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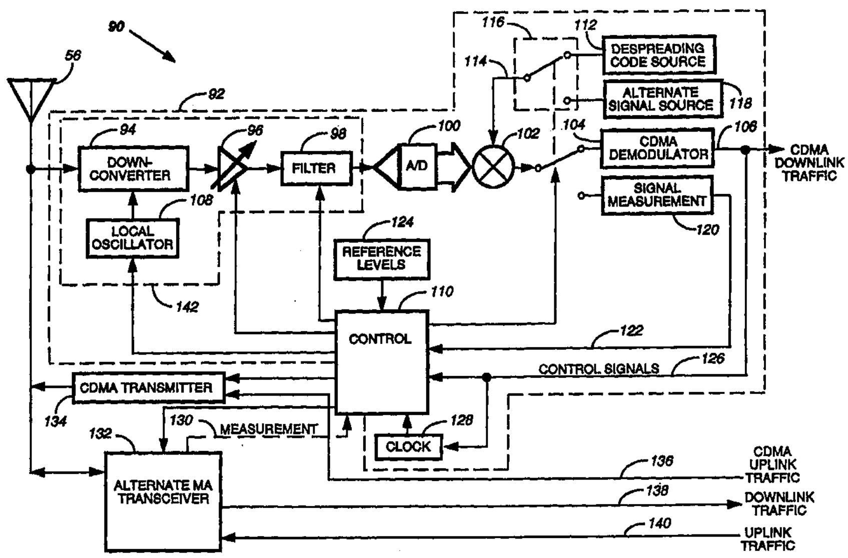


(57) Abstract

In a method in a cellular telecommunications system for performing a subscriber (28) handoff (216) from a first multiple access communications system to a second multiple access communications system, a subscriber unit in communication with said first multiple access communications system measures (206) a signal characteristic of a signal from the second multiple access communications system to produce a signal characteristic value. In response to the signal characteristic value, the subscriber unit is configured to communicate with the second multiple access communications system. Thereafter a subscriber handoff (216) is performed from the first multiple access communications system to the second multiple access communications system. The signal characteristic value may be signal strength. The signal characteristic may be measured with the receiver (92) for the first multiple access communications system.

SUBSCRIBER HANDOFF BETWEEN MULTIPLE ACCESS COMMUNICATIONS SYSTEM

Field of the Invention

The present invention is related in general to wireless communication systems, and more particularly to an improved method and system for performing a handoff between cellular communication systems having different multiple access schemes.

Background of the Invention

In order to maximize the use and reuse of radio frequency spectrum, wireless communication systems use various schemes for allowing multiple users to simultaneously, or nearly simultaneously, access communication resources. For example, in cellular telephone systems, many cellular subscribers are allowed access to wireline communications resources (*i.e.*, the public switched telephone network (PSTN)) via various air interfaces that permit multiple subscriber access.

A multiple access scheme may be defined as a set of rules for sharing a communication resource, such as radio frequency spectrum, by allocating combinations of transmit or receive times, channel frequency, channel bandwidth, channel codes, transmit or receive locations, or the like. Examples of well known multiple access schemes include: AMPS (Advanced Mobile Phone System), NAMPS (Narrowband AMPS), TACS (Total Access Communications System), GSM (Global System for Mobile Communications), TDMA (Time Division Multiple Access), and CDMA (Code Division Multiple Access). Many of these multiple access schemes are well documented in industry standards promulgated by the Cellular Telecommunications Industry Association (CTIA), the Telecommunication Industry Association (TIA), and other standards bodies. An example is the standard IS-95 for code division multiple access cellular communications systems.

As newer multiple access schemes are deployed, the coverage area of the new multiple access system is typically not as widespread as the older, more established communication systems that use a different multiple access scheme. Therefore, in order to provide subscribers using the new multiple access scheme a wider area of communications service, dual mode subscriber units have been developed so that subscribers may have service from the newer multiple access system, and when they roam outside the coverage of the newer multiple access system, the subscriber unit is able to communicate with an older or alternate multiple access system.

With reference now to **FIG. 1**, there is depicted a typical relationship between the coverage of a communications system with a first multiple access scheme and the coverage of a communications system using a second multiple access scheme. More specifically, the cellular coverage area **20** of **FIG. 1** shows a cellular system using a code division multiple access (CDMA) scheme, illustrated with hexagonal cells **22**, and, for clarity of illustration, an alternate multiple access (MA) scheme, illustrated with circularly shaped cells **24**. The boundary between the area covered by CDMA cells **22** and an area covered by an alternate MA with alternate MA cells **24** is shown by border **26**, shown with a heavy line.

As subscriber **28** moves between CDMA cells **22**, a CDMA base station controller **30** supervises or manages handoffs between CDMA cells **22**. Similarly, as subscriber **28** moves between alternate MA cells **24**, alternate MA base station controller **32** supervises or manages handoffs between alternate MA cells **24**. A handoff is a process in a cellular communications system by which a traffic channel is switched from communication with one cell to communication with another cell.

The problem solved by the present invention occurs when the communications system using a first MA wants to handoff a subscriber to a communications system using a second MA. This problem occurs in **FIG. 1** when subscriber **28** moves from CDMA cell **22**, across border **26** to an alternate MA cell **24**. The problem may also occur without subscriber **28** crossing border **26**, when, for example, the first MA communications system wants to handoff subscriber **28** to an alternate MA cell **24** having coverage within the area covered by the first MA communications system.

In the prior art, when, for example, the first MA is CDMA, a pilot beacon **34** is used to warn CDMA base station controller **30** that subscriber **28** is nearing the edge of CDMA coverage (*i.e.*, border **26**). As used herein, a pilot beacon **34** is a transmitted signal that is defined in, or typically received by a component in, the first MA, the MA that is the source of the handoff. For example, when CDMA is the source MA, pilot beacon **34** is a pilot channel beacon, which makes alternate MA cells **24** outside and adjacent to border **26** look like another CDMA cell **22**. This means that subscriber **28** reports the presence and strength of pilot beacon **34** to CDMA base station controller **30**, according to the rules of CDMA IS-95, so that it can arrange a handoff with the alternate MA base station controller **32** through an inter-MA base station controller communication link **36**. For a more detailed description, see United States Patent No. 5,594,718 to Weaver, Jr., et al., issued January 14, 1997.

Placing pilot beacons **34** in cells adjacent and outside border **26** has many problems. First, it is expensive. Each pilot beacon **34** requires a transmitter coupled to an antenna mounted on a suitable structure.

Second, it increases the complexity of the communication system. CDMA pilot beacons must be synchronized with the rest of the system and identified with a unique timing offset. Power levels must be properly set.

Third, additional antenna sites must be leased or purchased. Some of these site agreements may require negotiation with cellular system competitors for space on a competitor's tower.

Fourth, the pilot beacons may add to the noise floor of a system operated in the same radio frequency band by another licensee.

Fifth, the pilot beacon measured by the first or source MA communications system may not be a good indicator of communication quality of a radio frequency link using the second MA communications system. That is, the signal quality of a CDMA pilot beacon transmitted from a collocated AMPS cell and measured at a subscriber location may not accurately correspond to an AMPS signal quality at the same subscriber location; the AMPS signal may be experiencing a fade while the CDMA pilot beacon is not. This may be caused by differences in propagation between the CDMA pilot signal on one frequency and the AMPS signal on another frequency.

An alternative to using pilot beacons for handoffs between different MA systems is a blind handoff—one without any prior knowledge of traffic channel conditions in the second MA communications system. This alternative may easily result in a dropped call. And when more than one cell the second MA communications system may handle the traffic channel, there is no intelligent choice as to which is the better handoff candidate.

For the reasons discussed above, there is a need for an improved method and apparatus for performing a handoff between communications systems having different multiple access schemes.

Brief Description of the Drawings

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 depicts a sample coverage area provided by two communications systems using two different multiple access schemes wherein handoff between the two systems uses pilot beacons, according to the prior art;

FIG. 2 is a high-level schematic of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention;

FIG. 3 illustrates an alternate embodiment of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention;

FIG. 4 depicts a high-level schematic of a code division multiple access system for performing a handoff with an alternate MA communication system in accordance with the method and system of the present invention;

FIG. 5 is a more detailed block diagram of a first embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention;

FIG. 6 depicts a second embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention;

FIG. 7 is a high-level logic flow chart which illustrates the method of performing a handoff with an alternate MA communication system according to the present invention;

FIG. 8 is a more detailed flow chart which illustrates the process of subscriber unit initialization according to the present invention;

FIG. 9 is a more detailed flow chart which illustrates the process of measuring a signal characteristic in an alternate MA communication system in accordance with the present invention; and

FIG. 10 is a more detailed flow chart which illustrates the process of configuring a receiver to measure a signal characteristic in an alternate MA communication system in accordance with the present invention.

Detailed Description of the Invention

With reference now to figures, and in particular with reference to FIG. 2, there is depicted a high-level schematic of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention. As is shown, subscriber unit **50** generally comprises first multiple access transceiver **52** and second multiple access transceiver **54**, both of which are coupled to antenna **56**. First MA transceiver **52** is adapted to communicate with cells in a first communication system using a first multiple access scheme. Similarly, second MA transceiver **54** is adapted to communicate with cells in a second communication system using a second multiple access scheme. Appropriate duplexers (not shown) may be used to separate transmitted signals from received signals. The frequency of first MA transceiver **52** is controlled by local oscillator **58**, and the frequency of second MA transceiver **54** is controlled by local oscillator **60**. Both local oscillators **58** and **60** may be set to a selected frequency by a command or signal from control circuit **62**.

Also shown in the embodiment of **FIG. 2** is second MA measurement circuit **64**, which has an input coupled to antenna **56** and a measurement output coupled to control circuit **62**. Second MA measurement circuit **64** also receives control signals via a control line from control circuit **62**.

Referring again to first MA transceiver **52**, downlink traffic **66** is output from first MA transceiver **52**, and may be coupled to control circuit **62** and clock **68**. Downlink traffic **66** may contain control information, clock or synchronization information, and voice data or other data for processing by circuits in the subscriber unit that are not shown.

Uplink traffic **70** is an input signal for first MA transceiver **52**. Uplink traffic **70** may contain voice or other subscriber data, and control information from control circuit **62**.

Second MA transceiver **54** may include an output for downlink traffic **72** and an input for uplink traffic **74** in a similar manner. Both downlink traffic **66** and **72** and uplink traffic **70** and **74** are processed in portions of subscriber unit **50** that are not shown in a manner known in the art of cellular subscriber units to provide either voice or computer data communication services.

In operation, subscriber unit **50** communicates with a cell in a first multiple access communication system via transceiver **52**. Subscriber unit **50** has been instructed to tune first MA transceiver **52** to a particular frequency, which is set or derived from local oscillator **58**. Periodically, control circuit **62** may receive an instruction that starts the process to switch or handoff to a traffic channel in the second multiple access communication system. After such an instruction has been received, control circuit **62** causes second MA measurement circuit **64** to measure a signal characteristic of a signal from the second MA communication system. Such a signal characteristic is typically signal strength. The second MA signal characteristic is measured to determine whether or not a successful handoff may take place between the first MA communication system and the second MA communication system. The measurement of the second MA signal is typically taken at a predetermined time according to clock **68**, preferably at a time that avoids interruption of downlink traffic **66** or uplink traffic **70**. Second MA measurement circuit reports the signal of characteristic measurement to control circuit **62**. Control circuit

62 then determines whether and how to report the second MA signal characteristic measurement to the first MA base station controller via uplink traffic **70** and first MA transceiver **52**.

The measurement frequency of second MA measurement circuit **64** is controlled by the frequency of local oscillator **60**, which may be set by control circuit **62**.

Once the reports of the second MA signal measurements have been received by the base station controller in the first MA communication system, the base station controller may decide that a handoff to the second MA communication system is appropriate and will be successful. Alternatively, this handoff determination may be made by the subscriber unit, in which case the subscriber requests the first MA base station controller to schedule the handoff.

Subscriber handoff to the second MA communication system is initiated by a command received through antenna **56** and first MA transceiver **52**. At the agreed upon time, control circuit **62** switches the downlink traffic and uplink traffic in subscriber unit **50** from first MA transceiver **52** to second MA transceiver **54**, thus completing a handoff from the first MA communications system to the second MA communications system.

With reference now to **FIG. 3**, there is depicted an alternate embodiment of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention. In this embodiment, the measurement of the signal from the second multiple access communication system is performed by second MA transceiver **80**. Such a measurement may be implemented with an RSSI (Receive Signal Strength Indicator) such as those included in many AMPS transceivers. To correctly take the second MA signal characteristic measurement, control circuit **62** may pass control information to second MA transceiver **80**. Such control information may include gain settings, frequencies, frequency ranges, the type of multiple access signal to be measured, time slot information, and the timing of the second MA signal measurement.

The embodiment of **FIG. 3** also includes a single local oscillator **82**. Thus, both transceivers **52** and **80** for the first and second MA communication systems share the same local oscillator **82**, which is under the control of control circuit **62**. Local oscillator **82** should be capable of quickly switching between two frequencies and settling in a short time so that a second MA signal characteristic may be measured without unduly interrupting downlink traffic **66** or uplink traffic **70**.

With reference now to **FIG. 4**, there is depicted a high-level schematic of a code division multiple access (CDMA) system for performing a handoff with an alternate communication system in accordance with the method and system of the present invention. As illustrated, subscriber unit **90** includes antenna **56** for receiving and transmitting signals from cells in both a CDMA and an alternate MA communication system. In this example, an alternate MA communication system is a communication system using a multiple access scheme different from CDMA. CDMA receiver **92** includes a CDMA downlink traffic path that includes down-converter **94**, gain control **96**, filter **98**, analog-to-digital (A-to-D) converter **100**, despreader **102**, and CDMA demodulator **104**. CDMA downlink traffic **106** is output by CDMA demodulator **104**.

Down-converter **94** performs a frequency translation from the radio frequency signals at antenna **56** to a lower intermediate frequency which is passed to gain control **96**. Local oscillator **108** provides an input reference frequency for down-converter **44**.

Gain control **96** may be implemented with a variable gain amplifier which operates under the control of signals from control circuit **110**.

A-to-D converter **100** converts analog signals into a digital word which has been sampled at discrete times.

Such a digital word is input into despreader **102**, wherein during normal CDMA operation, the digital word is multiplied with a despreading code from despreading code source **112**.

According to an important aspect of the present invention, despreader signal **114** is selected by despreader signal selector **116** under the control of control circuit **110**. When despreading code source **112** is selected to provide despreader signal **114**, the output of despreader **102** is directed to CDMA demodulator **104** which provides CDMA downlink traffic signal **106** for operation in a normal CDMA demodulation mode. In a measurement mode, despreader signal selector **116** selects despreader signal **114** from alternate signal source **118**. Thus, when the signal from alternate signal source **118** is input into despreader **102**, the output of despreader **102** is directed to signal characteristic measurement circuit **120**. A signal characteristic value **122** produced by signal characteristic measurement circuit **120** is then input into control circuit **110**. Two embodiments of signal characteristic measurement circuit **120** will be described below in relation to **FIGs.** 5 and 6.

Also providing inputs for control circuit **110** are reference levels **124**, control signals **126**, clock **128**, and optionally measurement signal **130** from alternate MA transceiver 132.

CDMA transmitter **134** is coupled to antenna **56** for transmitting CDMA uplink traffic **136**. CDMA transmitter **134** also operates under the control of signals from control circuit **110**.

Alternate MA transceiver **132** is coupled to antenna **56** for receiving downlink traffic **138** and transmitting uplink traffic **140** according to the rules of the alternate MA scheme. Alternate MA transceiver **132** operates under the control of signals from control circuit **110**. Such control signals may control the frequency of alternate MA transceiver **132**, the type of MA used by alternate MA transceiver **132**, the precise timing for switching to downlink traffic **138** and uplink traffic **140**, which are to be received and transmitted via alternate MA transceiver **132**, and other similar controls.

In operation, control circuit **110** receives a command via CDMA downlink traffic **106** to initiate a handoff procedure to an alternate MA communication system. Before the handoff is made, however, a measurement of a signal from the MA communication system is made and reported to the CDMA base station controller. In the embodiment shown in **FIG. 4**, CDMA receiver **92** operates in two modes: a normal CDMA demodulation mode, and an alternate MA signal measurement mode.

In the normal CDMA demodulation mode, despreader signal selector **116** selects a signal from despreading code source **112** for despreader signal **114** that is input into despreader **102**. In this mode, regular CDMA downlink traffic **106** is output by CDMA demodulator **104**. Such CDMA downlink traffic **106** may include control signals **126** and timing signals or queues, which are input into control circuit **110** and clock **128**, respectively.

In the alternate MA signal measurement mode, despreader signal selector **116** selects a signal from alternate signal source **118** for the despreader signal **114** which is input into despreader **102**. The output of despreader **102** is then used by signal characteristic measurement circuit **120** to measure a signal characteristic of a signal from an alternate MA system. A signal characteristic value **122**, the result of the measurement, is input into control circuit **110**, and may be compared with a reference level recalled from or calculated by reference levels **124**. In accordance with an agreed upon reporting criteria, control circuit **110** reports such a comparison to the CDMA base station controller **30** (see **FIG. 1**) via CDMA transmitter **134**. When the data pertinent to the handoff decision has been collected, the decision to handoff is made either by the subscriber unit, the base station controller, or at some other location; the specific place or functional unit that makes the decision is up to the system designer.

When directed to perform a handoff between communication systems, subscriber unit **90** will switch from using CDMA downlink traffic **106** and CDMA uplink traffic **136** to using alternate MA downlink traffic **138** and alternate MA uplink traffic **140**.

With reference now to **FIG. 5**, there is depicted a more detailed block diagram of a first embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention. As illustrated, signal characteristic measurement circuit **120** includes narrowband filter **150**, power measurement function **152**, and integrator **154**. Thus, the output of signal characteristic measurement circuit **120** may be a estimated power level integrated over a period of time. Such a power level value may be compared to a reference level in control circuit **110**. If signal characteristic measurement circuit **120** is measuring a signal from a single AMPS communications system channel, narrowband filter **150** may be tuned to the bandwidth of an AMPS channel, which is 30 kHz.

With reference now to **FIG. 6**, there is depicted a second embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention. As illustrated, this second embodiment of signal characteristic measurement circuit **120** includes wideband filter **156** and frequency analysis circuit **158**. In operation, wideband filter **156** may, for example, be set to receive a frequency range that covers several AMPS channels. Frequency analysis circuit **158** may be used to perform a Fourier transform on the filtered signal. Such a Fourier transform may reveal several AMPS frequencies from several AMPS base stations, any one which may be selected as the destination base station of a handoff from the CDMA system to the AMPS system.

Prior to measurements by signal characteristic measurement circuit **120** shown in either **FIG. 5** or **FIG. 6**, it may be necessary to set an appropriate gain at gain control **96** (see **FIG. 4**). Depending upon which measurement circuit is used, and what multiple access system is to be measured, control circuit **110** may set gain control **96** in an appropriate manner so that a valid measurement may be made.

With reference now to **FIG. 7**, there is depicted a high-level logic flowchart which illustrates the method of performing a handoff with an alternate communications system in accordance with the present invention. As illustrated, the process begins at block **200** and thereafter passes to block **202** wherein the process initializes the subscriber unit. This initialization process involves transferring parameters and negotiating protocols between the base station controller and the subscriber unit. Such an initialization process is described in greater detail below with reference to **FIG. 8**.

Next, the subscriber unit measures a signal characteristic of a signal from an alternate multiple access communication system, as illustrated at block **204**. Such a measurement may be accomplished with an alternate MA transceiver in the subscriber unit as illustrated in **FIG. 3**, or with an alternate MA measurement circuit in the subscriber unit as illustrated in the example of **FIG. 2**. Yet another way of measuring the alternate MA signal is to use the current MA receiver, as illustrated in **FIG. 4**, wherein a CDMA receiver may be reconfigured to measure a signal in an alternate MA, such as AMPS.

After measuring the alternate MA signal, the subscriber unit optionally measures a signal characteristic of a signal from the current MA communications system, as depicted at block **206**. In some communications systems, this step may be optional because the signal characteristic of a signal from the current MA system may be irrelevant to the handoff decision. However, some systems may be designed to compare the signal characteristic of the signal from the alternate MA with the signal characteristic of the signal from the current MA.

After taking the appropriate signal measurements, the subscriber unit reports these signal characteristic measurements to the base station controller, as illustrated at block **208**. The criteria for reporting signal characteristic measurements may be negotiated during the initialization procedure in block **202**. Some measurements may only be reported if they exceed a certain threshold value, wherein the absence of a signal characteristic report is interpreted as a measurement of a value below the threshold value.

Note that the step at block **208** may not be necessary if the system is designed to let the subscriber decide when and where to handoff, in which case the subscriber may ask to be handedoff rather than reporting signal measurement values.

After all signal characteristic measurements have been reported to the current MA base station controller, the process determines whether or not a handoff should be attempted to the alternate MA communication system, as depicted at block **210**. If, for whatever reason, a handoff attempt should not be made, the process iteratively returns to block **204** to update the signal measurements. If the system determines that a handoff should be made from the current MA communications system to the alternate MA communications system, the process then determines whether or not the alternate MA system can accept the subscriber traffic, as illustrated at block **212**.

If the alternate system cannot accept the subscriber traffic, the process iteratively returns to block **204**, wherein the measurements are updated. If the alternate MA communications system can accept the subscriber traffic, the process coordinates a handoff with the alternate MA communication system, as depicted at block **214**. This step may be implemented by communication between the current MA base station controller and the alternate MA base station controller via inter-MA base station controller communications link **36** (see **FIG. 1**). Coordination of the handoff may include parameters such as a destination frequency of a channel in the alternate MA communications system and a specific time for the handoff to occur.

After coordinating the handoff, the process performs a subscriber handoff from the current MA communication system to the alternate MA communication system, as illustrated at block **216**. As with handoffs between cells of any cellular communication system, the handoff between communication systems with different MAs should take place quickly so that the subscriber traffic channel is not unduly interrupted.

The process of performing a handoff from a communication system with a first MA to a communication system with a second MA is then terminated at block **218**.

With reference now to **FIG. 8**, there is depicted a more detailed flowchart which illustrates the process of initializing a subscriber unit according to the present invention. As illustrated, the initialization procedure starts at block **300**, and thereafter passes to block **302** wherein the process sends the alternate MA communication system type to the subscriber. This step may be implicit if the subscriber unit is only designed to handoff to one other alternate communications system type. The alternate communication system type may, for example, specify an AMPS system, a TDMA system, a GSM system, or any other standardized multiple access system.

After receiving the alternate MA communication system type, the process sends a frequency list or frequency range which is used by the alternate MA communication system, as illustrated at block **304**. The frequency list may include a list of frequencies of control channels used at various base stations in, for example, an AMPS system. Alternatively, a frequency range may be specified wherein the signal strength, or other signal characteristic, of several frequencies within the range may be reported back to the base station controller.

Next, the subscriber unit receives the reporting criteria for reporting measurements of signals from the alternate MA communication system, as depicted at block **306**. Such reporting criteria may include instructions not to report signal characteristics from the alternate MA that fall below a threshold value. Thus, the absence of a response to request for a report may be interpreted by the base station controller as a measurement of a value that falls below the agreed upon threshold. The reason for such reporting criteria may be to reduce reporting traffic between the subscriber unit and the base station controller.

Thereafter, the process negotiates the timing of alternate MA signal measurements with the current MA communications system, as illustrated at block **308**. Such negotiation may result in measurements being taken at predetermined time intervals, or measurements taken only upon request.

The initialization process is then terminated, as indicated at block **310**.

With reference now to **FIG. 9**, there is depicted a more detailed flowchart which illustrates the process of measuring a signal characteristic or a signal in an alternate MA communications system in accordance with the method of the present invention. As illustrated, the process begins at block **400**, and thereafter passes to block **402** wherein the process determines whether or not it is time to measure a signal characteristic of a signal from an alternate MA communication system. If it is not time to take a measurement, the process iteratively loops until it is time to take a measurement. The time to take a measurement may be set at predetermined intervals or only as requested by a base station controller in the current MA communication system. The time to take alternate MA communication system measurements may be negotiated during the initialization procedure, as described with reference to **FIG. 8**.

If it is time to take a signal characteristic measurement of a signal from an alternate communication system, the process configures the subscriber unit for the alternate MA signal measurement, as depicted at block **404**. In some embodiments of the present invention, this configuration process prepares signal characteristic circuit **120** to take the measurement, and may also set various filters and gain adjustments so that the measurement circuit may provide a valid measurement. This subscriber configuration process is described in greater detail with reference to **FIG. 10** below.

Next, the process measures the signal characteristic of the signal from the alternate MA communication system, as illustrated at block **406**. In a preferred embodiment, this signal characteristic is signal strength. According to the architecture of the subscriber unit, the signal measurement may be taken with a special configuration of the current MA demodulator, or with a dedicated receiver that receives alternate MA signals, or with the receiver portion of the alternate MA transceiver. These various subscriber architectures are described with reference to **FIGs. 2-4**.

After making the signal characteristic measurement, the process reconfigures the subscriber unit for normal operation in the current MA communication system, as depicted at block **408**. If the circuit used to measure the signal characteristic is not completely independent from the current MA transceiver, the period of time between blocks **404** and **408** should be minimized so that subscriber traffic is not unduly interrupted.

After reconfiguring the subscriber unit for normal demodulation in the current MA communication system, the process determines whether or not the alternate MA signal measurement was valid, as illustrated at block **410**. If the measurement was valid, the process ends, as depicted at "return" block **412**. Alternatively, if the measurement was not good, the process adjusts the measurement configuration parameters, such as filter and gain settings, as depicted at block **414**. Thereafter, the process iteratively returns to block **402** to await another measurement time. For obvious reasons, the subscriber unit will probably be returned to normal operations while waiting for the next opportunity to take a measurement.

With reference now to **FIG. 10**, there is depicted a more detailed flowchart which illustrates the process of configuring a receiver to measure a signal characteristic in an alternate MA communication system in accordance with the method of the present invention. As illustrated, the process begins at block **500** and thereafter passes to block **502** wherein the process suspends code division multiple access talking and listening, or modulating and demodulating. Note that the process described in relation to **FIG. 10** specifically relates to a CDMA receiver which is used to make signal characteristic measurements of a signal from an alternate MA communication system, such as the CDMA receiver shown in **FIG. 4**.

Next, the process sets the local oscillator frequency to receive an alternate MA communication system frequency, as illustrated at block **504**. This step may be used to set local oscillator **108** with a control signal from control circuit **110** in subscriber unit **90** illustrated in **FIG. 4**.

After setting the local oscillator, the process sets the signal gain and filters for receiving the signal from the alternate MA communication system, as depicted at block **506**. Similarly, control circuit **110** may send signals to gain control **96** and filter **98** in preparation for measuring a signal from an alternate MA communication system.

Note that steps **504** and **506** may be referred to as configuring a tuner to receive a signal from an alternate MA system. Such a tuner is shown at reference numeral **142** in **FIG. 4**. Next, the process selects an alternate despreading signal for use in the CDMA despreader, as illustrated at block **508**. With reference to **FIG. 4**, this step may be accomplished by switching despreader signal selector **116** to the alternate signal source position so that despreader signal **114** comes from alternate signal source **118**. Alternate signal source **118** may be a series of zeros or ones, which produces a constant valued signal that suspends the despreading operation in despreader **102**.

After selecting the alternate despreading signal, the process enables the alternate MA signal characteristic measurement circuitry, as depicted at block **510**. This step may be accomplished by clearing registers or otherwise resetting signal characteristic measurement circuit **120**. Thereafter, the configuration process terminates, as illustrated at block **512**.

To configure a subscriber unit having an architecture such as that illustrated in **FIG.** 3, the configuration process may execute blocks **502**, **504**, **506**, and then jump to block **510** to enable the measurement circuitry within second MA transceiver **80**. In a subscriber unit having architecture depicted in **FIG.** 2, the measurement configuration process may execute step **506** and then skip to step **510** to take the measurement with second MA measurement circuit **64**. Setting a local oscillator is not necessary because the measurement circuitry uses an independent local oscillator **60**.

In summary, the invention described above permits a handoff from a first multiple access communication system to a second multiple access communication system, wherein a dual mode subscriber unit assists the handoff by measuring signals from the second multiple access system at the subscriber unit. A plurality of pilot beacons transmitting signals in the MA scheme of the first multiple access communication system are not required, thereby lowering the cost of infrastructure necessary to enable the inter-system handoff.

While some of the specific examples described above relate to handing-off a subscriber unit from a CDMA system to an AMPS system, the principles and basic architectures of the present invention may be used to perform a handoff from any MA communication system to any other MA communication system.

Various means of measuring alternate MA signal characteristics have been described, including: a subscriber system that uses an independent measurement circuit, a subscriber unit that shares a local oscillator circuit between transceivers for the different MA's, and a subscriber unit that uses a reconfigured CDMA receiver to measure a signal characteristic of a signal from an alternate MA communication system. Such a CDMA receiver may be set so that the despreading operation is suspended and the alternate signal passing through the despreader may be analyzed by integrating power over a narrow band, or by analyzing a wide band frequency spectrum.

In some embodiments of the present invention, alternate signal source **118** may be a specialized signal that will enhance the measurement of an alternate MA signal or signals that have known characteristics. For example, such a signal may contain multiple discrete frequencies that can be used to detect the power of multiple alternative MA signals.

The foregoing description of a preferred embodiment of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Modifications or variations are possible in light of the above teachings. The embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application, and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

Claims

What is claimed is:

1. A method in a cellular telecommunications system for performing a subscriber handoff from a first multiple access communications system to a second multiple access communications system, said method comprising the steps of:

from a subscriber unit in communication with said first multiple access communications system, measuring a signal characteristic of a signal from said second multiple access communications system to produce a signal characteristic value;

in response to said signal characteristic value, configuring said subscriber unit to communicate with said second multiple access communications system; and

performing a subscriber handoff from said first multiple access communications system to said second multiple access communications system.

2. The method for performing a subscriber handoff according to claim 1 wherein said signal characteristic is signal strength.

3. The method for performing a subscriber handoff according to claim 1 wherein said first multiple access communications system is a code division multiple access system and said subscriber unit includes a despreader using a despreading signal, and wherein the step of measuring a signal characteristic further includes:

selecting an alternate despreading signal for use in said despreader;

passing said signal from said second multiple access communications system through said despreader; and

measuring a signal characteristic of a signal from said second multiple access communications system to produce a signal characteristic value.

4. The method for performing a subscriber handoff according to claim 3 wherein said alternate despreading signal includes a constant value despreading signal.

5. The method for performing a subscriber handoff according to claim 3 wherein said alternate despreading signal includes a signal having multiple preselected discrete frequencies for measuring power in multiple signals in said second multiple access communications system having different frequencies.

6. The method for performing a subscriber handoff according to claim 3 wherein said step of measuring a signal characteristic of a signal from said second multiple access communications system to produce a signal characteristic value further includes performing a frequency analysis of a signal from said second multiple access communications system to produce signal power values over a frequency range.

7. The method for performing a subscriber handoff according to claim 1 wherein said step of configuring said subscriber unit to communicate with said second multiple access communications system in response to said signal characteristic value further includes configuring said subscriber unit to communicate with said second multiple access communications system in response to said signal characteristic value exceeding a predetermined threshold.

8. The method for performing a subscriber handoff according to claim 1 further including the steps of:

from said subscriber unit, measuring a signal characteristic of a signal from said first multiple access communications system to produce a first system signal characteristic value;

comparing said signal characteristic value with said first system signal characteristic value; and

configuring said subscriber unit to communicate with said second multiple access communications system in response to said signal characteristic value exceeding said first system signal characteristic value.

9. The method for performing a subscriber handoff according to claim 1 wherein said step of configuring said subscriber unit to communicate with said second multiple access communications system in response to said signal characteristic value further includes switching subscriber uplink and downlink traffic from a first multiple access transceiver to a second multiple access transceiver to communicate with said second multiple access communications system in response to said signal characteristic value.

10. A method in a code division multiple access subscriber unit for measuring a signal characteristic of a signal from an alternate multiple access communication system, said method comprising the steps of:

configuring a tuner to receive said signal from said alternate multiple access communication system;

selecting an alternate despreading signal for use in a despreader in said code division multiple access subscriber unit;

passing said signal from said alternate multiple access communication system through said despreader; and

measuring said signal characteristic of said signal from said alternate multiple access communication system.

11. The method in a code division multiple access subscriber unit according to claim **10** wherein said step of configuring a tuner to receive said signal from said alternate multiple access communication system further includes setting a frequency, setting a gain, and setting a filter, wherein each are set to receive said signal from said alternate multiple access communication system.

12. The method in a code division multiple access subscriber unit according to claim **10** wherein said alternate despreading signal is a constant value signal.

13. The method in a code division multiple access subscriber unit according to claim **10** wherein said step of measuring said signal characteristic of said signal from said alternate multiple access communication system further includes performing a frequency analysis of said signal from said alternate multiple access communication system.

14. An apparatus for receiving a code division multiple access signal and measuring a signal characteristic of a signal from an alternate multiple access communications system comprising:

a despreader having a signal input, a despreading input, and a despreader output;

a despreading code signal source;

an alternate despreading signal source;

a despreader signal selector having inputs coupled to said despreading code signal source and said alternate despreading signal source, and an output coupled to said despreading input;

a tuner having an output coupled to said signal input;

a signal characteristic measurement circuit coupled to said despreader output; and

a control circuit coupled to said tuner and said despreader signal selector for configuring said apparatus for receiving said code division multiple access signal or for measuring a signal characteristic of a signal from an alternate multiple access communications system.

15. The apparatus according to claim **14** wherein said alternate despreading signal source is a constant value signal source.

16. The apparatus according to claim **14** wherein said alternate despreading signal source produces a signal having multiple preselected discrete frequencies.

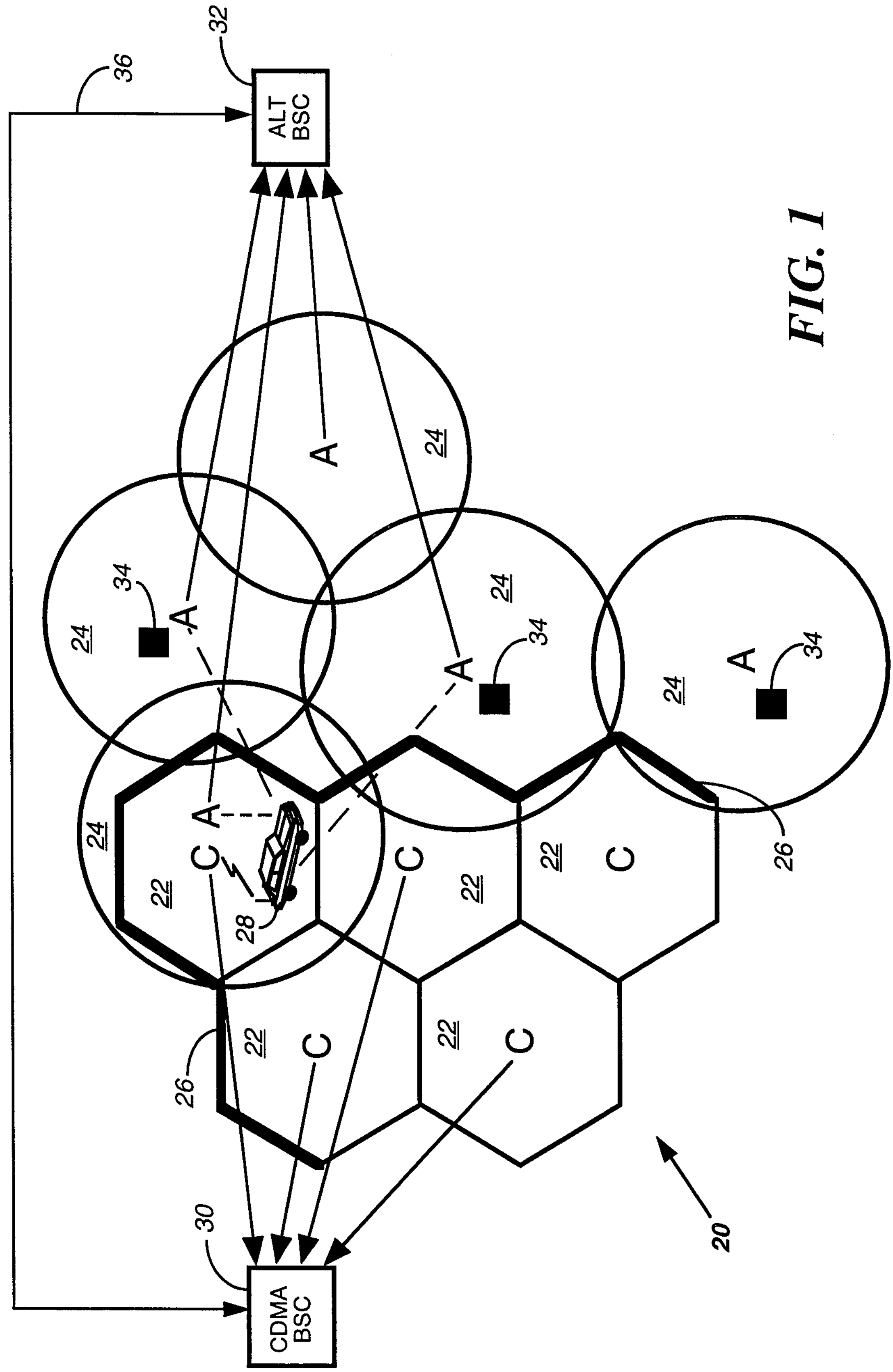


FIG. 1

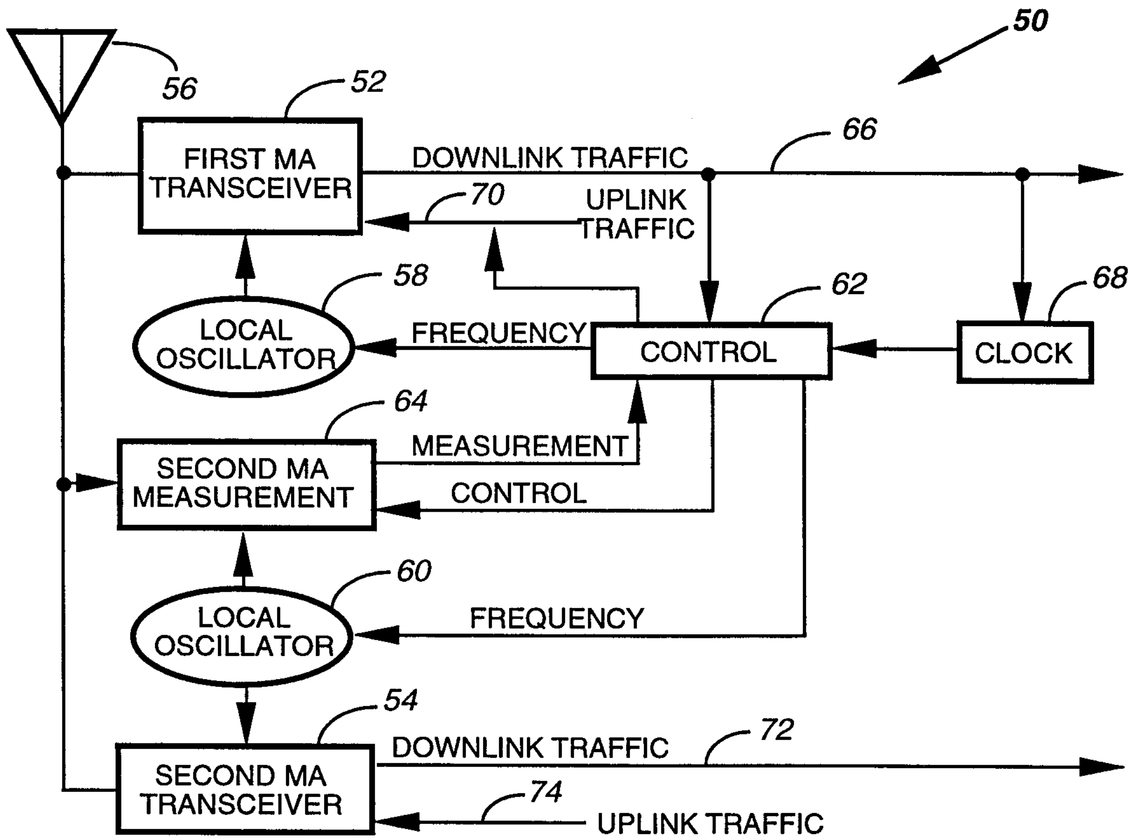

50
56
52
FIRST MA TRANSCEIVER
DOWNLINK TRAFFIC
66
70
UPLINK TRAFFIC
58
62
68
LOCAL OSCILLATOR
FREQUENCY
CONTROL
CLOCK
64
MEASUREMENT
SECOND MA MEASUREMENT
CONTROL
60
LOCAL OSCILLATOR
FREQUENCY
54
DOWNLINK TRAFFIC
72
SECOND MA TRANSCEIVER
74
UPLINK TRAFFIC

FIG. 2

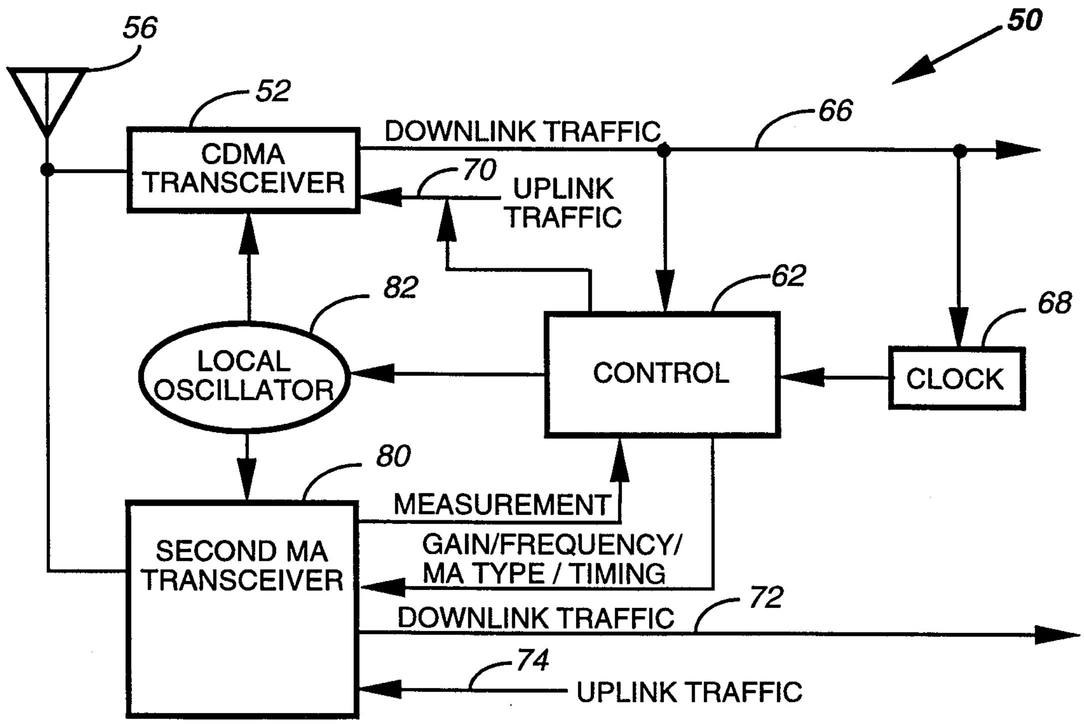
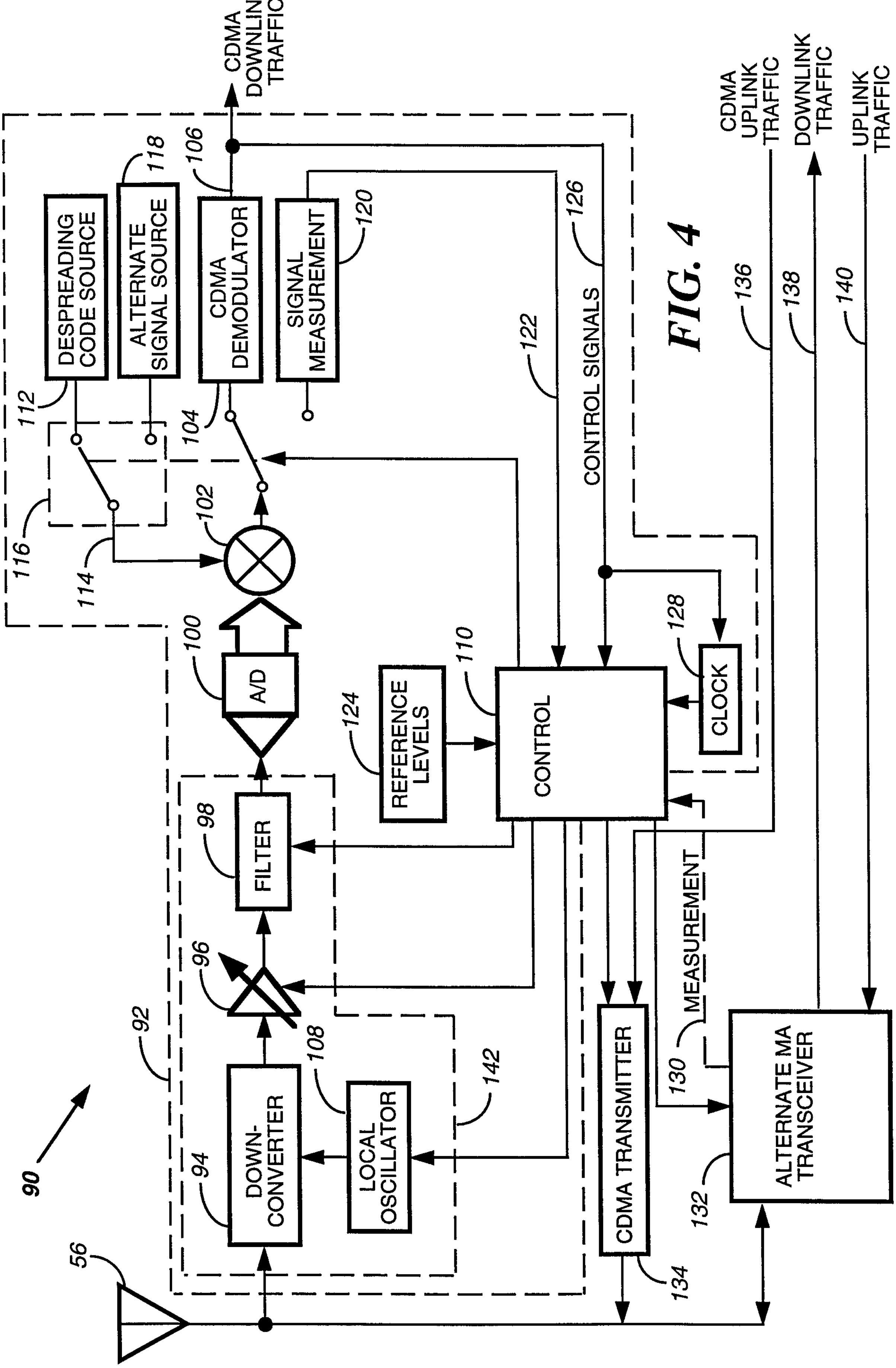

56
50
52
CDMA TRANSCEIVER
DOWNLINK TRAFFIC
66
70
UPLINK TRAFFIC
82
62
68
LOCAL OSCILLATOR
CONTROL
CLOCK
80
MEASUREMENT
GAIN/FREQUENCY/
MA TYPE / TIMING
SECOND MA TRANSCEIVER
DOWNLINK TRAFFIC
72
74
UPLINK TRAFFIC

FIG. 3



CDMA DOWNLINK TRAFFIC
CDMA UPLINK TRAFFIC
DOWNLINK TRAFFIC
UPLINK TRAFFIC
DESPREADING CODE SOURCE
ALTERNATE SIGNAL SOURCE
CDMA DEMODULATOR
SIGNAL MEASUREMENT
CONTROL SIGNALS
A/D
REFERENCE LEVELS
CONTROL
CLOCK
FILTER
MEASUREMENT
DOWN-CONVERTER
LOCAL OSCILLATOR
CDMA TRANSMITTER
ALTERNATE MA TRANSCEIVER
90
56
92
94
96
98
100
102
104
106
108
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112
114
116
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140
142

FIG. 4

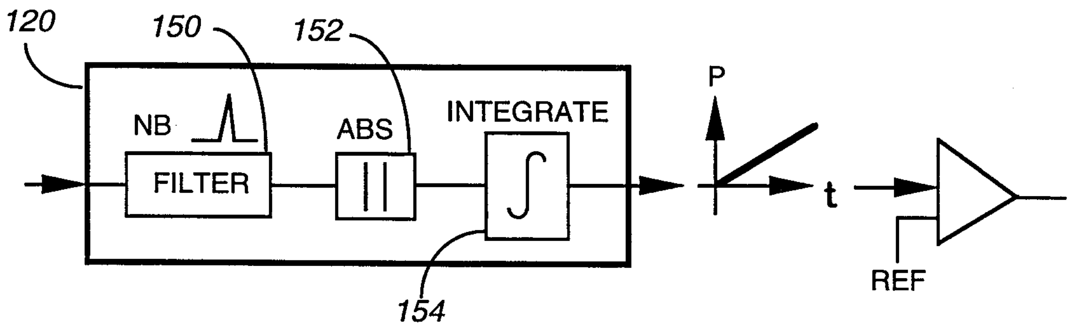
120
150
152
NB
FILTER
ABS
INTEGRATE
154
P
t
REF

FIG. 5

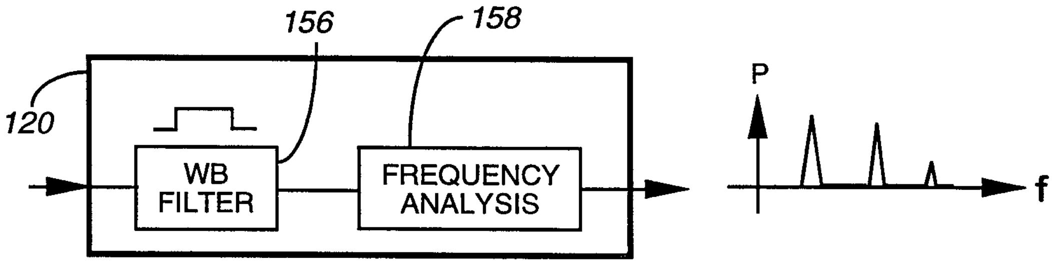
156
158
120
WB
FILTER
FREQUENCY
ANALYSIS
P
f

FIG. 6

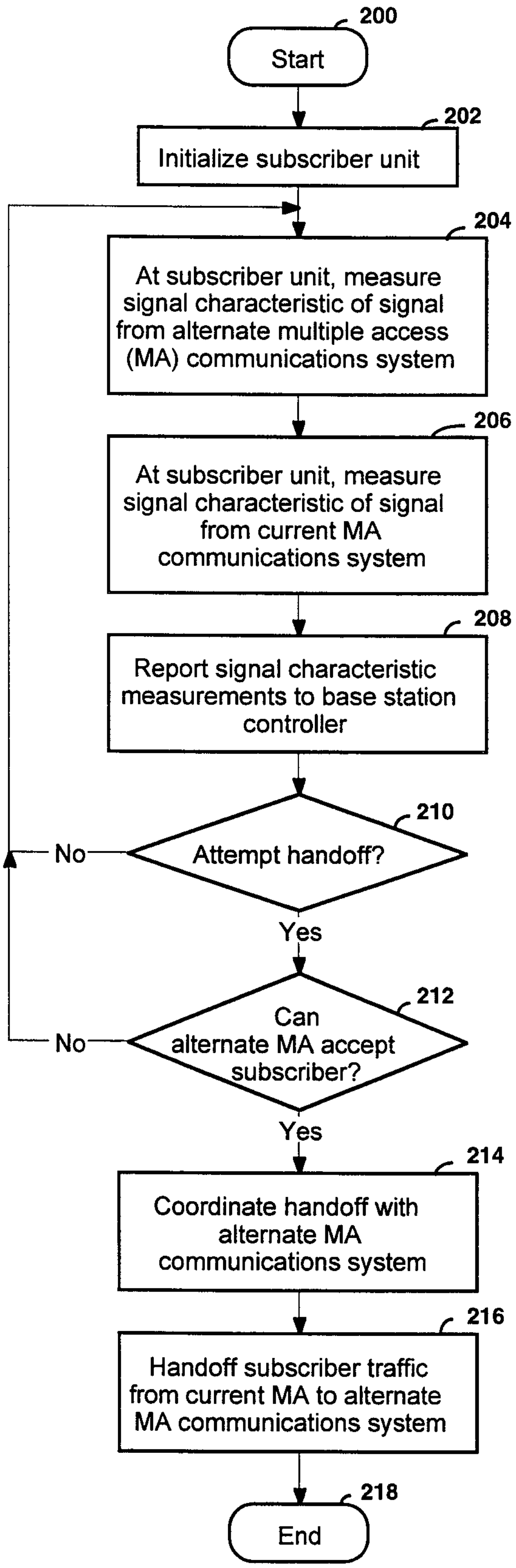
200
Start
202
Initialize subscriber unit
204
At subscriber unit, measure signal characteristic of signal from alternate multiple access (MA) communications system
206
At subscriber unit, measure signal characteristic of signal from current MA communications system
208
Report signal characteristic measurements to base station controller
210
Attempt handoff?
No
Yes
212
Can alternate MA accept subscriber?
No
Yes
214
Coordinate handoff with alternate MA communications system
216
Handoff subscriber traffic from current MA to alternate MA communications system
218
End

FIG. 7

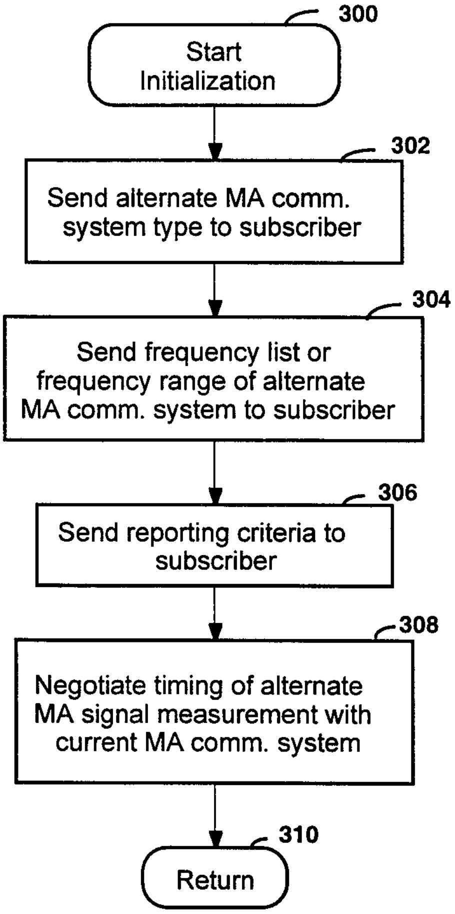
300
Start Initialization
302
Send alternate MA comm. system type to subscriber
304
Send frequency list or frequency range of alternate MA comm. system to subscriber
306
Send reporting criteria to subscriber
308
Negotiate timing of alternate MA signal measurement with current MA comm. system
310
Return

FIG. 8

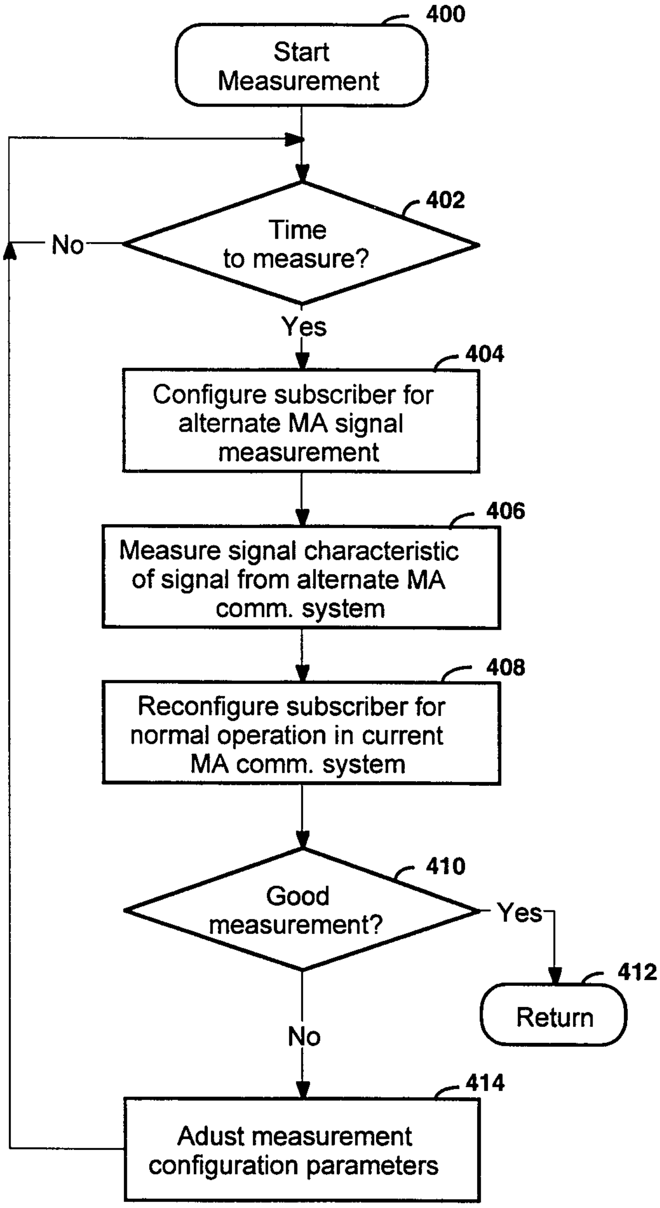
400
Start Measurement
402
Time to measure?
No
Yes
404
Configure subscriber for alternate MA signal measurement
406
Measure signal characteristic of signal from alternate MA comm. system
408
Reconfigure subscriber for normal operation in current MA comm. system
410
Good measurement?
Yes
412
Return
No
414
Adust measurement configuration parameters

FIG. 9

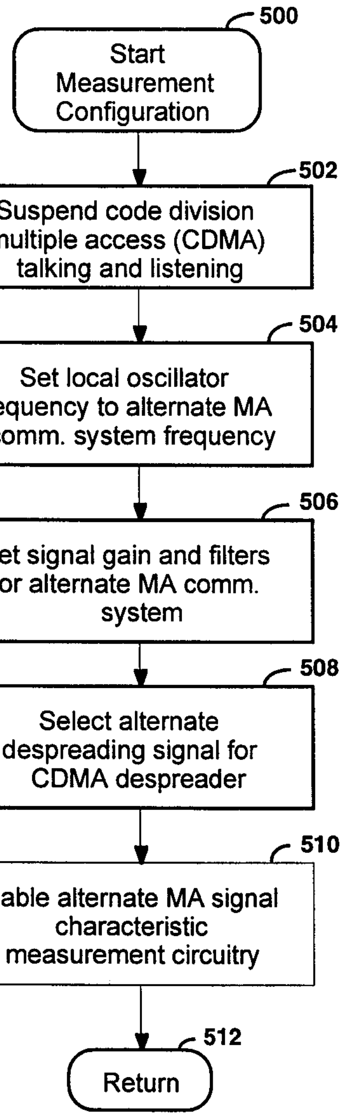
500
Start Measurement Configuration
502
Suspend code division multiple access (CDMA) talking and listening
504
Set local oscillator frequency to alternate MA comm. system frequency
506
Set signal gain and filters for alternate MA comm. system
508
Select alternate despreading signal for CDMA despreader
510
Enable alternate MA signal characteristic measurement circuitry
512
Return

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/05047

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G10L 9/00
US CL :704/201
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 704/201, 200, 226,227,228

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, IEEE CDROM library

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,555,257 A (DENT) 10 September 1996, see abstract.	1-16
A	US 5,216,744 A (ALLEYNE et al) 01 June 1993, see abstract.	1-16
A	US 5,353,374 A (WILSON et al) 04 October 1994, see abstract.	1-16
A	VERHELST, W. et al. An Overlap-add technique based on waveform similarity (WSOLA) for high quality time-scale modification of speech. ICASSP-93. IEEE International Conference on Acoustics, Speech, and Signal Processing. April 1993. vol. 5. pages 554-557.	1-16

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 JUNE 1998	30 JUL 1998

Name and mailing address of the ISA/US	Authorized officer
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