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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 1/00, H04Q 7/00, 7/22, 7/38

A1

(11) International Publication Number: WO 99/31810

(43) International Publication Date: 24 June 1999 (24.06.99)

(21) International Application Number: PCT/US98/16338

(22) International Filing Date: 10 August 1998 (10.08.98)

(30) Priority Data:
08/991,117 16 December 1997 (16.12.97) US

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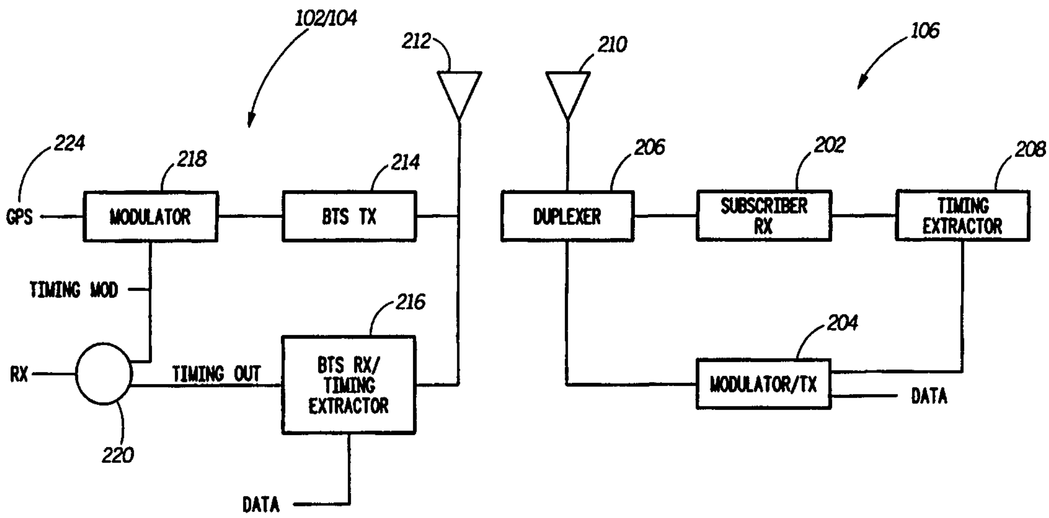
(81) Designated States: BR, CA, CN, DE, FI, GB, IL, JP, KR, SE.

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR COMMUNICATION SYSTEM CONTROL UTILIZING REMOTE UNIT SIGNAL INFORMATION



(57) Abstract

A characteristic of the remote unit (106) reverse link transmission is analyzed by the communication system (100, 108) for determining which of a plurality of forward links is being demodulated. Communication system (100) operations, such as soft handoff, forward link diversity, forward link power control and slow speed data transmission are managed in view of the forward link being demodulated by the remote unit (106).

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METHOD AND APPARATUS FOR COMMUNICATION SYSTEM CONTROL UTILIZING REMOTE UNIT SIGNAL INFORMATION

Field of the Invention

The present invention relates generally to wireless communication systems and more particularly to a method and apparatus for determining which of several signals is received and demodulated by a remote unit and for using this information for communication system control

Background of the Invention

Wireless communication systems are known to allow several base stations to communicate with a remote unit (such as a cellular subscriber unit) operating within the wireless communication system. This technique is sometimes referred to as forward link diversity and is employed in handoff techniques such as soft handoff (SHO). That is, multiple base stations may communicate on a common communication channel with the remote unit. The remote unit, employing a received signal detection strategy, receives and demodulates these signals and, where possible, combines the multiple received signals to improve reception reliability. As described in the Electronic Industry Association/Telecommunications Industry Association Interim Standard 95A (TIA/EIA/IS-95A), one such communication system employing forward link diversity and SHO is a

Code-Division, Multiple-Access (CDMA) spread-spectrum communication system. (TIA/EIA can be contacted at 2001 Pennsylvania Ave. NW Washington DC 20006).

Control of system resources, based on knowledge as to which of several signals directed by base stations to the remote unit is being received and demodulated by the remote unit is desirable. For example, while forward link diversity and SHO generally improve the quality and the stability of communications between the remote unit and the base station. it may lead to performance degradation. Communication resources may be wasted were several base stations are transmitting to a remote unit yet the remote unit is not receiving or capable of receiving one or more of these signals. Assumptions regarding an ability of the remote unit to receive signals from a particular base station may lead to excess forward link noise generation if the remote unit is actually unable to adequately receive and demodulate these extra signals. Unnecessary forward link traffic channel (TCH) power may lead to system coverage and capacity limitations and/or audio degradation.

Presently, the only method for determining those potentially detectable signals at the remote unit from any of several neighboring base station signals is via a signaling message from a remote unit. This message contains information as to the potential likelihood of detectability of signals emanating from various nearby base stations.

The initiation of this message is either autonomous by the remote unit (based on particular signal threshold criteria being triggered) or manually by the base station infrastructure. This latter process involves the base station sending a message to the remote unit requesting the neighbor measurement results, and the remote unit responding with the requested information. Unfortunately, the reported information may not necessarily correspond with the reported information. For example, the remote unit may report good detectability of a distant signal it is receiving in one moment from one base station and then immediately begin receiving signals from another, perhaps closer base station. Further, each message consumes valuable traffic channel bandwidth leading to potential audio degradation as well as increasing the messaging load on the systems control capabilities.

Thus there is a need for a method and apparatus to directly, accurately and efficiently determine which of several base stations a remote unit is receiving and demodulating. There is also a need for a method and apparatus for communication system controlthat utilizes remote unit received signal information.

Brief Description of the Drawings

FIG. 1 illustrates a communication system in accordance with a preferred embodiment of the present invention.

FIG. 2 illustrates a base station and a remote unit of FIG. 1 in accordance with a preferred embodiment of the present invention.

FIG. 3 is a flow chart illustrating a method for determining which of a plurality of transmitted signals is received by a remote unit.

FIG. 4 is a flow chart illustrating a method of controlling a communication system responsive to which of a plurality of signals is being received by a remote unit.

Detailed Description of the Preferred Embodiments

Communication system control, and hence performance of the communication system, is enhanced through a technique which allows for the determination of forward link demodulation by the remote unit. A characteristic of the remote unit reverse link transmission is analyzed by the communication system infrastructure for determining which of a plurality of forward links is being demodulated. Communication system operations, such as soft handoff, forward link diversity, forward link power control and slow speed data transmission are managed on the basis of which forward links are determined to be demodulated by the remote unit.

FIG. 1 illustrates communication system 100 that preferably operates in accordance with a Code Division Multiple Access (CDMA) system protocol. It will be appreciated that communication system 100 may operate in accordance with other analog, digital or dual-mode communication system protocols such as, but not limited to, the Narrowband Advanced Mobile Phone System (NAMPS), the Advanced Mobile Phone System (AMPS), the Global System for Mobile Communications (GSM), the Personal Digital Communications (PDC), or the United States Digital Cellular (USDC) protocols. Communication system 100 includes a base station 102, base station 104, remote unit 106, centralized base station controller (CBSC) 108, and mobile switching center (MSC) 110. In the preferred embodiment of the present invention base stations 102 and 104 are preferably Motorola SC9600 base stations located at different geographic cell site locations, MSC 110 is preferably a Motorola EMX2500 MSC, and CBSC 108 is preferably comprised of a Motorola SG1128BF CBSC component. In the preferred embodiment of the present invention, base stations 102 and 104 are suitably coupled to CBSC 108, and CBSC is suitably coupled to MSC 110. Remote unit 106 is preferably a mobile radiotelephone installed within a vehicle or a portable handset such as a personal communication system (PCS) handset.

In a CDMA cellular communication system, such as communication system 100, the same frequency band can be used for all cells. As a result, more than one base station may be instructed to transmit a coded signal to a remote unit operating in the communication system and these signals may be simultaneously received by the remote unit. This provides forward link diversity and soft handoff capability. For purposes of discussion, and as shown in FIG. 1, remote unit 106 is engaged in an active call communicating with base stations 102 and 104 via uplink communication signals 112 and base stations 102 and 104 are communicating with remote unit 106 via downlink communication signals 114 in either a soft handoff or diversity mode. It is noted that the information on signals 114 emanating from BTSs 102 and 104 is the same, although they have different spreading sequences that are known to the remote unit. The call is routed through CBSC 108 and MSC 110 to other remote units or via the public switched telephone network (PSTN) to a land line telephone. The call may have originated at remote unit 106 or terminated at remote unit 106 as is known in the art, and each base station 102 and 104 transmit and receive information to and from remote unit 106 on one of a plurality of traffic channels. As is known, the traffic channel signals are coded, interleaved, scrambled, spread and modulated to become direct sequence, spread spectrum signals transmitted to remote unit 106 on the traffic channel.

It is understood that during the duration of the call, the subscriber may be told to communicate with one or both of the base stations. This selection is controlled by signaling between the infrastructure equipment and the remote units. When communication is set up between the infrastructure and the remote unit during a call, the remote may be assigned to operate with both of the base stations. However, the remote unit 106 may alternately receive a stronger signal from either of base stations 102 or 104 and may alternately receive either a signal from one or the other or both base stations. It is possible that one or more of the assigned signals in the multiple handoff condition cannot, in fact, be demodulated by the remote unit. It would be desirable to know which signals are actually being demodulated by the remote unit, since a signal that cannot be received is of no value and actually degrades system operation. In accordance with the IS-95 standard and as long as it is able, remote unit 106 will receive and demodulate the two signals (regardless of the strength of the signal) and adjust its transmitter timing based on the time the earliest arriving signal of all that can be received. A strict guideline is provided in the specification for changing the remote unit's transmitter timing based on changes of the timing of the earliest arriving signal it can detect. This selection of signals to demodulate occurs strictly by the ability of the remote unit, without intervention by base stations 102 and 104 or CBSC 108. In fact, base stations 102 and 104 and CBSC 108 are generally unaware of the signal actively being received and demodulated by remote unit 106. However, remote unit

106 will, in accordance with the standard, adjust its timing to the earliest of the arriving signals that it is able to receive and demodulate. The inventive technique described involves measuring in the infrastructure, either absolutely, relatively, or via an identification marker, the transmitter timing of the remote unit, the basis of which allows certain system control decisions to be made.

With reference to FIG. 2, remote unit 106 includes receive circuitry 202, transmit/modulation circuitry 204, receive circuitry and transmit/modulation circuitry 204 being coupled via duplexer 206 to antenna 210. Coupled to both receive circuitry 202 and transmit/modulation circuitry 204 is timing extractor 208. Timing extractor 208 operates in accordance with the IS-95 standard to extract timing information from the first to arrive traffic channel signal from base stations 102 and 104 that it is able to successfully demodulate. This timing information is coupled to transmit/modulation circuitry 204 for adjusting the transmit timing of remote unit 106 to the timing of the earliest arriving base station signal.

In accordance with the present invention, base stations 102 and 104 are adapted to observe the transmitted signals from remote unit 106 for timing changes and respond in a particular controlled way. With continued reference to FIG. 2, base stations 102 and 104 include, operatively coupled to antenna 212 transmit circuitry 214 and receive/timing extractor circuitry 216. Coupled to transmit circuitry 214 is transmit modulator 218 which receives a global timing reference signal from a central source 224, such as the global positioning system (GPS) satellite system. The timing extracted from the received signal and the base station transmit timing are compared using comparator 220 providing an indication as to the absolute time of arrival of remote unit 106 signals. Remote unit timing information may then be coupled to CBSC 108 for communication system control in accordance with preferred embodiments of the present invention.

As is known, base stations 102 and 104 or preferably CBSC 108 include remote unit location estimation capability. As remote unit 106 adjusts its timing, by slewing its clock to the earlier arriving signal, the timing of its transmitted signals are affected. Using remote unit timing information and base station timing information the absolute time of arrival of remote unit 106 transmitted signals may be determined. Based upon the estimation of the location of remote unit 106 from either base station 102 or 104 or CBSC 108 and the absolute time of arrival of remote unit 106 signals to the base station whether remote unit 106 is receiving and demodulating signals transmitted by that base station is determined directly from the signal transmitted by remote unit 106.

In another embodiment, with continued reference to FIG. 2, a timing modulation input 222 to modulator 218 is shown. Timing modulation input 222 is preferably a slow modulation on the timing of the base station which is also unique to each base station in operating in communication system 100. Remote unit 106 operates as described to detect the timing of the earliest arriving signal and to adjust its timing to the earliest arriving signal. In doing so, the timing of remote unit 106, and hence the timing of its transmitted signals, will reflect the unique modulation of the received base station. In an alternate preferred embodiment of the present invention, comparator 220 is adapted to compare timing modulation input 220 with remote unit 106 timing modulation and to provide a direct indication of the earliest arriving base station being received and demodulated by remote unit 106.

It might appear that the capability of the inventive technique is limited, since the transmitter timing of the remote unit is based strictly on what it receives as the earliest arriving signal from any base station signals in its active signal signal set. However, it is possible to adjust base station timing advantageously, preferably slowly and incrementally, under software control. Doing so can creates the illusion to the remote unit that a distant base station that it happens also able to receive is closer, or conversely, that a proximal base station is more distant by adjusting forward or backward, respectively, the relative base station timing. In this regard, CBSC 108 may control which base station remote unit 106 perceives as being received first and verify the same through observation of remote unit 106 timing.

FIG. 3 illustrates in flow chart form a method 300 of determining which of a plurality of base stations transmitting to a remote unit is being received and demodulated by the remote unit. Beginning at step 302, remote unit 106 receives and demodulates one of a plurality of signals transmitted by base stations, such as base stations 102 and 104, operating in communication system 100. Remote unit 106 extracts timing information from the transmitted signals, step 304, and adjusts its timing to the timing of the received signal, i.e., the transmitting base station timing, step 306. Remote unit 106 then transmits utilizing the adjusted timing information, step 308. Remote unit 106 transmitted signals are received by the base stations, step 310, and timing information, and hence information from which the received base station may be determined, is extracted from the signals transmitted by remote unit 106, step 312. This information is used either by the base stations or CBSC 108 to determine which base station is being received and demodulated by remote unit 106, step 314.

Base stations may include in their timing a modulated signal and step 302 would include demodulating the modulated signal. In addition, step 314 may involve observing in the remote unit 106 timing the base station timing modulation. The overall method may include the step of remote unit 106 demodulating the base station timing signal to extract information and data.

In FIG. 4 a method 400 is shown in flow chart form of controlling a communication system using information relating to which of several signals transmitted by base stations is received and demodulated by a remote unit. At step 402 communications between at least one base station and remote unit 106 is initiated. This may be the result of remote unit 106 initiating a call or a call termination at remote unit 106. At step 404, and in accordance with method 300, the earliest base station being received and demodulated by remote unit 106 is determined. At step 406, CBSC 108 initiates a communication control function. For example, another base station may be directed to begin communications with remote unit 106 in a diversity or soft handoff mode, or a base station presently communicating with remote unit 106 may be instructed, because it is not being received, to discontinue communications. With knowledge of which base station is being received by remote unit 106, CBSC may extinguish forward links to remote unit 106 which are not benefiting the communications or attempt to establish new links which may be beneficial. In a soft handoff mode, CBSC 108 may determine if a target forward link is actually being received by remote unit 106 prior to terminating active forward links thereby reducing orphan conditions. CBSC 108 may further conduct power control by directing a base station to increase its transmit power until it is observed that remote unit 106 is receiving the base station's signal or to decrease power until another base station's signals are received.

The present invention has been described in terms of several preferred embodiments for determining which of several signals transmitted from base stations are received and demodulated by a remote unit operating in the communication system. For example, information observed in the remote unit's transmitted signals and location information is used to deduce which base station was received. Additionally, a base station applies a uniquely identifying element to its signals which are reflected in the remote unit's transmissions again allowing for direct determination of which base station is being received. The techniques are employed in several preferred methods of controlling a communication system, including but not limited to, controlling forward link diversity, soft handoff and power control. The many advantageous of the present invention will be appreciated from the foregoing detailed description of the preferred embodiments and from the subjoined claims.

CLAIMS

I claim:

1. A method for communication control comprising the steps of:

receiving at a remote station signals transmitted from a plurality of transmitting stations;

adjusting a transmitted signal from the remote station in accordance with a rule for receiving multiple signals; and

performing a communication control function in response to a characteristic of the adjusted transmitted signal.

2. The method of claim 1 wherein the step of performing a communication control function comprises one of: performing forward link diversity control, performing soft handoff control and performing power control.

3. The method of claim 1 wherein the step of performing a communication control function comprises adjusting a transmission characteristic of at least one of the transmitting stations.

4. The method of claim 1 wherein the step of adjusting a transmitted signal from the remote station comprises:

extracting information from at least one of the signals transmitted from a plurality of transmitting stations and adjusting the transmitted signal based upon the extracted information.

5. The method of claim 4 wherein the information comprises at least one of: timing information and a modulated signal.

6. An apparatus for detecting reception of a transmitted signal comprising:

a first transceiver for transmitting a first signal having a signal characteristic and for receiving a second signal;

a second transceiver including a signal characteristic extractor and a signal transmission adaptor, for receiving the first signal, extracting the signal characteristic and for transmitting the second signal, the second signal being adapted in response to the signal characteristic;

an analyzer coupled to the first transceiver for analyzing the second signal for the signal characteristic.

7. The apparatus of claim 6 wherein the first transceiver comprises a signal characteristic modulator.

8. The apparatus of claim 6 wherein the analyzer comprises a signal characteristic extractor for extracting a signal characteristic from the second signal and a comparator for comparing the first signal characteristic with the second signal characteristic.

9. The apparatus of claim 6 wherein the signal characteristic comprises a timing characteristic.

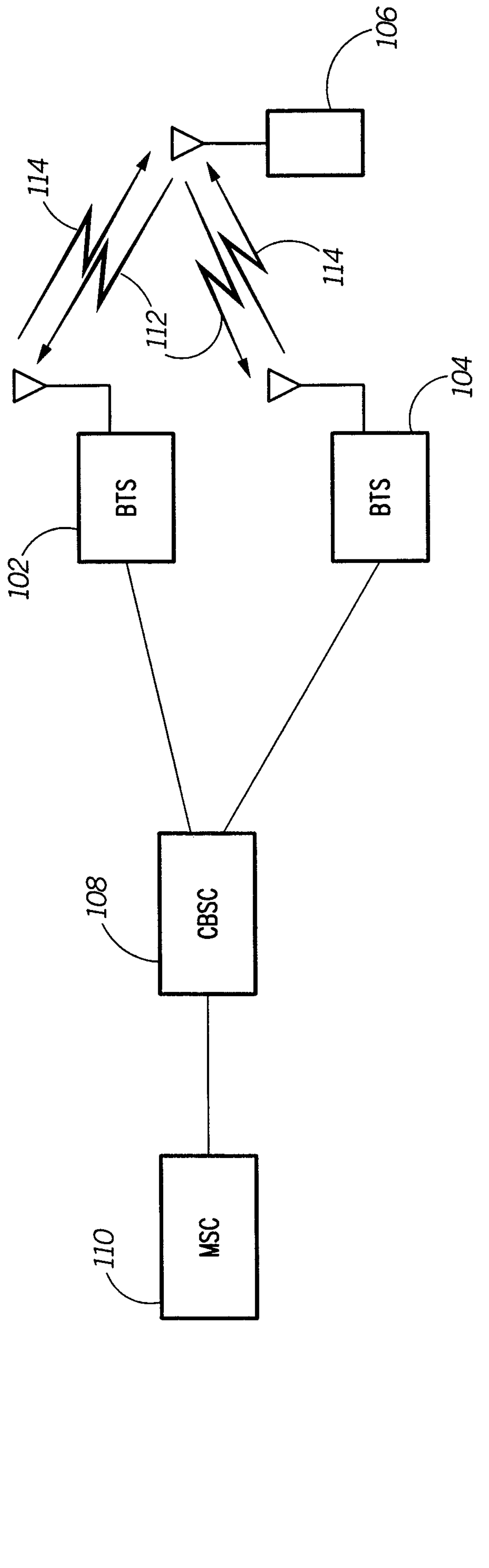

FIG. 1

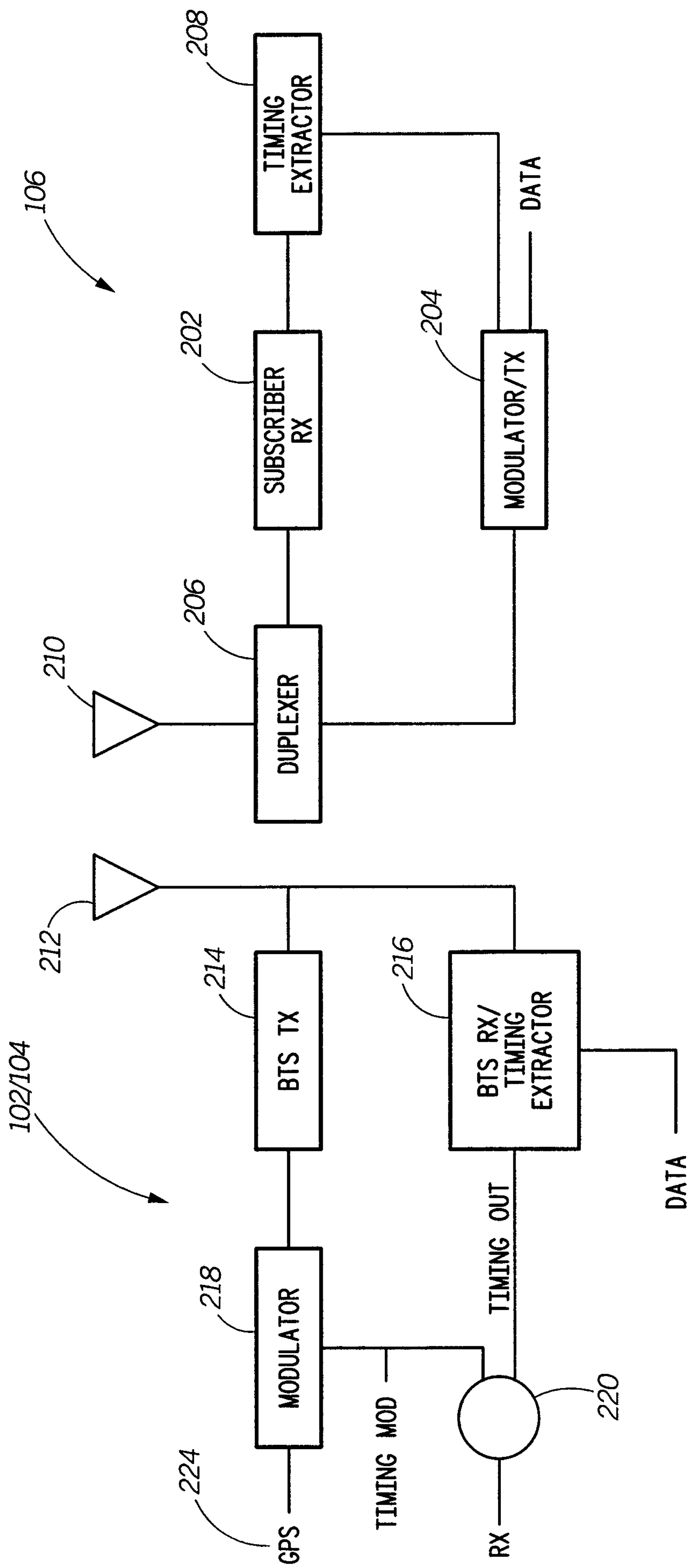
106
208
TIMING EXTRACTOR
DATA
202
SUBSCRIBER RX
204
MODULATOR/TX
210
206
DUPLEXER
212
214
BTS TX
216
BTS RX/ TIMING EXTRACTOR
102/104
DATA
218
MODULATOR
TIMING OUT
TIMING MOD
220
224
GPS
RX

FIG. 2

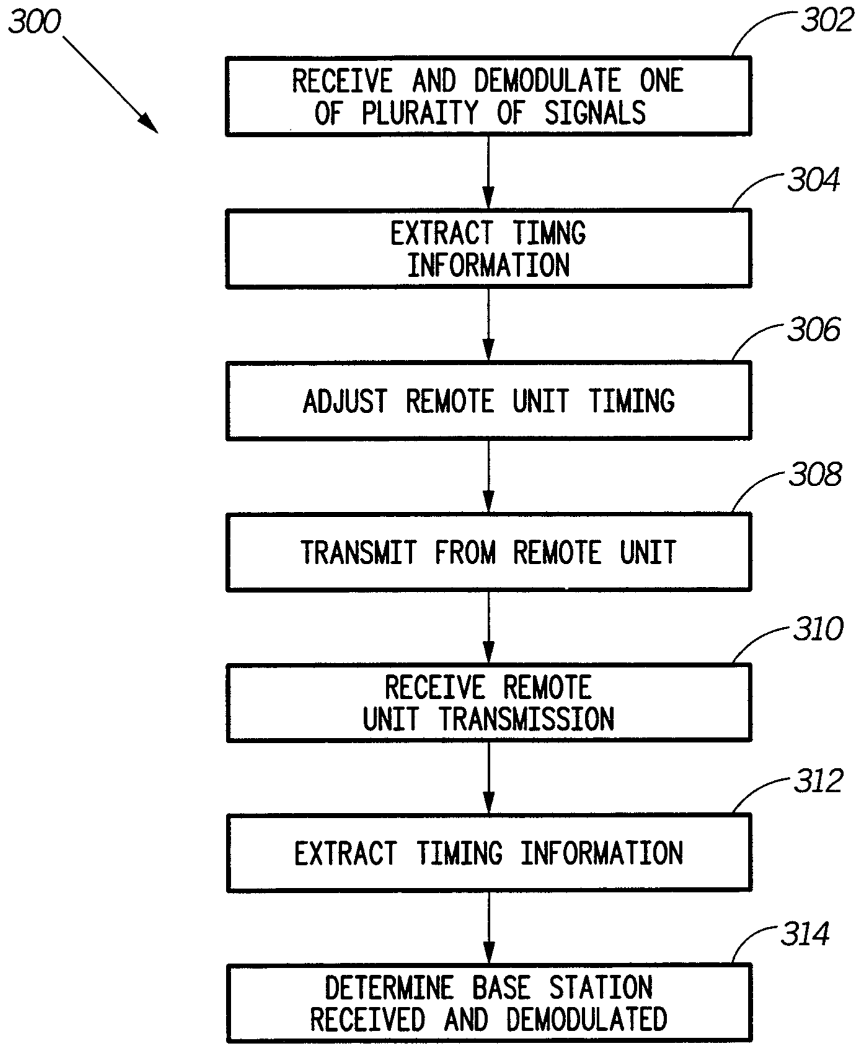
300
302
RECEIVE AND DEMODULATE ONE OF PLURAITY OF SIGNALS
304
EXTRACT TIMNG INFORMATION
306
ADJUST REMOTE UNIT TIMING
308
TRANSMIT FROM REMOTE UNIT
310
RECEIVE REMOTE UNIT TRANSMISSION
312
EXTRACT TIMING INFORMATION
314
DETERMINE BASE STATION RECEIVED AND DEMODULATED

FIG. 3

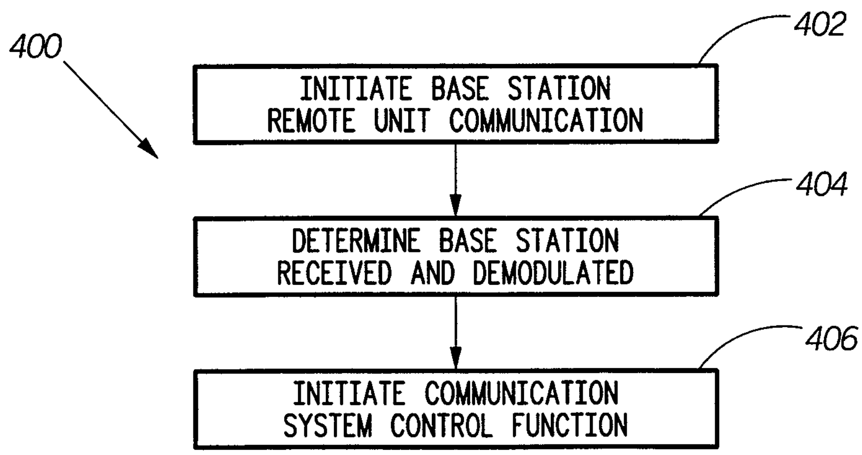
400
402
INITIATE BASE STATION REMOTE UNIT COMMUNICATION
404
DETERMINE BASE STATION RECEIVED AND DEMODULATED
406
INITIATE COMMUNICATION SYSTEM CONTROL FUNCTION

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/16338

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04B 1/00; H04Q 7/00, 7/22, 7/38
US CL :455/440, 442, 447, 502, 512, 513, 517, 524, 525
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,574,983 A (DOUZONO ET AL) 12 NOVEMBER 1996, SEE ABSTRACT AND FIGURES 1-6.	1-9
Y,P	US 5,771,451 A (TAKAI ET AL) 23 JUNE 1998, SEE ABSTRACT AND FIGURES 1-11	1-9
Y,E	US 5,809,430 A (D'AMICO) 15 SEPTEMBER 1998, SEE ABSTRACT AND FIGURE 1	1-9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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