(12) PATENT

(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 199898155 B2**

(10) Patent No. **730854**

(54) Title
      Intra-cell-inter-frequency hard handoff method in a CDMA cellular system

(51)[6] International Patent Classification(s)
         H04Q 007/36

(21) Application No: 199898155

(22) Application Date: 1998 .12 .23

(30) Priority Data

(31) Number   (32) Date   (33) Country
      74604   1997 .12 .26   KR

(43) Publication Date :   1999 .07 .15
(43) Publication Journal Date : 1999 .07 .15
(44) Accepted Journal Date :   2001 .03 .15

(71) Applicant(s)
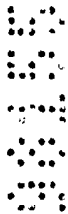   Samsung Electronics Co, Ltd

(72) Inventor(s)
      Wan-soo Kim

(74) Agent/Attorney
      WRAY and ASSOCIATES,PO Box 6292,Hay Street,EAST PERTH WA 6892

(56) Related Art
      WO   97/44984
      AU   54323/96
      AU   72855/98

ABSTRACT

A method for processing a hard handoff between a moving mobile station and base stations in a code division multiple access is disclosed. In accordance with a preferred embodiment of the present invention, the method of intra-cell-inter-frequency hard handoff comprises the steps of setting up a new call, confirming whether a current base station satisfies a condition of inter-frequency hard handoff and whether a currently used frequency satisfies a condition of inter-frequency hard handoff, and performing a general handoff and call processing if both the conditions of the two confirming steps are not satisfied. If both conditions of the two confirming steps are satisfied, the method further comprises the steps of setting a threshold value on output signal strength and on distance, instructing a mobile station to periodically report the base station's output signal strength, estimating a distance between the base station and the mobile station, checking whether the base station's output signal strength is less than the set threshold value and if it is, commanding a hard handoff. However, if it is not less, the base station-mobile station distance is checked whether to be greater than the set threshold value. If it is greater, the method includes the steps of commanding a hard handoff. Subsequent to the hard handoff, the method performs a general handoff and call processing in a common frequency. On the contrary, in the event that the base station-mobile station distance is less than the set threshold value, the method is returning to the steps of estimating a distance between the base station and the mobile station and continues to checking the output signal strength of the base station and distance between base station and mobile station. A mobile station in communication with a base station having a common frequency and non-common frequency over the non-common frequency is capable of performing a hard handoff without additional devices when moving to a neighboring base station which has no common frequency.

AUSTRALIA

Patents Act 1990

ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Name of Applicant: Samsung Electronics Co, Ltd

Actual Inventor   Wan-soo Kim

Address for service is: WRAY & ASSOCIATES
239 Adelaide Terrace
Perth, WA 6000

Attorney code: WR

Invention Title: "Intra-Cell-Inter-Frequency Hard Handoff Method In A CDMA Cellular System"

The following statement is a full description of this invention, including the best method of performing it known to me:-

TITLE

"Intra-Cell-Inter-Frequency Hard Handoff Method In A CDMA Cellular System"

FIELD OF THE INVENTION

The present invention relates to a method for performing a hard handoff between
5 a moving mobile station and a base station in a code division multiple access
(CDMA) cellular system. The method is performed based upon the base station's
output signal strength and a distance between the mobile station and the base
station without the need for other devices.

BACKGROUND ART

10 Generally, a hard handoff occurs when a mobile station crosses a boundary of a
service area of a base station which currently maintains a connection with the
mobile station and enters a service area of another base station. Such handoff
enables a mobile station to be given a continuous service while moving from a
service area of one base station to a service area of a neighboring base station
15 and is typically divided to two types: soft handoff and hard handoff.

A soft handoff, which is possible to perform due to CDMA system's features,
establishes a new channel without terminating the original channel. Therefore,
the mobile station is in communication with at least one base station during the
soft handoff process. In contrast, a hard handoff terminates the original channel
20 before establishing a new channel, and occurs when a frequency channel, frame
offset or system are changed.

The handoff is explained in reference with FIG. 1. In the FIG. 1, a base station
BS1 operates channels on two frequencies F1 and F2, while a base station BS2
operates channels only on the frequency F1. When a first mobile station having a
25 channel to base station BS1 using frequency F1 and a second mobile station
having a channel to base station BS1 using frequency F2 move into the service
area of base station BS2, a handoff is performed on the two mobile stations as
follows.

Firstly, there is the case when the first mobile station using the frequency F1 moves from a cell covered by base station BS1 to another cell covered by base station BS2. If the output signal strength of the base station BS2 on frequency F1 is greater than a predetermined threshold value (T_ADD), the first mobile station

5   reports the output signal strength of the base stations BS1 and BS2 on frequency F1 to the base station BS1. The base station BS1 reports the output signal strength of the base stations BS1 and BS2 received from the first mobile station to a base station controller (BSC) and the BSC orders the base station BS2 to assign a channel to the first mobile station. In response to this order, the base

10   station BS2 assigns the channel and reports the result to the BSC. When the base station BS2 has completed assigning the channel, the BSC orders the first mobile station via the base station BS1 to connect to the channel created by the base station BS2. The first mobile station maintains the channel with the base station BS1 and simultaneously connects to the new channel with the base

15   station BS2, and therefore maintains connection with the two base stations BS1 and BS2. If the first mobile station moves closer to the base station BS2 and consequently further from the base station BS1, the output signal strength from the base station BS1 received by the first mobile station becomes weaker. The first mobile station reports the output signal strength of the two base stations BS1

20   and BS2 to the BSC via the base stations BS1 and BS2 if the output signal strength of the base station BS1 is less than a predetermined threshold value (T_DROP). The BSC then orders the base station BS1 to break the channel with the first mobile station and orders via the base station BS2 the first mobile station to break the connection with the base station BS1 and to maintain connection

25   with the base station BS2. In accordance with the order, the first mobile station maintains connection with the base station BS2 and a handoff from the base station BS1 to the base station BS2 is completed.

Next, there is the case when the second mobile station using the frequency F2 moves from the cell covered by base station BS1 to the cell covered by base

30   station BS2. Unlike the first mobile station which used the frequency F1, the second mobile station is not able to recognize the base station BS2 because the base station BS2 has no output signal on the frequency F2. A handoff does not

occur and as the second mobile station moves to the base station BS2, the second mobile station escapes the service area of the base station BS1 and accordingly the channel between the base station BS1 and the second mobile station is discontinued.

5   The number of different frequencies used by each base station is decided by the amount of subscriber demand. When the amount of subscriber demand is greater in the certain area than the neighboring areas, using additional frequencies is very effective and useful in CDMA systems.

In a code division multiple access (CDMA) system, a handoff is necessary if a

10   mobile station enters a base station BS2 that operates only frequency F1, while the mobile station maintains a channel with a base station BS1 operating a frequency F2.
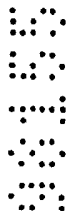
U.S. Pat. No. 5,594,718 and 5,680,395 disclose a method and apparatus for processing a hard handoff between base stations in which a pilot channel on

15   frequency F2, indicating the existence and identity of a base station, is installed to the base station BS2, which otherwise uses only frequency F1. A mobile station is then capable of reporting the base station output signal strength by referring to the pilot channel on moving from the base station BS1 to BS2. A BSC receives a report message concerning output signal strength of the base stations BS1 and

20   BS2 from the mobile station via the base station BS1 and commands the mobile station to perform an inter-frequency hard handoff from the base station BS1 to BS2, because the BSC knows that the base station BS2 has only the pilot channel at frequency F2. As a result, the mobile station with a channel on frequency F2 to the base station BS1 is successfully handedoff to the base

25   station BS2 on frequency F1 without discontinuing communication. Additionally, this method has an advantage in that it enables a handoff with only the pilot channel, without installing a number of channels corresponding to the frequency F2 to the base station BS2. However, the method suffers from the disadvantage that it requires RF devices to be installed in the base station BS2 to support the

30   addition of a pilot channel on frequency F2, namely: frequency converter, filter, frequency combiner, amplifier etc.

DISCLOSURE OF THE INVENTION

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion

5   of any other integer or group of integers.

It is an object of the present invention to provide a method for performing an inter-frequency hard handoff based on a base station output signal strength and a distance between the base station and a mobile station, while avoiding the need for additional devices.
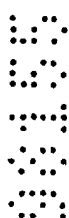
10   In accordance with one aspect of this invention, there is provided an intra-cell-inter-frequency hard handoff method for a code division multiple access cellular system comprising the steps of:

setting up a new call from a mobile station to a base station on a frequency;

confirming whether the base station satisfies a first condition that may

15   require an inter-frequency hard handoff;

confirming whether the frequency satisfies a second condition that may require an inter-frequency hard handoff;

performing a general handoff and call processing, as required, if both said conditions of said two confirming steps are not satisfied;

20   setting a threshold value on an output signal strength and on distance, if said both conditions of said two confirming steps are satisfied;

instructing the mobile station to periodically report the base station's output signal strength received by the mobile station;

estimating a distance between said base station and said mobile station;

25   checking whether the reported output signal strength of said base station is less than said threshold value on output signal strength;

commanding a hard handoff when the reported station output signal strength

is less than said threshold value on output signal strength in said step of checking;

checking whether the estimated distance between said base station and the mobile station is greater than said threshold value on distance;

5 commanding a hard handoff when said estimated distance between the base station and the mobile station is greater than said threshold value on distance in said step of checking;

performing a general handoff as required and processing said call in a common frequency subsequent to said hard handoff command; and

10 returning to said step of estimating a distance between said base station and mobile station, when said estimated distance is not greater than said threshold value on distance.

Preferably, in said step of instructing said mobile stations to periodically report, said base station continuously checks changes to said base station output signal

15 strength.

Preferably, the distance between said base station and mobile station is estimated through a radio wave round trip delay.

Preferably, said inter-frequency hard handoff performance is decided based upon base station output signal strength and a base station-mobile station distance.

20 Preferably, a command of hard handoff performance from a non-common frequency to a common frequency is given in the event that said base station output signal strength is less than said threshold value on output signal strength.

Preferably, said threshold values are chosen such that after said hard handoff from said non-common frequency to said common frequency, said mobile station

25 is located within a service area of said common frequency.

Preferably, said mobile station subsequently maintains connection with said base station and is given communication service while an inter-frequency hard handoff process.

Preferably, a data base search is initiated as soon as said call is set up.

Preferably, a command of performing hard handoff from a non-common frequency to a common frequency F1 is given in the event that said distance between said base station and mobile station is greater than said threshold value

5   on distance.

Preferably, said mobile station recognizes a neighboring base station if said hard handoff is performed from said non-common frequency to common frequency.

Preferably, said mobile station subsequently maintains connection with said base station and is given communication service while an inter-frequency hard handoff

10   process.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will now be described with reference to one embodiment thereof and the accompanying drawings, in which:

FIG. 1 illustrates that a mobile station moves from a current cell to a neighboring

15   cell in a CDMA communication system;

FIG. 2 illustrates a flow chart of processing a hard handoff according to the present invention; and

FIG. 3 illustrates a structure of cells where an inter-frequency hard handoff has the potential to occur.

20   ## BEST MODE(S) FOR CARRYING OUT THE INVENTION

The embodiment is directed towards a method for performing an inter-frequency hard handoff in a CDMA cellular system having a plurality of base stations labelled BSO through BS6 and a base station controller (BSC), not shown.

Referring to FIGs. 2 and 3, all of the base stations BSO - BS6 use a common

25   frequency F1, while the base station BSO additionally uses another frequency F2 along with the common frequency F1 to accommodate the amount of subscriber
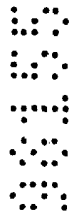
demand. The frequency F2 is not used in the neighboring base stations BS1 - BS6, only in the base station BS0.

When a mobile station has a call using frequency F2 connected to the base station BS0, the mobile station maintains a stable connection with the base

5 station BS0 within a service area of frequency F2 used by the base station BS0. As the mobile station moves towards a neighboring base station, the distance between the mobile station and the base station BS0 will increase and the output signal strength of the base station BS0 received by the mobile station will weaken. The base station BS0 instructs the mobile station to periodically report

10 the received output signal strength of the base station BS0 and commands the mobile station to perform a hard handoff to the common frequency F1 if the output signal strength received by the mobile station is less than a predetermined threshold value.

Generally, the output signal strength of frequency F2 of the base station BS0 that

15 a mobile station receives depends on distance from the base station BS0; the longer the distance, the weaker signal strength is. However, the environment surrounding the base stations is also a factor. For example, roads and buildings affect relationship between distance and received output signal strength and can produce results contrary to the general expectation concerning the relationship

20 between distance and received output signal strength.

There are two cases where the received output signal strength may be contrary to expectation: firstly, when a mobile station is on a road or open land without obstacles in the straight line path to the base station, the distance between the mobile station and the base station can increase without significant reduction of

25 the base station's output signal strength received by the mobile station; and secondly, when a mobile station is in a shadow area caused by buildings located between the mobile station and the base station, the base station's output signal strength received by the mobile station will be significantly reduced in spite of a short distance between the base station and the mobile station.

30 In the second case, when the base station's output signal strength is less than a threshold value, a hard handoff from frequency F2 to frequency F1 is performed

and the mobile station is still located within the service area of the frequency F1 from the base station. In such a case, the hard handoff does not discontinue communication between the mobile station and the base station BS0.

In the first case, however when the base station output signal strength is less
5   than the threshold value, if the mobile station performs a hard handoff from the frequency F2 to frequency F1, the mobile station may be located out of the service area of frequency F1 from the base station. This is because the frequency F2 is not used in the neighboring base stations which results in reduced interference on frequency F2 from neighbouring base stations.
10   Consequently the service area of frequency F2 may be greater than the service area of frequency F1 in spite of the base station using the same output signal power at both frequencies F1 and F2.

To solve the problems associated with the first case above, a distance from the base station as well as output signal strength of the base station is taken into
15   consideration in the method of the embodiment in determining whether to perform an inter-frequency hard handoff.

FIG. 2 illustrates a method of inter-frequency hard handoff in accordance with the preferred embodiment of the present invention. When a new call is set up (s100), a BSC searches a data base storing information on the base stations and
20   confirms whether the base station currently handling the call satisfies conditions that may require an inter-frequency hard handoff (s110) to be performed. In the embodiment, base station BS0 will satisfy these conditions since it operates a frequency that at least one neighbouring base station does not, namely frequency F2. If the base station satisfies these conditions, the BSC checks whether the
25   current call is set up on frequency F2 (s130).

If the current call is not set up on frequency F2, usual call processing and a general handoff are performed, as needed, instead of hard handoff (s120).

If the current call is set up on frequency F2, a threshold value on output signal strength of the base station and a threshold value on distance between the base
30   station and the mobile station are set (s140). The mobile station is then

instructed to periodically report the received output signal strength of the base station by reply to the base station (s150). The base station also estimates the distance to the mobile station, for instance from the mean return packet delay (s160).

5   The base station monitors the reported output signal strength and monitors the distance. When the output signal strength is less than the set threshold value on output signal strength (s170) or when the distance is more than the set threshold value on distance (s180), the base station commands the mobile station to perform a hard handoff to frequency F1 (s190).

10   After performing the hard handoff to the frequency F1, the mobile station is able to recognize neighboring base stations, because the neighboring base stations also use frequency F1. A general handoff to a neighbouring base station can then be performed as needed. The mobile station maintains connection with base station without discontinuing communication during the hard handoff
15   process from one base station to a neighboring base station.

As stated above, a mobile station connected to a base station having a common frequency and non-common frequency via the non-common frequency is able to perform a hard handoff without additional devices when moving to a neighboring base station which has only the common frequency.

20   Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various other changes and modifications may be affected therein by one skilled in the art without departing from the scope or spirit of the invention. All such changes and
25   modifications are intended to be included within the scope of the invention as defined by the appended claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

1. An intra-cell-inter-frequency hard handoff method for a code division multiple access cellular system comprising the steps of:

5   setting up a new call from a mobile station to a base station on a frequency;

confirming whether the base station satisfies a first condition that may require an inter-frequency hard handoff;

confirming whether the frequency satisfies a second condition that may require an inter-frequency hard handoff;

10   performing a general handoff and call processing, as required, if both said conditions of said two confirming steps are not satisfied;

setting a threshold value on an output signal strength and on distance, if said both conditions of said two confirming steps are satisfied;

15   instructing the mobile station to periodically report the base station's output signal strength received by the mobile station;

estimating a distance between said base station and said mobile station;

checking whether the reported output signal strength of said base station is less than said threshold value on output signal strength;

commanding a hard handoff when the reported station output signal

20   strength is less than said threshold value on output signal strength in said step of checking;

checking whether the estimated distance between said base station and the mobile station is greater than said threshold value on distance;

commanding a hard handoff when said estimated distance between the

25   base station and the mobile station is greater than said threshold value on distance in said step of checking;

performing a general handoff as required and processing said call in a common frequency subsequent to said hard handoff command; and

returning to said step of estimating a distance between said base station and mobile station, when said estimated distance is not greater than said threshold value on distance.

2. An intra-cell-inter-frequency hard handoff method as claimed in claim 1, wherein in said step of instructing said mobile stations to periodically report, said base station continuously checks changes to said base station output signal strength.

3. An intra-cell-inter-frequency hard handoff method as claimed in claim 1 or 2, wherein the distance between said base station and mobile station is estimated through a radio wave round trip delay.

4. An intra-cell-inter-frequency hard handoff method as claimed in claim 1, wherein said inter-frequency hard handoff performance is decided based upon base station output signal strength and a base station-mobile station distance.

5. An intra-cell-inter-frequency hard handoff method as claimed in claim 1, wherein a command of hard handoff performance from a non-common frequency to a common frequency is given in the event that said base station output signal strength is less than said threshold value on output signal strength.

6. An intra-cell-inter-frequency hard handoff method as claimed in claim 5, wherein said threshold values are chosen such that after said hard handoff from said non-common frequency to said common frequency, said mobile station is located within a service area of said common frequency.

7. An intra-cell-inter-frequency hard handoff method as claimed in claim 5 or 6, wherein said mobile station subsequently maintains connection with said base station and is given communication service during an inter-frequency hard handoff process.

8. An intra-cell-inter-frequency hard handoff method as claimed in claim 1, wherein a data base search is initiated as soon as said call is set up.

9. An intra-cell-inter-frequency hard handoff method as claimed in claim 1, wherein a command of performing hard handoff from a non-common frequency to a common frequency F1 is given in the event that said distance between said base station and mobile station is greater than said threshold value on distance.

10. An intra-cell-inter-frequency hard handoff method as claimed in claim 9, wherein said mobile station recognizes a neighboring base station if said hard handoff is performed from said non-common frequency to common frequency.

11. An intra-cell-inter-frequency hard handoff method as claimed in claim 9 or 10, wherein said mobile station subsequently maintains connection with said base station and is given communication service while an inter-frequency hard handoff process.

12. An intra-cell-inter-frequency hard handoff method substantially as described herein with reference to figures 2 and 3.

Dated this TWENTY THIRD day of DECEMBER 1998.

Samsung Electronics Co, Ltd

Applicant

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicant

FIG. 1

SERVICE AREA OF
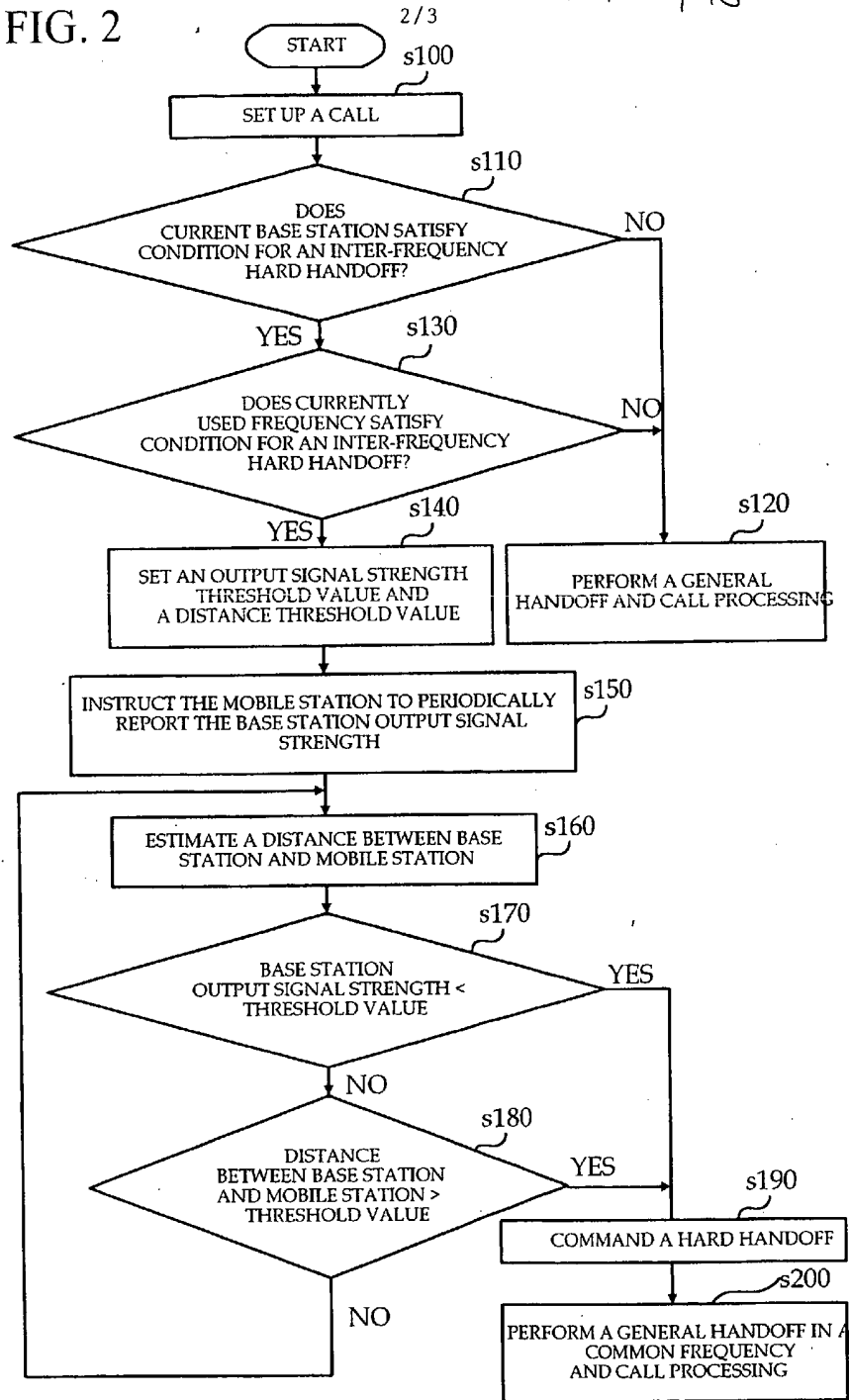F1 OF BASE STATION 2

SERVICE AREA OF F2 OF
BASE STATION 1

BASE STATION
2

MOBILE STATION
1

BASE STATION
1

MOBILE STATION
2

SERVICE AREA OF
F1 OF BASE STATION 1

98155/98

FIG. 2

START s100

SET UP A CALL

s110

DOES
CURRENT BASE STATION SATISFY
CONDITION FOR AN INTER-FREQUENCY
HARD HANDOFF? — NO

YES ↓ s130

DOES CURRENTLY
USED FREQUENCY SATISFY
CONDITION FOR AN INTER-FREQUENCY
HARD HANDOFF? — NO

YES ↓ s140

SET AN OUTPUT SIGNAL STRENGTH
THRESHOLD VALUE AND
A DISTANCE THRESHOLD VALUE

s120

PERFORM A GENERAL
HANDOFF AND CALL PROCESSING

INSTRUCT THE MOBILE STATION TO PERIODICALLY
REPORT THE BASE STATION OUTPUT SIGNAL
STRENGTH   s150

ESTIMATE A DISTANCE BETWEEN BASE
STATION AND MOBILE STATION   s160

s170

BASE STATION
OUTPUT SIGNAL STRENGTH <
THRESHOLD VALUE   YES

NO

s180

DISTANCE
BETWEEN BASE STATION
AND MOBILE STATION >
THRESHOLD VALUE   YES

s190

COMMAND A HARD HANDOFF

s200

PERFORM A GENERAL HANDOFF IN A
COMMON FREQUENCY
AND CALL PROCESSING

NO

FIG. 3