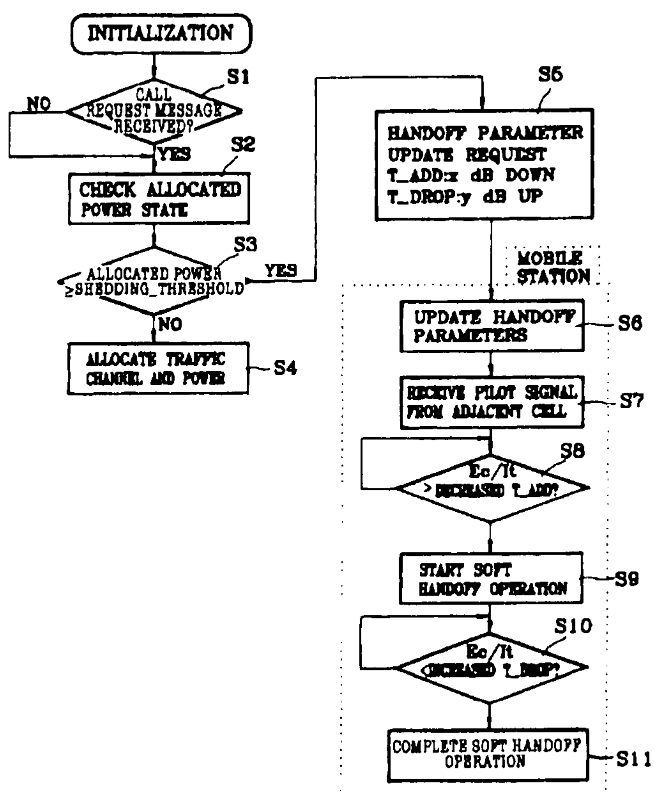


FIG. 1

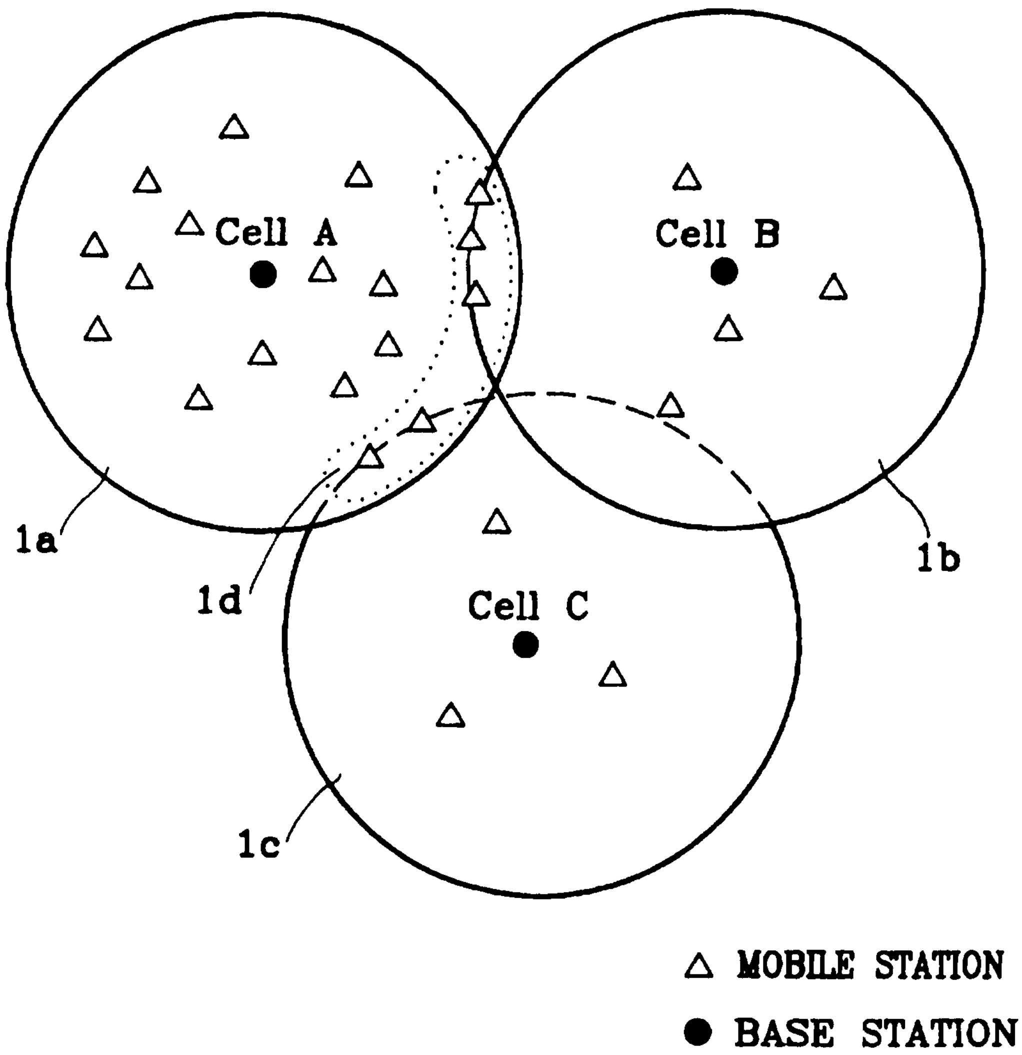


FIG. 2

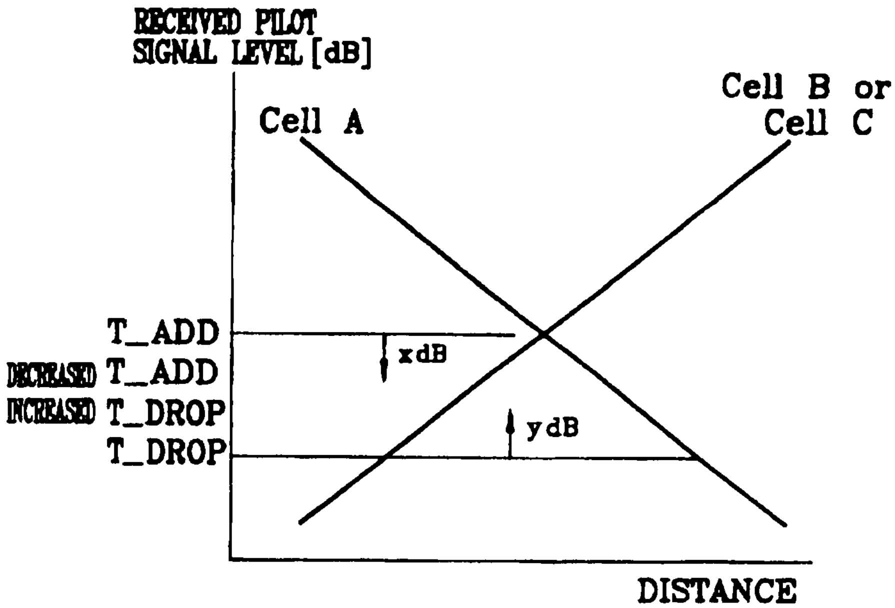

RECEIVED PILOT
SIGNAL LEVEL [dB]
Cell A
Cell B or
Cell C
T_ADD
DECREASED T_ADD
INCREASED T_DROP
T_DROP
xdB
ydB
DISTANCE

FIG. 3

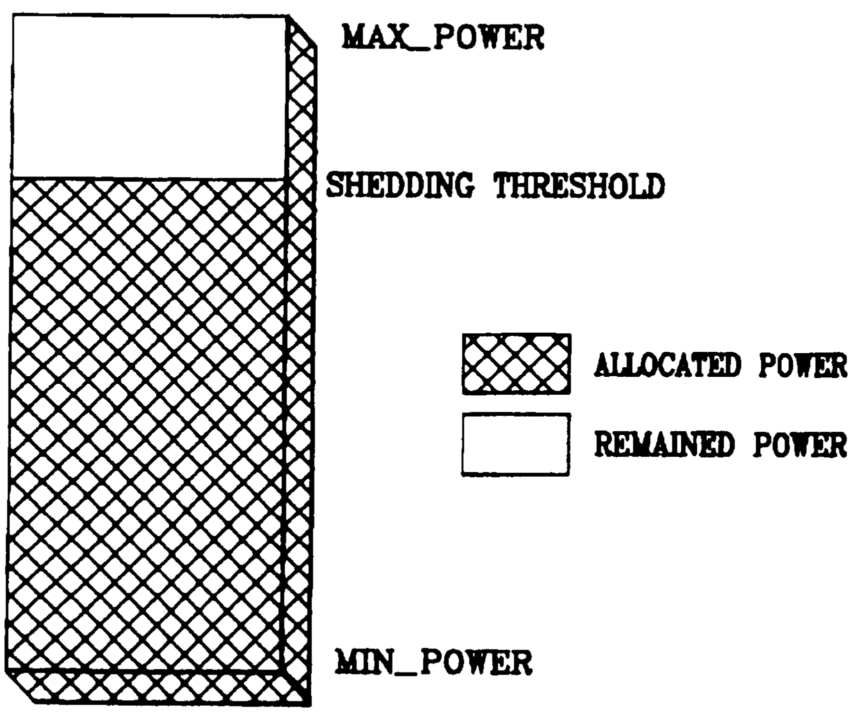
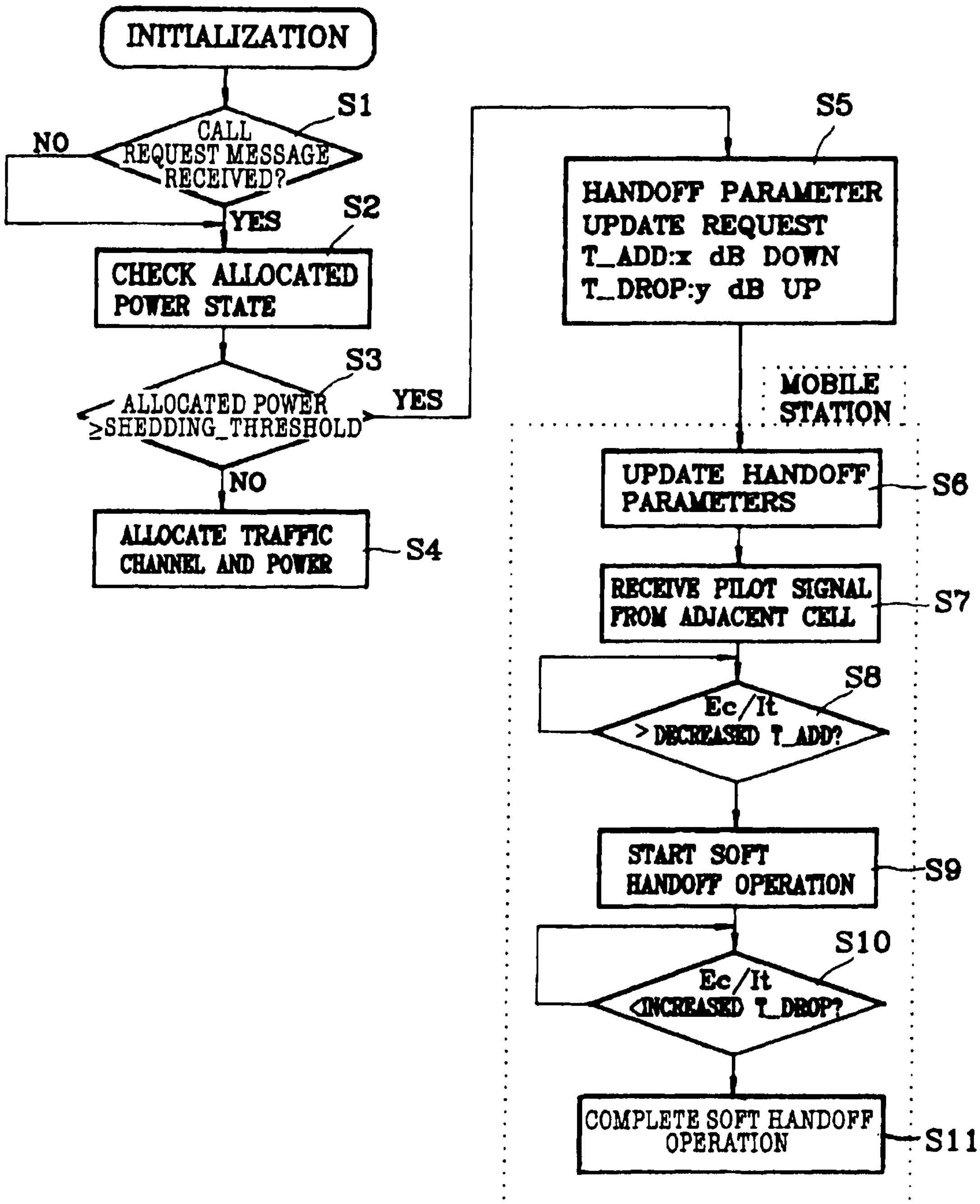

MAX_POWER
SHEDDING THRESHOLD
ALLOCATED POWER
REMAINED POWER
MIN_POWER

FIG. 4


INITIALIZATION
S1
CALL REQUEST MESSAGE RECEIVED?
NO
YES
S2
CHECK ALLOCATED POWER STATE
S3
ALLOCATED POWER ≥SHEDDING_THRESHOLD
YES
NO
ALLOCATE TRAFFIC CHANNEL AND POWER
S4
S5
HANDOFF PARAMETER UPDATE REQUEST T_ADD:x dB DOWN T_DROP:y dB UP
MOBILE STATION
UPDATE HANDOFF PARAMETERS
S6
RECEIVE PILOT SIGNAL FROM ADJACENT CELL
S7
S8
Ec/It > DECREASED T_ADD?
START SOFT HANDOFF OPERATION
S9
S10
Ec/It <INCREASED T_DROP?
COMPLETE SOFT HANDOFF OPERATION
S11

METHOD FOR SHEDDING TRAFFIC LOAD IN CODE DIVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates in general to shedding traffic load in a code division multiple access (referred to hereinafter as CDMA) mobile communication system, and more particularly to a method for shedding traffic load in a CDMA mobile communication system, which is capable of, when the amount of traffic load in a specified cell is excessively increased by mobile subscribers and the amount of traffic load in an adjacent cell is small, performing a soft handoff operation from the specified cell to the adjacent cell to transfer a portion of the excessive traffic load in the specified cell to the adjacent cell, so that the excessive traffic load in the specified cell can effectively be shed.

2. Description of the Prior Art

Generally, in a CDMA mobile communication system, there are provided forward CDMA channels such as a pilot channel, control channels and traffic channels. The pilot channel is used to determine the coverage of a forward link (base station→mobile station) and to allow the mobile station to demodulate information received from the base station. The control channels are used to allow the base station to transfer information necessary to the call setup with the mobile station. The traffic channel is used for the transfer of data such as voice information between the base station and mobile station.

The base station allocates desired powers to the forward CDMA channels so that the radio channels can reach the corresponding receivers at their proper signal levels. At this time, the powers to the pilot and control channels are maintained constant. But, the power to the traffic channel is adjusted due to channel environmental variations resulting from the movement of the communicating mobile station and multipath propagation, etc.

As a result, the base station allocates the power only to the control channel when no traffic load is present in a cell managed thereby. In this case, the base station allocates the minimum power Min_power as will be mentioned later with reference to FIG. 3. As the amount of traffic load is increased in the cell, the base station increases the power to the traffic channels necessary to the communication with a plurality of mobile stations.

On the other hand, in the CDMA mobile communication system, the base station allocates a forward traffic channel and the associated power to the new arrived mobile call.

Referring to FIG. 2, a communicating mobile station in the present serving cell may receive a pilot signal from an adjacent cell as it moves to the adjacent cell. At this time, the communicating mobile station measures Ec/It, the ratio of the received pilot signal power to the sum of all interference signals power and compares the Ec/It with a handoff start threshold value T_ADD. If the measured Ec/It exceeds the handoff start threshold value T_ADD, the mobile station transmits a specified message to the serving cell to inform it of an identifier of the adjacent cell and the measured Ec/It. As a result, a soft handoff operation is started. The "soft handoff" signifies the switching of a traffic(communication) channel between cells with the same frequency. On the other hand, "softer handoff" signifies the swiching of a communication channel between sectors with the same frequency in the same cell.

On the other hand, when the Ec/It in the serving cell falls below a handoff complete threshold value T_DROP, the mobile station informs the present serving cell of such a situation in the same manner as mentioned above. As a result, the soft handoff operation is completed.

Referring to FIG. 1, when the traffic load in a specified one CELL A 1*a* among a plurality of cells in a mobile communication network is increased and thus exceeds a link capacity of the specified cell CELL A 1*a*, namely, when allocatable resources (traffic code channels, traffic channel power and etc.) are not enough in the specified cell CELL A 1*a*, the specified cell CELL A 1*a* blocks a new subscriber call or drops a handed-over call from the adjacent cell. As a result, the entire system performance is degraded.

Further, in the case where mobile stations at the edge of the specified cell CELL A 1*a* with the high traffic density receive a pilot signal from an adjacent cell CELL B 1*b* or CELL C 1*c* with a low traffic density and the Ec/It received from the adjacent cell CELL B 1*b* or cell C 1*c* is below the handoff start threshold value T_ADD, the soft handoff operation cannot be performed from the mobile stations to the adjacent cell CELL B 1*b* or CELL C 1*c*.

SUMMARY OF THE INVENTION

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a method for shedding traffic load in a CDMA mobile communication system, which is capable of, when the amount of traffic load in a specified cell is increased and thus exceeds a link capacity of the specified cell, performing a soft handoff operation from a part of communicating mobile stations in the specified cell to an adjacent cell with a low traffic density on the basis of a power allocation state managed by a base station without reducing the coverage of a forward link, so that the excessive traffic load amount in the specified cell can effectively be shed.

In accordance with the present invention, the above and other objects can be accomplished by a provision of a method for shedding traffic load in a code division multiple access mobile communication system, the method performing a soft handoff operation using the ratio of power of a forward link pilot signal to the sum of powers of all interference signals to transfer a portion of traffic load in the present serving cell with a high traffic density to an adjacent cell with a low traffic density, comprising the first step of checking the total amount of power allocated to forward CDMA channels and requesting all mobile stations in the present serving cell to update first and second handoff parameters, if the total amount of allocated power exceeds a threshold value of power which can be allocated to the mobile stations in the present serving cell; the second step of updating the first handoff parameters of the mobile stations by decreasing them by a first predetermined value received from a network and the second handoff parameters of the mobile stations by increasing them by a second predetermined value received from the network and starting the soft handoff operation from a part of the mobile stations in the present serving cell to the adjacent cell if the ratio of power of a pilot signal received from the adjacent cell to the sum of powers of all interference signals is higher than the updated first handoff parameter; and the third step of the soft handoff completion from the part of the mobile stations in the present serving cell to the adjacent cell if the ratio of power of a pilot signal received from the present serving cell to the sum of powers of all interference signals is lower than the updated second handoff parameter; whereby the amount of traffic load in the present serving cell with the high traffic density can effectively be shed to the adjacent cell with the low traffic density.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view illustrating the traffic distribution by cells and the traffic load shedding;

FIG. 2 is a view illustrating the relation between a distance and a received pilot signal level for the handoff request by a mobile station;

FIG. 3 is a view illustrating a forward link power allocation state and a threshold value of power which one base station can allocate to mobile stations managed thereby; and

FIG. 4 is a flowchart illustrating a method for shedding traffic load in a CDMA mobile communication system in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a view illustrating the traffic distribution by cells and the traffic load shedding. In this drawing, a cell CELL A 1*a* has a relatively high traffic density, whereas adjacent cells CELL B 1*b* and CELL C 1*c* have a relatively low traffic density.

FIG. 2 is a view illustrating the relation between a distance and a received pilot signal level for the handoff determination (request) by a mobile station. In this drawing, "T_ADD" designates a handoff start threshold value which is received from a network and set by a mobile station, "Decreased T_ADD" designates a handoff start threshold value obtained by decreasing the handoff start threshold value T_ADD by a predetermined value received from the network. "T_DROP" designates a handoff complete threshold value which is received from the network and set by the mobile station and "Increased T_DROP" designates a handoff complete threshold value obtained by increasing the handoff complete threshold value T_DROP by a predetermined value received from the network.

FIG. 3 is a view illustrating a forward link power allocation state and a threshold value Shedding_Threshold of power which one base station can allocate to mobile stations managed thereby. In this drawing, "Min_power" designates the minimum value of power which the base station allocates to forward CDMA channels and "Max_Power" designates the maximum value of power which the base station allocates to the forward CDMA channels.

Now, a method for shedding traffic load in a CDMA mobile communication system in accordance with the present invention will hereinafter be described in detail with reference to FIGS. 1 to 4.

FIG. 4 is a flowchart illustrating the method for shedding traffic load in the CDMA mobile communication system in accordance with the present invention. First, the base station checks at the first step S1 whether a call request message from a new mobile station in the CDMA mobile communication system has been received. If it is checked at the first step S1 that the call request message from the new mobile station in the CDMA mobile communication system has been received, the base station checks the total amount of power previously allocated to the present traffic channels, at the second step S2. Then, the base station checks at the third step S3 whether the total amount of allocated power checked at the second step S2 has reached the allocatable power threshold value Shedding_Threshold.

If it is checked at the third step S3 that the total amount of allocated power checked at the second step S2 has not reached the allocatable power threshold value Shedding_Threshold, the base station allocates a new traffic channel and power to the new mobile station at the fourth step S4. To the contrary, in the case where it is checked at the third step S3 that the total amount of allocatable power checked at the second step S2 has reached the allocated power threshold value Shedding_Threshold, the base station requests all mobile stations in the present serving cell (for example, CELL A 1*a*) to update their previously set handoff parameters (handoff start threshold value T_ADD and handoff complete threshold value T_DROP), at the fifth step S5. Namely, when power cannot be allocated according to a new call request or a handoff call request in the present serving cell, the base station requests all mobile stations in the present serving cell to update their previously set handoff parameters.

At the sixth step S6, each mobile station updates its previously set handoff parameters in response to the handoff parameter update request from the base station in the present serving cell (for example, CELL A 1*a*).

At the seventh step S7, each mobile station in the cell CELL A 1*a* receives a pilot signal from the adjacent cell (for example, CELL B 1*b* or CELL C 1*c*).

At the eighth step S8, each mobile station in the cell CELL A 1*a* measures the ratio of the received pilot signal power to the sum of all interference signals power(Ec/It) and compares the measured Ec/It with the handoff start threshold value Decreased T_ADD obtained by decreasing the handoff start threshold value T_ADD by the predetermined value received from the network.

At the ninth step S9, in the case where the measured Ec/It is higher than the handoff start threshold value Decreased T_ADD at the eighth step S8, the soft handoff operation is started from a part of the mobile stations in the cell CELL A 1*a* with the high traffic density (for example, mobile stations at the edge of the cell CELL A 1*a*, designated by the reference numeral 1*d* in FIG. 1) to the adjacent cell CELL B 1*b* or CELL C 1*c* with the low traffic density.

At the tenth step S10, each mobile station 1*d* at the edge of the cell CELL A 1*a* measures the Ec/It of the pilot signal received from the cell CELL A 1*a* to the sum of all interference signals power and checks whether the measured Ec/It is lower than the handoff complete threshold value Increased T_DROP obtained by increasing the handoff end threshold value T_DROP by the predetermined value received from the network. If it is checked at the tenth step S10 that the measured Ec/It is lower than the handoff complete threshold value Increased T_DROP, the soft handoff operation is completed at the eleventh step S11 from the mobile stations id at the edge of the cell CELL A 1*a* to the adjacent cell CELL B 1*b* or CELL C 1*c*.

The method for shedding traffic load in the CDMA mobile communication system in accordance with the present invention will hereinafter be described in more detail.

First, the base station checks at the first step S1 whether a call request message from a new mobile station in the CDMA mobile communication system has been received. Among the radio associated resources managed by the base station, power to be allocated to the forward CDMA channels is limited, whereas the traffic channels are sufficient. In other words, the power is limited because the excessive power allocation may cause a hardware (RF device) of the base station to be in saturation and generate interference signals to mobile stations in the adjacent cells CELL B **1***b* and CELL C **1***c*.

For this reason, at the second step S2, a resource manager (not shown) in the base station checks the total amount of power previously allocated to the present traffic channels, when the traffic channel power is allocated for a new call request or a handoff call request, or at an interval of predetermined time. Here, the total amount of power checked by the base station resource manager is the sum of powers which the base station allocates to traffic channels and other forward DCMA channels.

Then, the base station checks at the third step S3 whether the total amount of allocated power checked at the second step S2 is greater than or equal to the allocatable power threshold value Shedding_Threshold. If it is checked at the third step S3 that the total amount of allocated power checked at the second step S2 is not greater than or equal to the allocatable power threshold value Shedding_Threshold, the base station allocates a new traffic channel and the associated power to the new mobile station at the fourth step S4.

However, in the case where it is checked at the third step S3 that the total amount of allocated power checked at the second step S2 is greater than or equal to the allocatable power threshold value Shedding_Threshold, namely, when the base station cannot allocate power according to a new call request or a handoff call request in the cell CELL A **1***a* with the increased traffic density, the base station requests all mobile stations in the cell CELL A **1***a* to update their previously set handoff parameters in the following manner, at the fifth step S5.

Namely, the base station instructs each mobile station to decrease the handoff start threshold value T_ADD by a predetermined value (x dB:FIG. **3**) received from a network as shown in FIG. **2** to produce the handoff start threshold value Decreased T_ADD and to increase the handoff complete threshold value T_DROP by a predetermined value (y dB: FIG. **3**) received from the network as shown in FIG. **2** to produce the handoff complete threshold value Decreased T_DROP.

As a result, at the sixth step S6, all the mobile stations in the cell CELL A **1***a* with the traffic density higher than that of the adjacent cells CELL B **1***b* and CELL C **1***c* update their previously set handoff parameters according to the values received from the network.

On the other hand, among the handoff parameters, the handoff start threshold value T_ADD is compared with the ratio Ec/It of the received forward link pilot signal power from the adjacent cell CELL B **1***b* or CELL C **1***c* to the sum of all interference signals power. In the case where the ratio Ec/It of the received pilot signal power at the seventh step S7 to the sum of all interference signals power is lower than the handoff start threshold value T_ADD, the corresponding mobile station cannot request the base station to perform the soft handoff operation.

For this reason, the handoff start threshold value Decreased T_ADD obtained by decreasing the handoff start threshold value T_ADD by the predetermined value received from the network is used as a new handoff start threshold value to be compared with the ratio Ec/It of the received pilot signal power to the sum of all interference signals power at the eighth step S8. As a result, at the ninth step S9, the soft handoff operation is more rapidly started from the mobile stations **1***d* at the edge of the cell CELL A **1***a* to the adjacent cell CELL B **1***b* or CELL C **1***c* without increasing the pilot channel power in the adjacent cell CELL B **1***b* or CELL C **1***c*.

Similarly, in order to complete the soft handoff operation, namely, to perform the complete switching to the communication channel of the adjacent cell CELL B **1***b* or CELL C **1***c*, the ratio Ec/It of the forward link pilot signal received from the busy cell CELL A **1***a* to the sum of all interference signals power must be lower than the handoff complete threshold value T_DROP in the mobile station.

For this reason, the handoff complete threshold value Increased T_DROP obtained by increasing the handoff complete threshold value T_DROP by the predetermined value received from the network is used as a new handoff complete threshold value to compared with the ratio Ec/It of power of the received pilot signal power to the sum of powers of all interference signals power at the tenth step S10. As a result, at the eleventh step S11, the soft handoff operation is more rapidly completed from the mobile stations **1***d* at the edge of the cell CELL A **1***a* to the adjacent cell CELL B **1***b* or CELL C **1***c* without increasing the forward link pilot channel power in the cell CELL A **1***a*.

Noticeably, in the case where the handoff start threshold value T_ADD and the handoff complete threshold value T_DROP are the same, they are adjusted in such a manner that the soft handoff operation can be rapidly started and completed at a lower signal level.

As apparent from the above description, according to the present invention, when the amount of traffic load in a specified cell is increased and thus exceeds a link capacity of the specified cell, handoff parameters of all mobile stations in the specified cell can be updated on the basis of a power allocation state managed by a base station without reducing the coverage of a forward link. On the basis of the updated handoff parameters, the soft handoff operation is performed from a part of the mobile stations in the specified cell with the high traffic density (for example, mobile stations at the edge of the specified cell) to an adjacent cell with the low traffic density. Therefore, the excessive traffic load amount in the specified cell can effectively be shed.

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

What is claimed is:

1. A method for shedding traffic load in a code division multiple access mobile communication system, said method performing a soft handoff operation using the ratio of a forward link pilot signal power to the sum of all interference signals power to transfer a portion of traffic load in the present serving cell with a high traffic density to an adjacent cell with a low traffic density, comprising the steps of:

(a) checking the total amount of power allocated to forward code division multiple access channels and requesting all mobile stations in the present serving cell to update first and second handoff parameters, if the total amount of allocated power exceeds a threshold value of power which can be allocated to said mobile stations in the present serving cell;

(b) updating the first handoff parameters of said mobile stations by decreasing them by a first predetermined value received from a network and the second handoff parameters of said mobile stations by increasing them by a second predetermined value received from said network and starting the soft handoff operation from a part of said mobile stations in the present serving cell to the adjacent cell if the a pilot signal power received from the adjacent cell to the sum of powers of all interference signals power is higher than said updated first handoff parameter; and

(c) completing the soft handoff operation from said part of said mobile stations in the present serving cell to the adjacent cell if the ratio of the a pilot signal power received from the present serving cell to the sum of all interference signals power is lower than said updated second handoff parameter;

whereby the amount of traffic load in the present serving cell with the high traffic density can effectively be shed to the adjacent cell with the low traffic density.

2. A method for shedding traffic load in a code division multiple access mobile communication system, as set forth in claim 1, wherein said step (a) includes the steps of:

(a-1) checking whether a call request message from a new mobile station in the code division multiple access mobile communication system has been received;

(a-2) checking the total amount of power previously allocated to the present traffic channels, if it is checked at said step (a-1) that the call request message from the new mobile station in the code division multiple access mobile communication system has been received;

(a-3) checking whether the total amount of allocated power checked at said step (a-2) has reached the threshold value of power which can be allocated to said mobile stations in the present serving cell;

(a-4) allocating a new traffic channel and power to the new mobile station if it is checked at said step (a-3) that the total amount of allocated power checked at the said step (a-2) has not reached the allocatable power threshold value; and

(a-5) requesting said mobile stations in the present serving cell to update the first and second handoff parameters, if it is checked at said step (a-3) that the total amount of allocated power checked at the said step (a-2) has reached the allocatable power threshold value.

3. A method for shedding traffic load in a code division multiple access mobile communication system, as set forth in claim 2, wherein said step (a-2) includes the step of checking the total amount of power previously allocated to the present traffic channels, when the traffic channel power is allocated for a new call request or a handoff call request, or at an interval of predetermined time.

4. A method for shedding traffic load in a code division multiple access mobile communication system, as set forth in claim 2, wherein said step (a-5) includes the step of requesting said mobile stations in the present serving cell to update the first and second handoff parameters, when power cannot be allocated according to a new call request or a handoff call request in the present serving cell.

5. A method for shedding traffic load in a code division multiple access mobile communication system, as set forth in claim 1, wherein said step (b) includes the steps of:

(b-1) updating the first handoff parameters of said mobile stations by decreasing them by the first predetermined value received from said network and the second handoff parameters of said mobile stations by increasing them by the second predetermined value received from said network;

(b-2) receiving the pilot signal from the adjacent cell;

(b-3) detecting the ratio of power of the pilot signal received at said step (b-2) to the sum of powers of all interference signals;

(b-4) checking whether the ratio detected at said step (b-3) is higher than said updated first handoff parameter; and

(b-5) starting the soft handoff operation from said part of said mobile stations in the present serving cell to the adjacent cell if it is checked at said step (b-4) that the ratio detected at said step (b-3) is higher than said updated first handoff parameter.

6. A method for shedding traffic load in a code division multiple access mobile communication system, as set forth in claim 1, wherein said step (c) includes the steps of:

(c-1) receiving the pilot signal from the present serving cell;

(c-2) detecting the ratio of power of the pilot signal received at said step (c-1) to the sum of powers of all interference signals;

(c-3) checking whether the ratio detected at said step (c-2) is lower than said updated second handoff parameter; and

(c-4) completing the soft handoff operation from said part of said mobile stations in the present serving cell to the adjacent cell if it is checked at said step (c-3) that the ratio detected at said step (c-2) is lower than said updated second handoff parameter.

* * * * *

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(12) **United States Patent**
Jeon et al.

(10) **Patent No.: US 6,377,563 B1**
(45) **Date of Patent: Apr. 23, 2002**

(54) **METHOD FOR HANDOFFING IN A CODE DEVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM**

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(51) **Int. Cl.**[7] **H04B 7/216**
(52) **U.S. Cl.** **370/335**; 370/331
(58) **Field of Search** 370/335, 331, 370/332, 333, 342, 329, 334, 441, 479, 277; 375/130, 134, 135, 136, 137, 140, 146, 147; 455/436, 439, 440, 442, 443, 456, 437, 520, 525

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Assistant Examiner—Phirin Sam
(74) *Attorney, Agent, or Firm*—Cohen, Pontani, Lieberman & Pavane

(57) **ABSTRACT**

This invention is directed to a method for increasing the probability of the success of handoff service in a mobile communication system. The present invention provides a handoff method for improving the talk quality in which a probability of the handoff success is raised and a probability of a call outage to disconnect a busy call is reduced. A handoff method of the present invention comprises the steps of a first step of requesting a handoff service repeatedly with a regular interval based on a timer from a mobile station to a service base station until the mobile station received the handoff service if a pilot strength of a neighboring base station is greater than a base station pilot strength value (T-ADD) when the mobile station enters a handoff service region; and a second step of holding back a new call service in the neighboring base station if the mobile station requesting the handoff service does not receive the handoff service and assigning a released channel to the mobile station requesting repeatedly the handoff service released call is present.

5 Claims, 3 Drawing Sheets

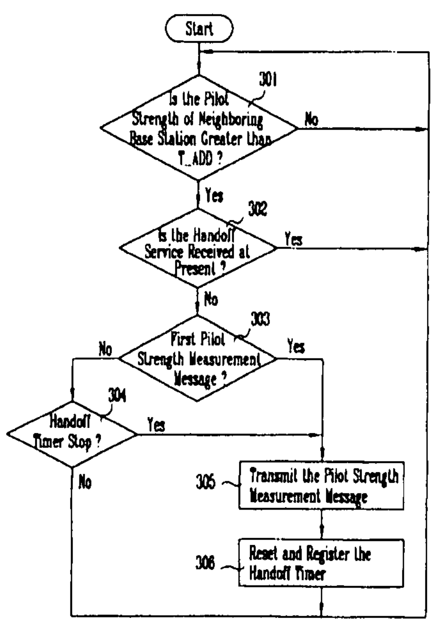
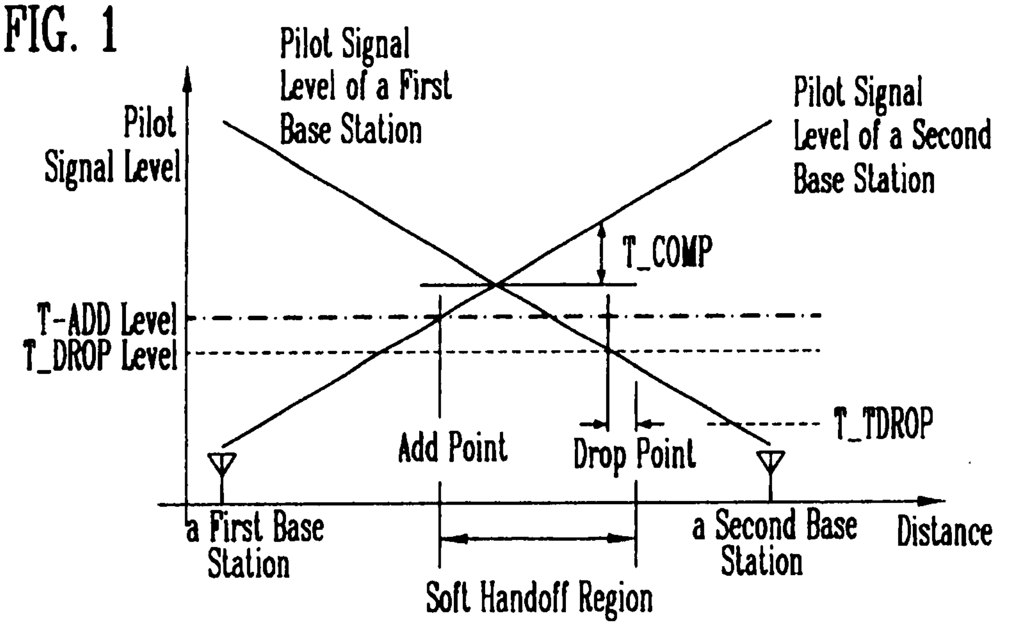
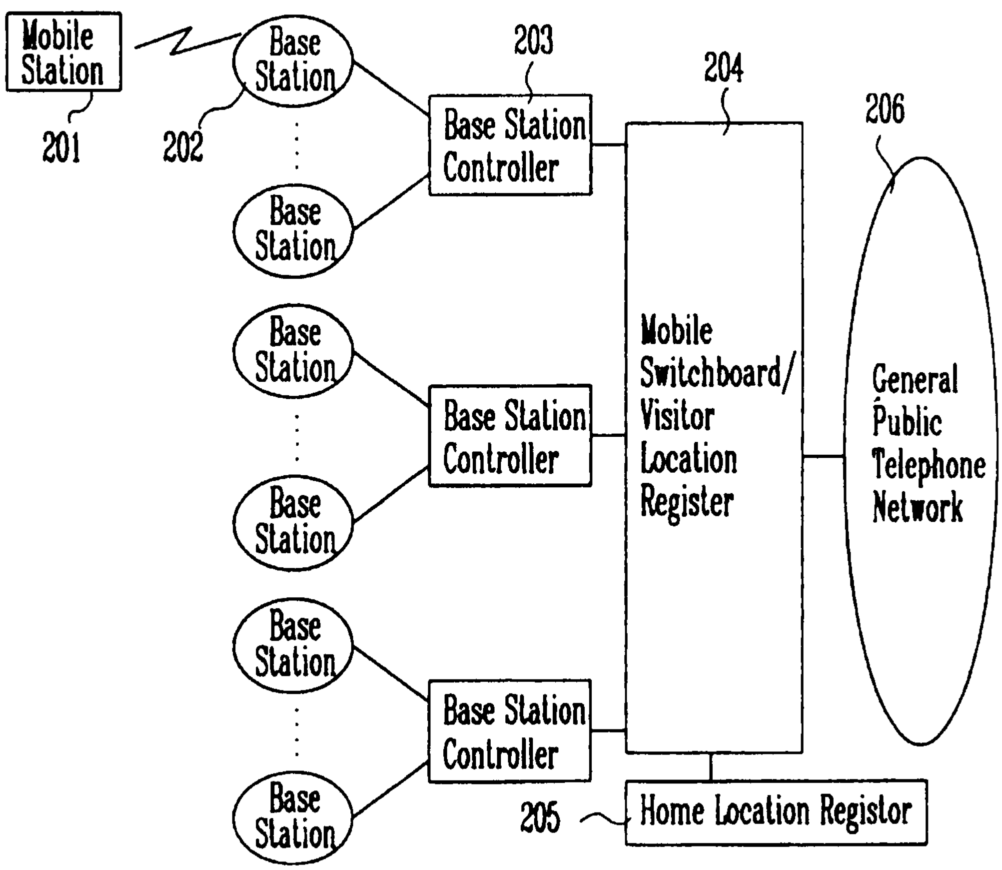


FIG. 1



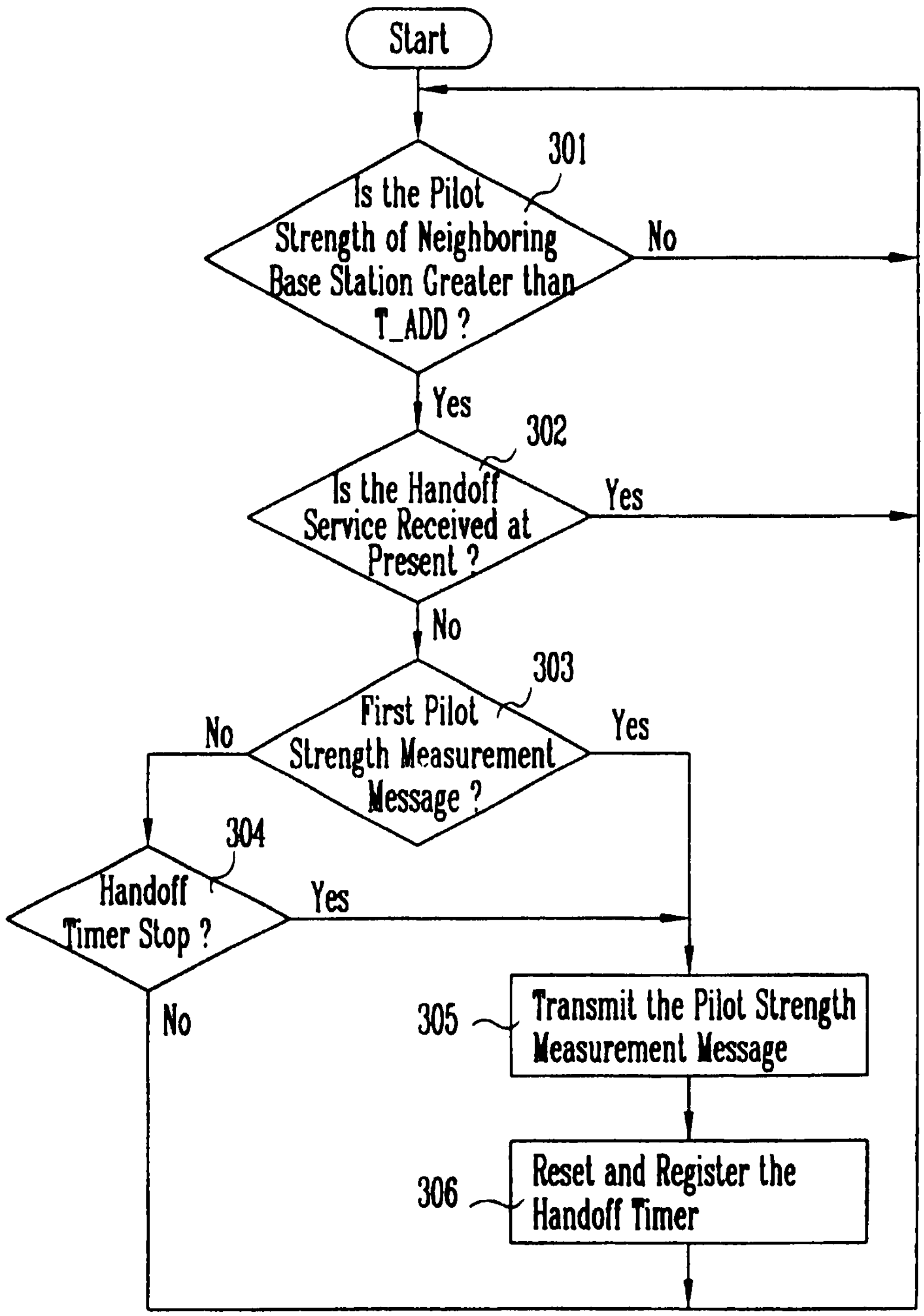
Pilot Signal Level of a First Base Station
Pilot Signal Level of a Second Base Station
Pilot Signal Level
T_COMP
T-ADD Level
T_DROP Level
T_TDROP
Add Point
Drop Point
a First Base Station
a Second Base Station
Distance
Soft Handoff Region

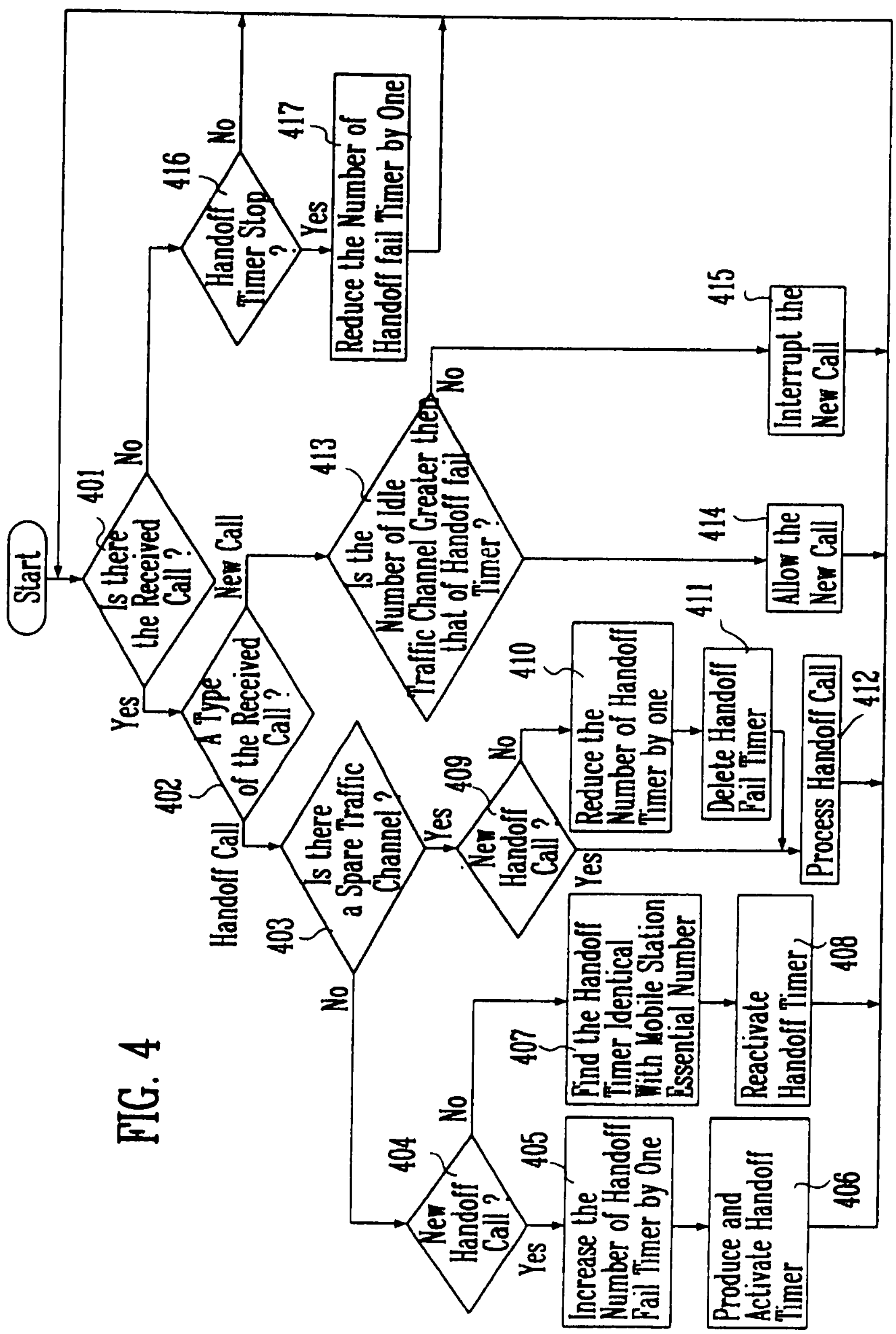
FIG. 2



Mobile Station
201
202
Base Station
Base Station
Base Station
Base Station
Base Station
Base Station
203
Base Station Controller
Base Station Controller
Base Station Controller
204
Mobile Switchboard/ Visitor Location Register
206
General Public Telephone Network
205
Home Location Registor

FIG. 3


Start
Is the Pilot Strength of Neighboring Base Station Greater than T_ADD ?
301
No
Yes
Is the Handoff Service Received at Present ?
302
Yes
No
First Pilot Strength Measurement Message ?
303
No
Yes
Handoff Timer Stop ?
304
Yes
No
305
Transmit the Pilot Strength Measurement Message
306
Reset and Register the Handoff Timer



Start
401
Is there the Received Call ?
Yes
No
402
A Type of the Received Call ?
Handoff Call
New Call
403
Is there a Spare Traffic Channel ?
Yes
No
404
New Handoff Call ?
Yes
No
405
Increase the Number of Handoff Fail Timer by One
406
Produce and Activate Handoff Timer
407
Find the Handoff Timer Identical With Mobile Station Essential Number
408
Reactivate Handoff Timer
409
New Handoff Call ?
Yes
No
410
Reduce the Number of Handoff Timer by one
411
Delete Handoff Fail Timer
412
Process Handoff Call
413
Is the Number of Idle Traffic Channel Greater then that of Handoff fail Timer ?
No
414
Allow the New Call
415
Interrupt the New Call
416
Handoff Timer Stop ?
Yes
No
417
Reduce the Number of Handoff fail Timer by One

FIG. 4

METHOD FOR HANDOFFING IN A CODE DEVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a Code Division Multiple Access (CDMA) mobile communication system, and more particularly, to a method for increasing the probability of the success of handoff service in the CDMA mobile communication system in which, when a mobile station enter a handoff service region, the mobile station continue to transmit with a regular interval a pilot strength measurement message (PSMM) to a base station to request a handoff service until the mobile station receives the handoff service if it does not so during its stay within the handoff service region and the base station holds back a new call service and assigns a released channel to the mobile station requesting repeatedly the handoff service if a released call is present.

2. Description of the Related Art service provided in a DS-CDMA (Direct Sequence-CDMA) implemented based on a IS-95 (International Standard-95) includes a soft handoff process and a hard handoff process.

The soft handoff process is a process that a mobile station is assigned simultaneously with traffic channels from two base stations while the mobile station is located between an in-service base station and its neighboring base stations. On the other hands, the hard handoff process is to be used when the frequency used in the in-service base station is different from that used in the neighboring base stations.

Such conventional handoff processes have been developed for the improvement of the voice quality over an analog process by introducing a soft handoff technique among sectors, among base stations, and among controllers of the base stations.

FIG. 1 is a diagram for explaining a relation of a pilot strength level to a distance between the base stations in the CDMA cellular system, wherein, as the mobile station moves from a service (or original) base station to a neighboring base station, the strength of the pilot signal from the service base station is reduced but the strength of the pilot signal from the neighboring base station is increased.

The pilot strength measurement message (PSMM) is a message for the measurement of the strength of the pilot signal received by a base station/base station controller from the mobile station and a handoff direction message (HDM) is a message used when the base station/base station controller requests the handoff to the mobile station.

A handoff completion message is a message which the mobile station transmits to the base station/base station controller and used for an acknowledge of the handoff direction message (HDM).

Parameters for the measurement of the pilot strength are as follows:

T_ADD is a value of the pilot strength required for the pilot signal to be a candidate set.

The mobile station transmits the PSMM message to the base station when the pilot strength of the candidate set is more by T_COMP than that of the active set.

T_DROP is a value of a minimum signal level for maintaining the base station in the active set.

T_TDROP is a value of a channel drop timer required to delete pilots belonging to the active set from the active set.

ADD means that pilots of the neighboring sectors or cells are added within the active set when the mobile station moves toward the neighboring sectors or cells in the CDMA handoff process. DROP means that pilots within the active set are deleted from the active set in the CDMA handoff process.

If the strength of the pilot signal in the second base station is greater than T_ADD when the mobile station moves from the service base station to a neighboring base station, the mobile station transmits the PSMM message to the neighboring base station through the base station controller that controls both the service base station and the neighboring base station. And then, the neighboring base station reserves an idle traffic channel and reports it to the base station controller.

The base station controller assigns the traffic channel of the neighboring base station to the mobile station through the handoff direction message (HDM) and instructs that the pilot of the neighboring base station is included in the active set. At that time, the mobile station forms communication pass simultaneously with two base stations (the service base station and the neighboring base station).

When the strength of the pilot signal of the first base station is reduced below T_DROP as the mobile station becomes closer to the neighboring base station, the mobile station activates a timer to measure the pilot strength of the service base station after a lapse of T_TDROPS sec. If the pilot strength of the base station remains below T_DROP, the PSMM message is transmitted to the control station in order to release the traffic channel with the base station 1.

The control station which has received the PSMM message releases the traffic channel in talk with the first base station by transmitting the handoff direction message to the mobile station to end the handoff.

A region in which the channel is released between T_TDROP point and T_TDROP point as shown in FIG. 1 is referred to a soft handoff region.

If the mobile station does not receive any handoff service at T_ADD point due to high traffic load in the second base station, the handoff service is held back until T_COMP point.

Also, as the mobile station which does not receive the handoff service at T_ADD becomes more distant from the first base station during the approach to T_COMP point, a call outage may occur when a radio wave environment becomes deteriorated. Accordingly, there are problems in that the failure of the handoff service is caused if the mobile station does not receive the handoff service at T_COMP point and the call is discontinued when a signal from the first base station becomes weak.

SUMMARY OF THE INVENTION

In consideration of the above problems, it is an object of the present invention to provide a handoff method for improving the talk quality in which a probability of the handoff success is raised and a probability of a call outage to disconnect a busy call is reduced by transmitting a pilot strength measurement message (PSMM) successively with a regular interval from a mobile station to a service base station to request a handoff service until the mobile station receives the handoff service if it does not so during its stay within a handoff service region when the mobile station enter the handoff service region, holding back a new call service from the base station and assigning a released channel to the mobile station requesting repeatedly the handoff service if a released call is present.

In order to accomplish the object, according to the present invention, a handoff method applicable to a mobile communication system comprises a first step of requesting a handoff service repeatedly with a regular interval based on a timer from a mobile station to a service base station until the mobile station receives the handoff service if a pilot strength of a neighboring base station is greater than a base station pilot strength value (T-ADD_when the mobile station enters a handoff service region; and a second step of holding back a new call service in the neighboring base station if the mobile station requesting the handoff service does not receive the handoff service and assigning a released channel to the mobile station requesting repeatedly the handoff service if a released call is present.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned aspect and other features of the invention will be explained in the following description, taken in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates a diagram for explaining a relation of a pilot signal level to a distance between the base stations in a code division multiple access (CDMA) cellular system.

FIG. 2 illustrates a schematic block diagram a mobile communication system to which the present invention is applicable.

FIG. 3 illustrates a flowchart of a procedure of handoff service request in a mobile station according to the present invention.

FIG. 4 illustrates a flowchart of a procedure of channel assignment in base stations according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Now, an preferred embodiment of the present invention will be discussed hereinafter in detail with reference to the accompany drawings.

FIG. 2 shows a schematic block diagram of a mobile communication system to which the present invention is applicable.

In the drawings, reference numeral **201** designates a mobile station, **202** designates base stations, **203** designates base station controllers, **204** designates a mobile switchboard/visitor location register, **205** designates a home location register, and **206** designates a general public telephone network.

The mobile station **201** is a radio station for public cellular radio service usable during the movement and includes a portable mobile terminal and an in-vehicle terminal.

The base stations **202** are radio station for performing cellular radio communication service with the mobile station **201** and undertake a variety of function for mobile subscribers. The base station controllers **203** are units for controlling the base station **202**.

The mobile switchboard/visitor location register **204** switches subscriber calls and stores visitor information. The home location register **205** is a database for storing subscriber information, subscriber location information, etc.

FIG. 3 is a flowchart of a procedure of handoff service request in the mobile station according to the present invention.

The mobile station requests handoff service to the service base station by transmitting a pilot strength measurement message (PSMM) when the pilot strength of the neighboring base station is greater than T_ADD and activates a handoff

timer Hd_Off_Timer as soon as the mobile station transmits the PSMM message to the base station.

Also, the mobile station stops the handoff timer and transmits the PSMM message no longer if the mobile station receives the handoff service before the handoff timer is stopped.

However, when the handoff time is expired and if the pilot strength of the neighboring base station is still greater than T_ADD, the mobile station transmits the PSMM message to the service base station.

Accordingly, the mobile station continues to transmit the PSMM message to the base station periodically and repeatedly until the mobile station receives the handoff service.

Referring to FIG. **3**, first, the mobile station determines whether the pilot strength of the neighboring base station is greater than the T_ADD threshold required to be the candidate base station (step **301**). If it is determined that the pilot strength of the neighboring base station is less than T_ADD, the procedure returns to the initial state.

If it is determined that the pilot strength of the neighboring base station is greater than T_ADD, the mobile station determines whether it is receiving the handoff service while it is located within a handoff region at present (step **302**).

As a result of determination, if the mobile station receives the handoff service while it is located within the handoff region at present, the procedure returns to the initial state. On the other hands, if the mobile station does not receive the handoff service while it is located within the handoff region at present, it determines whether the pilot strength measurement message is a first message (step **303**).

As a result of determination, if the pilot strength measurement message is a first message, the mobile station transmits the pilot strength measurement message (PSMM) to the service base station immediately (step **305**) and initializes the handoff timer (step **306**).

If the pilot strength measurement message is not a first message, the mobile station determines whether the handoff timer has expired (step **304**).

Then, if the handoff timer has expired, the mobile station transmits the pilot strength measurement message to the service base station immediately (step **305**) in order to transmit the PSMM periodically and reactivates the handoff timer (step **306**). If the handoff timer has not expired, the procedure returns to the initial state to monitor whether the handoff timer is stopped.

As described above, the mobile station periodically requests the handoff service to the base station if the mobile station is located within the handoff region. Also, the mobile station continues to request the handoff service to the service base station with a regular interval until the mobile station receives the handoff service while it is located within the handoff service region. As a result, a probability of the handoff service success can be increased, resulting in the improvement of the talk quality.

FIG. **4** is a flowchart of the procedure of the channel assignment in the base station according to the present invention for explaining a method of channel assignment in the base station when the mobile station request the handoff service to the base station.

Referring to FIG. **4**, first, the base station determines whether a call is received in the base station (step **401**).

As a result of determination, if there is no received signal in the base station, the base **1**_Timer has been stopped (step **416**). Then, if it is determined that the handoff fail timer has not been stopped, the procedure returns to the initial state.

On the other hands, if it is determined that there is any stopped handoff timer, the stopped handoff timer is deleted from a list and the number of the handoff fail timer is reduced by one (step **417**).

Then, the base station determines a type of a call received in the base station (step **402**).

As a result of determination, if the call received in the base station is a handoff request call by the PSMM, the base station confirms whether there is any available traffic channel (step **403**). If so, it is determined whether the received call is a new handoff call (step **409**).

As a result of determination, if the received call is a new handoff call, the base station processes the handoff call (step **412**). However, if the received call is not a new handoff call, the number of the handoff fail timer is reduced by 1 (step **410**), and the handoff call is processed (step **412**) after the handoff fail timer is deleted from the list (step **411**).

On the other hands, if the base station can not serve the handoff service because it does not have any spare traffic channel, it confirms whether the handoff request call is a new handoff call or an existing repetitive handoff call (step **404**).

As a result of confirmation, if the handoff request call is a new handoff call, the handoff fail timer (Hd_Fail_Timer) is increased by one (step **405**) and a new handoff timer with a timer identifier as a mobile station essential number (ESN) is produced and activated (stop **406**). On the other hands, if the handoff request call is a handoff call required more than one time repeatedly by the stop of the handoff timer (Hd_Off_Timer), a new handoff timer is not produced and the base station finds a handoff timer with the mobile essential number (ESN) identical with the timer identifier (step **407**) and then reactivates it (step **408**).

On the other hands, if the call received in the base station is a new call, the base station confirms the number of the idle traffic channel (Num_Idle_Tch) and the number of the handoff fail timer (Num_Hd_Timer) in activation. If the number of the idle traffic channel is equal to or less than the number of the handoff fail timer, the new call is unconditionally interrupted (step **415**) and the base station allows the new call only if the number of the idle traffic channel is greater than the number of the handoff fail timer (step **414**).

When the handoff service is served using the method described above, a traffic channel need not be reserved separately in order to increase a probability of the handoff success, resulting in the improvement of the efficiency of the channel use.

As explained hereinbefore, according to the present invention, since a probability of a handoff service success is increased, a talk quality can be improved. Also, since the handoff service continues to be requested at a handoff failure, a probability of a soft handoff success is increased when the mobile station is located within a soft handoff region and a call outage and a consumption of power in the mobile station within a cell boundary region are reduced, resulting in the reduction of the occurrence of an interference. In addition, when the handoff service is served, a traffic channel need not to be reserved separately in order to increase a probability of the handoff success, resulting in the improvement of the efficiency of the channel use.

The present invention has been described with reference to a particular embodiment in connection with a particular application. Those having ordinary skill in the art and access to the teachings of the present invention will recognize additional modifications and applications are within the scope of the present invention. It is therefore intended by the appended claims to cover any and all such applications, modifications, and embodiments within the scope of the present invention.

What is claimed is:

1. A handoff method applicable to a mobile communication system comprising the steps of:

a first step of requesting a handoff service repeatedly with a regular interval based on a timer from a mobile station to a service base station until the mobile station receives the handoff service if a pilot strength of a neighboring base station is greater than a base station pilot strength value (T-ADD) when the mobile station enters a handoff service region, said first step including the steps of

1(a) determining whether the handoff service request is a first request if the pilot strength of the neighboring base station is greater than the base station pilot strength value (T-ADD) and the mobile station does not receive the handoff service while it is located with a soft handoff region;

1(b) transmitting the handoff service request to the service base station and activating the handoff timer if the handoff service request is a first request according to a result of determination at said step 1(a);

1(c) determining whether the handoff timer is stopped if the handoff service request is not the first request according to a result of determination at said third step 1(a); and

1(d) resetting the handoff timer after the handoff service request is transmitted immediately if the handoff timer is expired and returning to said first step if the handoff timer is not stopped according to a result of determination at said step 1(c); and

a second step of holding back a new call service in the neighboring base station if the mobile station requesting the handoff service does not receive the handoff service and assigning a released channel to the mobile station requesting repeatedly the handoff service if a released call is present.

2. The method of claim **1**, wherein said second step comprises the steps of:

2(a) determining whether there is any call received in the base station;

2(b) determining a type of the received call if there is any call received in the base station according to a result of determination at said step 2(a);

2(c) determining whether any available traffic channel is present if the call received in the base station is a handoff request call according to a result of determination of said step 2(b);

2(d) determining whether the received call is a new handoff call if any available traffic channel is present according to a result of determination at said step 2(c);

2(e) processing the handoff call if the received call is a new handoff call after the number of handoff fail timers is reduced by one and the handoff fail timer is deleted if the received call is not a new handoff call according to a result of determination at said step 2(d);

2(f) determining whether the received call is a new handoff call or a repetitive handoff call is the handoff service is not served because any available traffic channel does not exist according to a result of determination at said step 2(c);

2(g) producing and activating a new handoff timer after the number of handoff fail timers is increased by one if the received call is new handoff call and reactivating a handoff timer with its identifier identical with the mobile station essential number is the received call is the repetitive handoff call according to a result of determination at said step 2(f);

2(h) determining whether the number if idle traffic channels is greater than that of handoff fail timers if the received call is a new handoff call according to a result of determination at said step 2(b);

2(i) allowing the new handoff call if the number of idle traffic channels is greater than that of handoff fail timers in activation and interrupting the new handoff call if the number of idle traffic channels is equal to or less than that of the handoff fail timer in activation according to a result of determination at said step 2(h); and

2(j) reducing the number of handoff fail timers by one after a stopped handoff timer is deleted from a handoff timer list if any call received in the base station is not present and any stopped handoff timer is present according to a result of determination at said step 2(a).

3. A handoff method applicable to a mobile communication system comprising the steps of:

a first step of requesting a handoff service repeatedly with a regular interval based on a timer from a mobile station to a service base station until the mobile station receives the handoff service if a pilot strength of a neighboring base station is greater than a base station pilot strength value (T-ADD) when the mobile station enters a handoff service region; and

a second step of holding back a new call service in the neighboring base station if the mobile station requesting the handoff service does not receive the handoff service and assigning a released channel to the mobile station requesting repeatedly the handoff service if a released call is present, said second step comprising the steps of

2(a) determining whether there is any call received in the base station;

2(b) determining a type of the received call if there is any call received in the base station according to a result of determination at said step 2(a);

2(c) determining whether any available traffic channel is present if the call received in the base station is a handoff request call according to a result of determination of said step 2(b);

2(d) determining whether the received call is a new handoff call if any available traffic channel is present according to a result of determination at said step 2(c);

2(e) processing the handoff call if the received call is a new handoff call after the number of handoff fail timers is reduced by one and the handoff fail timer is deleted if the received call is not a new handoff call according to a result of determination at said step 2(d);

2(f) determining whether the received call is a new handoff call or a repetitive handoff call is the handoff service is not served because any available traffic channel does not exist according to a result of determination at said step 2(c);

2(g) producing and activating a new handoff timer after the number of handoff fail timers is increased by one if the received call is new handoff call and reactivating a handoff timer with its identifier identical with the mobile station essential number is the received call is the repetitive handoff call according to a result of determination at said step 2(f);

2(h) determining whether the number if idle traffic channels is greater than that of handoff fail timers if the received call is a new handoff call according to a result of determination at said step 2(b);

2(i) allowing the new handoff call if the number of idle traffic channels is greater than that of handoff fail timers in activation and interrupting the new handoff call if the number of idle traffic channels is equal to or less than that of the handoff fail timer in activation according to a result of determination at said step 2(h); and

2(j) reducing the number of handoff fail timers by one after a stopped handoff timer is deleted from a handoff timer list if any call received in the base station is not present and any stopped handoff timer is present according to a result of determination at said step 2(a).

4. The method of claim 3, wherein said first step comprises the steps of:

1(a) determining whether the handoff service request is a first request if the pilot strength of the neighboring base station is greater than the base station pilot strength value (T-ADD) and the mobile station does not receive the handoff service while it is located with a soft handoff region;

1(b) transmitting the handoff service request to the service base station and activating the handoff timer if the handoff service request is a first request according to a result of determination at said step 1(a);

1(c) determining whether the handoff timer is stopped if the handoff service request is not the first request according to a result of determination at said third step 1(a); and

1(d) resetting the handoff timer after the handoff service request is transmitted immediately if the handoff timer is expired and returning to said first step if the handoff timer is not stopped according to a result of determination at said step 1(c).

5. A handoff method applicable to a mobile communication system comprising the steps of:

a first step of requesting a handoff service repeatedly with a regular interval based on a timer from a mobile station to a service base station until the mobile station receives the handoff service if a pilot strength of a neighboring base station is greater than a base station pilot strength value (T-ADD) when the mobile station enters a handoff service region; and

a second step of holding back a new call service in the neighboring base station if the mobile station requesting the handoff service does not receive the handoff service and assigning a released channel to the mobile station requesting repeatedly the handoff service if a released call is present;

wherein said first step comprises:

a third step of determining whether the handoff service request is a first request if the pilot strength of the neighboring base station is greater than the base station pilot strength value (T-ADD) and the mobile station does not receive the handoff service while it is located with a soft handoff region;

a fourth step of transmitting the handoff service request to the service base station and activating the handoff timer if the handoff service request is a first request according to a result of determination at said third step;

a fifth step of determining whether the handoff timer is stopped if the handoff service request is not the first request according to a result of determination at said third step; and

a sixth step of resetting the handoff timer after the handoff service request is transmitted immediately if the handoff timer is expired and returning to said first step if the handoff timer is not stopped according to a result of determination at said fifth step; and

wherein said second step comprises;

a seventh step of determining whether there is any call received in the base station;

an eighth step of determining a type of the received call if there is any call received in the base station according to a result of determination at said seventh step;

a ninth step of determining whether any available traffic channel is present if the call received in the base station is a handoff request call according to a result of determination of said eighth step;

a tenth step of determining whether the received call is a new handoff call if any available traffic channel is present according to a result of determination at said ninth step;

an eleventh step of processing the handoff call if the received call is a new handoff call after the number of handoff fail timers is reduced by one and the handoff fail timer is deleted if the received call is not a new handoff call according to a result of determination at said tenth step;

a twelfth step of determining whether the received call is a new handoff call or a repetitive handoff call is the handoff service is not served because any available traffic channel does not exist according to a result of determination at said ninth step;

a thirteenth step of producing and activating a new handoff timer after the number of handoff fail timers is increased by one if the received call is new handoff call and reactivating a handoff timer with its identifier identical with the mobile station essential number is the received call is the repetitive handoff call according to a result of determination at said twelfth step;

a fourteenth step of determining whether the number if idle traffic channels is greater than that of handoff fail timers if the received call is a new handoff call according to a result of determination at said eight step;

a fifteenth step of allowing the new handoff call if the number of idle traffic channels is greater than that of handoff fail timers in activation and interrupting the new handoff call if the number of idle traffic channels is equal to or less than that of the handoff fail timer in activation according to a result of determination at said fourteenth step;

a sixteenth step of reducing the number of handoff fail timers by one after a stopped handoff timer is deleted from a handoff timer list if any call received in the base station is not present and any stopped handoff timer is present according to a result of determination at said seventh step.

* * * * *

JS 44 (Rev. 12/07)

ORIGINAL CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

FILED 09 FEB 18 PM 3:00

I. (a) PLAINTIFFS
Kyocera Wireless Corp.; Kyocera Sanyo Telecom, Inc.; Kyocera Corp.

DEFENDANTS
SPH America, LLC

(b) County of Residence of First Listed Plaintiff: San Diego, CA
(EXCEPT IN U.S. PLAINTIFF CASES)

County of Residence of First Listed Defendant: Virginia
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.

SOUTHERN DISTRICT OF CALIFORNIA — DEPUTY

(c) Attorney's (Firm Name, Address, and Telephone Number)
David E. Kleinfeld; Foley & Lardner, LLP; 11250 El Camino Real, San Diego CA 92130

Attorneys (If Known) '09 CV 0299 W JMA
Fish & Richardson, 12390 El Camino Real, San Diego CA 92130; 1425 K Street NW, Ste. 1100, Washington DC 20005

II. BASIS OF JURISDICTION (Place an "X" in One Box Only)

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question (U.S. Government Not a Party)
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES (Place an "X" in One Box for Plaintiff and One Box for Defendant) (For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT (Place an "X" in One Box Only)

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excl. Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury

PERSONAL INJURY
- ☐ 362 Personal Injury - Med. Malpractice
- ☐ 365 Personal Injury - Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 444 Welfare
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities - Other
- ☐ 440 Other Civil Rights

PRISONER PETITIONS
- ☐ 510 Motions to Vacate Sentence

Habeas Corpus:
- ☐ 530 General
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition

FORFEITURE/PENALTY
- ☐ 610 Agriculture
- ☐ 620 Other Food & Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 R.R. & Truck
- ☐ 650 Airline Regs.
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Mgmt. Relations
- ☐ 730 Labor/Mgmt.Reporting & Disclosure Act
- ☐ 740 Railway Labor Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Empl. Ret. Inc. Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 463 Habeas Corpus - Alien Detainee
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Sat TV
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 895 Freedom of Information Act
- ☐ 900Appeal of Fee Determination Under Equal Access to Justice
- ☐ 950 Constitutionality of State Statutes

V. ORIGIN (Place an "X" in One Box Only)

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify) ☐ 6 Multidistrict Litigation ☐ 7 Appeal to District Judge from Magistrate Judgment

VI. CAUSE OF ACTION
Cite the U.S. Civil Statute under which you are filing (Do not cite jurisdictional statutes unless diversity):
Declaratory Judgment Act, 28 USC §§2201 and 2202.
Brief description of cause:
Declaratory Judgment of non-infringement and invalidity of Defendants threatened patents.

VII. REQUESTED IN COMPLAINT: ☐ CHECK IF THIS IS A CLASS ACTION UNDER F.R.C.P. 23 DEMAND $
CHECK YES only if demanded in complaint: JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY (See instructions): JUDGE Dana M. Sabraw DOCKET NUMBER 3:08cv2146

DATE 02/18/2009 SIGNATURE OF ATTORNEY OF RECORD [signature]

FOR OFFICE USE ONLY

RECEIPT # 160218 AMOUNT $350 APPLYING IFP ______ JUDGE ______ MAG. JUDGE ______

TAC 2/18/09

CR

JS 44 Reverse (Rev. 12/07)

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I. **(a) Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) County of Residence. For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) Attorneys. Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. **Jurisdiction**. The basis of jurisdiction is set forth under Rule 8(a), F.R.C.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.

United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.

United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.

Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.

Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below; federal question actions take precedence over diversity cases.)

III. **Residence (citizenship) of Principal Parties.** This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. **Nature of Suit**. Place an "X" in the appropriate box. If the nature of suit cannot be determined, be sure the cause of action, in Section VI below, is sufficient to enable the deputy clerk or the statistical clerks in the Administrative Office to determine the nature of suit. If the cause fits more than one nature of suit, select the most definitive.

V. **Origin**. Place an "X" in one of the seven boxes.

Original Proceedings. (1) Cases which originate in the United States district courts.

Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441. When the petition for removal is granted, check this box.

Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.

Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.

Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.

Multidistrict Litigation. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407. When this box is checked, do not check (5) above.

Appeal to District Judge from Magistrate Judgment. (7) Check this box for an appeal from a magistrate judge's decision.

VI. **Cause of Action**. Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553
Brief Description: Unauthorized reception of cable service

VII. **Requested in Complaint**. Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.

Demand. In this space enter the dollar amount (in thousands of dollars) being demanded or indicate other demand such as a preliminary injunction.

Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. **Related Cases**. This section of the JS 44 is used to reference related pending cases if any. If there are related pending cases, insert the docket numbers and the corresponding judge names for such cases.

Date and Attorney Signature. Date and sign the civil cover sheet.

UNITED STATES
DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA
SAN DIEGO DIVISION

 # 160218 - TC
*** * C O P Y * ***
February 18, 2009
15:01:33

Civ Fil Non-Pris
USAO #.: 09CV0299
Judge..: THOMAS J WHELAN
Amount.: $350.00 CK
Check#.: 53712

Total-> $350.00

FROM: KYOCERA VS SPH AMERICA